Using GNU Fortran

For gcc version 7.2.0

(GCC)

The gfortran team
Short Contents

1 Introduction ..................................................... 1

Invoking GNU Fortran
2 GNU Fortran Command Options ................................. 7
3 Runtime: Influencing runtime behavior with environment
   variables ..................................................... 29

Language Reference
4 Fortran 2003 and 2008 Status ................................. 35
5 Compiler Characteristics ....................................... 39
6 Extensions ...................................................... 43
7 Mixed-Language Programming ................................. 63
8 Coarray Programming .......................................... 77
9 Intrinsic Procedures .......................................... 101
10 Intrinsic Modules ............................................. 273

Contributing ...................................................... 279
GNU General Public License .................................. 283
GNU Free Documentation License ............................. 295
Funding Free Software .......................................... 303
Option Index ..................................................... 305
Keyword Index ................................................... 307
# Table of Contents

1 Introduction ......................................................... 1
   1.1 About GNU Fortran ........................................ 1
   1.2 GNU Fortran and GCC ..................................... 2
   1.3 Preprocessing and conditional compilation ............. 2
   1.4 GNU Fortran and G77 .................................... 3
   1.5 Project Status ........................................... 3
   1.6 Standards ................................................. 4
      1.6.1 Varying Length Character Strings ................. 4

Part I: Invoking GNU Fortran .......................... 5

2 GNU Fortran Command Options ...................... 7
   2.1 Option summary ........................................... 7
   2.2 Options controlling Fortran dialect ..................... 8
   2.3 Enable and customize preprocessing ..................... 12
   2.4 Options to request or suppress errors and warnings .... 15
   2.5 Options for debugging your program or GNU Fortran .... 19
   2.6 Options for directory search ............................ 20
   2.7 Influencing the linking step ............................. 21
   2.8 Influencing runtime behavior ............................ 21
   2.9 Options for code generation conventions .............. 21
   2.10 Environment variables affecting gfortran ............. 28

3 Runtime: Influencing runtime behavior with environment variables .... 29
   3.1 TMPDIR—Directory for scratch files .................... 29
   3.2 GFORTRAN_STDIN_UNIT—Unit number for standard input ... 29
   3.3 GFORTRAN_STDOUT_UNIT—Unit number for standard output ... 29
   3.4 GFORTRAN_STDERR_UNIT—Unit number for standard error ...... 29
   3.5 GFORTRAN_UNBUFFERED_ALL—Do not buffer I/O on all units ... 29
   3.6 GFORTRAN_UNBUFFERED_PRECONNECTED—Do not buffer I/O on preconnected units .......................... 29
   3.7 GFORTRAN_SHOW_LOCUS—Show location for runtime errors ... 29
   3.8 GFORTRAN_OPTIONAL_PLUS—Print leading + where permitted ... 30
   3.9 GFORTRAN_DEFAULT_RECL—Default record length for new files ... 30
   3.10 GFORTRAN_LIST_SEPARATOR—Separator for list output .... 30
   3.11 GFORTRAN_CONVERT_UNIT—Set endianness for unformatted I/O .... 30
   3.12 GFORTRAN_ERROR_BACKTRACE—Show backtrace on run-time errors .......................... 31

Part II: Language Reference ................. 33
4 Fortran 2003 and 2008 Status .......... 35
  4.1 Fortran 2003 status ........................... 35
  4.2 Fortran 2008 status ........................... 36
  4.3 Technical Specification 29113 Status .................. 38
  4.4 Technical Specification 18508 Status .................. 38

5 Compiler Characteristics ................. 39
  5.1 KIND Type Parameters .......................... 39
  5.2 Internal representation of LOGICAL variables ........... 39
  5.3 Thread-safety of the runtime library ................. 40
  5.4 Data consistency and durability .................... 40
  5.5 Files opened without an explicit ACTION= specifier .. 41
  5.6 File operations on symbolic links .................. 41

6 Extensions ............................... 43
  6.1 Extensions implemented in GNU Fortran ................. 43
    6.1.1 Old-style kind specifications .................. 43
    6.1.2 Old-style variable initialization ................ 43
    6.1.3 Extensions to namelist ........................ 44
    6.1.4 X format descriptor without count field ........... 45
    6.1.5 Commas in FORMAT specifications ................ 45
    6.1.6 Missing period in FORMAT specifications ........... 45
    6.1.7 I/O item lists ................................ 45
    6.1.8 Q exponent-letter ............................. 45
    6.1.9 BOZ literal constants ........................... 45
    6.1.10 Real array indices ............................. 46
    6.1.11 Unary operators ................................ 46
    6.1.12 Implicitly convert LOGICAL and INTEGER values ....... 46
    6.1.13 Hollerith constants support ..................... 47
    6.1.14 Cray pointers .................................. 47
    6.1.15 CONVERT specifier ................................ 49
    6.1.16 OpenMP ........................................ 50
    6.1.17 OpenACC ....................................... 50
    6.1.18 Argument list functions %VAL, %REF and %LOC ....... 51
    6.1.19 Read/Write after EOF marker ....................... 51
    6.1.20 STRUCTURE and RECORD ......................... 51
    6.1.21 UNION and MAP ................................ 54
    6.1.22 Type variants for integer intrinsics ............... 56
    6.1.23 AUTOMATIC and STATIC attributes ................. 57
    6.1.24 Extended math intrinsics ......................... 57
    6.1.25 Form feed as whitespace ........................ 58
    6.1.26 TYPE as an alias for PRINT ....................... 58
    6.1.27 %LOC as an rvalue ............................. 58
    6.1.28 .XOR. operator .................................. 59
    6.1.29 Bitwise logical operators ......................... 59
    6.1.30 Extended I/O specifiers ........................ 59
    6.1.31 Legacy PARAMETER statements ...................... 60
6.1.32 Default exponents ....................................... 61
6.2 Extensions not implemented in GNU Fortran ............ 61
  6.2.1 ENCODE and DECODE statements ..................... 61
  6.2.2 Variable FORMAT expressions ....................... 62
  6.2.3 Alternate complex function syntax .................. 62
  6.2.4 Volatile COMMON blocks ............................. 62
  6.2.5 OPEN( ... NAME=) .................................. 62

7 Mixed-Language Programming ............................. 63
  7.1 Interoperability with C ..................................... 63
    7.1.1 Intrinsic Types ........................................ 63
    7.1.2 Derived Types and struct ............................. 63
    7.1.3 Interoperable Global Variables ....................... 64
    7.1.4 Interoperable Subroutines and Functions ............. 64
    7.1.5 Working with Pointers ................................ 66
    7.1.6 Further Interoperability of Fortran with C ........... 68
  7.2 GNU Fortran Compiler Directives ....................... 69
  7.3 Non-Fortran Main Program ..................................... 70
    7.3.1 _gfortran_set_args — Save command-line arguments ... 70
    7.3.2 _gfortran_set_options — Set library option flags ...... 71
    7.3.3 _gfortran_set_convert — Set endian conversion ......... 72
    7.3.4 _gfortran_set_record_marker — Set length of record marks ..... 72
    7.3.5 _gfortran_set_fpe — Enable floating point exception traps
                         .................................................. 73
    7.3.6 _gfortran_set_max_subrecord_length — Set subrecord length
                         .................................................. 73
  7.4 Naming and argument-passing conventions ............... 73
    7.4.1 Naming conventions ...................................... 74
    7.4.2 Argument passing conventions .......................... 74

8 Coarray Programming ........................................ 77
  8.1 Type and enum ABI Documentation ........................ 77
    8.1.1 caf_token_t ........................................ 77
    8.1.2 caf_register_t ....................................... 77
    8.1.3 caf_deregister_t ..................................... 77
    8.1.4 caf_reference_t ...................................... 77
    8.1.5 caf_team_t .......................................... 79
  8.2 Function ABI Documentation .............................. 79
    8.2.1 _gfortran_caf_init — Initialization function ....... 80
    8.2.2 _gfortran_caf_finish — Finalization function ........ 80
    8.2.3 _gfortran_caf_this_image — Querying the image number
                         .................................................. 80
    8.2.4 _gfortran_caf_num_images — Querying the maximal number of images
                         .................................................. 81
    8.2.5 _gfortran_caf_image_status — Query the status of an image
                         .................................................. 81
8.2.6  _gfortran_caf_failed_images — Get an array of the
indexes of the failed images ................................. 81
8.2.7  _gfortran_caf_stopped_images — Get an array of the
indexes of the stopped images ................................. 82
8.2.8  _gfortran_caf_register — Registering coarrays.... 82
8.2.9  _gfortran_caf_deregister — Deregistering coarrays.... 83
8.2.10 _gfortran_caf_is_present — Query whether an
    allocatable or pointer component in a derived type coarray is
    allocated .................................................. 84
8.2.11 _gfortran_caf_send — Sending data from a local image to
    a remote image ............................................ 84
8.2.12 _gfortran_caf_get — Getting data from a remote image
                                .................................................. 85
8.2.13 _gfortran_caf_sendget — Sending data between remote
    images ..................................................... 86
8.2.14 _gfortran_caf_send_by_ref — Sending data from a local
    image to a remote image with enhanced referencing options 87
8.2.15 _gfortran_caf_get_by_ref — Getting data from a remote
    image using enhanced references .......................... 88
8.2.16 _gfortran_caf_sendget_by_ref — Sending data between
    remote images using enhanced references on both sides .... 89
8.2.17 _gfortran_caf_lock — Locking a lock variable ........ 90
8.2.18 _gfortran_caf_lock — Unlocking a lock variable .... 91
8.2.19 _gfortran_caf_event_post — Post an event ............ 91
8.2.20 _gfortran_caf_event_wait — Wait that an event occurred
                                .................................................. 92
8.2.21 _gfortran_caf_event_query — Query event count .... 93
8.2.22 _gfortran_caf_sync_all — All-image barrier .......... 93
8.2.23 _gfortran_caf_sync_images — Barrier for selected images
                                .................................................. 93
8.2.24 _gfortran_caf_sync_memory — Wait for completion of
    segment-memory operations ............................... 94
8.2.25 _gfortran_caf_error_stop — Error termination with exit
    code ....................................................... 94
8.2.26 _gfortran_caf_error_stop_str — Error termination with
    string ...................................................... 95
8.2.27 _gfortran_caf_fail_image — Mark the image failed and
    end its execution ........................................ 95
8.2.28 _gfortran_caf_atomic_define — Atomic variable
    assignment ................................................ 95
8.2.29 _gfortran_caf_atomic_ref — Atomic variable reference
                                .................................................. 95
8.2.30 _gfortran_caf_atomic_cas — Atomic compare and swap
                                .................................................. 95
8.2.31 _gfortran_caf_atomic_op — Atomic operation ....... 96
8.2.32 _gfortran_caf_co_broadcast — Sending data to all
    images ....................................................... 97
9 Intrinsic Procedures ............................................ 101

9.1 Introduction to intrinsic procedures .......................... 101
9.2 ABORT — Abort the program .................................. 101
9.3 ABS — Absolute value ........................................... 102
9.4 ACCESS — Checks file access modes ......................... 103
9.5 ACHAR — Character in ASCII collating sequence .......... 103
9.6 ACOS — Arccosine function .................................... 104
9.7 ACOSD — Arccosine function, degrees ....................... 105
9.8 ACOSH — Inverse hyperbolic cosine function ............... 105
9.9 ADJUSTL — Left adjust a string ............................. 106
9.10 ADJUSTR — Right adjust a string ............................ 106
9.11 AIMAG — Imaginary part of complex number ............... 107
9.12 AINT — Truncate to a whole number ......................... 107
9.13 ALARM — Execute a routine after a given delay .......... 108
9.14 ALL — All values in MASK along DIM are true ........... 109
9.15 ALLOCATED — Status of an allocatable entity ............. 110
9.16 AND — Bitwise logical AND .................................. 110
9.17 ANINT — Nearest whole number .............................. 111
9.18 ANY — Any value in MASK along DIM is true ............... 112
9.19 ASIN — Arcsine function ..................................... 112
9.20 ASIND — Arcsine function, degrees ......................... 113
9.21 ASINH — Inverse hyperbolic sine function .................. 114
9.22 ASSOCIATED — Status of a pointer or pointer/target pair .. 114
9.23 ATAN — Arctangent function ................................ 115
9.24 ATAND — Arctangent function, degrees .................... 116
9.25 ATAN2 — Arctangent function ................................. 117
9.26 ATAN2D — Arctangent function, degrees .................... 118
9.27 ATANH — Inverse hyperbolic tangent function .............. 119
9.28 ATOMIC_ADD — Atomic ADD operation ..................... 119
9.29 ATOMIC_AND — Atomic bitwise AND operation .......... 120
9.30 ATOMIC_CAS — Atomic compare and swap .................. 120
9.31 ATOMIC_DEFINE — Setting a variable atomically ......... 121
9.32 ATOMIC_FETCH_ADD — Atomic ADD operation with prior fetch .............................................................. 122
9.33 ATOMIC_FETCH_AND — Atomic bitwise AND operation with prior fetch .................................................. 123
9.34 ATOMIC_FETCH_OR — Atomic bitwise OR operation with prior fetch .................................................. 123
9.35 ATOMIC_FETCH_XOR — Atomic bitwise XOR operation with prior
fetch .......................................................... 124
9.36 ATOMIC_OR — Atomic bitwise OR operation .................. 125
9.37 ATOMIC_REF — Obtaining the value of a variable atomically .. 125
9.38 ATOMIC_XOR — Atomic bitwise OR operation ................. 126
9.39 BACKTRACE — Show a backtrace ................................ 127
9.40 BESSEL_J0 — Bessel function of the first kind of order 0 .... 127
9.41 BESSEL_J1 — Bessel function of the first kind of order 1 .... 128
9.42 BESSEL_JN — Bessel function of the first kind ............... 128
9.43 BESSEL_Y0 — Bessel function of the second kind of order 0 .. 129
9.44 BESSEL_Y1 — Bessel function of the second kind of order 1 .. 130
9.45 BESSEL_YN — Bessel function of the second kind .......... 130
9.46 BGE — Bitwise greater than or equal to ........................ 131
9.47 BGT — Bitwise greater than .................................... 131
9.48 BIT_SIZE — Bit size inquiry function .......................... 132
9.49 BLE — Bitwise less than or equal to ............................ 132
9.50 BLT — Bitwise less than ........................................... 132
9.51 BTST — Bit test function ......................................... 133
9.52 C_ASSOCIATED — Status of a C pointer ....................... 134
9.53 C_F_POINTER — Convert C into Fortran pointer .............. 134
9.54 C_F_PROCPOINTER — Convert C into Fortran procedure pointer
.................................................................................. 135
9.55 C_FUNLOC — Obtain the C address of a procedure ............ 136
9.56 C_LOC — Obtain the C address of an object .................... 136
9.57 C_SIZEOF — Size in bytes of an expression .................... 137
9.58 CEILING — Integer ceiling function ............................ 138
9.59 CHAR — Character conversion function .......................... 138
9.60 CHDIR — Change working directory ............................. 139
9.61 CHMOD — Change access permissions of files ................. 139
9.62 CMPLX — Complex conversion function ........................ 140
9.63 CO_BROADCAST — Copy a value to all images the current set of
images ......................................................................... 141
9.64 CO_MAX — Maximal value on the current set of images ...... 142
9.65 CO_MIN — Minimal value on the current set of images ...... 142
9.66 CO_REDUCE — Reduction of values on the current set of images
.................................................................................. 143
9.67 CO_SUM — Sum of values on the current set of images ...... 144
9.68 COMMAND_ARGUMENT_COUNT — Get number of command line
arguments ..................................................................... 145
9.69 COMPILER_OPTIONS — Options passed to the compiler ..... 146
9.70 COMPILER_VERSION — Compiler version string .............. 146
9.71 CMPLX — Complex conversion function ........................ 147
9.72 CONJG — Complex conjugate function .......................... 147
9.73 COS — Cosine function .............................................. 148
9.74 COSD — Cosine function, degrees ............................... 149
9.75 COSH — Hyperbolic cosine function ............................ 149
9.76 COTAN — Cotangent function ..................................... 150
9.77 COTAND — Cotangent function, degrees ....................... 150
9.78  COUNT — Count function .......................... 151
9.79  CPU_TIME — CPU elapsed time in seconds .......... 152
9.80  CSHIFT — Circular shift elements of an array .......... 153
9.81  CTIME — Convert a time into a string ................. 153
9.82  DATE_AND_TIME — Date and time subroutine .......... 154
9.83  DBLE — Double conversion function .................. 155
9.84  DCMPLX — Double complex conversion function .......... 156
9.85  DIGITS — Significant binary digits function .......... 156
9.86  DIM — Positive difference ......................... 157
9.87  DOT_PRODUCT — Dot product function ................. 157
9.88  DPROD — Double product function .................... 158
9.89  DREAL — Double real part function ................... 159
9.90  DSHIFTL — Combined left shift ....................... 159
9.91  DSHIFTR — Combined right shift ....................... 160
9.92  DTIME — Execution time subroutine (or function) .... 160
9.93  EOSHIFT — End-off shift elements of an array ........ 161
9.94  EPSILON — Epsilon function .......................... 162
9.95  ERF — Error function .............................. 163
9.96  ERFC — Error function .............................. 163
9.97  ERFC_SCALED — Error function ......................... 164
9.98  ETIME — Execution time subroutine (or function) .... 164
9.99  EVENT_QUERY — Query whether a coarray event has occurred ........................................... 165
9.100 EXECUTE_COMMAND_LINE — Execute a shell command .... 166
9.101 EXIT — Exit the program with status .................. 167
9.102 EXP — Exponential function .......................... 167
9.103 EXPONENT — Exponent function ......................... 168
9.104 EXTENDS_TYPE_OF — Query dynamic type for extension .... 168
9.105 FDATE — Get the current time as a string .......... 169
9.106 FGET — Read a single character in stream mode from stdin ........................................... 169
9.107 FGETC — Read a single character in stream mode ..... 170
9.108 FLOOR — Integer floor function ....................... 171
9.109 FLUSH — Flush I/O unit(s) ........................... 172
9.110 FNUM — File number function ........................ 172
9.111 FPUT — Write a single character in stream mode to stdout .. 173
9.112 FPUTC — Write a single character in stream mode .. 174
9.113 FRACTION — Fractional part of the model representation .... 175
9.114 FREE — Frees memory .................................. 175
9.115 FSEEK — Low level file positioning subroutine .......... 175
9.116 FSTAT — Get file status ............................. 177
9.117 FTELL — Current stream position ....................... 177
9.118 GAMMA — Gamma function ............................ 178
9.119 GERROR — Get last system error message .............. 178
9.120 GETARG — Get command line arguments ............... 179
9.121 GET_COMMAND — Get the entire command line .......... 180
9.122 GET_COMMAND_ARGUMENT — Get command line arguments .. 180
9.123 GETCWD — Get current working directory ............. 181
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>GETENV</td>
<td>Get an environmental variable</td>
<td>182</td>
</tr>
<tr>
<td>GET_ENVIRONMENT_VARIABLE</td>
<td>Get an environmental variable</td>
<td>182</td>
</tr>
<tr>
<td>GETGID</td>
<td>Group ID function</td>
<td>183</td>
</tr>
<tr>
<td>GETLOG</td>
<td>Get login name</td>
<td>183</td>
</tr>
<tr>
<td>GETPID</td>
<td>Process ID function</td>
<td>184</td>
</tr>
<tr>
<td>GETUID</td>
<td>User ID function</td>
<td>184</td>
</tr>
<tr>
<td>GMTIME</td>
<td>Convert time to GMT info</td>
<td>185</td>
</tr>
<tr>
<td>HOSTNM</td>
<td>Get system host name</td>
<td>185</td>
</tr>
<tr>
<td>HUGE</td>
<td>Largest number of a kind</td>
<td>186</td>
</tr>
<tr>
<td>HYPOT</td>
<td>Euclidean distance function</td>
<td>186</td>
</tr>
<tr>
<td>IACHAR</td>
<td>Code in ASCII collating sequence</td>
<td>187</td>
</tr>
<tr>
<td>IALL</td>
<td>Bitwise AND of array elements</td>
<td>187</td>
</tr>
<tr>
<td>IAND</td>
<td>Bitwise logical and</td>
<td>188</td>
</tr>
<tr>
<td>IANY</td>
<td>Bitwise OR of array elements</td>
<td>189</td>
</tr>
<tr>
<td>IARGC</td>
<td>Get the number of command line arguments</td>
<td>190</td>
</tr>
<tr>
<td>IBCLR</td>
<td>Clear bit</td>
<td>190</td>
</tr>
<tr>
<td>IBITS</td>
<td>Bit extraction</td>
<td>191</td>
</tr>
<tr>
<td>IBSET</td>
<td>Set bit</td>
<td>191</td>
</tr>
<tr>
<td>ICHAR</td>
<td>Character-to-integer conversion function</td>
<td>192</td>
</tr>
<tr>
<td>IDATE</td>
<td>Get current local time subroutine (day/month/year)</td>
<td>193</td>
</tr>
<tr>
<td>IERROR</td>
<td>Bitwise logical exclusive or</td>
<td>193</td>
</tr>
<tr>
<td>IERRNO</td>
<td>Get the last system error number</td>
<td>194</td>
</tr>
<tr>
<td>IMAGE_INDEX</td>
<td>Function that converts a cosubscript to an image index</td>
<td>194</td>
</tr>
<tr>
<td>INDEX</td>
<td>Position of a substring within a string</td>
<td>195</td>
</tr>
<tr>
<td>INT</td>
<td>Convert to integer type</td>
<td>195</td>
</tr>
<tr>
<td>INT2</td>
<td>Convert to 16-bit integer type</td>
<td>196</td>
</tr>
<tr>
<td>INT8</td>
<td>Convert to 64-bit integer type</td>
<td>197</td>
</tr>
<tr>
<td>IOR</td>
<td>Bitwise logical or</td>
<td>197</td>
</tr>
<tr>
<td>IPARITY</td>
<td>Bitwise XOR of array elements</td>
<td>198</td>
</tr>
<tr>
<td>IRAND</td>
<td>Integer pseudo-random number</td>
<td>198</td>
</tr>
<tr>
<td>IS_IOSTAT_END</td>
<td>Test for end-of-file value</td>
<td>199</td>
</tr>
<tr>
<td>IS_IOSTAT_EOR</td>
<td>Test for end-of-record value</td>
<td>200</td>
</tr>
<tr>
<td>ISATTY</td>
<td>Whether a unit is a terminal device</td>
<td>200</td>
</tr>
<tr>
<td>ISHFT</td>
<td>Shift bits</td>
<td>201</td>
</tr>
<tr>
<td>ISHFTC</td>
<td>Shift bits circularly</td>
<td>201</td>
</tr>
<tr>
<td>ISNAN</td>
<td>Test for a NaN</td>
<td>202</td>
</tr>
<tr>
<td>ITIME</td>
<td>Get current local time subroutine (hour/minutes/seconds)</td>
<td>202</td>
</tr>
<tr>
<td>KILL</td>
<td>Send a signal to a process</td>
<td>203</td>
</tr>
<tr>
<td>KIND</td>
<td>Kind of an entity</td>
<td>203</td>
</tr>
<tr>
<td>LBOUND</td>
<td>Lower dimension bounds of an array</td>
<td>204</td>
</tr>
<tr>
<td>LCOBOUND</td>
<td>Lower codimension bounds of an array</td>
<td>204</td>
</tr>
<tr>
<td>LEADZ</td>
<td>Number of leading zero bits of an integer</td>
<td>205</td>
</tr>
<tr>
<td>LEN</td>
<td>Length of a character entity</td>
<td>205</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>9.167</td>
<td>LEN_TRIM — Length of a character entity without trailing blank characters.</td>
<td></td>
</tr>
<tr>
<td>9.168</td>
<td>LGE — Lexical greater than or equal.</td>
<td></td>
</tr>
<tr>
<td>9.169</td>
<td>LGT — Lexical greater than.</td>
<td></td>
</tr>
<tr>
<td>9.170</td>
<td>LINK — Create a hard link.</td>
<td></td>
</tr>
<tr>
<td>9.171</td>
<td>LLE — Lexical less than or equal.</td>
<td></td>
</tr>
<tr>
<td>9.172</td>
<td>LLT — Lexical less than.</td>
<td></td>
</tr>
<tr>
<td>9.173</td>
<td>LNBLNK — Index of the last non-blank character in a string.</td>
<td></td>
</tr>
<tr>
<td>9.174</td>
<td>LOC — Returns the address of a variable.</td>
<td></td>
</tr>
<tr>
<td>9.175</td>
<td>LOG — Natural logarithm function.</td>
<td></td>
</tr>
<tr>
<td>9.176</td>
<td>LOG10 — Base 10 logarithm function.</td>
<td></td>
</tr>
<tr>
<td>9.178</td>
<td>LOGICAL — Convert to logical type.</td>
<td></td>
</tr>
<tr>
<td>9.179</td>
<td>LONG — Convert to integer type.</td>
<td></td>
</tr>
<tr>
<td>9.180</td>
<td>LSHIFT — Left shift bits.</td>
<td></td>
</tr>
<tr>
<td>9.181</td>
<td>LSTAT — Get file status.</td>
<td></td>
</tr>
<tr>
<td>9.182</td>
<td>LTIME — Convert time to local time info.</td>
<td></td>
</tr>
<tr>
<td>9.183</td>
<td>MALLOC — Allocate dynamic memory.</td>
<td></td>
</tr>
<tr>
<td>9.184</td>
<td>MASKL — Left justified mask.</td>
<td></td>
</tr>
<tr>
<td>9.185</td>
<td>MASKR — Right justified mask.</td>
<td></td>
</tr>
<tr>
<td>9.186</td>
<td>MATMUL — Matrix multiplication.</td>
<td></td>
</tr>
<tr>
<td>9.187</td>
<td>MAX — Maximum value of an argument list.</td>
<td></td>
</tr>
<tr>
<td>9.188</td>
<td>MAXEXPONENT — Maximum exponent of a real kind.</td>
<td></td>
</tr>
<tr>
<td>9.189</td>
<td>MAXLOC — Location of the maximum value within an array.</td>
<td></td>
</tr>
<tr>
<td>9.190</td>
<td>MAXVAL — Maximum value of an array.</td>
<td></td>
</tr>
<tr>
<td>9.191</td>
<td>MCLOCK — Time function.</td>
<td></td>
</tr>
<tr>
<td>9.192</td>
<td>MCLOCK8 — Time function (64-bit).</td>
<td></td>
</tr>
<tr>
<td>9.193</td>
<td>MERGE — Merge variables.</td>
<td></td>
</tr>
<tr>
<td>9.194</td>
<td>MERGE_BITS — Merge of bits under mask.</td>
<td></td>
</tr>
<tr>
<td>9.195</td>
<td>MIN — Minimum value of an argument list.</td>
<td></td>
</tr>
<tr>
<td>9.196</td>
<td>MINEXPONENT — Minimum exponent of a real kind.</td>
<td></td>
</tr>
<tr>
<td>9.197</td>
<td>MINLOC — Location of the minimum value within an array.</td>
<td></td>
</tr>
<tr>
<td>9.198</td>
<td>MINVAL — Minimum value of an array.</td>
<td></td>
</tr>
<tr>
<td>9.199</td>
<td>MOD — Remainder function.</td>
<td></td>
</tr>
<tr>
<td>9.200</td>
<td>MODULO — Modulo function.</td>
<td></td>
</tr>
<tr>
<td>9.201</td>
<td>MOVE_ALLOC — Move allocation from one object to another.</td>
<td></td>
</tr>
<tr>
<td>9.202</td>
<td>MVBITS — Move bits from one integer to another.</td>
<td></td>
</tr>
<tr>
<td>9.203</td>
<td>NEAREST — Nearest representable number.</td>
<td></td>
</tr>
<tr>
<td>9.204</td>
<td>NEW_LINE — New line character.</td>
<td></td>
</tr>
<tr>
<td>9.205</td>
<td>NINT — Nearest whole number.</td>
<td></td>
</tr>
<tr>
<td>9.206</td>
<td>NORM2 — Euclidean vector norms.</td>
<td></td>
</tr>
<tr>
<td>9.207</td>
<td>NOT — Logical negation.</td>
<td></td>
</tr>
<tr>
<td>9.208</td>
<td>NULL — Function that returns an disassociated pointer.</td>
<td></td>
</tr>
<tr>
<td>9.209</td>
<td>NUM_IMAGES — Function that returns the number of images.</td>
<td></td>
</tr>
<tr>
<td>9.210</td>
<td>OR — Bitwise logical OR.</td>
<td></td>
</tr>
<tr>
<td>9.211</td>
<td>PACK — Pack an array into an array of rank one.</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>9.212</td>
<td>PARITY — Reduction with exclusive OR</td>
<td></td>
</tr>
<tr>
<td>9.213</td>
<td>PERROR — Print system error message</td>
<td></td>
</tr>
<tr>
<td>9.214</td>
<td>POPCNT — Number of bits set</td>
<td></td>
</tr>
<tr>
<td>9.215</td>
<td>POPPAR — Parity of the number of bits set</td>
<td></td>
</tr>
<tr>
<td>9.216</td>
<td>PRECISION — Decimal precision of a real kind</td>
<td></td>
</tr>
<tr>
<td>9.217</td>
<td>PRESENT — Determine whether an optional dummy argument is specified</td>
<td></td>
</tr>
<tr>
<td>9.218</td>
<td>PRODUCT — Product of array elements</td>
<td></td>
</tr>
<tr>
<td>9.219</td>
<td>RADIX — Base of a model number</td>
<td></td>
</tr>
<tr>
<td>9.220</td>
<td>RAN — Real pseudo-random number</td>
<td></td>
</tr>
<tr>
<td>9.221</td>
<td>RAND — Real pseudo-random number</td>
<td></td>
</tr>
<tr>
<td>9.222</td>
<td>RANDOM_NUMBER — Pseudo-random number</td>
<td></td>
</tr>
<tr>
<td>9.223</td>
<td>RANDOM_SEED — Initialize a pseudo-random number sequence</td>
<td></td>
</tr>
<tr>
<td>9.224</td>
<td>RANGE — Decimal exponent range</td>
<td></td>
</tr>
<tr>
<td>9.225</td>
<td>RANK — Rank of a data object</td>
<td></td>
</tr>
<tr>
<td>9.226</td>
<td>REAL — Convert to real type</td>
<td></td>
</tr>
<tr>
<td>9.227</td>
<td>RENAME — Rename a file</td>
<td></td>
</tr>
<tr>
<td>9.228</td>
<td>REPEAT — Repeated string concatenation</td>
<td></td>
</tr>
<tr>
<td>9.229</td>
<td>RESHAPE — Function to reshape an array</td>
<td></td>
</tr>
<tr>
<td>9.230</td>
<td>RRSPPACING — Reciprocal of the relative spacing</td>
<td></td>
</tr>
<tr>
<td>9.231</td>
<td>RSHIFT — Right shift</td>
<td></td>
</tr>
<tr>
<td>9.232</td>
<td>SAME_TYPE_AS — Query dynamic types for equality</td>
<td></td>
</tr>
<tr>
<td>9.233</td>
<td>SCALE — Scale a real value</td>
<td></td>
</tr>
<tr>
<td>9.234</td>
<td>SCAN — Scan a string for the presence of a set of characters</td>
<td></td>
</tr>
<tr>
<td>9.235</td>
<td>SECONDS — Time function</td>
<td></td>
</tr>
<tr>
<td>9.236</td>
<td>SECOND — CPU time function</td>
<td></td>
</tr>
<tr>
<td>9.237</td>
<td>SELECTED_CHAR_KIND — Choose character kind</td>
<td></td>
</tr>
<tr>
<td>9.238</td>
<td>SELECTED_INT_KIND — Choose integer kind</td>
<td></td>
</tr>
<tr>
<td>9.239</td>
<td>SELECTED_REAL_KIND — Choose real kind</td>
<td></td>
</tr>
<tr>
<td>9.240</td>
<td>SET_EXPONENT — Set the exponent of the model</td>
<td></td>
</tr>
<tr>
<td>9.241</td>
<td>SHAPE — Determine the shape of an array</td>
<td></td>
</tr>
<tr>
<td>9.242</td>
<td>SHIFTA — Right shift with fill</td>
<td></td>
</tr>
<tr>
<td>9.243</td>
<td>SHIFTL — Left shift</td>
<td></td>
</tr>
<tr>
<td>9.244</td>
<td>SHIFTR — Right shift</td>
<td></td>
</tr>
<tr>
<td>9.245</td>
<td>SIGN — Sign copying function</td>
<td></td>
</tr>
<tr>
<td>9.246</td>
<td>SIGNAL — Signal handling subroutine (or function)</td>
<td></td>
</tr>
<tr>
<td>9.247</td>
<td>SIN — Sine function</td>
<td></td>
</tr>
<tr>
<td>9.248</td>
<td>SIND — Sine function, degrees</td>
<td></td>
</tr>
<tr>
<td>9.249</td>
<td>SINH — Hyperbolic sine function</td>
<td></td>
</tr>
<tr>
<td>9.250</td>
<td>SIZE — Determine the size of an array</td>
<td></td>
</tr>
<tr>
<td>9.251</td>
<td>SIZEOF — Size in bytes of an expression</td>
<td></td>
</tr>
<tr>
<td>9.252</td>
<td>SLEEP — Sleep for the specified number of seconds</td>
<td></td>
</tr>
<tr>
<td>9.253</td>
<td>SPACING — Smallest distance between two numbers of a given type</td>
<td></td>
</tr>
<tr>
<td>9.254</td>
<td>SPREAD — Add a dimension to an array</td>
<td></td>
</tr>
<tr>
<td>9.255</td>
<td>SQRT — Square-root function</td>
<td></td>
</tr>
<tr>
<td>Page</td>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>256</td>
<td>SRAND</td>
<td>Reinitialize the random number generator</td>
</tr>
<tr>
<td>256</td>
<td>STAT</td>
<td>Get file status</td>
</tr>
<tr>
<td>258</td>
<td>STORAGE_SIZE</td>
<td>Storage size in bits</td>
</tr>
<tr>
<td>258</td>
<td>SUM</td>
<td>Sum of array elements</td>
</tr>
<tr>
<td>259</td>
<td>SYMLNK</td>
<td>Create a symbolic link</td>
</tr>
<tr>
<td>259</td>
<td>SYSTEM</td>
<td>Execute a shell command</td>
</tr>
<tr>
<td>260</td>
<td>SYSTEM_CLOCK</td>
<td>Time function</td>
</tr>
<tr>
<td>261</td>
<td>TAN</td>
<td>Tangent function</td>
</tr>
<tr>
<td>261</td>
<td>TAND</td>
<td>Tangent function, degrees</td>
</tr>
<tr>
<td>262</td>
<td>TANH</td>
<td>Hyperbolic tangent function</td>
</tr>
<tr>
<td>262</td>
<td>THIS_IMAGE</td>
<td>Function that returns the cosubscript index of this image</td>
</tr>
<tr>
<td>263</td>
<td>TIME</td>
<td>Time function</td>
</tr>
<tr>
<td>264</td>
<td>TIME8</td>
<td>Time function (64-bit)</td>
</tr>
<tr>
<td>264</td>
<td>TINY</td>
<td>Smallest positive number of a real kind</td>
</tr>
<tr>
<td>265</td>
<td>TRAILZ</td>
<td>Number of trailing zero bits of an integer</td>
</tr>
<tr>
<td>265</td>
<td>TRANSFER</td>
<td>Transfer bit patterns</td>
</tr>
<tr>
<td>266</td>
<td>TRANSPOSE</td>
<td>Transpose an array of rank two</td>
</tr>
<tr>
<td>267</td>
<td>TRIM</td>
<td>Remove trailing blank characters of a string</td>
</tr>
<tr>
<td>267</td>
<td>TTYNAM</td>
<td>Get the name of a terminal device</td>
</tr>
<tr>
<td>268</td>
<td>UBOUND</td>
<td>Upper dimension bounds of an array</td>
</tr>
<tr>
<td>268</td>
<td>UCOBOUND</td>
<td>Upper codimension bounds of an array</td>
</tr>
<tr>
<td>269</td>
<td>UMASK</td>
<td>Set the file creation mask</td>
</tr>
<tr>
<td>269</td>
<td>UNLINK</td>
<td>Remove a file from the file system</td>
</tr>
<tr>
<td>269</td>
<td>UNPACK</td>
<td>Unpack an array of rank one into an array</td>
</tr>
<tr>
<td>270</td>
<td>VERIFY</td>
<td>Scan a string for characters not a given set</td>
</tr>
<tr>
<td>271</td>
<td>XOR</td>
<td>Bitwise logical exclusive OR</td>
</tr>
</tbody>
</table>

10 Intrinsic Modules ........................................... 273

10.1 ISO_FORTRAN_ENV ........................................... 273
10.2 ISO_C_BINDING ............................................. 275
10.3 IEEE modules: IEEE_EXCEPTIONS, IEEE_ARITHMETIC, and IEEE_FEATURES ........................................... 276
10.4 OpenMP Modules OMP_LIB and OMP_LIB_KINDS ............ 277
10.5 OpenACC Module OPENACC .................................. 277

Contributing ..................................................... 279

Contributors to GNU Fortran .................................. 279
Projects .......................................................... 280
Proposed Extensions ........................................... 280
Compiler extensions: ............................................ 280
Environment Options ............................................ 281

GNU General Public License ................................. 283

GNU Free Documentation License ............................. 295

ADDENDUM: How to use this License for your documents .... 302
Funding Free Software.......................... 303
Option Index....................................... 305
Keyword Index..................................... 307


1 Introduction

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

The GNU Fortran compiler front end was designed initially as a free replacement for, or alternative to, the Unix f95 command; gfortran is the command you will use to invoke the compiler.

1.1 About GNU Fortran

The GNU Fortran compiler supports the Fortran 77, 90 and 95 standards completely, parts of the Fortran 2003 and Fortran 2008 standards, and several vendor extensions. The development goal is to provide the following features:

- Read a user’s program, stored in a file and containing instructions written in Fortran 77, Fortran 90, Fortran 95, Fortran 2003 or Fortran 2008. 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 are not as good writing machine code as they are at writing Fortran (or C++, Ada, or Java), because it 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. The Fortran 90 standard 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.

The GNU Fortran compiler 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 compile 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 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 contain 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 GNU Fortran 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.

1.2 GNU Fortran and GCC

GNU Fortran is a part of GCC, the GNU Compiler Collection. GCC consists of a collection of front ends for various languages, which translate the source code into a language-independent form called GENERIC. This is then processed by a common middle end which provides optimization, and then passed to one of a collection of back ends which generate code for different computer architectures and operating systems.

Functionally, this is implemented with a driver program (gcc) which provides the command-line interface for the compiler. It calls the relevant compiler front-end program (e.g., f951 for Fortran) for each file in the source code, and then calls the assembler and linker as appropriate to produce the compiled output. In a copy of GCC which has been compiled with Fortran language support enabled, gcc will recognize files with `.f`, `.for`, `.ftn`, `.f90`, `.f95`, `.f03` and `.f08` extensions as Fortran source code, and compile it accordingly. A gfortran driver program is also provided, which is identical to gcc except that it automatically links the Fortran runtime libraries into the compiled program.

Source files with `.f`, `.for`, `.fpp`, `.ftn`, `.F`, `.FOR`, `.FPP` and `.FTN` extensions are treated as fixed form. Source files with `.f90`, `.f95`, `.f03`, `.f08`, `.F90`, `.F95`, `.F03` and `.F08` extensions are treated as free form. The capitalized versions of either form are run through preprocessing. Source files with the lower case `.fpp` extension are also run through preprocessing.

This manual specifically documents the Fortran front end, which handles the programming language’s syntax and semantics. The aspects of GCC which relate to the optimization passes and the back-end code generation are documented in the GCC manual; see Section “Introduction” in Using the GNU Compiler Collection (GCC). The two manuals together provide a complete reference for the GNU Fortran compiler.

1.3 Preprocessing and conditional compilation

Many Fortran compilers including GNU Fortran allow passing the source code through a C preprocessor (CPP; sometimes also called the Fortran preprocessor, FPP) to allow for conditional compilation. In the case of GNU Fortran, this is the GNU C Preprocessor in the traditional mode. On systems with case-preserving file names, the preprocessor is automatically invoked if the filename extension is `.F`, `.FOR`, `.FTN`, `.fpp`, `.FPP`, `.F90`,
To manually invoke the preprocessor on any file, use ‘-cpp’, to disable preprocessing on files where the preprocessor is run automatically, use ‘-nocpp’.

If a preprocessed file includes another file with the Fortran INCLUDE statement, the included file is not preprocessed. To preprocess included files, use the equivalent preprocessor statement #include.

If GNU Fortran invokes the preprocessor, __GFORTRAN__ is defined and __GNUC__, __GNUC_MINOR__ and __GNUC_PATCHLEVEL__ can be used to determine the version of the compiler. See Section “Overview” in The C Preprocessor for details.

While CPP is the de-facto standard for preprocessing Fortran code, Part 3 of the Fortran 95 standard (ISO/IEC 1539-3:1998) defines Conditional Compilation, which is not widely used and not directly supported by the GNU Fortran compiler. You can use the program coco to preprocess such files (http://www.daniellnagle.com/coco.html).

1.4 GNU Fortran and G77

The GNU Fortran compiler is the successor to g77, the Fortran 77 front end included in GCC prior to version 4. It is an entirely new program that has been designed to provide Fortran 95 support and extensibility for future Fortran language standards, as well as providing backwards compatibility for Fortran 77 and nearly all of the GNU language extensions supported by g77.

1.5 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, of course).

The GNU Fortran compiler is able to compile nearly all standard-compliant Fortran 95, Fortran 90, and Fortran 77 programs, including a number of standard and non-standard extensions, and can be used on real-world programs. In particular, the supported extensions include OpenMP, Cray-style pointers, some old vendor extensions, and several Fortran 2003 and Fortran 2008 features, including TR 15581. However, it is still under development and has a few remaining rough edges. There also is initial support for OpenACC. Note that this is an experimental feature, incomplete, and subject to change in future versions of GCC. See https://gcc.gnu.org/wiki/OpenACC for more information.

At present, the GNU Fortran compiler passes the NIST Fortran 77 Test Suite, and produces acceptable results on the LAPACK Test Suite. It also provides respectable performance on the Polyhedron Fortran compiler benchmarks and the Livermore Fortran Kernels test. It has been used to compile a number of large real-world programs, including the HARMONIE and HIRLAM weather forecasting code and the Tonto quantum chemistry package; see https://gcc.gnu.org/wiki/GfortranApps for an extended list.

Among other things, the GNU Fortran compiler is intended as a replacement for G77. At this point, nearly all programs that could be compiled with G77 can be compiled with GNU Fortran, although there are a few minor known regressions.
The primary work remaining to be done on GNU Fortran falls into three categories: bug fixing (primarily regarding the treatment of invalid code and providing useful error messages), improving the compiler optimizations and the performance of compiled code, and extending the compiler to support future standards—in particular, Fortran 2003 and Fortran 2008.

1.6 Standards

The GNU Fortran compiler implements ISO/IEC 1539:1997 (Fortran 95). As such, it can also compile essentially all standard-compliant Fortran 90 and Fortran 77 programs. It also supports the ISO/IEC TR-15581 enhancements to allocatable arrays.

GNU Fortran also have a partial support for ISO/IEC 1539-1:2004 (Fortran 2003), ISO/IEC 1539-1:2010 (Fortran 2008), the Technical Specification Further Interoperability of Fortran with C (ISO/IEC TS 29113:2012). Full support of those standards and future Fortran standards is planned. The current status of the support is can be found in the Section 4.1 [Fortran 2003 status], page 35, Section 4.2 [Fortran 2008 status], page 36, Section 4.3 [TS 29113 status], page 38 and Section 4.4 [TS 18508 status], page 38 sections of the documentation.

Additionally, the GNU Fortran compilers supports the OpenMP specification (version 4.0 and most of the features of the 4.5 version, http://openmp.org/wp/openmp-specifications/). There also is initial support for the OpenACC specification (targeting version 2.0, http://www.openacc.org/). Note that this is an experimental feature, incomplete, and subject to change in future versions of GCC. See https://gcc.gnu.org/wiki/OpenACC for more information.

1.6.1 Varying Length Character Strings

The Fortran 95 standard specifies in Part 2 (ISO/IEC 1539-2:2000) varying length character strings. While GNU Fortran currently does not support such strings directly, there exist two Fortran implementations for them, which work with GNU Fortran. They can be found at http://www.fortran.com/iso_varying_string.f95 and at ftp://ftp.nag.co.uk/sc22wg5/ISO_VARYING_STRING/.

Deferred-length character strings of Fortran 2003 supports part of the features of ISO_VARYING_STRING and should be considered as replacement. (Namely, allocatable or pointers of the type character(len=::).)
Part I: Invoking GNU Fortran
2 GNU Fortran Command Options

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

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 GNU Fortran 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 GNU Fortran to the GCC distribution enables acceptance of GNU Fortran 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.

2.1 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 2.2 [Options controlling Fortran dialect], page 8.

- -fall-intrinsics -fbackslash -fcray-pointer -fd-lines-as-code
- -fd-lines-as-comments -fdec -fdec-structure -fdec-intrinsic-ints -fdec-static -fdec-math
- -fdefault-double-8 -fdefault-integer-8
- -fdefault-real-8 -fdollar-ok -ffixed-line-length-n
- -ffixed-line-length-none -ffree-form -ffree-line-length-n
- -ffree-line-length-none -fimplicit-none -finteger-4-integer-8
- -fmax-identifier-length -fmodule-private -ffixed-form -fno-range-check
- -fopenacc -fopenmp -freal-4-real-10 -freal-4-real-16 -freal-4-real-8
- -freal-8-real-10 -freal-8-real-16 -freal-8-real-4 -std=std -ftest-forall-temp

**Preprocessing Options**
See Section 2.3 [Enable and customize preprocessing], page 12.

- -Umacro -cpp -D -di -dm -DU -fworking-directory -imultilib dir
- -iprefix file -iquote -isysroot dir -isystem dir -inocpp -nostdinc
- -undef

**Error and Warning Options**
See Section 2.4 [Options to request or suppress errors and warnings], page 15.

- -Wall -Wall -Warg -Warg NDP -Warg bounds -Wc-binding -Wcharacter-truncation
- -Wconversion -Wfunction-elimination -Wimplicit-interface
- -Wimplicit-procedure -W intrinsic-shadow -Wuse-without-only -W intrinsic-std
- -Wline-truncation -Wno-align-commons -Wno-tabs -Wreal-q-constant
- -Wsurprising -Wunderflow -Wnumed-parameter -Wrealloc-lhs -Wrealloc-lhs-all
- -Wtarget-lifetime -fmax-errors=n -fsyntax-only -pedantic -pedantic-errors

**Debugging Options**
See Section 2.5 [Options for debugging your program or GNU Fortran], page 19.
-fbacktrace -fdump-fortran-optimized -fdump-fortran-original
-fdump-parse-tree -ffpe-trap=list -ffpe-summary=list

Directory Options
See Section 2.6 [Options for directory search], page 20.
-Idir -Jdir -fintrinsic-modules-path dir

Link Options
See Section 2.7 [Options for influencing the linking step], page 21.
-static-libgfortran

Runtime Options
See Section 2.8 [Options for influencing runtime behavior], page 21.
-fconvert=conversion -fmax-subrecord-length=length
-frecord-marker=length -fsign-zero

Code Generation Options
See Section 2.9 [Options for code generation conventions], page 21.
-faggressive-function-elimination -fblas-matmul-limit=n
-fbounds-check -fcheck-array-temporaries
-fcheck=<all|array-temps|bounds|do|mem|pointer|recursion>
-fcoarray=<none|single|lib> -fexternal-blas -ff2c -ffrontend-optimize
-finit-character=n -finit-integer=n -finit-local-zero
-finit-derived
-finit-logical=<true|false> -finit-real=<zero|inf|-inf|nan|snan>
-finline-matmul-limit=n
-fmax-array-constructor=n -fmax-stack-var-size=n -fno-align-commons
-fno-automatic -fno-protect-parens -fno-underscoring
-fsecond-underscore -fpack-derived -frealloc-lhs -frecursive
-frepack-arrays -fshort-enums -fstack-arrays

2.2 Options controlling Fortran dialect
The following options control the details of the Fortran dialect accepted by the compiler:
-ffree-form
-ffixed-form
Specify the layout used by the source file. The free form layout was introduced in Fortran 90. Fixed form was traditionally used in older Fortran programs. When neither option is specified, the source form is determined by the file extension.

-fall-intrinsics
This option causes all intrinsic procedures (including the GNU-specific extensions) to be accepted. This can be useful with ‘-std=f95’ to force standard-compliance but get access to the full range of intrinsics available with gfortran. As a consequence, ‘-Wintrinsics-std’ will be ignored and no user-defined procedure with the same name as any intrinsic will be called except when it is explicitly declared EXTERNAL.

-fd-lines-as-code
-fd-lines-as-comments
Enable special treatment for lines beginning with d or D in fixed form sources. If the ‘-fd-lines-as-code’ option is given they are treated as if the first column
-fdec

DEC compatibility mode. Enables extensions and other features that mimic the default behavior of older compilers (such as DEC). These features are non-

standard and should be avoided at all costs. For details on GNU Fortran’s implementation of these extensions see the full documentation.

Other flags enabled by this switch are: ‘-fdollar-ok’ ‘-fcray-pointer’ ‘-fdec-structure’ ‘-fdec-intrinsic-ints’ ‘-fdec-static’ ‘-fdec-math’

If ‘-fd-lines-as-code’/‘-fd-lines-as-comments’ are unset, then ‘-fdec’ also sets ‘-fd-lines-as-comments’.

-fdec-structure

Enable DEC STRUCTURE and RECORD as well as UNION, MAP, and dot (‘.’) as a member separator (in addition to ‘%’). This is provided for compatibility only; Fortran 90 derived types should be used instead where possible.

-fdec-intrinsic-ints

Enable B/I/J/K kind variants of existing integer functions (e.g. BIAND, HIAND, JIAND, etc...). For a complete list of intrinsics see the full documentation.

-fdec-math

Enable legacy math intrinsics such as COTAN and degree-valued trigonometric functions (e.g. TAND, ATAND, etc...) for compatability with older code.

-fdec-static

Enable DEC-style STATIC and AUTOMATIC attributes to explicitly specify the storage of variables and other objects.

-fdollar-ok

Allow ‘$’ as a valid non-first character in a symbol name. Symbols that start with ‘$’ are rejected since it is unclear which rules to apply to implicit typing as different vendors implement different rules. Using ‘$’ in IMPLICIT statements is also rejected.

-fbackslash

Change the interpretation of backslashes in string literals from a single back-

slash character to “C-style” escape characters. The following combinations are expanded \a, \b, \f, \n, \r, \t, \v, \", and \0 to the ASCII characters alert, backspace, form feed, newline, carriage return, horizontal tab, vertical tab, backslash, and NUL, respectively. Additionally, \
xnn, \unnnn and \Unnnnnnnnn (where each \n is a hexadecimal digit) are translated into the Unicode characters corresponding to the specified code points. All other combinations of a character preceded by \ are unexpanded.

-fmodule-private

Set the default accessibility of module entities to PRIVATE. Use-associated en-

tities will not be accessible unless they are explicitly declared as PUBLIC.
-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 (corresponding to “extended-source” options in some popular compilers). n may also 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’.

-ffree-line-length=n
Set column after which characters are ignored in typical free-form lines in the source file. The default value is 132. n may be ‘none’, meaning that the entire line is meaningful. ‘-ffree-line-length-0’ means the same thing as ‘-ffree-line-length-none’.

-fmax-identifier-length=n
Specify the maximum allowed identifier length. Typical values are 31 (Fortran 95) and 63 (Fortran 2003 and Fortran 2008).

-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.

-fcray-pointer
Enable the Cray pointer extension, which provides C-like pointer functionality.

-fopenacc
Enable the OpenACC extensions. This includes OpenACC !$acc directives in free form and c$acc, *$acc and !$acc directives in fixed form, !$ conditional compilation sentinels in free form and c$, *$ and !$ sentinels in fixed form, and when linking arranges for the OpenACC runtime library to be linked in.

Note that this is an experimental feature, incomplete, and subject to change in future versions of GCC. See https://gcc.gnu.org/wiki/OpenACC for more information.

-fopenmp
Enable the OpenMP extensions. This includes OpenMP !$omp directives in free form and c$omp, *$omp and !$omp directives in fixed form, !$ conditional compilation sentinels in free form and c$, *$ and !$ sentinels in fixed form, and when linking arranges for the OpenMP runtime library to be linked in. The option ‘-fopenmp’ implies ‘-frecursive’.

-fno-range-check
Disable range checking on results of simplification of constant expressions during compilation. For example, GNU Fortran will give an error at compile time when simplifying a = 1. / 0. With this option, no error will be given and a will be assigned the value +Infinity. If an expression evaluates to a value outside of the relevant range of [−HUGE():HUGE()], then the expression will be replaced by
-Inf or +Inf as appropriate. Similarly, DATA i/Z'FFFFFFFF'/ will result in an integer overflow on most systems, but with `-fno-range-check' the value will “wrap around” and i will be initialized to −1 instead.

-fdefault-integer-8
Set the default integer and logical types to an 8 byte wide type. This option also affects the kind of integer constants like 42. Unlike `-finteger-4-integer-8', it does not promote variables with explicit kind declaration.

-fdefault-real-8
Set the default real type to an 8 byte wide type. This option also affects the kind of non-double real constants like 1.0, and does promote the default width of DOUBLE PRECISION to 16 bytes if possible, unless `-fdefault-double-8' is given, too. Unlike `-freal-4-real-8', it does not promote variables with explicit kind declaration.

-fdefault-double-8
Set the DOUBLE PRECISION type to an 8 byte wide type. Do nothing if this is already the default. If `-fdefault-real-8' is given, DOUBLE PRECISION would instead be promoted to 16 bytes if possible, and `-fdefault-double-8' can be used to prevent this. The kind of real constants like 1.d0 will not be changed by `-fdefault-real-8' though, so also `-fdefault-double-8' does not affect it.

-finteger-4-integer-8
Promote all INTEGER(KIND=4) entities to an INTEGER(KIND=8) entities. If KIND=8 is unavailable, then an error will be issued. This option should be used with care and may not be suitable for your codes. Areas of possible concern include calls to external procedures, alignment in EQUIVALENCE and/or COMMON, generic interfaces, BOZ literal constant conversion, and I/O. Inspection of the intermediate representation of the translated Fortran code, produced by `-fdump-tree-original', is suggested.

-freal-4-real-8
-freal-4-real-10
-freal-4-real-16
-freal-8-real-4
-freal-8-real-10
-freal-8-real-16
Promote all REAL(KIND=M) entities to REAL(KIND=N) entities. If REAL(KIND=N) is unavailable, then an error will be issued. All other real kind types are unaffected by this option. These options should be used with care and may not be suitable for your codes. Areas of possible concern include calls to external procedures, alignment in EQUIVALENCE and/or COMMON, generic interfaces, BOZ literal constant conversion, and I/O. Inspection of the intermediate representation of the translated Fortran code, produced by `-fdump-tree-original', is suggested.

-std=std Specify the standard to which the program is expected to conform, which may be one of ‘f95’, ‘f2003’, ‘f2008’, ‘gnu’, or ‘legacy’. The default value for std
is `gnu`, which specifies a superset of the Fortran 95 standard that includes all of the extensions supported by GNU Fortran, although warnings will be given for obsolete extensions not recommended for use in new code. The `legacy` value is equivalent but without the warnings for obsolete extensions, and may be useful for old non-standard programs. The `f95`, `f2003` and `f2008` values specify strict conformance to the Fortran 95, Fortran 2003 and Fortran 2008 standards, respectively; errors are given for all extensions beyond the relevant language standard, and warnings are given for the Fortran 77 features that are permitted but obsolescent in later standards. `-std=f2008ts` allows the Fortran 2008 standard including the additions of the Technical Specification (TS) 29113 on Further Interoperability of Fortran with C and TS 18508 on Additional Parallel Features in Fortran.

`-f test forall temp`
Enhance test coverage by forcing most forall assignments to use temporary.

### 2.3 Enable and customize preprocessing

Preprocessor related options. See section Section 1.3 [Preprocessing and conditional compilation], page 2 for more detailed information on preprocessing in gfortran.

`-cpp`  
Enable preprocessing. The preprocessor is automatically invoked if the file extension is `.fpp`, `.FPP`, `.F`, `.FOR`, `.FTN`, `.F90`, `.F95`, `.F03` or `.F08`. Use this option to manually enable preprocessing of any kind of Fortran file. To disable preprocessing of files with any of the above listed extensions, use the negative form: `-nocpp`.

The preprocessor is run in traditional mode. Any restrictions of the file format, especially the limits on line length, apply for preprocessed output as well, so it might be advisable to use the `-ffree-line-length-none` or `-ffixed-line-length-none` options.

`-dM`  
Instead of the normal output, generate a list of `#define` directives for all the macros defined during the execution of the preprocessor, including predefined macros. This gives you a way of finding out what is predefined in your version of the preprocessor. Assuming you have no file `foo.f90`, the command

```
touch foo.f90; gfortran -cpp -E -dM foo.f90
```

will show all the predefined macros.

`-dD`  
Like `-dM` except in two respects: it does not include the predefined macros, and it outputs both the `#define` directives and the result of preprocessing. Both kinds of output go to the standard output file.

`-dN`  
Like `-dD`, but emit only the macro names, not their expansions.

`-dU`  
Like `-dD` except that only macros that are expanded, or whose definedness is tested in preprocessor directives, are output; the output is delayed until the use or test of the macro; and `#undef` directives are also output for macros tested but undefined at the time.

`-dI`  
Output `#include` directives in addition to the result of preprocessing.
-fworking-directory
Enable generation of linemarkers in the preprocessor output that will let the
compiler know the current working directory at the time of preprocessing.
When this option is enabled, the preprocessor will emit, after the initial linemarker, a second linemarker with the current working directory followed by
two slashes. GCC will use this directory, when it is present in the preprocessed input, as the directory emitted as the current working directory in some debugging information formats. This option is implicitly enabled if debugging information is enabled, but this can be inhibited with the negated form `-fno-working-directory'. If the `-P' flag is present in the command line, this option has no effect, since no #line directives are emitted whatsoever.

-idirafter dir
Search dir for include files, but do it after all directories specified with `-I'
and the standard system directories have been exhausted. dir is treated as a
system include directory. If dir begins with =, then the = will be replaced by
the sysroot prefix; see `--sysroot' and `-isysroot'.

-imultilib dir
Use dir as a subdirectory of the directory containing target-specific C++ headers.

-iprefix prefix
Specify prefix as the prefix for subsequent `-withprefix' options. If the prefix
represents a directory, you should include the final '/'.

-isysroot dir
This option is like the `--sysroot' option, but applies only to header files. See
the `--sysroot' option for more information.

-iquote dir
Search dir only for header files requested with #include "file"; they are not
searched for #include <file>, before all directories specified by `-I' and before
the standard system directories. If dir begins with =, then the = will be replaced
by the sysroot prefix; see `--sysroot' and `-isysroot'.

-isystem dir
Search dir for header files, after all directories specified by `-I' but before the
standard system directories. Mark it as a system directory, so that it gets the
same special treatment as is applied to the standard system directories. If dir
begins with =, then the = will be replaced by the sysroot prefix; see `--sysroot'
and `-isysroot'.

-nostdinc
Do not search the standard system directories for header files. Only the directories you have specified with `-I' options (and the directory of the current file, if appropriate) are searched.

-undef
Do not predefine any system-specific or GCC-specific macros. The standard predefined macros remain defined.
-A predicate=answer
Make an assertion with the predicate predicate and answer answer. This form
is preferred to the older form -A predicate(answer), which is still supported,
because it does not use shell special characters.

-A-predicate=answer
Cancel an assertion with the predicate predicate and answer answer.

-C
Do not discard comments. All comments are passed through to the output file,
except for comments in processed directives, which are deleted along with the
directive.

You should be prepared for side effects when using ‘-C’; it causes the prepro-
cessor to treat comments as tokens in their own right. For example, comments
appearing at the start of what would be a directive line have the effect of turn-
ing that line into an ordinary source line, since the first token on the line is no
longer a ‘#’.

Warning: this currently handles C-Style comments only. The preprocessor does
not yet recognize Fortran-style comments.

-CC
Do not discard comments, including during macro expansion. This is like ‘-C’,
except that comments contained within macros are also passed through to the
output file where the macro is expanded.

In addition to the side-effects of the ‘-C’ option, the ‘-CC’ option causes all
C++-style comments inside a macro to be converted to C-style comments. This
is to prevent later use of that macro from inadvertently commenting out the
remainder of the source line. The ‘-CC’ option is generally used to support lint
comsents.

Warning: this currently handles C- and C++-Style comments only. The prepro-
cessor does not yet recognize Fortran-style comments.

-D name
Predefine name as a macro, with definition 1.

-D name=definition
The contents of definition are tokenized and processed as if they appeared
during translation phase three in a ‘#define’ directive. In particular, the
definition will be truncated by embedded newline characters.

If you are invoking the preprocessor from a shell or shell-like program you may
need to use the shell’s quoting syntax to protect characters such as spaces that
have a meaning in the shell syntax.

If you wish to define a function-like macro on the command line, write its
argument list with surrounding parentheses before the equals sign (if any).
Parentheses are meaningful to most shells, so you will need to quote the option.
With sh and csh, -D‘name(args...)=definition’ works.

‘-D’ and ‘-U’ options are processed in the order they are given on the command
line. All -imacros file and -include file options are processed after all -D and -U
options.

-H
Print the name of each header file used, in addition to other normal activities.
Each name is indented to show how deep in the ‘#include’ stack it is.
-P
Inhibit generation of linemarkers in the output from the preprocessor. This might be useful when running the preprocessor on something that is not C code, and will be sent to a program which might be confused by the linemarkers.

-U name
Cancel any previous definition of name, either built in or provided with a ‘-D’ option.

2.4 Options to request or suppress errors and warnings

Errors are diagnostic messages that report that the GNU Fortran compiler cannot compile the relevant piece of source code. The compiler will continue to process the program in an attempt to report further errors to aid in debugging, but will not produce any compiled output.

Warnings are diagnostic messages that report constructions which are not inherently erroneous but which are risky or suggest there is likely to be a bug in the program. Unless ‘-Werror’ is specified, they do not prevent compilation of the program.

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 errors and warnings produced by GNU Fortran:

- **fmax-errors=n**
  Limits the maximum number of error messages to n, at which point GNU Fortran bails out rather than attempting to continue processing the source code. If n is 0, there is no limit on the number of error messages produced.

- **fsyntax-only**
  Check the code for syntax errors, but do not actually compile it. This will generate module files for each module present in the code, but no other output file.

- **Wpedantic**
- **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 GNU Fortran in this area are welcome.
  This should be used in conjunction with ‘-std=f95’, ‘-std=f2003’ or ‘-std=f2008’.
-pedantic-errors
Like ‘-pedantic’, except that errors are produced rather than warnings.

-Wall
Enables commonly used warning options pertaining to usage that we recommend avoiding and that we believe are easy to avoid. This currently includes ‘-Waliasing’, ‘-Wampersand’, ‘-Wconversion’, ‘-Wsurprising’, ‘-Wc-binding-type’, ‘-Wtrinsics-std’, ‘-Wtabs’, ‘-Wtrintrinsic-shadow’, ‘-Wline-truncation’, ‘-Wtarget-lifetime’, ‘-Winteger-division’, ‘-Wreal-q-constant’, ‘-Wunused’ and ‘-Wundefined-do-loop’.

-Waliasing
Warn about possible aliasing of dummy arguments. Specifically, it warns if the same actual argument is associated with a dummy argument with INTENT(IN) and a dummy argument with INTENT(OUT) in a call with an explicit interface.

The following example will trigger the warning.

```fortran
interface
    subroutine bar(a,b)
        integer, intent(in) :: a
        integer, intent(out) :: b
    end subroutine
end interface
integer :: a
call bar(a,a)
```

-Wampersand
Warn about missing ampersand in continued character constants. The warning is given with ‘-Wampersand’, ‘-pedantic’, ‘-std=f95’, ‘-std=f2003’ and ‘-std=f2008’. Note: With no ampersand given in a continued character constant, GNU Fortran assumes continuation at the first non-comment, non-whitespace character after the ampersand that initiated the continuation.

-Wargument-mismatch
Warn about type, rank, and other mismatches between formal parameters and actual arguments to functions and subroutines. These warnings are recommended and thus enabled by default.

-Warray-temporaries
Warn about array temporaries generated by the compiler. The information generated by this warning is sometimes useful in optimization, in order to avoid such temporaries.

-Wc-binding-type
Warn if the a variable might not be C interoperable. In particular, warn if the variable has been declared using an intrinsic type with default kind instead of using a kind parameter defined for C interoperability in the intrinsic ISO_C_BINDING module. This option is implied by ‘-Wall’.

-Wcharacter-truncation
Warn when a character assignment will truncate the assigned string.
-Wline-truncation
Warn when a source code line will be truncated. This option is implied by ‘-Wall’. For free-form source code, the default is ‘-Werror=line-truncation’ such that truncations are reported as error.

-Wconversion
Warn about implicit conversions that are likely to change the value of the expression after conversion. Implied by ‘-Wall’.

-Wconversion-extra
Warn about implicit conversions between different types and kinds. This option does not imply ‘-Wconversion’.

-Wextra
Enables some warning options for usages of language features which may be problematic. This currently includes ‘-Wcompare-reals’ and ‘-Wunused-parameter’.

-Wimplicit-interface
Warn if a procedure is 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.

-Wimplicit-procedure
Warn if a procedure is called that has neither an explicit interface nor has been declared as EXTERNAL.

-Winteger-division
Warn if a constant integer division truncates its result. As an example, 3/5 evaluates to 0.

-Wintrinsics-std
Warn if gfortran finds a procedure named like an intrinsic not available in the currently selected standard (with ‘-std’) and treats it as EXTERNAL procedure because of this. ‘-fall-intrinsics’ can be used to never trigger this behavior and always link to the intrinsic regardless of the selected standard.

-Wreal-q-constant
Produce a warning if a real-literal-constant contains a q exponent-letter.

-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.
- A TRANSFER specifies a source that is shorter than the destination.
- The type of a function result is declared more than once with the same type. If ‘-pedantic’ or standard-conforming mode is enabled, this is an error.
- A CHARACTER variable is declared with negative length.
-Wtabs
By default, tabs are accepted as whitespace, but tabs are not members of the Fortran Character Set. For continuation lines, a tab followed by a digit between 1 and 9 is supported. ‘-Wtabs’ will cause a warning to be issued if a tab is encountered. Note, ‘-Wtabs’ is active for ‘-pedantic’, ‘-std=f95’, ‘-std=f2003’, ‘-std=f2008’, ‘-std=f2008ts’ and ‘-Wall’.

-Wundefined-do-loop
Warn if a DO loop with step either 1 or -1 yields an underflow or an overflow during iteration of an induction variable of the loop. This option is implied by ‘-Wall’.

-Wunderflow
Produce a warning when numerical constant expressions are encountered, which yield an UNDERFLOW during compilation. Enabled by default.

-Wintrinsic-shadow
Warn if a user-defined procedure or module procedure has the same name as an intrinsic; in this case, an explicit interface or EXTERNAL or INTRINSIC declaration might be needed to get calls later resolved to the desired intrinsic/procedure. This option is implied by ‘-Wall’.

-Wuse-without-only
Warn if a USE statement has no ONLY qualifier and thus implicitly imports all public entities of the used module.

-Wunused-dummy-argument
Warn about unused dummy arguments. This option is implied by ‘-Wall’.

-Wunused-parameter
Contrary to gcc’s meaning of ‘-Wunused-parameter’, gfortran’s implementation of this option does not warn about unused dummy arguments (see ‘-Wunused-dummy-argument’), but about unused PARAMETER values. ‘-Wunused-parameter’ is implied by ‘-Wextra’ if also ‘-Wunused’ or ‘-Wall’ is used.

-Walign-commons
By default, gfortran warns about any occasion of variables being padded for proper alignment inside a COMMON block. This warning can be turned off via ‘-Wno-align-commons’. See also ‘-falign-commons’.

-Wfunction-elimination
Warn if any calls to functions are eliminated by the optimizations enabled by the ‘-ffrontend-optimize’ option.

-Wrealloc-lhs
Warn when the compiler might insert code to for allocation or reallocation of an allocatable array variable of intrinsic type in intrinsic assignments. In hot loops, the Fortran 2003 reallocation feature may reduce the performance. If the array is already allocated with the correct shape, consider using a whole-array array-spec (e.g. (::,:)) for the variable on the left-hand side to prevent the reallocation check. Note that in some cases the warning is shown, even if the compiler will optimize reallocation checks away. For instance, when the
right-hand side contains the same variable multiplied by a scalar. See also
‘-frealloc-lhs’.

-Wrealloc-lhs-all
Warn when the compiler inserts code to for allocation or reallocation of an
allocatable variable; this includes scalars and derived types.

-Wcompare-reals
Warn when comparing real or complex types for equality or inequality. This
option is implied by ‘-Wextra’.

-Wtarget-lifetime
Warn if the pointer in a pointer assignment might be longer than the its target.
This option is implied by ‘-Wall’.

-Wzerotrip
Warn if a DO loop is known to execute zero times at compile time. This option
is implied by ‘-Wall’.

-Werror
Turns all warnings into errors.

See Section “Options to Request or Suppress Errors and 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.

2.5 Options for debugging your program or GNU Fortran

GNU Fortran has various special options that are used for debugging either your program
or the GNU Fortran compiler.

-ffpe-trap=list
Specify a list of floating point exception traps to enable. On most systems, if
a floating point exception occurs and the trap for that exception is enabled, a
SIGFPE signal will be sent and the program being aborted, producing a core
file useful for debugging. list is a (possibly empty) comma-separated list of
the following exceptions: ‘invalid’ (invalid floating point operation, such as
SQRT(-1.0)), ‘zero’ (division by zero), ‘overflow’ (overflow in a floating point
operation), ‘underflow’ (underflow in a floating point operation), ‘inexact’
(loss of precision during operation), and ‘denormal’ (operation performed on a denormal value). The first five exceptions correspond to the five IEEE 754 exceptions, whereas the last one ('denormal') is not part of the IEEE 754 standard but is available on some common architectures such as x86.

The first three exceptions ('invalid', 'zero', and 'overflow') often indicate serious errors, and unless the program has provisions for dealing with these exceptions, enabling traps for these three exceptions is probably a good idea. Many, if not most, floating point operations incur loss of precision due to rounding, and hence the ffpe-trap=inexact is likely to be uninteresting in practice.

By default no exception traps are enabled.

-ffpe-summary=list

Specify a list of floating-point exceptions, whose flag status is printed to ERROR_UNIT when invoking STOP and ERROR STOP. list can be either 'none', 'all' or a comma-separated list of the following exceptions: 'invalid', 'zero', 'overflow', 'underflow', 'inexact' and 'denormal'. (See ‘-ffpe-trap’ for a description of the exceptions.)

By default, a summary for all exceptions but 'inexact' is shown.

-fno-backtrace

When a serious runtime error is encountered or a deadly signal is emitted (segmentation fault, illegal instruction, bus error, floating-point exception, and the other POSIX signals that have the action 'core'), the Fortran runtime library tries to output a backtrace of the error. -fno-backtrace disables the backtrace generation. This option only has influence for compilation of the Fortran main program.

See Section “Options for Debugging Your Program or GCC” in Using the GNU Compiler Collection (GCC), for more information on debugging options.

2.6 Options for directory search

These options affect how GNU Fortran searches for files specified by 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.

-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.
-fintrinsic-modules-path dir
   This option specifies the location of pre-compiled intrinsic modules, if they are not in the default location expected by the compiler.

2.7 Influencing the linking step
These options come into play when the compiler links object files into an executable output file. They are meaningless if the compiler is not doing a link step.

-static-libgfortran
   On systems that provide 'libgfortran' as a shared and a static library, this option forces the use of the static version. If no shared version of 'libgfortran' was built when the compiler was configured, this option has no effect.

2.8 Influencing runtime behavior
These options affect the runtime behavior of programs compiled with GNU Fortran.

-fconvert=conversion
   Specify the representation of data for unformatted files. Valid values for conversion are: ‘native’, the default; ‘swap’, swap between big- and little-endian; ‘big-endian’, use big-endian representation for unformatted files; ‘little-endian’, use little-endian representation for unformatted files.
   This option has an effect only when used in the main program. The CONVERT specifier and the GFORTRAN_CONVERT_UNIT environment variable override the default specified by ‘-fconvert’.

-frecord-marker=length
   Specify the length of record markers for unformatted files. Valid values for length are 4 and 8. Default is 4. This is different from previous versions of gfortran, which specified a default record marker length of 8 on most systems. If you want to read or write files compatible with earlier versions of gfortran, use ‘-frecord-marker=8’.

-fmax-subrecord-length=length
   Specify the maximum length for a subrecord. The maximum permitted value for length is 2147483639, which is also the default. Only really useful for use by the gfortran testsuite.

-fsign-zero
   When enabled, floating point numbers of value zero with the sign bit set are written as negative number in formatted output and treated as negative in the SIGN intrinsic. ‘-fno-sign-zero’ does not print the negative sign of zero values (or values rounded to zero for I/O) and regards zero as positive number in the SIGN intrinsic for compatibility with Fortran 77. The default is ‘-fsign-zero’.

2.9 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 (except those marked as RECURSIVE) as if the SAVE statement were 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’ or ‘-save’.) The default, which is ‘-fautomatic’, uses the stack for local variables smaller than the value given by ‘-fmax-stack-var-size’. Use the option ‘-frecursive’ to use no static memory.

- **-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, GNU Fortran 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 GNU Fortran is incompatible with f2c and g77, please use the ‘-ff2c’ option if you want object files compiled with GNU Fortran 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-à-vis existing libraries, tools, and so on).
For example, with ‘-funderscoring’, and assuming that \( j() \) and \( \text{max\_count()} \) are external functions while \( \text{my\_var} \) and \( \text{lvar} \) are local variables, a statement like
\[
I = j() + \text{max\_count}(\text{my\_var}, \text{lvar})
\]
is implemented as something akin to:
\[
i = j_() + \text{max\_count\_}(&\text{my\_var\_}, &\text{lvar});
\]
With ‘-fno-underscoring’, the same statement is implemented as:
\[
i = j() + \text{max\_count}(\text{my\_var}, \text{lvar});
\]
Use of ‘-fno-underscoring’ allows direct specification of user-defined names while debugging and when interfacing GNU Fortran code with other languages. Note that just because the names match does \textit{not} mean that the interface implemented by GNU Fortran for an external name matches the interface implemented by some other language for that same name. That is, getting code produced by GNU Fortran 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 GNU Fortran 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.

\textbf{-fsecond-underscore}

By default, GNU Fortran appends an underscore to external names. If this option is used GNU Fortran appends two underscores to names with underscores and one underscore to external names with no underscores. GNU Fortran 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 \( \text{MAX\_COUNT} \) is implemented as a reference to the link-time external symbol \( \text{max\_count\_} \), instead of \( \text{max\_count\_} \). This is required for compatibility with \( g77 \) and \( f2c \), and is implied by use of the ‘-ff2c’ option.

\textbf{-fcoarray=<keyword>}

‘none’ Disable coarray support; using coarray declarations and image-control statements will produce a compile-time error. (Default)

‘single’ Single-image mode, i.e. \( \text{num\_images()} \) is always one.
'lib'  Library-based coarray parallelization; a suitable GNU Fortran coarray library needs to be linked.

-fcheck=<keyword>
Enable the generation of run-time checks; the argument shall be a comma-delimited list of the following keywords. Prefixing a check with 'no-' disables it if it was activated by a previous specification.

'all' Enable all run-time test of '-fcheck'.

'array-temps'
Warns at run time when for passing an actual argument a temporary array had to be generated. The information generated by this warning is sometimes useful in optimization, in order to avoid such temporaries.
Note: The warning is only printed once per location.

'bounds' 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 and ensures that all string lengths are equal for character array constructors without an explicit typespec.
Some checks require that '-fcheck=bounds' is set for the compilation of the main program.
Note: In the future this may also include other forms of checking, e.g., checking substring references.

'do' Enable generation of run-time checks for invalid modification of loop iteration variables.

'mem' Enable generation of run-time checks for memory allocation. Note: This option does not affect explicit allocations using the ALLOCATE statement, which will be always checked.

'pointer' Enable generation of run-time checks for pointers and allocatables.

'recursion'
Enable generation of run-time checks for recursively called subroutines and functions which are not marked as recursive. See also '-frecursive'. Note: This check does not work for OpenMP programs and is disabled if used together with '-frecursive' and '-fopenmp'.

Example: Assuming you have a file 'foo.f90', the command

```
gfortran -fcheck=all,no-array-temps foo.f90
```

will compile the file with all checks enabled as specified above except warnings for generated array temporaries.

-fbounds-check
Deprecated alias for '-fcheck=bounds'.
-fcheck-array-temporaries
  Deprecated alias for ‘-fcheck=array-temps’.

-fmax-array-constructor=n
  This option can be used to increase the upper limit permitted in array constructors. The code below requires this option to expand the array at compile time.

  ```fortran
  program test
  implicit none
  integer j
  integer, parameter :: n = 100000
  integer, parameter :: i(n) = (/ (2*j, j = 1, n) /)
  print '(10(I0,1X))', i
  end program test
  ```
  Caution: This option can lead to long compile times and excessively large object files.

  The default value for n is 65535.

-fmax-stack-var-size=n
  This option specifies the size in bytes of the largest array that will be put on the stack; if the size is exceeded static memory is used (except in procedures marked as RECURSIVE). Use the option ‘-frecursive’ to allow for recursive procedures which do not have a RECURSIVE attribute or for parallel programs. Use ‘-fno-automatic’ to never use the stack.

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

  The default value for n is 32768.

-fstack-arrays
  Adding this option will make the Fortran compiler put all local arrays, even those of unknown size onto stack memory. If your program uses very large local arrays it is possible that you will have to extend your runtime limits for stack memory on some operating systems. This flag is enabled by default at optimization level ‘-Ofast’.

-fpack-derived
  This option tells GNU Fortran 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 GNU Fortran may pass assumed shape array sections via a descriptor describing a noncontiguous 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 noncontiguous.
The GNU Fortran Compiler

-fshort-enums
This option is provided for interoperability with C code that was compiled with the ‘-fshort-enums’ option. It will make GNU Fortran choose the smallest INTEGER kind a given enumerator set will fit in, and give all its enumerators this kind.

-fexternal-blas
This option will make gfortran generate calls to BLAS functions for some matrix operations like MATMUL, instead of using our own algorithms, if the size of the matrices involved is larger than a given limit (see ‘-fblas-matmul-limit’). This may be profitable if an optimized vendor BLAS library is available. The BLAS library will have to be specified at link time.

-fblas-matmul-limit=n
Only significant when ‘-fexternal-blas’ is in effect. Matrix multiplication of matrices with size larger than (or equal to) n will be performed by calls to BLAS functions, while others will be handled by gfortran internal algorithms. If the matrices involved are not square, the size comparison is performed using the geometric mean of the dimensions of the argument and result matrices.

The default value for n is 30.

-finline-matmul-limit=n
When front-end optimization is active, some calls to the MATMUL intrinsic function will be inlined. This may result in code size increase if the size of the matrix cannot be determined at compile time, as code for both cases is generated. Setting -finline-matmul-limit=0 will disable inlining in all cases. Setting this option with a value of n will produce inline code for matrices with size up to n. If the matrices involved are not square, the size comparison is performed using the geometric mean of the dimensions of the argument and result matrices.

The default value for n is 30. The -fblas-matmul-limit can be used to change this value.

-frecursive
Allow indirect recursion by forcing all local arrays to be allocated on the stack. This flag cannot be used together with ‘-fmax-stack-var-size’ or ‘-fno-automatic’.

-finit-local-zero
-finit-derived
-finit-integer=n
-finit-real=<zero|inf|-inf|nan|snan>
-finit-logical=<true|false>
-finit-character=n

The ‘-finit-local-zero’ option instructs the compiler to initialize local INTEGER, REAL, and COMPLEX variables to zero, LOGICAL variables to false, and CHARACTER variables to a string of null bytes. Finer-grained initialization options are provided by the ‘-finit-integer=n’, ‘-finit-real=<zero|inf|-inf|nan|snan>’ (which also initializes the real and imaginary parts of local COMPLEX variables), ‘-finit-logical=<true|false>’, and
`-finit-character=n` (where \( n \) is an ASCII character value) options. Components of derived type variables will be initialized according to these flags only with `-finit-derived`. These options do not initialize

- allocatable arrays
- variables that appear in an `EQUIVALENCE` statement.

(These limitations may be removed in future releases).

Note that the `'-finit-real=nan'` option initializes `REAL` and `COMPLEX` variables with a quiet NaN. For a signalling NaN use `'-finit-real=snan'`; note, however, that compile-time optimizations may convert them into quiet NaN and that trapping needs to be enabled (e.g. via `'-ffpe-trap'`).

Finally, note that enabling any of the `'-finit-*'` options will silence warnings that would have been emitted by `'-Wuninitialized'` for the affected local variables.

`-falign-commons`

By default, `gfortran` enforces proper alignment of all variables in a `COMMON` block by padding them as needed. On certain platforms this is mandatory, on others it increases performance. If a `COMMON` block is not declared with consistent data types everywhere, this padding can cause trouble, and `'-fno-align-commons'` can be used to disable automatic alignment. The same form of this option should be used for all files that share a `COMMON` block. To avoid potential alignment issues in `COMMON` blocks, it is recommended to order objects from largest to smallest.

`-fno-protect-parens`

By default the parentheses in expression are honored for all optimization levels such that the compiler does not do any re-association. Using `'-fno-protect-parens'` allows the compiler to reorder `REAL` and `COMPLEX` expressions to produce faster code. Note that for the re-association optimization `'-fno-signed-zeros'` and `'-fno-trapping-math'` need to be in effect. The parentheses protection is enabled by default, unless `'-Ofast'` is given.

`-frealloc-lhs`

An allocatable left-hand side of an intrinsic assignment is automatically (re)allocated if it is either unallocated or has a different shape. The option is enabled by default except when `'-std=f95'` is given. See also `'-Wreallocate-lhs'`.

`-faggressive-function-elimination`

Functions with identical argument lists are eliminated within statements, regardless of whether these functions are marked `PURE` or not. For example, in

\[
    a = f(b,c) + f(b,c)
\]

there will only be a single call to \( f \). This option only works if `'-ffrontend-optimize'` is in effect.

`-ffrontend-optimize`

This option performs front-end optimization, based on manipulating parts the Fortran parse tree. Enabled by default by any `'-O'` option. Optimizations enabled by this option include inlining calls to `MATMUL`, elimination of identical
function calls within expressions, removing unnecessary calls to \texttt{TRIM} in comparisons and assignments and replacing \texttt{TRIM(a)} with \texttt{a(1:LEN_TRIM(a))}. It can be deselected by specifying ‘-fno-frontend-optimize’.

See Section “Options for Code Generation Conventions” in \textit{Using the GNU Compiler Collection (GCC)}, for information on more options offered by the GBE shared by \texttt{gfortran}, \texttt{gcc}, and other GNU compilers.

\textbf{2.10 Environment variables affecting gfortran}

The \texttt{gfortran} compiler currently does not make use of any environment variables to control its operation above and beyond those that affect the operation of \texttt{gcc}.

See Section “Environment Variables Affecting GCC” in \textit{Using the GNU Compiler Collection (GCC)}, for information on environment variables.

See Chapter 3 [Runtime], page 29, for environment variables that affect the run-time behavior of programs compiled with GNU Fortran.
Chapter 3: Runtime: Influencing runtime behavior with environment variables

3 Runtime: Influencing runtime behavior with environment variables

The behavior of the gfortran can be influenced by environment variables. Malformed environment variables are silently ignored.

3.1 TMPDIR—Directory for scratch files

When opening a file with STATUS='SCRATCH', GNU Fortran tries to create the file in one of the potential directories by testing each directory in the order below.

1. The environment variable TMPDIR, if it exists.
2. On the MinGW target, the directory returned by the GetTempPath function. Alternatively, on the Cygwin target, the TMP and TEMP environment variables, if they exist, in that order.
3. The P_tmpdir macro if it is defined, otherwise the directory ‘/tmp’.

3.2 GFORTRAN_STDIN_UNIT—Unit number for standard input

This environment variable can be used to select the unit number preconnected to standard input. This must be a positive integer. The default value is 5.

3.3 GFORTRAN_STDOUT_UNIT—Unit number for standard output

This environment variable can be used to select the unit number preconnected to standard output. This must be a positive integer. The default value is 6.

3.4 GFORTRAN_STDERR_UNIT—Unit number for standard error

This environment variable can be used to select the unit number preconnected to standard error. This must be a positive integer. The default value is 0.

3.5 GFORTRAN_UNBUFFERED_ALL—Do not buffer I/O on all units

This environment variable controls whether all I/O is unbuffered. If the first letter is ‘y’, ‘Y’ or ‘1’, all I/O is unbuffered. This will slow down small sequential reads and writes. If the first letter is ‘n’, ‘N’ or ‘0’, I/O is buffered. This is the default.

3.6 GFORTRAN_UNBUFFERED_PRECONNECTED—Do not buffer I/O on preconnected units

The environment variable named GFORTRAN_UNBUFFERED_PRECONNECTED controls whether I/O on a preconnected unit (i.e. STDOUT or STDERR) is unbuffered. If the first letter is ‘y’, ‘Y’ or ‘1’, I/O is unbuffered. This will slow down small sequential reads and writes. If the first letter is ‘n’, ‘N’ or ‘0’, I/O is buffered. This is the default.

3.7 GFORTRAN_SHOW_LOCUS—Show location for runtime errors

If the first letter is ‘y’, ‘Y’ or ‘1’, filename and line numbers for runtime errors are printed. If the first letter is ‘n’, ‘N’ or ‘0’, do not print filename and line numbers for runtime errors. The default is to print the location.
3.8 GFORTRAN_OPTIONAL_PLUS—Print leading + where permitted

If the first letter is ‘y’, ‘Y’ or ‘I’, a plus sign is printed where permitted by the Fortran standard. If the first letter is ‘n’, ‘N’ or ‘0’, a plus sign is not printed in most cases. Default is not to print plus signs.

3.9 GFORTRAN_DEFAULT_RECL—Default record length for new files

This environment variable specifies the default record length, in bytes, for files which are opened without a RECL tag in the OPEN statement. This must be a positive integer. The default value is 1073741824 bytes (1 GB).

3.10 GFORTRAN_LIST_SEPARATOR—Separator for list output

This environment variable specifies the separator when writing list-directed output. It may contain any number of spaces and at most one comma. If you specify this on the command line, be sure to quote spaces, as in

$ GFORTRAN_LIST_SEPARATOR=' , ' ./a.out

when a.out is the compiled Fortran program that you want to run. Default is a single space.

3.11 GFORTRAN_CONVERT_UNIT—Set endianness for unformatted I/O

By setting the GFORTRAN_CONVERT_UNIT variable, it is possible to change the representation of data for unformatted files. The syntax for the GFORTRAN_CONVERT_UNIT variable is:

GFORTRAN_CONVERT_UNIT: mode | mode ':' exception | exception ;
mode: 'native' | 'swap' | 'big_endian' | 'little_endian';
exception: mode ':' unit_list | unit_list ;
unit_list: unit_spec | unit_list unit_spec ;
unit_spec: INTEGER | INTEGER '-' INTEGER ;

The variable consists of an optional default mode, followed by a list of optional exceptions, which are separated by semicolons from the preceding default and each other. Each exception consists of a format and a comma-separated list of units. Valid values for the modes are the same as for the CONVERT specifier:

NATIVE Use the native format. This is the default.
SWAP Swap between little- and big-endian.
LITTLE_ENDIAN Use the little-endian format for unformatted files.
BIG_ENDIAN Use the big-endian format for unformatted files.

A missing mode for an exception is taken to mean BIG_ENDIAN. Examples of values for GFORTRAN_CONVERT_UNIT are:

'big_endian' Do all unformatted I/O in big-endian mode.
'little_endian:native:10-20,25' Do all unformatted I/O in little_endian mode, except for units 10 to 20 and 25, which are in native format.
'10-20' Units 10 to 20 are big-endian, the rest is native.
Setting the environment variables should be done on the command line or via the `export` command for `sh`-compatible shells and via `setenv` for `csh`-compatible shells.

Example for `sh`:

```sh
$ gfortran foo.f90
$ GFORTRAN_CONVERT_UNIT='big_endian.native:10-20' ./a.out
```

Example code for `csh`:

```csh
% gfortran foo.f90
% setenv GFORTRAN_CONVERT_UNIT 'big_endian.native:10-20'
% ./a.out
```

Using anything but the native representation for unformatted data carries a significant speed overhead. If speed in this area matters to you, it is best if you use this only for data that needs to be portable.

See Section 6.1.15 [CONVERT specifier], page 49, for an alternative way to specify the data representation for unformatted files. See Section 2.8 [Runtime Options], page 21, for setting a default data representation for the whole program. The CONVERT specifier overrides the `-fconvert` compile options.

*Note that the values specified via the GFORTRAN_CONVERT_UNIT environment variable will override the CONVERT specifier in the open statement.* This is to give control over data formats to users who do not have the source code of their program available.

### 3.12 GFORTRAN_ERROR_BACKTRACE—Show backtrace on run-time errors

If the GFORTRAN_ERROR_BACKTRACE variable is set to ‘y’, ‘Y’ or ‘1’ (only the first letter is relevant) then a backtrace is printed when a serious run-time error occurs. To disable the backtracing, set the variable to ‘n’, ‘N’, ‘0’. Default is to print a backtrace unless the ‘-fno-backtrace’ compile option was used.
Part II: Language Reference
4 Fortran 2003 and 2008 Status

4.1 Fortran 2003 status

GNU Fortran supports several Fortran 2003 features; an incomplete list can be found below. See also the wiki page about Fortran 2003.

- Procedure pointers including procedure-pointer components with `PASS` attribute.
- Procedures which are bound to a derived type (type-bound procedures) including `PASS`, `PROCEDURE` and `GENERIC`, and operators bound to a type.
- Abstract interfaces and type extension with the possibility to override type-bound procedures or to have deferred binding.
- Polymorphic entities ("CLASS") for derived types and unlimited polymorphism ("CLASS(*)") – including `SAME_TYPE_AS`, `EXTENDS_TYPE_OF` and `SELECT TYPE` for scalars and arrays and finalization.
- Generic interface names, which have the same name as derived types, are now supported. This allows one to write constructor functions. Note that Fortran does not support static constructor functions. For static variables, only default initialization or structure-constructor initialization are available.
- The `ASSOCIATE` construct.
- Interoperability with C including enumerations,
- In structure constructors the components with default values may be omitted.
- Extensions to the `ALLOCATE` statement, allowing for a type-specification with type parameter and for allocation and initialization from a `SOURCE=` expression; `ALLOCATE` and `DEALLOCATE` optionally return an error message string via `ERRMSG=`.
- Reallocation on assignment: If an intrinsic assignment is used, an allocatable variable on the left-hand side is automatically allocated (if unallocated) or reallocated (if the shape is different). Currently, scalar deferred character length left-hand sides are correctly handled but arrays are not yet fully implemented.
- Deferred-length character variables and scalar deferred-length character components of derived types are supported. (Note that array-valued components are not yet implemented.)
- Transferring of allocations via `MOVE_ALLOC`.
- The `PRIVATE` and `PUBLIC` attributes may be given individually to derived-type components.
- In pointer assignments, the lower bound may be specified and the remapping of elements is supported.
- For pointers an `INTENT` may be specified which affect the association status not the value of the pointer target.
- Intrinsics `command_argument_count`, `get_command`, `get_command_argument`, and `get_environment_variable`.
- Support for Unicode characters (ISO 10646) and UTF-8, including the `SELECTED_CHAR_KIND` and `NEW_LINE` intrinsic functions.
- Support for binary, octal and hexadecimal (BOZ) constants in the intrinsic functions INT, REAL, CMPLX and DBLE.
- Support for namelist variables with allocatable and pointer attribute and nonconstant length type parameter.
- Array constructors using square brackets. That is, [...] rather than (/.../). Type-specification for array constructors like (/ some-type :: ... /).
- Extensions to the specification and initialization expressions, including the support for intrinsics with real and complex arguments.
- Support for the asynchronous input/output syntax; however, the data transfer is currently always synchronously performed.
- FLUSH statement.
- IOMSG= specifier for I/O statements.
- Support for the declaration of enumeration constants via the ENUM and ENUMERATOR statements. Interoperability with gcc is guaranteed also for the case where the -fshort-enums command line option is given.
- TR 15581:
  - ALLOCATABLE dummy arguments.
  - ALLOCATABLE function results
  - ALLOCATABLE components of derived types
- The OPEN statement supports the ACCESS='STREAM' specifier, allowing I/O without any record structure.
- Namelist input/output for internal files.
- Minor I/O features: Rounding during formatted output, using of a decimal comma instead of a decimal point, setting whether a plus sign should appear for positive numbers. On systems where strtod honours the rounding mode, the rounding mode is also supported for input.
- The PROTECTED statement and attribute.
- The VALUE statement and attribute.
- The VOLATILE statement and attribute.
- The IMPORT statement, allowing to import host-associated derived types.
- The intrinsic modules ISO_FORTRAN_ENVIRONMENT is supported, which contains parameters of the I/O units, storage sizes. Additionally, procedures for C interoperability are available in the ISO_C_BINDING module.
- USE statement with INTRINSIC and NON_INTRINSIC attribute; supported intrinsic modules: ISO_FORTRAN_ENV, ISO_C_BINDING, OMP_LIB and OMP_LIB_KINDS, and OPENACC.
- Renaming of operators in the USE statement.

4.2 Fortran 2008 status

The latest version of the Fortran standard is ISO/IEC 1539-1:2010, informally known as Fortran 2008. The official version is available from International Organization for Standardization (ISO) or its national member organizations. The the final draft (FDIS) can
be downloaded free of charge from http://www.nag.co.uk/sc22wg5/links.html. Fortran is developed by the Working Group 5 of Sub-Committee 22 of the Joint Technical Committee 1 of the International Organization for Standardization and the International Electrotechnical Commission (IEC). This group is known as WG5.

The GNU Fortran compiler supports several of the new features of Fortran 2008; the wiki has some information about the current Fortran 2008 implementation status. In particular, the following is implemented.

- The `-std=f2008` option and support for the file extensions `.f08` and `.F08`.
- The OPEN statement now supports the NEWUNIT= option, which returns a unique file unit, thus preventing inadvertent use of the same unit in different parts of the program.
- The `g0` format descriptor and unlimited format items.
- The mathematical intrinsics ASINH, ACOSH, ATANH, ERF, ERFC, GAMMA, LOG_GAMMA, BESSEL_J0, BESSEL_J1, BESSEL_JN, BESSEL_Y0, BESSEL_Y1, BESSEL_YN, HYPOT, NORM2, and ERFC_SCALED.
- Using complex arguments with TAN, SINH, COSH, TANH, ASIN, ACOS, and ATAN is now possible; ATAN(Y,X) is now an alias for ATAN2(Y,X).
- Support of the PARITY intrinsic functions.
- The following bit intrinsics: LEADZ and TRAILZ for counting the number of leading and trailing zero bits, POPCNT and POPPAR for counting the number of one bits and returning the parity; BGE, BGT, BLE, and BLT for bitwise comparisons; DSHIFTL and DSHIFTR for combined left and right shifts, MASKL and MASKR for simple left and right justified masks, MERGE_BITS for a bitwise merge using a mask, SHIFTA, SHIFTL and SHIFTR for shift operations, and the transformational bit intrinsics IALL, IANY and IPARITY.
- Support of the EXECUTE_COMMAND_LINE intrinsic subroutine.
- Support for the STORAGE_SIZE intrinsic inquiry function.
- The INT{8,16,32} and REAL{32,64,128} kind type parameters and the array-valued named constants INTEGER_KINDS, LOGICAL_KINDS, REAL_KINDS and CHARACTER_KINDS of the intrinsic module ISO_FORTRAN_ENV.
- The module procedures C_SIZEOF of the intrinsic module ISO_C_BINDINGS and COMPILER_VERSION and COMPILER_OPTIONS of ISO_FORTRAN_ENV.
- Coarray support for serial programs with `-fcoarray=single` flag and experimental support for multiple images with the `-fcoarray=lib` flag.
- Submodules are supported. It should noted that MODULEs do not produce the smod file needed by the descendent SUBMODULEs unless they contain at least one MODULE PROCEDURE interface. The reason for this is that SUBMODULEs are useless without MODULE PROCEDURES. See http://j3-fortran.org/doc/meeting/207/15-209.txt for a discussion and a draft interpretation. Adopting this interpretation has the advantage that code that does not use submodules does not generate smod files.
- The DO CONCURRENT construct is supported.
- The BLOCK construct is supported.
- The STOP and the new ERROR STOP statements now support all constant expressions. Both show the signals which were signaling at termination.
- Support for the CONTIGUOUS attribute.
• Support for \texttt{ALLOCATE} with \texttt{MOLD}.
• Support for the \texttt{IMPURE} attribute for procedures, which allows for \texttt{ELEMENTAL} procedures without the restrictions of \texttt{PURE}.
• Null pointers (including \texttt{NULL()}) and not-allocated variables can be used as actual argument to optional non-pointer, non-allocatable dummy arguments, denoting an absent argument.
• Non-pointer variables with \texttt{TARGET} attribute can be used as actual argument to \texttt{POINTER} dummies with \texttt{INTENT(IN)}.
• Pointers including procedure pointers and those in a derived type (pointer components) can now be initialized by a target instead of only by \texttt{NULL}.
• The \texttt{EXIT} statement (with construct-name) can be now be used to leave not only the \texttt{DO} but also the \texttt{ASSOCIATE}, \texttt{BLOCK}, \texttt{IF}, \texttt{SELECT CASE} and \texttt{SELECT TYPE} constructs.
• Internal procedures can now be used as actual argument.
• Minor features: obsolesce diagnostics for \texttt{ENTRY} with \textquoteleft-std=f2008\textquoteright; a line may start with a semicolon; for internal and module procedures \texttt{END} can be used instead of \texttt{END SUBROUTINE} and \texttt{END FUNCTION}; \texttt{SELECTED_REAL_KIND} now also takes a \texttt{RADIX} argument; intrinsic types are supported for \texttt{TYPE(intrinsic-type-spec)}; multiple type-bound procedures can be declared in a single \texttt{PROCEDURE} statement; implied-shape arrays are supported for named constants (\texttt{PARAMETER}).

4.3 Technical Specification 29113 Status
GNU Fortran supports some of the new features of the Technical Specification (TS) 29113 on Further Interoperability of Fortran with C. The wiki has some information about the current TS 29113 implementation status. In particular, the following is implemented. See also Section 7.1.6 [Further Interoperability of Fortran with C], page 68.

• The \textquoteleft-std=f2008ts\textquoteright option.
• The \texttt{OPTIONAL} attribute is allowed for dummy arguments of \texttt{BIND(C)} procedures.
• The \texttt{RANK} intrinsic is supported.
• GNU Fortran’s implementation for variables with \texttt{ASYNCHRONOUS} attribute is compatible with TS 29113.
• Assumed types (\texttt{TYPE(*)}).
• Assumed-rank (\texttt{DIMENSION(\ldots)}). However, the array descriptor of the TS is not yet supported.

4.4 Technical Specification 18508 Status
GNU Fortran supports the following new features of the Technical Specification 18508 on Additional Parallel Features in Fortran:

• The new atomic \texttt{ADD}, \texttt{CAS}, \texttt{FETCH} and \texttt{ADD/OR/XOR}, \texttt{OR} and \texttt{XOR} intrinsics.
• The \texttt{CO\_MIN} and \texttt{CO\_MAX} and \texttt{SUM} reduction intrinsics. And the \texttt{CO\_BROADCAST} and \texttt{CO\_REDUCE} intrinsic, except that those do not support polymorphic types or types with allocatable, pointer or polymorphic components.
• Events (\texttt{EVENT POST}, \texttt{EVENT WAIT}, \texttt{EVENT\_QUERY})
• Failed images (\texttt{FAIL IMAGE}, \texttt{IMAGE\_STATUS}, \texttt{FAILED\_IMAGES}, \texttt{STOPPED\_IMAGES})
5 Compiler Characteristics

This chapter describes certain characteristics of the GNU Fortran compiler, that are not specified by the Fortran standard, but which might in some way or another become visible to the programmer.

5.1 KIND Type Parameters

The **KIND** type parameters supported by GNU Fortran for the primitive data types are:

<table>
<thead>
<tr>
<th>Data Type</th>
<th>KIND Values</th>
<th>Default Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTEGER</td>
<td>1, 2, 4, 8*, 16*, default: 4**</td>
<td></td>
</tr>
<tr>
<td>LOGICAL</td>
<td>1, 2, 4, 8*, 16*, default: 4**</td>
<td></td>
</tr>
<tr>
<td>REAL</td>
<td>4, 8, 10*, 16*, default: 4***</td>
<td></td>
</tr>
<tr>
<td>COMPLEX</td>
<td>4, 8, 10*, 16*, default: 4***</td>
<td></td>
</tr>
<tr>
<td>DOUBLE PRECISION</td>
<td>4, 8, 10*, 16*, default: 8***</td>
<td></td>
</tr>
<tr>
<td>CHARACTER</td>
<td>1, 4, default: 1</td>
<td></td>
</tr>
</tbody>
</table>

* not available on all systems
** unless ‘-fdefault-integer-8’ is used
*** unless ‘-fdefault-real-8’ is used (see Section 2.2 [Fortran Dialect Options], page 8)

The **KIND** value matches the storage size in bytes, except for **COMPLEX** where the storage size is twice as much (or both real and imaginary part are a real value of the given size). It is recommended to use the Section 9.237 [SELECTED_CHARACTER_KIND], page 245, Section 9.238 [SELECTED_INTEGER_KIND], page 245 and Section 9.239 [SELECTED_REAL_KIND], page 246 intrinsics or the INT8, INT16, INT32, INT64, REAL32, REAL64, and REAL128 parameters of the ISO_FORTRAN_ENV module instead of the concrete values. The available kind parameters can be found in the constant arrays CHARACTER_KINDS, INTEGER_KINDS, LOGICAL_KINDS and REAL_KINDS in the Section 10.1 [ISO_FORTRAN_ENV], page 273 module. For C interoperability, the kind parameters of the Section 10.2 [ISO_C_BINDING], page 275 module should be used.

5.2 Internal representation of LOGICAL variables

The Fortran standard does not specify how variables of **LOGICAL** type are represented, beyond requiring that **LOGICAL** variables of default kind have the same storage size as default **INTEGER** and **REAL** variables. The GNU Fortran internal representation is as follows.

A **LOGICAL(KIND=N)** variable is represented as an **INTEGER(KIND=N)** variable, however, with only two permissible values: 1 for .TRUE. and 0 for .FALSE.. Any other integer value results in undefined behavior.

See also Section 7.4.2 [Argument passing conventions], page 74 and Section 7.1 [Interoperability with C], page 63.
5.3 Thread-safety of the runtime library

GNU Fortran can be used in programs with multiple threads, e.g. by using OpenMP, by calling OS thread handling functions via the ISO_C_BINDING facility, or by GNU Fortran compiled library code being called from a multi-threaded program.

The GNU Fortran runtime library, (libgfortran), supports being called concurrently from multiple threads with the following exceptions.

During library initialization, the C getenv function is used, which need not be thread-safe. Similarly, the getenv function is used to implement the GET_ENVIRONMENT_VARIABLE and GETENV intrinsics. It is the responsibility of the user to ensure that the environment is not being updated concurrently when any of these actions are taking place.

The EXECUTE_COMMAND_LINE and SYSTEM intrinsics are implemented with the system function, which need not be thread-safe. It is the responsibility of the user to ensure that system is not called concurrently.

For platforms not supporting thread-safe POSIX functions, further functionality might not be thread-safe. For details, please consult the documentation for your operating system.

The GNU Fortran runtime library uses various C library functions that depend on the locale, such as strtod and snprintf. In order to work correctly in locale-aware programs that set the locale using setlocale, the locale is reset to the default “C” locale while executing a formatted READ or WRITE statement. On targets supporting the POSIX 2008 per-thread locale functions (e.g. newlocale, uselocale, freelocale), these are used and thus the global locale set using setlocale or the per-thread locales in other threads are not affected. However, on targets lacking this functionality, the global LC_NUMERIC locale is set to “C” during the formatted I/O. Thus, on such targets it’s not safe to call setlocale concurrently from another thread while a Fortran formatted I/O operation is in progress. Also, other threads doing something dependent on the LC_NUMERIC locale might not work correctly if a formatted I/O operation is in progress in another thread.

5.4 Data consistency and durability

This section contains a brief overview of data and metadata consistency and durability issues when doing I/O.

With respect to durability, GNU Fortran makes no effort to ensure that data is committed to stable storage. If this is required, the GNU Fortran programmer can use the intrinsic FNUM to retrieve the low level file descriptor corresponding to an open Fortran unit. Then, using e.g. the ISO_C_BINDING feature, one can call the underlying system call to flush dirty data to stable storage, such as fsync on POSIX, _commit on MingW, or fcntl(fd, F_FULLSYNC, 0) on Mac OS X. The following example shows how to call fsync:

```fortran
! Declare the interface for POSIX fsync function
interface
  function fsync (fd) bind(c,name="fsync")
    use iso_c_binding, only: c_int
    integer(c_int), value :: fd
    integer(c_int) :: fsync
  end function fsync
end interface

! Variable declaration
```
integer :: ret

! Opening unit 10
open (10, file="foo")

! ... ! Perform I/O on unit 10
! ... ! Flush and sync
flush(10)
ret = fsync(fnum(10))

! Handle possible error
if (ret /= 0) stop "Error calling FSYNC"

With respect to consistency, for regular files GNU Fortran uses buffered I/O in order to improve performance. This buffer is flushed automatically when full and in some other situations, e.g. when closing a unit. It can also be explicitly flushed with the FLUSH statement. Also, the buffering can be turned off with the GFORTRAN_UNBUFFERED_ALL and GFORTRAN_UNBUFFERED_PRECONNECTED environment variables. Special files, such as terminals and pipes, are always unbuffered. Sometimes, however, further things may need to be done in order to allow other processes to see data that GNU Fortran has written, as follows.

The Windows platform supports a relaxed metadata consistency model, where file metadata is written to the directory lazily. This means that, for instance, the dir command can show a stale size for a file. One can force a directory metadata update by closing the unit, or by calling _commit on the file descriptor. Note, though, that _commit will force all dirty data to stable storage, which is often a very slow operation.

The Network File System (NFS) implements a relaxed consistency model called open-to-close consistency. Closing a file forces dirty data and metadata to be flushed to the server, and opening a file forces the client to contact the server in order to revalidate cached data. fsync will also force a flush of dirty data and metadata to the server. Similar to open and close, acquiring and releasing fcntl file locks, if the server supports them, will also force cache validation and flushing dirty data and metadata.

5.5 Files opened without an explicit ACTION= specifier

The Fortran standard says that if an OPEN statement is executed without an explicit ACTION= specifier, the default value is processor dependent. GNU Fortran behaves as follows:
1. Attempt to open the file with ACTION='READWRITE'
2. If that fails, try to open with ACTION='READ'
3. If that fails, try to open with ACTION='WRITE'
4. If that fails, generate an error

5.6 File operations on symbolic links

This section documents the behavior of GNU Fortran for file operations on symbolic links, on systems that support them.
- Results of INQUIRE statements of the “inquire by file” form will relate to the target of the symbolic link. For example, INQUIRE(FILE="foo",EXIST=ex) will set ex to
.true. if foo is a symbolic link pointing to an existing file, and .false. if foo points to an non-existing file ("dangling" symbolic link).

- Using the OPEN statement with a STATUS="NEW" specifier on a symbolic link will result in an error condition, whether the symbolic link points to an existing target or is dangling.
- If a symbolic link was connected, using the CLOSE statement with a STATUS="DELETE" specifier will cause the symbolic link itself to be deleted, not its target.
6 Extensions

The two sections below detail the extensions to standard Fortran that are implemented in GNU Fortran, as well as some of the popular or historically important extensions that are not (or not yet) implemented. For the latter case, we explain the alternatives available to GNU Fortran users, including replacement by standard-conforming code or GNU extensions.

6.1 Extensions implemented in GNU Fortran

GNU Fortran implements a number of extensions over standard Fortran. This chapter contains information on their syntax and meaning. There are currently two categories of GNU Fortran extensions, those that provide functionality beyond that provided by any standard, and those that are supported by GNU Fortran 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’, ‘-std=f2003’ or ‘-std=f2008’ disables both types of extensions, and ‘-std=legacy’ allows both without warning. The special compile flag ‘-fdec’ enables additional compatibility extensions along with those enabled by ‘-std=legacy’.

6.1.1 Old-style kind specifications

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

```
TYPESPEC*size x,y,z
```

where TYPESPEC is a basic type (INTEGER, REAL, etc.), and where size is a byte count corresponding to the storage size of a valid kind for that type. (For COMPLEX variables, size is the total size of the real and imaginary parts.) The statement then declares x, y and z to be of type TYPESPEC with the appropriate kind. This is equivalent to the standard-conforming declaration

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

where k is the kind parameter suitable for the intended precision. As kind parameters are implementation-dependent, use the KIND, SELECTED_INT_KIND and SELECTED_REAL_KIND intrinsics to retrieve the correct value, for instance REAL*8 x can be replaced by:

```
INTEGER, PARAMETER :: dbl = KIND(1.0d0)
REAL(KIND=dbl) :: x
```

6.1.2 Old-style variable initialization

GNU Fortran allows old-style initialization of variables of the form:

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

The syntax for the initializers is as for the DATA statement, but unlike in a DATA statement, an initializer only applies to the variable immediately preceding the initialization. In other words, something like INTEGER I,J/2,3/ is not valid. This style of initialization is only allowed in declarations without double colons (::); the double colons were introduced in Fortran 90, which also introduced a standard syntax for initializing variables in type declarations.

Examples of standard-conforming code equivalent to the above example are:
! Fortran 90
INTEGER :: i = 1, j = 2
REAL :: x(2,2) = RESHAPE((/0.,0.,0.,1./),SHAPE(x))

! Fortran 77
INTEGER i, j
REAL x(2,2)
DATA i/1/, j/2/, x/3*0.,1./

Note that variables which are explicitly initialized in declarations or in DATA statements automatically acquire the SAVE attribute.

6.1.3 Extensions to namelist

GNU Fortran fully supports the Fortran 95 standard for namelist I/O 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 noted 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:

?  
&myml
  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 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 /myml/ x
  PRINT mynml
END PROGRAM test_print

Expanded namelist reads are permitted. This causes an error if ‘-std=f95’ is used. In the following example, the first element of the array will be given the value 0.00 and the two succeeding elements will be given the values 1.00 and 2.00.
When writing a namelist, if no \texttt{DELIM=} is specified, by default a double quote is used to delimit character strings. If \texttt{-std=F95, F2003, or F2008, etc}, the delim status is set to \textquoteleft none\textquoteright. Defaulting to quotes ensures that namelists with character strings can be subsequently read back in accurately.

\textbf{6.1.4 X format descriptor without count field}

To support legacy codes, GNU Fortran permits the count field of the \texttt{X} edit descriptor in \texttt{FORMAT} statements to be omitted. When omitted, the count is implicitly assumed to be one.

\begin{verbatim}
PRINT 10, 2, 3
10 FORMAT (I1, X, I1)
\end{verbatim}

\textbf{6.1.5 Commas in \texttt{FORMAT} specifications}

To support legacy codes, GNU Fortran allows the comma separator to be omitted immediately before and after character string edit descriptors in \texttt{FORMAT} statements.

\begin{verbatim}
PRINT 10, 2, 3
10 FORMAT ('FOO='I1' BAR='I2)
\end{verbatim}

\textbf{6.1.6 Missing period in \texttt{FORMAT} specifications}

To support legacy codes, GNU Fortran allows missing periods in format specifications if and only if \texttt{'-std=legacy'} is given on the command line. This is considered non-conforming code and is discouraged.

\begin{verbatim}
REAL :: value
READ(*,10) value
10 FORMAT ('F4')
\end{verbatim}

\textbf{6.1.7 I/O item lists}

To support legacy codes, GNU Fortran allows the input item list of the \texttt{READ} statement, and the output item lists of the \texttt{WRITE} and \texttt{PRINT} statements, to start with a comma.

\textbf{6.1.8 Q exponent-letter}

GNU Fortran accepts real literal constants with an exponent-letter of \texttt{Q}, for example, \texttt{1.23Q45}. The constant is interpreted as a \texttt{REAL(16)} entity on targets that support this type. If the target does not support \texttt{REAL(16)} but has a \texttt{REAL(10)} type, then the real-literal-constant will be interpreted as a \texttt{REAL(10)} entity. In the absence of \texttt{REAL(16)} and \texttt{REAL(10)}, an error will occur.

\textbf{6.1.9 BOZ literal constants}

Besides decimal constants, Fortran also supports binary (\texttt{b}), octal (\texttt{o}) and hexadecimal (\texttt{z}) integer constants. The syntax is: \texttt{'prefix quote digits quote'}, were the prefix is either \texttt{b}, \texttt{o} or \texttt{z}, quote is either \textquoteleft or \textquoteright{} and the digits are for binary 0 or 1, for octal between 0 and 7, and for hexadecimal between 0 and F. (Example: \texttt{b'o1011101'}.)

Up to Fortran 95, BOZ literals were only allowed to initialize integer variables in \texttt{DATA} statements. Since Fortran 2003 BOZ literals are also allowed as argument of \texttt{REAL, DBLE,}
INT and CMPLX; the result is the same as if the integer BOZ literal had been converted by TRANSFER to, respectively, real, double precision, integer or complex. As GNU Fortran extension the intrinsic procedures FLOAT, DFLOAT, COMPLEX and DCMPLX are treated alike.

As an extension, GNU Fortran allows hexadecimal BOZ literal constants to be specified using the X prefix, in addition to the standard Z prefix. The BOZ literal can also be specified by adding a suffix to the string, for example, Z'ABC' and 'ABC'Z are equivalent.

Furthermore, GNU Fortran allows using BOZ literal constants outside DATA statements and the four intrinsic functions allowed by Fortran 2003. In DATA statements, in direct assignments, where the right-hand side only contains a BOZ literal constant, and for old-style initializers of the form integer i /o'0173'/, the constant is transferred as if TRANSFER had been used; for COMPLEX numbers, only the real part is initialized unless CMPLX is used. In all other cases, the BOZ literal constant is converted to an INTEGER value with the largest decimal representation. This value is then converted numerically to the type and kind of the variable in question. (For instance, real :: r = b'0000001' + 1 initializes r with 2.0.) As different compilers implement the extension differently, one should be careful when doing bitwise initialization of non-integer variables.

Note that initializing an INTEGER variable with a statement such as DATA i/Z'FFFFFFFF'/ will give an integer overflow error rather than the desired result of −1 when i is a 32-bit integer on a system that supports 64-bit integers. The ‘-fno-range-check’ option can be used as a workaround for legacy code that initializes integers in this manner.

6.1.10 Real array indices
As an extension, GNU Fortran allows the use of REAL expressions or variables as array indices.

6.1.11 Unary operators
As an extension, GNU Fortran allows unary plus and unary minus operators to appear as the second operand of binary arithmetic operators without the need for parenthesis.

\[ x = y * -z \]

6.1.12 Implicitly convert LOGICAL and INTEGER values
As an extension for backwards compatibility with other compilers, GNU Fortran allows the implicit conversion of LOGICAL values to INTEGER values and vice versa. When converting from a LOGICAL to an INTEGER, .FALSE. is interpreted as zero, and .TRUE. is interpreted as one. When converting from INTEGER to LOGICAL, the value zero is interpreted as .FALSE. and any nonzero value is interpreted as .TRUE..

```
LOGICAL :: i
i = 1

INTEGER :: i
i = .TRUE.
```

However, there is no implicit conversion of INTEGER values in if-statements, nor of LOGICAL or INTEGER values in I/O operations.
6.1.13 Hollerith constants support

GNU Fortran supports Hollerith constants in assignments, function arguments, and DATA and ASSIGN statements. A Hollerith constant is written as a string of characters preceded by an integer constant indicating the character count, and the letter H or h, and stored in bytewise fashion in a numeric (INTEGER, REAL, or complex) or LOGICAL variable. The constant will be padded or truncated to fit the size of the variable in which it is stored.

Examples of valid uses of Hollerith constants:

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

Invalid Hollerith constants examples:

```
integer*4 a
a = 8H12345678 ! Valid, but the Hollerith constant will be truncated.
a = 0H ! At least one character is needed.
```

In general, Hollerith constants were used to provide a rudimentary facility for handling character strings in early Fortran compilers, prior to the introduction of CHARACTER variables in Fortran 77; in those cases, the standard-compliant equivalent is to convert the program to use proper character strings. On occasion, there may be a case where the intent is specifically to initialize a numeric variable with a given byte sequence. In these cases, the same result can be obtained by using the TRANSFER statement, as in this example.

```
INTEGER(KIND=4) :: a
a = TRANSFER ("abcd", a) ! equivalent to: a = 4Habcd
```

6.1.14 Cray pointers

Cray pointers are part of a non-standard extension that provides a C-like pointer in Fortran. This is accomplished through a pair of variables: an integer "pointer" that holds a memory address, and a "pointee" that is used to dereference the pointer.

```
pointer (<pointer>, <pointee>)
```

or,

```
pointer (<pointer1>, <pointee1>), (<pointer2>, <pointee2>), ...
```

The pointer is an integer that is intended to hold a memory address. The pointee may be an array or scalar. A pointee can be an assumed size array—that is, the last dimension may be left unspecified by using a * in place of a value—but a pointee cannot be an assumed shape array. No space is allocated for the pointee.

The pointee may have its type declared before or after the pointer statement, and its array specification (if any) may be declared before, during, or after the pointer statement. The pointer may be declared as an integer prior to the pointer statement. However, some machines have default integer sizes that are different than the size of a pointer, and so the following code is not portable:

```
integer ipt
pointer (ipt, iarr)
```

If a pointer is declared with a kind that is too small, the compiler will issue a warning; the resulting binary will probably not work correctly, because the memory addresses stored in the pointers may be truncated. It is safer to omit the first line of the above example;
if explicit declaration of ipt’s type is omitted, then the compiler will ensure that ipt is an integer variable large enough to hold a pointer.

Pointer arithmetic is valid with Cray pointers, but it is not the same as C pointer arithmetic. Cray pointers are just ordinary integers, so the user is responsible for determining how many bytes to add to a pointer in order to increment it. Consider the following example:

```fortran
real target(10)
real pointee(10)
pointer (ipt, pointee)
ipt = loc (target)
ipt = ipt + 1
```

The last statement does not set `ipt` to the address of `target(1)`, as it would in C pointer arithmetic. Adding 1 to `ipt` just adds one byte to the address stored in `ipt`.

Any expression involving the pointee will be translated to use the value stored in the pointer as the base address.

To get the address of elements, this extension provides an intrinsic function LOC(). The LOC() function is equivalent to the & operator in C, except the address is cast to an integer type:

```fortran
real ar(10)
pointer(ipt, arpte(10))
real arpte
ipt = loc(ar) ! Makes arpte is an alias for ar
arpte(1) = 1.0 ! Sets ar(1) to 1.0
```

The pointer can also be set by a call to the `MALLOC` intrinsic (see Section 9.183 [MALLOC], page 215).

Cray pointees often are used to alias an existing variable. For example:

```fortran
integer target(10)
integer iarr(10)
pointer (ipt, iarr)
ipt = loc(target)
```

As long as `ipt` remains unchanged, `iarr` is now an alias for `target`. The optimizer, however, will not detect this aliasing, so it is unsafe to use `iarr` and `target` simultaneously. Using a pointee in any way that violates the Fortran aliasing rules or assumptions is illegal. It is the user’s responsibility to avoid doing this; the compiler works under the assumption that no such aliasing occurs.

Cray pointers will work correctly when there is no aliasing (i.e., when they are used to access a dynamically allocated block of memory), and also in any routine where a pointee is used, but any variable with which it shares storage is not used. Code that violates these rules may not run as the user intends. This is not a bug in the optimizer; any code that violates the aliasing rules is illegal. (Note that this is not unique to GNU Fortran; any Fortran compiler that supports Cray pointers will “incorrectly” optimize code with illegal aliasing.)

There are a number of restrictions on the attributes that can be applied to Cray pointers and pointees. Pointees may not have the `ALLOCATABLE`, `INTENT`, `OPTIONAL`, `DUMMY`, `TARGET`, `INTRINSIC`, or `POINTER` attributes. Pointers may not have the `DIMENSION`, `POINTER`, `TARGET`, `ALLOCATABLE`, `EXTERNAL`, or `INTRINSIC` attributes, nor may they be function results. Pointees may not occur in more than one pointer statement. A pointee cannot be a pointer. Pointees cannot occur in equivalence, common, or data statements.
A Cray pointer may also point to a function or a subroutine. For example, the following excerpt is valid:

```fortran
implicit none
external sub
pointer (subptr,subpte)
external subpte
subptr = loc(sub)
call subpte()
[...]
subroutine sub
[...]
end subroutine sub
```

A pointer may be modified during the course of a program, and this will change the location to which the pointee refers. However, when pointees are passed as arguments, they are treated as ordinary variables in the invoked function. Subsequent changes to the pointer will not change the base address of the array that was passed.

### 6.1.15 CONVERT specifier

GNU Fortran allows the conversion of unformatted data between little- and big-endian representation to facilitate moving of data between different systems. The conversion can be indicated with the `CONVERT` specifier on the `OPEN` statement. See Section 3.11 [GFORTRAN_CONVERT_UNIT], page 30, for an alternative way of specifying the data format via an environment variable.

Valid values for `CONVERT` are:

- `CONVERT='NATIVE'` Use the native format. This is the default.
- `CONVERT='SWAP'` Swap between little- and big-endian.
- `CONVERT='LITTLE_ENDIAN'` Use the little-endian representation for unformatted files.
- `CONVERT='BIG_ENDIAN'` Use the big-endian representation for unformatted files.

Using the option could look like this:

```fortran
open(file='big.dat',form='unformatted',access='sequential', &
     convert='big_endian')
```

The value of the conversion can be queried by using `INQUIRE(CONVERT=ch)`. The values returned are `BIG_ENDIAN` and `LITTLE_ENDIAN`.

`CONVERT` works between big- and little-endian for `INTEGER` values of all supported kinds and for `REAL` on IEEE systems of kinds 4 and 8. Conversion between different “extended double” types on different architectures such as m68k and x86_64, which GNU Fortran supports as `REAL(KIND=10)` and `REAL(KIND=16)`, will probably not work.

*Note that the values specified via the GFORTRAN_CONVERT_UNIT environment variable will override the CONVERT specifier in the open statement.* This is to give control over data formats to users who do not have the source code of their program available.

Using anything but the native representation for unformatted data carries a significant speed overhead. If speed in this area matters to you, it is best if you use this only for data that needs to be portable.
6.1.16 OpenMP

OpenMP (Open Multi-Processing) is an application programming interface (API) that supports multi-platform shared memory multiprocessing programming in C/C++ and Fortran on many architectures, including Unix and Microsoft Windows platforms. It consists of a set of compiler directives, library routines, and environment variables that influence run-time behavior.

GNU Fortran strives to be compatible to the OpenMP Application Program Interface v4.5.

To enable the processing of the OpenMP directive !$omp in free-form source code; the c$omp, *$omp and !$omp directives in fixed form; the !$ conditional compilation sentinels in free form; and the c$, *$ and !$ sentinels in fixed form, gfortran needs to be invoked with the `-fopenmp`.

GNU Offloading and Multi Processing Runtime Library Section “libgomp” in GNU Offloading and Multi Processing Runtime Library.

The OpenMP Fortran runtime library routines are provided both in a form of a Fortran 90 module named omp_lib and in a form of a Fortran include file named ‘omp_lib.h’.

An example of a parallelized loop taken from Appendix A.1 of the OpenMP Application Program Interface v2.5:

```fortran
SUBROUTINE A1(N, A, B)
  INTEGER I, N
  REAL B(N), A(N)
  !$OMP PARALLEL DO !I is private by default
  DO I=2,N
    B(I) = (A(I) + A(I-1)) / 2.0
  ENDDO
  !$OMP END PARALLEL DO
END SUBROUTINE A1
```

Please note:
- `-fopenmp` implies ‘-frecursive’, i.e., all local arrays will be allocated on the stack. When porting existing code to OpenMP, this may lead to surprising results, especially to segmentation faults if the stacksize is limited.
- On glibc-based systems, OpenMP enabled applications cannot be statically linked due to limitations of the underlying pthreads-implementation. It might be possible to get a working solution if `-Wl,--whole-archive -lpthread -Wl,--no-whole-archive` is added to the command line. However, this is not supported by gcc and thus not recommended.

6.1.17 OpenACC

OpenACC is an application programming interface (API) that supports offloading of code to accelerator devices. It consists of a set of compiler directives, library routines, and environment variables that influence run-time behavior.

GNU Fortran strives to be compatible to the OpenACC Application Programming Interface v2.0.

To enable the processing of the OpenACC directive !$acc in free-form source code; the c$acc, *$acc and !$acc directives in fixed form; the !$ conditional compilation sentinels in free form; and the c$, *$ and !$ sentinels in fixed form, gfortran needs to be invoked with
Chapter 6: Extensions

The ‘-fopenacc’. This also arranges for automatic linking of the GNU Offloading and Multi Processing Runtime Library Section “libgomp” in GNU Offloading and Multi Processing Runtime Library.

The OpenACC Fortran runtime library routines are provided both in a form of a Fortran 90 module named openacc and in a form of a Fortran include file named ‘openacc_lib.h’.

Note that this is an experimental feature, incomplete, and subject to change in future versions of GCC. See https://gcc.gnu.org/wiki/OpenACC for more information.

6.1.18 Argument list functions %VAL, %REF and %LOC

GNU Fortran supports argument list functions %VAL, %REF and %LOC statements, for backward compatibility with g77. It is recommended that these should be used only for code that is accessing facilities outside of GNU Fortran, such as operating system or windowing facilities. It is best to constrain such uses to isolated portions of a program–portions that deal specifically and exclusively with low-level, system-dependent facilities. Such portions might well provide a portable interface for use by the program as a whole, but are themselves not portable, and should be thoroughly tested each time they are rebuilt using a new compiler or version of a compiler.

%VAL passes a scalar argument by value, %REF passes it by reference and %LOC passes its memory location. Since gfortran already passes scalar arguments by reference, %REF is in effect a do-nothing. %LOC has the same effect as a Fortran pointer.

An example of passing an argument by value to a C subroutine foo.:

```c
C
C prototype void foo_ (float x);
C
external foo
real*4 x
x = 3.14159
call foo (%VAL (x))
end
```

For details refer to the g77 manual https://gcc.gnu.org/onlinedocs/gcc-3.4.6/g77/index.html#Top.

Also, c_by_val.f and its partner c_by_val.c of the GNU Fortran testsuite are worth a look.

6.1.19 Read/Write after EOF marker

Some legacy codes rely on allowing READ or WRITE after the EOF file marker in order to find the end of a file. GNU Fortran normally rejects these codes with a run-time error message and suggests the user consider BACKSPACE or REWIND to properly position the file before the EOF marker. As an extension, the run-time error may be disabled using -std=legacy.

6.1.20 STRUCTURE and RECORD

Record structures are a pre-Fortran-90 vendor extension to create user-defined aggregate data types. Support for record structures in GNU Fortran can be enabled with the ‘-fdec-structure’ compile flag. If you have a choice, you should instead use Fortran 90’s “derived types”, which have a different syntax.

In many cases, record structures can easily be converted to derived types. To convert, replace STRUCTURE /structure-name/ by TYPE type-name. Additionally, replace RECORD
/structure-name/ by TYPE(type-name). Finally, in the component access, replace the period (.) by the percent sign (%).

Here is an example of code using the non portable record structure syntax:

```fortran
! Declaring a structure named ‘‘item’’ and containing three fields:
! an integer ID, an description string and a floating-point price.
STRUCTURE /item/
    INTEGER id
    CHARACTER(LEN=200) description
    REAL price
END STRUCTURE

! Define two variables, an single record of type ‘‘item’’
! named ‘‘pear’’, and an array of items named ‘‘store_catalog’’
RECORD /item/ pear, store_catalog(100)

! We can directly access the fields of both variables
pear.id = 92316
pear.description = "juicy D'Anjou pear"
pear.price = 0.15
store_catalog(7).id = 7831
store_catalog(7).description = "milk bottle"
store_catalog(7).price = 1.2

! We can also manipulate the whole structure
store_catalog(12) = pear
print *, store_catalog(12)
```

This code can easily be rewritten in the Fortran 90 syntax as following:

```fortran
! ‘‘STRUCTURE /name/ ... END STRUCTURE’’ becomes
! ‘‘TYPE name ... END TYPE’’
TYPE item
    INTEGER id
    CHARACTER(LEN=200) description
    REAL price
END TYPE

! ‘‘RECORD /name/ variable’’ becomes ‘‘TYPE(name) variable’’
TYPE(item) pear, store_catalog(100)

! Instead of using a dot (.) to access fields of a record, the
! standard syntax uses a percent sign (%)
pear%id = 92316
pear%description = "juicy D'Anjou pear"
pear%price = 0.15
store_catalog(7)%id = 7831
store_catalog(7)%description = "milk bottle"
store_catalog(7)%price = 1.2
```
Assignments of a whole variable do not change:
store_catalog(12) = pear
print *, store_catalog(12)

GNU Fortran implements STRUCTURES like derived types with the following rules and exceptions:

- Structures act like derived types with the SEQUENCE attribute. Otherwise they may contain no specifiers.
- Structures may share names with other symbols. For example, the following is invalid for derived types, but valid for structures:

```fortran
structure /header/
  ! ...
end structure
record /header/ header
```

- Structure types may be declared nested within another parent structure. The syntax is:

```fortran
structure /type-name/
  ...
  structure [/<type-name>/] <field-list>
  ...
end structure
```

The type name may be omitted, in which case the structure type itself is anonymous, and other structures of the same type cannot be instantiated. The following shows some examples:

```fortran
structure /appointment/
  ! nested structure definition: app_time is an array of two 'time'
structure /time/ app_time (2)
  integer(1) hour, minute
end structure
character(10) memo
end structure
```

```fortran
! The 'time' structure is still usable
record /time/ now
now = time(5, 30)
```

```fortran
...
structure /appointment/
  ! anonymous nested structure definition
structure start, end
  integer(1) hour, minute
end structure
character(10) memo
end structure
```

- Structures may contain UNION blocks. For more detail see the section on Section 6.1.21 [UNION and MAP], page 54.
• Structures support old-style initialization of components, like those described in Section 6.1.2 [Old-style variable initialization], page 43. For array initializers, an initializer may contain a repeat specification of the form `<literal-integer> * <constant-initializer>`. The value of the integer indicates the number of times to repeat the constant initializer when expanding the initializer list.

6.1.21 UNION and MAP

Unions are an old vendor extension which were commonly used with the non-standard Section 6.1.20 [STRUCTURE and RECORD], page 51 extensions. Use of UNION and MAP is automatically enabled with `'-fdec-structure'`.

A UNION declaration occurs within a structure; within the definition of each union is a number of MAP blocks. Each MAP shares storage with its sibling maps (in the same union), and the size of the union is the size of the largest map within it, just as with unions in C. The major difference is that component references do not indicate which union or map the component is in (the compiler gets to figure that out).

Here is a small example:

```
structure /myunion/
  union
    map
      character(2) w0, w1, w2
    end map
    map
      character(6) long
    end map
  end union
end structure

record /myunion/ rec
  ! After this assignment...
  rec.long = 'hello!' 
  ! The following is true:
  ! rec.w0 === 'he'
  ! rec.w1 === 'll'
  ! rec.w2 === 'o!' 

The two maps share memory, and the size of the union is ultimately six bytes:
```

```
<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>
```

```
\ | \ | \ | \ | \ | \ |
\-/-  \-/-  \-/-  
```

\-/- 

\-/- 

\-/- 

Following is an example mirroring the layout of an Intel x86_64 register:

```
structure /reg/
  union ! U0  ! rax
```
map
  character(16) rx
end map
map
  character(8) rh ! rah
union ! U1
  map
    character(8) rl ! ral
end map
map
  character(8) ex ! eax
end map
map
  character(4) eh ! eah
union ! U2
  map
    character(4) el ! eal
end map
map
  character(4) x ! ax
end map
map
  character(2) h ! ah
  character(2) l ! al
end map
end union
end map
end union
end map
end union
end structure
end

record /reg/ a

! After this assignment...
a.rx = 'AAAAAAAA.BBB.C.D'

! The following is true:
a.rx == 'AAAAAAAA.BBB.C.D'
a.rh == 'AAAAAAAA'
a.rl == '.BBB.C.D'
a.ex == '.BBB.C.D'
a.eh == '.BBB'
a.el == '.C.D'
a.x == '.C.D'
a.h == '.C'
a.l == '.D'
6.1.22 Type variants for integer intrinsics

Similar to the D/C prefixes to real functions to specify the input/output types, GNU Fortran offers B/I/J/K prefixes to integer functions for compatibility with DEC programs. The types implied by each are:

- B - INTEGER(kind=1)
- I - INTEGER(kind=2)
- J - INTEGER(kind=4)
- K - INTEGER(kind=8)

GNU Fortran supports these with the flag `-fdec-intrinsic-ints`. Intrinsics for which prefixed versions are available and in what form are noted in Chapter 9 [Intrinsic Procedures], page 101. The complete list of supported intrinsics is here:

<table>
<thead>
<tr>
<th>Intrinsic</th>
<th>B</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 9.3 [ABS], page 102</td>
<td>BABS</td>
<td>IIABS</td>
<td>JIABS</td>
<td>KIABS</td>
</tr>
<tr>
<td>Section 9.51 [BTEST], page 133</td>
<td>BBTEST</td>
<td>BITEST</td>
<td>BJTEST</td>
<td>BKTEST</td>
</tr>
<tr>
<td>Section 9.136 [IAND], page 188</td>
<td>BIAND</td>
<td>IIAND</td>
<td>JIAND</td>
<td>KIAND</td>
</tr>
<tr>
<td>Section 9.139 [IBCLR], page 190</td>
<td>BBCLR</td>
<td>IIBCLR</td>
<td>JIBCLR</td>
<td>KIBCLR</td>
</tr>
<tr>
<td>Section 9.140 [IBITS], page 191</td>
<td>BBITS</td>
<td>IIBITS</td>
<td>JIBITS</td>
<td>KIBITS</td>
</tr>
<tr>
<td>Section 9.141 [IBSET], page 191</td>
<td>BBSET</td>
<td>IIBSET</td>
<td>JIBSET</td>
<td>KIBSET</td>
</tr>
<tr>
<td>Section 9.144 [IEOR], page 193</td>
<td>BIEOR</td>
<td>IIEOR</td>
<td>JIEOR</td>
<td>KIEOR</td>
</tr>
<tr>
<td>Section 9.151 [IOR], page 197</td>
<td>BIOR</td>
<td>IIOR</td>
<td>JIOR</td>
<td>KIOR</td>
</tr>
<tr>
<td>Section 9.157 [ISHFT], page 201</td>
<td>BSHFT</td>
<td>IISHFT</td>
<td>JISHFT</td>
<td>KISHFT</td>
</tr>
<tr>
<td>Section 9.158 [ISHFTC], page 201</td>
<td>BSHFTC</td>
<td>IISHFTC</td>
<td>JISHFTC</td>
<td>KISHFTC</td>
</tr>
<tr>
<td>Section 9.199 [MOD], page 223</td>
<td>BMOD</td>
<td>IMOD</td>
<td>JMOD</td>
<td>KMOD</td>
</tr>
</tbody>
</table>
6.1.23 AUTOMATIC and STATIC attributes

With `-fdec-static' GNU Fortran supports the DEC extended attributes STATIC and AUTOMATIC to provide explicit specification of entity storage. These follow the syntax of the Fortran standard SAVE attribute.

STATIC is exactly equivalent to SAVE, and specifies that an entity should be allocated in static memory. As an example, STATIC local variables will retain their values across multiple calls to a function.

Entities marked AUTOMATIC will be stack automatic whenever possible. AUTOMATIC is the default for local variables smaller than `-fmax-stack-var-size', unless `-fno-automatic' is given. This attribute overrides `-fno-automatic', `-fmax-stack-var-size', and blanket SAVE statements.

Examples:

```fortran
subroutine f
    integer, automatic :: i ! automatic variable
    integer x, y      ! static variables
    save
    ...
endsubroutine

subroutine f
    integer a, b, c, x, y, z
    static :: x
    save y
    automatic z, c
    ! a, b, c, and z are automatic
    ! x and y are static
endsubroutine

! Compiled with -fno-automatic
subroutine f
    integer a, b, c, d
    automatic :: a
    ! a is automatic; b, c, and d are static
endsubroutine
```

6.1.24 Extended math intrinsics

GNU Fortran supports an extended list of mathematical intrinsics with the compile flag `-fdec-math' for compatability with legacy code. These intrinsics are described fully in Chapter 9 [Intrinsic Procedures], page 101 where it is noted that they are extensions and should be avoided whenever possible.
Specifically, `'-fdec-math'` enables the Section 9.76 [COTAN], page 150 intrinsic, and trigonometric intrinsics which accept or produce values in degrees instead of radians. Here is a summary of the new intrinsics:

<table>
<thead>
<tr>
<th>Radians</th>
<th>Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 9.6 [ACOS], page 104</td>
<td>Section 9.7 [ACOSD], page 105*</td>
</tr>
<tr>
<td>Section 9.19 [ASIN], page 112</td>
<td>Section 9.20 [ASIND], page 113*</td>
</tr>
<tr>
<td>Section 9.23 [ATAN], page 115</td>
<td>Section 9.24 [ATAND], page 116*</td>
</tr>
<tr>
<td>Section 9.25 [ATAN2], page 117</td>
<td>Section 9.26 [ATAN2D], page 118*</td>
</tr>
<tr>
<td>Section 9.73 [COS], page 148</td>
<td>Section 9.74 [COSD], page 149*</td>
</tr>
<tr>
<td>Section 9.76 [COTAN], page 150*</td>
<td>Section 9.77 [COTAND], page 150*</td>
</tr>
<tr>
<td>Section 9.247 [SIN], page 251</td>
<td>Section 9.248 [SIND], page 251*</td>
</tr>
<tr>
<td>Section 9.263 [TAN], page 261</td>
<td>Section 9.264 [TAND], page 261*</td>
</tr>
</tbody>
</table>

* Enabled with `'-fdec-math'`.

For advanced users, it may be important to know the implementation of these functions. They are simply wrappers around the standard radian functions, which have more accurate built-in versions. These functions convert their arguments (or results) to degrees (or radians) by taking the value modulus 360 (or $2\pi$) and then multiplying it by a constant radian-to-degree (or degree-to-radian) factor, as appropriate. The factor is computed at compile-time as $180/\pi$ (or $\pi/180$).

### 6.1.25 Form feed as whitespace

Historically, legacy compilers allowed insertion of form feed characters (`\f`, ASCII 0xC) at the beginning of lines for formatted output to line printers, though the Fortran standard does not mention this. GNU Fortran supports the interpretation of form feed characters in source as whitespace for compatibility.

### 6.1.26 TYPE as an alias for PRINT

For compatibility, GNU Fortran will interpret `TYPE` statements as `PRINT` statements with the flag `'-fdec'`. With this flag asserted, the following two examples are equivalent:

```fortran
    TYPE *, 'hello world'
    PRINT *, 'hello world'
```

### 6.1.27 %LOC as an rvalue

Normally `%LOC` is allowed only in parameter lists. However the intrinsic function `LOC` does the same thing, and is usable as the right-hand-side of assignments. For compatibility, GNU Fortran supports the use of `%LOC` as an alias for the built-in `LOC` with `'-std=legacy'`. With this feature enabled the following two examples are equivalent:

```fortran
    integer :: i, l
    l = %loc(i)
    call sub(l)

    integer :: i
    call sub(%loc(i))
```
6.1.28 .XOR. operator
GNU Fortran supports .XOR. as a logical operator with -std=legacy for compatibility with legacy code. .XOR. is equivalent to .NEQV.. That is, the output is true if and only if the inputs differ.

6.1.29 Bitwise logical operators
With `-fdec', GNU Fortran relaxes the type constraints on logical operators to allow integer operands, and performs the corresponding bitwise operation instead. This flag is for compatibility only, and should be avoided in new code. Consider:

```fortran
INTEGER :: i, j
i = z'33'
j = z'cc'
print *, i .AND. j
```

In this example, compiled with `-fdec', GNU Fortran will replace the .AND. operation with a call to the intrinsic Section 9.136 [IAND], page 188 function, yielding the bitwise-and of i and j.

Note that this conversion will occur if at least one operand is of integral type. As a result, a logical operand will be converted to an integer when the other operand is an integer in a logical operation. In this case, .TRUE. is converted to 1 and .FALSE. to 0.

Here is the mapping of logical operator to bitwise intrinsic used with `-fdec':

<table>
<thead>
<tr>
<th>Operator</th>
<th>Intrinsic</th>
<th>Bitwise operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>.NOT.</td>
<td>Section 9.207 [NOT], page 228</td>
<td>complement</td>
</tr>
<tr>
<td>.AND.</td>
<td>Section 9.136 [IAND], page 188</td>
<td>intersection</td>
</tr>
<tr>
<td>.OR.</td>
<td>Section 9.151 [IOR], page 197</td>
<td>union</td>
</tr>
<tr>
<td>.NEQV.</td>
<td>Section 9.144 [IEOR], page 193</td>
<td>exclusive or</td>
</tr>
<tr>
<td>.EQV.</td>
<td>Section 9.207 [NOT], page 228 (Section 9.144 [IEOR], page 193)</td>
<td>complement of exclusive or</td>
</tr>
</tbody>
</table>

6.1.30 Extended I/O specifiers
GNU Fortran supports the additional legacy I/O specifiers CARRIAGECONTROL, READONLY, and SHARE with the compile flag `-fdec', for compatibility.

CARRIAGECONTROL

The CARRIAGECONTROL specifier allows a user to control line termination settings between output records for an I/O unit. The specifier has no meaning for readonly files. When CARRIAGECONTROL is specified upon opening a unit for formatted writing, the exact CARRIAGECONTROL setting determines what characters to write between output records. The syntax is:

```fortran
OPEN(..., CARRIAGECONTROL=cc)
```
Where \( cc \) is a character expression that evaluates to one of the following values:

- `'LIST'`: One line feed between records (default)
- `'FORTRAN'`: Legacy interpretation of the first character (see below)
- `'NONE'`: No separator between records

With `CARRIAGECONTROL='FORTRAN'`, when a record is written, the first character of the input record is not written, and instead determines the output record separator as follows:

<table>
<thead>
<tr>
<th>Leading character</th>
<th>Meaning</th>
<th>Output separating character(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>`+'</td>
<td>Overprinting</td>
<td>Carriage return only</td>
</tr>
<tr>
<td>`-'</td>
<td>New line</td>
<td>Line feed and carriage return</td>
</tr>
<tr>
<td>`'0'</td>
<td>Skip line</td>
<td>Two line feeds and carriage return</td>
</tr>
<tr>
<td>`'1'</td>
<td>New page</td>
<td>Form feed and carriage return</td>
</tr>
<tr>
<td><code>$</code></td>
<td>Prompting</td>
<td>Line feed (no carriage return)</td>
</tr>
<tr>
<td><code>CHAR(0)</code></td>
<td>Overprinting</td>
<td>(no advance)</td>
</tr>
</tbody>
</table>

**READONLY**

The `READONLY` specifier may be given upon opening a unit, and is equivalent to specifying `ACTION='READ'`, except that the file may not be deleted on close (i.e. `CLOSE` with `STATUS="DELETE"`). The syntax is:

```fortran
OPEN(..., READONLY)
```

**SHARE**

The `SHARE` specifier allows system-level locking on a unit upon opening it for controlled access from multiple processes/threads. The `SHARE` specifier has several forms:

```fortran
OPEN(..., SHARE=sh)
OPEN(..., SHARED)
OPEN(..., NOSHARED)
```

Where `sh` in the first form is a character expression that evaluates to a value as seen in the table below. The latter two forms are aliases for particular values of `sh`:

<table>
<thead>
<tr>
<th>Explicit form</th>
<th>Short form</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>SHARE='DENYRW'</code></td>
<td>NOSHARED</td>
<td>Exclusive (write) lock</td>
</tr>
<tr>
<td><code>SHARE='DENYNONE'</code></td>
<td>SHARED</td>
<td>Shared (read) lock</td>
</tr>
</tbody>
</table>

In general only one process may hold an exclusive (write) lock for a given file at a time, whereas many processes may hold shared (read) locks for the same file.

The behavior of locking may vary with your operating system. On POSIX systems, locking is implemented with `fcntl`. Consult your corresponding operating system’s manual pages for further details. Locking via `SHARE=` is not supported on other systems.

### 6.1.31 Legacy `PARAMETER` statements

For compatibility, GNU Fortran supports legacy `PARAMETER` statements without parentheses with `'-std=legacy'`. A warning is emitted if used with `'-std=gnu'`, and an error is
acknowledged with a real Fortran standard flag (`-std=f95', etc...). These statements take the following form:

```fortran
implicit real (E)
parameter e = 2.718282
real c
parameter c = 3.0e8
```

### 6.1.32 Default exponents

For compatibility, GNU Fortran supports a default exponent of zero in real constants with `'-fdec'`. For example, `9e` would be interpreted as `9e0`, rather than an error.

### 6.2 Extensions not implemented in GNU Fortran

The long history of the Fortran language, its wide use and broad userbase, the large number of different compiler vendors and the lack of some features crucial to users in the first standards have lead to the existence of a number of important extensions to the language. While some of the most useful or popular extensions are supported by the GNU Fortran compiler, not all existing extensions are supported. This section aims at listing these extensions and offering advice on how best make code that uses them running with the GNU Fortran compiler.

#### 6.2.1 ENCODE and DECODE statements

GNU Fortran does not support the `ENCODE` and `DECODE` statements. These statements are best replaced by `READ` and `WRITE` statements involving internal files (`CHARACTER` variables and arrays), which have been part of the Fortran standard since Fortran 77. For example, replace a code fragment like

```fortran
INTEGER*1 LINE(80)
REAL A, B, C
  c ... Code that sets LINE
DECODE (80, 9000, LINE) A, B, C
9000 FORMAT (1X, 3(F10.5))
```

with the following:

```fortran
CHARACTER(LEN=80) LINE
REAL A, B, C
  c ... Code that sets LINE
READ (UNIT=LINE, FMT=9000) A, B, C
9000 FORMAT (1X, 3(F10.5))
```

Similarly, replace a code fragment like

```fortran
INTEGER*1 LINE(80)
REAL A, B, C
  c ... Code that sets A, B and C
ENCODE (80, 9000, LINE) A, B, C
9000 FORMAT (1X, 'OUTPUT IS ', 3(F10.5))
```

with the following:

```fortran
CHARACTER(LEN=80) LINE
REAL A, B, C
  c ... Code that sets A, B and C
WRITE (UNIT=LINE, FMT=9000) A, B, C
9000 FORMAT (1X, 'OUTPUT IS ', 3(F10.5))
```
6.2.2 Variable FORMAT expressions

A variable FORMAT expression is format statement which includes angle brackets enclosing a Fortran expression: FORMAT(I<N>). GNU Fortran does not support this legacy extension. The effect of variable format expressions can be reproduced by using the more powerful (and standard) combination of internal output and string formats. For example, replace a code fragment like this:

```
WRITE(6,20) INT1
20 FORMAT(I<N+1>)
```

with the following:

```
c Variable declaration
CHARACTER(LEN=20) FMT
c
Other code here...
c
WRITE(FMT,’("(I", I0, ",")") N+1
WRITE(6,FMT) INT1
```
or with:

```
c Variable declaration
CHARACTER(LEN=20) FMT
c
Other code here...
c
WRITE(FMT,* ) N+1
WRITE(6,"(I" // ADJUSTL(FMT) // ")") INT1
```

6.2.3 Alternate complex function syntax

Some Fortran compilers, including g77, let the user declare complex functions with the syntax COMPLEX FUNCTION name*16(), as well as COMPLEX*16 FUNCTION name(). Both are non-standard, legacy extensions. gfortran accepts the latter form, which is more common, but not the former.

6.2.4 Volatile COMMON blocks

Some Fortran compilers, including g77, let the user declare COMMON with the VOLATILE attribute. This is invalid standard Fortran syntax and is not supported by gfortran. Note that gfortran accepts VOLATILE variables in COMMON blocks since revision 4.3.

6.2.5 OPEN( ... NAME=)

Some Fortran compilers, including g77, let the user declare OPEN( ... NAME=). This is invalid standard Fortran syntax and is not supported by gfortran. OPEN( ... NAME=) should be replaced with OPEN( ... FILE=).
Chapter 7: Mixed-Language Programming

7 Mixed-Language Programming

This chapter is about mixed-language interoperability, but also applies if one links Fortran code compiled by different compilers. In most cases, use of the C Binding features of the Fortran 2003 standard is sufficient, and their use is highly recommended.

7.1 Interoperability with C

Since Fortran 2003 (ISO/IEC 1539-1:2004(E)) there is a standardized way to generate procedure and derived-type declarations and global variables which are interoperable with C (ISO/IEC 9899:1999). The bind(C) attribute has been added to inform the compiler that a symbol shall be interoperable with C; also, some constraints are added. Note, however, that not all C features have a Fortran equivalent or vice versa. For instance, neither C’s unsigned integers nor C’s functions with variable number of arguments have an equivalent in Fortran.

Note that array dimensions are reversely ordered in C and that arrays in C always start with index 0 while in Fortran they start by default with 1. Thus, an array declaration A(n,m) in Fortran matches A[m][n] in C and accessing the element A(i,j) matches A[j-1][i-1]. The element following A(i,j) (C: A[j-1][i-1]; assuming i < n) in memory is A(i+1,j) (C: A[j-1][i+1]).

7.1.1 Intrinsic Types

In order to ensure that exactly the same variable type and kind is used in C and Fortran, the named constants shall be used which are defined in the ISO_C_BINDING intrinsic module. That module contains named constants for kind parameters and character named constants for the escape sequences in C. For a list of the constants, see Section 10.2 [ISO_C_BINDING], page 275.

For logical types, please note that the Fortran standard only guarantees interoperability between C99’s _Bool and Fortran’s C_Bool-kind logicals and C99 defines that true has the value 1 and false the value 0. Using any other integer value with GNU Fortran’s LOGICAL (with any kind parameter) gives an undefined result. (Passing other integer values than 0 and 1 to GCC’s _Bool is also undefined, unless the integer is explicitly or implicitly casted to _Bool.)

7.1.2 Derived Types and struct

For compatibility of derived types with struct, one needs to use the BIND(C) attribute in the type declaration. For instance, the following type declaration

```
USE ISO_C_BINDING
TYPE, BIND(C) :: myType
  INTEGER(C_INT) :: i1, i2
  INTEGER(C_SIGNED_CHAR) :: i3
  REAL(C_DOUBLE) :: d1
  COMPLEX(C_FLOAT_COMPLEX) :: c1
  CHARACTER(KIND=C_CHAR) :: str(5)
END TYPE
```

matches the following struct declaration in C

```
struct {
  int i1, i2;
```
/* Note: "char" might be signed or unsigned. */
signed char i3;
double d1;
float _Complex c1;
char str[5];
} myType;

Derived types with the C binding attribute shall not have the sequence attribute, type parameters, the extends attribute, nor type-bound procedures. Every component must be of interoperable type and kind and may not have the pointer or allocatable attribute. The names of the components are irrelevant for interoperability.

As there exist no direct Fortran equivalents, neither unions nor structs with bit field or variable-length array members are interoperable.

### 7.1.3 Interoperable Global Variables

Variables can be made accessible from C using the C binding attribute, optionally together with specifying a binding name. Those variables have to be declared in the declaration part of a MODULE, be of interoperable type, and have neither the pointer nor the allocatable attribute.

```fortran
MODULE m
  USE myType_module
  USE ISO_C_BINDING
  integer(C_INT), bind(C, name="_MyProject_flags") :: global_flag
  type(myType), bind(C) :: tp
END MODULE
```

Here, `_MyProject_flags` is the case-sensitive name of the variable as seen from C programs while `global_flag` is the case-insensitive name as seen from Fortran. If no binding name is specified, as for `tp`, the C binding name is the (lowercase) Fortran binding name. If a binding name is specified, only a single variable may be after the double colon. Note of warning: You cannot use a global variable to access `errno` of the C library as the C standard allows it to be a macro. Use the `IERRNO` intrinsic (GNU extension) instead.

### 7.1.4 Interoperable Subroutines and Functions

Subroutines and functions have to have the BIND(C) attribute to be compatible with C. The dummy argument declaration is relatively straightforward. However, one needs to be careful because C uses call-by-value by default while Fortran behaves usually similar to call-by-reference. Furthermore, strings and pointers are handled differently. Note that in Fortran 2003 and 2008 only explicit size and assumed-size arrays are supported but not assumed-shape or deferred-shape (i.e. allocatable or pointer) arrays. However, those are allowed since the Technical Specification 29113, see Section 7.1.6 [Further Interoperability of Fortran with C], page 68

To pass a variable by value, use the VALUE attribute. Thus, the following C prototype

```c
int func(int i, int *j)
```

matches the Fortran declaration

```fortran
integer(c_int) function func(i,j)
  use iso_c_binding, only: c_int
  integer(c_int), VALUE :: i
  integer(c_int) :: j
```
Note that pointer arguments also frequently need the \texttt{VALUE} attribute, see Section 7.1.5 [Working with Pointers], page 66.

Strings are handled quite differently in C and Fortran. In C a string is a \texttt{NUL}-terminated array of characters while in Fortran each string has a length associated with it and is thus not terminated (by e.g. \texttt{NUL}). For example, if one wants to use the following C function,

```c
#include <stdio.h>
void print_C(char *string) /* equivalent: char string[] */
{
    printf("%s\n", string);
}
```

to print “Hello World” from Fortran, one can call it using

```fortran
use iso_c_binding, only: C_CHAR, C_NULL_CHAR
interface
    subroutine print_c(string) bind(C, name="print_C")
        use iso_c_binding, only: c_char
        character(kind=c_char) :: string(*)
    end subroutine print_c
end interface
```

call print_c(C_CHAR_"Hello World"/C_NULL_CHAR)

As the example shows, one needs to ensure that the string is \texttt{NUL} terminated. Additionally, the dummy argument \texttt{string} of \texttt{print\_C} is a length-one assumed-size array; using \texttt{character(len=*)} is not allowed. The example above uses \texttt{c_char_"Hello World"} to ensure the string literal has the right type; typically the default character kind and \texttt{c_char} are the same and thus \texttt{"Hello World"} is equivalent. However, the standard does not guarantee this.

The use of strings is now further illustrated using the C library function \texttt{strncpy}, whose prototype is

```c
char *strncpy(char *restrict s1, const char *restrict s2, size_t n);
```

The function \texttt{strncpy} copies at most \texttt{n} characters from string \texttt{s2} to \texttt{s1} and returns \texttt{s1}. In the following example, we ignore the return value:

```fortran
use iso_c_binding
implicit none
character(len=30) :: str,str2
interface
    ! Ignore the return value of strncpy -> subroutine
    ! "restrict" is always assumed if we do not pass a pointer
    subroutine strncpy(dest, src, n) bind(C)
        import
        character(kind=c_char), intent(out) :: dest(*)
        character(kind=c_char), intent(in) :: src(*)
        integer(c_size_t), value, intent(in) :: n
    end subroutine strncpy
end interface
str = repeat('X',30) ! Initialize whole string with 'X'
call strncpy(str, c_char_"Hello World"/C_NULL_CHAR, &
             len(c_char_"Hello World",kind=c_size_t))
print '__(a)__', str ! prints: "Hello WorldXXXXXXXXXXXXXXXXXXX"
end
```

The intrinsic procedures are described in Chapter 9 [Intrinsic Procedures], page 101.
7.1.5 Working with Pointers

C pointers are represented in Fortran via the special opaque derived type `type(c_ptr)` (with private components). Thus one needs to use intrinsic conversion procedures to convert from or to C pointers.

For some applications, using an assumed type (TYPE(*)) can be an alternative to a C pointer; see Section 7.1.6 [Further Interoperability of Fortran with C], page 68.

For example,

```fortran
use iso_c_binding

type(c_ptr) :: cptr1, cptr2
integer, target :: array(7), scalar
integer, pointer :: pa(:), ps

! The programmer needs to ensure that the array is contiguous if required by the C procedure

cptr1 = c_loc(array(1))
cptr2 = c_loc(scalar)
call c_f_pointer(cptr2, ps)
call c_f_pointer(cptr2, pa, shape=[7])
```

When converting C to Fortran arrays, the one-dimensional SHAPE argument has to be passed.

If a pointer is a dummy-argument of an interoperable procedure, it usually has to be declared using the VALUE attribute. `void*` matches TYPE(C_PTR), VALUE, while TYPE(C_PTR) alone matches `void**`.

Procedure pointers are handled analogously to pointers; the C type is TYPE(C_FUNPTR) and the intrinsic conversion procedures are C_F_PROCPOINTER and C_FUNLOC.

Let us consider two examples of actually passing a procedure pointer from C to Fortran and vice versa. Note that these examples are also very similar to passing ordinary pointers between both languages. First, consider this code in C:

```c
/* Procedure implemented in Fortran. */
void get_values (void (*)(double));

/* Call-back routine we want called from Fortran. */
void
print_it (double x)
{
    printf ("Number is %f.\n", x);
}

/* Call Fortran routine and pass call-back to it. */
void
foobar ()
{
    get_values (&print_it);
}
```

A matching implementation for `get_values` in Fortran, that correctly receives the procedure pointer from C and is able to call it, is given in the following MODULE:

```fortran
MODULE m
IMPLICIT NONE

! Define interface of call-back routine.
ABSTRACT INTERFACE
    SUBROUTINE callback (x)
```

```fortran
/* Procedure implemented in Fortran. */
void get_values (void (*)(double));

/* Call-back routine we want called from Fortran. */
void
print_it (double x)
{
    printf ("Number is %f.\n", x);
}

/* Call Fortran routine and pass call-back to it. */
void
foobar ()
{
    get_values (&print_it);
}```
USE, INTRINSIC :: ISO_C_BINDING
REAL(KIND=C_DOUBLE), INTENT(IN), VALUE :: x
END SUBROUTINE callback
END INTERFACE

CONTAINS

! Define C-bound procedure.
SUBROUTINE get_values (cproc) BIND(C)
USE, INTRINSIC :: ISO_C_BINDING
TYPE(C_FUNPTR), INTENT(IN), VALUE :: cproc
PROCEDURE(callback), POINTER :: proc

! Convert C to Fortran procedure pointer.
CALL C_F_PROCPOINTER (cproc, proc)

! Call it.
CALL proc (1.0_C_DOUBLE)
CALL proc (-42.0_C_DOUBLE)
CALL proc (18.12_C_DOUBLE)
END SUBROUTINE get_values

END MODULE m

Next, we want to call a C routine that expects a procedure pointer argument and pass it a Fortran procedure (which clearly must be interoperable!). Again, the C function may be:

```c
int
call_it (int (*func)(int), int arg)
{
    return func (arg);
}
```

It can be used as in the following Fortran code:

```
MODULE m
USE, INTRINSIC :: ISO_C_BINDING
IMPLICIT NONE

! Define interface of C function.
INTERFACE
    INTEGER(KIND=C_INT) FUNCTION call_it (func, arg) BIND(C)
    USE, INTRINSIC :: ISO_C_BINDING
    TYPE(C_FUNPTR), INTENT(IN), VALUE :: func
    INTEGER(KIND=C_INT), INTENT(IN), VALUE :: arg
END FUNCTION call_it
END INTERFACE

CONTAINS

! Define procedure passed to C function.
! It must be interoperable!
INTEGER(KIND=C_INT) FUNCTION double_it (arg) BIND(C)
    INTEGER(KIND=C_INT), INTENT(IN), VALUE :: arg
    double_it = arg + arg
END FUNCTION double_it

! Call C function.
SUBROUTINE foobar ()
  TYPE(C_FUNPTR) :: cproc
  INTEGER(KIND=C_INT) :: i

  ! Get C procedure pointer.
  cproc = C_FUNLOC (double_it)

  ! Use it.
  DO i = 1_C_INT, 10_C_INT
    PRINT *, call_it (cproc, i)
  END DO
END SUBROUTINE foobar

END MODULE m

7.1.6 Further Interoperability of Fortran with C

The Technical Specification ISO/IEC TS 29113:2012 on further interoperability of Fortran with C extends the interoperability support of Fortran 2003 and Fortran 2008. Besides removing some restrictions and constraints, it adds assumed-type (TYPE(*)) and assumed-rank (dimension) variables and allows for interoperability of assumed-shape, assumed-rank and deferred-shape arrays, including allocatables and pointers.

Note: Currently, GNU Fortran does not support the array descriptor (dope vector) as specified in the Technical Specification, but uses an array descriptor with different fields. The Chasm Language Interoperability Tools, http://chasm-interop.sourceforge.net/, provide an interface to GNU Fortran’s array descriptor.

The Technical Specification adds the following new features, which are supported by GNU Fortran:

- The ASYNCHRONOUS attribute has been clarified and extended to allow its use with asynchronous communication in user-provided libraries such as in implementations of the Message Passing Interface specification.
- Many constraints have been relaxed, in particular for the C_LOC and C_F_POINTER intrinsics.
- The OPTIONAL attribute is now allowed for dummy arguments; an absent argument matches a NULL pointer.
- Assumed types (TYPE(*)) have been added, which may only be used for dummy arguments. They are unlimited polymorphic but contrary to CLASS(*) they do not contain any type information, similar to C’s void * pointers. Expressions of any type and kind can be passed; thus, it can be used as replacement for TYPE(C_PTR), avoiding the use of C_LOC in the caller.

Note, however, that TYPE(*) only accepts scalar arguments, unless the DIMENSION is explicitly specified. As DIMENSION(*) only supports array (including array elements) but no scalars, it is not a full replacement for C_LOC. On the other hand, assumed-type assumed-rank dummy arguments (TYPE(*), DIMENSION(..)) allow for both scalars and arrays, but require special code on the callee side to handle the array descriptor.

- Assumed-rank arrays (DIMENSION(..)) as dummy argument allow that scalars and arrays of any rank can be passed as actual argument. As the Technical Specification does not provide for direct means to operate with them, they have to be used either
from the C side or be converted using \texttt{C\_LOC} and \texttt{C\_F\_POINTER} to scalars or arrays of a specific rank. The rank can be determined using the \texttt{RANK} intrinsic.

Currently unimplemented:

- GNU Fortran always uses an array descriptor, which does not match the one of the Technical Specification. The \texttt{ISO\_Fortran\_binding.h} header file and the C functions it specifies are not available.
- Using assumed-shape, assumed-rank and deferred-shape arrays in \texttt{BIND(C)} procedures is not fully supported. In particular, C interoperable strings of other length than one are not supported as this requires the new array descriptor.

### 7.2 GNU Fortran Compiler Directives

The Fortran standard describes how a conforming program shall behave; however, the exact implementation is not standardized. In order to allow the user to choose specific implementation details, compiler directives can be used to set attributes of variables and procedures which are not part of the standard. Whether a given attribute is supported and its exact effects depend on both the operating system and on the processor; see Section “C Extensions” in \textit{Using the GNU Compiler Collection (GCC)} for details.

For procedures and procedure pointers, the following attributes can be used to change the calling convention:

- \texttt{CDECL} – standard C calling convention
- \texttt{STDCALL} – convention where the called procedure pops the stack
- \texttt{FASTCALL} – part of the arguments are passed via registers instead using the stack

Besides changing the calling convention, the attributes also influence the decoration of the symbol name, e.g., by a leading underscore or by a trailing at-sign followed by the number of bytes on the stack. When assigning a procedure to a procedure pointer, both should use the same calling convention.

On some systems, procedures and global variables (module variables and \texttt{COMMON} blocks) need special handling to be accessible when they are in a shared library. The following attributes are available:

- \texttt{DLELEXPORT} – provide a global pointer to a pointer in the DLL
- \texttt{DLLIMPORT} – reference the function or variable using a global pointer

For dummy arguments, the \texttt{NO\_ARG\_CHECK} attribute can be used; in other compilers, it is also known as \texttt{IGNORE\_TKR}. For dummy arguments with this attribute actual arguments of any type and kind (similar to \texttt{TYPE(*)}), scalars and arrays of any rank (no equivalent in Fortran standard) are accepted. As with \texttt{TYPE(*)}, the argument is unlimited polymorphic and no type information is available. Additionally, the argument may only be passed to dummy arguments with the \texttt{NO\_ARG\_CHECK} attribute and as argument to the \texttt{PRESENT} intrinsic function and to \texttt{C\_LOC} of the \texttt{ISO\_C\_BINDING} module.

Variables with \texttt{NO\_ARG\_CHECK} attribute shall be of assumed-type (\texttt{TYPE(*)}; recommended) or of type \texttt{INTEGER}, \texttt{LOGICAL}, \texttt{REAL} or \texttt{COMPLEX}. They shall not have the \texttt{ALLOCATE}, \texttt{CODIMENSION}, \texttt{INTENT(OUT)}, \texttt{POINTER} or \texttt{VALUE} attribute; furthermore, they shall be either scalar or of assumed-size (\texttt{dimension(*)}). As \texttt{TYPE(*)}, the \texttt{NO\_ARG\_CHECK} attribute requires an explicit interface.
• NO_ARG_CHECK – disable the type, kind and rank checking

The attributes are specified using the syntax

!GCC$ ATTRIBUTES attribute-list :: variable-list

where in free-form source code only whitespace is allowed before !GCC$ and in fixed-form source code !GCC$, cGCC$ or *GCC$ shall start in the first column.

For procedures, the compiler directives shall be placed into the body of the procedure; for variables and procedure pointers, they shall be in the same declaration part as the variable or procedure pointer.

7.3 Non-Fortran Main Program

Even if you are doing mixed-language programming, it is very likely that you do not need to know or use the information in this section. Since it is about the internal structure of GNU Fortran, it may also change in GCC minor releases.

When you compile a PROGRAM with GNU Fortran, a function with the name main (in the symbol table of the object file) is generated, which initializes the libgfortran library and then calls the actual program which uses the name MAIN__, for historic reasons. If you link GNU Fortran compiled procedures to, e.g., a C or C++ program or to a Fortran program compiled by a different compiler, the libgfortran library is not initialized and thus a few intrinsic procedures do not work properly, e.g. those for obtaining the command-line arguments.

Therefore, if your PROGRAM is not compiled with GNU Fortran and the GNU Fortran compiled procedures require intrinsics relying on the library initialization, you need to initialize the library yourself. Using the default options, gfortran calls _gfortran_set_args and _gfortran_set_options. The initialization of the former is needed if any of the command-line intrinsics is called. Additionally, it shall be called if backtracing is enabled (see _gfortran_set_options).

If your PROGRAM is compiled with GNU Fortran, you shall not call any of the following functions. The libgfortran initialization functions are shown in C syntax but using C bindings they are also accessible from Fortran.

7.3.1 _gfortran_set_args — Save command-line arguments

Description:

_gfortran_set_args saves the command-line arguments; this initialization is required if any of the command-line intrinsics is called. Additionally, it shall be called if backtracing is enabled (see _gfortran_set_options).

Syntax: void _gfortran_set_args (int argc, char *argv[])

Arguments:

argc number of command line argument strings
argv the command-line argument strings; argv[0] is the pathname

of the executable itself.

Example:
```c
int main (int argc, char *argv[]) {
    /* Initialize libgfortran. */
    _gfortran_set_args (argc, argv);
    return 0;
}
```

### 7.3.2 \_gfortran\_set\_options — Set library option flags

**Description:**

\_gfortran\_set\_options sets several flags related to the Fortran standard to be used, whether backtracing should be enabled and whether range checks should be performed. The syntax allows for upward compatibility since the number of passed flags is specified; for non-passed flags, the default value is used. See also Section 2.9 [Code Gen Options], page 21. Please note that not all flags are actually used.

**Syntax:**

```c
void \_gfortran\_set\_options (int num, int options[])
```

**Arguments:**

- `num`: number of options passed
- `argv`: The list of flag values

**option flag list:**

- **option[0]**: Allowed standard; can give run-time errors if e.g. an input-output edit descriptor is invalid in a given standard. Possible values are (bitwise or-ed) GFC\_STD\_F77 (1), GFC\_STD\_F95\_OBS (2), GFC\_STD\_F95\_DEL (4), GFC\_STD\_F95 (8), GFC\_STD\_F2003 (16), GFC\_STD\_GNU (32), GFC\_STD\_LEGACY (64), GFC\_STD\_F2008 (128), GFC\_STD\_F2008\_OBS (256) and GFC\_STD\_F2008\_TS (512). Default: GFC\_STD\_F95\_OBS | GFC\_STD\_F95\_DEL | GFC\_STD\_F95 | GFC\_STD\_F2003 | GFC\_STD\_F2008 | GFC\_STD\_F2008\_TS | GFC\_STD\_F2008\_OBS | GFC\_STD\_F77 | GFC\_STD\_GNU | GFC\_STD\_LEGACY.

- **option[1]**: Standard-warning flag; prints a warning to standard error. Default: GFC\_STD\_F95\_DEL | GFC\_STD\_LEGACY.

- **option[2]**: If non zero, enable pedantic checking. Default: off.

- **option[3]**: Unused.

- **option[4]**: If non zero, enable backtracing on run-time errors. Default: off. (Default in the compiler: on.) Note: Installs a signal handler and requires command-line initialization using \_gfortran\_set\_args.

- **option[5]**: If non zero, supports signed zeros. Default: enabled.

- **option[6]**: Enables run-time checking. Possible values are (bitwise or-ed): GFC\_RTCHECK\_BOUNDS (1), GFC\_RTCHECK\_ARRAY\_TEMPS (2), GFC\_RTCHECK\_RECURSION (4), GFC\_RTCHECK\_DO (16), GFC\_RTCHECK\_POINTER (32). Default: disabled.

- **option[7]**: Unused.
Show a warning when invoking \texttt{STOP} and \texttt{ERROR STOP} if a floating-point exception occurred. Possible values are (bitwise or-ed) \texttt{GFC\_FPE\_INVALID} (1), \texttt{GFC\_FPE\_DENORMAL} (2), \texttt{GFC\_FPE\_ZERO} (4), \texttt{GFC\_FPE\_OVERFLOW} (8), \texttt{GFC\_FPE\_UNDERFLOW} (16), \texttt{GFC\_FPE\_INEXACT} (32). Default: None (0). (Default in the compiler: \texttt{GFC\_FPE\_INVALID | GFC\_FPE\_DENORMAL | GFC\_FPE\_ZERO | GFC\_FPE\_OVERFLOW | GFC\_FPE\_UNDERFLOW}.)

Example:

\begin{verbatim}
/* Use gfortran 4.9 default options. */
static int options[] = {68, 511, 0, 0, 1, 1, 0, 0, 31};
_gfortran_set_options (9, &options);
\end{verbatim}

7.3.3 \texttt{_gfortran_set_convert} — Set endian conversion

\textbf{Description:}
\texttt{_gfortran_set_convert} set the representation of data for unformatted files.

\textbf{Syntax:}
\begin{verbatim}
void _gfortran_set_convert (int conv)
\end{verbatim}

\textbf{Arguments:}
\begin{itemize}
  \item \texttt{conv} \hspace{1cm} Endian conversion, possible values:
    \begin{itemize}
      \item \texttt{GFC\_CONVERT\_NATIVE} (0, default),
      \item \texttt{GFC\_CONVERT\_SWAP} (1), \texttt{GFC\_CONVERT\_BIG} (2), \texttt{GFC\_CONVERT\_LITTLE} (3).
    \end{itemize}
\end{itemize}

Example:

\begin{verbatim}
int main (int argc, char *argv[]) {
  /* Initialize libgfortran. */
  _gfortran_set_args (argc, argv);
  _gfortran_set_convert (1);
  return 0;
}
\end{verbatim}

7.3.4 \texttt{_gfortran_set_record_marker} — Set length of record markers

\textbf{Description:}
\texttt{_gfortran_set_record_marker} sets the length of record markers for unformatted files.

\textbf{Syntax:}
\begin{verbatim}
void _gfortran_set_record_marker (int val)
\end{verbatim}

\textbf{Arguments:}
\begin{itemize}
  \item \texttt{val} \hspace{1cm} Length of the record marker; valid values are 4 and 8. Default is 4.
\end{itemize}

Example:

\begin{verbatim}
int main (int argc, char *argv[]) {
  /* Initialize libgfortran. */
  _gfortran_set_args (argc, argv);
  _gfortran_set_record_marker (8);
  return 0;
}
\end{verbatim}
7.3.5 \_gfortran\_set\_fpe — Enable floating point exception traps

**Description:**

\_gfortran\_set\_fpe enables floating point exception traps for the specified exceptions. On most systems, this will result in a SIGFPE signal being sent and the program being aborted.

**Syntax:**

```c
void \_gfortran\_set\_fpe (int val)
```

**Arguments:**

- `option[0]` IEEE exceptions. Possible values are (bitwise or-ed) zero (0, default) no trapping, `GFC_FPE_INVALID` (1), `GFC_FPE_DENORMAL` (2), `GFC_FPE_ZERO` (4), `GFC_FPE_OVERFLOW` (8), `GFC_FPE_UNDERFLOW` (16), and `GFC_FPE_INEXACT` (32).

**Example:**

```c
int main (int argc, char *argv[])
{
    /* Initialize libgfortran. */
    \_gfortran\_set\_args (argc, argv);
    /* FPE for invalid operations such as SQRT(-1.0). */
    \_gfortran\_set\_fpe (1);
    return 0;
}
```

7.3.6 \_gfortran\_set\_max\_subrecord\_length — Set subrecord length

**Description:**

\_gfortran\_set\_max\_subrecord\_length set the maximum length for a subrecord. This option only makes sense for testing and debugging of unformatted I/O.

**Syntax:**

```c
void \_gfortran\_set\_max\_subrecord\_length (int val)
```

**Arguments:**

- `val` the maximum length for a subrecord; the maximum permitted value is 2147483639, which is also the default.

**Example:**

```c
int main (int argc, char *argv[])
{
    /* Initialize libgfortran. */
    \_gfortran\_set\_args (argc, argv);
    \_gfortran\_set\_max\_subrecord\_length (8);
    return 0;
}
```

7.4 Naming and argument-passing conventions

This section gives an overview about the naming convention of procedures and global variables and about the argument passing conventions used by GNU Fortran. If a C binding has been specified, the naming convention and some of the argument-passing conventions change. If possible, mixed-language and mixed-compiler projects should use the better defined C binding for interoperability. See see Section 7.1 [Interoperability with C], page 63.
7.4.1 Naming conventions

According to the Fortran standard, valid Fortran names consist of a letter between A to Z, a to z, digits 0 to 9 and underscores (_) with the restriction that names may only start with a letter. As a vendor extension, the dollar sign ($) is additionally permitted with the option `-fdollar-ok`, but not as first character and only if the target system supports it.

By default, the procedure name is the lower-cased Fortran name with an appended underscore (_); using `-fno-underscoring` no underscore is appended while `-fsecond-underscore` appends two underscores. Depending on the target system and the calling convention, the procedure might be additionally dressed; for instance, on 32bit Windows with `stdcall`, an at-sign @ followed by an integer number is appended. For the changing the calling convention, see Section 7.2 [GNU Fortran Compiler Directives], page 69.

For common blocks, the same convention is used, i.e. by default an underscore is appended to the lower-cased Fortran name. Blank commons have the name __BLNK__.

For procedures and variables declared in the specification space of a module, the name is formed by ___, followed by the lower-cased module name, _MOD_, and the lower-cased Fortran name. Note that no underscore is appended.

7.4.2 Argument passing conventions

Subroutines do not return a value (matching C99's void) while functions either return a value as specified in the platform ABI or the result variable is passed as hidden argument to the function and no result is returned. A hidden result variable is used when the result variable is an array or of type CHARACTER.

Arguments are passed according to the platform ABI. In particular, complex arguments might not be compatible to a struct with two real components for the real and imaginary part. The argument passing matches the one of C99's _Complex. Functions with scalar complex result variables return their value and do not use a by-reference argument. Note that with the `-ff2c` option, the argument passing is modified and no longer completely matches the platform ABI. Some other Fortran compilers use f2c semantic by default; this might cause problems with interoperability.

GNU Fortran passes most arguments by reference, i.e. by passing a pointer to the data. Note that the compiler might use a temporary variable into which the actual argument has been copied, if required semantically (copy-in/copy-out).

For arguments with `ALLOCATABLE` and `POINTER` attribute (including procedure pointers), a pointer to the pointer is passed such that the pointer address can be modified in the procedure.

For dummy arguments with the `VALUE` attribute: Scalar arguments of the type INTEGER, LOGICAL, REAL and COMPLEX are passed by value according to the platform ABI. (As a vendor extension and not recommended, using `%VAL()` in the call to a procedure has the same effect.) For `TYPE(C_PTR)` and procedure pointers, the pointer itself is passed such that it can be modified without affecting the caller.

For Boolean (LOGICAL) arguments, please note that GCC expects only the integer value 0 and 1. If a GNU Fortran LOGICAL variable contains another integer value, the result is undefined. As some other Fortran compilers use -1 for .TRUE., extra care has to be taken – such as passing the value as INTEGER. (The same value restriction also applies to other front ends of GCC, e.g. to GCC’s C99 compiler for _Bool or GCC’s Ada compiler for Boolean.)
For arguments of CHARACTER type, the character length is passed as hidden argument. For deferred-length strings, the value is passed by reference, otherwise by value. The character length has the type INTEGER(kind=4). Note with C binding, CHARACTER(len=1) result variables are returned according to the platform ABI and no hidden length argument is used for dummy arguments; with VALUE, those variables are passed by value.

For OPTIONAL dummy arguments, an absent argument is denoted by a NULL pointer, except for scalar dummy arguments of type INTEGER, LOGICAL, REAL and COMPLEX which have the VALUE attribute. For those, a hidden Boolean argument (logical(kind=C_bool),value) is used to indicate whether the argument is present.

Arguments which are assumed-shape, assumed-rank or deferred-rank arrays or, with '-fcoarray=lib', allocatable scalar coarrays use an array descriptor. All other arrays pass the address of the first element of the array. With '-fcoarray=lib', the token and the offset belonging to nonallocatable coarrays dummy arguments are passed as hidden argument along the character length hidden arguments. The token is an opaque pointer identifying the coarray and the offset is a passed-by-value integer of kind C_PTRDIFF_T, denoting the byte offset between the base address of the coarray and the passed scalar or first element of the passed array.

The arguments are passed in the following order

- Result variable, when the function result is passed by reference
- Character length of the function result, if it is a of type CHARACTER and no C binding is used
- The arguments in the order in which they appear in the Fortran declaration
- The the present status for optional arguments with value attribute, which are internally passed by value
- The character length and/or coarray token and offset for the first argument which is a CHARACTER or a nonallocatable coarray dummy argument, followed by the hidden arguments of the next dummy argument of such a type
8 Coarray Programming

8.1 Type and enum ABI Documentation

8.1.1 caf_token_t
Typedef of type void * on the compiler side. Can be any data type on the library side.

8.1.2 caf_register_t
Indicates which kind of coarray variable should be registered.

typedef enum caf_register_t {
    CAF_REGTYPE_COARRAY_STATIC,
    CAF_REGTYPE_COARRAY_ALLOC,
    CAF_REGTYPE_LOCK_STATIC,
    CAF_REGTYPE_LOCK_ALLOC,
    CAF_REGTYPE_CRITICAL,
    CAF_REGTYPE_EVENT_STATIC,
    CAF_REGTYPE_EVENT_ALLOC,
    CAF_REGTYPE_COARRAY_ALLOC_REGISTER_ONLY,
    CAF_REGTYPE_COARRAY_ALLOCALLOCATE_ONLY
} caf_register_t;

The values CAF_REGTYPE_COARRAY_ALLOC_REGISTER_ONLY and CAF_REGTYPE_COARRAY_ALLOCALLOCATE_ONLY are for allocatable components in derived type coarrays only. The first one sets up the token without allocating memory for allocatable component. The latter one only allocates the memory for an allocatable component in a derived type coarray. The token needs to be setup previously by the REGISTERONLY. This allows to have allocatable components un-allocated on some images. The status whether an allocatable component is allocated on a remote image can be queried by _caf_is_present which used internally by the ALLOCATED intrinsic.

8.1.3 caf_deregister_t
typedef enum caf_deregister_t {
    CAF_DEREGTYPE_COARRAY_DEREGISTER,
    CAF_DEREGTYPE_COARRAY_DEALLOCATE_ONLY
} caf_deregister_t;

Allows to specify the type of deregistration of a coarray object. The CAF_DEREGTYPE_COARRAY_DEALLOCATE_ONLY flag is only allowed for allocatable components in derived type coarrays.

8.1.4 caf_reference_t
The structure used for implementing arbitrary reference chains. A CAF_REFERENCE_T allows to specify a component reference or any kind of array reference of any rank supported by gfortran. For array references all kinds as known by the compiler/Fortran standard are supported indicated by a MODE.
typedef enum caf_ref_type_t {
    /* Reference a component of a derived type, either regular one or an 
       allocatable or pointer type. For regular ones idx in caf_reference_t is 
       set to -1. */
    CAF_REF_COMPONENT,
    /* Reference an allocatable array. */
    CAF_REF_ARRAY,
    /* Reference a non-allocatable/non-pointer array. I.e., the coarray object 
       has no array descriptor associated and the addressing is done 
       completely using the ref. */
    CAF_REF_STATIC_ARRAY
} caf_ref_type_t;

typedef enum caf_array_ref_t {
    /* No array ref. This terminates the array ref. */
    CAF_ARR_REF_NONE = 0,
    /* Reference array elements given by a vector. Only for this mode 
       caf_reference_t.u.a.dim[i].v is valid. */
    CAF_ARR_REF_VECTOR,
    /* A full array ref (:). */
    CAF_ARR_REF_FULL,
    /* Reference a range on elements given by start, end and stride. */
    CAF_ARR_REF_RANGE,
    /* Only a single item is referenced given in the start member. */
    CAF_ARR_REF_SINGLE,
    /* An array ref of the kind (i:), where i is an arbitrary valid index in the 
       array. The index i is given in the start member. */
    CAF_ARR_REF_OPEN_END,
    /* An array ref of the kind (:i), where the lower bound of the array ref 
       is given by the remote side. The index i is given in the end member. */
    CAF_ARR_REF_OPEN_START
} caf_array_ref_t;

typedef struct caf_reference_t {
    /* A pointer to the next ref or NULL. */
    struct caf_reference_t *next;
    /* The type of the reference. */
    int type;
    /* The size of an item referenced in bytes. I.e. in an array ref this is 
       the factor to advance the array pointer with to get to the next item. 
       For component refs this gives just the size of the element referenced. */
    size_t item_size;
} caf_reference_t;

struct { /* The offset (in bytes) of the component in the derived type. */
    /* Unused for allocatable or pointer components. */
}
ptrdiff_t offset;
/* The offset (in bytes) to the caf_token associated with this
component. NULL, when not allocatable/pointer ref. */
ptrdiff_t caf_token_offset;
} c;

struct {
  /* The mode of the array ref. See CAF_ARR_REF_. */
  /* caf_array_ref_t, replaced by unsigned char to allow specification in
   * fortran FE. */
  unsigned char mode[GFC_MAX_DIMENSIONS];
  /* The type of a static array. Unset for array's with descriptors. */
  int static_array_type;
  /* Subscript refs (s) or vector refs (v). */
  union {
    struct {
      /* The start and end boundary of the ref and the stride. */
      index_type start, end, stride;
    } s;
    struct {
      /* nvec entries of kind giving the elements to reference. */
      void *vector;
      /* The number of entries in vector. */
      size_t nvec;
      /* The integer kind used for the elements in vector. */
      int kind;
    } v;
  } dim[GFC_MAX_DIMENSIONS];
} a;
} u;
} caf_reference_t;

The references make up a single linked list of reference operations. The NEXT member
links to the next reference or NULL to indicate the end of the chain. Component and array
refs can be arbitrarily mixed as long as they comply to the Fortran standard.

NOTES The member STATIC_ARRAY_TYPE is used only when the TYPE is CAF_REF_-
STATIC_ARRAY. The member gives the type of the data referenced. Because no array
descriptor is available for a descriptor-less array and type conversion still needs to take
place the type is transported here.

At the moment CAF_ARR_REF_VECTOR is not implemented in the front end for descriptor-
less arrays. The library caf_single has untested support for it.

8.1.5 caf_team_t
Opaque pointer to represent a team-handle. This type is a stand-in for the future imple-
mentation of teams. It is about to change without further notice.

8.2 Function ABI Documentation
8.2.1 _gfortran_caf_init — Initialization function

Description:
This function is called at startup of the program before the Fortran main program, if the latter has been compiled with ‘-fcoarray=lib’. It takes as arguments the command-line arguments of the program. It is permitted to pass two NULL pointers as argument; if non-NUL, the library is permitted to modify the arguments.

Syntax:  void _gfortran_caf_init (int *argc, char ***argv)

Arguments:

argc    intent(inout) An integer pointer with the number of arguments passed to the program or NULL.
argv    intent(inout) A pointer to an array of strings with the command-line arguments or NULL.

NOTES  The function is modelled after the initialization function of the Message Passing Interface (MPI) specification. Due to the way coarray registration works, it might not be the first call to the library. If the main program is not written in Fortran and only a library uses coarrays, it can happen that this function is never called. Therefore, it is recommended that the library does not rely on the passed arguments and whether the call has been done.

8.2.2 _gfortran_caf_finish — Finalization function

Description:
This function is called at the end of the Fortran main program, if it has been compiled with the ‘-fcoarray=lib’ option.

Syntax:  void _gfortran_caf_finish (void)

NOTES  For non-Fortran programs, it is recommended to call the function at the end of the main program. To ensure that the shutdown is also performed for programs where this function is not explicitly invoked, for instance non-Fortran programs or calls to the system’s exit() function, the library can use a destructor function. Note that programs can also be terminated using the STOP and ERROR STOP statements; those use different library calls.

8.2.3 _gfortran_caf_this_image — Querying the image number

Description:
This function returns the current image number, which is a positive number.

Syntax:  int _gfortran_caf_this_image (int distance)

Arguments:

distance  As specified for the this_image intrinsic in TS18508. Shall be a non-negative number.

NOTES  If the Fortran intrinsic this_image is invoked without an argument, which is the only permitted form in Fortran 2008, GCC passes 0 as first argument.
8.2.4 _gfortran_caf_num_images — Querying the maximal number of images

Description:
This function returns the number of images in the current team, if distance is 0 or the number of images in the parent team at the specified distance. If failed is -1, the function returns the number of all images at the specified distance; if it is 0, the function returns the number of nonfailed images, and if it is 1, it returns the number of failed images.

Syntax: int _gfortran_caf_num_images(int distance, int failed)

Arguments:
- distance: the distance from this image to the ancestor. Shall be positive.
- failed: shall be -1, 0, or 1

NOTES: This function follows TS18508. If the num_image intrinsic has no arguments, then the compiler passes distance=0 and failed=-1 to the function.

8.2.5 _gfortran_caf_image_status — Query the status of an image

Description:
Get the status of the image given by the id image of the team given by team. Valid results are zero, for image is ok, STAT_STOPPED_IMAGE from the ISO_FORTRAN_ENV module to indicate that the image has been stopped and STAT_FAILED_IMAGE also from ISO_FORTRAN_ENV to indicate that the image has executed a FAIL IMAGE statement.

Syntax: int _gfortran_caf_image_status (int image, caf_team_t * team)

Arguments:
- image: the positive scalar id of the image in the current TEAM.
- team: optional; team on the which the inquiry is to be performed.

NOTES: This function follows TS18508. Because team-functionality is not yet implemented a null-pointer is passed for the team argument at the moment.

8.2.6 _gfortran_caf_failed_images — Get an array of the indexes of the failed images

Description:
Get an array of image indexes in the current team that have failed. The array is sorted ascendingly. When team is not provided the current team is to be used. When kind is provided then the resulting array is of that integer kind else it is of default integer kind. The returns an unallocated size zero array when no images have failed.

Syntax: int _gfortran_caf_failed_images (caf_team_t * team, int * kind)

Arguments:
- team: optional; team on the which the inquiry is to be performed.
- image: optional; the kind of the resulting integer array.

NOTES: This function follows TS18508. Because team-functionality is not yet implemented a null-pointer is passed for the team argument at the moment.
8.2.7 _gfortran_caf_stopped_images — Get an array of the indexes of the stopped images

Description:
Get an array of image indexes in the current team that have stopped. The array is sorted ascendingly. When team is not provided the current team is to be used. When kind is provided then the resulting array is of that integer kind else it is of default integer kind. The returns an unallocated size zero array when no images have failed.

Syntax: int _gfortran_caf_stopped_images (caf_team_t * team, int * kind)

Arguments:
- team: optional; team on the which the inquiry is to be performed.
- image: optional; the kind of the resulting integer array.

NOTES This function follows TS18508. Because team-functionality is not yet implemented a null-pointer is passed for the team argument at the moment.

8.2.8 _gfortran_caf_register — Registering coarrays

Description:
Registers memory for a coarray and creates a token to identify the coarray. The routine is called for both coarrays with SAVE attribute and using an explicit ALLOCATE statement. If an error occurs and STAT is a NULL pointer, the function shall abort with printing an error message and starting the error termination. If no error occurs and STAT is present, it shall be set to zero. Otherwise, it shall be set to a positive value and, if not-NULL, ERRMSG shall be set to a string describing the failure. The routine shall register the memory provided in the DATA-component of the array descriptor DESC, when that component is non-NULL, else it shall allocate sufficient memory and provide a pointer to it in the DATA-component of DESC. The array descriptor has rank zero, when a scalar object is to be registered and the array descriptor may be invalid after the call to _gfortran_caf_register. When an array is to be allocated the descriptor persists.

For CAF_REGTYPE_COARRAY_STATIC and CAF_REGTYPE_COARRAY_ALLOC, the passed size is the byte size requested. For CAF_REGTYPE_LOCK_STATIC, CAF_REGTYPE_LOCK_ALLOC and CAF_REGTYPE_CRITICAL it is the array size or one for a scalar.

When CAF_REGTYPE_COARRAY_ALLOC_REGISTER_ONLY is used, then only a token for an allocatable or pointer component is created. The SIZE parameter is not used then. On the contrary when CAF_REGTYPE_COARRAY_ALLOCALLOCATE_ONLY is specified, then the token needs to be registered by a previous call with regtype CAF_REGTYPE_COARRAY_ALLOC_REGISTER_ONLY and either the memory specified in the desc’s data-ptr is registered or allocate when the data-ptr is NULL.

Syntax: void caf_register (size_t size, caf_register_t type, caf_token_t *token, gfc_descriptor_t *desc, int *stat, char *errmsg, int errmsg_len)
**Arguments:**

- **size**: For normal coarrays, the byte size of the coarray to be allocated; for lock types and event types, the number of elements.
- **type**: one of the caf_register_t types.
- **token**: intent(out) An opaque pointer identifying the coarray.
- **desc**: intent(inout) The (pseudo) array descriptor.
- **stat**: intent(out) For allocatable coarrays, stores the STAT=; may be NULL
- **errmsg**: intent(out) When an error occurs, this will be set to an error message; may be NULL
- **errmsg_len**: the buffer size of errmsg.

**NOTES**
Nonallocatable coarrays have to be registered prior use from remote images. In order to guarantee this, they have to be registered before the main program. This can be achieved by creating constructor functions. That is what GCC does such that also nonallocatable coarrays the memory is allocated and no static memory is used. The token permits to identify the coarray; to the processor, the token is a nonaliasing pointer. The library can, for instance, store the base address of the coarray in the token, some handle or a more complicated struct. The library may also store the array descriptor DESC when its rank is non-zero.

For lock types, the value shall only used for checking the allocation status. Note that for critical blocks, the locking is only required on one image; in the locking statement, the processor shall always pass an image index of one for critical-block lock variables (CAF_REGTYPE_CRITICAL). For lock types and critical-block variables, the initial value shall be unlocked (or, respectively, not in critical section) such as the value false; for event types, the initial state should be no event, e.g. zero.

### 8.2.9 _gfortran_caf_deregister — Deregistering coarrays

**Description:**
Called to free or deregister the memory of a coarray; the processor calls this function for automatic and explicit deallocation. In case of an error, this function shall fail with an error message, unless the STAT variable is not null. The library is only expected to free memory it allocated itself during a call to _gfortran_caf_register.

**Syntax:**
```c
void caf_deregister (caf_token_t *token, caf_deregister_t type, int *stat, char *errmsg, int errmsg_len)
```

**Arguments:**

- **token**: the token to free.
- **type**: the type of action to take for the coarray. A CAF_DEREGTYPE_COARRAY DEALLOCATE ONLY is allowed only for allocatable or pointer components of derived type coarrays. The action only deallocates the local memory without deleting the token.
- **stat**: intent(out) Stores the STAT=; may be NULL
- **errmsg**: intent(out) When an error occurs, this will be set to an error message; may be NULL
errmsg_len  the buffer size of errmsg.

NOTES  For nonalloatable coarrays this function is never called. If a cleanup is required, it has to be handled via the finish, stop and error stop functions, and via destructors.

8.2.10 _gfortran_caf_is_present — Query whether an allocatable or pointer component in a derived type coarray is allocated

Description:  
Used to query the coarray library whether an allocatable component in a derived type coarray is allocated on a remote image.

Syntax:  
void _gfortran_caf_is_present (caf_token_t token, int image_index, gfc_reference_t *ref)

Arguments:  
token  An opaque pointer identifying the coarray.
image_index  The ID of the remote image; must be a positive number.
ref  A chain of references to address the allocatable or pointer component in the derived type coarray. The object reference needs to be a scalar or a full array reference, respectively.

8.2.11 _gfortran_caf_send — Sending data from a local image to a remote image

Description:  
Called to send a scalar, an array section or a whole array from a local to a remote image identified by the image_index.

Syntax:  
void _gfortran_caf_send (caf_token_t token, size_t offset, int image_index, gfc_descriptor_t *dest, caf_vector_t *dst_vector, gfc_descriptor_t *src, int dst_kind, int src_kind, bool may_require_tmp, int *stat)

Arguments:  
token  intent(in) An opaque pointer identifying the coarray.
offset  intent(in) By which amount of bytes the actual data is shifted compared to the base address of the coarray.
image_index  intent(in) The ID of the remote image; must be a positive number.
dest  intent(in) Array descriptor for the remote image for the bounds and the size. The base_addr shall not be accessed.
dst_vector  intent(in) If not NULL, it contains the vector subscript of the destination array; the values are relative to the dimension triplet of the dest argument.
src  intent(in) Array descriptor of the local array to be transferred to the remote image
dst_kind  intent(in) Kind of the destination argument
src_kind  intent(in) Kind of the source argument
may_require_tmp \text{intent(in)} \text{The variable is false when it is known at compile time that the dest and src either cannot overlap or overlap (fully or partially) such that walking src and dest in element wise element order (honoring the stride value) will not lead to wrong results. Otherwise, the value is true.}

stat \text{intent(out)} \text{when non-NULL give the result of the operation, i.e., zero on success and non-zero on error. When NULL and an error occurs, then an error message is printed and the program is terminated.}

NOTES \text{It is permitted to have image_index equal the current image; the memory of the send-to and the send-from might (partially) overlap in that case. The implementation has to take care that it handles this case, e.g. using memmove which handles (partially) overlapping memory. If mayRequireTmp is true, the library might additionally create a temporary variable, unless additional checks show that this is not required (e.g. because walking backward is possible or because both arrays are contiguous and memmove takes care of overlap issues).}

Note that the assignment of a scalar to an array is permitted. In addition, the library has to handle numeric-type conversion and for strings, padding and different character kinds.

8.2.12 \_gfortran\_caf\_get — Getting data from a remote image

Description:
Called to get an array section or a whole array from a remote, image identified by the image_index.

Syntax:
```c
void \_gfortran\_caf\_get (caf_token_t token, size_t offset, int image_index, gfc_descriptor_t *src, caf_vector_t *src_vector, gfc_descriptor_t *dest, int src_kind, int dst_kind, bool may_require_tmp, int *stat)
```

Arguments:

\text{token} \text{intent(in)} \text{An opaque pointer identifying the coarray.}

\text{offset} \text{intent(in)} \text{By which amount of bytes the actual data is shifted compared to the base address of the coarray.}

\text{image_index} \text{intent(in)} \text{The ID of the remote image; must be a positive number.}

\text{dest} \text{intent(out)} \text{Array descriptor of the local array to store the data retrieved from the remote image}

\text{src} \text{intent(in)} \text{Array descriptor for the remote image for the bounds and the size. The base_addr shall not be accessed.}

\text{src_vector} \text{intent(in)} \text{If not NULL, it contains the vector subscript of the source array; the values are relative to the dimension triplet of the src argument.}

\text{dst_kind} \text{intent(in)} \text{Kind of the destination argument}

\text{src_kind} \text{intent(in)} \text{Kind of the source argument}
may_require_tmp intent(in) The variable is false when it is known at compile
time that the dest and src either cannot overlap or overlap
(fully or partially) such that walking src and dest in element
wise element order (honoring the stride value) will not lead
to wrong results. Otherwise, the value is true.

stat intent(out) When non-NULL give the result of the operation,
i.e., zero on success and non-zero on error. When NULL and
an error occurs, then an error message is printed and the
program is terminated.

NOTES It is permitted to have image_index equal the current image; the memory of
the send-to and the send-from might (partially) overlap in that case. The
implementation has to take care that it handles this case, e.g. using memmove
which handles (partially) overlapping memory. If may_require_tmp is true, the
library might additionally create a temporary variable, unless additional checks
show that this is not required (e.g. because walking backward is possible or
because both arrays are contiguous and memmove takes care of overlap issues).

Note that the library has to handle numeric-type conversion and for strings,
padding and different character kinds.

8.2.13 _gfortran_caf_sendget — Sending data between remote
images

Description:
Called to send a scalar, an array section or a whole array from a remote
image identified by the src_image_index to a remote image identified by the
dst_image_index.

Syntax:
void _gfortran_caf_sendget (caf_token_t dst_token, size_t dst_
offset, int dst_image_index, gfc_descriptor_t *dest, caf_vector_t
*dst_vector, caf_token_t src_token, size_t src_offset, int src_
image_index, gfc_descriptor_t *src, caf_vector_t *src_vector, int
dst_kind, int src_kind, bool may_require_tmp, int *stat)

Arguments:
dst_token intent(in) An opaque pointer identifying the destination
coarray.
dst_offset intent(in) By which amount of bytes the actual data is shifted
compared to the base address of the destination coarray.
dst_image_index intent(in) The ID of the destination remote image; must be a
positive number.
dest intent(in) Array descriptor for the destination remote image
for the bounds and the size. The base_addr shall not be
accessed.
dst_vector intent(int) If not NULL, it contains the vector subscript of
the destination array; the values are relative to the dimension
triplet of the dest argument.
src_token intent(in) An opaque pointer identifying the source coarray.
**src_offset**  intent(in) By which amount of bytes the actual data is shifted compared to the base address of the source coarray.

**src_image_index**  intent(in) The ID of the source remote image; must be a positive number.

**src**  intent(in) Array descriptor of the local array to be transferred to the remote image.

**src_vector**  intent(in) Array descriptor of the local array to be transferred to the remote image

**dst_kind**  intent(in) Kind of the destination argument

**src_kind**  intent(in) Kind of the source argument

**may_require_tmp**  intent(in) The variable is false when it is known at compile time that the dest and src either cannot overlap or overlap (fully or partially) such that walking src and dest in element wise element order (honoring the stride value) will not lead to wrong results. Otherwise, the value is true.

**stat**  intent(out) when non-NULL give the result of the operation, i.e., zero on success and non-zero on error. When NULL and an error occurs, then an error message is printed and the program is terminated.

**NOTES**  It is permitted to have the same image index for both src_image_index and dst_image_index; the memory of the send-to and the send-from might (partially) overlap in that case. The implementation has to take care that it handles this case, e.g. using memmove which handles (partially) overlapping memory. If may_require_tmp is true, the library might additionally create a temporary variable, unless additional checks show that this is not required (e.g. because walking backward is possible or because both arrays are contiguous and memmove takes care of overlap issues).

Note that the assignment of a scalar to an array is permitted. In addition, the library has to handle numeric-type conversion and for strings, padding and different character kinds.

### 8.2.14 _gfortran_caf_send_by_ref — Sending data from a local image to a remote image with enhanced referencing options

**Description:**

Called to send a scalar, an array section or a whole array from a local to a remote image identified by the image_index.

**Syntax:**

```c
void _gfortran_caf_send_by_ref (caf_token_t token, int image_index,
gfc_descriptor_t *src, caf_reference_t *refs, int dst_kind, int
src_kind, bool may_require_tmp, bool dst_reallocatable, int *stat)
```

**Arguments:**

**token**  intent(in) An opaque pointer identifying the coarray.

**image_index**  intent(in) The ID of the remote image; must be a positive number.

**src**  intent(in) Array descriptor of the local array to be transferred to the remote image
The GNU Fortran Compiler

### refs

`intent(in)` The references on the remote array to store the data given by `src`. Guaranteed to have at least one entry.

### dst_kind

`intent(in)` Kind of the destination argument

### src_kind

`intent(in)` Kind of the source argument

### may_require_tmp

`intent(in)` The variable is `false` when it is known at compile time that the `dest` and `src` either cannot overlap or overlap (fully or partially) such that walking `src` and `dest` in element wise element order (honoring the stride value) will not lead to wrong results. Otherwise, the value is `true`.

### dst_reallocatable

`intent(in)` Set when the destination is of allocatable or pointer type and the `refs` will allow reallocation, i.e., the ref is a full array or component ref.

### stat

`intent(out)` When non-`NULL` give the result of the operation, i.e., zero on success and non-zero on error. When `NULL` and an error occurs, then an error message is printed and the program is terminated.

### NOTES

It is permitted to have `image_index` equal the current image; the memory of the send-to and the send-from might (partially) overlap in that case. The implementation has to take care that it handles this case, e.g. using `memmove` which handles (partially) overlapping memory. If `may_require_tmp` is true, the library might additionally create a temporary variable, unless additional checks show that this is not required (e.g. because walking backward is possible or because both arrays are contiguous and `memmove` takes care of overlap issues).

Note that the assignment of a scalar to an array is permitted. In addition, the library has to handle numeric-type conversion and for strings, padding and different character kinds.

Because of the more complicated references possible some operations may be unsupported by certain libraries. The library is expected to issue a precise error message why the operation is not permitted.

## 8.2.15 `_gfortran_caf_get_by_ref` — Getting data from a remote image using enhanced references

### Description:

Called to get a scalar, an array section or a whole array from a remote image identified by the `image_index`.

### Syntax:

```c
void _gfortran_caf_get_by_ref (caf_token_t token, int image_index, caf_reference_t *refs, gfc_descriptor_t *dst, int dst_kind, int src_kind, bool may_require_tmp, bool dst_reallocatable, int *stat)
```

### Arguments:

- **token**
  `intent(in)` An opaque pointer identifying the coarray.

- **image_index**
  `intent(in)` The ID of the remote image; must be a positive number.

- **refs**
  `intent(in)` The references to apply to the remote structure to get the data.
Chapter 8: Coarray Programming

8.2.16 _gfortran_caf_sendget_by_ref — Sending data between remote images using enhanced references on both sides

Description:
Called to send a scalar, an array section or a whole array from a remote image identified by the src_image_index to a remote image identified by the dst_image_index.

Syntax:
```c
void _gfortran_caf_sendget_by_ref (caf_token_t dst_token, int dst_image_index, caf_reference_t *dst_refs, caf_token_t src_token, int src_image_index, caf_reference_t *src_refs, int dst_kind, int src_kind, bool may_require_tmp, int *dst_stat, int *src_stat)
```

Arguments:
- `dst_token` intent(in) An opaque pointer identifying the destination coarray.
- `dst_image_index` intent(in) The ID of the destination remote image; must be a positive number.
dst_refs intent(in) The references on the remote array to store the data given by the source. Guaranteed to have at least one entry.

src_token intent(in) An opaque pointer identifying the source coarray.

src_image_index intent(in) The ID of the source remote image; must be a positive number.

src_refs intent(in) The references to apply to the remote structure to get the data.

dst_kind intent(in) Kind of the destination argument

src_kind intent(in) Kind of the source argument

may_require_tmp intent(in) The variable is false when it is known at compile time that the dest and src either cannot overlap or overlap (fully or partially) such that walking src and dest in elementwise element order (honoring the stride value) will not lead to wrong results. Otherwise, the value is true.

dst_stat intent(out) when non-NULL give the result of the send-operation, i.e., zero on success and non-zero on error. When NULL and an error occurs, then an error message is printed and the program is terminated.

src_stat intent(out) When non-NULL give the result of the get-operation, i.e., zero on success and non-zero on error. When NULL and an error occurs, then an error message is printed and the program is terminated.

NOTES It is permitted to have the same image index for both src_image_index and dst_image_index; the memory of the send-to and the send-from might (partially) overlap in that case. The implementation has to take care that it handles this case, e.g. using memmove which handles (partially) overlapping memory. If may_require_tmp is true, the library might additionally create a temporary variable, unless additional checks show that this is not required (e.g. because walking backward is possible or because both arrays are contiguous and memmove takes care of overlap issues).

Note that the assignment of a scalar to an array is permitted. In addition, the library has to handle numeric-type conversion and for strings, padding and different character kinds.

Because of the more complicated references possible some operations may be unsupported by certain libraries. The library is expected to issue a precise error message why the operation is not permitted.

8.2.17 _gfortran_caf_lock — Locking a lock variable

Description:

Acquire a lock on the given image on a scalar locking variable or for the given array element for an array-valued variable. If the acquired_lock is NULL, the function returns after having obtained the lock. If it is non-NULL, then acquired_lock is assigned the value true (one) when the lock could be obtained and false (zero) otherwise. Locking a lock variable which has already been locked by the same image is an error.
Syntax:
void _gfortran_caf_lock (caf_token_t token, size_t index, int image_index, int *aquired_lock, int *stat, char *errmsg, int errmsg_len)

Arguments:
- **token** intent(in) An opaque pointer identifying the coarray.
- **index** intent(in) Array index; first array index is 0. For scalars, it is always 0.
- **image_index** intent(in) The ID of the remote image; must be a positive number.
- **aquired_lock** intent(out) If not NULL, it returns whether lock could be obtained.
- **stat** intent(out) Stores the STAT=; may be NULL.
- **errmsg** intent(out) When an error occurs, this will be set to an error message; may be NULL.
- **errmsg_len** intent(in) the buffer size of errmsg

NOTES This function is also called for critical blocks; for those, the array index is always zero and the image index is one. Libraries are permitted to use other images for critical-block locking variables.

8.2.18 _gfortran_caf_lock — Unlocking a lock variable

Description:
Release a lock on the given image on a scalar locking variable or for the given array element for an array-valued variable. Unlocking a lock variable which is unlocked or has been locked by a different image is an error.

Syntax:
void _gfortran_caf_unlock (caf_token_t token, size_t index, int image_index, int *stat, char *errmsg, int errmsg_len)

Arguments:
- **token** intent(in) An opaque pointer identifying the coarray.
- **index** intent(in) Array index; first array index is 0. For scalars, it is always 0.
- **image_index** intent(in) The ID of the remote image; must be a positive number.
- **stat** intent(out) For allocatable coarrays, stores the STAT=; may be NULL.
- **errmsg** intent(out) When an error occurs, this will be set to an error message; may be NULL.
- **errmsg_len** intent(in) the buffer size of errmsg

NOTES This function is also called for critical block; for those, the array index is always zero and the image index is one. Libraries are permitted to use other images for critical-block locking variables.

8.2.19 _gfortran_caf_event_post — Post an event

Description:
Increment the event count of the specified event variable.
The GNU Fortran Compiler

Syntax:    
\[
\text{void } \_\text{gfortran}_\text{caf}_\text{event}_\text{post} \left( \text{caf}_\text{token}_\text{t} \text{ token}, \text{size}_\text{t} \text{ index}, \text{int image}_\text{index}, \text{int }*\text{stat}, \text{char }*\text{errmsg}, \text{int errmsg}_\text{len} \right)
\]

Arguments: 
- \text{token} \quad \text{intent(in)} \quad \text{An opaque pointer identifying the coarray.}
- \text{index} \quad \text{intent(in)} \quad \text{Array index; first array index is 0. For scalars, it is always 0.}
- \text{image}_\text{index} \quad \text{intent(in)} \quad \text{The ID of the remote image; must be a positive number; zero indicates the current image, when accessed noncoindexed.}
- \text{stat} \quad \text{intent(out)} \quad \text{Stores the } \text{STAT}=; \text{ may be NULL.}
- \text{errmsg} \quad \text{intent(out)} \quad \text{When an error occurs, this will be set to an error message; may be NULL.}
- \text{errmsg}_\text{len} \quad \text{intent(in)} \quad \text{the buffer size of errmsg}

NOTES  
This acts like an atomic add of one to the remote image’s event variable. The statement is an image-control statement but does not imply sync memory. Still, all preceeding push communications of this image to the specified remote image have to be completed before \text{event}_\text{wait} on the remote image returns.

8.2.20 \_\text{gfortran}_\text{caf}_\text{event}_\text{wait} — Wait that an event occurred

Description:  
Wait until the event count has reached at least the specified \text{until}_\text{count}; if so, atomically decrement the event variable by this amount and return.

Syntax:    
\[
\text{void } \_\text{gfortran}_\text{caf}_\text{event}_\text{wait} \left( \text{caf}_\text{token}_\text{t} \text{ token}, \text{size}_\text{t} \text{ index, int until}_\text{count}, \text{int }*\text{stat}, \text{char }*\text{errmsg, int errmsg}_\text{len} \right)
\]

Arguments: 
- \text{token} \quad \text{intent(in)} \quad \text{An opaque pointer identifying the coarray.}
- \text{index} \quad \text{intent(in)} \quad \text{Array index; first array index is 0. For scalars, it is always 0.}
- \text{until}_\text{count} \quad \text{intent(in)} \quad \text{The number of events which have to be available before the function returns.}
- \text{stat} \quad \text{intent(out)} \quad \text{Stores the } \text{STAT}=; \text{ may be NULL.}
- \text{errmsg} \quad \text{intent(out)} \quad \text{When an error occurs, this will be set to an error message; may be NULL.}
- \text{errmsg}_\text{len} \quad \text{intent(in)} \quad \text{the buffer size of errmsg}

NOTES  
This function only operates on a local coarray. It acts like a loop checking atomically the value of the event variable, breaking if the value is greater or equal the requested number of counts. Before the function returns, the event variable has to be decremented by the requested \text{until}_\text{count} value. A possible implementation would be a busy loop for a certain number of spins (possibly depending on the number of threads relative to the number of available cores) followed by another waiting strategy such as a sleeping wait (possibly with an increasing number of sleep time) or, if possible, a futex wait.
The statement is an image-control statement but does not imply sync memory. Still, all preceding push communications of this image to the specified remote image have to be completed before \texttt{event\_wait} on the remote image returns.

8.2.21 \texttt{gfortran\_caf\_event\_query} — Query event count

\textbf{Description:}
Return the event count of the specified event variable.

\textbf{Syntax:}
\begin{verbatim}
void \texttt{gfortran\_caf\_event\_query} (caf\_token\_t token, size\_t index, int image\_index, int *count, int *stat)
\end{verbatim}

\textbf{Arguments:}
\begin{itemize}
  \item \texttt{token} intent(in) An opaque pointer identifying the coarray.
  \item \texttt{index} intent(in) Array index; first array index is 0. For scalars, it is always 0.
  \item \texttt{image\_index} intent(in) The ID of the remote image; must be a positive number; zero indicates the current image when accessed noncoindexed.
  \item \texttt{count} intent(out) The number of events currently posted to the event variable.
  \item \texttt{stat} intent(out) Stores the STAT=; may be NULL.
\end{itemize}

\textbf{Notes:}
The typical use is to check the local event variable to only call \texttt{event\_wait} when the data is available. However, a coindexed variable is permitted; there is no ordering or synchronization implied. It acts like an atomic fetch of the value of the event variable.

8.2.22 \texttt{gfortran\_caf\_sync\_all} — All-image barrier

\textbf{Description:}
Synchronization of all images in the current team; the program only continues on a given image after this function has been called on all images of the current team. Additionally, it ensures that all pending data transfers of previous segment have completed.

\textbf{Syntax:}
\begin{verbatim}
void \texttt{gfortran\_caf\_sync\_all} (int *stat, char *errmsg, int errmsg\_len)
\end{verbatim}

\textbf{Arguments:}
\begin{itemize}
  \item \texttt{stat} intent(out) Stores the status STAT= and may be NULL.
  \item \texttt{errmsg} intent(out) When an error occurs, this will be set to an error message; may be NULL.
  \item \texttt{errmsg\_len} intent(in) the buffer size of \texttt{errmsg}
\end{itemize}

8.2.23 \texttt{gfortran\_caf\_sync\_images} — Barrier for selected images

\textbf{Description:}
Synchronization between the specified images; the program only continues on a given image after this function has been called on all images specified for that image. Note that one image can wait for all other images in the current
team (e.g. via sync images(*)) while those only wait for that specific image. Additionally, sync images ensures that all pending data transfers of previous segments have completed.

**Syntax:**

```
void _gfortran_caf_sync_images (int count, int images[], int *stat, char *errmsg, int errmsg_len)
```

**Arguments:**

- `count` intent(in) The number of images which are provided in the next argument. For a zero-sized array, the value is zero. For sync images (*), the value is \(-1\).
- `images` intent(in) An array with the images provided by the user. If `count` is zero, a NULL pointer is passed.
- `stat` intent(out) Stores the status STAT= and may be NULL.
- `errmsg` intent(out) When an error occurs, this will be set to an error message; may be NULL.
- `errmsg_len` intent(in) the buffer size of errmsg

### 8.2.24 _gfortran_caf_sync_memory — Wait for completion of segment-memory operations

**Description:**

Acts as optimization barrier between different segments. It also ensures that all pending memory operations of this image have been completed.

**Syntax:**

```
void _gfortran_caf_sync_memory (int *stat, char *errmsg, int errmsg_len)
```

**Arguments:**

- `stat` intent(out) Stores the status STAT= and may be NULL.
- `errmsg` intent(out) When an error occurs, this will be set to an error message; may be NULL.
- `errmsg_len` intent(in) the buffer size of errmsg

**NOTE** A simple implementation could be

```
__asm__ __volatile__ (":::"memory"")
```

to prevent code movements.

### 8.2.25 _gfortran_caf_error_stop — Error termination with exit code

**Description:**

Invoked for an ERROR STOP statement which has an integer argument. The function should terminate the program with the specified exit code.

**Syntax:**

```
void _gfortran_caf_error_stop (int32_t error)
```

**Arguments:**

- `error` intent(in) The exit status to be used.
8.2.26 _gfortran_caf_error_stop_str — Error termination with string

*Description:* Invoked for an ERROR STOP statement which has a string as argument. The function should terminate the program with a nonzero-exit code.

*Syntax:* `void _gfortran_caf_error_stop (const char *string, int32_t len)`

*Arguments:*
- `string` intent(in) the error message (not zero terminated)
- `len` intent(in) the length of the string

8.2.27 _gfortran_caf_fail_image — Mark the image failed and end its execution

*Description:* Invoked for an FAIL IMAGE statement. The function should terminate the current image.

*Syntax:* `void _gfortran_caf_fail_image ()`

*NOTES* This function follows TS18508.

8.2.28 _gfortran_caf_atomic_define — Atomic variable assignment

*Description:* Assign atomically a value to an integer or logical variable.

*Syntax:* `void _gfortran_caf_atomic_define (caf_token_t token, size_t offset, int image_index, void *value, int *stat, int type, int kind)`

*Arguments:*
- `token` intent(in) An opaque pointer identifying the coarray.
- `offset` intent(in) By which amount of bytes the actual data is shifted compared to the base address of the coarray.
- `image_index` intent(in) The ID of the remote image; must be a positive number; zero indicates the current image when used noncoindexed.
- `value` intent(in) the value to be assigned, passed by reference
- `stat` intent(out) Stores the status STAT= and may be NULL.
- `type` intent(in) The data type, i.e. BT_INTEGER (1) or BT_LOGICAL (2).
- `kind` intent(in) The kind value (only 4; always int)

8.2.29 _gfortran_caf_atomic_ref — Atomic variable reference

*Description:* Reference atomically a value of a kind-4 integer or logical variable.

*Syntax:* `void _gfortran_caf_atomic_ref (caf_token_t token, size_t offset, int image_index, void *value, int *stat, int type, int kind)`

*Arguments:*
- `token` intent(in) An opaque pointer identifying the coarray.
offset intent(in) By which amount of bytes the actual data is shifted compared to the base address of the coarray.

image_index intent(in) The ID of the remote image; must be a positive number; zero indicates the current image when used noncoindexed.

description intent(out) The variable assigned the atomically referenced variable.

stat intent(out) Stores the status STAT= and may be NULL.

type intent(in) the data type, i.e. BT_INTEGER (1) or BT_LOGICAL (2).

kind intent(in) The kind value (only 4; always int)

8.2.30 _gfortran_caf_atomic_cas — Atomic compare and swap

Description:

Atomic compare and swap of a kind-4 integer or logical variable. Assigns atomically the specified value to the atomic variable, if the latter has the value specified by the passed condition value.

Syntax:

void _gfortran_caf_atomic_cas (caf_token_t token, size_t offset, int image_index, void *old, void *compare, void *new_val, int *stat, int type, int kind)

Arguments:

token intent(in) An opaque pointer identifying the coarray.

offset intent(in) By which amount of bytes the actual data is shifted compared to the base address of the coarray.

image_index intent(in) The ID of the remote image; must be a positive number; zero indicates the current image when used noncoindexed.

old intent(out) The value which the atomic variable had just before the cas operation.

compare intent(in) The value used for comparision.

new_val intent(in) The new value for the atomic variable, assigned to the atomic variable, if compare equals the value of the atomic variable.

stat intent(out) Stores the status STAT= and may be NULL.

type intent(in) the data type, i.e. BT_INTEGER (1) or BT_LOGICAL (2).

kind intent(in) The kind value (only 4; always int)

8.2.31 _gfortran_caf_atomic_op — Atomic operation

Description:

Apply an operation atomically to an atomic integer or logical variable. After the operation, old contains the value just before the operation, which, respectively, adds (GFC_CAF_ATOMIC_ADD) atomically the value to the atomic integer variable or does a bitwise AND, OR or exclusive OR between the atomic variable and value; the result is then stored in the atomic variable.
8.2.32 _gfortran_caf_co_broadcast — Sending data to all images

**Description:**
Distribute a value from a given image to all other images in the team. Has to be called collectively.

**Syntax:**
```c
void _gfortran_caf_co_broadcast (gfc_descriptor_t *a, int source_image, int *stat, char *errmsg, int errmsg_len)
```

**Arguments:**
- `a` intent(inout) An array descriptor with the data to be broadcasted (on `source_image`) or to be received (other images).
- `source_image` intent(in) The ID of the image from which the data should be broadcasted.
- `stat` intent(out) Stores the status STAT= and may be NULL.
- `errmsg` intent(out) When an error occurs, this will be set to an error message; may be NULL.
- `errmsg_len` intent(in) the buffer size of errmsg.

8.2.33 _gfortran_caf_co_max — Collective maximum reduction

**Description:**
Calculates for each array element of the variable `a` the maximum value for that element in the current team; if `result_image` has the value 0, the result shall be stored on all images, otherwise, only on the specified image. This function operates on numeric values and character strings.
Syntax:  
void _gfortran_caf_co_max (gfc_descriptor_t *a, int result_image, int *stat, char *errmsg, int a_len, int errmsg_len)

Arguments:

a  intent(inout) An array descriptor for the data to be processed. On the destination image(s) the result overwrites the old content.

result_image  intent(in) The ID of the image to which the reduced value should be copied to; if zero, it has to be copied to all images.

stat  intent(out) Stores the status STAT= and may be NULL.

errmsg  intent(out) When an error occurs, this will be set to an error message; may be NULL.

a_len  intent(in) the string length of argument a

errmsg_len  intent(in) the buffer size of errmsg

NOTES  If result_image is nonzero, the data in the array descriptor a on all images except of the specified one become undefined; hence, the library may make use of this.

8.2.34 _gfortran_caf_co_min — Collective minimum reduction

Description:
Calculates for each array element of the variable a the minimum value for that element in the current team; if result_image has the value 0, the result shall be stored on all images, otherwise, only on the specified image. This function operates on numeric values and character strings.

Syntax:  
void _gfortran_caf_co_min (gfc_descriptor_t *a, int result_image, int *stat, char *errmsg, int a_len, int errmsg_len)

Arguments:

a  intent(inout) An array descriptor for the data to be processed. On the destination image(s) the result overwrites the old content.

result_image  intent(in) The ID of the image to which the reduced value should be copied to; if zero, it has to be copied to all images.

stat  intent(out) Stores the status STAT= and may be NULL.

errmsg  intent(out) When an error occurs, this will be set to an error message; may be NULL.

a_len  intent(in) the string length of argument a

errmsg_len  intent(in) the buffer size of errmsg

NOTES  If result_image is nonzero, the data in the array descriptor a on all images except of the specified one become undefined; hence, the library may make use of this.

8.2.35 _gfortran_caf_co_sum — Collective summing reduction

Description:
Calculates for each array element of the variable a the sum of all values for that element in the current team; if result_image has the value 0, the result shall
be stored on all images, otherwise, only on the specified image. This function operates on numeric values only.

**Syntax:**
```c
void _gfortran_caf_co_sum (gfc_descriptor_t *a, int result_image, int *stat, char *errmsg, int errmsg_len)
```

**Arguments:**
- `a` intent(inout) An array descriptor with the data to be processed. On the destination image(s) the result overwrites the old content.
- `result_image` intent(in) The ID of the image to which the reduced value should be copied to; if zero, it has to be copied to all images.
- `stat` intent(out) Stores the status STAT= and may be NULL.
- `errmsg` intent(out) When an error occurs, this will be set to an error message; may be NULL.
- `errmsg_len` intent(in) the buffer size of errmsg

**NOTES** If `result_image` is nonzero, the data in the array descriptor `a` on all images except of the specified one become undefined; hence, the library may make use of this.

### 8.2.36 _gfortran_caf_co_reduce — Generic collective reduction

**Description:**
Calculates for each array element of the variable `a` the reduction value for that element in the current team; if `result_image` has the value 0, the result shall be stored on all images, otherwise, only on the specified image. The `opr` is a pure function doing a mathematically commutative and associative operation.

The `opr_flags` denote the following; the values are bitwise ored. `GFC_CAF_BYREF` (1) if the result should be returned by reference; `GFC_CAF_HIDDENLEN` (2) whether the result and argument string lengths shall be specified as hidden arguments; `GFC_CAF_ARG_VALUE` (4) whether the arguments shall be passed by value, `GFC_CAF_ARG_DESC` (8) whether the arguments shall be passed by descriptor.

**Syntax:**
```c
void _gfortran_caf_co_reduce (gfc_descriptor_t *a, void * (*opr) (void *, void *), int opr_flags, int result_image, int *stat, char *errmsg, int a_len, int errmsg_len)
```

**Arguments:**
- `a` intent(inout) An array descriptor with the data to be processed. On the destination image(s) the result overwrites the old content.
- `opr` intent(in) Function pointer to the reduction function
- `opr_flags` intent(in) Flags regarding the reduction function
- `result_image` intent(in) The ID of the image to which the reduced value should be copied to; if zero, it has to be copied to all images.
- `stat` intent(out) Stores the status STAT= and may be NULL.
- `errmsg` intent(out) When an error occurs, this will be set to an error message; may be NULL.
a_len        intent(in) the string length of argument a
errmsg_len   intent(in) the buffer size of errmsg

**NOTES** If result_image is nonzero, the data in the array descriptor a on all images except of the specified one become undefined; hence, the library may make use of this.

For character arguments, the result is passed as first argument, followed by the result string length, next come the two string arguments, followed by the two hidden string length arguments. With C binding, there are no hidden arguments and by-reference passing and either only a single character is passed or an array descriptor.
9 Intrinsic Procedures

9.1 Introduction to intrinsic procedures

The intrinsic procedures provided by GNU Fortran include all of the intrinsic procedures required by the Fortran 95 standard, a set of intrinsic procedures for backwards compatibility with G77, and a selection of intrinsic procedures from the Fortran 2003 and Fortran 2008 standards. Any conflict between a description here and a description in either the Fortran 95 standard, the Fortran 2003 standard or the Fortran 2008 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. GNU Fortran 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 intrinsic 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.

GNU Fortran 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 standard for each intrinsic procedure is noted.

9.2 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. It will also print a backtrace, unless -fno-backtrace is given.

Standard: GNU extension
Class: 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

See also: Section 9.101 [EXIT], page 167, Section 9.161 [KILL], page 203, Section 9.39 [BACKTRACE], page 127

9.3 ABS — Absolute value

Description:

ABS(A) computes the absolute value of A.

Standard: Fortran 77 and later, has overloads that are GNU extensions

Class: Elemental function

Syntax: RESULT = ABS(A)

Arguments:

A 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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS(A)</td>
<td>REAL(4) A</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>CABS(A)</td>
<td>COMPLEX(4) A</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DABS(A)</td>
<td>REAL(8) A</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>IABS(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>BABS(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IIABS(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JIABS(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KIABS(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>ZABS(A)</td>
<td>COMPLEX(8) A</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>CDABS(A)</td>
<td>COMPLEX(8) A</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>
9.4 ACCESS — Checks file access modes

Description:

ACCESS(NAME, MODE) checks whether the file NAME exists, is readable, writable or executable. Except for the executable check, ACCESS can be replaced by Fortran 95's INQUIRE.

Standard: GNU extension

Class: Inquiry function

Syntax: RESULT = ACCESS(NAME, MODE)

Arguments:

NAME Scalar CHARACTER of default kind with the file name. Tailing blank are ignored unless the character achar(0) is present, then all characters up to and excluding achar(0) are used as file name.

MODE Scalar CHARACTER of default kind with the file access mode, may be any concatenation of "r" (readable), "w" (writable) and "x" (executable), or " " to check for existence.

Return value:

Returns a scalar INTEGER, which is 0 if the file is accessible in the given mode; otherwise or if an invalid argument has been given for MODE the value 1 is returned.

Example:

```fortran
program access_test
  implicit none
  character(len=*) , parameter :: file = 'test.dat'
  character(len=*) , parameter :: file2 = 'test.dat' // achar(0)
  if(access(file,' ') == 0) print *, trim(file),' is exists'
  if(access(file,'r') == 0) print *, trim(file),' is readable'
  if(access(file,'w') == 0) print *, trim(file),' is writable'
  if(access(file,'x') == 0) print *, trim(file),' is executable'
  if(access(file2,'rwx') == 0) &
    print *, trim(file2),' is readable, writable and executable'
end program access_test
```

Specific names:

See also:

9.5 ACHAR — Character in ASCII collating sequence

Description:

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

Standard: Fortran 77 and later, with KIND argument Fortran 2003 and later

Class: Elemental function

Syntax: RESULT = ACHAR(I [, KIND])
Arguments:
- \( I \) The type shall be \texttt{INTEGER}.
- \( \text{KIND} \) (Optional) An \texttt{INTEGER} initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type \texttt{CHARACTER} with a length of one. If the \text{KIND} argument is present, the return value is of the specified kind and of the default kind otherwise.

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

Note: See Section 9.142 [ICHAR], page 192 for a discussion of converting between numerical values and formatted string representations.

See also: Section 9.59 [CHAR], page 138, Section 9.134 [IACHAR], page 187, Section 9.142 [ICHAR], page 192

9.6 ACOS — Arccosine function

Description:
\( \text{ACOS}(X) \) computes the arccosine of \( X \) (inverse of \( \text{COS}(X) \)).

Standard: Fortran 77 and later, for a complex argument Fortran 2008 or later

Class: Elemental function

Syntax: \( \text{RESULT} = \text{ACOS}(X) \)

Arguments:
- \( X \) The type shall either be \texttt{REAL} with a magnitude that is less than or equal to one - or the type shall be \texttt{COMPLEX}.

Return value:
The return value is of the same type and kind as \( X \). The real part of the result is in radians and lies in the range \( 0 \leq \Re \text{acos}(x) \leq \pi \).

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACOS(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DACOS(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.73 [COS], page 148 Degrees function: Section 9.7 [ACOSD], page 105
9.7 ACOSD — Arccosine function, degrees

Description:

ACOSD(X) computes the arccosine of X in degrees (inverse of COSD(X)).

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with ‘-fdec-math’

Class: Elemental function

Syntax:

RESULT = ACOSD(X)

Arguments:

X  The type shall either be REAL with a magnitude that is less than or equal to one - or the type shall be COMPLEX.

Return value:

The return value is of the same type and kind as X. The real part of the result is in degrees and lies in the range 0 ≤ ℜacos(x) ≤ 180.

Example:

program test_acosd
  real(8) :: x = 0.866_8
  x = acosd(x)
end program test_acosd

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACOSD(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DACOSD(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.74 [COSD], page 149 Radians function: Section 9.6 [ACOS], page 104

9.8 ACOSH — Inverse hyperbolic cosine function

Description:

ACOSH(X) computes the inverse hyperbolic cosine of X.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax:

RESULT = ACOSH(X)

Arguments:

X  The type shall be REAL or COMPLEX.

Return value:

The return value has the same type and kind as X. If X is complex, the imaginary part of the result is in radians and lies between 0 ≤ ℑacosh(x) ≤ π.

Example:
PROGRAM test_acosh
    REAL(8), DIMENSION(3) :: x = (/ 1.0, 2.0, 3.0 /)
    WRITE (*,*) ACOSH(x)
END PROGRAM

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DACOSH(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.75 [COSH], page 149

9.9 ADJUSTL — Left adjust a string

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

Standard: Fortran 90 and later

Class: Elemental function

Syntax: RESULT = ADJUSTL(STRING)

Arguments:
STRING The type shall be CHARACTER.

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

Example:

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

See also: Section 9.10 [ADJUSTR], page 106, Section 9.273 [TRIM], page 267

9.10 ADJUSTR — Right adjust a string

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

Standard: Fortran 95 and later

Class: Elemental function

Syntax: RESULT = ADJUSTR(STRING)

Arguments:
STR The type shall be CHARACTER.
Return value:
The return value is of type CHARACTER and of the same kind as STRING where trailing spaces are removed and the same number of spaces are inserted at the start of STRING.

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

See also: Section 9.9 [ADJUSTL], page 106, Section 9.273 [TRIM], page 267

9.11 AIMAG — Imaginary part of complex number

Description:
AIMAG(Z) yields the imaginary part of complex argument Z. The IMAG(Z) and IMAGPART(Z) intrinsic functions are provided for compatibility with g77, and their use in new code is strongly discouraged.

Standard: Fortran 77 and later, has overloads that are GNU extensions

Class: Elemental function

Syntax:
RESULT = 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:
```fortran
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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIMAG(Z)</td>
<td>COMPLEX Z</td>
<td>REAL</td>
<td>GNU extension</td>
</tr>
<tr>
<td>DIMAG(Z)</td>
<td>COMPLEX(8) Z</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IMAG(Z)</td>
<td>COMPLEX Z</td>
<td>REAL</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IMAGPART(Z)</td>
<td>COMPLEX Z</td>
<td>REAL</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

9.12 AINT — Truncate to a whole number

Description:

AINT(A [, KIND]) truncates its argument to a whole number.

Standard: Fortran 77 and later
**Class:** Elemental function

**Syntax:** 
RESULT = AINT(A [, KIND])

**Arguments:**
- **A** The type of the argument shall be **REAL**.
- **KIND** (Optional) An **INTEGER** initialization expression indicating the kind parameter of the result.

**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, 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:**

```fortran
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:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>AINT(A)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DINT(A)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

### 9.13 ALARM — Execute a routine after a given delay

**Description:**

ALARM(SECONDS, HANDLER [, STATUS]) causes external subroutine HANDLER to be executed after a delay of SECONDS by using alarm(2) to set up a signal and signal(2) to catch it. If STATUS is supplied, it will be returned with the number of seconds remaining until any previously scheduled alarm was due to be delivered, or zero if there was no previously scheduled alarm.

**Standard:** GNU extension

**Class:** Subroutine

**Syntax:** 
CALL ALARM(SECONDS, HANDLER [, STATUS])

**Arguments:**
- **SECONDS** The type of the argument shall be a scalar **INTEGER**. It is INTENT(IN).
- **HANDLER** Signal handler (**INTEGER FUNCTION** or **SUBROUTINE**) or dummy/global **INTEGER** scalar. The scalar values may be either SIG_IGN=1 to ignore the alarm generated or SIG_DFL=0 to set the default action. It is INTENT(IN).
STATUS  (Optional) STATUS shall be a scalar variable of the default INTEGER kind. It is INTENT(OUT).

Example:

```fortran
program test_alarm
  external handler_print
  integer i
  call alarm (3, handler_print, i)
  print *, i
  call sleep(10)
end program test_alarm
```

This will cause the external routine handler_print to be called after 3 seconds.

9.14 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.

Standard: Fortran 95 and later

Class: Transformational function

Syntax: RESULT = 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:

```fortran
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

9.15 ALLOCATED — Status of an allocatable entity

Description:
ALLOCATED(ARRAY) and ALLOCATED(SCALAR) check the allocation status of ARRAY and SCALAR, respectively.

Standard: Fortran 95 and later. Note, the SCALAR= keyword and allocatable scalar entities are available in Fortran 2003 and later.

Class: Inquiry function

Syntax:
RESULT = ALLOCATED(ARRAY)
RESULT = ALLOCATED(SCALAR)

Arguments:
ARRAY The argument shall be an ALLOCATABLE array.
SCALAR The argument shall be an ALLOCATABLE scalar.

Return value:
The return value is a scalar LOGICAL with the default logical kind type parameter. If the argument is allocated, then the result is .TRUE.; otherwise, it returns .FALSE.

Example:
program test_allocated
integer :: i = 4
real(4), allocatable :: x(:)
if (.not. allocated(x)) allocate(x(i))
end program test_allocated

9.16 AND — Bitwise logical AND

Description:
Bitwise logical AND.
This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. For integer arguments, programmers should consider the use of the Section 9.136 [IAND], page 188 intrinsic defined by the Fortran standard.

Standard: GNU extension

Class: Function

Syntax: RESULT = AND(I, J)

Arguments:
I The type shall be either a scalar INTEGER type or a scalar LOGICAL type.
J The type shall be the same as the type of I.
Return value:
The return type is either a scalar INTEGER or a scalar LOGICAL. If the kind type parameters differ, then the smaller kind type is implicitly converted to larger kind, and the return has the larger kind.

Example:

```fortran
PROGRAM test_and
  LOGICAL :: T = .TRUE., F = .FALSE.
  INTEGER :: a, b
  DATA a / Z'F' /, b / Z'3' /
  WRITE (*,*) AND(T, T), AND(T, F), AND(F, T), AND(F, F)
  WRITE (*,*) AND(a, b)
END PROGRAM
```

See also: Fortran 95 elemental function: Section 9.136 [IAND], page 188

9.17 ANINT — Nearest whole number

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

Standard: Fortran 77 and later

Class: Elemental function

Syntax: `RESULT = ANINT(A [, KIND])`

Arguments:
- `A`: The type of the argument shall be REAL.
- `KIND` (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

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 A is greater than zero, ANINT(A) returns AINT(X+0.5). If A is less than or equal to zero then it returns AINT(X-0.5).

Example:

```fortran
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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>AINT(A)</td>
<td>REAL(4) A</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DNINT(A)</td>
<td>REAL(8) A</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>
9.18 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..

Standard: Fortran 95 and later
Class: Transformational function
Syntax: RESULT = 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:

```fortran
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
```

9.19 Asin — Arcsine function

Description:
ASIN(X) computes the arcsine of its X (inverse of SIN(X)).

Standard: Fortran 77 and later, for a complex argument Fortran 2008 or later
Class: Elemental function
Chapter 9: Intrinsic Procedures

Syntax: \( \text{RESULT} = \text{ASIN}(X) \)

Arguments:

\( X \) The type shall be either \texttt{REAL} and a magnitude that is less than or equal to one - or be \texttt{COMPLEX}.

Return value:

The return value is of the same type and kind as \( X \). The real part of the result is in radians and lies in the range \(-\pi/2 \leq \Re \text{asin}(x) \leq \pi/2\).

Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASIN(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DASIN(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.247 [SIN], page 251 Degrees function: Section 9.20 [ASIND], page 113

9.20 \texttt{ASIND} — Arcsine function, degrees

Description:

\texttt{ASIND(X)} computes the arcsine of its \( X \) in degrees (inverse of \texttt{SIND(X)}).

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with \texttt{-fdec-math}.

Class: Elemental function

Syntax: \( \text{RESULT} = \text{ASIND}(X) \)

Arguments:

\( X \) The type shall be either \texttt{REAL} and a magnitude that is less than or equal to one - or be \texttt{COMPLEX}.

Return value:

The return value is of the same type and kind as \( X \). The real part of the result is in degrees and lies in the range \(-90 \leq \Re \text{asin}(x) \leq 90\).

Example:

```fortran
program test_asind
  real(8) :: x = 0.866_8
  x = asind(x)
end program test_asind
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASIND(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DASIND(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>
See also: Inverse function: Section 9.248 [SIND], page 251 Radians function: Section 9.19 [ASIN], page 112

9.21 ASINH — Inverse hyperbolic sine function

Description:
ASINH(X) computes the inverse hyperbolic sine of X.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax: RESULT = ASINH(X)

Arguments:
X The type shall be REAL or COMPLEX.

Return value:
The return value is of the same type and kind as X. If X is complex, the imaginary part of the result is in radians and lies between $-\pi/2 \leq \Im \text{asinh}(x) \leq \pi/2$.

Example:

```
PROGRAM test_asinh
REAL(8), DIMENSION(3) :: x = (/ -1.0, 0.0, 1.0 /)
WRITE (*,*) ASINH(x)
END PROGRAM
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASINH(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>GNU extension.</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.249 [SINH], page 252

9.22 ASSOCIATED — Status of a pointer or pointer/target pair

Description:
ASSOCIATED(POINTER [, TARGET]) determines the status of the pointer POINTER or if POINTER is associated with the target TARGET.

Standard: Fortran 95 and later

Class: Inquiry function

Syntax: RESULT = ASSOCIATED(POINTER [, TARGET])

Arguments:
POINTER POINTER shall have the POINTER attribute and it can be of any type.

TARGET (Optional) TARGET shall be a pointer or a target. It must have the same type, kind type parameter, and array rank as POINTER.

The association status of neither POINTER nor TARGET shall be undefined.
Return value:

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

(A) When the optional TARGET is not present then
    ASSOCIATED(P) is true if P is associated with a target; otherwise, it returns false.

(B) If TARGET is present and a scalar target, the result is true if
    TARGET is not a zero-sized storage sequence and the target associated with P occupies the same storage units. If P is disassociated, the result is false.

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

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

(E) If TARGET is present and an array pointer, the result is true if
    target associated with P and the target associated with TARGET have the same shape, are not zero-sized arrays, are arrays whose elements are not zero-sized storage sequences, and TARGET and P occupy the same storage units in array element order. The result is false, if either TARGET or P 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

See also:  Section 9.208 [NULL], page 229

9.23 ATAN — Arctangent function

Description:

ATAN(X) computes the arctangent of X.

Standard:  Fortran 77 and later, for a complex argument and for two arguments Fortran 2008 or later
Class: Elemental function

Syntax:

RESULT = ATAN(X)
RESULT = ATAN(Y, X)

Arguments:

X The type shall be REAL or COMPLEX; if Y is present, X shall be REAL.
Y shall be of the same type and kind as X.

Return value:

The return value is of the same type and kind as X. If Y is present, the result is identical to ATAN2(Y, X). Otherwise, it the arcus tangent of X, where the real part of the result is in radians and lies in the range \(-\pi/2 \leq \Re \text{atan}(x) \leq \pi/2\).

Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATAN(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DATAN(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.263 [TAN], page 261 Degrees function: Section 9.24 [ATAND], page 116

9.24 ATAND — Arctangent function, degrees

Description:

ATAND(X) computes the arctangent of X in degrees (inverse of Section 9.264 [TAND], page 261).

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with ‘-fdec-math’.

Class: Elemental function

Syntax:

RESULT = ATAND(X)
RESULT = ATAND(Y, X)

Arguments:

X The type shall be REAL or COMPLEX; if Y is present, X shall be REAL.
Y shall be of
the same type
and kind as
X.

Return value:
The return value is of the same type and kind as X. If Y is present, the result
is identical to ATAND2(Y, X). Otherwise, it is the arcus tangent of X, where the
real part of the result is in degrees and lies in the range $-90 \leq \Re \arctan(x) \leq 90$.

Example:

```
program test_atand
  real(8) :: x = 2.866_8
  x = atand(x)
end program test_atand
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATAND(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DATAND(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.264 [TAND], page 261
Radians function: Section 9.23 [ATAN], page 115

9.25 ATAN2 — Arctangent function

Description:
ATAN2(Y, X) computes the principal value of the argument function of the com-
plex number $X + iY$. This function can be used to transform from Cartesian into
polar coordinates and allows to determine the angle in the correct quadrant.

Standard: Fortran 77 and later

Class: Elemental function

Syntax: `RESULT = 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
principal value of the complex number $X + iY$. If X is nonzero, then it lies in
the range $-\pi \leq \arctan(x) \leq \pi$. The sign is positive if Y is positive. If Y is zero,
then the return value is zero if X is strictly positive, $\pi$ if X is negative and Y
is positive zero (or the processor does not handle signed zeros), and $-\pi$ if X is
negative and Y is negative zero. 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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATAN2(X, Y)</td>
<td>REAL(4) X, Y</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DATAN2(X, Y)</td>
<td>REAL(8) X, Y</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Alias: Section 9.23 [ATAN], page 115 Degrees function: Section 9.26 [ATAN2D], page 118

9.26 ATAN2D — Arctangent function, degrees

Description:

ATAN2D(Y, X) computes the principal value of the argument function of the complex number \( X + iY \) in degrees. This function can be used to transform from Cartesian into polar coordinates and allows to determine the angle in the correct quadrant.

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with ‘-fdec-math’.

Class: Elemental function

Syntax: \( \text{RESULT} = \text{ATAN2D}(Y, X) \)

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 principal value of the complex number \( X + iY \). If \( X \) is nonzero, then it lies in the range \(-180 \leq \text{atan}(x) \leq 180\). The sign is positive if \( Y \) is positive. If \( Y \) is zero, then the return value is zero if \( X \) is strictly positive, 180 if \( X \) is negative and \( Y \) is positive zero (or the processor does not handle signed zeros), and \(-180 \) if \( X \) is negative and \( Y \) is negative zero. Finally, if \( X \) is zero, then the magnitude of the result is 90.

Example:

```
program test_atan2d
  real(4) :: x = 1.e0_4, y = 0.5e0_4
  x = atan2d(y,x)
end program test_atan2d
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATAN2D(X, Y)</td>
<td>REAL(4) X, Y</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DATAN2D(X, Y)</td>
<td>REAL(8) X, Y</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>
9.27 ATANH — Inverse hyperbolic tangent function

**Description:**

\( \text{ATANH}(X) \) computes the inverse hyperbolic tangent of \( X \).

**Standard:** Fortran 2008 and later

**Class:** Elemental function

**Syntax:**

\[ \text{RESULT} = \text{ATANH}(X) \]

**Arguments:**

- \( X \) The type shall be REAL or COMPLEX.

**Return value:**

The return value has same type and kind as \( X \). If \( X \) is complex, the imaginary part of the result is in radians and lies between \( -\pi/2 \leq \Im\text{atanh}(x) \leq \pi/2 \).

**Example:**

```fortran
PROGRAM test_atanh
    REAL, DIMENSION(3) :: x = (/ -1.0, 0.0, 1.0 /)
    WRITE (*,*) ATANH(x)
END PROGRAM
```

**Specific names:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATANH(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

**See also:**

Inverse function: Section 9.265 [TANH], page 262

9.28 ATOMIC_ADD — Atomic ADD operation

**Description:**

\( \text{ATOMIC_ADD}(\text{ATOM}, \text{VALUE}) \) atomically adds the value of \( \text{VAR} \) to the variable \( \text{ATOM} \). When \( \text{STAT} \) is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed \( \text{ATOM} \), if the remote image has stopped, it is assigned the value of \( \text{ISO_FORTRAN_ENV}'s \text{STAT_STOPPED_IMAGE} \) and if the remote image has failed, the value \( \text{STAT_FAILED_IMAGE} \).

**Standard:** TS 18508 or later

**Class:** Atomic subroutine

**Syntax:**

\[ \text{CALL ATOMIC_ADD (ATOM, VALUE [, STAT])} \]

**Arguments:**

- \( \text{ATOM} \) Scalar coarray or coindexed variable of integer type with \( \text{ATOMIC_INT_KIND} \) kind.
- \( \text{VALUE} \) Scalar of the same type as \( \text{ATOM} \). If the kind is different, the value is converted to the kind of \( \text{ATOM} \).
- \( \text{STAT} \) (optional) Scalar default-kind integer variable.
Example:

```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*]
  call atomic_add (atom[1], this_image())
end program atomic
```

See also: Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.32 [ATOMIC_FETCH_ADD], page 122, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.29 [ATOMIC_AND], page 120, Section 9.36 [ATOMIC_OR], page 125, Section 9.38 [ATOMIC XOR], page 126

### 9.29 ATOMIC_AND — Atomic bitwise AND operation

**Description:**

ATOMIC_AND(ATOM, VALUE) atomically defines ATOM with the bitwise AND between the values of ATOM and VALUE. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV’s STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.

**Standard:** TS 18508 or later

**Class:** Atomic subroutine

**Syntax:**

```fortran
CALL ATOMIC_AND (ATOM, VALUE [, STAT])
```

**Arguments:**

- **ATOM**  
  Scalar coarray or coindexed variable of integer type with ATOMIC_INT_KIND kind.

- **VALUE**  
  Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.

- **STAT**  
  (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*]
  call atomic_and (atom[1], int(b’10100011101’))
end program atomic
```

See also: Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.33 [ATOMIC_FETCH_AND], page 123, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.28 [ATOMIC_ADD], page 119, Section 9.36 [ATOMIC_OR], page 125, Section 9.38 [ATOMIC XOR], page 126

### 9.30 ATOMIC_CAS — Atomic compare and swap

**Description:**

ATOMIC_CAS compares the variable ATOM with the value of COMPARE; if the value is the same, ATOM is set to the value of NEW. Additionally, OLD is set
to the value of \texttt{ATOM} that was used for the comparison. When \texttt{STAT} is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed \texttt{ATOM}, if the remote image has stopped, it is assigned the value of \texttt{ISO_FORTRAN_ENV}\texttt{'s STAT_STOPPED_IMAGE} and if the remote image has failed, the value \texttt{STAT_FAILED_IMAGE}.

\textbf{Standard:} TS 18508 or later  
\textbf{Class:} Atomic subroutine  
\textbf{Syntax:} \texttt{CALL ATOMIC_CAS (ATOM, OLD, COMPARE, NEW [, STAT])}  
\textbf{Arguments:}

\begin{itemize}
  \item \texttt{ATOM} \hspace{1cm} Scalar coarray or coindexed variable of either integer type with \texttt{ATOMIC_INT_KIND} kind or logical type with \texttt{ATOMIC_LOGICAL_KIND} kind.
  \item \texttt{OLD} \hspace{1cm} Scalar of the same type and kind as \texttt{ATOM}.
  \item \texttt{COMPARE} \hspace{1cm} Scalar variable of the same type and kind as \texttt{ATOM}.
  \item \texttt{NEW} \hspace{1cm} Scalar variable of the same type as \texttt{ATOM}. If kind is different, the value is converted to the kind of \texttt{ATOM}.
  \item \texttt{STAT} (optional) \hspace{1cm} Scalar default-kind integer variable.
\end{itemize}

\textbf{Example:}

\begin{verbatim}
program atomic
use iso_fortran_env
logical(atomic_logical_kind) :: atom[*], prev
call atomic_cas (atom[1], prev, .false., .true.))
end program atomic
\end{verbatim}

\textbf{See also:} Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.37 [ATOMIC_REF], page 125, Section 10.1 [ISO_FORTRAN_ENV], page 273

9.31 \textbf{ATOMIC_DEFINE — Setting a variable atomically}

\textbf{Description:}

\texttt{ATOMIC_DEFINE(ATOM, VALUE)} defines the variable \texttt{ATOM} with the value \texttt{VALUE} atomically. When \texttt{STAT} is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed \texttt{ATOM}, if the remote image has stopped, it is assigned the value of \texttt{ISO_FORTRAN_ENV}\texttt{'s STAT_STOPPED_IMAGE} and if the remote image has failed, the value \texttt{STAT_FAILED_IMAGE}.

\textbf{Standard:} Fortran 2008 and later; with \texttt{STAT}, TS 18508 or later  
\textbf{Class:} Atomic subroutine  
\textbf{Syntax:} \texttt{CALL ATOMIC_DEFINE (ATOM, VALUE [, , STAT])}  
\textbf{Arguments:}

\begin{itemize}
  \item \texttt{ATOM} \hspace{1cm} Scalar coarray or coindexed variable of either integer type with \texttt{ATOMIC_INT_KIND} kind or logical type with \texttt{ATOMIC_LOGICAL_KIND} kind.
\end{itemize}
VALUE    Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.

STAT     (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*]
  call atomic_define (atom[1], this_image())
end program atomic
```

See also: Section 9.37 [ATOMIC_REF], page 125, Section 9.30 [ATOMIC_CAS], page 120, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.28 [ATOMIC_ADD], page 119, Section 9.29 [ATOMIC_AND], page 120, Section 9.36 [ATOMIC_OR], page 125, Section 9.38 [ATOMIC_XOR], page 126

9.32 ATOMIC_FETCH_ADD — Atomic ADD operation with prior fetch

Description:

ATOMIC_FETCH_ADD(ATOM, VALUE, OLD) atomically stores the value of ATOM in OLD and adds the value of VAR to the variable ATOM. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV’s STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.

Standard: TS 18508 or later

Class: Atomic subroutine

Syntax: CALL ATOMIC_FETCH_ADD (ATOM, VALUE, old [, STAT])

Arguments:

ATOM    Scalar coarray or coindexed variable of integer type with ATOMIC_INT_KIND kind. ATOMIC_LOGICAL_KIND kind.

VALUE   Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.

OLD     Scalar of the same type and kind as ATOM.

STAT    (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*], old
  call atomic_add (atom[1], this_image(), old)
end program atomic
```

See also: Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.28 [ATOMIC_ADD], page 119, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.33 [ATOMIC_FETCH_AND], page 123, Section 9.34 [ATOMIC_FETCH_OR], page 123, Section 9.35 [ATOMIC_FETCH_XOR], page 124
9.33 ATOMIC_FETCH_AND — Atomic bitwise AND operation with prior fetch

Description:

ATOMIC_AND(ATOM, VALUE) atomically stores the value of ATOM in OLD and defines ATOM with the bitwise AND between the values of ATOM and VALUE. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV’s STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.

Standard: TS 18508 or later
Class: Atomic subroutine
Syntax: CALL ATOMIC_FETCH_AND (ATOM, VALUE, OLD [, STAT])
Arguments:
ATOM Scalar coarray or coindexed variable of integer type with ATOMIC_INT_KIND kind.
VALUE Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.
OLD Scalar of the same type and kind as ATOM.
STAT (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  integer(atOMIC_int_kind) :: atom[*], old
  call atomic_fetch_and (atom[1], int(b'10100011101'), old)
end program atomic
```

See also: Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.29 [ATOMIC_AND], page 120, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.32 [ATOMIC_FETCH_ADD], page 122, Section 9.34 [ATOMIC_FETCH_OR], page 123, Section 9.35 [ATOMIC_FETCH_XOR], page 124

9.34 ATOMIC_FETCH_OR — Atomic bitwise OR operation with prior fetch

Description:

ATOMIC_OR(ATOM, VALUE) atomically stores the value of ATOM in OLD and defines ATOM with the bitwise OR between the values of ATOM and VALUE. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV’s STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.

Standard: TS 18508 or later
Class: Atomic subroutine
**Syntax:**

```
CALL ATOMIC_FETCH_OR (ATOM, VALUE, OLD [, STAT])
```

**Arguments:**

- **ATOM**: Scalar coarray or coindexed variable of integer type with `ATOMIC_INT_KIND` kind.
- **VALUE**: Scalar of the same type as `ATOM`. If the kind is different, the value is converted to the kind of `ATOM`.
- **OLD**: Scalar of the same type and kind as `ATOM`.
- **STAT**: (optional) Scalar default-kind integer variable.

**Example:**
```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*], old
  call atomic_fetch_or (atom[1], int(b'10100011101'), old)
end program atomic
```

**See also:**
Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.36 [ATOMIC_OR], page 125, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.32 [ATOMIC_FETCH_ADD], page 122, Section 9.33 [ATOMIC_FETCH_AND], page 123, Section 9.35 [ATOMIC_FETCH_XOR], page 124

### 9.35 ATOMIC_FETCH_XOR — Atomic bitwise XOR operation with prior fetch

**Description:**

`ATOMIC_XOR(ATOM, VALUE)` atomically stores the value of `ATOM` in `OLD` and defines `ATOM` with the bitwise XOR between the values of `ATOM` and `VALUE`. When `STAT` is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed `ATOM`, if the remote image has stopped, it is assigned the value of `ISO_FORTRAN_ENV`’s `STAT_STOPPED_IMAGE` and if the remote image has failed, the value `STAT_FAILED_IMAGE`.

**Standard:** TS 18508 or later

**Class:** Atomic subroutine

**Syntax:**

```
CALL ATOMIC_FETCH_XOR (ATOM, VALUE, OLD [, STAT])
```

**Arguments:**

- **ATOM**: Scalar coarray or coindexed variable of integer type with `ATOMIC_INT_KIND` kind.
- **VALUE**: Scalar of the same type as `ATOM`. If the kind is different, the value is converted to the kind of `ATOM`.
- **OLD**: Scalar of the same type and kind as `ATOM`.
- **STAT**: (optional) Scalar default-kind integer variable.

**Example:**
```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*], old
  call atomic_fetch_xor (atom[1], int(b'10100011101'), old)
end program atomic
```
9.36 ATOMIC_OR — Atomic bitwise OR operation

Description:

ATOMIC_OR(ATOM, VALUE) atomically defines ATOM with the bitwise AND between the values of ATOM and VALUE. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV's STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.

Standard: TS 18508 or later
Class: Atomic subroutine
Syntax: CALL ATOMIC_OR (ATOM, VALUE [, , STAT])
Arguments:

ATOM Scalar coarray or coindexed variable of integer type with ATOMIC_INT_KIND kind.
VALUE Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.
STAT (optional) Scalar default-kind integer variable.

Example:

```
program atomic
use iso_fortran_env
integer(atomic_int_kind) :: atom[*]
call atomic_or (atom[1], int(b'10100011101'))
end program atomic
```

See also: Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.34 [ATOMIC_FETCH_OR], page 123, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.32 [ATOMIC_FETCH_ADD], page 122, Section 9.33 [ATOMIC_FETCH_AND], page 123, Section 9.34 [ATOMIC_FETCH_OR], page 123

9.37 ATOMIC_REF — Obtaining the value of a variable atomically

Description:

ATOMIC_DEFINE(ATOM, VALUE) atomically assigns the value of the variable ATOM to VALUE. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV's STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.
Standard: Fortran 2008 and later; with STAT, TS 18508 or later

Class: Atomic subroutine

Syntax: CALL ATOMIC_REF(VALUE, ATOM [, STAT])

Arguments:
VALUE Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.
ATOM Scalar coarray or coindexed variable of either integer type with ATOMIC_INT_KIND kind or logical type with ATOMIC_LOGICAL_KIND kind.
STAT (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  logical(atomic_logical_kind) :: atom[*]
  logical :: val
  call atomic_ref (atom, .false.)
  ! ...
  call atomic_ref (atom, val)
  if (val) then
    print *, "Obtained"
  end if
end program atomic
```

See also: Section 9.31 [ATOMIC_DEFINE], page 121, Section 9.30 [ATOMIC_CAS], page 120, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.32 [ATOMIC_FETCH_ADD], page 122, Section 9.33 [ATOMIC_FETCH_AND], page 123, Section 9.34 [ATOMIC_FETCH_OR], page 123, Section 9.35 [ATOMIC_FETCH_XOR], page 124

9.38 ATOMIC_XOR — Atomic bitwise OR operation

Description:

ATOMIC_AND(ATOM, VALUE) atomically defines ATOM with the bitwise XOR between the values of ATOM and VALUE. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value; in particular, for a coindexed ATOM, if the remote image has stopped, it is assigned the value of ISO_FORTRAN_ENV’s STAT_STOPPED_IMAGE and if the remote image has failed, the value STAT_FAILED_IMAGE.

Standard: TS 18508 or later

Class: Atomic subroutine

Syntax: CALL ATOMIC_XOR (ATOM, VALUE [, STAT])

Arguments:
ATOM Scalar coarray or coindexed variable of integer type with ATOMIC_INT_KIND kind.
VALUE Scalar of the same type as ATOM. If the kind is different, the value is converted to the kind of ATOM.

STAT (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  integer(atomic_int_kind) :: atom[*]
  call atomic_xor (atom[1], int(b'10100011101'))
end program atomic
```

See also: Section 9.31 [ATOMIC DEFINE], page 121, Section 9.35 [ATOMIC_FETCH XOR], page 124, Section 10.1 [ISO_FORTRAN_ENV], page 273, Section 9.28 [ATOMIC_ADD], page 119, Section 9.36 [ATOMIC OR], page 125, Section 9.38 [ATOMIC XOR], page 126

**9.39 BACKTRACE — Show a backtrace**

**Description:**

BACKTRACE shows a backtrace at an arbitrary place in user code. Program execution continues normally afterwards. The backtrace information is printed to the unit corresponding to ERROR_UNIT in ISO_FORTRAN_ENV.

**Standard:** GNU Extension

**Class:** Subroutine

**Syntax:**

```fortran
CALL BACKTRACE
```

**Arguments:**

None

**See also:** Section 9.2 [ABORT], page 101

**9.40 BESSEL_J0 — Bessel function of the first kind of order 0**

**Description:**

BESSEL_J0(X) computes the Bessel function of the first kind of order 0 of X. This function is available under the name BESJ0 as a GNU extension.

**Standard:** Fortran 2008 and later

**Class:** Elemental function

**Syntax:**

```fortran
RESULT = BESSEL_J0(X)
```

**Arguments:**

X The type shall be REAL.

**Return value:**

The return value is of type REAL and lies in the range $-0.4027... \leq Bessel(0,x) \leq 1$. It has the same kind as X.

**Example:**
```fortran
program test_besj0
  real(8) :: x = 0.0_8
  x = bessel_j0(x)
end program test_besj0
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBESJ0(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

### 9.41 BESSEL_J1 — Bessel function of the first kind of order 1

**Description:**

BESSEL_J1(X) computes the Bessel function of the first kind of order 1 of X. This function is available under the name BESJ1 as a GNU extension.

**Standard:** Fortran 2008

**Class:** Elemental function

**Syntax:**

```
RESULT = BESSEL_J1(X)
```

**Arguments:**

X  The type shall be REAL.

**Return value:**

The return value is of type REAL and lies in the range $-0.5818... \leq Bessel(0,x) \leq 0.5818$. It has the same kind as X.

**Example:**

```fortran
program test_besj1
  real(8) :: x = 1.0_8
  x = bessel_j1(x)
end program test_besj1
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBESJ1(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

### 9.42 BESSEL_JN — Bessel function of the first kind

**Description:**

BESSEL_JN(N, X) computes the Bessel function of the first kind of order N of X. This function is available under the name BESJN as a GNU extension. If N and X are arrays, their ranks and shapes shall conform.

BESSEL_JN(N1, N2, X) returns an array with the Bessel functions of the first kind of the orders N1 to N2.

**Standard:** Fortran 2008 and later, negative N is allowed as GNU extension

**Class:** Elemental function, except for the transformational function BESSEL_JN(N1, N2, X)

**Syntax:**

```
RESULT = BESSEL_JN(N, X)
RESULT = BESSEL_JN(N1, N2, X)
```
Arguments:

\begin{align*}
N & \quad \text{Shall be a scalar or an array of type INTEGER.} \\
N_1 & \quad \text{Shall be a non-negative scalar of type INTEGER.} \\
N_2 & \quad \text{Shall be a non-negative scalar of type INTEGER.} \\
X & \quad \text{Shall be a scalar or an array of type REAL; for } \text{BESSEL}_\text{JN}(N_1, N_2, X) \text{ it shall be scalar.}
\end{align*}

Return value:

The return value is a scalar of type REAL. It has the same kind as X.

Note:

The transformational function uses a recurrence algorithm which might, for some values of X, lead to different results than calls to the elemental function.

Example:

\begin{verbatim}
program test_besjn
  real(8) :: x = 1.0_8
  x = bessel_jn(5, x)
end program test_besjn
\end{verbatim}

Specific names:

\begin{tabular}{llll}
Name & Argument & Return type & Standard \\
\hline
DBESJN(N, X) & INTEGER N & REAL(8) & GNU extension \\
& REAL(8) X & & \\
\end{tabular}

9.43 BESSEL_Y0 — Bessel function of the second kind of order 0

Description:

BESSEL_Y0(X) computes the Bessel function of the second kind of order 0 of X.

This function is available under the name BESY0 as a GNU extension.

Standard:

Fortran 2008 and later

Class:

Elemental function

Syntax:

RESULT = BESSEL_Y0(X)

Arguments:

\begin{align*}
X & \quad \text{The type shall be REAL.}
\end{align*}

Return value:

The return value is of type REAL. It has the same kind as X.

Example:

\begin{verbatim}
program test_besy0
  real(8) :: x = 0.0_8
  x = bessel_y0(x)
end program test_besy0
\end{verbatim}

Specific names:

\begin{tabular}{llll}
Name & Argument & Return type & Standard \\
\hline
DBESY0(X) & REAL(8) X & REAL(8) & GNU extension \\
& & & \\
\end{tabular}
9.44 BESSEL_Y1 — Bessel function of the second kind of order 1

Description:
BESSEL_Y1(X) computes the Bessel function of the second kind of order 1 of X. This function is available under the name BESY1 as a GNU extension.

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: RESULT = BESSEL_Y1(X)
Arguments:
X The type shall be REAL.
Return value:
The return value is of type REAL. It has the same kind as X.
Example:
program test_besy1
  real(8) :: x = 1.0_8
  x = bessel_y1(x)
end program test_besy1
Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBESY1(X)</td>
<td>REAL(8)</td>
<td>X</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

9.45 BESSEL_YN — Bessel function of the second kind

Description:
BESSEL_YN(N, X) computes the Bessel function of the second kind of order N of X. This function is available under the name BESYN as a GNU extension. If N and X are arrays, their ranks and shapes shall conform.
BESSEL_YN(N1, N2, X) returns an array with the Bessel functions of the first kind of the orders N1 to N2.

Standard: Fortran 2008 and later, negative N is allowed as GNU extension
Class: Elemental function, except for the transformational function BESSEL_YN(N1, N2, X)
Syntax:
RESULT = BESSEL_YN(N, X)
RESULT = BESSEL_YN(N1, N2, X)
Arguments:
N Shall be a scalar or an array of type INTEGER.
N1 Shall be a non-negative scalar of type INTEGER.
N2 Shall be a non-negative scalar of type INTEGER.
X Shall be a scalar or an array of type REAL; for BESSEL_YN(N1, N2, X) it shall be scalar.
Return value:
The return value is a scalar of type REAL. It has the same kind as X.
Note: The transformational function uses a recurrence algorithm which might, for some values of X, lead to different results than calls to the elemental function.

Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBESYN(N,X)</td>
<td>INTEGER N</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td></td>
<td>REAL(8) X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9.46 BGE — Bitwise greater than or equal to

Description:
Determines whether an integral is a bitwise greater than or equal to another.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax: `RESULT = BGE(I, J)`

Arguments:

- **I**: Shall be of INTEGER type.
- **J**: Shall be of INTEGER type, and of the same kind as **I**.

Return value:
The return value is of type LOGICAL and of the default kind.

See also: Section 9.46 [BGE], page 131, Section 9.49 [BLE], page 132, Section 9.50 [BLT], page 132

9.47 BGT — Bitwise greater than

Description:
Determines whether an integral is a bitwise greater than another.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax: `RESULT = BGT(I, J)`

Arguments:

- **I**: Shall be of INTEGER type.
- **J**: Shall be of INTEGER type, and of the same kind as **I**.

Return value:
The return value is of type LOGICAL and of the default kind.

See also: Section 9.46 [BGE], page 131, Section 9.49 [BLE], page 132, Section 9.50 [BLT], page 132
9.48 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. The result of BIT_SIZE(I) is independent of the actual value of I.

*Standard:* Fortran 95 and later

*Class:* Inquiry function

*Syntax:* 
RESULT = BIT_SIZE(I)

*Arguments:* 
I 
The type shall be INTEGER.

*Return value:* 
The return value is of type INTEGER

*Example:* 

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

9.49 BLE — Bitwise less than or equal to

*Description:* 
Determines whether an integral is a bitwise less than or equal to another.

*Standard:* Fortran 2008 and later

*Class:* Elemental function

*Syntax:* 
RESULT = BLE(I, J)

*Arguments:* 
I 
Shall be of INTEGER type.

J 
Shall be of INTEGER type, and of the same kind as I.

*Return value:* 
The return value is of type LOGICAL and of the default kind.

*See also:* Section 9.47 [BGT], page 131, Section 9.46 [BGE], page 131, Section 9.50 [BLT], page 132

9.50 BLT — Bitwise less than

*Description:* 
Determines whether an integral is a bitwise less than another.

*Standard:* Fortran 2008 and later

*Class:* Elemental function
Chapter 9: Intrinsic Procedures

Syntax: \[
\text{RESULT} = \text{BLT}(I, J)
\]

Arguments:
- \( I \) shall be of INTEGER type.
- \( J \) shall be of INTEGER type, and of the same kind as \( I \).

Return value:
The return value is of type LOGICAL and of the default kind.

See also: Section 9.46 [BGE], page 131, Section 9.47 [BGT], page 131, Section 9.49 [BLE], page 132

9.51 BTEST — Bit test function

Description:
\( \text{BTEST}(I, POS) \) returns logical .TRUE. if the bit at \( POS \) in \( I \) is set. The counting of the bits starts at 0.

Standard: Fortran 95 and later, has overloads that are GNU extensions

Class: Elemental function

Syntax: \[
\text{RESULT} = \text{BTEST}(I, POS)
\]

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
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTEST(I,POS)</td>
<td>INTEGER I,POS</td>
<td>LOGICAL</td>
<td>F95 and later</td>
</tr>
<tr>
<td>BBTEST(I,POS)</td>
<td>INTEGER(1) I,POS</td>
<td>LOGICAL(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>BITEST(I,POS)</td>
<td>INTEGER(2) I,POS</td>
<td>LOGICAL(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>BJTEST(I,POS)</td>
<td>INTEGER(4) I,POS</td>
<td>LOGICAL(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>BKTEST(I,POS)</td>
<td>INTEGER(8) I,POS</td>
<td>LOGICAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>
9.52 C_ASSOCIATED — Status of a C pointer

Description:

C_ASSOCIATED(c_ptr_1[, c_ptr_2]) determines the status of the C pointer c_ptr_1 or if c_ptr_1 is associated with the target c_ptr_2.

Standard: Fortran 2003 and later

Class: Inquiry function

Syntax:

RESULT = C_ASSOCIATED(c_ptr_1[, , c_ptr_2])

Arguments:

  c_ptr_1          Scalar of the type C_PTR or C_FUNPTR.
  c_ptr_2         (Optional) Scalar of the same type as c_ptr_1.

Return value:

The return value is of type LOGICAL; it is .false. if either c_ptr_1 is a C NULL pointer or if c_ptr1 and c_ptr_2 point to different addresses.

Example:

subroutine association_test(a,b)
  use iso_c_binding, only: c_associated, c_loc, c_ptr
  implicit none
  real, pointer :: a
  type(c_ptr) :: b
  if(c_associated(b, c_loc(a))) &
    stop 'b and a do not point to same target'
end subroutine association_test

See also: Section 9.56 [C_LOC], page 136, Section 9.55 [C_FUNLOC], page 136

9.53 C_F_POINTER — Convert C into Fortran pointer

Description:

C_F_POINTER(CPTR, FPTR[, SHAPE]) assigns the target of the C pointer CPTR to the Fortran pointer FPTR and specifies its shape.

Standard: Fortran 2003 and later

Class: Subroutine

Syntax:

CALL C_F_POINTER(CPTR, FPTR[, , SHAPE])

Arguments:

  CPTR              scalar of the type C_PTR. It is INTENT(IN).
  FPTR              pointer interoperable with cptr. It is INTENT(OUT).
  SHAPE             (Optional) Rank-one array of type INTEGER with INTENT(IN).
                      It shall be present if and only if fptr is an array. The size must
                      be equal to the rank of fptr.

Example:

program main
  use iso_c_binding
  implicit none
  interface


subroutine my_routine(p) bind(c,name='myC_func')
  import :: c_ptr
  type(c_ptr), intent(out) :: p
end subroutine
end interface

type(c_ptr) :: cptr
real,pointer :: a(:)
call my_routine(cptr)
call c_f_pointer(cptr, a, [12])
end program main

See also: Section 9.56 [C_LOC], page 136, Section 9.54 [C_F_PROCPOINTER], page 135

9.54 C_F_PROCPOINTER — Convert C into Fortran procedure pointer

**Description:**

*C_F_PROCPOINTER(CPTR, FPTR)* Assign the target of the C function pointer *CPTR* to the Fortran procedure pointer *FPTR*.

**Standard:** Fortran 2003 and later

**Class:** Subroutine

**Syntax:**

CALL C_F_PROCPOINTER(cptr, fptr)

**Arguments:**

*CPTR* scalar of the type C_FUNPTR. It is INTENT(IN).

*FPTR* procedure pointer interoperable with *cptr*. It is INTENT(OUT).

**Example:**

```fortran
program main
  use iso_c_binding
  implicit none
  abstract interface
    function func(a)
      import :: c_float
      real(c_float), intent(in) :: a
      real(c_float) :: func
    end function
  end interface
end interface
interface
  function getIterFunc() bind(c,name="getIterFunc")
    import :: c_funptr
    type(c_funptr) :: getIterFunc
  end function
end interface
interface
  type(c_funptr) :: cfunptr
  procedure(func), pointer :: myFunc
  cfunptr = getIterFunc()
call c_f_procpointer(cfunptr, myFunc)
end program main
```

See also: Section 9.56 [C_LOC], page 136, Section 9.53 [C_F_POINTER], page 134
9.55 C_FUNLOC — Obtain the C address of a procedure

Description:
C_FUNLOC(x) determines the C address of the argument.

Standard: Fortran 2003 and later

Class: Inquiry function

Syntax: RESULT = C_FUNLOC(x)

Arguments:

x Interoperable function or pointer to such function.

Return value:
The return value is of type C_FUNPTR and contains the C address of the argument.

Example:

```fortran
module x
  use iso_c_binding
  implicit none
contains
  subroutine sub(a) bind(c)
    real(c_float) :: a
    a = sqrt(a)+5.0
  end subroutine sub
end module x
program main
  use iso_c_binding
  use x
  implicit none
  interface
    subroutine my_routine(p) bind(c,name='myC_func')
      import :: c_funptr
      type(c_funptr), intent(in) :: p
    end subroutine
  end interface
  call my_routine(c_funloc(sub))
end program main
```

See also: Section 9.52 [C_ASSOCIATED], page 134, Section 9.56 [C_LOC], page 136, Section 9.53 [C_F_POINTER], page 134, Section 9.54 [C_F_PROCPOINTER], page 135

9.56 C_LOC — Obtain the C address of an object

Description:
C_LOC(X) determines the C address of the argument.

Standard: Fortran 2003 and later

Class: Inquiry function

Syntax: RESULT = C_LOC(X)
Arguments:

\( X \)  
Shall have either the POINTER or TARGET attribute. It shall not be a coindexed object. It shall either be a variable with interoperable type and kind type parameters, or be a scalar, non polymorphic variable with no length type parameters.

Return value:
The return value is of type \( \text{C\_PTR} \) and contains the C address of the argument.

Example:

```fortran
subroutine association_test(a,b)
  use iso_c_binding, only: c_associated, c_loc, c_ptr
  implicit none
  real, pointer :: a
  type(c_ptr) :: b
  if(c_associated(b, c_loc(a))) &
    stop 'b and a do not point to same target'
end subroutine association_test
```

See also:  
Section 9.52 [C\_ASSOCIATED], page 134, Section 9.55 [C\_FUNLOC], page 136, Section 9.53 [C\_F\_POINTER], page 134, Section 9.54 [C\_F\_PROCPOINTER], page 135

9.57 \texttt{C\_SIZEOF} — Size in bytes of an expression

Description:  
\texttt{C\_SIZEOF}(\( X \)) calculates the number of bytes of storage the expression \( X \) occupies.

Standard:  
Fortran 2008

Class:  
Inquiry function of the module \texttt{ISO\_C\_BINDING}

Syntax:  
\[ N = \texttt{C\_SIZEOF}(X) \]

Arguments:

\( X \)  
The argument shall be an interoperable data entity.

Return value:
The return value is of type integer and of the system-dependent kind \texttt{C\_SIZE\_T} (from the \texttt{ISO\_C\_BINDING} module). Its value is the number of bytes occupied by the argument. If the argument has the \texttt{POINTER} attribute, the number of bytes of the storage area pointed to is returned. If the argument is of a derived type with \texttt{POINTER} or \texttt{ALLOCATABLE} components, the return value does not account for the sizes of the data pointed to by these components.

Example:

```fortran
use iso_c_binding
integer(c_int) :: i
real(c_float) :: r, s(5)
print *, (c_sizeof(s)/c_sizeof(r) == 5)
end
```

The example will print \texttt{.TRUE.} unless you are using a platform where default \texttt{REAL} variables are unusually padded.
9.58 CEILING — Integer ceiling function

Description:
CEILING(A) returns the least integer greater than or equal to A.

Standard: Fortran 95 and later
Class: Elemental function
Syntax: RESULT = CEILING(A [, KIND])

Arguments:
A The type shall be REAL.
KIND (Optional) An INTEGER initialization expression indicating
the kind parameter of the result.

Return value:
The return value is of type INTEGER(KIND) if KIND is present and a default-
kind INTEGER otherwise.

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

See also: Section 9.108 [FLOOR], page 171, Section 9.205 [NINT], page 227

9.59 CHAR — Character conversion function

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

Standard: Fortran 77 and later
Class: Elemental function
Syntax: RESULT = CHAR(I [, KIND])

Arguments:
I The type shall be INTEGER.
KIND (Optional) An INTEGER initialization expression indicating
the kind parameter of the result.

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
Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAR(I)</td>
<td>INTEGER I</td>
<td>CHARACTER(LEN=1)</td>
<td>F77 and later</td>
</tr>
</tbody>
</table>

Note: See Section 9.142 [ICHAR], page 192 for a discussion of converting between numerical values and formatted string representations.

See also: Section 9.5 [ACHAR], page 103, Section 9.134 [IACHAR], page 187, Section 9.142 [ICHAR], page 192

9.60 CHDIR — Change working directory

Description:
Change current working directory to a specified path.
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension

Class: Subroutine, function

Syntax:

CALL CHDIR(NAME [, STATUS])

STATUS = CHDIR(NAME)

Arguments:

NAME The type shall be CHARACTER of default kind and shall specify a valid path within the file system.

STATUS (Optional) INTEGER status flag of the default kind. Returns 0 on success, and a system specific and nonzero error code otherwise.

Example:

```
PROGRAM test_chdir
    CHARACTER(len=255) :: path
    CALL getcwd(path)
    WRITE(*,*) TRIM(path)
    CALL chdir("/tmp")
    CALL getcwd(path)
    WRITE(*,*) TRIM(path)
END PROGRAM
```

See also: Section 9.123 [GETCWD], page 181

9.61 CHMOD — Change access permissions of files

Description:
CHMOD changes the permissions of a file.
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension

Class: Subroutine, function
Syntax:

CALL CHMOD(NAME, MODE[, STATUS])
STATUS = CHMOD(NAME, MODE)

Arguments:

NAME Scalar CHARACTER of default kind with the file name. Trailing blanks are ignored unless the character `achar(0)` is present, then all characters up to and excluding `achar(0)` are used as the file name.

MODE Scalar CHARACTER of default kind giving the file permission. MODE uses the same syntax as the chmod utility as defined by the POSIX standard. The argument shall either be a string of a nonnegative octal number or a symbolic mode.

STATUS (optional) scalar INTEGER, which is 0 on success and nonzero otherwise.

Return value:

In either syntax, STATUS is set to 0 on success and nonzero otherwise.

Example: CHMOD as subroutine

```fortran
program chmod_test
  implicit none
  integer :: status
  call chmod('test.dat','u+x',status)
  print *, 'Status: ', status
end program chmod_test
```

CHMOD as function:

```fortran
program chmod_test
  implicit none
  integer :: status
  status = chmod('test.dat','u+x')
  print *, 'Status: ', status
end program chmod_test
```

9.62 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.

Standard: Fortran 77 and later

Class: Elemental function

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

Arguments:

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

KIND (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of COMPLEX type, with a kind equal to KIND if it is specified. If KIND is not specified, the result is of the default COMPLEX kind, regardless of the kinds of X and Y.

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

See also: Section 9.71 [COMPLEX], page 147

9.63 CO_BROADCAST — Copy a value to all images the current set of images

Description:
CO_BROADCAST copies the value of argument A on the image with image index SOURCE_IMAGE to all images in the current team. A becomes defined as if by intrinsic assignment. If the execution was successful and STAT is present, it is assigned the value zero. If the execution failed, STAT gets assigned a nonzero value and, if present, ERRMSG gets assigned a value describing the occurred error.

Standard: Technical Specification (TS) 18508 or later

Class: Collective subroutine

Syntax:
CALL CO_BROADCAST(A, SOURCE_IMAGE [, STAT, ERRMSG])

Arguments:
A INTENT(INOUT) argument; shall have the same dynamic type and type parameters on all images of the current team. If it is an array, it shall have the same shape on all images.

SOURCE_IMAGE scalar integer expression. It shall have the same value on all images and refer to an image of the current team.

STAT (optional) a scalar integer variable

ERRMSG (optional) a scalar character variable

Example:
program test
  integer :: val(3)
  if (this_image() == 1) then
    val = [1, 5, 3]
  end if
The GNU Fortran Compiler

call co_broadcast (val, source_image=1)
print *, this_image, ":", val
end program test

See also: Section 9.64 [CO_MAX], page 142, Section 9.65 [CO_MIN], page 142,
Section 9.67 [CO_SUM], page 144, Section 9.66 [CO_REDUCE], page 143

9.64 CO_MAX — Maximal value on the current set of images

Description:

CO_MAX determines element-wise the maximal value of A on all images of the current team. If RESULT_IMAGE is present, the maximum values are returned in A on the specified image only and the value of A on the other images become undefined. If RESULT_IMAGE is not present, the value is returned on all images. If the execution was successful and STAT is present, it is assigned the value zero. If the execution failed, STAT gets assigned a nonzero value and, if present, ERRMSG gets assigned a value describing the occurred error.

Standard: Technical Specification (TS) 18508 or later

Class: Collective subroutine

Syntax: CALL CO_MAX(A [, RESULT_IMAGE, STAT, ERRMSG])

Arguments:

A shall be an integer, real or character variable, which has the same type and type parameters on all images of the team.

RESULT_IMAGE (optional) a scalar integer expression; if present, it shall have the same value on all images and refer to an image of the current team.

STAT (optional) a scalar integer variable

ERRMSG (optional) a scalar character variable

Example:

program test
  integer :: val
  val = this_image ()
  call co_max (val, result_image=1)
  if (this_image() == 1) then
    write(*,*) "Maximal value", val ! prints num_images()
  end if
end program test

See also: Section 9.65 [CO_MIN], page 142, Section 9.67 [CO_SUM], page 144,
Section 9.66 [CO_REDUCE], page 143, Section 9.63 [CO_BROADCAST], page 141

9.65 CO_MIN — Minimal value on the current set of images

Description:

CO_MIN determines element-wise the minimal value of A on all images of the current team. If RESULT_IMAGE is present, the minimal values are returned in A on the specified image only and the value of A on the other images become
undefined. If RESULT_IMAGE is not present, the value is returned on all images. If the execution was successful and STAT is present, it is assigned the value zero. If the execution failed, STAT gets assigned a nonzero value and, if present, ERRMSG gets assigned a value describing the occurred error.

Standard: Technical Specification (TS) 18508 or later

Class: Collective subroutine

Syntax: \texttt{CALL CO\_MIN(A [, RESULT\_IMAGE, STAT, ERRMSG])}

Arguments:

- \texttt{A} shall be an integer, real or character variable, which has the same type and type parameters on all images of the team.
- \texttt{RESULT\_IMAGE} (optional) a scalar integer expression; if present, it shall have the same value on all images and refer to an image of the current team.
- \texttt{STAT} (optional) a scalar integer variable
- \texttt{ERRMSG} (optional) a scalar character variable

Example:

```fortran
program test
  integer :: val
  val = this_image()
  call co_min(val, result_image=1)
  if (this_image() == 1) then
    write(*,*) "Minimal value", val ! prints 1
  end if
end program test
```

See also: Section 9.64 [CO\_MAX], page 142, Section 9.67 [CO\_SUM], page 144, Section 9.66 [CO\_REDUCE], page 143, Section 9.63 [CO\_BROADCAST], page 141

9.66 CO\_REDUCE — Reduction of values on the current set of images

Description:

CO\_REDUCE determines element-wise the reduction of the value of \texttt{A} on all images of the current team. The pure function passed as \texttt{OPERATOR} is used to pairwise reduce the values of \texttt{A} by passing either the value of \texttt{A} of different images or the result values of such a reduction as argument. If \texttt{A} is an array, the deduction is done element wise. If RESULT_IMAGE is present, the result values are returned in \texttt{A} on the specified image only and the value of \texttt{A} on the other images become undefined. If RESULT_IMAGE is not present, the value is returned on all images. If the execution was successful and STAT is present, it is assigned the value zero. If the execution failed, STAT gets assigned a nonzero value and, if present, ERRMSG gets assigned a value describing the occurred error.

Standard: Technical Specification (TS) 18508 or later

Class: Collective subroutine
**Syntax:**

```
CALL CO_REDUCE(A, OPERATOR, [, RESULT_IMAGE, STAT, ERRMSG])
```  

**Arguments:**

- **A**
  - is an INTENT(INOUT) argument and shall be nonpolymorphic. If it is allocatable, it shall be allocated; if it is a pointer, it shall be associated. A shall have the same type and type parameters on all images of the team; if it is an array, it shall have the same shape on all images.
  - **OPERATOR**
    - pure function with two scalar nonallocatable arguments, which shall be nonpolymorphic and have the same type and type parameters as A. The function shall return a nonallocatable scalar of the same type and type parameters as A. The function shall be the same on all images and with regards to the arguments mathematically commutative and associative. Note that OPERATOR may not be an elemental function, unless it is an intrinsic function.
  - **RESULT_IMAGE** (optional) a scalar integer expression; if present, it shall have the same the same value on all images and refer to an image of the current team.
  - **STAT** (optional) a scalar integer variable
  - **ERRMSG** (optional) a scalar character variable

**Example:**

```fortran
program test
  integer :: val
  val = this_image()
  call co_reduce(val, result_image=1, operator=myprod)
  if (this_image() == 1) then
    write(*,*) "Product value", val ! prints num_images() factorial
  end if
contains
  pure function myprod(a, b)
    integer, value :: a, b
    integer :: myprod
    myprod = a * b
  end function myprod
end program test
```

**Note:**

While the rules permit in principle an intrinsic function, none of the intrinsics in the standard fulfill the criteria of having a specific function, which takes two arguments of the same type and returning that type as result.

**See also:** Section 9.65 [CO_MIN], page 142, Section 9.64 [CO_MAX], page 142, Section 9.67 [CO_SUM], page 144, Section 9.63 [CO_BROADCAST], page 141

### 9.67 CO_SUM — Sum of values on the current set of images

**Description:**

CO_SUM sums up the values of each element of A on all images of the current team. If RESULT_IMAGE is present, the summed-up values are returned in A on the specified image only and the value of A on the other images become undefined. If RESULT_IMAGE is not present, the value is returned on all
images. If the execution was successful and \texttt{STAT} is present, it is assigned the value zero. If the execution failed, \texttt{STAT} gets assigned a nonzero value and, if present, \texttt{ERRMSG} gets assigned a value describing the occurred error.

\textbf{Standard:} Technical Specification (TS) 18508 or later

\textbf{Class:} Collective subroutine

\textbf{Syntax:} \texttt{CALL CO\_MIN(A [, RESULT\_IMAGE, STAT, ERRMSG])}

\textbf{Arguments:}

- \texttt{A} shall be an integer, real or complex variable, which has the same type and type parameters on all images of the team.
- \texttt{RESULT\_IMAGE} (optional) a scalar integer expression; if present, it shall have the same value on all images and refer to an image of the current team.
- \texttt{STAT} (optional) a scalar integer variable
- \texttt{ERRMSG} (optional) a scalar character variable

\textbf{Example:}

```fortran
program test
  integer :: val
  val = this_image ()
call co_sum (val, result_image=1)
  if (this_image() == 1) then
    write(*,*) "The sum is ", val ! prints (n**2 + n)/2, with n = num_images()"
  end if
end program test
```

\textbf{See also:} Section 9.64 [CO\_MAX], page 142, Section 9.65 [CO\_MIN], page 142, Section 9.66 [CO\_REDUCE], page 143, Section 9.63 [CO\_BROADCAST], page 141

\textbf{9.68 COMMAND\_ARGUMENT\_COUNT — Get number of command line arguments}

\textbf{Description:}

\texttt{COMMAND\_ARGUMENT\_COUNT} returns the number of arguments passed on the command line when the containing program was invoked.

\textbf{Standard:} Fortran 2003 and later

\textbf{Class:} Inquiry function

\textbf{Syntax:} \texttt{RESULT = COMMAND\_ARGUMENT\_COUNT()}

\textbf{Arguments:}

None

\textbf{Return value:}

The return value is an \texttt{INTEGER} of default kind.

\textbf{Example:}

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

See also: Section 9.121 [GET_COMMAND], page 180, Section 9.122 [GET_COMMAND_ARGUMENT], page 180

9.69 COMPILER_OPTIONS — Options passed to the compiler

Description:

COMPILER_OPTIONS returns a string with the options used for compiling.

Standard: Fortran 2008

Class: Inquiry function of the module ISO_FORTRAN_ENV

Syntax: STR = COMPILER_OPTIONS()

Arguments:

None.

Return value:

The return value is a default-kind string with system-dependent length. It contains the compiler flags used to compile the file, which called the COMPILER_OPTIONS intrinsic.

Example:

use iso_fortran_env
print '(4a)', 'This file was compiled by ', &
   compiler_version(), ' using the options ', &
   compiler_options()
end

See also: Section 9.70 [COMPILER_VERSION], page 146, Section 10.1 [ISO_FORTRAN_ENV], page 273

9.70 COMPILER_VERSION — Compiler version string

Description:

COMPILER_VERSION returns a string with the name and the version of the compiler.

Standard: Fortran 2008

Class: Inquiry function of the module ISO_FORTRAN_ENV

Syntax: STR = COMPILER_VERSION()

Arguments:

None.

Return value:

The return value is a default-kind string with system-dependent length. It contains the name of the compiler and its version number.

Example:
use iso_fortran_env
print '(4a)', 'This file was compiled by ', 
    compiler_version(), ' using the options ', 
    compiler_options()
end

See also: Section 9.69 [COMPILER_OPTIONS], page 146, Section 10.1 [ISO_FORTRAN_ENV], page 273

9.71 COMPLEX — Complex conversion function

Description:
COMPLEX(X, Y) returns a complex number where X is converted to the real component and Y is converted to the imaginary component.

Standard: GNU extension
Class: Elemental function
Syntax: RESULT = COMPLEX(X, Y)
Arguments:
X The type may be INTEGER or REAL.
Y The type may be INTEGER or REAL.

Return value:
If X and Y are both of INTEGER type, then the return value is of default COMPLEX type.
If X and Y are of REAL type, or one is of REAL type and one is of INTEGER type, then the return value is of COMPLEX type with a kind equal to that of the REAL argument with the highest precision.

Example:

program test_complex
    integer :: i = 42
    real :: x = 3.14
    print *, complex(i, x)
end program test_complex

See also: Section 9.62 [CMPLX], page 140

9.72 CONJG — Complex conjugate function

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

Standard: Fortran 77 and later, has overloads that are GNU extensions
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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONJG(Z)</td>
<td>COMPLEX Z</td>
<td>COMPLEX</td>
<td>GNU extension</td>
</tr>
<tr>
<td>DCONJG(Z)</td>
<td>COMPLEX(8) Z</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

9.73 COS — Cosine function

Description:

COS(X) computes the cosine of X.

Standard: 
Fortran 77 and later, has overloads that are GNU extensions

Class: 
Elemental function

Syntax:

RESULT = COS(X)

Arguments:

X 
The type shall be REAL or COMPLEX.

Return value:

The return value is of the same type and kind as X. The real part of the result is in radians. If X is of the type REAL, the return value lies in the range $-1 \leq \cos(x) \leq 1$.

Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DCOS(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>CCOS(X)</td>
<td>COMPLEX(4) X</td>
<td>COMPLEX(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>ZCOS(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>CDCOS(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: 
Inverse function: Section 9.6 [ACOS], page 104 Degrees function: Section 9.74 [COSD], page 149
9.74 COSD — Cosine function, degrees

Description: 
COSD(X) computes the cosine of X in degrees.

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with ‘-fdec-math’.

Class: Elemental function

Syntax: 
RESULT = COSD(X)

Arguments: 
X The type shall be REAL or COMPLEX.

Return value: 
The return value is of the same type and kind as X. The real part of the result is in degrees. If X is of the type REAL, the return value lies in the range $-1 \leq \cosd(x) \leq 1$.

Example: 
program test_cosd
  real :: x = 0.0
  x = cosd(x)
end program test_cosd

Specific names: 

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSD(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DCOSD(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>CCOSD(X)</td>
<td>COMPLEX(4) X</td>
<td>COMPLEX(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>ZCOSD(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>CDCOSD(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.7 [ACOSD], page 105 Radians function: Section 9.73 [COS], page 148

9.75 COSH — Hyperbolic cosine function

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

Standard: Fortran 77 and later, for a complex argument Fortran 2008 or later

Class: Elemental function

Syntax: 
X = COSH(X)

Arguments: 
X The type shall be REAL or COMPLEX.

Return value: 
The return value has same type and kind as X. If X is complex, the imaginary part of the result is in radians. If X is REAL, the return value has a lower bound of one, $\cosh(x) \geq 1$. 
Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSH(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>D_COSH(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.8 [ACOSH], page 105

9.76 COTAN — Cotangent function

Description:

COTAN(X) computes the cotangent of X. Equivalent to \( \cos(x) \) divided by \( \sin(x) \), or \( 1 / \tan(x) \).

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with ‘-fdec-math’.

Class: Elemental function

Syntax: RESULT = COTAN(X)

Arguments:

X The type shall be REAL or COMPLEX.

Return value:

The return value has same type and kind as X, and its value is in radians.

Example:

```fortran
program test_cotan
  real(8) :: x = 0.165_8
  x = cotan(x)
end program test_cotan
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>COTAN(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>D_COTAN(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>

See also: Converse function: Section 9.263 [TAN], page 261 Degrees function: Section 9.77 [COTAND], page 150

9.77 COTAND — Cotangent function, degrees

Description:

COTAND(X) computes the cotangent of X in degrees. Equivalent to \( \cosd(x) \) divided by \( \sind(x) \), or \( 1 / \tand(x) \).
Chapter 9: Intrinsic Procedures

Standard: GNU Extension, enabled with ‘-fdec-math’.
This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Class: Elemental function

Syntax: \( \text{RESULT} = \text{COTAND}(X) \)

Arguments:
- \( X \) The type shall be \( \text{REAL} \) or \( \text{COMPLEX} \).

Return value:
The return value has same type and kind as \( X \), and its value is in degrees.

Example:

```fortran
program test_cotand
  real(8) :: x = 0.165_8
  x = cotand(x)
end program test_cotand
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>COTAND</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DCOTAND</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>

See also: Converse function: Section 9.264 [TAND], page 261 Radians function: Section 9.76 [COTAN], page 150

9.78 COUNT — Count function

Description:
Counts the number of .TRUE. elements in a logical \( \text{MASK} \), or, if the \( \text{DIM} \) argument is supplied, counts the number of elements along each row of the array in the \( \text{DIM} \) direction. If the array has zero size, or all of the elements of \( \text{MASK} \) are .FALSE., then the result is 0.

Standard: Fortran 95 and later, with \( \text{KIND} \) argument Fortran 2003 and later

Class: Transformational function

Syntax: \( \text{RESULT} = \text{COUNT}(\text{MASK} [, \text{DIM}, \text{KIND}]) \)

Arguments:
- \( \text{MASK} \) The type shall be \( \text{LOGICAL} \).
- \( \text{DIM} \) (Optional) The type shall be \( \text{INTEGER} \).
- \( \text{KIND} \) (Optional) An \( \text{INTEGER} \) initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type \( \text{INTEGER} \) and of kind \( \text{KIND} \). If \( \text{KIND} \) is absent, the return value is of default integer kind. If \( \text{DIM} \) is present, the result is an array with a rank one less than the rank of \( \text{ARRAY} \), and a size corresponding to the shape of \( \text{ARRAY} \) with the \( \text{DIM} \) dimension removed.

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 '(3i3)', mask(1,:)
  print '(3i3)', mask(2,:)
  print *
  print '(3i3)', count(mask)
  print *
  print '(3i3)', count(mask, 1)
  print *
  print '(3i3)', count(mask, 2)
end program test_count

9.79 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.
If a time source is available, time will be reported with microsecond resolution.
If no time source is available, TIME is set to -1.0.
Note that TIME may contain a, system dependent, arbitrary offset and may not start with 0.0. For CPU_TIME, the absolute value is meaningless, only differences between subsequent calls to this subroutine, as shown in the example below, should be used.

Standard: Fortran 95 and later
Class: Subroutine
Syntax: CALL CPU_TIME(TIME)
Arguments:
TIME 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
See also: Section 9.262 [SYSTEM_CLOCK], page 260, Section 9.82 [DATE_AND_TIME], page 154
9.80 CSHIFT — Circular shift elements of an array

*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 scalar of type INTEGER in the range of 1 \( \leq \) DIM \( \leq \) n 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.

*Standard:* Fortran 95 and later  
*Class:* Transformational function  
*Syntax:*  
RESULT = CSHIFT(ARRAY, SHIFT [, DIM])

*Arguments:*  
ARRAY Shall be an array of any type.  
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

9.81 CTIME — Convert a time into a string

*Description:*  
CTIME converts a system time value, such as returned by Section 9.268 [TIMES8], page 264, to a string. The output will be of the form ‘Sat Aug 19 18:13:14 1995’.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

*Standard:* GNU extension  
*Class:* Subroutine, function  
*Syntax:*  
CALL CTIME(TIME, RESULT).  
RESULT = CTIME(TIME).
Arguments:

\[
\begin{align*}
\text{TIME} & \quad \text{The type shall be of type INTEGER.} \\
\text{RESULT} & \quad \text{The type shall be of type CHARACTER and of default kind. It is an INTENT(OUT) argument. If the length of this variable is too short for the time and date string to fit completely, it will be blank on procedure return.}
\end{align*}
\]

Return value:

The converted date and time as a string.

Example:

```fortran
program test_ctime
    integer(8) :: i
    character(len=30) :: date
    i = time8()
    date = cttime(i, date)
    print *, 'Program was started on ', date
end program test_ctime
```

See Also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.130 [GMTIME], page 185, Section 9.182 [LTIME], page 214, Section 9.267 [TIME], page 264, Section 9.268 [TIME8], page 264

9.82 DATE_AND_TIME — Date and time subroutine

Description:

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

VALUES is INTENT(OUT) and provides the following:

\[
\begin{align*}
\text{VALUE(1):} & \quad \text{The year} \\
\text{VALUE(2):} & \quad \text{The month} \\
\text{VALUE(3):} & \quad \text{The day of the month} \\
\text{VALUE(4):} & \quad \text{Time difference with UTC in minutes} \\
\text{VALUE(5):} & \quad \text{The hour of the day} \\
\text{VALUE(6):} & \quad \text{The minutes of the hour} \\
\text{VALUE(7):} & \quad \text{The seconds of the minute} \\
\text{VALUE(8):} & \quad \text{The milliseconds of the second}
\end{align*}
\]

Standard: Fortran 95 and later

Class: Subroutine

Syntax: \text{CALL DATE_AND_TIME([DATE, TIME, ZONE, VALUES])}
Arguments:

DATE  (Optional) The type shall be CHARACTER(LEN=8) or larger, and of default kind.
TIME  (Optional) The type shall be CHARACTER(LEN=10) or larger, and of default kind.
ZONE  (Optional) The type shall be CHARACTER(LEN=5) or larger, and of default kind.
VALUES (Optional) The type shall be INTEGER(8).

Return value:
None

Example:

```fortran
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
```

See also: Section 9.79 [CPU_TIME], page 152, Section 9.262 [SYSTEM_CLOCK], page 260

9.83 DBLE — Double conversion function

Description:

DBLE(A) Converts A to double precision real type.

Standard: Fortran 77 and later

Class: Elemental function

Syntax: RESULT = DBLE(A)

Arguments:

A The type shall be INTEGER, REAL, or COMPLEX.

Return value:

The return value is of type double precision real.

Example:

```fortran
program test_dble
  real    :: x = 2.18
  integer :: i = 5
  complex :: z = (2.3,1.4)
  print *, dble(x), dble(i), dble(z)
end program test_dble
```

See also: Section 9.226 [REAL], page 239
9.84 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.

*Standard*: GNU extension

*Class*: Elemental function

*Syntax*:  
RESULT = 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*:  
```fortran
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
```

9.85 DIGITS — Significant binary digits function

*Description*:  
DIGITS(X) returns the number of significant binary 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.

*Standard*: Fortran 95 and later

*Class*: Inquiry function

*Syntax*:  
RESULT = DIGITS(X)

*Arguments*:  
X The type may be INTEGER or REAL.

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

*Example*:  
```fortran
program test_digits
  integer :: i = 12345
  real :: x = 3.143
```

9.86 DIM — Positive difference

Description:

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

Standard: Fortran 77 and later

Class: Elemental function

Syntax: RESULT = 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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIM(X,Y)</td>
<td>REAL(4) X, Y</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>IDIM(X,Y)</td>
<td>INTEGER(4) X,</td>
<td>INTEGER(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDIM(X,Y)</td>
<td>REAL(8) X, Y</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

9.87 DOT_PRODUCT — Dot product function

Description:

DOT_PRODUCT VECTOR_A, VECTOR_B computes the dot product multiplication of two vectors VECTOR_A and VECTOR_B. 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(VECTOR_A*VECTOR_B). If the vectors are COMPLEX, the result is SUM(CONJG(VECTOR_A)*VECTOR_B). If the vectors are LOGICAL, the result is ANY(VECTOR_A .AND. VECTOR_B).

Standard: Fortran 95 and later

Class: Transformational function
**Syntax:**
\[
\text{RESULT} = \text{DOT\_PRODUCT}(\text{VECTOR\_A}, \text{VECTOR\_B})
\]

**Arguments:**
- **VECTOR\_A** The type shall be numeric or LOGICAL, rank 1.
- **VECTOR\_B** The type shall be numeric if **VECTOR\_A** is of numeric type or LOGICAL if **VECTOR\_A** is of type LOGICAL. **VECTOR\_B** shall be a rank-one array.

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

**Example:**
```fortran
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 *, dot_product(a,b)
end program test_dot_prod
```

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

9.88 DPROD — Double product function

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

**Standard:** Fortran 77 and later

**Class:** Elemental function

**Syntax:**
\[
\text{RESULT} = \text{DPROD}(X, Y)
\]

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

**Specific names:**
<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPROD(X,Y)</td>
<td>REAL(4) X, Y</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>
9.89 DREAL — Double real part function

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

Standard: GNU extension

Class: Elemental function

Syntax: RESULT = DREAL(A)

Arguments:
A 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

See also: Section 9.11 [AIMAG], page 107

9.90 DSHIFTL — Combined left shift

Description:
DSHIFTL(I, J, SHIFT) combines bits of I and J. The rightmost SHIFT bits of the result are the leftmost SHIFT bits of J, and the remaining bits are the rightmost bits of I.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax: RESULT = DSHIFTL(I, J, SHIFT)

Arguments:
I Shall be of type INTEGER or a BOZ constant.
J Shall be of type INTEGER or a BOZ constant. If both I and J have integer type, then they shall have the same kind type parameter. I and J shall not both be BOZ constants.
SHIFT Shall be of type INTEGER. It shall be nonnegative. If I is not a BOZ constant, then SHIFT shall be less than or equal to BIT_SIZE(I); otherwise, SHIFT shall be less than or equal to BIT_SIZE(J).

Return value:
If either I or J is a BOZ constant, it is first converted as if by the intrinsic function INT to an integer type with the kind type parameter of the other.

See also: Section 9.91 [DSHIFTR], page 160
9.91 DSHIFTR — Combined right shift

*Description:*  
DSHIFTR(I, J, SHIFT) combines bits of I and J. The leftmost SHIFT bits of the result are the rightmost SHIFT bits of I, and the remaining bits are the leftmost bits of J.

*Standard:* Fortran 2008 and later  
*Class:* Elemental function

**Syntax:**  
RESULT = DSHIFTR(I, J, SHIFT)

**Arguments:**  
- **I** Shall be of type INTEGER or a BOZ constant.  
- **J** Shall be of type INTEGER or a BOZ constant. If both I and J have integer type, then they shall have the same kind type parameter. I and J shall not both be BOZ constants.  
- **SHIFT** Shall be of type INTEGER. It shall be nonnegative. If I is not a BOZ constant, then SHIFT shall be less than or equal to BIT_SIZE(I); otherwise, SHIFT shall be less than or equal to BIT_SIZE(J).

*Return value:*  
If either I or J is a BOZ constant, it is first converted as if by the intrinsic function INT to an integer type with the kind type parameter of the other.

*See also:* Section 9.90 [DSHIFTL], page 159

9.92 DTIME — Execution time subroutine (or function)

*Description:*  
DTIME(VALUES, TIME) initially returns the number of seconds of runtime since the start of the process’s execution in TIME. VALUES returns the user and system components of this time in VALUES(1) and VALUES(2) respectively. TIME is equal to VALUES(1) + VALUES(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 (wrap around) 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.

Please note, that this implementation is thread safe if used within OpenMP directives, i.e., its state will be consistent while called from multiple threads. However, if DTIME is called from multiple threads, the result is still the time since the last invocation. This may not give the intended results. If possible, use CPU_TIME instead.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.
VALUES and TIME are INTENT(OUT) and provide the following:

VALUES(1): User time in seconds.
VALUES(2): System time in seconds.
TIME: Run time since start in seconds.

Standard: GNU extension
Class: Subroutine, function
Syntax:

CALL DTIME(VALUES, TIME).
TIME = DTIME(VALUES), (not recommended).

Arguments:

VALUES The type shall be REAL(4), DIMENSION(2).
TIME The type shall be REAL(4).

Return value:
Elapsed time in seconds since the last invocation or since the start of program execution if not called before.

Example:

```fortran
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=1,10000000 ! 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
```

See also: Section 9.79 [CPU_TIME], page 152

9.93 EOSHIFT — End-off shift elements of an array

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 scalar of type INTEGER in the range of 1 ≤ DIM ≤ n) 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.

Standard: Fortran 95 and later
Class: Transformational function
Syntax: RESULT = EOSHIFT(ARRAY, SHIFT [, BOUNDARY, DIM])

Arguments:
ARRAY May be any type, not scalar.
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:

```fortran
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
```

9.94 EPSILON — Epsilon function

Description:
EPSILON(X) returns the smallest number E of the same kind as X such that 
1 + E > 1.

Standard: Fortran 95 and later
Class: Inquiry function
Syntax: RESULT = EPSILON(X)

Arguments:
X The type shall be REAL.

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

Example:

```fortran
program test_epsilon
    real :: x = 3.143
    real(8) :: y = 2.33
    print *, EPSILON(x)
    print *, EPSILON(y)
end program test_epsilon
```
9.95 ERF — Error function

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

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: RESULT = ERF(X)

Arguments:
X The type shall be REAL.

Return value:
The return value is of type REAL, of the same kind as X and lies in the range $-1 \leq erf(x) \leq 1$.

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DERF(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

9.96 ERFC — Error function

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

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: RESULT = ERFC(X)

Arguments:
X The type shall be REAL.

Return value:
The return value is of type REAL and of the same kind as X. It lies in the range $0 \leq erfc(x) \leq 2$.

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>DERFC(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>
9.97 ERFC_SCALED — Error function

Description:

ERFC_SCALED(X) computes the exponentially-scaled complementary error function of X.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax:

RESULT = ERFC_SCALED(X)

Arguments:

X The type shall be REAL.

Return value:

The return value is of type REAL and of the same kind as X.

Example:

program test_erfc_scaled
  real(8) :: x = 0.17_8
  x = erfc_scaled(x)
end program test_erfc_scaled

9.98 ETIME — Execution time subroutine (or function)

Description:

ETIME(VALUES, TIME) returns the number of seconds of runtime since the start of the process’s execution in TIME. VALUES returns the user and system components of this time in VALUES(1) and VALUES(2) respectively. TIME is equal to VALUES(1) + VALUES(2).

On some systems, the underlying timings are represented using types with sufficiently small limits that overflows (wrap around) 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.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

VALUES and TIME are INTENT(OUT) and provide the following:

VALUES(1): User time in seconds.
VALUES(2): System time in seconds.
TIME: Run time since start in seconds.

Standard: GNU extension

Class: Subroutine, function

Syntax:

CALL ETIME(VALUES, TIME).
TIME = ETIME(VALUES), (not recommended).

Arguments:

VALUES The type shall be REAL(4), DIMENSION(2).
TIME The type shall be REAL(4).
Return value:

Elapsed time in seconds since the start of program execution.

Example:

```fortran
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
```

See also:  Section 9.79 [CPU_TIME], page 152

9.99 EVENT_QUERY — Query whether a coarray event has occurred

Description:

EVENT_QUERY assigns the number of events to COUNT which have been posted to the EVENT variable and not yet been removed by calling EVENT_WAIT. When STAT is present and the invocation was successful, it is assigned the value 0. If it is present and the invocation has failed, it is assigned a positive value and COUNT is assigned the value −1.

Standard:  TS 18508 or later

Class: subroutine

Syntax:  CALL EVENT_QUERY (EVENT, COUNT [, STAT])

Arguments:

EVENT (intent(IN)) Scalar of type EVENT_TYPE, defined in ISO_FORTRAN_ENV; shall not be coindexed.

COUNT (intent(out)) Scalar integer with at least the precision of default integer.

STAT (optional) Scalar default-kind integer variable.

Example:

```fortran
program atomic
  use iso_fortran_env
  implicit none
  type(event_type) :: event_value_has_been_set[*]
  integer :: cnt
  if (this_image() == 1) then
    call event_query (event_value_has_been_set, cnt)
    if (cnt > 0) write(*,*) "Value has been set"
  end if
end program atomic
```
9.100 EXECUTE_COMMAND_LINE — Execute a shell command

Description:

EXECUTE_COMMAND_LINE runs a shell command, synchronously or asynchronously.

The COMMAND argument is passed to the shell and executed, using the C library’s system call. (The shell is sh on Unix systems, and cmd.exe on Windows.) If WAIT is present and has the value false, the execution of the command is asynchronous if the system supports it; otherwise, the command is executed synchronously.

The three last arguments allow the user to get status information. After synchronous execution, EXITSTAT contains the integer exit code of the command, as returned by system. CMDSTAT is set to zero if the command line was executed (whatever its exit status was). CMDMSG is assigned an error message if an error has occurred.

Note that the system function need not be thread-safe. It is the responsibility of the user to ensure that system is not called concurrently.

Standard:     Fortran 2008 and later
Class:        Subroutine
Syntax:       CALL EXECUTE_COMMAND_LINE(COMMAND [, WAIT, EXITSTAT, CMDSTAT, CMDMSG ])
Arguments:
COMMAND       Shall be a default CHARACTER scalar.
WAIT          (Optional) Shall be a default LOGICAL scalar.
EXITSTAT      (Optional) Shall be an INTEGER of the default kind.
CMDSTAT       (Optional) Shall be an INTEGER of the default kind.
CMDMSG        (Optional) Shall be an CHARACTER scalar of the default kind.
Example:

program test_exec
  integer :: i

  call execute_command_line ("external_prog.exe", exitstat=i)
  print *, "Exit status of external_prog.exe was ", i

  call execute_command_line ("reindex_files.exe", wait=.false.)
  print *, "Now reindexing files in the background"

end program test_exec

Note:        Because this intrinsic is implemented in terms of the system function call, its behavior with respect to signaling is processor dependent. In particular, on
POSIX-compliant systems, the SIGINT and SIGQUIT signals will be ignored, and the SIGCHLD will be blocked. As such, if the parent process is terminated, the child process might not be terminated alongside.

See also: Section 9.261 [SYSTEM], page 259

9.101 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.

Standard: GNU extension

Class: Subroutine

Syntax: CALL EXIT([STATUS])

Arguments:
STATUS Shall be an INTEGER of the default kind.

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

Example:

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

See also: Section 9.2 [ABORT], page 101, Section 9.161 [KILL], page 203

9.102 EXP — Exponential function

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

Standard: Fortran 77 and later, has overloads that are GNU extensions

Class: Elemental function

Syntax: RESULT = EXP(X)

Arguments:

X The type shall be REAL or COMPLEX.

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

Example:

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DEXP(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>CEXP(X)</td>
<td>COMPLEX(4) X</td>
<td>COMPLEX(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>ZEXP(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>CDEXP(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

9.103 EXPONENT — Exponent function

Description:

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

Standard: Fortran 95 and later
Class: Elemental function
Syntax: RESULT = EXPONENT(X)
Arguments:
X The type shall be REAL.
Return value:
The return value is of type default INTEGER.
Example:

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

9.104 EXTENDS_TYPE_OF — Query dynamic type for extension

Description:

Query dynamic type for extension.

Standard: Fortran 2003 and later
Class: Inquiry function
Syntax: RESULT = EXTENDS_TYPE_OF(A, MOLD)
Arguments:
A Shall be an object of extensible declared type or unlimited polymorphic.
MOLD Shall be an object of extensible declared type or unlimited polymorphic.
Return value:
The return value is a scalar of type default logical. It is true if and only if the dynamic type of A is an extension type of the dynamic type of MOLD.
See also: Section 9.232 [SAME_TYPE_AS], page 242
9.105 FDATE — Get the current time as a string

Description:
FDATE(DATE) returns the current date (using the same format as Section 9.81 [CTIME], page 153) in DATE. It is equivalent to CALL CTIME(DATE, TIME()). This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:
CALL FDATE(DATE).
DATE = FDATE().

Arguments:
DATE The type shall be of type CHARACTER of the default kind. It is an INTENT(OUT) argument. If the length of this variable is too short for the date and time string to fit completely, it will be blank on procedure return.

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

See also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.81 [CTIME], page 153

9.106 FGET — Read a single character in stream mode from stdin

Description:
Read a single character in stream mode from stdin by bypassing normal formatted output. Stream I/O should not be mixed with normal record-oriented (formatted or unformatted) I/O on the same unit; the results are unpredictable. This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Note that the FGET intrinsic is provided for backwards compatibility with g77. GNU Fortran provides the Fortran 2003 Stream facility. Programmers should consider the use of new stream IO feature in new code for future portability. See also Section 4.1 [Fortran 2003 status], page 35.
**Standard:** GNU extension

**Class:** Subroutine, function

**Syntax:**
```
CALL FGET(C [, STATUS])
STATUS = FGET(C)
```

**Arguments:**
- `C`: The type shall be `CHARACTER` and of default kind.
- `STATUS`: (Optional) status flag of type `INTEGER`. Returns 0 on success, -1 on end-of-file, and a system specific positive error code otherwise.

**Example:**
```
PROGRAM test_fget
  INTEGER, PARAMETER :: strlen = 100
  INTEGER :: status, i = 1
  CHARACTER(len=strlen) :: str = ""
  WRITE (*,*) 'Enter text:'
  DO
    CALL fget(str(i:i), status)
    if (status /= 0 .OR. i > strlen) exit
    i = i + 1
  END DO
  WRITE (*,*) TRIM(str)
END PROGRAM
```

**See also:** Section 9.107 [FGETC], page 170, Section 9.111 [FPUT], page 173, Section 9.112 [FPUTC], page 174

### 9.107 FGETC — Read a single character in stream mode

**Description:**
Read a single character in stream mode by bypassing normal formatted output. Stream I/O should not be mixed with normal record-oriented (formatted or unformatted) I/O on the same unit; the results are unpredictable.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Note that the FGET intrinsic is provided for backwards compatibility with g77. GNU Fortran provides the Fortran 2003 Stream facility. Programmers should consider the use of new stream IO feature in new code for future portability.

**Standard:** GNU extension

**Class:** Subroutine, function

**Syntax:**
```
CALL FGETC(UNIT, C [, STATUS])
STATUS = FGETC(UNIT, C)
```
Arguments:

UNIT                The type shall be INTEGER.
C                   The type shall be CHARACTER and of default kind.
STATUS              (Optional) status flag of type INTEGER. Returns 0 on success, -1 on end-of-file and a system specific positive error code otherwise.

Example:

```
PROGRAM test_fgetc
    INTEGER :: fd = 42, status
    CHARACTER :: c
    OPEN(UNIT=fd, FILE="/etc/passwd", ACTION="READ", STATUS = "OLD")
    DO
        CALL fgetc(fd, c, status)
        IF (status /= 0) EXIT
        call fputc(c)
    END DO
    CLOSE(UNIT=fd)
END PROGRAM
```

See also: Section 9.106 [FGET], page 169, Section 9.111 [FPUT], page 173, Section 9.112 [FPUTC], page 174

9.108 FLOOR — Integer floor function

Description:

FLOOR(A) returns the greatest integer less than or equal to X.

Standard: Fortran 95 and later

Class: Elemental function

Syntax: RESULT = FLOOR(A [, KIND])

Arguments:

A                     The type shall be REAL.
KIND                  (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:

The return value is of type INTEGER(KIND) if KIND is present and of default-kind INTEGER otherwise.

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
```

See also: Section 9.58 [CEILING], page 138, Section 9.205 [NINT], page 227
9.109 FLUSH — Flush I/O unit(s)

*Description:* Flushes Fortran unit(s) currently open for output. Without the optional argument, all units are flushed, otherwise just the unit specified.

*Standard:* GNU extension

*Class:* Subroutine

*Syntax:* `CALL FLUSH(UNIT)`

*Arguments:*

- `UNIT` (Optional) The type shall be `INTEGER`.

*Note:* Beginning with the Fortran 2003 standard, there is a `FLUSH` statement that should be preferred over the `FLUSH` intrinsic.

The `FLUSH` intrinsic and the Fortran 2003 `FLUSH` statement have identical effect: they flush the runtime library’s I/O buffer so that the data becomes visible to other processes. This does not guarantee that the data is committed to disk.

On POSIX systems, you can request that all data is transferred to the storage device by calling the `fsync` function, with the POSIX file descriptor of the I/O unit as argument (retrieved with GNU intrinsic `FNUM`). The following example shows how:

```fortran
! Declare the interface for POSIX fsync function
interface
  function fsync (fd) bind(c,name="fsync")
  use iso_c_binding, only: c_int
  integer(c_int), value :: fd
  integer(c_int) :: fsync
  end function fsync
end interface

! Variable declaration
integer :: ret

! Opening unit 10
open (10,file="foo")

! ... 
! Perform I/O on unit 10
! ...

! Flush and sync
flush(10)
ret = fsync(fnum(10))

! Handle possible error
if (ret /= 0) stop "Error calling FSYNC"
```

9.110 FNUM — File number function

*Description:* `FNUM(UNIT)` returns the POSIX file descriptor number corresponding to the open Fortran I/O unit `UNIT`. 
**Standard:** GNU extension  
**Class:** Function  
**Syntax:**  
\[
\text{RESULT} = \text{FNUM} (\text{UNIT})
\]

**Arguments:**  
\[
\text{UNIT} \quad \text{The type shall be INTEGER.}
\]

**Return value:**  
The return value is of type INTEGER

**Example:**

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

### 9.111 FPUT — Write a single character in stream mode to stdout

**Description:**  
Write a single character in stream mode to stdout by bypassing normal formatted output. Stream I/O should not be mixed with normal record-oriented (formatted or unformatted) I/O on the same unit; the results are unpredictable. This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Note that the FGET intrinsic is provided for backwards compatibility with g77. GNU Fortran provides the Fortran 2003 Stream facility. Programmers should consider the use of new stream IO feature in new code for future portability. See also Section 4.1 [Fortran 2003 status], page 35.

**Standard:** GNU extension  
**Class:** Subroutine, function  
**Syntax:**  
\[
\text{CALL} \text{FPUT} (C \left[\text{, STATUS}\right])
\]

\[
\text{STATUS} = \text{FPUT} (C)
\]

**Arguments:**  
\[
C \quad \text{The type shall be CHARACTER and of default kind.}
\]

\[
\text{STATUS} \quad \text{(Optional) status flag of type INTEGER. Returns 0 on success, -1 on end-of-file and a system specific positive error code otherwise.}
\]

**Example:**

```fortran
program test_fput
    CHARACTER(len=10) :: str = "gfortran"
    INTEGER :: i
    DO i = 1, len_trim(str)
```

CALL fputc(str(i:i))
END DO
END PROGRAM

See also: Section 9.112 [FPUTC], page 174, Section 9.106 [FGET], page 169, Section 9.107 [FGETC], page 170

9.112 FPUTC — Write a single character in stream mode

Description:
Write a single character in stream mode by bypassing normal formatted output. Stream I/O should not be mixed with normal record-oriented (formatted or unformatted) I/O on the same unit; the results are unpredictable.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Note that the FGET intrinsic is provided for backwards compatibility with g77. GNU Fortran provides the Fortran 2003 Stream facility. Programmers should consider the use of new stream IO feature in new code for future portability. See also Section 4.1 [Fortran 2003 status], page 35.

Standard: GNU extension

Class: Subroutine, function

Syntax:

CALL FPUTC(UNIT, C [, STATUS])
STATUS = FPUTC(UNIT, C)

Arguments:

UNIT The type shall be INTEGER.
C The type shall be CHARACTER and of default kind.
STATUS (Optional) status flag of type INTEGER. Returns 0 on success, -1 on end-of-file and a system specific positive error code otherwise.

Example:

PROGRAM test_fputc
  CHARACTER(len=10) :: str = "gfortran"
  INTEGER :: fd = 42, i

  OPEN(UNIT = fd, FILE = "out", ACTION = "WRITE", STATUS="NEW")
  DO i = 1, len_trim(str)
    CALL fputc(fd, str(i:i))
  END DO
  CLOSE(fd)
END PROGRAM

See also: Section 9.111 [FPUT], page 173, Section 9.106 [FGET], page 169, Section 9.107 [FGETC], page 170
9.113 FRACTION — Fractional part of the model representation

Description:
FRACTION(X) returns the fractional part of the model representation of X.

Standard: Fortran 95 and later
Class: Elemental function
Syntax: Y = FRACTION(X)
Arguments:
X The type of the argument shall be a REAL.

Return value:
The return value is of the same type and kind as the argument. The fractional part of the model representation of X is returned; it is X * RADIX(X)**(-EXPONENT(X)).

Example:
program test_fraction
real :: x
x = 178.1387e-4
print *, fraction(x), x * radix(x)**(-exponent(x))
end program test_fraction

9.114 FREE — Frees memory

Description:
Frees memory previously allocated by MALLOC. The FREE intrinsic is an extension intended to be used with Cray pointers, and is provided in GNU Fortran to allow user to compile legacy code. For new code using Fortran 95 pointers, the memory de-allocation intrinsic is DEALLOCATE.

Standard: GNU extension
Class: Subroutine
Syntax: CALL FREE(PTR)
Arguments:
PTR The type shall be INTEGER. It represents the location of the memory that should be de-allocated.

Return value:
None
Example: See MALLOC for an example.
See also: Section 9.183 [MALLOC], page 215

9.115 FSEEK — Low level file positioning subroutine

Description:
Moves UNIT to the specified OFFSET. If WHENCE is set to 0, the OFFSET is taken as an absolute value SEEK_SET, if set to 1, OFFSET is taken to be
relative to the current position \texttt{SEEK\_CUR}, and if set to 2 relative to the end of the file \texttt{SEEK\_END}. On error, \texttt{STATUS} is set to a nonzero value. If \texttt{STATUS} the seek fails silently.

This intrinsic routine is not fully backwards compatible with \texttt{g77}. In \texttt{g77}, the \texttt{FSEEK} takes a statement label instead of a \texttt{STATUS} variable. If \texttt{FSEEK} is used in old code, change

\begin{verbatim}
CALL FSEEK(UNIT, OFFSET, WHENCE, *label)
\end{verbatim}

to

\begin{verbatim}
INTEGER :: status
CALL FSEEK(UNIT, OFFSET, WHENCE, status)
IF (status /= 0) GO TO label
\end{verbatim}

Please note that GNU Fortran provides the Fortran 2003 Stream facility. Programmers should consider the use of new stream IO feature in new code for future portability. See also Section 4.1 [Fortran 2003 status], page 35.

\textbf{Standard:} GNU extension

\textbf{Class:} Subroutine

\textbf{Syntax:} \texttt{CALL FSEEK(UNIT, OFFSET, WHENCE[, STATUS])}

\textbf{Arguments:}

- \texttt{UNIT} \quad Shall be a scalar of type \texttt{INTEGER}.
- \texttt{OFFSET} \quad Shall be a scalar of type \texttt{INTEGER}.
- \texttt{WHENCE} \quad Shall be a scalar of type \texttt{INTEGER}. Its value shall be either 0, 1 or 2.
- \texttt{STATUS} \quad (Optional) shall be a scalar of type \texttt{INTEGER}(4).

\textbf{Example:}

\begin{verbatim}
PROGRAM test_fseek
  INTEGER, PARAMETER :: SEEK_SET = 0, SEEK_CUR = 1, SEEK_END = 2
  INTEGER :: fd, offset, ierr

  ierr = 0
  offset = 5
  fd = 10

  OPEN(UNIT=fd, FILE="fseek.test")
  CALL FSEEK(fd, offset, SEEK_SET, ierr) ! move to OFFSET
  print *, FTELL(fd), ierr

  CALL FSEEK(fd, 0, SEEK_END, ierr) ! move to end
  print *, FTELL(fd), ierr

  CALL FSEEK(fd, 0, SEEK_SET, ierr) ! move to beginning
  print *, FTELL(fd), ierr

  CLOSE(UNIT=fd)
END PROGRAM
\end{verbatim}

\textbf{See also:} Section 9.117 [FTELL], page 177
9.116 FSTAT — Get file status

Description:

FSTAT is identical to Section 9.257 [STAT], page 256, except that information about an already opened file is obtained.
The elements in VALUES are the same as described by Section 9.257 [STAT], page 256.
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function

Syntax:

\[
\begin{align*}
\text{CALL FSTAT(UNIT, VALUES [, , STATUS])} \\
\text{STATUS} = \text{FSTAT(UNIT, VALUES)}
\end{align*}
\]

Arguments:

\[
\begin{align*}
\text{UNIT} & \quad \text{An open I/O unit number of type INTEGER.} \\
\text{VALUES} & \quad \text{The type shall be INTEGER(4), DIMENSION(13).} \\
\text{STATUS} & \quad \text{(Optional) status flag of type INTEGER(4). Returns 0 on success and a system specific error code otherwise.}
\end{align*}
\]

Example: See Section 9.257 [STAT], page 256 for an example.

See also: To stat a link: Section 9.181 [LSTAT], page 213, to stat a file: Section 9.257 [STAT], page 256

9.117 FTELL — Current stream position

Description:

Retrieves the current position within an open file.
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function

Syntax:

\[
\begin{align*}
\text{CALL FTELL(UNIT, OFFSET)} \\
\text{OFFSET} = \text{FTELL(UNIT)}
\end{align*}
\]

Arguments:

\[
\begin{align*}
\text{OFFSET} & \quad \text{Shall of type INTEGER.} \\
\text{UNIT} & \quad \text{Shall of type INTEGER.}
\end{align*}
\]

Return value:

In either syntax, OFFSET is set to the current offset of unit number UNIT, or to −1 if the unit is not currently open.

Example:
PROGRAM test_ftell
INTEGER :: i
OPEN(10, FILE="temp.dat")
CALL ftell(10,i)
WRITE(*,*) i
END PROGRAM

See also: Section 9.115 [FSEEK], page 175

9.118 GAMMA — Gamma function

Description:
GAMMA(X) computes Gamma (Γ) of X. For positive, integer values of X the Gamma function simplifies to the factorial function \( \Gamma(x) = (x - 1)! \).

\[
\Gamma(x) = \int_0^\infty t^{x-1}e^{-t} dt
\]

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: \( X = \text{GAMMA}(X) \)
Arguments:
X Shall be of type REAL and neither zero nor a negative integer.
Return value: The return value is of type REAL of the same kind as X.
Example:

```
program test_gamma
real :: x = 1.0
x = gamma(x) ! returns 1.0
end program test_gamma
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAMMA(X)</td>
<td>REAL(4)  X</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DGAMMA(X)</td>
<td>REAL(8)  X</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>

See also: Logarithm of the Gamma function: Section 9.177 [LOG_GAMMA], page 211

9.119 GERROR — Get last system error message

Description:
Returns the system error message corresponding to the last system error. This resembles the functionality of \texttt{strerror(3)} in C.

Standard: GNU extension
Class: Subroutine
Syntax: \texttt{CALL GERROR(RESULT)}
Arguments:
RESULT Shall of type CHARACTER and of default
Example:

```fortran
PROGRAM test_gerror
    CHARACTER(len=100) :: msg
    CALL gerror(msg)
    WRITE(*,*) msg
END PROGRAM
```

See also: Section 9.145 [IERRNO], page 194, Section 9.213 [PERROR], page 232

9.120 GETARG — Get command line arguments

Description:
Retrieve the \texttt{POS}-th argument that was passed on the command line when the containing program was invoked.

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. In new code, programmers should consider the use of the Section 9.122 [GET_COMMAND_ARGUMENT], page 180 intrinsic defined by the Fortran 2003 standard.

Standard: GNU extension

Class: Subroutine

Syntax: \texttt{CALL \texttt{GETARG}(\texttt{POS}, \texttt{VALUE})}

Arguments:

\begin{itemize}
  \item \texttt{POS} \hspace{1cm} Shall be of type \texttt{INTEGER} and not wider than the default integer kind; \texttt{POS} \geq 0
  \item \texttt{VALUE} \hspace{1cm} Shall be of type \texttt{CHARACTER} and of default kind.
  \item \texttt{VALUE} \hspace{1cm} Shall be of type \texttt{CHARACTER}.
\end{itemize}

Return value:
After \texttt{GETARG} returns, the \texttt{VALUE} argument holds the \texttt{POS}th command line argument. If \texttt{VALUE} can not hold the argument, it is truncated to fit the length of \texttt{VALUE}. If there are less than \texttt{POS} arguments specified at the command line, \texttt{VALUE} will be filled with blanks. If \texttt{POS} = 0, \texttt{VALUE} is set to the name of the program (on systems that support this feature).

Example:

```fortran
PROGRAM test_getarg
    INTEGER :: i
    CHARACTER(len=32) :: arg
    DO i = 1, iargc()
        CALL getarg(i, arg)
        WRITE (*,*) arg
    END DO
END PROGRAM
```

See also: GNU Fortran 77 compatibility function: Section 9.138 [IARGC], page 190
Fortran 2003 functions and subroutines: Section 9.121 [GET_COMMAND], page 180, Section 9.122 [GET_COMMAND_ARGUMENT], page 180, Section 9.68 [COMMAND_ARGUMENT_COUNT], page 145
9.121 GET_COMMAND — Get the entire command line

Description:
Retrieve the entire command line that was used to invoke the program.

Standard: Fortran 2003 and later
Class: Subroutine
Syntax: CALL GET_COMMAND([COMMAND, LENGTH, STATUS])
Arguments:
- COMMAND (Optional) shall be of type CHARACTER and of default kind.
- LENGTH (Optional) Shall be of type INTEGER and of default kind.
- STATUS (Optional) Shall be of type INTEGER and of default kind.

Return value:
If COMMAND is present, stores the entire command line that was used to invoke the program in COMMAND. If LENGTH is present, it is assigned the length of the command line. If STATUS is present, it is assigned 0 upon success of the command, -1 if COMMAND is too short to store the command line, or a positive value in case of an error.

Example:
```
PROGRAM test_get_command
  CHARACTER(len=255) :: cmd
  CALL get_command(cmd)
  WRITE (*,*) TRIM(cmd)
END PROGRAM
```

See also: Section 9.122 [GET_COMMAND_ARGUMENT], page 180, Section 9.68 [COMMAND_ARGUMENT_COUNT], page 145

9.122 GET_COMMAND_ARGUMENT — Get command line arguments

Description:
Retrieve the NUMBER-th argument that was passed on the command line when the containing program was invoked.

Standard: Fortran 2003 and later
Class: Subroutine
Syntax: CALL GET_COMMAND_ARGUMENT(NUMBER [, VALUE, LENGTH, STATUS])
Arguments:
- NUMBER Shall be a scalar of type INTEGER and of default kind, NUMBER ≥ 0
- VALUE (Optional) Shall be a scalar of type CHARACTER and of default kind.
- LENGTH (Optional) Shall be a scalar of type INTEGER and of default kind.
- STATUS (Optional) Shall be a scalar of type INTEGER and of default kind.
Return value:
After \texttt{GET\_COMMAND\_ARGUMENT} returns, the \texttt{VALUE} argument holds the \texttt{NUMBER}-th command line argument. If \texttt{VALUE} can not hold the argument, it is truncated to fit the length of \texttt{VALUE}. If there are less than \texttt{NUMBER} arguments specified at the command line, \texttt{VALUE} will be filled with blanks. If \texttt{NUMBER} = 0, \texttt{VALUE} is set to the name of the program (on systems that support this feature). The \texttt{LENGTH} argument contains the length of the \texttt{NUMBER}-th command line argument. If the argument retrieval fails, \texttt{STATUS} is a positive number; if \texttt{VALUE} contains a truncated command line argument, \texttt{STATUS} is -1; and otherwise the \texttt{STATUS} is zero.

Example:

\begin{verbatim}
PROGRAM test_get_command_argument  
  INTEGER :: i  
  CHARACTER(len=32) :: arg  
  i = 0  
  DO  
    CALL get_command_argument(i, arg)  
    IF (LEN_TRIM(arg) == 0) EXIT  
    WRITE (*,*) TRIM(arg)  
    i = i+1  
  END DO  
END PROGRAM
\end{verbatim}

See also: Section 9.121 [GET\_COMMAND], page 180, Section 9.68 [COMMAND\_ARGUMENT\_COUNT], page 145

9.123 GETCWD — Get current working directory

Description:
Get current working directory.
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:
\begin{verbatim}
CALL GETCWD(C [, STATUS])  
STATUS = GETCWD(C)
\end{verbatim}

Arguments:
\begin{itemize}
  \item \texttt{C} The type shall be \texttt{CHARACTER} and of default kind.
  \item \texttt{STATUS} (Optional) status flag. Returns 0 on success, a system specific and nonzero error code otherwise.
\end{itemize}

Example:

\begin{verbatim}
PROGRAM test_getcwd  
  CHARACTER(len=255) :: cwd  
  CALL getcwd(cwd)  
  WRITE(*,*), TRIM(cwd)  
END PROGRAM
\end{verbatim}
9.124 GETENV — Get an environmental variable

Description:
Get the VALUE of the environmental variable NAME.
This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. In new code, programmers should consider the use of the Section 9.125 \[GET\_ENVIRONMENT\_VARIABLE], page 182 intrinsic defined by the Fortran 2003 standard.
Note that GETENV need not be thread-safe. It is the responsibility of the user to ensure that the environment is not being updated concurrently with a call to the GETENV intrinsic.

Standard: GNU extension
Class: Subroutine
Syntax: CALL GETENV(NAME, VALUE)

Arguments:
NAME Shall be of type CHARACTER and of default kind.
VALUE Shall be of type CHARACTER and of default kind.

Return value:
Stores the value of NAME in VALUE. If VALUE is not large enough to hold the data, it is truncated. If NAME is not set, VALUE will be filled with blanks.

Example:

PROGRAM test_getenv
CHARACTER(len=255) :: homedir
CALL getenv("HOME", homedir)
WRITE (*,*) TRIM(homedir)
END PROGRAM

See also: Section 9.125 \[GET\_ENVIRONMENT\_VARIABLE], page 182

9.125 GET_ENVIRONMENT_VARIABLE — Get an environmental variable

Description:
Get the VALUE of the environmental variable NAME.
Note that GET_ENVIRONMENT_VARIABLE need not be thread-safe. It is the responsibility of the user to ensure that the environment is not being updated concurrently with a call to the GET_ENVIRONMENT_VARIABLE intrinsic.

Standard: Fortran 2003 and later
Class: Subroutine
Syntax: CALL GET_ENVIRONMENT_VARIABLE(NAME[, VALUE, LENGTH, STATUS, TRIM_NAME])
Arguments:

- **NAME**: Shall be a scalar of type `CHARACTER` and of default kind.
- **VALUE**: (Optional) Shall be a scalar of type `CHARACTER` and of default kind.
- **LENGTH**: (Optional) Shall be a scalar of type `INTEGER` and of default kind.
- **STATUS**: (Optional) Shall be a scalar of type `INTEGER` and of default kind.
- **TRIM_NAME**: (Optional) Shall be a scalar of type `LOGICAL` and of default kind.

Return value:

Stores the value of `NAME` in `VALUE`. If `VALUE` is not large enough to hold the data, it is truncated. If `NAME` is not set, `VALUE` will be filled with blanks. Argument `LENGTH` contains the length needed for storing the environment variable `NAME` or zero if it is not present. `STATUS` is -1 if `VALUE` is present but too short for the environment variable; it is 1 if the environment variable does not exist and 2 if the processor does not support environment variables; in all other cases `STATUS` is zero. If `TRIM_NAME` is present with the value `.FALSE.`, the trailing blanks in `NAME` are significant; otherwise they are not part of the environment variable name.

Example:

```fortran
PROGRAM test_getenv
  CHARACTER(len=255) :: homedir
  CALL get_environment_variable("HOME", homedir)
  WRITE (*,*) TRIM(homedir)
END PROGRAM
```

### 9.126 GETGID — Group ID function

**Description:**

Returns the numerical group ID of the current process.

**Standard:** GNU extension

**Class:** Function

**Syntax:** `RESULT = GETGID()`

**Return value:**

The return value of `GETGID` is an `INTEGER` of the default kind.

**Example:** See `GETPID` for an example.

**See also:** Section 9.128 [GETPID], page 184, Section 9.129 [GETUID], page 184

### 9.127 GETLOG — Get login name

**Description:**

Gets the username under which the program is running.

**Standard:** GNU extension
Class: Subroutine

Syntax: CALL GETLOG(C)

Arguments:

\( C \) Shall be of type CHARACTER and of default kind.

Return value:

Stores the current user name in LOGIN. (On systems where POSIX functions geteuid and getpwuid are not available, and the getlogin function is not implemented either, this will return a blank string.)

Example:

```fortran
PROGRAM TEST_GETLOG
  CHARACTER(32) :: login
  CALL GETLOG login
  WRITE(*,*) login
END PROGRAM
```

See also: Section 9.129 [GETUID], page 184

9.128 GETPID — Process ID function

Description:

Returns the numerical process identifier of the current process.

Standard: GNU extension

Class: Function

Syntax: RESULT = GETPID()

Return value:

The return value of GETPID is an INTEGER of the default kind.

Example:

```fortran
program info
  print *, "The current process ID is ", getpid()
  print *, "Your numerical user ID is ", getuid()
  print *, "Your numerical group ID is ", getgid()
end program info
```

See also: Section 9.126 [GETGID], page 183, Section 9.129 [GETUID], page 184

9.129 GETUID — User ID function

Description:

Returns the numerical user ID of the current process.

Standard: GNU extension

Class: Function

Syntax: RESULT = GETUID()

Return value:

The return value of GETUID is an INTEGER of the default kind.

Example: See GETPID for an example.

See also: Section 9.128 [GETPID], page 184, Section 9.127 [GETLOG], page 183
9.130 GMTIME — Convert time to GMT info

Description:
Given a system time value TIME (as provided by the Section 9.267 [TIME], page 264 intrinsic), fills VALUES with values extracted from it appropriate to the UTC time zone (Universal Coordinated Time, also known in some countries as GMT, Greenwich Mean Time), using gmtime(3).

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. In new code, programmers should consider the use of the Section 9.82 [DATE_AND_TIME], page 154 intrinsic defined by the Fortran 95 standard.

Standard: GNU extension
Class: Subroutine
Syntax: CALL GMTIME(TIME, VALUES)
Arguments:
TIME An INTEGER scalar expression corresponding to a system time, with INTENT(IN).
VALUES A default INTEGER array with 9 elements, with INTENT(OUT).

Return value:
The elements of VALUES are assigned as follows:
1. Seconds after the minute, range 0–59 or 0–61 to allow for leap seconds
2. Minutes after the hour, range 0–59
3. Hours past midnight, range 0–23
4. Day of month, range 1–31
5. Number of months since January, range 0–11
6. Years since 1900
7. Number of days since Sunday, range 0–6
8. Days since January 1, range 0–365
9. Daylight savings indicator: positive if daylight savings is in effect, zero if not, and negative if the information is not available.

See also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.81 [CTIME], page 153, Section 9.182 [LTIME], page 214, Section 9.267 [TIME], page 264, Section 9.268 [TIME8], page 264

9.131 HOSTNM — Get system host name

Description:
Retrieves the host name of the system on which the program is running.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:

```fortran
CALL HOSTNM(C [, STATUS])
STATUS = HOSTNM(NAME)
```

**Arguments:**

- `C` Shall of type `CHARACTER` and of default kind.
- `STATUS` (Optional) status flag of type `INTEGER`. Returns 0 on success, or a system specific error code otherwise.

**Return value:**

In either syntax, `NAME` is set to the current hostname if it can be obtained, or to a blank string otherwise.

### 9.132 HUGE — Largest number of a kind

**Description:**

`HUGE(X)` returns the largest number that is not an infinity in the model of the type of `X`.

**Standard:** Fortran 95 and later

**Class:** Inquiry function

**Syntax:**

```fortran
RESULT = HUGE(X)
```

**Arguments:**

- `X` Shall be of type `REAL` or `INTEGER`.

**Return value:**

The return value is of the same type and kind as `X`

**Example:**

```fortran
program test_huge_tiny
  print *, huge(0), huge(0.0), huge(0.0d0)
  print *, tiny(0.0), tiny(0.0d0)
end program test_huge_tiny
```

### 9.133 HYPOT — Euclidean distance function

**Description:**

`HYPOT(X,Y)` is the Euclidean distance function. It is equal to \( \sqrt{X^2 + Y^2} \), without undue underflow or overflow.

**Standard:** Fortran 2008 and later

**Class:** Elemental function

**Syntax:**

```fortran
RESULT = HYPOT(X, Y)
```

**Arguments:**

- `X` The type shall be `REAL`.
- `Y` The type and kind type parameter shall be the same as `X`.

**Return value:**

The return value has the same type and kind type parameter as `X`.
Example:

```fortran
program test_hypot
  real(4) :: x = 1.e0_4, y = 0.5e0_4
  x = hypot(x,y)
end program test_hypot
```

9.134 IACHAR — Code in ASCII collating sequence

Description:
IACHAR(C) returns the code for the ASCII character in the first character position of C.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Elemental function

Syntax: RESULT = IACHAR(C [, KIND])

Arguments:
- C Shall be a scalar CHARACTER, with INTENT(IN)
- KIND (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind.

Example:

```fortran
program test_iachar
  integer i
  i = iachar(‘ ’)
end program test_iachar
```

Note: See Section 9.142 [ICHAR], page 192 for a discussion of converting between numerical values and formatted string representations.

See also: Section 9.5 [ACHAR], page 103, Section 9.59 [CHAR], page 138, Section 9.142 [ICHAR], page 192

9.135 IALL — Bitwise AND of array elements

Description:
Reduces with bitwise AND the elements of ARRAY along dimension DIM if the corresponding element in MASK is TRUE.

Standard: Fortran 2008 and later

Class: Transformational function

Syntax:
RESULT = IALL(ARRAY [, MASK])
RESULT = IALL(ARRAY, DIM [, MASK])

Arguments:
- ARRAY Shall be an array of type INTEGER
DIM (Optional) shall be a scalar of type INTEGER with a value in the range from 1 to n, where n equals the rank of ARRAY.

MASK (Optional) shall be of type LOGICAL and either be a scalar or an array of the same shape as ARRAY.

Return value:
The result is of the same type as ARRAY.
If DIM is absent, a scalar with the bitwise ALL of all elements in ARRAY is returned. Otherwise, an array of rank n-1, where n equals the rank of ARRAY, and a shape similar to that of ARRAY with dimension DIM dropped is returned.

Example:

```
PROGRAM test_iand
  INTEGER(1) :: a(2)
  a(1) = b'00100100'
  a(2) = b'01101010'
  ! prints 00100000
  PRINT '(b8.8)', IALL(a)
END PROGRAM
```

See also: Section 9.137 [IANY], page 189, Section 9.152 [IPARITY], page 198, Section 9.136 [IAND], page 188

9.136 IAND — Bitwise logical AND

Description:
Bitwise logical AND.

Standard: Fortran 95 and later, has overloads that are GNU extensions

Class: Elemental function

Syntax: RESULT = IAND(I, J)

Arguments:

- I The type shall be INTEGER.
- J The type shall be INTEGER, of the same kind as I. (As a GNU extension, different kinds are also permitted.)

Return value:
The return type is INTEGER, of the same kind as the arguments. (If the argument kinds differ, it is of the same kind as the larger argument.)

Example:

```
PROGRAM test_iand
  INTEGER :: a, b
  DATA a / Z'F' /, b / Z'3' /
  WRITE (*,*) IAND(a, b)
END PROGRAM
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAND</td>
<td>I, J</td>
<td>INTEGER</td>
<td></td>
</tr>
</tbody>
</table>
IAND(A)

| INTEGER A | INTEGER | Fortran 95 and later |

BIAND(A)

| INTEGER(1) A | INTEGER(1) | GNU extension |

IIAND(A)

| INTEGER(2) A | INTEGER(2) | GNU extension |

JIAND(A)

| INTEGER(4) A | INTEGER(4) | GNU extension |

KIAND(A)

| INTEGER(8) A | INTEGER(8) | GNU extension |

See also: Section 9.151 [IOR], page 197, Section 9.144 [IEOR], page 193, Section 9.140 [IBITS], page 191, Section 9.141 [IBSET], page 191, Section 9.139 [IBCLR], page 190, Section 9.207 [NOT], page 228

9.137 IANY — Bitwise OR of array elements

Description:
Reduces with bitwise OR (inclusive or) the elements of ARRAY along dimension DIM if the corresponding element in MASK is TRUE.

Standard: Fortran 2008 and later

Class: Transformational function

Syntax:
RESULT = IANY(ARRAY[, MASK])
RESULT = IANY(ARRAY, DIM[, MASK])

Arguments:
ARRAY Shall be an array of type INTEGER
DIM (Optional) shall be a scalar of type INTEGER with a value in the range from 1 to n, where n equals the rank of ARRAY.
MASK (Optional) shall be of type LOGICAL and either be a scalar or an array of the same shape as ARRAY.

Return value:
The result is of the same type as ARRAY.
If DIM is absent, a scalar with the bitwise OR of all elements in ARRAY is returned. Otherwise, an array of rank n-1, where n equals the rank of ARRAY, and a shape similar to that of ARRAY with dimension DIM dropped is returned.

Example:

```
PROGRAM test_iany
  INTEGER(1) :: a(2)

  a(1) = b'00100100'
  a(2) = b'01101010'

  ! prints 01101110
  PRINT '(b8.8)', IANY(a)
END PROGRAM
```

See also: Section 9.152 [IPARITY], page 198, Section 9.135 [IALL], page 187, Section 9.151 [IOR], page 197
9.138 IARGC — Get the number of command line arguments

Description:
IARGC returns the number of arguments passed on the command line when the containing program was invoked.
This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. In new code, programmers should consider the use of the Section 9.68 [COMMAND_ARGUMENT_COUNT], page 145 intrinsic defined by the Fortran 2003 standard.

Standard: GNU extension
Class: Function
Syntax: RESULT = IARGC()
Arguments: None.
Return value: The number of command line arguments, type INTEGER(4).
Example: See Section 9.120 [GETARG], page 179
See also: GNU Fortran 77 compatibility subroutine: Section 9.120 [GETARG], page 179 Fortran 2003 functions and subroutines: Section 9.121 [GET_COMMAND], page 180, Section 9.122 [GET_COMMAND_ARGUMENT], page 180, Section 9.68 [COMMAND_ARGUMENT_COUNT], page 145

9.139 IBCLR — Clear bit

Description:
IBCLR returns the value of I with the bit at position POS set to zero.

Standard: Fortran 95 and later, has overloads that are GNU extensions
Class: Elemental function
Syntax: RESULT = IBCLR(I, POS)
Arguments:
I The type shall be INTEGER.
POS The type shall be INTEGER.

Return value:
The return value is of type INTEGER and of the same kind as I.
Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBCLR(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BBCLR(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IIBCLR(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JIBCLR(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KIBCLR(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>


**9.140 IBITS — Bit extraction**

*Description:*  
IBITS extracts a field of length LEN from I, starting from bit position POS and extending left for LEN bits. The result is right-justified and the remaining bits are zeroed. The value of POS+LEN must be less than or equal to the value BIT_SIZE(I).

*Standard:* Fortran 95 and later, has overloads that are GNU extensions

*Class:* Elemental function

*Syntax:*  
RESULT = IBITS(I, POS, LEN)

*Arguments:*  
- **I**: The type shall be INTEGER.  
- **POS**: The type shall be INTEGER.  
- **LEN**: The type shall be INTEGER.

*Return value:*  
The return value is of type INTEGER and of the same kind as I.

*Specific names:*  
<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBITS(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BBITS(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IBITS(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JIBITS(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KIBITS(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

*See also:*  
Section 9.48 [BIT_SIZE], page 132, Section 9.139 [IBCLR], page 190, Section 9.141 [IBSET], page 191, Section 9.136 [IAND], page 188, Section 9.151 [IOR], page 197, Section 9.144 [IEOR], page 193

**9.141 IBSET — Set bit**

*Description:*  
IBSET returns the value of I with the bit at position POS set to one.

*Standard:* Fortran 95 and later, has overloads that are GNU extensions

*Class:* Elemental function

*Syntax:*  
RESULT = IBSET(I, POS)

*Arguments:*  
- **I**: The type shall be INTEGER.  
- **POS**: The type shall be INTEGER.

*Return value:*  
The return value is of type INTEGER and of the same kind as I.
Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBSET(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BBSET(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IIBSET(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JIBSET(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KIBSET(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Section 9.139 [IBCLR], page 190, Section 9.140 [IBITS], page 191, Section 9.136 [IAND], page 188, Section 9.151 [IOR], page 197, Section 9.144 [IEOR], page 193, Section 9.202 [MVBITS], page 225

9.142 ICHAR — Character-to-integer conversion function

Description:
ICHAR(C) returns the code for the character in the first character position of C in the system’s native character set. The correspondence between characters and their codes is not necessarily the same across different GNU Fortran implementations.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Elemental function

Syntax: RESULT = ICHAR(C [, KIND])

Arguments:
C Shall be a scalar CHARACTER, with INTENT(IN)
KIND (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind.

Example:

```fortran
program test_ichar
    integer i
    i = ichar(' ')
end program test_ichar
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICHAR(C)</td>
<td>CHARACTER C</td>
<td>INTEGER(4)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

Note: No intrinsic exists to convert between a numeric value and a formatted character string representation – for instance, given the CHARACTER value ’154’, obtaining an INTEGER or REAL value with the value 154, or vice versa. Instead, this functionality is provided by internal-file I/O, as in the following example:

```fortran
program read_val
    integer value
    character(len=10) string, string2
    string = '154'
```
! Convert a string to a numeric value
read (string,'(I10)') value
print *, value

! Convert a value to a formatted string
write (string2,'(I10)') value
print *, string2
end program read_val

See also: Section 9.5 [ACHAR], page 103, Section 9.59 [CHAR], page 138, Section 9.134 [IACHAR], page 187

9.143 IDATE — Get current local time subroutine
(day/month/year)

Description:
IDATE(VALUES) Fills VALUES with the numerical values at the current local
time. The day (in the range 1-31), month (in the range 1-12), and year appear
in elements 1, 2, and 3 of VALUES, respectively. The year has four significant
digits.
This intrinsic routine is provided for backwards compatibility with GNU Fortran
77. In new code, programmers should consider the use of the Section 9.82
[DATE_AND_TIME], page 154 intrinsic defined by the Fortran 95 standard.

Standard: GNU extension
Class: Subroutine
Syntax: CALL IDATE(VALUES)
Arguments:
VALUES The type shall be INTEGER, DIMENSION(3) and the kind shall
be the default integer kind.

Return value:
Does not return anything.

Example:
program test_idate
integer, dimension(3) :: tarray
call idate(tarray)
print *, tarray(1)
print *, tarray(2)
print *, tarray(3)
end program test_idate

See also: Section 9.82 [DATE_AND_TIME], page 154

9.144 IEOR — Bitwise logical exclusive or

Description:
IEOR returns the bitwise Boolean exclusive-OR of I and J.

Standard: Fortran 95 and later, has overloads that are GNU extensions
Class: Elemental function

Syntax: RESULT = Ieor(I, J)

Arguments:

I The type shall be INTEGER.
J The type shall be INTEGER, of the same kind as I. (As a GNU
extension, different kinds are also permitted.)

Return value:
The return type is INTEGER, of the same kind as the arguments. (If the argument
kinds differ, it is of the same kind as the larger argument.)

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ieor(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>Bieor(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>Iieor(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>Jieor(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>Kieor(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Section 9.151 [IOR], page 197, Section 9.136 [IAND], page 188, Section 9.140
[IBITS], page 191, Section 9.141 [IBSET], page 191, Section 9.139 [IBCLR],
page 190, Section 9.207 [NOT], page 228

9.145 IERRNO — Get the last system error number

Description:
Returns the last system error number, as given by the C errno variable.

Standard: GNU extension

Class: Function

Syntax: RESULT = IERRNO()

Arguments:
None.

Return value:
The return value is of type INTEGER and of the default integer kind.

See also: Section 9.213 [PERROR], page 232

9.146 IMAGE_INDEX — Function that converts a cosubscript to
an image index

Description:
Returns the image index belonging to a cosubscript.

Standard: Fortran 2008 and later

Class: Inquiry function.

Syntax: RESULT = IMAGE_INDEX(COARRAY, SUB)
Chapter 9: Intrinsic Procedures

Arguments: None.

COARRAY  Coarray of any type.
SUB      default integer rank-1 array of a size equal to the corank of COARRAY.

Return value:
Scalar default integer with the value of the image index which corresponds to the cosubscripts. For invalid cosubscripts the result is zero.

Example:

INTEGER :: array[2,-1:4,8,*]
! Writes 28 (or 0 if there are fewer than 28 images)
WRITE (*,*) IMAGE_INDEX (array, [2,0,3,1])

See also: Section 9.266 [THIS_IMAGE], page 263, Section 9.209 [NUM_IMAGES], page 229

9.147 INDEX — Position of a substring within a string

Description:
Returns the position of the start of the first occurrence of string SUBSTRING as a substring in STRING, counting from one. If SUBSTRING is not present in STRING, zero is returned. If the BACK argument is present and true, the return value is the start of the last occurrence rather than the first.

Standard: Fortran 77 and later, with KIND argument Fortran 2003 and later
Class: Elemental function
Syntax: RESULT = INDEX(STRING, SUBSTRING [, BACK [, KIND]])

Arguments:
STRING        Shall be a scalar CHARACTER, with INTENT(IN)
SUBSTRING      Shall be a scalar CHARACTER, with INTENT(IN)
BACK          (Optional) Shall be a scalar LOGICAL, with INTENT(IN)
KIND          (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind.

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDEX(STRING, SUBSTRING)</td>
<td>CHARACTER</td>
<td>INTEGER(4)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Section 9.234 [SCAN], page 243, Section 9.280 [VERIFY], page 270

9.148 INT — Convert to integer type

Description:
Convert to integer type
Standard: Fortran 77 and later

Class: Elemental function

Syntax: \( \text{RESULT} = \text{INT}(A \ [ , \ \text{KIND})] \)

Arguments:

- \( A \) shall be of type INTEGER, REAL, or COMPLEX.
- \( \text{KIND} \) (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:

These functions return a INTEGER variable or array under the following rules:

(A) If \( A \) is of type INTEGER, \( \text{INT}(A) = A \)

(B) If \( A \) is of type REAL and \( |A| < 1 \), \( \text{INT}(A) \) equals 0. If \( |A| \geq 1 \), then \( \text{INT}(A) \) is the integer whose magnitude is the largest integer that does not exceed the magnitude of \( A \) and whose sign is the same as the sign of \( A \).

(C) If \( A \) is of type COMPLEX, rule B is applied to the real part of \( A \).

Example:

```fortran
program test_int
  integer :: i = 42
  complex :: z = (-3.7, 1.0)
  print *, int(i)
  print *, int(z), int(z, 8)
end program
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT(A)</td>
<td>REAL(4)</td>
<td>A</td>
<td>INTEGER</td>
</tr>
<tr>
<td>IFIX(A)</td>
<td>REAL(4)</td>
<td>A</td>
<td>INTEGER</td>
</tr>
<tr>
<td>IDINT(A)</td>
<td>REAL(8)</td>
<td>A</td>
<td>INTEGER</td>
</tr>
</tbody>
</table>

9.149 INT2 — Convert to 16-bit integer type

Description:

Convert to a KIND=2 integer type. This is equivalent to the standard INT intrinsic with an optional argument of KIND=2, and is only included for backwards compatibility.

The SHORT intrinsic is equivalent to INT2.

Standard: GNU extension

Class: Elemental function

Syntax: \( \text{RESULT} = \text{INT2}(A) \)

Arguments:

- \( A \) shall be of type INTEGER, REAL, or COMPLEX.

Return value:

The return value is a INTEGER(2) variable.
9.150 INT8 — Convert to 64-bit integer type

Description:
Convert to a KIND=8 integer type. This is equivalent to the standard INT intrinsic with an optional argument of KIND=8, and is only included for backwards compatibility.

Standard: GNU extension
Class: Elemental function
Syntax: RESULT = INT8(A)
Arguments:
A Shall be of type INTEGER, REAL, or COMPLEX.

Return value:
The return value is a INTEGER(8) variable.

See also: Section 9.148 [INT], page 195, Section 9.150 [INT8], page 197, Section 9.179 [LONG], page 212

9.151 IOR — Bitwise logical or

Description:
IOR returns the bitwise Boolean inclusive-OR of I and J.

Standard: Fortran 95 and later, has overloads that are GNU extensions
Class: Elemental function
Syntax: RESULT = IOR(I, J)
Arguments:
I The type shall be INTEGER.
J The type shall be INTEGER, of the same kind as I. (As a GNU extension, different kinds are also permitted.)

Return value:
The return type is INTEGER, of the same kind as the arguments. (If the argument kinds differ, it is of the same kind as the larger argument.)

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOR(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BIOR(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IIOR(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JIOR(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KIOR(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Section 9.144 [IEOR], page 193, Section 9.136 [IAND], page 188, Section 9.140 [IBITS], page 191, Section 9.141 [IBSET], page 191, Section 9.139 [IBCLR], page 190, Section 9.207 [NOT], page 228
9.152 IPARITY — Bitwise XOR of array elements

Description:
Reduces with bitwise XOR (exclusive or) the elements of ARRAY along dimension DIM if the corresponding element in MASK is TRUE.

Standard: Fortran 2008 and later
Class: Transformational function
Syntax:
RESULT = IPARITY(ARRAY[, MASK])
RESULT = IPARITY(ARRAY, DIM[, MASK])

Arguments:

- **ARRAY**: Shall be an array of type INTEGER
- **DIM** (Optional) shall be a scalar of type INTEGER with a value in the range from 1 to n, where n equals the rank of ARRAY.
- **MASK** (Optional) shall be of type LOGICAL and either be a scalar or an array of the same shape as ARRAY.

Return value:
The result is of the same type as ARRAY.
If DIM is absent, a scalar with the bitwise XOR of all elements in ARRAY is returned. Otherwise, an array of rank n-1, where n equals the rank of ARRAY, and a shape similar to that of ARRAY with dimension DIM dropped is returned.

Example:

```fortran
PROGRAM test_iparity
  INTEGER(1) :: a(2)
  a(1) = b’00100100’
  a(2) = b’01101010’
  ! prints 01001110
  PRINT ’(b8.8)’, IPARITY(a)
END PROGRAM
```

See also: Section 9.137 [IANY], page 189, Section 9.135 [IALL], page 187, Section 9.144 [IEOR], page 193, Section 9.212 [PARITY], page 231

9.153 IRAND — Integer pseudo-random number

Description:
IRAND(FLAG) returns a pseudo-random number from a uniform distribution between 0 and a system-dependent limit (which is in most cases 2147483647). If FLAG is 0, the next number in the current sequence is returned; if FLAG is 1, the generator is restarted by CALL SRAND(0); if FLAG has any other value, it is used as a new seed with SRAND.

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. It implements a simple modulo generator as provided by g77. For new code,
one should consider the use of Section 9.222 [RANDOM_NUMBER], page 236 as it implements a superior algorithm.

Standard: GNU extension

Class: Function

Syntax: \( \text{RESULT} = \text{IRAND}(I) \)

Arguments:
\( I \)  Shall be a scalar INTEGER of kind 4.

Return value:
The return value is of INTEGER(kind=4) type.

Example:
```fortran
program test_irand
  integer,parameter :: seed = 86456
  call srand(seed)
  print *, irand(), irand(), irand(), irand()
  print *, irand(seed), irand(), irand(), irand()
end program test_irand
```

9.154 **IS_IOSTAT_END** — Test for end-of-file value

Description:
IS_IOSTAT_END tests whether an variable has the value of the I/O status “end of file”. The function is equivalent to comparing the variable with the IOSTAT_END parameter of the intrinsic module ISO_FORTRAN_ENV.

Standard: Fortran 2003 and later

Class: Elemental function

Syntax: \( \text{RESULT} = \text{IS_IOSTAT_END}(I) \)

Arguments:
\( I \)  Shall be of the type INTEGER.

Return value:
Returns a LOGICAL of the default kind, which .TRUE. if \( I \) has the value which indicates an end of file condition for IOSTAT= specifiers, and is .FALSE. otherwise.

Example:
```fortran
PROGRAM iostat
  IMPLICIT NONE
  INTEGER :: stat, i
  OPEN(88, FILE='test.dat')
  READ(88, *, IOSTAT=stat) i
  IF(IS_IOSTAT_END(stat)) STOP 'END OF FILE'
END PROGRAM
```
9.155 IS_IOSTAT_EOR — Test for end-of-record value

Description:

IS_IOSTAT_EOR tests whether an variable has the value of the I/O status “end of record”. The function is equivalent to comparing the variable with the IOSTAT_EOR parameter of the intrinsic module ISO_FORTRAN_ENV.

Standard: Fortran 2003 and later
Class: Elemental function
Syntax: RESULT = IS_IOSTAT_EOR(I)
Arguments:
I Shall be of the type INTEGER.
Return value:
Returns a LOGICAL of the default kind, which .TRUE. if I has the value which indicates an end of file condition for IOSTAT= specifiers, and is .FALSE. otherwise.

Example:

PROGRAM iostat
IMPLICIT NONE
INTEGER :: stat, i(50)
OPEN(88, FILE='test.dat', FORM='UNFORMATTED')
READ(88, IOSTAT=stat) i
IF(IS_IOSTAT_EOR(stat)) STOP 'END OF RECORD'
END PROGRAM

9.156 ISATTY — Whether a unit is a terminal device.

Description:

Determine whether a unit is connected to a terminal device.

Standard: GNU extension
Class: Function
Syntax: RESULT = ISATTY(UNIT)
Arguments:
UNIT Shall be a scalar INTEGER.
Return value:
Returns .TRUE. if the UNIT is connected to a terminal device, .FALSE. otherwise.

Example:

PROGRAM test_isatty
INTEGER(kind=1) :: unit
DO unit = 1, 10
write(*,*) isatty(unit=unit)
END DO
END PROGRAM

See also: Section 9.274 [TTYNAM], page 267
9.157 ISHFT — Shift bits

Description:
ISHFT returns a value corresponding to I with all of the bits shifted SHIFT places. A value of SHIFT greater than zero corresponds to a left shift, a value of zero corresponds to no shift, and a value less than zero corresponds to a right shift. If the absolute value of SHIFT is greater than BIT_SIZE(I), the value is undefined. Bits shifted out from the left end or right end are lost; zeros are shifted in from the opposite end.

Standard: Fortran 95 and later, has overloads that are GNU extensions
Class: Elemental function
Syntax: RESULT = ISHFT(I, SHIFT)
Arguments:
I The type shall be INTEGER.
SHIFT The type shall be INTEGER.
Return value:
The return value is of type INTEGER and of the same kind as I.

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISHFT(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BSHIFT(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IISHFT(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JISHFT(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KISHFT(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Section 9.158 [ISHFTC], page 201

9.158 ISHFTC — Shift bits circularly

Description:
ISHFTC returns a value corresponding to I with the rightmost SIZE bits shifted circularly SHIFT places; that is, bits shifted out one end are shifted into the opposite end. A value of SHIFT greater than zero corresponds to a left shift, a value of zero corresponds to no shift, and a value less than zero corresponds to a right shift. The absolute value of SHIFT must be less than SIZE. If the SIZE argument is omitted, it is taken to be equivalent to BIT_SIZE(I).

Standard: Fortran 95 and later, has overloads that are GNU extensions
Class: Elemental function
Syntax: RESULT = ISHFTC(I, SHIFT [, SIZE])
Arguments:
I The type shall be INTEGER.
SHIFT The type shall be INTEGER.
SIZE (Optional) The type shall be INTEGER; the value must be greater than zero and less than or equal to BIT_SIZE(I).
Return value:
The return value is of type INTEGER and of the same kind as $I$.

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISHFTC(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BSHFTC(A)</td>
<td>INTEGER(1)A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IISHFTC(A)</td>
<td>INTEGER(2)A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JISHFTC(A)</td>
<td>INTEGER(4)A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KISHFTC(A)</td>
<td>INTEGER(8)A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Section 9.157 [ISHFT], page 201

9.159 **ISNAN** — Test for a NaN

Description:
```fortran
ISNAN tests whether a floating-point value is an IEEE Not-a-Number (NaN).
```

Standard: GNU extension

Class: Elemental function

Syntax: ISNAN(X)

Arguments:
```fortran
X Variable of the type REAL.
```

Return value:
```fortran
Returns a default-kind LOGICAL. The returned value is TRUE if X is a NaN and FALSE otherwise.
```

Example:
```fortran
program test_nan
  implicit none
  real :: x
  x = -1.0
  x = sqrt(x)
  if (isnan(x)) stop '"x" is a NaN'
end program test_nan
```

9.160 **ITIME** — Get current local time subroutine
(hour/minutes/seconds)

Description:
```fortran
ITIME(VALUE) Fills VALUES with the numerical values at the current local time. The hour (in the range 1-24), minute (in the range 1-60), and seconds (in the range 1-60) appear in elements 1, 2, and 3 of VALUES, respectively.
```

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. In new code, programmers should consider the use of the Section 9.82 [DATE_AND_TIME], page 154 intrinsic defined by the Fortran 95 standard.

Standard: GNU extension
Section 9.161 KILL — Send a signal to a process

Description:
Standard: Sends the signal specified by SIGNAL to the process PID. See kill(2).

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Class: Subroutine, function

Syntax:
CALL KILL(C, VALUE [, STATUS])
STATUS = KILL(C, VALUE)

Arguments:
C Shall be a scalar INTEGER, with INTENT(IN)
VALUE Shall be a scalar INTEGER, with INTENT(IN)
STATUS (Optional) status flag of type INTEGER(4) or INTEGER(8). Returns 0 on success, or a system-specific error code otherwise.

See also: Section 9.2 [ABORT], page 101, Section 9.101 [EXIT], page 167

Section 9.162 KIND — Kind of an entity

Description:
KIND(X) returns the kind value of the entity X.

Standard: Fortran 95 and later

Class: Inquiry function

Syntax: K = KIND(X)
Arguments:

\[ X \] Shall be of type LOGICAL, INTEGER, REAL, COMPLEX or CHARACTER.

Return value:

The return value is a scalar of type INTEGER and of the default integer kind.

Example:

```
program test_kind
    integer, parameter :: kc = kind(’ ’)
    integer, parameter :: kl = kind(.true.)

    print *, “The default character kind is ”, kc
    print *, “The default logical kind is ”, kl
end program test_kind
```

9.163 LBOUND — Lower dimension bounds of an array

Description:

Returns the lower bounds of an array, or a single lower bound along the \texttt{DIM} dimension.

Standard: Fortran 95 and later, with \texttt{KIND} argument Fortran 2003 and later

Class: Inquiry function

Syntax: \texttt{RESULT = LBOUND(ARRAY [, DIM [, KIND]])}

Arguments:

\texttt{ARRAY} Shall be an array, of any type.

\texttt{DIM} (Optional) Shall be a scalar INTEGER.

\texttt{KIND} (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:

The return value is of type INTEGER and of kind \texttt{KIND}. If \texttt{KIND} is absent, the return value is of default integer kind. If \texttt{DIM} is absent, the result is an array of the lower bounds of \texttt{ARRAY}. If \texttt{DIM} is present, the result is a scalar corresponding to the lower bound of the array along that dimension. If \texttt{ARRAY} is an expression rather than a whole array or array structure component, or if it has a zero extent along the relevant dimension, the lower bound is taken to be 1.

See also: Section 9.275 [UBOUND], page 268, Section 9.164 [LCOBOUND], page 204

9.164 LCOBOUND — Lower codimension bounds of an array

Description:

Returns the lower bounds of a coarray, or a single lower cobound along the \texttt{DIM} codimension.

Standard: Fortran 2008 and later

Class: Inquiry function
Syntax: \( \text{RESULT} = \text{LCOBOUND} (\text{COARRAY} [, \text{DIM} [, \text{KIND}]]) \)

Arguments:
- ARRAY: Shall be an coarray, of any type.
- DIM: (Optional) Shall be a scalar INTEGER.
- KIND: (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind. If DIM is absent, the result is an array of the lower cobounds of COARRAY. If DIM is present, the result is a scalar corresponding to the lower cobound of the array along that codimension.

See also: Section 9.276 [UCOBOUND], page 268, Section 9.163 [LBOUND], page 204

9.165 LEADZ — Number of leading zero bits of an integer

Description:
LEADZ returns the number of leading zero bits of an integer.

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: \( \text{RESULT} = \text{LEADZ} (\text{I}) \)
Arguments:
- I: Shall be of type INTEGER.

Return value:
The type of the return value is the default INTEGER. If all the bits of I are zero, the result value is BIT_SIZE(I).

Example:
```fortran
PROGRAM test_leadz
  WRITE (*,*) BIT_SIZE(1) ! prints 32
  WRITE (*,*) LEADZ(1) ! prints 31
END PROGRAM
```

See also: Section 9.48 [BIT_SIZE], page 132, Section 9.270 [TRAILZ], page 265, Section 9.214 [POPCNT], page 232, Section 9.215 [POPPAR], page 233

9.166 LEN — Length of a character entity

Description:
Returns the length of a character string. If STRING is an array, the length of an element of STRING is returned. Note that STRING need not be defined when this intrinsic is invoked, since only the length, not the content, of STRING is needed.

Standard: Fortran 77 and later, with KIND argument Fortran 2003 and later
Class: Inquiry function
**Syntax:**  
\[ L = \text{LEN}(\text{STRING} \ [, \ \text{KIND}]) \]

**Arguments:**
- **STRING**  
  Shall be a scalar or array of type `CHARACTER`, with `INTENT(IN)`
- **KIND**  
  (Optional) An `INTEGER` initialization expression indicating the kind parameter of the result.

**Return value:**
- The return value is of type `INTEGER` and of kind `KIND`. If `KIND` is absent, the return value is of default integer kind.

**Specific names:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEN(STRING)</td>
<td>CHARACTER</td>
<td>INTEGER</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

**See also:** Section 9.167 [LEN_TRIM], page 206, Section 9.9 [ADJUSTL], page 106, Section 9.10 [ADJUSTR], page 106

### 9.167 LEN_TRIM — Length of a character entity without trailing blank characters

**Description:**

Returns the length of a character string, ignoring any trailing blanks.

**Standard:** Fortran 95 and later, with `KIND` argument Fortran 2003 and later

**Class:** Elemental function

**Syntax:**
\[ \text{RESULT} = \text{LEN}_\text{TRIM}(\text{STRING} \ [, \ \text{KIND}]) \]

**Arguments:**
- **STRING**  
  Shall be a scalar of type `CHARACTER`, with `INTENT(IN)`
- **KIND**  
  (Optional) An `INTEGER` initialization expression indicating the kind parameter of the result.

**Return value:**
- The return value is of type `INTEGER` and of kind `KIND`. If `KIND` is absent, the return value is of default integer kind.

**See also:** Section 9.166 [LEN], page 205, Section 9.9 [ADJUSTL], page 106, Section 9.10 [ADJUSTR], page 106

### 9.168 LGE — Lexical greater than or equal

**Description:**

Determines whether one string is lexically greater than or equal to another string, where the two strings are interpreted as containing ASCII character codes. If the String A and String B are not the same length, the shorter is compared as if spaces were appended to it to form a value that has the same length as the longer.

In general, the lexical comparison intrinsics `LGE`, `LGT`, `LLE`, and `LLT` differ from the corresponding intrinsic operators `.GE.`, `.GT.`, `.LE.`, and `.LT.`, in that the latter use the processor’s character ordering (which is not ASCII on some targets), whereas the former always use the ASCII ordering.
**Standard:** Fortran 77 and later  
**Class:** Elemental function  
**Syntax:** \( \text{RESULT} = \text{LGE} (\text{STRING}_A, \text{STRING}_B) \)  
**Arguments:**  
- \( \text{STRING}_A \) Shall be of default CHARACTER type.  
- \( \text{STRING}_B \) Shall be of default CHARACTER type.  
**Return value:**  
Returns .TRUE. if \( \text{STRING}_A \geq \text{STRING}_B \), and .FALSE. otherwise, based on the ASCII ordering.  

**Specific names:**  
<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGE(STRING_A,</td>
<td>CHARACTER</td>
<td>LOGICAL</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>STRING_B)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**See also:** Section 9.169 [LGT], page 207, Section 9.171 [LLE], page 208, Section 9.172 [LLT], page 209

### 9.169 LGE — Lexical greater than

**Description:**  
Determines whether one string is lexically greater than another string, where the two strings are interpreted as containing ASCII character codes. If the String A and String B are not the same length, the shorter is compared as if spaces were appended to it to form a value that has the same length as the longer.  
In general, the lexical comparison intrinsics LGE, LGT, LLE, and LLT differ from the corresponding intrinsic operators .GE., .GT., .LE., and .LT., in that the latter use the processor’s character ordering (which is not ASCII on some targets), whereas the former always use the ASCII ordering.  

**Standard:** Fortran 77 and later  
**Class:** Elemental function  
**Syntax:** \( \text{RESULT} = \text{LGT} (\text{STRING}_A, \text{STRING}_B) \)  
**Arguments:**  
- \( \text{STRING}_A \) Shall be of default CHARACTER type.  
- \( \text{STRING}_B \) Shall be of default CHARACTER type.  
**Return value:**  
Returns .TRUE. if \( \text{STRING}_A > \text{STRING}_B \), and .FALSE. otherwise, based on the ASCII ordering.  

**Specific names:**  
<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGT(STRING_A,</td>
<td>CHARACTER</td>
<td>LOGICAL</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>STRING_B)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**See also:** Section 9.168 [LGE], page 206, Section 9.171 [LLE], page 208, Section 9.172 [LLT], page 209
9.170 LINK — Create a hard link

Description:
Makes a (hard) link from file PATH1 to PATH2. A null character (CHAR(0)) can be used to mark the end of the names in PATH1 and PATH2; otherwise, trailing blanks in the file names are ignored. If the STATUS argument is supplied, it contains 0 on success or a nonzero error code upon return; see link(2).
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:
CALL LINK(PATH1, PATH2 [, STATUS])
STATUS = LINK(PATH1, PATH2)

Arguments:
PATH1 Shall be of default CHARACTER type.
PATH2 Shall be of default CHARACTER type.
STATUS (Optional) Shall be of default INTEGER type.

See also: Section 9.260 [SYMLNK], page 259, Section 9.278 [UNLINK], page 269

9.171 LLE — Lexical less than or equal

Description:
Determines whether one string is lexically less than or equal to another string, where the two strings are interpreted as containing ASCII character codes. If the String A and String B are not the same length, the shorter is compared as if spaces were appended to it to form a value that has the same length as the longer.
In general, the lexical comparison intrinsics LGE, LGT, LLE, and LLT differ from the corresponding intrinsic operators .GE., .GT., .LE., and .LT., in that the latter use the processor’s character ordering (which is not ASCII on some targets), whereas the former always use the ASCII ordering.

Standard: Fortran 77 and later
Class: Elemental function
Syntax: RESULT = LLE(STRING_A, STRING_B)

Arguments:
STRING_A Shall be of default CHARACTER type.
STRING_B Shall be of default CHARACTER type.

Return value:
Returns .TRUE. if STRING_A <= STRING_B, and .FALSE. otherwise, based on the ASCII ordering.
9.172 LLT — Lexical less than

Description:

Determines whether one string is lexically less than another string, where the
two strings are interpreted as containing ASCII character codes. If the String
A and String B are not the same length, the shorter is compared as if spaces
were appended to it to form a value that has the same length as the longer.

In general, the lexical comparison intrinsics LGE, LGT, LLE, and LLT differ from
the corresponding intrinsic operators .GE., .GT., .LE., and .LT., in that the
latter use the processor’s character ordering (which is not ASCII on some tar-
gets), whereas the former always use the ASCII ordering.

Standard: Fortran 77 and later

Class: Elemental function

Syntax: \texttt{RESULT = LLT(STRING\_A, STRING\_B)}

Arguments:

\begin{itemize}
  \item \texttt{STRING\_A} Shall be of default \texttt{CHARACTER} type.
  \item \texttt{STRING\_B} Shall be of default \texttt{CHARACTER} type.
\end{itemize}

Return value:

Returns \texttt{.TRUE.} if \texttt{STRING\_A < STRING\_B}, and \texttt{.FALSE.} otherwise, based on the
ASCII ordering.

Specific names:

\begin{itemize}
  \item Name \quad Argument \quad Return type \quad Standard
  \item \texttt{LLT(STRING\_A, STRING\_B)} \quad \texttt{CHARACTER} \quad \texttt{LOGICAL} \quad Fortran 77 and later
\end{itemize}

See also: Section 9.168 \[LGE\], page 206, Section 9.169 \[LGT\], page 207, Section 9.172
\[LLT\], page 209

9.173 LNBLNK — Index of the last non-blank character in a string

Description:

Returns the length of a character string, ignoring any trailing blanks. This is
identical to the standard \texttt{LEN\_TRIM} intrinsic, and is only included for backwards
compatibility.

Standard: GNU extension

Class: Elemental function
Syntax: \[ \text{RESULT} = \text{LNBLNK}(\text{STRING}) \]

Arguments:
\[ \text{STRING} \quad \text{Shall be a scalar of type CHARACTER, with INTENT(IN)} \]

Return value:
The return value is of \text{INTEGER(kind=4)} type.

See also: Section 9.147 [INDEX intrinsic], page 195, Section 9.167 [LEN_TRIM], page 206

9.174 \text{LOC} — Returns the address of a variable

Description:
\text{LOC}(X) returns the address of \( X \) as an integer.

Standard: GNU extension

Class: Inquiry function

Syntax: \[ \text{RESULT} = \text{LOC}(\text{X}) \]

Arguments:
\[ \text{X} \quad \text{Variable of any type.} \]

Return value:
The return value is of type \text{INTEGER}, with a \text{KIND} corresponding to the size (in bytes) of a memory address on the target machine.

Example:

\begin{verbatim}
program test_loc
  integer :: i
  real :: r
  i = loc(r)
  print *, i
end program test_loc
\end{verbatim}

9.175 \text{LOG} — Natural logarithm function

Description:
\text{LOG}(X) computes the natural logarithm of \( X \), i.e. the logarithm to the base \( e \).

Standard: Fortran 77 and later

Class: Elemental function

Syntax: \[ \text{RESULT} = \text{LOG}(\text{X}) \]

Arguments:
\[ \text{X} \quad \text{The type shall be REAL or COMPLEX.} \]

Return value:
The return value is of type \text{REAL} or \text{COMPLEX}. The kind type parameter is the same as \( X \). If \( X \) is \text{COMPLEX}, the imaginary part \( \omega \) is in the range \(-\pi < \omega \leq \pi \).

Example:
program test_log
    real(8) :: x = 2.7182818284590451_8
    complex :: z = (1.0, 2.0)
    x = log(x) ! will yield (approximately) 1
    z = log(z)
end program test_log

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALOG(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>DLOG(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>CLOG(X)</td>
<td>COMPLEX(4)</td>
<td>COMPLEX(4)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>ZLOG(X)</td>
<td>COMPLEX(8)</td>
<td>COMPLEX(8)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>CDLOG(X)</td>
<td>COMPLEX(8)</td>
<td>COMPLEX(8)</td>
<td>f95, gnu</td>
</tr>
</tbody>
</table>

9.176 LOG10 — Base 10 logarithm function

Description:

LOG10(X) computes the base 10 logarithm of X.

Standard: Fortran 77 and later

Class: Elemental function

Syntax:

RESULT = LOG10(X)

Arguments:

X The type shall be REAL.

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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALOG10(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>DLOG10(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>Fortran 95 and later</td>
</tr>
</tbody>
</table>

9.177 LOG_GAMMA — Logarithm of the Gamma function

Description:

LOG_GAMMA(X) computes the natural logarithm of the absolute value of the Gamma (Γ) function.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax:

X = LOG_GAMMA(X)
Arguments:

\[ X \]  
Shall be of type \texttt{REAL} and neither zero nor a negative integer.

Return value:

The return value is of type \texttt{REAL} of the same kind as \( X \).

Example:

\begin{verbatim}
program test_log_gamma
  real :: x = 1.0
  x = lgamma(x) ! returns 0.0
end program test_log_gamma
\end{verbatim}

Specific names:

\begin{tabular}{llll}
Name & Argument & Return type & Standard \\
------------ & ----------- & ------------- & ----------- \\
LGAMMA(X) & REAL(4) X & REAL(4) & GNU Extension \\
ALGAMA(X) & REAL(4) X & REAL(4) & GNU Extension \\
DLGAMA(X) & REAL(8) X & REAL(8) & GNU Extension \\
\end{tabular}

See also: Gamma function: Section 9.118 [GAMMA], page 178

9.178 \texttt{LOGICAL} — Convert to logical type

Description:

Converts one kind of \texttt{LOGICAL} variable to another.

Standard: Fortran 95 and later

Class: Elemental function

Syntax: \texttt{RESULT = LOGICAL(L [, KIND])}

Arguments:

\begin{itemize}
  \item \texttt{L} The type shall be \texttt{LOGICAL}.
  \item \texttt{KIND} (Optional) An \texttt{INTEGER} initialization expression indicating the kind parameter of the result.
\end{itemize}

Return value:

The return value is a \texttt{LOGICAL} value equal to \texttt{L}, with a kind corresponding to \texttt{KIND}, or of the default logical kind if \texttt{KIND} is not given.

See also: Section 9.148 [INT], page 195, Section 9.226 [REAL], page 239, Section 9.62 [CMPLX], page 140

9.179 \texttt{LONG} — Convert to integer type

Description:

Convert to a \texttt{KIND=4} integer type, which is the same size as a C \texttt{long} integer. This is equivalent to the standard \texttt{INT} intrinsic with an optional argument of \texttt{KIND=4}, and is only included for backwards compatibility.

Standard: GNU extension

Class: Elemental function

Syntax: \texttt{RESULT = LONG(A)}
Arguments:

A Shall be of type INTEGER, REAL, or COMPLEX.

Return value:

The return value is a INTEGER(4) variable.

See also: Section 9.148 [INT], page 195, Section 9.149 [INT2], page 196, Section 9.150 [INT8], page 197

9.180 LSHIFT — Left shift bits

Description:

LSHIFT returns a value corresponding to I with all of the bits shifted left by SHIFT places. If the absolute value of SHIFT is greater than BIT_SIZE(I), the value is undefined. Bits shifted out from the left end are lost; zeros are shifted in from the opposite end.

This function has been superseded by the ISHFT intrinsic, which is standard in Fortran 95 and later, and the SHIFTL intrinsic, which is standard in Fortran 2008 and later.

Standard: GNU extension

Class: Elemental function

Syntax: RESULT = LSHIFT(I, SHIFT)

Arguments:

I The type shall be INTEGER.

SHIFT The type shall be INTEGER.

Return value:

The return value is of type INTEGER and of the same kind as I.

See also: Section 9.157 [ISHFT], page 201, Section 9.158 [ISHFTC], page 201, Section 9.231 [RSHIFT], page 242, Section 9.242 [SHIFTA], page 248, Section 9.243 [SHIFTL], page 249, Section 9.244 [SHIFTR], page 249

9.181 LSTAT — Get file status

Description:

LSTAT is identical to Section 9.257 [STAT], page 256, except that if path is a symbolic link, then the link itself is statted, not the file that it refers to.

The elements in VALUES are the same as described by Section 9.257 [STAT], page 256.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension

Class: Subroutine, function

Syntax:

CALL LSTAT(NAME, VALUES [, STATUS])

STATUS = LSTAT(NAME, VALUES)
Arguments:

NAME The type shall be CHARACTER of the default kind, a valid path within the file system.
VALUES The type shall be INTEGER(4), DIMENSION(13).
STATUS (Optional) status flag of type INTEGER(4). Returns 0 on success and a system specific error code otherwise.

Example: See Section 9.257 [STAT], page 256 for an example.
See also: To stat an open file: Section 9.116 [FSTAT], page 177, to stat a file: Section 9.257 [STAT], page 256

9.182 LTIME — Convert time to local time info

Description:
Given a system time value TIME (as provided by the Section 9.267 [TIME], page 264 intrinsic), fills VALUES with values extracted from it appropriate to the local time zone using localtime(3).
This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. In new code, programmers should consider the use of the Section 9.82 [DATE_AND_TIME], page 154 intrinsic defined by the Fortran 95 standard.

Standard: GNU extension
Class: Subroutine
Syntax: CALL LTIME(TIME, VALUES)
Arguments:
TIME An INTEGER scalar expression corresponding to a system time, with INTENT(IN).
VALUES A default INTEGER array with 9 elements, with INTENT(OUT).

Return value:
The elements of VALUES are assigned as follows:
1. Seconds after the minute, range 0–59 or 0–61 to allow for leap seconds
2. Minutes after the hour, range 0–59
3. Hours past midnight, range 0–23
4. Day of month, range 1–31
5. Number of months since January, range 0–11
6. Years since 1900
7. Number of days since Sunday, range 0–6
8. Days since January 1, range 0–365
9. Daylight savings indicator: positive if daylight savings is in effect, zero if not, and negative if the information is not available.

See also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, Section 9.267 [TIME], page 264, Section 9.268 [TIMES], page 264
9.183 MALLOC — Allocate dynamic memory

Description:
MALLOC(SIZE) allocates SIZE bytes of dynamic memory and returns the address of the allocated memory. The MALLOC intrinsic is an extension intended to be used with Cray pointers, and is provided in GNU Fortran to allow the user to compile legacy code. For new code using Fortran 95 pointers, the memory allocation intrinsic is ALLOCATE.

Standard: GNU extension
Class: Function
Syntax: PTR = MALLOC(SIZE)
Arguments:
SIZE The type shall be INTEGER.
Return value:
The return value is of type INTEGER(K), with K such that variables of type INTEGER(K) have the same size as C pointers (sizeof(void *)).
Example: The following example demonstrates the use of MALLOC and FREE with Cray pointers.

```fortran
program test_malloc
  implicit none
  integer i
  real*8 x(*), z
  pointer(ptr_x,x)

  ptr_x = malloc(20*8)
  do i = 1, 20
    x(i) = sqrt(1.0d0 / i)
  end do
  z = 0
  do i = 1, 20
    z = z + x(i)
  end do
  print *, z
  call free(ptr_x)
end program test_malloc
```

See also: Section 9.114 [FREE], page 175

9.184 MASKL — Left justified mask

Description:
MASKL(I[, KIND]) has its leftmost I bits set to 1, and the remaining bits set to 0.
Standard: Fortran 2008 and later
Class: Elemental function
Syntax: RESULT = MASKL(I[, KIND])
**Arguments:**

- \( I \) Shall be of type `INTEGER`.
- `KIND` Shall be a scalar constant expression of type `INTEGER`.

**Return value:**

The return value is of type `INTEGER`. If `KIND` is present, it specifies the kind value of the return type; otherwise, it is of the default integer kind.

**See also:** Section 9.185 [MASKR], page 216

---

### 9.185 MASKR — Right justified mask

**Description:**

\( \text{MASKL}(I[, \ KIND]) \) has its rightmost \( I \) bits set to 1, and the remaining bits set to 0.

**Standard:** Fortran 2008 and later

**Class:** Elemental function

**Syntax:**

\[
\text{RESULT} = \text{MASKR}(I[, \ KIND])
\]

**Arguments:**

- \( I \) Shall be of type `INTEGER`.
- `KIND` Shall be a scalar constant expression of type `INTEGER`.

**Return value:**

The return value is of type `INTEGER`. If `KIND` is present, it specifies the kind value of the return type; otherwise, it is of the default integer kind.

**See also:** Section 9.184 [MASKL], page 215

---

### 9.186 MATMUL — matrix multiplication

**Description:**

Performs a matrix multiplication on numeric or logical arguments.

**Standard:** Fortran 95 and later

**Class:** Transformational function

**Syntax:**

\[
\text{RESULT} = \text{MATMUL}(\text{MATRIX}_A, \text{MATRIX}_B)
\]

**Arguments:**

- `MATRIX_A` An array of `INTEGER`, `REAL`, `COMPLEX`, or `LOGICAL` type, with a rank of one or two.
- `MATRIX_B` An array of `INTEGER`, `REAL`, or `COMPLEX` type if `MATRIX_A` is of a numeric type; otherwise, an array of `LOGICAL` type. The rank shall be one or two, and the first (or only) dimension of `MATRIX_B` shall be equal to the last (or only) dimension of `MATRIX_A`.

**Return value:**

The matrix product of `MATRIX_A` and `MATRIX_B`. The type and kind of the result follow the usual type and kind promotion rules, as for the \(*\) or `.AND.` operators.
See also:

9.187 **MAX** — Maximum value of an argument list

*Description:*

Returns the argument with the largest (most positive) value.

*Standard:* Fortran 77 and later

*Class:* Elemental function

*Syntax:* 

\[
\text{RESULT} = \text{MAX}(A_1, A_2 [, A_3 [, \ldots]])
\]

*Arguments:*

- **A1**
  - The type shall be `INTEGER` or `REAL`.
- **A2, A3, ...**
  - An expression of the same type and kind as **A1**. (As a GNU extension, arguments of different kinds are permitted.)

*Return value:*

The return value corresponds to the maximum value among the arguments, and has the same type and kind as the first argument.

*Specific names:*

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX0(A1)</td>
<td><code>INTEGER(4)</code> A1</td>
<td><code>INTEGER(4)</code></td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>AMAX0(A1)</td>
<td><code>INTEGER(4)</code> A1</td>
<td><code>REAL(MAX(X))</code></td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>MAX1(A1)</td>
<td><code>REAL</code> A1</td>
<td><code>INT(MAX(X))</code></td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>AMAX1(A1)</td>
<td><code>REAL(4)</code> A1</td>
<td><code>REAL(4)</code></td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DMAX1(A1)</td>
<td><code>REAL(8)</code> A1</td>
<td><code>REAL(8)</code></td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Section 9.189 [MAXLOC], page 218, Section 9.190 [MAXVAL], page 218, Section 9.195 [MIN], page 221

9.188 **MAXEXPONENT** — Maximum exponent of a real kind

*Description:*

`MAXEXPONENT(X)` returns the maximum exponent in the model of the type of **X**.

*Standard:* Fortran 95 and later

*Class:* Inquiry function

*Syntax:* 

\[
\text{RESULT} = \text{MAXEXPONENT}(X)
\]

*Arguments:*

- **X**
  - Shall be of type `REAL`.

*Return value:*

The return value is of type `INTEGER` and of the default integer kind.

*Example:*

```fortran
program exponents
    real(kind=4) :: x
    real(kind=8) :: y

    print *, minexponent(x), maxexponent(x)
    print *, minexponent(y), maxexponent(y)
end program exponents
```
9.189 MAXLOC — Location of the maximum value within an array

Description:
Determines the location of the element in the array with the maximum value, or, if the DIM argument is supplied, determines the locations of the maximum element along each row of the array in the DIM direction. If MASK is present, only the elements for which MASK is .TRUE. are considered. If more than one element in the array has the maximum value, the location returned is that of the first such element in array element order. If the array has zero size, or all of the elements of MASK are .FALSE., then the result is an array of zeroes. Similarly, if DIM is supplied and all of the elements of MASK along a given row are zero, the result value for that row is zero.

Standard: Fortran 95 and later
Class: Transformational function
Syntax:
RESULT = MAXLOC(ARRAY, DIM [, MASK])
RESULT = MAXLOC(ARRAY [, MASK])

Arguments:
ARRAY Shall be an array of type INTEGER or REAL.
DIM (Optional) Shall be a scalar of type INTEGER, with a value between one and the rank of ARRAY, inclusive. It may not be an optional dummy argument.
MASK Shall be an array of type LOGICAL, and conformable with ARRAY.

Return value:
If DIM is absent, the result is a rank-one array with a length equal to the rank of ARRAY. If DIM is present, the result is an array with a rank one less than the rank of ARRAY, and a size corresponding to the size of ARRAY with the DIM dimension removed. If DIM is present and ARRAY has a rank of one, the result is a scalar. In all cases, the result is of default INTEGER type.

See also: Section 9.187 [MAX], page 217, Section 9.190 [MAXVAL], page 218

9.190 MAXVAL — Maximum value of an array

Description:
Determines the maximum value of the elements in an array value, or, if the DIM argument is supplied, determines the maximum value along each row of the array in the DIM direction. If MASK is present, only the elements for which MASK is .TRUE. are considered. If the array has zero size, or all of the elements of MASK are .FALSE., then the result is -HUGE(ARRAY) if ARRAY is numeric, or a string of nulls if ARRAY is of character type.

Standard: Fortran 95 and later
Class: Transformational function
Syntax:

\[
\text{RESULT} = \text{MAXVAL}(\text{ARRAY}, \text{DIM} [, \text{MASK}]) \\
\text{RESULT} = \text{MAXVAL}(\text{ARRAY} [, \text{MASK}])
\]

Arguments:

- **ARRAY**: Shall be an array of type INTEGER or REAL.
- **DIM** (Optional): Shall be a scalar of type INTEGER, with a value between one and the rank of ARRAY, inclusive. It may not be an optional dummy argument.
- **MASK**: Shall be an array of type LOGICAL, and conformable with ARRAY.

Return value:

If DIM is absent, or if ARRAY has a rank of one, the result is a scalar. If DIM is present, the result is an array with a rank one less than the rank of ARRAY, and a size corresponding to the size of ARRAY with the DIM dimension removed. In all cases, the result is of the same type and kind as ARRAY.

See also: Section 9.187 [MAX], page 217, Section 9.189 [MAXLOC], page 218

### 9.191 MCLOCK — Time function

Description:

Returns the number of clock ticks since the start of the process, based on the function `clock(3)` in the C standard library.

This intrinsic is not fully portable, such as to systems with 32-bit INTEGER types but supporting times wider than 32 bits. 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.

Standard: GNU extension

Class: Function

Syntax: \n
\[
\text{RESULT} = \text{MCLOCK}()
\]

Return value:

The return value is a scalar of type INTEGER(4), equal to the number of clock ticks since the start of the process, or -1 if the system does not support `clock(3)`.

See also: Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, Section 9.182 [LTIME], page 214, Section 9.191 [MCLOCK], page 219, Section 9.267 [TIME], page 264

### 9.192 MCLOCK8 — Time function (64-bit)

Description:

Returns the number of clock ticks since the start of the process, based on the function `clock(3)` in the C standard library.

**Warning**: this intrinsic does not increase the range of the timing values over that returned by `clock(3)`. On a system with a 32-bit `clock(3)`, MCLOCK8 will
return a 32-bit value, even though it is converted to a 64-bit INTEGER(8) value. That means overflows of the 32-bit value can still occur. 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.

**Standard:** GNU extension  
**Class:** Function  
**Syntax:** 

\[
\text{RESULT} = \text{MCLOCK8}()
\]

**Return value:**  
The return value is a scalar of type INTEGER(8), equal to the number of clock ticks since the start of the process, or -1 if the system does not support clock(3).

**See also:** Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, Section 9.182 [LTIME], page 214, Section 9.191 [MCLOCK], page 219, Section 9.268 [TIME8], page 264

### 9.193 MERGE — Merge variables

**Description:**  
Select values from two arrays according to a logical mask. The result is equal to TSOURCE if MASK is .TRUE., or equal to FSOURCE if it is .FALSE..

**Standard:** Fortran 95 and later  
**Class:** Elemental function  
**Syntax:** 

\[
\text{RESULT} = \text{MERGE(TSOURCE, FSOURCE, MASK)}
\]

**Arguments:**  
- **TSOURCE**  
  May be of any type.
- **FSOURCE**  
  Shall be of the same type and type parameters as TSOURCE.
- **MASK**  
  Shall be of type LOGICAL.

**Return value:**  
The result is of the same type and type parameters as TSOURCE.

### 9.194 MERGE_BITS — Merge of bits under mask

**Description:**  
\[
\text{MERGE_BITS(I, J, MASK)}
\]

merges the bits of \( I \) and \( J \) as determined by the mask. The i-th bit of the result is equal to the i-th bit of \( I \) if the i-th bit of \( MASK \) is 1; it is equal to the i-th bit of \( J \) otherwise.

**Standard:** Fortran 2008 and later  
**Class:** Elemental function  
**Syntax:** 

\[
\text{RESULT} = \text{MERGE_BITS(I, J, MASK)}
\]

**Arguments:**  
- **I**  
  Shall be of type INTEGER.
- **J**  
  Shall be of type INTEGER and of the same kind as I.
- **MASK**  
  Shall be of type INTEGER and of the same kind as I.
Return value:
The result is of the same type and kind as I.

9.195 MIN — Minimum value of an argument list

Description:
Returns the argument with the smallest (most negative) value.

Standard: Fortran 77 and later
Class: Elemental function
Syntax: RESULT = MIN(A1, A2 [, A3, ...])

Arguments:
A1 The type shall be INTEGER or REAL.
A2, A3, ... An expression of the same type and kind as A1. (As a GNU extension, arguments of different kinds are permitted.)

Return value:
The return value corresponds to the maximum value among the arguments, and has the same type and kind as the first argument.

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN0(A1)</td>
<td>INTEGER(4) A1</td>
<td>INTEGER(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>AMIN0(A1)</td>
<td>INTEGER(4) A1</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>MIN1(A1)</td>
<td>REAL A1</td>
<td>INTEGER(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>AMIN1(A1)</td>
<td>REAL(4) A1</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DMIN1(A1)</td>
<td>REAL(8) A1</td>
<td>REAL(8)</td>
<td>Fortran 77 and later</td>
</tr>
</tbody>
</table>

See also: Section 9.187 [MAX], page 217, Section 9.197 [MINLOC], page 222, Section 9.198 [MINVAL], page 222

9.196 MINEXPONENT — Minimum exponent of a real kind

Description:
MINEXPONENT(X) returns the minimum exponent in the model of the type of X.

Standard: Fortran 95 and later
Class: Inquiry function
Syntax: RESULT = MINEXPONENT(X)

Arguments:
X Shall be of type REAL.

Return value:
The return value is of type INTEGER and of the default integer kind.

Example: See MAXEXPONENT for an example.
9.197 MINLOC — Location of the minimum value within an array

Description:
Determines the location of the element in the array with the minimum value, or, if the DIM argument is supplied, determines the locations of the minimum element along each row of the array in the DIM direction. If MASK is present, only the elements for which MASK is .TRUE. are considered. If more than one element in the array has the minimum value, the location returned is that of the first such element in array element order. If the array has zero size, or all of the elements of MASK are .FALSE., then the result is an array of zeroes. Similarly, if DIM is supplied and all of the elements of MASK along a given row are zero, the result value for that row is zero.

Standard: Fortran 95 and later
Class: Transformational function
Syntax:
RESULT = MINLOC(ARRAY, DIM [, MASK])
RESULT = MINLOC(ARRAY [, MASK])

Arguments:
ARRAY Shall be an array of type INTEGER or REAL.
DIM (Optional) Shall be a scalar of type INTEGER, with a value between one and the rank of ARRAY, inclusive. It may not be an optional dummy argument.
MASK Shall be an array of type LOGICAL, and conformable with ARRAY.

Return value:
If DIM is absent, the result is a rank-one array with a length equal to the rank of ARRAY. If DIM is present, the result is an array with a rank one less than the rank of ARRAY, and a size corresponding to the size of ARRAY with the DIM dimension removed. If DIM is present and ARRAY has a rank of one, the result is a scalar. In all cases, the result is of default INTEGER type.

See also: Section 9.195 [MIN], page 221, Section 9.198 [MINVAL], page 222

9.198 MINVAL — Minimum value of an array

Description:
Determines the minimum value of the elements in an array value, or, if the DIM argument is supplied, determines the minimum value along each row of the array in the DIM direction. If MASK is present, only the elements for which MASK is .TRUE. are considered. If the array has zero size, or all of the elements of MASK are .FALSE., then the result is Huge(ARRAY) if ARRAY is numeric, or a string of CHAR(255) characters if ARRAY is of character type.

Standard: Fortran 95 and later
Class: Transformational function
Syntax:

\[
\text{RESULT} = \text{MINVAL}(\text{ARRAY}, \text{DIM} [, \text{MASK}]) \\
\text{RESULT} = \text{MINVAL}(\text{ARRAY} [, \text{MASK}])
\]

Arguments:

- **ARRAY**: Shall be an array of type INTEGER or REAL.
- **DIM** (Optional): Shall be a scalar of type INTEGER, with a value between one and the rank of ARRAY, inclusive. It may not be an optional dummy argument.
- **MASK**: Shall be an array of type LOGICAL, and conformable with ARRAY.

Return value:

If DIM is absent, or if ARRAY has a rank of one, the result is a scalar. If DIM is present, the result is an array with a rank one less than the rank of ARRAY, and a size corresponding to the size of ARRAY with the DIM dimension removed. In all cases, the result is of the same type and kind as ARRAY.

See also: Section 9.195 [MIN], page 221, Section 9.197 [MINLOC], page 222

9.199 **MOD** — Remainder function

Description:

MOD(A, P) computes the remainder of the division of A by P.

Standard: Fortran 77 and later, has overloads that are GNU extensions

Class: Elemental function

Syntax: RESULT = MOD(A, P)

Arguments:

- **A**: Shall be a scalar of type INTEGER or REAL.
- **P**: Shall be a scalar of the same type and kind as A and not equal to zero.

Return value:

The return value is the result of \( A - (\text{INT}(A/P) \times P) \). The type and kind of the return value is the same as that of the arguments. The returned value has the same sign as A and a magnitude less than the magnitude of P.

Example:

```fortran
program test_mod
  print *, mod(17,3)
  print *, mod(17.5,5.5)
  print *, mod(17.5d0,5.5)
  print *, mod(17.5,5.5d0)
  print *, mod(-17,3)
  print *, mod(-17.5,5.5)
  print *, mod(-17.5d0,5.5)
  print *, mod(-17.5,5.5d0)
  print *, mod(17,-3)
end program test_mod
```
print *, mod(17.5,-5.5)
print *, mod(17.5d0,-5.5)
print *, mod(17.5,-5.5d0)
end program test_mod

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Arguments</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOD(A,P)</td>
<td>INTEGER A,P</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>AMOD(A,P)</td>
<td>REAL(4) A,P</td>
<td>REAL(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>DMOD(A,P)</td>
<td>REAL(8) A,P</td>
<td>REAL(8)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BMOD(A,P)</td>
<td>INTEGER(1) A,P</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IMOD(A,P)</td>
<td>INTEGER(2) A,P</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JMOD(A,P)</td>
<td>INTEGER(4) A,P</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KMOD(A,P)</td>
<td>INTEGER(8) A,P</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also: Section 9.200 [MODULO], page 224

9.200 MODULO — Modulo function

Description:

MODULO(A,P) computes the A modulo P.

Standard: Fortran 95 and later

Class: Elemental function

Syntax: RESULT = MODULO(A, P)

Arguments:

A Shall be a scalar of type INTEGER or REAL.

P Shall be a scalar of the same type and kind as A. It shall not be zero.

Return value:

The type and kind of the result are those of the arguments.

If A and P are of type INTEGER:

MODULO(A,P) has the value R such that A=Q*P+R, where Q is an integer and R is between 0 (inclusive) and P (exclusive).

If A and P are of type REAL:

MODULO(A,P) has the value of A - FLOOR (A / P) * P.

The returned value has the same sign as P and a magnitude less than the magnitude of P.

Example:

program test_modulo
print *, modulo(17,3)
print *, modulo(17.5,5.5)
print *, modulo(-17,3)
print *, modulo(-17.5,5.5)

print *, modulo(17,-3)
print *, modulo(17.5,-5.5)
end program

See also: Section 9.199 [MOD], page 223

9.201 **MOVE_ALLOC** — Move allocation from one object to another

*Description:*

MOVE_ALLOC(FROM, TO) moves the allocation from FROM to TO. FROM will become deallocated in the process.

*Standard:* Fortran 2003 and later

*Class:* Pure subroutine

*Syntax:* CALL MOVE_ALLOC(FROM, TO)

*Arguments:*

FROM ALLOCATABLE, INTENT(INOUT), may be of any type and kind.
TO ALLOCATABLE, INTENT(OUT), shall be of the same type, kind and rank as FROM.

*Return value:* None

*Example:*

program test_move_alloc
integer, allocatable :: a(:), b(:)

allocate(a(3))
a = [ 1, 2, 3 ]
call move_alloc(a, b)
print *, allocated(a), allocated(b)
print *, b
end program test_move_alloc

9.202 **MVBITS** — Move bits from one integer to another

*Description:*

Moves LEN bits from positions FROMPOS through FROMPOS+LEN-1 of FROM to positions TOPOS through TOPOS+LEN-1 of TO. The portion of argument TO not affected by the movement of bits is unchanged. The values of FROMPOS+LEN-1 and TOPOS+LEN-1 must be less than BIT_SIZE(FROM).

*Standard:* Fortran 95 and later, has overloads that are GNU extensions

*Class:* Elemental subroutine

*Syntax:* CALL MVBITS(FROM, FROMPOS, LEN, TO, TOPOS)
Arguments:

- **FROM** The type shall be INTEGER.
- **FROMPOS** The type shall be INTEGER.
- **LEN** The type shall be INTEGER.
- **TO** The type shall be INTEGER, of the same kind as **FROM**.
- **TOPOS** The type shall be INTEGER.

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVBITS(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BMVBITS(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>IMVBITS(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JMVBITS(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KMVBITS(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

See also:
Section 9.139 [IBCLR], page 190, Section 9.141 [IBSET], page 191, Section 9.140 [IBITS], page 191, Section 9.136 [IAND], page 188, Section 9.151 [IOR], page 197, Section 9.144 [IEOR], page 193

9.203 NEAREST — Nearest representable number

**Description:**

NEAREST(X, S) returns the processor-representable number nearest to X in the direction indicated by the sign of S.

**Standard:** Fortran 95 and later

**Class:** Elemental function

**Syntax:** RESULT = NEAREST(X, S)

**Arguments:**

- **X** Shall be of type REAL.
- **S** Shall be of type REAL and not equal to zero.

**Return value:**

The return value is of the same type as X. If S is positive, NEAREST returns the processor-representable number greater than X and nearest to it. If S is negative, NEAREST returns the processor-representable number smaller than X and nearest to it.

**Example:**

```fortran
program test_nearest
  real :: x, y
  x = nearest(42.0, 1.0)
  y = nearest(42.0, -1.0)
  write (*,"(3(G20.15))") x, y, x - y
end program test_nearest
```

9.204 NEW_LINE — New line character

**Description:**

NEW_LINE(C) returns the new-line character.
Chapter 9: Intrinsic Procedures

Standard: Fortran 2003 and later

Class: Inquiry function

Syntax: \texttt{RESULT = NEW\_LINE(C)}

Arguments:

\texttt{C} \quad The argument shall be a scalar or array of the type \texttt{CHARACTER}.

Return value:

Returns a \texttt{CHARACTER} scalar of length one with the new-line character of the same kind as parameter \texttt{C}.

Example:

\begin{verbatim}
program newline
  implicit none
  write(*,'(A)') 'This is record 1.'//NEW\_LINE('A')//'This is record 2.'
end program newline
\end{verbatim}

9.205 \textbf{NINT} — Nearest whole number

Description:

\texttt{NINT(A)} rounds its argument to the nearest whole number.

Standard: Fortran 77 and later, with \texttt{KIND} argument Fortran 90 and later

Class: Elemental function

Syntax: \texttt{RESULT = NINT(A [, KIND])}

Arguments:

\texttt{A} \quad The type of the argument shall be \texttt{REAL}.

\texttt{KIND} \quad (Optional) An \texttt{INTEGER} initialization expression indicating the kind parameter of the result.

Return value:

Returns \texttt{A} with the fractional portion of its magnitude eliminated by rounding to the nearest whole number and with its sign preserved, converted to an \texttt{INTEGER} of the default kind.

Example:

\begin{verbatim}
program test_nint
  real(4) x4
  real(8) x8
  x4 = 1.234E0_4
  x8 = 4.321_8
  print *, nint(x4), idnint(x8)
end program test_nint
\end{verbatim}

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>NINT(A)</td>
<td>REAL(4) A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>IDNINT(A)</td>
<td>REAL(8) A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
</tbody>
</table>

See also: Section 9.58 [CEILING], page 138, Section 9.108 [FLOOR], page 171
9.206 NORM2 — Euclidean vector norms

Description:
Calculates the Euclidean vector norm ($L_2$ norm) of of ARRAY along dimension DIM.

Standard: Fortran 2008 and later
Class: Transformational function
Syntax:
RESULT = NORM2(ARRAY[, DIM])

Arguments:
ARRAY Shall be an array of type REAL
DIM (Optional) shall be a scalar of type INTEGER with a value in the range from 1 to n, where n equals the rank of ARRAY.

Return value:
The result is of the same type as ARRAY.
If DIM is absent, a scalar with the square root of the sum of all elements in ARRAY squared is returned. Otherwise, an array of rank $n - 1$, where $n$ equals the rank of ARRAY, and a shape similar to that of ARRAY with dimension DIM dropped is returned.

Example:
PROGRAM test_sum
   REAL :: x(5) = [ real :: 1, 2, 3, 4, 5 ]
   print *, NORM2(x) ! = sqrt(55.) ~ 7.416
END PROGRAM

9.207 NOT — Logical negation

Description:
NOT returns the bitwise Boolean inverse of I.

Standard: Fortran 95 and later, has overloads that are GNU extensions
Class: Elemental function
Syntax: RESULT = NOT(I)

Arguments:
I The type shall be INTEGER.

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT(A)</td>
<td>INTEGER A</td>
<td>INTEGER</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>BNOT(A)</td>
<td>INTEGER(1) A</td>
<td>INTEGER(1)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>INOT(A)</td>
<td>INTEGER(2) A</td>
<td>INTEGER(2)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>JNOT(A)</td>
<td>INTEGER(4) A</td>
<td>INTEGER(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>KNOT(A)</td>
<td>INTEGER(8) A</td>
<td>INTEGER(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>
See also: Section 9.136 [IAND], page 188, Section 9.144 [IEOR], page 193, Section 9.151 [IOR], page 197, Section 9.140 [IBITS], page 191, Section 9.141 [IBSET], page 191, Section 9.139 [IBCLR], page 190

9.208 NULL — Function that returns an disassociated pointer

Description:
Returns a disassociated pointer.
If MOLD is present, a disassociated pointer of the same type is returned, otherwise the type is determined by context.
In Fortran 95, MOLD is optional. Please note that Fortran 2003 includes cases where it is required.

Standard: Fortran 95 and later
Class: Transformational function
Syntax: PTR => NULL([MOLD])
Arguments:
MOLD (Optional) shall be a pointer of any association status and of any type.

Return value:
A disassociated pointer.

Example:
REAL, POINTER, DIMENSION(:) :: VEC => NULL()

See also: Section 9.22 [ASSOCIATED], page 114

9.209 NUM_IMAGES — Function that returns the number of images

Description:
Returns the number of images.

Standard: Fortran 2008 and later. With DISTANCE or FAILED argument, Technical Specification (TS) 18508 or later
Class: Transformational function
Syntax: RESULT = NUM_IMAGES(DISTANCE, FAILED)
Arguments:
DISTANCE (optional, intent(in)) Nonnegative scalar integer
FAILED (optional, intent(in)) Scalar logical expression

Return value:
Scalar default-kind integer. If DISTANCE is not present or has value 0, the number of images in the current team is returned. For values smaller or equal distance to the initial team, it returns the number of images index on the ancestor team which has a distance of DISTANCE from the invoking team. If
DISTANCE is larger than the distance to the initial team, the number of images of the initial team is returned. If FAILED is not present the total number of images is returned; if it has the value .TRUE., the number of failed images is returned, otherwise, the number of images which do not have the failed status.

Example:

```
INTEGER :: value[*]
INTEGER :: i
value = THIS_IMAGE()
SYNC ALL
IF (THIS_IMAGE() == 1) THEN
  DO i = 1, NUM_IMAGES()
    WRITE(*,'(2(a,i0))') 'value[', i, '] is ', value[i]
  END DO
END IF
```

See also: Section 9.266 [THIS_IMAGE], page 263, Section 9.146 [IMAGE_INDEX], page 194

9.210 OR — Bitwise logical OR

Description:

Bitwise logical OR.

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. For integer arguments, programmers should consider the use of the Section 9.151 [IOR], page 197 intrinsic defined by the Fortran standard.

Standard: GNU extension

Class: Function

Syntax: 

```
RESULT = OR(I, J)
```

Arguments:

- **I**: The type shall be either a scalar INTEGER type or a scalar LOGICAL type.
- **J**: The type shall be the same as the type of **J**.

Return value:

The return type is either a scalar INTEGER or a scalar LOGICAL. If the kind type parameters differ, then the smaller kind type is implicitly converted to larger kind, and the return has the larger kind.

Example:

```
PROGRAM test_or
  LOGICAL :: T = .TRUE., F = .FALSE.
  INTEGER :: a, b
  DATA a / Z'F' /, b / Z'3' /
  WRITE (*,*) OR(T, T), OR(T, F), OR(F, T), OR(F, F)
  WRITE (*,*) OR(a, b)
END PROGRAM
```

See also: Fortran 95 elemental function: Section 9.151 [IOR], page 197
Chapter 9: Intrinsic Procedures

231

9.211 PACK — Pack an array into an array of rank one
Description:
Stores the elements of ARRAY in an array of rank one.
The beginning of the resulting array is made up of elements whose MASK equals
TRUE. Afterwards, positions are filled with elements taken from VECTOR.
Standard :

Fortran 95 and later

Class:

Transformational function

Syntax :

RESULT = PACK(ARRAY, MASK[,VECTOR])

Arguments:
ARRAY
MASK
VECTOR

Shall be an array of any type.
Shall be an array of type LOGICAL and of the same size as
ARRAY. Alternatively, it may be a LOGICAL scalar.
(Optional) shall be an array of the same type as ARRAY and
of rank one. If present, the number of elements in VECTOR
shall be equal to or greater than the number of true elements
in MASK. If MASK is scalar, the number of elements in
VECTOR shall be equal to or greater than the number of
elements in ARRAY.

Return value:
The result is an array of rank one and the same type as that of ARRAY. If
VECTOR is present, the result size is that of VECTOR, the number of TRUE
values in MASK otherwise.
Example:

Gathering nonzero elements from an array:
PROGRAM test_pack_1
INTEGER :: m(6)
m = (/ 1, 0, 0, 0, 5, 0 /)
WRITE(*, FMT="(6(I0, ’ ’))") pack(m, m /= 0)
END PROGRAM

! "1 5"

Gathering nonzero elements from an array and appending elements from VECTOR:
PROGRAM test_pack_2
INTEGER :: m(4)
m = (/ 1, 0, 0, 2 /)
WRITE(*, FMT="(4(I0, ’ ’))") pack(m, m /= 0, (/ 0, 0, 3, 4 /))
END PROGRAM

See also:

! "1 2 3 4"

Section 9.279 [UNPACK], page 269

9.212 PARITY — Reduction with exclusive OR
Description:
Calculates the parity, i.e. the reduction using .XOR., of MASK along dimension
DIM.
Standard :

Fortran 2008 and later

Class:

Transformational function


**Syntax:**

```
RESULT = PARITY(MASK[, DIM])
```

**Arguments:**

- `LOGICAL` Shall be an array of type `LOGICAL`
- `DIM` (Optional) shall be a scalar of type `INTEGER` with a value in the range from 1 to n, where n equals the rank of `MASK`.

**Return value:**

The result is of the same type as `MASK`.

If `DIM` is absent, a scalar with the parity of all elements in `MASK` is returned, i.e. true if an odd number of elements is `.true.`, and false otherwise. If `DIM` is present, an array of rank n – 1, where n equals the rank of `ARRAY`, and a shape similar to that of `MASK` with dimension `DIM` dropped is returned.

**Example:**

```
PROGRAM test_sum
  LOGICAL :: x(2) = [ .true., .false. ]
  print *, PARITY(x) ! prints "T" (true).
END PROGRAM
```

---

### 9.213 PERROR — Print system error message

**Description:**

Prints (on the C `stderr` stream) a newline-terminated error message corresponding to the last system error. This is prefixed by `STRING`, a colon and a space. See `perror(3)`.

**Standard:** GNU extension

**Class:** Subroutine

**Syntax:**

```
CALL PERROR(STRING)
```

**Arguments:**

- `STRING` A scalar of type `CHARACTER` and of the default kind.

**See also:** Section 9.145 [IERRNO], page 194

---

### 9.214 POPCNT — Number of bits set

**Description:**

`POPCNT(I)` returns the number of bits set (‘1’ bits) in the binary representation of `I`.

**Standard:** Fortran 2008 and later

**Class:** Elemental function

**Syntax:**

```
RESULT = POPCNT(I)
```

**Arguments:**

- `I` Shall be of type `INTEGER`.
Return value:
The return value is of type INTEGER and of the default integer kind.

See also: Section 9.215 [POPPAR], page 233, Section 9.165 [LEADZ], page 205, Section 9.270 [TRAILZ], page 265

Example:

```fortran
program test_population
  print *, popcnt(127), poppar(127)
  print *, popcnt(huge(0_4)), poppar(huge(0_4))
  print *, popcnt(huge(0_8)), poppar(huge(0_8))
end program test_population
```

9.215 POPPAR — Parity of the number of bits set

Description:
POPPAR(I) returns parity of the integer I, i.e. the parity of the number of bits set ('1' bits) in the binary representation of I. It is equal to 0 if I has an even number of bits set, and 1 for an odd number of '1' bits.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax:
RESULT = POPPAR(I)

Arguments:
I Shall be of type INTEGER.

Return value:
The return value is of type INTEGER and of the default integer kind.

See also: Section 9.214 [POPCNT], page 232, Section 9.165 [LEADZ], page 205, Section 9.270 [TRAILZ], page 265

Example:

```fortran
program test_population
  print *, popcnt(127), poppar(127)
  print *, popcnt(huge(0_4)), poppar(huge(0_4))
  print *, popcnt(huge(0_8)), poppar(huge(0_8))
end program test_population
```

9.216 PRECISION — Decimal precision of a real kind

Description:
PRECISION(X) returns the decimal precision in the model of the type of X.

Standard: Fortran 95 and later

Class: Inquiry function

Syntax:
RESULT = PRECISION(X)

Arguments:
X Shall be of type REAL or COMPLEX.
Return value:

The return value is of type INTEGER and of the default integer kind.

See also: Section 9.239 [SELECTED_REAL_KIND], page 246, Section 9.224 [RANGE], page 238

Example:

```fortran
program prec_and_range
  real(kind=4) :: x(2)
  complex(kind=8) :: y
  print *, precision(x), range(x)
  print *, precision(y), range(y)
end program prec_and_range
```

### 9.217 PRESENT — Determine whether an optional dummy argument is specified

**Description:**

Determines whether an optional dummy argument is present.

**Standard:** Fortran 95 and later

**Class:** Inquiry function

**Syntax:**

```
RESULT = PRESENT(A)
```

**Arguments:**

- **A**
  
  May be of any type and may be a pointer, scalar or array value, or a dummy procedure. It shall be the name of an optional dummy argument accessible within the current subroutine or function.

**Return value:**

Returns either TRUE if the optional argument A is present, or FALSE otherwise.

**Example:**

```fortran
PROGRAM test_present
  WRITE(*,*) f(), f(42) ! "F T"
CONTAINS
  LOGICAL FUNCTION f(x)
  INTEGER, INTENT(IN), OPTIONAL :: x
  f = PRESENT(x)
  END FUNCTION
END PROGRAM
```

### 9.218 PRODUCT — Product of array elements

**Description:**

Multiplies the elements of ARRAY along dimension DIM if the corresponding element in MASK is TRUE.

**Standard:** Fortran 95 and later

**Class:** Transformational function
Chapter 9: Intrinsic Procedures

Syntax:

RESULT = PRODUCT(ARRAY[, MASK])
RESULT = PRODUCT(ARRAY, DIM[, MASK])

Arguments:

ARRAY Shall be an array of type INTEGER, REAL or COMPLEX.
DIM (Optional) shall be a scalar of type INTEGER with a value in the range from 1 to n, where n equals the rank of ARRAY.
MASK (Optional) shall be of type LOGICAL and either be a scalar or an array of the same shape as ARRAY.

Return value:
The result is of the same type as ARRAY.
If DIM is absent, a scalar with the product of all elements in ARRAY is returned. Otherwise, an array of rank n-1, where n equals the rank of ARRAY, and a shape similar to that of ARRAY with dimension DIM dropped is returned.

Example:

PROGRAM test_product
  INTEGER :: x(5) = (/ 1, 2, 3, 4, 5 /)
  print *, PRODUCT(x) ! all elements, product = 120
  print *, PRODUCT(x, MASK=MOD(x, 2)==1) ! odd elements, product = 15
END PROGRAM

See also: Section 9.259 [SUM], page 258

9.219 RADIX — Base of a model number

Description:
RADIX(X) returns the base of the model representing the entity X.

Standard: Fortran 95 and later

Class: Inquiry function

Syntax: RESULT = RADIX(X)

Arguments:
X Shall be of type INTEGER or REAL

Return value:
The return value is a scalar of type INTEGER and of the default integer kind.

See also: Section 9.239 [SELECTED_REAL_KIND], page 246

Example:

program test_radix
  print *, "The radix for the default integer kind is", radix(0)
  print *, "The radix for the default real kind is", radix(0.0)
end program test_radix
9.220 RAN — Real pseudo-random number

Description:
For compatibility with HP FORTRAN 77/iX, the RAN intrinsic is provided as an alias for RAND. See Section 9.221 [RAND], page 236 for complete documentation.

Standard: GNU extension
Class: Function
See also: Section 9.221 [RAND], page 236, Section 9.222 [RANDOM_NUMBER], page 236

9.221 RAND — Real pseudo-random number

Description:
RAND(FLAG) returns a pseudo-random number from a uniform distribution between 0 and 1. If FLAG is 0, the next number in the current sequence is returned; if FLAG is 1, the generator is restarted by CALL SRAND(0); if FLAG has any other value, it is used as a new seed with SRAND.

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. It implements a simple modulo generator as provided by g77. For new code, one should consider the use of Section 9.222 [RANDOM_NUMBER], page 236 as it implements a superior algorithm.

Standard: GNU extension
Class: Function
Syntax: RESULT = RAND(I)
Arguments:
I Shall be a scalar INTEGER of kind 4.
Return value:
The return value is of REAL type and the default kind.
Example:

```
program test_rand
    integer,parameter :: seed = 86456

    call srand(seed)
    print *, rand(), rand(), rand(), rand()
    print *, rand(seed), rand(), rand(), rand()
end program test_rand
```

See also: Section 9.256 [SRAND], page 256, Section 9.222 [RANDOM_NUMBER], page 236

9.222 RANDOM_NUMBER — Pseudo-random number

Description:
Returns a single pseudorandom number or an array of pseudorandom numbers from the uniform distribution over the range 0 ≤ x < 1.
The runtime-library implements the xorshift1024* random number generator (RNG). This generator has a period of $2^{1024} - 1$, and when using multiple threads up to $2^{512}$ threads can each generate $2^{512}$ random numbers before any aliasing occurs.

Note that in a multi-threaded program (e.g. using OpenMP directives), each thread will have its own random number state. For details of the seeding procedure, see the documentation for the `RANDOM_SEED` intrinsic.

**Standard:** Fortran 95 and later  
**Class:** Subroutine  
**Syntax:** `RANDOM_NUMBER(HARVEST)`  
**Arguments:**  
- `HARVEST` Shall be a scalar or an array of type `REAL`.  

**Example:**

```fortran
program test_random_number
  REAL :: r(5,5)
  CALL RANDOM_NUMBER(r)
end program
```

**See also:** Section 9.223 [RANDOM_SEED], page 237

9.223 `RANDOM_SEED` — Initialize a pseudo-random number sequence

**Description:**

Restarts or queries the state of the pseudorandom number generator used by `RANDOM_NUMBER`.

If `RANDOM_SEED` is called without arguments, it is seeded with random data retrieved from the operating system.

As an extension to the Fortran standard, the GFortran `RANDOM_NUMBER` supports multiple threads. Each thread in a multi-threaded program has its own seed. When `RANDOM_SEED` is called either without arguments or with the `PUT` argument, the given seed is copied into a master seed as well as the seed of the current thread. When a new thread uses `RANDOM_NUMBER` for the first time, the seed is copied from the master seed, and forwarded $N \times 2^{512}$ steps to guarantee that the random stream does not alias any other stream in the system, where $N$ is the number of threads that have used `RANDOM_NUMBER` so far during the program execution.

**Standard:** Fortran 95 and later  
**Class:** Subroutine  
**Syntax:** `CALL RANDOM_SEED([SIZE, PUT, GET])`  
**Arguments:**
- `SIZE` (Optional) Shall be a scalar and of type default `INTEGER`, with `INTENT(OUT)`. It specifies the minimum size of the arrays used with the `PUT` and `GET` arguments.
**PUT** (Optional) Shall be an array of type default INTEGER and rank one. It is INTENT(IN) and the size of the array must be larger than or equal to the number returned by the SIZE argument.

**GET** (Optional) Shall be an array of type default INTEGER and rank one. It is INTENT(OUT) and the size of the array must be larger than or equal to the number returned by the SIZE argument.

*Example:*

```fortran
program test_random_seed
  implicit none
  integer, allocatable :: seed(:)
  integer :: n
  call random_seed(size = n)
  allocate(seed(n))
  call random_seed(get=seed)
  write (*, *) seed
end program test_random_seed
```

*See also:* Section 9.222 [RANDOM_NUMBER], page 236

### 9.224 RANGE — Decimal exponent range

*Description:*

RANGE(X) returns the decimal exponent range in the model of the type of X.

*Standard:* Fortran 95 and later

*Class:* Inquiry function

*Syntax:* RESULT = RANGE(X)

*Arguments:*

- **X** Shall be of type INTEGER, REAL or COMPLEX.

*Return value:*

The return value is of type INTEGER and of the default integer kind.

*See also:* Section 9.239 [SELECTED_REAL_KIND], page 246, Section 9.216 [PRECISION], page 233

*Example:* See PRECISION for an example.

### 9.225 RANK — Rank of a data object

*Description:*

RANK(A) returns the rank of a scalar or array data object.

*Standard:* Technical Specification (TS) 29113

*Class:* Inquiry function

*Syntax:* RESULT = RANK(A)

*Arguments:*

- **A** can be of any type
Return value:
The return value is of type INTEGER and of the default integer kind. For arrays, their rank is returned; for scalars zero is returned.

Example:
```
program test_rank
  integer :: a
  real, allocatable :: b(:,:)
  print *, rank(a), rank(b) ! Prints: 0 2
end program test_rank
```

9.226 REAL — Convert to real type

Description:
REAL(A [, KIND]) converts its argument A to a real type. The REALPART function is provided for compatibility with g77, and its use is strongly discouraged.

Standard: Fortran 77 and later
Class: Elemental function
Syntax:
```
RESULT = REAL(A [, KIND])
RESULT = REALPART(Z)
```

Arguments:
- \( A \) Shall be INTEGER, REAL, or COMPLEX.
- \( KIND \) (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
These functions return a REAL variable or array under the following rules:

(A) REAL(A) is converted to a default real type if A is an integer or real variable.

(B) REAL(A) is converted to a real type with the kind type parameter of A if A is a complex variable.

(C) REAL(A, KIND) is converted to a real type with kind type parameter KIND if A is a complex, integer, or real variable.

Example:
```
program test_real
  complex :: x = (1.0, 2.0)
  print *, real(x), real(x,8), realpart(x)
end program test_real
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOAT(A)</td>
<td>INTEGER(4)</td>
<td>REAL(4)</td>
<td>Fortran 77 and later</td>
</tr>
<tr>
<td>DFLOAT(A)</td>
<td>INTEGER(4)</td>
<td>REAL(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>FLOATI(A)</td>
<td>INTEGER(2)</td>
<td>REAL(4)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>FLOATJ(A)</td>
<td>INTEGER(4)</td>
<td>REAL(4)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>
9.227 RENAME — Rename a file

Description:
Renames a file from file PATH1 to PATH2. A null character (CHAR(0)) can be used to mark the end of the names in PATH1 and PATH2; otherwise, trailing blanks in the file names are ignored. If the STATUS argument is supplied, it contains 0 on success or a nonzero error code upon return; see rename(2).

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:
CALL RENAME(PATH1, PATH2 [, STATUS])
STATUS = RENAME(PATH1, PATH2)

Arguments:
PATH1 Shall be of default CHARACTER type.
PATH2 Shall be of default CHARACTER type.
STATUS (Optional) Shall be of default INTEGER type.

See also: Section 9.170 [LINK], page 208

9.228 REPEAT — Repeated string concatenation

Description:
Concatenates NCOPIES copies of a string.

Standard: Fortran 95 and later
Class: Transformational function
Syntax: RESULT = REPEAT(STRING, NCOPIES)

Arguments:
STRING Shall be scalar and of type CHARACTER.
NCOPIES Shall be scalar and of type INTEGER.

Return value:
A new scalar of type CHARACTER built up from NCOPIES copies of STRING.

Example:
program test_repeat
  write(*,*) repeat("x", 5)  ! "xxxxx"
end program
9.229 RESHAPE — Function to reshape an array

Description:
Reshapes SOURCE to correspond to SHAPE. If necessary, the new array may be padded with elements from PAD or permuted as defined by ORDER.

Standard: Fortran 95 and later
Class: Transformational function
Syntax: \[
\text{RESULT} = \text{RESHAPE} (\text{SOURCE}, \text{SHAPE}, \text{PAD}, \text{ORDER})
\]

Arguments:
- SOURCE Shall be an array of any type.
- SHAPE Shall be of type INTEGER and an array of rank one. Its values must be positive or zero.
- PAD (Optional) shall be an array of the same type as SOURCE.
- ORDER (Optional) shall be of type INTEGER and an array of the same shape as SHAPE. Its values shall be a permutation of the numbers from 1 to n, where n is the size of SHAPE. If ORDER is absent, the natural ordering shall be assumed.

Return value:
The result is an array of shape SHAPE with the same type as SOURCE.

Example:
\[
\begin{verbatim}
PROGRAM test_reshape
  INTEGER, DIMENSION(4) :: x
  WRITE(*,*) SHAPE(x) ! prints "4"
  WRITE(*,*) SHAPE(RESHAPE(x, (/2, 2/))) ! prints "2 2"
END PROGRAM
\end{verbatim}
\]

See also: Section 9.241 [SHAPE], page 248

9.230 RRSPACING — Reciprocal of the relative spacing

Description:
RRSPACING(X) returns the reciprocal of the relative spacing of model numbers near X.

Standard: Fortran 95 and later
Class: Elemental function
Syntax: \[
\text{RESULT} = \text{RRSPACING} (\text{X})
\]

Arguments:
- X Shall be of type REAL.

Return value:
The return value is of the same type and kind as X. The value returned is equal to \[\text{ABS(FRACTION(X))} \times \text{FLOAT(RADIX(X))}^{\text{DIGITS(X)}}\].

See also: Section 9.253 [SPACING], page 254
9.231 RSHIFT — Right shift bits

Description:
RSHIFT returns a value corresponding to $I$ with all of the bits shifted right by $SHIFT$ places. If the absolute value of $SHIFT$ is greater than $\text{BIT\_SIZE}(I)$, the value is undefined. Bits shifted out from the right end are lost. The fill is arithmetic: the bits shifted in from the left end are equal to the leftmost bit, which in two's complement representation is the sign bit.

This function has been superseded by the \texttt{SHIFTA} intrinsic, which is standard in Fortran 2008 and later.

Standard: GNU extension

Class: Elemental function

Syntax: \texttt{RESULT = RSHIFT(I, SHIFT)}

Arguments:

$I$ The type shall be \texttt{INTEGER}.

$SHIFT$ The type shall be \texttt{INTEGER}.

Return value:
The return value is of type \texttt{INTEGER} and of the same kind as $I$.

See also: Section 9.157 [ISHFT], page 201, Section 9.158 [ISHFTC], page 201, Section 9.180 [LSHIFT], page 213, Section 9.242 [SHIFTA], page 248, Section 9.244 [SHIFTR], page 249, Section 9.243 [SHIFTL], page 249

9.232 SAME_TYPE_AS — Query dynamic types for equality

Description:
Query dynamic types for equality.

Standard: Fortran 2003 and later

Class: Inquiry function

Syntax: \texttt{RESULT = SAME\_TYPE\_AS(A, B)}

Arguments:

$A$ Shall be an object of extensible declared type or unlimited polymorphic.

$B$ Shall be an object of extensible declared type or unlimited polymorphic.

Return value:
The return value is a scalar of type default logical. It is true if and only if the dynamic type of $A$ is the same as the dynamic type of $B$.

See also: Section 9.104 [EXTENDS\_TYPE\_OF], page 168
9.233 SCALE — Scale a real value

Description:

\[ \text{SCALE}(X, I) \text{ returns } X \times \text{RADIX}(X)^I. \]

Standard: Fortran 95 and later

Class: Elemental function

Syntax: RESULT = SCALE(X, I)

Arguments:

- \( X \) The type of the argument shall be a REAL.
- \( I \) The type of the argument shall be a INTEGER.

Return value:

The return value is of the same type and kind as \( X \). Its value is \( X \times \text{RADIX}(X)^I \).

Example:

```fortran
program test_scale
  real :: x = 178.1387e-4
  integer :: i = 5
  print *, scale(x,i), x*radix(x)**i
end program test_scale
```

9.234 SCAN — Scan a string for the presence of a set of characters

Description:

Scans a STRING for any of the characters in a SET of characters.

If \( \text{BACK} \) is either absent or equals FALSE, this function returns the position of the leftmost character of STRING that is in SET. If \( \text{BACK} \) equals TRUE, the rightmost position is returned. If no character of SET is found in STRING, the result is zero.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Elemental function

Syntax: RESULT = SCAN(STRING, SET[, BACK [, KIND]])

Arguments:

- \( \text{STRING} \) Shall be of type CHARACTER.
- \( \text{SET} \) Shall be of type CHARACTER.
- \( \text{BACK} \) Optional) shall be of type LOGICAL.
- \( \text{KIND} \) (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:

The return value is of type INTEGER and of kind \( \text{KIND} \). If \( \text{KIND} \) is absent, the return value is of default integer kind.

Example:
PROGRAM test_scan
WRITE(*,*) SCAN("FORTRAN", "AO")  ! 2, found ‘O’
WRITE(*,*) SCAN("FORTRAN", "AO", .TRUE.) ! 6, found ‘A’
WRITE(*,*) SCAN("FORTRAN", "C++")  ! 0, found none
END PROGRAM

See also: Section 9.147 [INDEX intrinsic], page 195, Section 9.280 [VERIFY], page 270

9.235 SECNDS — Time function

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.

Standard: GNU extension
Class: Function
Syntax: RESULT = SECNDS (X)
Arguments:
T        Shall be of type REAL(4).
X        Shall be of type REAL(4).
Return value: None
Example:

program test_secnds
   integer :: i
   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

9.236 SECOND — CPU time function

Description:
Returns a REAL(4) value representing the elapsed CPU time in seconds. This provides the same functionality as the standard CPU_TIME intrinsic, and is only included for backwards compatibility.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:
CALL SECOND(TIME)
TIME = SECOND()
**Arguments:**

TIME  Shall be of type REAL(4).

**Return value:**

In either syntax, TIME is set to the process’s current runtime in seconds.

**See also:** Section 9.79 [CPU_TIME], page 152

9.237 SELECTED_CHAR_KIND — Choose character kind

**Description:**

SELECTED_CHAR_KIND(NAME) returns the kind value for the character set named NAME, if a character set with such a name is supported, or –1 otherwise. Currently, supported character sets include “ASCII” and “DEFAULT”, which are equivalent, and “ISO_10646” (Universal Character Set, UCS-4) which is commonly known as Unicode.

**Standard:** Fortran 2003 and later

**Class:** Transformational function

**Syntax:** RESULT = SELECTED_CHAR_KIND(NAME)

**Arguments:**

NAME  Shall be a scalar and of the default character type.

**Example:**

```fortran
program character_kind
  use iso_fortran_env
  implicit none
  integer, parameter :: ascii = selected_char_kind ("ascii")
  integer, parameter :: ucs4 = selected_char_kind ('ISO_10646')

  character(kind=ascii, len=26) :: alphabet
  character(kind=ucs4, len=30) :: hello_world

  alphabet = ascii_"abcdefghijklmnopqrstuvwxyz"
  hello_world = ucs4_'Hello World and Ni Hao -- ' &
               // char (int (z'4F60'), ucs4) &
               // char (int (z'597D'), ucs4)

  write (*,*) alphabet
  open (output_unit, encoding='UTF-8')
  write (*,*) trim (hello_world)
end program character_kind
```

9.238 SELECTED_INT_KIND — Choose integer kind

**Description:**

SELECTED_INT_KIND(R) return the kind value of the smallest integer type that can represent all values ranging from $-10^R$ (exclusive) to $10^R$ (exclusive). If there is no integer kind that accommodates this range, SELECTED_INT_KIND returns –1.

**Standard:** Fortran 95 and later
Class: Transformational function

Syntax: RESULT = SELECTED_INT_KIND(R)

Arguments:
$R$ Shall be a scalar and of type INTEGER.

Example:

```
program large_integers
  integer, parameter :: k5 = selected_int_kind(5)
  integer, parameter :: k15 = selected_int_kind(15)
  integer(kind=k5) :: i5
  integer(kind=k15) :: i15

  print *, huge(i5), huge(i15)
  ! The following inequalities are always true
  print *, huge(i5) >= 10_k5**5-1
  print *, huge(i15) >= 10_k15**15-1
end program large_integers
```

9.239 SELECTED_REAL_KIND — Choose real kind

Description:
SELECTED_REAL_KIND(P, R) returns the kind value of a real data type with
decimal precision of at least $P$ digits, exponent range of at least $R$, and with a
radix of RADIX.

Standard: Fortran 95 and later, with RADIX Fortran 2008 or later

Class: Transformational function

Syntax: RESULT = SELECTED_REAL_KIND([P, R, RADIX])

Arguments:
$P$ (Optional) shall be a scalar and of type INTEGER.
$R$ (Optional) shall be a scalar and of type INTEGER.
RADIX (Optional) shall be a scalar and of type INTEGER.

Before Fortran 2008, at least one of the arguments $R$ or $P$ shall be present;
since Fortran 2008, they are assumed to be zero if absent.

Return value:
SELECTED_REAL_KIND returns the value of the kind type parameter of a real
data type with decimal precision of at least $P$ digits, a decimal exponent range
of at least $R$, and with the requested RADIX. If the RADIX parameter is absent,
real kinds with any radix can be returned. If more than one real data type
meet the criteria, the kind of the data type with the smallest decimal precision
is returned. If no real data type matches the criteria, the result is

-1 if the processor does not support a real data type with a
  precision greater than or equal to $P$, but the $R$ and RADIX require-
  ments can be fulfilled

-2 if the processor does not support a real type with an exponent
  range greater than or equal to $R$, but $P$ and RADIX are fulfillable
-3 if RADIX but not P and R requirements are fulfillable

-4 if RADIX and either P or R requirements are fulfillable

-5 if there is no real type with the given RADIX

*See also:* Section 9.216 [PRECISION], page 233, Section 9.224 [RANGE], page 238, Section 9.219 [RADIX], page 235

**Example:**

```fortran
program real_kinds
  integer, parameter :: p6 = selected_real_kind(6)
  integer, parameter :: p10r100 = selected_real_kind(10,100)
  integer, parameter :: r400 = selected_real_kind(r=400)
  real(kind=p6) :: x
  real(kind=p10r100) :: y
  real(kind=r400) :: z
  print *, precision(x), range(x)
  print *, precision(y), range(y)
  print *, precision(z), range(z)
end program real_kinds
```

### 9.240 SET_EXPONENT — Set the exponent of the model

**Description:**

The `SET_EXPONENT(X, I)` function returns the real number whose fractional part is that of `X` and whose exponent part is `I`.

**Standard:** Fortran 95 and later

**Class:** Elemental function

**Syntax:**

```
RESULT = SET_EXPONENT(X, I)
```

**Arguments:**

- `X` Shall be of type `REAL`
- `I` Shall be of type `INTEGER`

**Return value:**

The return value is of the same type and kind as `X`. The real number whose fractional part is that of `X` and whose exponent part if `I` is returned; it is `FRACTION(X) * RADIX(X)**I`.

**Example:**

```fortran
PROGRAM test_setexp
  REAL :: x = 178.1387e-4
  INTEGER :: i = 17
  print *, SET_EXPONENT(x, i), FRACTION(x) * RADIX(x)**i
END PROGRAM
```
9.241 SHAPE — Determine the shape of an array

Description:
Determine the shape of an array.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Inquiry function

Syntax: RESULT = SHAPE(SOURCE [, KIND])

Arguments:
SOURCE Shall be an array or scalar of any type. If SOURCE is a pointer it must be associated and allocatable arrays must be allocated.
KIND (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
An INTEGER array of rank one with as many elements as SOURCE has dimensions. The elements of the resulting array correspond to the extend of SOURCE along the respective dimensions. If SOURCE is a scalar, the result is the rank one array of size zero. If KIND is absent, the return value has the default integer kind otherwise the specified kind.

Example:
PROGRAM test_shape
 INTEGER, DIMENSION(-1:1, -1:2) :: A
 WRITE(*,*) SHAPE(A) ! (/ 3, 4 /)
 WRITE(*,*) SIZE(SHAPE(42)) ! (/ /)
END PROGRAM

See also: Section 9.229 [RESHAPE], page 241, Section 9.250 [SIZE], page 253

9.242 SHIFTA — Right shift with fill

Description:
SHIFTA returns a value corresponding to I with all of the bits shifted right by SHIFT places. If the absolute value of SHIFT is greater than BIT_SIZE(I), the value is undefined. Bits shifted out from the right end are lost. The fill is arithmetic: the bits shifted in from the left end are equal to the leftmost bit, which in two’s complement representation is the sign bit.

Standard: Fortran 2008 and later

Class: Elemental function

Syntax: RESULT = SHIFTA(I, SHIFT)

Arguments:
I The type shall be INTEGER.
SHIFT The type shall be INTEGER.

Return value:
The return value is of type INTEGER and of the same kind as I.

See also: Section 9.243 [SHIFTL], page 249, Section 9.244 [SHIFTR], page 249
9.243 SHIFTL — Left shift

Description:
SHIFTL returns a value corresponding to $I$ with all of the bits shifted left by $SHIFT$ places. If the absolute value of $SHIFT$ is greater than $\text{BIT} \_\text{SIZE}(I)$, the value is undefined. Bits shifted out from the left end are lost, and bits shifted in from the right end are set to 0.

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: $\text{RESULT} = \text{SHIFTL}(I, SHIFT)$

Arguments:
- $I$ The type shall be INTEGER.
- $SHIFT$ The type shall be INTEGER.

Return value:
The return value is of type INTEGER and of the same kind as $I$.
See also: Section 9.242 [SHIFTA], page 248, Section 9.244 [SHIFTR], page 249

9.244 SHIFTR — Right shift

Description:
SHIFTR returns a value corresponding to $I$ with all of the bits shifted right by $SHIFT$ places. If the absolute value of $SHIFT$ is greater than $\text{BIT} \_\text{SIZE}(I)$, the value is undefined. Bits shifted out from the right end are lost, and bits shifted in from the left end are set to 0.

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: $\text{RESULT} = \text{SHIFTR}(I, SHIFT)$

Arguments:
- $I$ The type shall be INTEGER.
- $SHIFT$ The type shall be INTEGER.

Return value:
The return value is of type INTEGER and of the same kind as $I$.
See also: Section 9.242 [SHIFTA], page 248, Section 9.243 [SHIFTL], page 249

9.245 SIGN — Sign copying function

Description:
SIGN($A,B$) returns the value of $A$ with the sign of $B$.

Standard: Fortran 77 and later
Class: Elemental function
Syntax: $\text{RESULT} = \text{SIGN}(A, B)$
Arguments:

- **A** Shall be of type INTEGER or REAL
- **B** Shall be of the same type and kind as **A**

Return value:

The kind of the return value is that of **A** and **B**. If **B** ≥ 0 then the result is \(\text{ABS}(A)\), else it is \(-\text{ABS}(A)\).

Example:

```fortran
program test_sign
  print *, sign(-12,1)
  print *, sign(-12,0)
  print *, sign(-12,-1)

  print *, sign(-12.,1.)
  print *, sign(-12.,0.)
  print *, sign(-12.,-1.)
end program test_sign
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Arguments</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGN(A,B)</td>
<td>REAL(4) A, B</td>
<td>REAL(4)</td>
<td>f77, gnu</td>
</tr>
<tr>
<td>ISIGN(A,B)</td>
<td>INTEGER(4) A, B</td>
<td>INTEGER(4)</td>
<td>f77, gnu</td>
</tr>
<tr>
<td>DSIGN(A,B)</td>
<td>REAL(8) A, B</td>
<td>REAL(8)</td>
<td>f77, gnu</td>
</tr>
</tbody>
</table>

9.246 SIGNAL — Signal handling subroutine (or function)

Description:

\texttt{SIGNAL(NUMBER, HANDLER [, STATUS])} causes external subroutine \texttt{HANDLER} to be executed with a single integer argument when signal \texttt{NUMBER} occurs. If \texttt{HANDLER} is an integer, it can be used to turn off handling of signal \texttt{NUMBER} or revert to its default action. See \texttt{signal(2)}.

If \texttt{SIGNAL} is called as a subroutine and the \texttt{STATUS} argument is supplied, it is set to the value returned by \texttt{signal(2)}.

Standard: GNU extension

Class: Subroutine, function

Syntax:

```fortran
CALL SIGNAL(NUMBER, HANDLER [, STATUS])
STATUS = SIGNAL(NUMBER, HANDLER)
```

Arguments:

- **NUMBER** Shall be a scalar integer, with INTENT(IN)
- **HANDLER** Signal handler (INTEGER FUNCTION or SUBROUTINE) or dummy/global INTEGER scalar. INTEGER. It is INTENT(IN).
- **STATUS** (Optional) **STATUS** shall be a scalar integer. It has INTENT(OUT).

Return value:

The \texttt{SIGNAL} function returns the value returned by \texttt{signal(2)}. 
Example:

```fortran
program test_signal
  intrinsic signal
  external handler_print
  call signal (12, handler_print)
  call signal (10, 1)
  call sleep (30)
end program test_signal
```

9.247 SIN — Sine function

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

Standard: Fortran 77 and later

Class: Elemental function

Syntax:
RESULT = SIN(X)

Arguments:
X The type shall be REAL or COMPLEX.

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

Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIN(X)</td>
<td>REAL(4)</td>
<td>REAL(4)</td>
<td>f77, gnu</td>
</tr>
<tr>
<td>DSIN(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>CSIN(X)</td>
<td>COMPLEX(4)</td>
<td>COMPLEX(4)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>ZSIN(X)</td>
<td>COMPLEX(8)</td>
<td>COMPLEX(8)</td>
<td>f95, gnu</td>
</tr>
<tr>
<td>CDSIN(X)</td>
<td>COMPLEX(8)</td>
<td>COMPLEX(8)</td>
<td>f95, gnu</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.19 [ASIN], page 112 Degrees function: Section 9.248 [SIND], page 251

9.248 SIND — Sine function, degrees

Description:
SIND(X) computes the sine of X in degrees.

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.

Standard: GNU Extension, enabled with `-fdec-math`

Class: Elemental function
**Syntax:** \[ \text{RESULT} = \text{SIND}(X) \]

**Arguments:**

\[ X \]  
The type shall be \texttt{REAL} or \texttt{COMPLEX}.

**Return value:**

The return value has same type and kind as \( X \), and its value is in degrees.

**Example:**

```
program test_sind
  real :: x = 0.0
  x = sind(x)
end program test_sind
```

**Specific names:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIND(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>DSIND(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>CSIND(X)</td>
<td>COMPLEX(4) X</td>
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</tr>
<tr>
<td>ZSIND(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU Extension</td>
</tr>
<tr>
<td>CDSIND(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU Extension</td>
</tr>
</tbody>
</table>

**See also:** Inverse function: Section 9.20 \([\text{ASIND}]\), page 113  
Radians function: Section 9.247 \([\text{SIN}]\), page 251

---

**9.249 SINH — Hyperbolic sine function**

**Description:**

\( \text{SINH}(X) \) computes the hyperbolic sine of \( X \).

**Standard:** Fortran 95 and later, for a complex argument Fortran 2008 or later

**Class:** Elemental function

**Syntax:** \[ \text{RESULT} = \text{SINH}(X) \]

**Arguments:**

\[ X \]  
The type shall be \texttt{REAL} or \texttt{COMPLEX}.

**Return value:**

The return value has same type and kind as \( X \).

**Example:**

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

**Specific names:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINH(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>DSINH(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>Fortran 95 and later</td>
</tr>
</tbody>
</table>

**See also:** Section 9.21 \([\text{ASINH}]\), page 114
9.250 SIZE — Determine the size of an array

Description:
Determine the extent of ARRAY along a specified dimension DIM, or the total number of elements in ARRAY if DIM is absent.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Inquiry function

Syntax: \( \text{RESULT} = \text{SIZE}(\text{ARRAY[, DIM [, KIND]}]) \)

Arguments:
- ARRAY: Shall be an array of any type. If ARRAY is a pointer it must be associated and allocatable arrays must be allocated.
- DIM (Optional): shall be a scalar of type INTEGER and its value shall be in the range from 1 to n, where n equals the rank of ARRAY.
- KIND (Optional): An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind.

Example:
```
PROGRAM test_size
  WRITE(*,*) SIZE((/ 1, 2 /)) ! 2
END PROGRAM
```

See also: Section 9.241 [SHAPE], page 248, Section 9.229 [RESHAPE], page 241

9.251 SIZEOF — Size in bytes of an expression

Description:
SIZEOF(X) calculates the number of bytes of storage the expression X occupies.

Standard: GNU extension

Class: Inquiry function

Syntax: \( N = \text{SIZEOF}(X) \)

Arguments:
- X: The argument shall be of any type, rank or shape.

Return value:
The return value is of type integer and of the system-dependent kind \( C_{\text{SIZE\_T}} \) (from the ISO_C_BINDING module). Its value is the number of bytes occupied by the argument. If the argument has the POINTER attribute, the number of bytes of the storage area pointed to is returned. If the argument is of a derived type with POINTER or ALLOCATABLE components, the return value does not account for the sizes of the data pointed to by these components. If the argument is polymorphic, the size according to the dynamic type is returned.
The argument may not be a procedure or procedure pointer. Note that the code assumes for arrays that those are contiguous; for contiguous arrays, it returns the storage or an array element multiplied by the size of the array.

Example:

```fortran
integer :: i
real :: r, s(5)
print *, (sizeof(s)/sizeof(r) == 5)
end
```

The example will print `.TRUE.` unless you are using a platform where default REAL variables are unusually padded.

See also: Section 9.57 [C.SIZEOF], page 137, Section 9.258 [STORAGE_SIZE], page 258

### 9.252 SLEEP — Sleep for the specified number of seconds

**Description:**
Calling this subroutine causes the process to pause for SECONDS seconds.

**Standard:** GNU extension

**Class:** Subroutine

**Syntax:**

```fortran
CALL SLEEP(SECONDS)
```

**Arguments:**

- **SECONDS**
  The type shall be of default INTEGER.

**Example:**

```fortran
program test_sleep
    call sleep(5)
end
```

### 9.253 SPACING — Smallest distance between two numbers of a given type

**Description:**
Determines the distance between the argument X and the nearest adjacent number of the same type.

**Standard:** Fortran 95 and later

**Class:** Elemental function

**Syntax:**

```fortran
RESULT = SPACING(X)
```

**Arguments:**

- **X**
  Shall be of type REAL.

**Return value:**
The result is of the same type as the input argument X.

**Example:**

```fortran
PROGRAM test_spacing
    INTEGER, PARAMETER :: SGL = SELECTED_REAL_KIND(p=6, r=37)
    INTEGER, PARAMETER :: DBL = SELECTED_REAL_KIND(p=13, r=200)
```
9.254 SPREAD — Add a dimension to an array

Description:
Replicates a \texttt{SOURCE} array \texttt{NCOPIES} times along a specified dimension \texttt{DIM}.

Standard: Fortran 95 and later

Class: Transformational function

Syntax: \texttt{RESULT = SPREAD(SOURCE, DIM, NCOPIES)}

Arguments:
- \texttt{SOURCE} Shall be a scalar or an array of any type and a rank less than seven.
- \texttt{DIM} Shall be a scalar of type \texttt{INTEGER} with a value in the range from 1 to \(n+1\), where \(n\) equals the rank of \texttt{SOURCE}.
- \texttt{NCOPIES} Shall be a scalar of type \texttt{INTEGER}.

Return value:
The result is an array of the same type as \texttt{SOURCE} and has rank \(n+1\) where \(n\) equals the rank of \texttt{SOURCE}.

Example:

```
PROGRAM test_spread
    INTEGER :: a = 1, b(2) = (/ 1, 2 /)
    WRITE(*,*) SPREAD(A, 1, 2) ! "1 1"
    WRITE(*,*) SPREAD(B, 1, 2) ! "1 1 2 2"
END PROGRAM
```

See also: Section 9.230 [RRSPACING], page 241

9.255 SQRT — Square-root function

Description:
\texttt{SQRT(X)} computes the square root of \(X\).

Standard: Fortran 77 and later

Class: Elemental function

Syntax: \texttt{RESULT = SQRT(X)}

Arguments:
- \texttt{X} The type shall be \texttt{REAL} or \texttt{COMPLEX}.

Return value:
The return value is of type \texttt{REAL} or \texttt{COMPLEX}. The kind type parameter is the same as \texttt{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:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQRT(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>DSQRT(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>CSQRT(X)</td>
<td>COMPLEX(4) X</td>
<td>COMPLEX(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>ZSQRT(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
<tr>
<td>CDSQRT(X)</td>
<td>COMPLEX(8) X</td>
<td>COMPLEX(8)</td>
<td>GNU extension</td>
</tr>
</tbody>
</table>

9.256 SRAND — Reinitialize the random number generator

Description:

SRAND reinitializes the pseudo-random number generator called by RAND and IRAND. The new seed used by the generator is specified by the required argument SEED.

Standard: GNU extension

Class: Subroutine

Syntax: CALL SRAND(SEED)

Arguments:

| SEED | Shall be a scalar INTEGER(kind=4). |

Return value:

Does not return anything.

Example: See RAND and IRAND for examples.

Notes: The Fortran standard specifies the intrinsic subroutines RANDOM_SEED to initialize the pseudo-random number generator and RANDOM_NUMBER to generate pseudo-random numbers. These subroutines should be used in new codes.

Please note that in GNU Fortran, these two sets of intrinsics (RAND, IRAND and SRAND on the one hand, RANDOM_NUMBER and RANDOM_SEED on the other hand) access two independent pseudo-random number generators.

See also: Section 9.221 [RAND], page 236, Section 9.223 [RANDOM_SEED], page 237, Section 9.222 [RANDOM_NUMBER], page 236

9.257 STAT — Get file status

Description:

This function returns information about a file. No permissions are required on the file itself, but execute (search) permission is required on all of the directories in path that lead to the file.

The elements that are obtained and stored in the array VALUES:
VALUES(1)  Device ID
VALUES(2)  Inode number
VALUES(3)  File mode
VALUES(4)  Number of links
VALUES(5)  Owner's uid
VALUES(6)  Owner's gid
VALUES(7)  ID of device containing directory entry for file (0 if not available)
VALUES(8)  File size (bytes)
VALUES(9)  Last access time
VALUES(10) Last modification time
VALUES(11) Last file status change time
VALUES(12) Preferred I/O block size (-1 if not available)
VALUES(13) Number of blocks allocated (-1 if not available)

Not all these elements are relevant on all systems. If an element is not relevant, it is returned as 0.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension

Class: Subroutine, function

Syntax:

CALL STAT(NAME, VALUES [, STATUS])
STATUS = STAT(NAME, VALUES)

Arguments:

NAME  The type shall be CHARACTER, of the default kind and a valid path within the file system.
VALUES  The type shall be INTEGER(4), DIMENSION(13).
STATUS  (Optional) status flag of type INTEGER(4). Returns 0 on success and a system specific error code otherwise.

Example:

PROGRAM test_stat
INTEGER, DIMENSION(13) :: buff
INTEGER :: status

CALL STAT("/etc/passwd", buff, status)

IF (status == 0) THEN
    WRITE (*, FMT="('Device ID:', T30, I19") buff(1)
    WRITE (*, FMT="('Inode number:', T30, I19") buff(2)
    WRITE (*, FMT="('File mode (octal):', T30, O19") buff(3)
    WRITE (*, FMT="('Number of links:', T30, I19") buff(4)
    WRITE (*, FMT="('Owner's uid:', T30, I19") buff(5)
    WRITE (*, FMT="('Owner's gid:', T30, I19") buff(6)
    WRITE (*, FMT="('Device where located:', T30, I19") buff(7)
    WRITE (*, FMT="('File size:', T30, I19") buff(8)
    WRITE (*, FMT="('Last access time:', T30, A19") CTIME(buff(9))
    WRITE (*, FMT="('Last modification time', T30, A19") CTIME(buff(10))
WRITE (*, FMT="('Last status change time:', T30, A19") CTIME(buff(11))
WRITE (*, FMT="('Preferred block size:', T30, I19") buff(12)
WRITE (*, FMT="('No. of blocks allocated:', T30, I19") buff(13)
END IF
END PROGRAM

See also: To stat an open file: Section 9.116 [FSTAT], page 177, to stat a link: Section 9.181 [LSTAT], page 213

9.258 STORAGE_SIZE — Storage size in bits

Description:
Returns the storage size of argument A in bits.

Standard: Fortran 2008 and later

Class: Inquiry function

Syntax: RESULT = STORAGE_SIZE(A [, KIND])

Arguments:
A: Shall be a scalar or array of any type.
KIND: (Optional) shall be a scalar integer constant expression.

Return Value:
The result is a scalar integer with the kind type parameter specified by KIND (or default integer type if KIND is missing). The result value is the size expressed in bits for an element of an array that has the dynamic type and type parameters of A.

See also: Section 9.57 [C_SIZEOF], page 137, Section 9.251 [SIZEOF], page 253

9.259 SUM — Sum of array elements

Description:
Adds the elements of ARRAY along dimension DIM if the corresponding element in MASK is TRUE.

Standard: Fortran 95 and later

Class: Transformational function

Syntax:
RESULT = SUM(ARRAY [, MASK])
RESULT = SUM(ARRAY, DIM [, MASK])

Arguments:
ARRAY: Shall be an array of type INTEGER, REAL or COMPLEX.
DIM: (Optional) shall be a scalar of type INTEGER with a value in the range from 1 to n, where n equals the rank of ARRAY.
MASK: (Optional) shall be of type LOGICAL and either be a scalar or an array of the same shape as ARRAY.

Return value:
The result is of the same type as ARRAY.
If $\text{DIM}$ is absent, a scalar with the sum of all elements in $\text{ARRAY}$ is returned. Otherwise, an array of rank n-1, where n equals the rank of $\text{ARRAY}$, and a shape similar to that of $\text{ARRAY}$ with dimension $\text{DIM}$ dropped is returned.

Example:

```
PROGRAM test_sum
    INTEGER :: x(5) = (/ 1, 2, 3, 4, 5 /)
    print *, SUM(x) ! all elements, sum = 15
    print *, SUM(x, MASK=MOD(x, 2)==1) ! odd elements, sum = 9
END PROGRAM
```

See also: Section 9.218 [PRODUCT], page 234

### 9.260 SYMLNK — Create a symbolic link

**Description:**

Makes a symbolic link from file $\text{PATH1}$ to $\text{PATH2}$. A null character ($\text{CHAR}(0)$) can be used to mark the end of the names in $\text{PATH1}$ and $\text{PATH2}$; otherwise, trailing blanks in the file names are ignored. If the $\text{STATUS}$ argument is supplied, it contains 0 on success or a nonzero error code upon return; see `symlink(2)`. If the system does not supply `symlink(2)`, `ENOSYS` is returned.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

**Standard:** GNU extension

**Class:** Subroutine, function

**Syntax:**

```
CALL SYMLNK(PATH1, PATH2 [, STATUS])
STATUS = SYMLNK(PATH1, PATH2)
```

**Arguments:**

- $\text{PATH1}$: Shall be of default $\text{CHARACTER}$ type.
- $\text{PATH2}$: Shall be of default $\text{CHARACTER}$ type.
- $\text{STATUS}$: (Optional) Shall be of default $\text{INTEGER}$ type.

See also: Section 9.170 [LINK], page 208, Section 9.278 [UNLINK], page 269

### 9.261 SYSTEM — Execute a shell command

**Description:**

Passes the command $\text{COMMAND}$ to a shell (see `system(3)`). If argument $\text{STATUS}$ is present, it contains the value returned by `system(3)`, which is presumably 0 if the shell command succeeded. Note that which shell is used to invoke the command is system-dependent and environment-dependent.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Note that the `system` function need not be thread-safe. It is the responsibility of the user to ensure that `system` is not called concurrently.

**Standard:** GNU extension
Class: Subroutine, function

Syntax:

CALL SYSTEM(COMMAND [, STATUS])
STATUS = SYSTEM(COMMAND)

Arguments:

COMMAND Shall be of default CHARACTER type.
STATUS (Optional) Shall be of default INTEGER type.

See also: Section 9.100 [EXECUTE_COMMAND_LINE], page 166, which is part of the Fortran 2008 standard and should considered in new code for future portability.

9.262 SYSTEM_CLOCK — Time function

Description:

Determines the COUNT of a processor clock since an unspecified time in the past modulo COUNT_MAX, COUNT_RATE determines the number of clock ticks per second. If the platform supports a monotonic clock, that clock is used and can, depending on the platform clock implementation, provide up to nanosecond resolution. If a monotonic clock is not available, the implementation falls back to a realtime clock.

COUNT_RATE is system dependent and can vary depending on the kind of the arguments. For kind=4 arguments (and smaller integer kinds), COUNT represents milliseconds, while for kind=8 arguments (and larger integer kinds), COUNT typically represents micro- or nanoseconds depending on resolution of the underlying platform clock. COUNT_MAX usually equals HUGE(COUNT_MAX). Note that the millisecond resolution of the kind=4 version implies that the COUNT will wrap around in roughly 25 days. In order to avoid issues with the wrap around and for more precise timing, please use the kind=8 version.

If there is no clock, or querying the clock fails, COUNT is set to -HUGE(COUNT), and COUNT_RATE and COUNT_MAX are set to zero.

When running on a platform using the GNU C library (glibc) version 2.16 or older, or a derivative thereof, the high resolution monotonic clock is available only when linking with the rt library. This can be done explicitly by adding the -lrt flag when linking the application, but is also done implicitly when using OpenMP.

On the Windows platform, the version with kind=4 arguments uses the GetTickCount function, whereas the kind=8 version uses QueryPerformanceCounter and QueryPerformanceCounterFrequency. For more information, and potential caveats, please see the platform documentation.

Standard: Fortran 95 and later

Class: Subroutine

Syntax: CALL SYSTEM_CLOCK([COUNT, COUNT_RATE, COUNT_MAX])
Arguments:

- **COUNT** (Optional) shall be a scalar of type INTEGER with INTENT(OUT).
- **COUNT_RATE** (Optional) shall be a scalar of type INTEGER or REAL, with INTENT(OUT).
- **COUNT_MAX** (Optional) shall be a scalar of type INTEGER with INTENT(OUT).

Example:

```fortran
PROGRAM test_system_clock
    INTEGER :: count, count_rate, count_max
    CALL SYSTEM_CLOCK(count, count_rate, count_max)
    WRITE(*,*) count, count_rate, count_max
END PROGRAM
```

See also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.79 [CPU_TIME], page 152

### 9.263 TAN — Tangent function

**Description:**

TAN(X) computes the tangent of X.

**Standard:** Fortran 77 and later, for a complex argument Fortran 2008 or later

**Class:** Elemental function

**Syntax:**

```fortran
RESULT = TAN(X)
```

**Arguments:**

- **X**
  
  The type shall be REAL or COMPLEX.

**Return value:**

The return value has same type and kind as X, and its value is in radians.

**Example:**

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

**Specific names:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAN(X)</td>
<td>REAL(4) X</td>
<td>REAL(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>DTAN(X)</td>
<td>REAL(8) X</td>
<td>REAL(8)</td>
<td>Fortran 95 and later</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.23 [ATAN], page 115 Degrees function: Section 9.264 [TAND], page 261

### 9.264 TAND — Tangent function, degrees

**Description:**

TAND(X) computes the tangent of X in degrees.

This function is for compatibility only and should be avoided in favor of standard constructs wherever possible.
The GNU Fortran Compiler

262

Standard: GNU Extension, enabled with ‘-fdec-math’.

Class: Elemental function

Syntax: RESULT = TAND(X)

Arguments:

X The type shall be REAL or COMPLEX.

Return value:

The return value has same type and kind as X, and its value is in degrees.

Example:

```
program test_tand
  real(8) :: x = 0.165_8
  x = tand(x)
end program test_tand
```

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
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<td>GNU Extension</td>
</tr>
</tbody>
</table>

See also: Inverse function: Section 9.24 [ATAND], page 116
Radian function: Section 9.263 [TAN], page 261

9.265 TANH — Hyperbolic tangent function

Description:

TANH(X) computes the hyperbolic tangent of X.

Standard: Fortran 77 and later, for a complex argument Fortran 2008 or later

Class: Elemental function

Syntax: X = TANH(X)

Arguments:

X The type shall be REAL or COMPLEX.

Return value:

The return value has same type and kind as X. If X is complex, the imaginary part of the result is in radians. If X is REAL, the return value lies in the range −1 ≤ tanh(x) ≤ 1.

Example:

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

Specific names:

<table>
<thead>
<tr>
<th>Name</th>
<th>Argument</th>
<th>Return type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
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<td>TANH(X)</td>
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<td>REAL(4)</td>
<td>Fortran 95 and later</td>
</tr>
<tr>
<td>DTANH(X)</td>
<td>REAL(8)</td>
<td>REAL(8)</td>
<td>Fortran 95 and later</td>
</tr>
</tbody>
</table>

See also: Section 9.27 [ATANH], page 119
9.266 THIS_IMAGE — Function that returns the cosubscript index of this image

Description:
Returns the cosubscript for this image.

Standard: Fortran 2008 and later. With DISTANCE argument, Technical Specification (TS) 18508 or later

Class: Transformational function

Syntax:
RESULT = THIS_IMAGE()
RESULT = THIS_IMAGE(DISTANCE)
RESULT = THIS_IMAGE(COARRAY [, DIM])

Arguments:
DISTANCE (optional, intent(in)) Nonnegative scalar integer (not permitted together with COARRAY).
COARRAY Coarray of any type (optional; if DIM present, required).
DIM default integer scalar (optional). If present, DIM shall be between one and the corank of COARRAY.

Return value:
Default integer. If COARRAY is not present, it is scalar; if DISTANCE is not present or has value 0, its value is the image index on the invoking image for the current team, for values smaller or equal distance to the initial team, it returns the image index on the ancestor team which has a distance of DISTANCE from the invoking team. If DISTANCE is larger than the distance to the initial team, the image index of the initial team is returned. Otherwise when the COARRAY is present, if DIM is not present, a rank-1 array with corank elements is returned, containing the cosubscripts for COARRAY specifying the invoking image. If DIM is present, a scalar is returned, with the value of the DIM element of THIS_IMAGE(COARRAY).

Example:

INTEGER :: value[*]
INTEGER :: i
value = THIS_IMAGE()
SYNC ALL
IF (THIS_IMAGE() == 1) THEN
  DO i = 1, NUM_IMAGE()
    WRITE(*,'(2(a,i0))') 'value[', i, '] is ', value[i]
  END DO
END IF

! Check whether the current image is the initial image
IF (THIS_IMAGE(HUGE(1)) /= THIS_IMAGE())
  error stop "something is rotten here"

See also: Section 9.209 [NUM_IMAGES], page 229, Section 9.146 [IMAGE_INDEX], page 194
9.267 TIME — Time function

Description:

Returns the current time encoded as an integer (in the manner of the function \texttt{time(3)} in the C standard library). This value is suitable for passing to Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, and Section 9.182 [LTIME], page 214.

This intrinsic is not fully portable, such as to systems with 32-bit \texttt{INTEGER} types but supporting times wider than 32 bits. 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.

See Section 9.268 [TIME8], page 264, for information on a similar intrinsic that might be portable to more GNU Fortran implementations, though to fewer Fortran compilers.

Standard: GNU extension

Class: Function

Syntax: \texttt{RESULT = TIME( )}

Return value:

The return value is a scalar of type \texttt{INTEGER(4)}.

See also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, Section 9.182 [LTIME], page 214, Section 9.191 [MCLOCK], page 219, Section 9.268 [TIME8], page 264

9.268 TIME8 — Time function (64-bit)

Description:

Returns the current time encoded as an integer (in the manner of the function \texttt{time(3)} in the C standard library). This value is suitable for passing to Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, and Section 9.182 [LTIME], page 214.

Warning: this intrinsic does not increase the range of the timing values over that returned by \texttt{time(3)}. On a system with a 32-bit \texttt{time(3)}, \texttt{TIME8} will return a 32-bit value, even though it is converted to a 64-bit \texttt{INTEGER(8)} value. That means overflows of the 32-bit value can still occur. 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.

Standard: GNU extension

Class: Function

Syntax: \texttt{RESULT = TIME8( )}

Return value:

The return value is a scalar of type \texttt{INTEGER(8)}.

See also: Section 9.82 [DATE_AND_TIME], page 154, Section 9.81 [CTIME], page 153, Section 9.130 [GMTIME], page 185, Section 9.182 [LTIME], page 214, Section 9.192 [MCLOCK8], page 219, Section 9.267 [TIME], page 264
9.269 TINY — Smallest positive number of a real kind

Description:
TINY(X) returns the smallest positive (non zero) number in the model of the type of X.

Standard: Fortran 95 and later
Class: Inquiry function
Syntax: RESULT = TINY(X)
Arguments:
X Shall be of type REAL.

Return value:
The return value is of the same type and kind as X
Example: See HUGE for an example.

9.270 TRAILZ — Number of trailing zero bits of an integer

Description:
TRAILZ returns the number of trailing zero bits of an integer.

Standard: Fortran 2008 and later
Class: Elemental function
Syntax: RESULT = TRAILZ(I)
Arguments:
I Shall be of type INTEGER.

Return value:
The type of the return value is the default INTEGER. If all the bits of I are zero, the result value is BIT_SIZE(I).

Example:

```fortran
PROGRAM test_trailz
  WRITE (*,*) TRAILZ(8) ! prints 3
END PROGRAM
```

See also: Section 9.48 [BIT_SIZE], page 132, Section 9.165 [LEADZ], page 205, Section 9.215 [POPPAR], page 233, Section 9.214 [POPCNT], page 232

9.271 TRANSFER — Transfer bit patterns

Description:
Interprets the bitwise representation of SOURCE in memory as if it is the representation of a variable or array of the same type and type parameters as MOLD.

This is approximately equivalent to the C concept of casting one type to another.

Standard: Fortran 95 and later
Class: Transformational function

Syntax: \( \text{RESULT} = \text{TRANSFER}(\text{SOURCE}, \text{MOLD}[, \text{SIZE}]) \)

Arguments:
- \( \text{SOURCE} \): Shall be a scalar or an array of any type.
- \( \text{MOLD} \): Shall be a scalar or an array of any type.
- \( \text{SIZE} \): (Optional) shall be a scalar of type \text{INTEGER}.

Return value:
The result has the same type as \( \text{MOLD} \), with the bit level representation of \( \text{SOURCE} \). If \( \text{SIZE} \) is present, the result is a one-dimensional array of length \( \text{SIZE} \). If \( \text{SIZE} \) is absent but \( \text{MOLD} \) is an array (of any size or shape), the result is a one-dimensional array of the minimum length needed to contain the entirety of the bitwise representation of \( \text{SOURCE} \). If \( \text{SIZE} \) is absent and \( \text{MOLD} \) is a scalar, the result is a scalar.

If the bitwise representation of the result is longer than that of \( \text{SOURCE} \), then the leading bits of the result correspond to those of \( \text{SOURCE} \) and any trailing bits are filled arbitrarily.

When the resulting bit representation does not correspond to a valid representation of a variable of the same type as \( \text{MOLD} \), the results are undefined, and subsequent operations on the result cannot be guaranteed to produce sensible behavior. For example, it is possible to create \text{LOGICAL} variables for which \text{VAR} and \text{.NOT. VAR} both appear to be true.

Example:
```fortran
PROGRAM test_transfer
  integer :: x = 2143289344
  print *, transfer(x, 1.0) ! prints "NaN" on i686
END PROGRAM
```

9.272 \textsc{TRANSPOSE} — Transpose an array of rank two

Description:
Transpose an array of rank two. Element \((i, j)\) of the result has the value \( \text{MATRIX}(j, i) \), for all \( i, j \).

Standard: Fortran 95 and later

Class: Transformational function

Syntax: \( \text{RESULT} = \text{TRANSPOSE}(\text{MATRIX}) \)

Arguments:
- \( \text{MATRIX} \): Shall be an array of any type and have a rank of two.

Return value:
The result has the same type as \( \text{MATRIX} \), and has shape \((/ m, n /)\) if \( \text{MATRIX} \) has shape \((/ n, m /)\).
9.273 TRIM — Remove trailing blank characters of a string

Description:
Removes trailing blank characters of a string.

Standard: Fortran 95 and later
Class: Transformational function
Syntax: \texttt{RESULT = TRIM(STRING)}

Arguments:
\texttt{STRING} \hspace{1em} Shall be a scalar of type \texttt{CHARACTER}.

Return value:
A scalar of type \texttt{CHARACTER} which length is that of \texttt{STRING} less the number of trailing blanks.

Example:
\begin{verbatim}
PROGRAM test_trim
  CHARACTER(len=10), PARAMETER :: s = "GFORTRAN 
  WRITE(*,*) LEN(s), LEN(TRIM(s)) ! "10 8", with/without trailing blanks
END PROGRAM
\end{verbatim}

See also: Section 9.9 [ADJUSTL], page 106, Section 9.10 [ADJUSTR], page 106

9.274 TTYNAM — Get the name of a terminal device.

Description:
Get the name of a terminal device. For more information, see \texttt{ttyname(3)}.
This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

Standard: GNU extension
Class: Subroutine, function
Syntax:
\begin{verbatim}
CALL TTYNAM(UNIT, NAME)
NAME = TTYNAM(UNIT)
\end{verbatim}

Arguments:
\texttt{UNIT} \hspace{1em} Shall be a scalar \texttt{INTEGER}.
\texttt{NAME} \hspace{1em} Shall be of type \texttt{CHARACTER}.

Example:
\begin{verbatim}
PROGRAM test_ttynam
  INTEGER :: unit
  DO unit = 1, 10
    IF (isatty(unit=unit)) write(*,*) ttynam(unit)
  END DO
END PROGRAM
\end{verbatim}

See also: Section 9.156 [ISATTY], page 200
9.275 UBOUND — Upper dimension bounds of an array

Description:
Returns the upper bounds of an array, or a single upper bound along the DIM dimension.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Inquiry function

Syntax: \[ \text{RESULT} = \text{UBOUND} (\text{ARRAY}[, \text{DIM}[, \text{KIND}]] \) \]

Arguments:
- \text{ARRAY} Shall be an array, of any type.
- \text{DIM} (Optional) Shall be a scalar INTEGER.
- \text{KIND} (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind. If DIM is absent, the result is an array of the upper bounds of ARRAY. If DIM is present, the result is a scalar corresponding to the upper bound of the array along that dimension. If ARRAY is an expression rather than a whole array or array structure component, or if it has a zero extent along the relevant dimension, the upper bound is taken to be the number of elements along the relevant dimension.

See also: Section 9.163 [LBOUND], page 204, Section 9.164 [LCOBOUND], page 204

9.276 UCOBOUND — Upper codimension bounds of an array

Description:
Returns the upper cobounds of a coarray, or a single upper cobound along the DIM codimension.

Standard: Fortran 2008 and later

Class: Inquiry function

Syntax: \[ \text{RESULT} = \text{UCOBOUND} (\text{COARRAY}[, \text{DIM}[, \text{KIND}]] \) \]

Arguments:
- \text{ARRAY} Shall be a coarray, of any type.
- \text{DIM} (Optional) Shall be a scalar INTEGER.
- \text{KIND} (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:
The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind. If DIM is absent, the result is an array of the lower cobounds of COARRAY. If DIM is present, the result is a scalar corresponding to the lower cobound of the array along that codimension.

See also: Section 9.164 [LCOBOUND], page 204, Section 9.163 [LBOUND], page 204
9.277 **UMASK — Set the file creation mask**

*Description:*  
Sets the file creation mask to MASK. If called as a function, it returns the old value. If called as a subroutine and argument OLD if it is supplied, it is set to the old value. See `umask(2)`.

*Standard:* GNU extension  
*Class:* Subroutine, function  
*Syntax:*  
```
CALL UMASK(MASK [, OLD])  
OLD = UMASK(MASK)
```

*Arguments:*  
- **MASK** Shall be a scalar of type INTEGER.  
- **OLD** (Optional) Shall be a scalar of type INTEGER.

9.278 **UNLINK — Remove a file from the file system**

*Description:*  
Unlinks the file PATH. A null character (CHAR(0)) can be used to mark the end of the name in PATH; otherwise, trailing blanks in the file name are ignored. If the STATUS argument is supplied, it contains 0 on success or a nonzero error code upon return; see `unlink(2)`.

This intrinsic is provided in both subroutine and function forms; however, only one form can be used in any given program unit.

*Standard:* GNU extension  
*Class:* Subroutine, function  
*Syntax:*  
```
CALL UNLINK(PATH [, STATUS])  
STATUS = UNLINK(PATH)
```

*Arguments:*  
- **PATH** Shall be of default CHARACTER type.  
- **STATUS** (Optional) Shall be of default INTEGER type.

*See also:* Section 9.170 [LINK], page 208, Section 9.260 [SYMLNK], page 259

9.279 **UNPACK — Unpack an array of rank one into an array**

*Description:*  
Store the elements of VECTOR in an array of higher rank.

*Standard:* Fortran 95 and later  
*Class:* Transformational function  
*Syntax:*  
```
RESULT = UNPACK(VECTOR, MASK, FIELD)
```
Arguments:

VECTOR Shall be an array of any type and rank one. It shall have at least as many elements as MASK has TRUE values.

MASK Shall be an array of type LOGICAL.

FIELD Shall be of the same type as VECTOR and have the same shape as MASK.

Return value:

The resulting array corresponds to FIELD with TRUE elements of MASK replaced by values from VECTOR in array element order.

Example:

```fortran
PROGRAM test_unpack
  integer :: vector(2) = (/1,1/)
  logical :: mask(4) = (/ .TRUE., .FALSE., .FALSE., .TRUE. /)
  integer :: field(2,2) = 0, unity(2,2)
  ! result: unity matrix
  unity = unpack(vector, reshape(mask, (/2,2/)), field)
END PROGRAM
```

See also: Section 9.211 [PACK], page 231, Section 9.254 [SPREAD], page 255

9.280 VERIFY — Scan a string for characters not a given set

Description:

Verifies that all the characters in STRING belong to the set of characters in SET.

If BACK is either absent or equals FALSE, this function returns the position of the leftmost character of STRING that is not in SET. If BACK equals TRUE, the rightmost position is returned. If all characters of STRING are found in SET, the result is zero.

Standard: Fortran 95 and later, with KIND argument Fortran 2003 and later

Class: Elemental function

Syntax: `RESULT = VERIFY(STRING, SET[, BACK [, KIND]])`

Arguments:

STRING Shall be of type CHARACTER.

SET Shall be of type CHARACTER.

BACK (Optional) shall be of type LOGICAL.

KIND (Optional) An INTEGER initialization expression indicating the kind parameter of the result.

Return value:

The return value is of type INTEGER and of kind KIND. If KIND is absent, the return value is of default integer kind.

Example:

```fortran
PROGRAM test_verify
  WRITE(*,*) VERIFY("FORTRAN", "AO") ! 1, found 'F'
  WRITE(*,*) VERIFY("FORTRAN", "FOO") ! 3, found 'R'
END PROGRAM
```
WRITE(*,*) VERIFY("FORTRAN", "C++") ! 1, found 'F'
WRITE(*,*) VERIFY("FORTRAN", "C++", .TRUE.) ! 7, found 'N'
WRITE(*,*) VERIFY("FORTRAN", "FORTRAN") ! 0’ found none
END PROGRAM

See also: Section 9.234 [SCAN], page 243, Section 9.147 [INDEX intrinsic], page 195

9.281 XOR — Bitwise logical exclusive OR

Description:

Bitwise logical exclusive or.

This intrinsic routine is provided for backwards compatibility with GNU Fortran 77. For integer arguments, programmers should consider the use of the Section 9.144 [IEOR], page 193 intrinsic and for logical arguments the .NEQV. operator, which are both defined by the Fortran standard.

Standard: GNU extension

Class: Function

Syntax: RESULT = XOR(I, J)

Arguments:

I The type shall be either a scalar INTEGER type or a scalar LOGICAL type.

J The type shall be the same as the type of I.

Return value:

The return type is either a scalar INTEGER or a scalar LOGICAL. If the kind type parameters differ, then the smaller kind type is implicitly converted to larger kind, and the return has the larger kind.

Example:

PROGRAM test_xor
  LOGICAL :: T = .TRUE., F = .FALSE.
  INTEGER :: a, b
  DATA a / Z’F’ /, b / Z’3’ /

  WRITE (*,*) XOR(T, T), XOR(T, F), XOR(F, T), XOR(F, F)
  WRITE (*,*) XOR(a, b)
END PROGRAM

See also: Fortran 95 elemental function: Section 9.144 [IEOR], page 193
10 Intrinsic Modules

10.1 ISO_FORTRAN_ENV

*Standard:* Fortran 2003 and later, except when otherwise noted

The ISO_FORTRAN_ENV module provides the following scalar default-integer named constants:

**ATOMIC_INT_KIND:**
Default-kind integer constant to be used as kind parameter when defining integer variables used in atomic operations. (Fortran 2008 or later.)

**ATOMIC_LOGICAL_KIND:**
Default-kind integer constant to be used as kind parameter when defining logical variables used in atomic operations. (Fortran 2008 or later.)

**CHARACTER_KINDS:**
Default-kind integer constant array of rank one containing the supported kind parameters of the CHARACTER type. (Fortran 2008 or later.)

**CHARACTER_STORAGE_SIZE:**
Size in bits of the character storage unit.

**ERROR_UNIT:**
Identifies the preconnected unit used for error reporting.

**FILE_STORAGE_SIZE:**
Size in bits of the file-storage unit.

**INPUT_UNIT:**
Identifies the preconnected unit identified by the asterisk (*) in READ statement.

**INT8, INT16, INT32, INT64:**
Kind type parameters to specify an INTEGER type with a storage size of 16, 32, and 64 bits. It is negative if a target platform does not support the particular kind. (Fortran 2008 or later.)

**INTEGER_KINDS:**
Default-kind integer constant array of rank one containing the supported kind parameters of the INTEGER type. (Fortran 2008 or later.)

**IOSTAT_END:**
The value assigned to the variable passed to the IOSTAT= specifier of an input/output statement if an end-of-file condition occurred.

**IOSTAT_EOR:**
The value assigned to the variable passed to the IOSTAT= specifier of an input/output statement if an end-of-record condition occurred.

**IOSTAT_INQUIRE_INTERNAL_UNIT:**
Scalar default-integer constant, used by INQUIRE for the IOSTAT= specifier to denote an that a unit number identifies an internal unit. (Fortran 2008 or later.)
**NUMERIC_STORAGE_SIZE:**
The size in bits of the numeric storage unit.

**LOGICAL_KINDS:**
Default-kind integer constant array of rank one containing the supported kind parameters of the LOGICAL type. (Fortran 2008 or later.)

**OUTPUT_UNIT:**
Identifies the preconnected unit identified by the asterisk (*) in WRITE statement.

**REAL32, REAL64, REAL128:**
Kind type parameters to specify a REAL type with a storage size of 32, 64, and 128 bits. It is negative if a target platform does not support the particular kind. (Fortran 2008 or later.)

**REAL_KINDS:**
Default-kind integer constant array of rank one containing the supported kind parameters of the REAL type. (Fortran 2008 or later.)

**STAT_LOCKED:**
Scalar default-integer constant used as STAT= return value by LOCK to denote that the lock variable is locked by the executing image. (Fortran 2008 or later.)

**STAT_LOCKED_OTHER_IMAGE:**
Scalar default-integer constant used as STAT= return value by UNLOCK to denote that the lock variable is locked by another image. (Fortran 2008 or later.)

**STAT_STOPPED_IMAGE:**
Positive, scalar default-integer constant used as STAT= return value if the argument in the statement requires synchronisation with an image, which has initiated the termination of the execution. (Fortran 2008 or later.)

**STAT_FAILED_IMAGE:**
Positive, scalar default-integer constant used as STAT= return value if the argument in the statement requires communication with an image, which has is in the failed state. (TS 18508 or later.)

**STAT_UNLOCKED:**
Scalar default-integer constant used as STAT= return value by UNLOCK to denote that the lock variable is unlocked. (Fortran 2008 or later.)

The module provides the following derived type:

**LOCK_TYPE:**
Derived type with private components to be use with the LOCK and UNLOCK statement. A variable of its type has to be always declared as coarray and may not appear in a variable-definition context. (Fortran 2008 or later.)

The module also provides the following intrinsic procedures: Section 9.69 [COMPILER_OPTIONS], page 146 and Section 9.70 [COMPILER_VERSION], page 146.
10.2 ISO_C_BINDING

*Standard:* Fortran 2003 and later, GNU extensions

The following intrinsic procedures are provided by the module; their definition can be found in the section Intrinsic Procedures of this manual.

- `C_ASSOCIATED`
- `C_F_POINTER`
- `C_F_PROCPOINTER`
- `C_FUNLOC`
- `C_LOC`
- `C_SIZEOF`

The ISO_C_BINDING module provides the following named constants of type default integer, which can be used as KIND type parameters.

In addition to the integer named constants required by the Fortran 2003 standard and `C_PTRDIFF_T` of TS 29113, GNU Fortran provides as an extension named constants for the 128-bit integer types supported by the C compiler: `C_INT128_T`, `C_INT_LEAST128_T`, `C_INT_FAST128_T`. Furthermore, if `__float128` is supported in C, the named constants `C_FLOAT128`, `C_FLOAT128_COMPLEX` are defined.

<table>
<thead>
<tr>
<th>Fortran Type</th>
<th>Named constant</th>
<th>C type</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTEGER C_INT</td>
<td>int</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_SHORT</td>
<td>short int</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_LONG</td>
<td>long int</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_LONG_LONG</td>
<td>long long int</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_SIGNED_CHAR</td>
<td>signed char/unsigned char</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_SIZE_T</td>
<td>size_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT8_T</td>
<td>int8_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT16_T</td>
<td>int16_t</td>
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<td></td>
</tr>
<tr>
<td>INTEGER C_INT32_T</td>
<td>int32_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT64_T</td>
<td>int64_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT128_T</td>
<td>int128_t</td>
<td></td>
<td>Ext.</td>
</tr>
<tr>
<td>INTEGER C_INT_LEAST8_T</td>
<td>int_least8_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_LEAST16_T</td>
<td>int_least16_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_LEAST32_T</td>
<td>int_least32_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_LEAST64_T</td>
<td>int_least64_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_LEAST128_T</td>
<td>int_least128_t</td>
<td></td>
<td>Ext.</td>
</tr>
<tr>
<td>INTEGER C_INT_FAST8_T</td>
<td>int_fast8_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_FAST16_T</td>
<td>int_fast16_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_FAST32_T</td>
<td>int_fast32_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_FAST64_T</td>
<td>int_fast64_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INT_FAST128_T</td>
<td>int_fast128_t</td>
<td></td>
<td>Ext.</td>
</tr>
<tr>
<td>INTEGER C_INTMAX_T</td>
<td>intmax_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_INTPTR_T</td>
<td>intptr_t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGER C_PTRDIFF_T</td>
<td>pptrdiff_t</td>
<td></td>
<td>TS 29113</td>
</tr>
<tr>
<td>REAL C_FLOAT</td>
<td>float</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REAL C_DOUBLE</td>
<td>double</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REAL       C_LONG_DOUBLE       long double  
REAL       C_FLOAT128       __float128     Ext.
COMPLEX    C_FLOAT_COMPLEX   float_Complex
COMPLEX    C_DOUBLE_COMPLEX  double_Complex
COMPLEX    C_LONG_DOUBLE_COMPLEX long double_Complex
REAL       C_FLOAT128_COMPLEX __float128_Complex  Ext.
LOGICAL    C_BOOL           _Bool
CHARACTER   C_CHAR           char

Additionally, the following parameters of type CHARACTER(KIND=C_CHAR) are defined.

<table>
<thead>
<tr>
<th>Name</th>
<th>C definition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_NULL_CHAR</td>
<td>null character</td>
<td>\0</td>
</tr>
<tr>
<td>C_ALERT</td>
<td>alert</td>
<td>\a</td>
</tr>
<tr>
<td>C_BACKSPACE</td>
<td>backspace</td>
<td>\b</td>
</tr>
<tr>
<td>C_FORM_FEED</td>
<td>form feed</td>
<td>\f</td>
</tr>
<tr>
<td>C_NEW_LINE</td>
<td>new line</td>
<td>\n</td>
</tr>
<tr>
<td>C_CARRIAGE_</td>
<td>carriage return</td>
<td>\r</td>
</tr>
<tr>
<td>RETURN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C_HORIZONTAL_</td>
<td>horizontal tab</td>
<td>\t</td>
</tr>
<tr>
<td>TAB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C_VERTICAL_TAB</td>
<td>vertical tab</td>
<td>\v</td>
</tr>
</tbody>
</table>

Moreover, the following two named constants are defined:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_NULL_PTR</td>
<td>C_PTR</td>
</tr>
<tr>
<td>C_NULL_FUNPTR</td>
<td>C_FUNPTR</td>
</tr>
</tbody>
</table>

Both are equivalent to the value NULL in C.

### 10.3 IEEE modules: IEEE_EXCEPTIONS, IEEE_ARITHMETIC, and IEEE_FEATURES

**Standard:** Fortran 2003 and later

The IEEE_EXCEPTIONS, IEEE_ARITHMETIC, and IEEE_FEATURES intrinsic modules provide support for exceptions and IEEE arithmetic, as defined in Fortran 2003 and later standards, and the IEC 60559:1989 standard (*Binary floating-point arithmetic for microprocessor systems*). These modules are only provided on the following supported platforms:

- i386 and x86_64 processors
- platforms which use the GNU C Library (glibc)
- platforms with support for SysV/386 routines for floating point interface (including Solaris and BSDs)
- platforms with the AIX OS

For full compliance with the Fortran standards, code using the IEEE_EXCEPTIONS or IEEE_ARITHMETIC modules should be compiled with the following options: -fno-unsafe-math-optimizations -frounding-math -fsignaling-nans.
10.4 OpenMP Modules OMP_LIB and OMP_LIB_KINDS

*Standard:* OpenMP Application Program Interface v4.5

The OpenMP Fortran runtime library routines are provided both in a form of two Fortran 90 modules, named OMP_LIB and OMP_LIB_KINDS, and in a form of a Fortran include file named `omp_lib.h`. The procedures provided by OMP_LIB can be found in the Section “Introduction” in GNU Offloading and Multi Processing Runtime Library manual, the named constants defined in the modules are listed below.

For details refer to the actual OpenMP Application Program Interface v4.5.

OMP_LIB_KINDS provides the following scalar default-integer named constants:

- `omp_lock_kind`
- `omp_nest_lock_kind`
- `omp_proc_bind_kind`
- `omp_sched_kind`

OMP_LIB provides the scalar default-integer named constant `openmp_version` with a value of the form `yyyyymm`, where `yyyy` is the year and `mm` the month of the OpenMP version; for OpenMP v4.5 the value is `201511`.

The following scalar integer named constants of the kind `omp_sched_kind`:

- `omp_sched_static`
- `omp_sched_dynamic`
- `omp_sched_guided`
- `omp_sched_auto`

And the following scalar integer named constants of the kind `omp_proc_bind_kind`:

- `omp_proc_bind_false`
- `omp_proc_bind_true`
- `omp_proc_bind_master`
- `omp_proc_bind_close`
- `omp_proc_bind_spread`

10.5 OpenACC Module OPENACC

*Standard:* OpenACC Application Programming Interface v2.0

The OpenACC Fortran runtime library routines are provided both in a form of a Fortran 90 module, named OPENACC, and in form of a Fortran include file named `openacc_lib.h`. The procedures provided by OPENACC can be found in the Section “Introduction” in GNU Offloading and Multi Processing Runtime Library manual, the named constants defined in the modules are listed below.

For details refer to the actual OpenACC Application Programming Interface v2.0.

OPENACC provides the scalar default-integer named constant `openacc_version` with a value of the form `yyyyymm`, where `yyyy` is the year and `mm` the month of the OpenACC version; for OpenACC v2.0 the value is `201306`. 
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, 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 GNU Fortran, but others are “mainstream” projects in need of enthusiastic hackers. All of these projects are important! We will eventually get around to the things here, but they are also things doable by someone who is willing and able.

Contributors to GNU Fortran

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 GNU Fortran project (in alphabetical order):

- Janne Blomqvist
- Steven Bosscher
- Paul Brook
- Tobias Burnus
- François-Xavier Coudert
- Bud Davis
- Jerry DeLisle
- Erik Edelmann
- Bernhard Fischer
- Daniel Franke
- Richard Guenther
- Richard Henderson
- Katherine Holcomb
- Jakub Jelinek
- Niels Kristian Bech Jensen
- Steven Johnson
- Steven G. Kargl
- Thomas Koenig
- Asher Langton
- H. J. Lu
- Toon Moene
- Brooks Moses
- Andrew Pinski
- Tim Prince
The following people have contributed bug reports, smaller or larger patches, and much needed feedback and encouragement for the GNU Fortran project:

- Christopher D. Rickett
- Richard Sandiford
- Tobias Schlüter
- Roger Sayle
- Paul Thomas
- Andy Vaught
- Feng Wang
- Janus Weil
- Daniel Kraft

Many other individuals have helped debug, test and improve the GNU Fortran compiler over the past few 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.

**Projects**

*Help build the test suite*

Solicit more code for donation to the test suite: the more extensive the test suite, the smaller the risk of breaking things in the future! 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. Going through the bugzilla database at [https://gcc.gnu.org/bugzilla/](https://gcc.gnu.org/bugzilla/) to reduce testcases posted there and add more information (for example, for which version does the testcase work, for which versions does it fail?) is also very helpful.

**Proposed Extensions**

Here’s a list of proposed extensions for the GNU Fortran compiler, 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.

**Compiler extensions:**

- User-specified alignment rules for structures.
- Automatically extend single precision constants to double.
Contributing

- Compile code that conserves memory by dynamically allocating common and module storage either on stack or heap.
- 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.

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).
- Variable 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).
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Version 3, 29 June 2007


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gfortran’s command line options are indexed here without any initial ‘-’ or ‘--’. Where an option has both positive and negative forms (such as -option and -fno-option), relevant entries in the manual are indexed under the most appropriate form; it may sometimes be useful to look up both forms.

**A**
- $A$-predicate=answer ........................................ 14
  - $A$ predicate=answer ....................................... 14

**B**
- backslash ....................................................... 9

**C**
- C ................................................................. 14
- CC ............................................................... 14
- cpp .............................................................. 12

**D**
- dD ................................................................. 12
- dI ................................................................. 12
- dM ................................................................. 12
- Dname ..................................................... 14
- Dname=definition ....................................... 14
- dN ................................................................. 12
- dU ................................................................. 12

**F**
- faggressive-function-elimination ......................... 27
- falign-commons .............................................. 27
- fall-intrinsics ............................................... 8
- fblas-matmul-limit ......................................... 26
- fbounds-check ............................................... 24
- fcheck .......................................................... 24
- fcheck-array-temporaries .................................. 25
- fcoarray ...................................................... 23
- fconvert=conversion ...................................... 21
- fcray-pointer ................................................. 10
- fd-lines-as-code ............................................ 8
- fd-lines-as-comments ....................................... 8
- fdec .............................................................. 9
- fdec-intrinsic-ints ........................................ 9
- fdec-math ...................................................... 9
- fdec-static .................................................... 9
- fdec-structure ............................................... 9
- fdefault-double-8 ......................................... 11
- fdefault-integer-8 ......................................... 11
- fdefault-real-8 ............................................. 11
- fdollar-ok ..................................................... 9
- fdump-fortran-optimized .................................. 19
  - fdump-fortran-original ..................................... 19
  - fdump-parse-tree .......................................... 19
  - fexternal-blas ............................................ 26
  - ff2c .......................................................... 22
  - ffixed-form ............................................... 8
  - ffixed-line-length-n ..................................... 10
  - ffpe-summary=list ........................................ 20
  - ffpe-trap=list ............................................. 19
  - ffree-form ................................................. 8
  - ffree-line-length-n ....................................... 10
  - fimplicit-none ............................................ 10
  - finit-character ........................................... 26
  - finit-derived ............................................. 26
  - finit-integer ............................................. 26
  - finit-local-zero ......................................... 26
  - finit-logical ............................................. 26
  - finit-real .................................................. 26
  - finline-matmul-limit ..................................... 26
  - integer-4-integer-8 ...................................... 11
  - fintrinsic-modules-path dir ................................
  - fmmax-array-constructor .................................. 25
  - fmmax-errors=n ............................................ 15
  - fmmax-identifier-length=n .............................. 10
  - fmmax-stack-var-size .................................... 25
  - fmmax-subrecord-length=length .......................... 21
  - fmodule-private .......................................... 9
  - fno-automatic ............................................ 22
  - fno-backtrace ............................................. 20
  - fno-protect-paren ....................................... 27
  - fno-underscoring ........................................ 22
  - fopenacc ................................................... 10
  - fopenmp ..................................................... 10
  - fpack-derived ............................................. 25
  - fpp .......................................................... 12
  - framge-check .............................................. 10
  - freal-4-real-10 ........................................... 11
  - freal-4-real-16 ........................................... 11
  - freal-4-real-8 ............................................. 11
  - freal-8-real-10 ........................................... 11
  - freal-8-real-16 ........................................... 11
  - freal-8-real-4 ............................................. 11
  - frealloc-1hs ............................................... 27
  - frecord-marker=length .................................... 21
  - freeursive .................................................. 26
  - frepack-arrays ............................................ 25
  - frontend-optimize ........................................ 27
  - fsecond-underscore ....................................... 23
  - fshort-enums ............................................. 26, 36
  - fsign-zero .................................................. 21
<table>
<thead>
<tr>
<th>Option</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>fstack-arrays</td>
<td>25</td>
</tr>
<tr>
<td>fsyntax-only</td>
<td>15</td>
</tr>
<tr>
<td>ftest-forall-temp</td>
<td>12</td>
</tr>
<tr>
<td>fworking-directory</td>
<td>13</td>
</tr>
<tr>
<td>H</td>
<td>14</td>
</tr>
<tr>
<td>H</td>
<td>14</td>
</tr>
<tr>
<td>J</td>
<td>20</td>
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<td>20</td>
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<td>20</td>
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<td>13</td>
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<td>13</td>
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<td>P</td>
<td>15</td>
</tr>
<tr>
<td>P</td>
<td>15</td>
</tr>
<tr>
<td>S</td>
<td>21</td>
</tr>
<tr>
<td>S</td>
<td>21</td>
</tr>
<tr>
<td>std=std option</td>
<td>11</td>
</tr>
<tr>
<td>U</td>
<td>15</td>
</tr>
<tr>
<td>U</td>
<td>15</td>
</tr>
<tr>
<td>W</td>
<td>16</td>
</tr>
<tr>
<td>W</td>
<td>16</td>
</tr>
<tr>
<td>W</td>
<td>16</td>
</tr>
<tr>
<td>Wall</td>
<td>16</td>
</tr>
<tr>
<td>Walign-commons</td>
<td>18</td>
</tr>
<tr>
<td>Wargument-mismatch</td>
<td>16</td>
</tr>
<tr>
<td>Warray-temporaries</td>
<td>16</td>
</tr>
<tr>
<td>Wc-binding-type</td>
<td>16</td>
</tr>
<tr>
<td>Wcharacter-truncation</td>
<td>16</td>
</tr>
<tr>
<td>Wcompare-reals</td>
<td>19</td>
</tr>
<tr>
<td>Wconversion</td>
<td>17</td>
</tr>
<tr>
<td>Wconversion-extra</td>
<td>17</td>
</tr>
<tr>
<td>Werror</td>
<td>19</td>
</tr>
<tr>
<td>Wextra</td>
<td>17</td>
</tr>
<tr>
<td>Wfunction-elimination</td>
<td>18</td>
</tr>
<tr>
<td>Wimplicit-interface</td>
<td>17</td>
</tr>
<tr>
<td>Wimplicit-procedure</td>
<td>17</td>
</tr>
<tr>
<td>Winteger-division</td>
<td>17</td>
</tr>
<tr>
<td>Wintrinsic-shadow</td>
<td>18</td>
</tr>
<tr>
<td>Wintrinsics-std</td>
<td>17</td>
</tr>
<tr>
<td>Wline-truncation</td>
<td>17</td>
</tr>
<tr>
<td>Wpedantic</td>
<td>16</td>
</tr>
<tr>
<td>Wrealloc-lhs</td>
<td>16</td>
</tr>
<tr>
<td>Wrealloc-lhs-all</td>
<td>18</td>
</tr>
<tr>
<td>Wsurprising</td>
<td>17</td>
</tr>
<tr>
<td>Wtabs</td>
<td>18</td>
</tr>
<tr>
<td>Wtargt-lifetime</td>
<td>19</td>
</tr>
<tr>
<td>Wundefined-do-loop</td>
<td>18</td>
</tr>
<tr>
<td>Wunderflow</td>
<td>18</td>
</tr>
<tr>
<td>Wunused-dummy-argument</td>
<td>18</td>
</tr>
<tr>
<td>Wunused-parameter</td>
<td>18</td>
</tr>
<tr>
<td>Wuse-without-only</td>
<td>18</td>
</tr>
<tr>
<td>Wzertroip</td>
<td>19</td>
</tr>
</tbody>
</table>
Keyword Index

$ ................................. 9
$ . ................................ 9
%
%LOC .................................. 51
%REF .................................. 51
%VAL .................................. 51
& ........................................ 16
& ........................................ 16
[ ........................................ 36
[ ........................................ 36
- 
- _gfortran_set_args .................. 70
- _gfortran_set_convert .............. 72
- _gfortran_set_fpe ................. 73
- _gfortran_set_max_subrecord_length 73
- _gfortran_set_options .......... 71
- _gfortran_set_record_marker ..... 72

A
ABORT .................................. 101
absolute value .......................... 102
ABS .................................. 102
ACCESS .................................. 103
ACCESS='STREAM' I/O .............. 36
ACCHAR .................................. 103
ACOS .................................. 104
ACOSD .................................. 105
ACOSH .................................. 105
adjust string .......................... 106
ADJUSTL .................................. 106
ADJUSTR .................................. 106
AIMAG .................................. 107
AINT .................................. 107
ALARM .................................. 108
ALGAMA .................................. 211
aliasing .................................. 16
alignment of COMMON blocks ........ 18, 27
all warnings ................................ 16
ALLOCATABLE components of derived types 36
ALLOCATABLE dummy arguments 36
ALLOCATABLE function results 36
ALLOCATED .................................. 110
allocation, moving .................... 225
allocation, status .................... 110

ALL ......................................... 109
ALOG ........................................ 210
ALOG10 ..................................... 211
AMAX0 ..................................... 217
AMAX1 ..................................... 217
AMIN ..................................... 221
AMIN1 ..................................... 221
AMOD ..................................... 223
AND ....................................... 110
ANINT ..................................... 111
ANY ....................................... 112
area hyperbolic cosine .............. 105
area hyperbolic sine .................. 114
area hyperbolic tangent .............. 119
argument list functions .............. 51
arguments, to program .............. 145, 179, 180, 190
array, add elements ................. 258
array, AND .................................. 187
array, apply condition .............. 109, 112
array, bounds checking ............. 24
array, change dimensions .......... 241
array, combine arrays .............. 220
array, condition testing .......... 109, 112
array, conditionally add elements 258
array, conditionally count elements 151
array, conditionally multiply elements 234
array, constructors ................. 36
array, count elements .............. 253
array, duplicate dimensions ........ 255
array, duplicate elements .......... 255
array, element counting ............. 151
array, gather elements ............. 231
array, increase dimension .......... 255, 269
array, indices of type real ........ 46
array, location of maximum element 218
array, location of minimum element 222
array, lower bound .................. 204
array, maximum value ............... 218
array, merge arrays .................. 220
array, minimum value ............... 222
array, multiply elements .......... 234
array, number of elements .......... 151, 253
array, OR .................................. 189
array, packing ....................... 231
array, parity ........................... 198
array, permutation .................. 153
array, product ....................... 234
array, reduce dimension .......... 231
array, rotate ........................... 153
array, scatter elements ............ 269
array, shape ........................... 248
array, shift .......................... 161
array, shift circularly .............. 153
array, size .......................... 253
<table>
<thead>
<tr>
<th>Keyword Index</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_F_PROCPOINTER</td>
<td>135</td>
</tr>
<tr>
<td>C_FUNLOC</td>
<td>136</td>
</tr>
<tr>
<td>C_LOC</td>
<td>136</td>
</tr>
<tr>
<td>C_SIZEOF</td>
<td>137</td>
</tr>
<tr>
<td>CABS</td>
<td>102</td>
</tr>
<tr>
<td>calling convention</td>
<td>22</td>
</tr>
<tr>
<td>CARRIAGECONTROL</td>
<td>59</td>
</tr>
<tr>
<td>CCOS</td>
<td>148</td>
</tr>
<tr>
<td>CCOSD</td>
<td>149</td>
</tr>
<tr>
<td>CDABS</td>
<td>102</td>
</tr>
<tr>
<td>CDCOS</td>
<td>148</td>
</tr>
<tr>
<td>CDEXP</td>
<td>167</td>
</tr>
<tr>
<td>CDLOG</td>
<td>210</td>
</tr>
<tr>
<td>CDSIN</td>
<td>251</td>
</tr>
<tr>
<td>CDSIND</td>
<td>251</td>
</tr>
<tr>
<td>CDSQRT</td>
<td>255</td>
</tr>
<tr>
<td>ceiling</td>
<td>111, 138</td>
</tr>
<tr>
<td>CEILING</td>
<td>138</td>
</tr>
<tr>
<td>CEXP</td>
<td>167</td>
</tr>
<tr>
<td>character kind</td>
<td>245</td>
</tr>
<tr>
<td>character set</td>
<td>9</td>
</tr>
<tr>
<td>CHAR</td>
<td>138</td>
</tr>
<tr>
<td>CHDIR</td>
<td>139</td>
</tr>
<tr>
<td>checking array temporaries</td>
<td>24</td>
</tr>
<tr>
<td>checking subscript</td>
<td>24</td>
</tr>
<tr>
<td>CHMOD</td>
<td>139</td>
</tr>
<tr>
<td>clock ticks</td>
<td>219, 260</td>
</tr>
<tr>
<td>CLOG</td>
<td>210</td>
</tr>
<tr>
<td>CMPLX</td>
<td>140</td>
</tr>
<tr>
<td>CD_BROADCAST</td>
<td>141</td>
</tr>
<tr>
<td>CD_MAX</td>
<td>142</td>
</tr>
<tr>
<td>CD_MIN</td>
<td>142</td>
</tr>
<tr>
<td>CD_REDUCE</td>
<td>143</td>
</tr>
<tr>
<td>CD_SUM</td>
<td>144</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_lock</td>
<td>90</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_num_images</td>
<td>81</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_register</td>
<td>82</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_send</td>
<td>84</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_send_by_ref</td>
<td>87</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_blocked_images</td>
<td>82</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_sync_all</td>
<td>93</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_sync_images</td>
<td>93</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_sync_memory</td>
<td>94</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_this_image</td>
<td>80</td>
</tr>
<tr>
<td>Coarray, gfortran_caf_unlock</td>
<td>91</td>
</tr>
<tr>
<td>Coarray, IMAGE_INDEX</td>
<td>194</td>
</tr>
<tr>
<td>Coarray, lower bound</td>
<td>204</td>
</tr>
<tr>
<td>Coarray, NUM_IMAGES</td>
<td>229</td>
</tr>
<tr>
<td>Coarray, THIS_IMAGE</td>
<td>263</td>
</tr>
<tr>
<td>Coarray, upper bound</td>
<td>268</td>
</tr>
<tr>
<td>Coarrays</td>
<td>23</td>
</tr>
<tr>
<td>Coarrays</td>
<td>77</td>
</tr>
<tr>
<td>code generation, conventions</td>
<td>21</td>
</tr>
<tr>
<td>collating sequence, ASCII</td>
<td>103, 187</td>
</tr>
<tr>
<td>Coarrays</td>
<td>143</td>
</tr>
<tr>
<td>Collectives, generic reduction</td>
<td>143</td>
</tr>
<tr>
<td>Collectives, maximal value</td>
<td>142</td>
</tr>
<tr>
<td>Collectives, minimal value</td>
<td>142</td>
</tr>
<tr>
<td>Collectives, sum of values</td>
<td>144</td>
</tr>
<tr>
<td>Collectives, value broadcasting</td>
<td>141</td>
</tr>
<tr>
<td>command line</td>
<td>166</td>
</tr>
<tr>
<td>command options</td>
<td>7</td>
</tr>
<tr>
<td>command-line arguments</td>
<td>145, 179, 180, 190</td>
</tr>
<tr>
<td>command-line arguments, number of</td>
<td>145, 190</td>
</tr>
<tr>
<td>COMMAND_ARGUMENT_COUNT</td>
<td>145</td>
</tr>
<tr>
<td>COMMON</td>
<td>62</td>
</tr>
<tr>
<td>compiler flags inquiry function</td>
<td>146</td>
</tr>
<tr>
<td>compiler, name and version</td>
<td>146</td>
</tr>
<tr>
<td>COMPILER_FLAGS</td>
<td>146</td>
</tr>
<tr>
<td>COMPILER_OPTIONS</td>
<td>146</td>
</tr>
<tr>
<td>COMPILER_VERSION</td>
<td>146</td>
</tr>
<tr>
<td>complex conjugate</td>
<td>147</td>
</tr>
<tr>
<td>Complex function</td>
<td>62</td>
</tr>
<tr>
<td>complex numbers, conversion to</td>
<td>140, 147, 156</td>
</tr>
<tr>
<td>complex numbers, imaginary part</td>
<td>107</td>
</tr>
<tr>
<td>complex numbers, real part</td>
<td>159, 239</td>
</tr>
<tr>
<td>COMPLEX</td>
<td>147</td>
</tr>
<tr>
<td>Conditional compilation</td>
<td>2</td>
</tr>
<tr>
<td>CONJG</td>
<td>147</td>
</tr>
<tr>
<td>consistency, durability</td>
<td>40</td>
</tr>
<tr>
<td>Contributing</td>
<td>279</td>
</tr>
<tr>
<td>Contributors</td>
<td>279</td>
</tr>
<tr>
<td>conversion</td>
<td>17</td>
</tr>
<tr>
<td>conversion, to character</td>
<td>138</td>
</tr>
<tr>
<td>conversion, to complex</td>
<td>140, 147, 156</td>
</tr>
<tr>
<td>conversion, to integer</td>
<td>46, 187, 192, 195, 196, 197, 212</td>
</tr>
<tr>
<td>conversion, to logical</td>
<td>46, 212</td>
</tr>
<tr>
<td>conversion, to real</td>
<td>155, 239</td>
</tr>
<tr>
<td>conversion, to string</td>
<td>153</td>
</tr>
<tr>
<td>CONVERT</td>
<td>49</td>
</tr>
<tr>
<td>core, dump</td>
<td>101</td>
</tr>
</tbody>
</table>
COSD ........................................ 149
COSH ........................................ 149
cosine ....................................... 148
cosine, degrees ................................ 149
cosine, hyperbolic ............................ 149
cosine, hyperbolic, inverse ................. 105
cosine, inverse ................................ 104
cosine, inverse, degrees ..................... 105
CDS ........................................... 148
CDTAN ....................................... 150
CDTAND ...................................... 150
cotangent .................................... 150
cotangent, degrees ............................ 150
CDUNT ....................................... 151
CPP ............................................ 2, 12
CPU_TIME .................................... 152
Credits ...................................... 279
CSHIFT ....................................... 153
CSIN ......................................... 251
CSIND ........................................ 251
CSQRT ........................................ 255
CTIME ........................................ 153
current date .................................. 154, 169, 193
current time .................................. 154, 169, 202, 264

D
DABS .......................................... 102
DACOS ........................................ 104
DACOSD ....................................... 105
DACOSH ....................................... 105
DASIN ........................................ 112
DASIND ....................................... 113
DASINH ....................................... 114
DATAN ........................................ 115
DATAN2 ....................................... 117
DATAN2D ...................................... 118
DATAND ....................................... 116
DATANH ....................................... 119
date, current ................................. 154, 169, 193
DATE_AND_TIME .............................. 154
DBESJ0 ...................................... 127
DBESJ1 ...................................... 128
DBESJN ...................................... 128
DBESYO ...................................... 129
DBESY1 ...................................... 130
DBESYN ...................................... 130
DBLE .......................................... 155
DCMPLX ...................................... 156
DCONJG ...................................... 147
DCOS .......................................... 148
DCOSD ........................................ 149
DCOSH ........................................ 149
DCOTAN ...................................... 150
DCOTAND ..................................... 150
DDIM .......................................... 157
debugging information options ............. 19
debugging, preprocessor .................... 12
DECODE ...................................... 61
delayed execution ......................... 108, 254
DEXP .......................................... 167
DFLOAT ....................................... 239
DGAMMA ...................................... 178
dialect options ............................... 8
DIGITS ........................................ 156
DIM ............................................ 157
DIMAG ......................................... 107
DINT ........................................... 107
directive, INCLUDE ......................... 20
directory, options ......................... 20
directory, search paths for inclusion .... 20
division, modulo ............................ 224
division, remainder ......................... 223
DLGAMA ...................................... 211
DLOG .......................................... 210
DLOG10 ....................................... 211
DMAX1 ........................................ 217
DMIN1 ......................................... 221
DMOD .......................................... 223
DNINT ......................................... 111
dot product .................................. 157
DOT_PRODUCT ................................. 157
DPROD ........................................ 158
DREAL ......................................... 159
DSHFTL ....................................... 159
DSHIFTR ...................................... 160
DSIGN ......................................... 249
DSIN ........................................... 251
DSIND ......................................... 251
DSINH ......................................... 252
DSQRT ......................................... 255
DTAN .......................................... 261
dtand ........................................... 261
dtanh ........................................... 262
dtime .......................................... 160
dummy argument, unused .................... 18

e
elapsed time ................................. 160, 244
Elimination of functions with identical argument
lists ........................................... 27
ENCODE ....................................... 61
ENUM statement ............................... 36
ENUMERATOR statement ................. 36
environment variable .................. 28, 29, 182
EOF ........................................... 51
EOSHIFT ...................................... 161
EPSILON ...................................... 162
ERF ............................................ 163
ERFC ........................................... 163
ERFC_SCALED ......................... 164
ttter function ............................... 163
ttter function, complementary ........... 163
ttter function, complementary,
exponentially-scaled ...................... 164
errors, limiting ........................................ 15
escape characters .................................... 9
ETIME ............................................. 164
Euclidean distance .................................. 186
Euclidean vector norm .............................. 228
EVENT_QUERY .................................... 165
Events, EVENT_QUERY .............................. 165
EXECUTE_COMMAND_LINE ......................... 166
EXIT .................................................. 167
exponent .............................................. 61
exponential function .................................. 167
exponential function, inverse ......................... 210, 211
EXP .................................................. 167
EXponent ............................................ 168
expression size ...................................... 137, 253
EXTENDS_TYPE_OF ................................ 168
extensions .......................................... 43
extensions, implemented ............................ 43
extensions, not implemented ........................ 61
extra warnings ...................................... 17
F
f2c calling convention ............................... 22, 23
Factorial function .................................... 178
FDATE .............................................. 169
FDL, GNU Free Documentation License ............ 295
FGET ............................................... 169
FGETC .............................................. 170
file format, fixed .................................... 8, 10
file format, free ..................................... 8, 10
file operation, file number .......................... 172
file operation, flush ................................ 172
file operation, position ................................ 175, 177
file operation, read character ......................... 169, 170
file operation, seek .................................. 175
file operation, write character ....................... 173, 174
file system, access mode ............................ 103
file system, change access mode ..................... 139
file system, create link ................................ 208, 259
file system, file creation mask ......................... 269
file system, file status ................................ 177, 213, 256
file system, hard link ................................ 208
file system, remove file ................................ 269
file system, rename file ................................ 240
file system, soft link .................................. 259
file, symbolic link ................................... 41
flags inquiry function ................................ 146
floating point, exponent ............................ 168
floating point, fraction .............................. 175
floating point, nearest different ...................... 226
floating point, relative spacing ......................... 241, 254
floating point, scale .................................. 243
floating point, set exponent .......................... 247
FLOAT .............................................. 239
FLOATI ............................................. 239
FLOATJ ............................................. 239
FLOATK ............................................. 239
floor .................................................. 107, 171
FLOOR ............................................. 171
FLUSH .............................................. 172
FLUSH statement .................................... 36
FNUN .............................................. 172
form feed whitespace ................................ 58
FORMAT .......................................... 62
Fortran 77 .......................................... 3
FP .................................................. 2
FPUTC .............................................. 174
FRACTION .......................................... 175
FREE ............................................ 175
Front-end optimization ............................... 27
FSEEK ............................................. 175
FSTAT .............................................. 177
FTELL .............................................. 177
function elimination .................................. 18
G
g77 .................................................. 3
g77 calling convention ............................... 22, 23
Gamma function ....................................... 178
Gamma function, logarithm of ......................... 211
Gamma .............................................. 178
GCC ............................................... 2
GError ............................................. 178
GET_COMMAND ..................................... 180
GET_COMMAND_ARGUMENT .......................... 180
GET_ENVIRONMENT_VARIABLE ....................... 182
GETARG ............................................ 179
GETCWD .......................................... 181
GETENV .......................................... 182
GETGID ............................................ 183
GETLOG ............................................ 183
GETPID ............................................ 184
GETUID ............................................ 184
Gmtime ............................................. 185
GNU Compiler Collection ................................ 2
GNU Fortran command options ....................... 7
H
Hollerith constants ................................... 47
HOSTNM .......................................... 185
HUGE ............................................. 186
hyperbolic cosine .................................... 149
hyperbolic function, cosine .......................... 149
hyperbolic function, cosine, inverse .................. 105
hyperbolic function, sine ........................... 252
hyperbolic function, sine, inverse .................... 114
hyperbolic function, tangent ........................ 262
hyperbolic function, tangent, inverse ................ 119
hyperbolic sine ..................................... 252
hyperbolic tangent .................................. 262
HYpot .............................................. 186
## I

| I/O item lists | .......................................................... | 45 |
| I/O specifiers | .......................................................... | 59 |
| IABS           | .......................................................... | 102 |
| IACHAR         | .......................................................... | 187 |
| IALL           | .......................................................... | 187 |
| IAND           | .......................................................... | 188 |
| IANY           | .......................................................... | 189 |
| IARGC          | .......................................................... | 190 |
| IBCLR          | .......................................................... | 190 |
| IBIT           | .......................................................... | 191 |
| IBSET          | .......................................................... | 191 |
| ICHAR          | .......................................................... | 192 |
| IDATE          | .......................................................... | 193 |
| IDIM           | .......................................................... | 157 |
| IDINT          | .......................................................... | 195 |
| IDNINT         | .......................................................... | 227 |
| IEEE, ISNAN    | .......................................................... | 202 |
| IEROR          | .......................................................... | 193 |
| IERROR         | .......................................................... | 194 |
| IFIX           | .......................................................... | 195 |
| IIABS          | .......................................................... | 102 |
| IIAND          | .......................................................... | 188 |
| IIBCLR         | .......................................................... | 190 |
| IIBITS         | .......................................................... | 191 |
| IISET          | .......................................................... | 191 |
| IIOR           | .......................................................... | 193 |
| IISHFT         | .......................................................... | 197 |
| IISHFTC        | .......................................................... | 201 |
| IMAGE_INDEX    | .......................................................... | 194 |
| images, cosubscript to image index conversion | | |
| images, index of this image | | 194 |
| images, number of | | 263 |
| IMGAPART       | .......................................................... | 229 |
| IMOD           | .......................................................... | 223 |
| IMPORT statement | .......................................................... | 36 |
| INVBITS        | .......................................................... | 225 |
| INCLUDE directive | .......................................................... | 20 |
| inclusion, directory search paths for | | 20 |
| INDEX          | .......................................................... | 195 |
| INOT           | .......................................................... | 228 |
| INT            | .......................................................... | 195 |
| INT2           | .......................................................... | 196 |
| INT8           | .......................................................... | 197 |
| integer kind   | .......................................................... | 245 |
| Interoperability | .......................................................... | 63 |
| intrinsic      | .......................................................... | 18 |
| intrinsic Modules | .......................................................... | 273 |
| intrinsic procedures | .......................................................... | 101 |
| intrinsics, integer | .......................................................... | 56 |
| intrinsics, math | .......................................................... | 57 |
| intrinsics, trigonometric functions | | 57 |
| inverse hyperbolic cosine | | 105 |
| inverse hyperbolic sine | | 114 |
| inverse hyperbolic tangent | | 119 |
| IOMSG= specifier | .......................................................... | 36 |
| IOR             | .......................................................... | 197 |
| IOSTAT, end of file | .......................................................... | 199 |
| IOSTAT, end of record | .......................................................... | 200 |
| IPARITY         | .......................................................... | 198 |
| IRAND           | .......................................................... | 198 |
| IS, IOSTAT_END  | .......................................................... | 199 |
| IS, IOSTAT_EOR  | .......................................................... | 200 |
| ISATTY          | .......................................................... | 200 |
| ISHFT           | .......................................................... | 201 |
| ISHFTC          | .......................................................... | 201 |
| ISNAN           | .......................................................... | 202 |
| ISO_FORTAN_ENV statement | .......................................................... | 36 |
| ITIME           | .......................................................... | 202 |

## J

| JIABS          | .......................................................... | 102 |
| JIAND          | .......................................................... | 188 |
| JIBCLR         | .......................................................... | 190 |
| JIBITS         | .......................................................... | 191 |
| JIBSET         | .......................................................... | 191 |
| JIEOR          | .......................................................... | 193 |
| JIOR           | .......................................................... | 197 |
| JISHFT         | .......................................................... | 201 |
| JISHFTC        | .......................................................... | 201 |
| JMOD           | .......................................................... | 223 |
| JMVBITS        | .......................................................... | 225 |
| JN OT           | .......................................................... | 228 |

## K

| KIABS          | .......................................................... | 102 |
| KIAND          | .......................................................... | 188 |
| KIBCLR         | .......................................................... | 190 |
| KIBITS         | .......................................................... | 191 |
| KIBSET         | .......................................................... | 191 |
| KIEOR          | .......................................................... | 193 |
| KILL           | .......................................................... | 203 |
| kind           | .......................................................... | 39, 203 |
| kind, character | .......................................................... | 245 |
| kind, integer  | .......................................................... | 245 |
| kind, old-style | .......................................................... | 43 |
| kind, real     | .......................................................... | 246 |
| KIND            | .......................................................... | 203 |
| KIOR            | .......................................................... | 197 |
| KISHFT          | .......................................................... | 201 |
| KISHFTC         | .......................................................... | 201 |
| KMOD            | .......................................................... | 223 |
| KMVBITS         | .......................................................... | 225 |
| KNOT            | .......................................................... | 228 |

## L

| L2 vector norm | .......................................................... | 228 |
| language, dialect options | .......................................................... | 8 |
| LBOUND         | .......................................................... | 204 |
Keyword Index 313

LCBOUND ........................................... 204
LEADZ .............................................. 205
left shift, combined ............................ 159
LEN ................................................ 205
LEN_TRIM ........................................... 206
lexical comparison of strings ................. 206, 207, 208, 209
LGAMMA ........................................... 211
LGE ................................................ 206
LGT ................................................... 207
libf2c calling convention ...................... 22, 23
libgfortran initialization, set_args ........... 70
libgfortran initialization, set_convert ......... 72
libgfortran initialization, set_fpe ............. 73
libgfortran initialization, set_max_subrecord_length ..... 73
libgfortran initialization, set_options ......... 71
limits, largest number .......................... 186
limits, smallest number .......................... 265
linking, static ................................... 21
LINK ............................................. 208
LLE ................................................ 208
LLT ................................................ 209
LNBLNK ............................................. 209
location of a variable in memory .............. 210
LOC ................................................ 183
logarithm function ............................... 58, 210
logarithm function with base 10 ............... 211
logarithm function, inverse .................... 167
logical and, bitwise ............................. 110, 188
logical exclusive or, bitwise .................... 193, 271
logical not, bitwise ................................ 228
logical or, bitwise ................................ 197, 230
logical, bitwise ................................... 59
logical, variable representation ............... 39
login name ....................................... 183
LOG ................................................ 210
LOG_GAMMA ....................................... 211
LOG10 ............................................. 211
LOGICAL .......................................... 212
LONG ............................................. 212
LSHIFT ........................................... 213
LSTAT ............................................. 213
LTIME ............................................. 214

M

MALLOC ........................................... 215
MAP ............................................... 215
mask, left justified ............................... 215
mask, right justified .............................. 216
MASKL ............................................ 215
MASKR ............................................ 216
MATMUL ........................................... 216
matrix multiplication ............................ 216
matrix, transpose ................................ 266
MAXO ............................................. 217
MAX1 ............................................. 217
MAXEXPONENT ..................................... 217
maximum value .................................... 217, 218
MAX ............................................. 217
MAXLOC .......................................... 218
MAXVAL .......................................... 218
MCLOCK .......................................... 219
MCLOCK8 .......................................... 219
memory checking .................................. 24
MERGE ........................................... 220
MERGE_BITS ....................................... 220
messages, error ................................... 15
messages, warning ................................ 15
minimum value .................................... 221, 222
MIN .............................................. 221
MIN0 .............................................. 221
MIN1 .............................................. 221
MINEXponent ..................................... 221
MINLOC .......................................... 222
MINVAL .......................................... 222
Mixed-language programming .................... 63
model representation, base ....................... 235
model representation, epsilon ..................... 162
model representation, largest number .......... 186
model representation, maximum exponent ...... 217
model representation, minimum exponent ..... 221
model representation, precision .................. 233
model representation, radix ....................... 235
model representation, range ..................... 238
model representation, significant digits ........ 156
model representation, smallest number .. 265
module entities .................................. 9
module search path ................................ 20, 21
modulo ............................................ 224
MOD .............................................. 223
MODULO ......................................... 224
MOVE_ALLOC ...................................... 225
moving allocation .................................. 225
duplicate array elements ....................... 234
MVBYTES ......................................... 225

N

Namelist ........................................... 44
NAM ............................................... 62
natural logarithm function ....................... 210
NEAREST ......................................... 226
NEW_LINE ......................................... 226
cnewline .......................................... 226
NINT ............................................. 227
norm, Euclidean .................................. 228
NORM ............................................ 228
NOSHARED ......................................... 59
NOT ............................................... 228
NULL ............................................. 229
NUM_IMAGES ...................................... 229
### O

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>open, action</td>
<td>41</td>
</tr>
<tr>
<td>OpenACC</td>
<td>10, 50</td>
</tr>
<tr>
<td>OpenMP</td>
<td>10, 50</td>
</tr>
<tr>
<td>operators, unary</td>
<td>46</td>
</tr>
<tr>
<td>operators, xor</td>
<td>59</td>
</tr>
<tr>
<td>options inquiry function</td>
<td>146</td>
</tr>
<tr>
<td>options, code generation</td>
<td>21</td>
</tr>
<tr>
<td>options, debugging</td>
<td>19</td>
</tr>
<tr>
<td>options, dialect</td>
<td>8</td>
</tr>
<tr>
<td>options, directory search</td>
<td>20</td>
</tr>
<tr>
<td>options, errors</td>
<td>15</td>
</tr>
<tr>
<td>options, Fortran dialect</td>
<td>8</td>
</tr>
<tr>
<td>options, fortran command</td>
<td>12</td>
</tr>
<tr>
<td>options, preprocessor</td>
<td>7</td>
</tr>
<tr>
<td>options, real kind type promotion</td>
<td>11</td>
</tr>
<tr>
<td>options, run-time</td>
<td>21</td>
</tr>
<tr>
<td>options, runtime</td>
<td>21</td>
</tr>
<tr>
<td>options, warnings</td>
<td>15</td>
</tr>
<tr>
<td>OR</td>
<td>230</td>
</tr>
<tr>
<td>output, newline</td>
<td>226</td>
</tr>
</tbody>
</table>

### P

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACK</td>
<td>231</td>
</tr>
<tr>
<td>PARAMETER</td>
<td>60</td>
</tr>
<tr>
<td>parity</td>
<td>233</td>
</tr>
<tr>
<td>Parity</td>
<td>231</td>
</tr>
<tr>
<td>PARITY</td>
<td>231</td>
</tr>
<tr>
<td>paths, search</td>
<td>20, 21</td>
</tr>
<tr>
<td>PERROR</td>
<td>232</td>
</tr>
<tr>
<td>pointer checking</td>
<td>24</td>
</tr>
<tr>
<td>pointer, C address of pointers</td>
<td>135</td>
</tr>
<tr>
<td>pointer, C address of procedures</td>
<td>136</td>
</tr>
<tr>
<td>pointer, C association status</td>
<td>134</td>
</tr>
<tr>
<td>pointer, convert C to Fortran</td>
<td>134</td>
</tr>
<tr>
<td>pointer, Cray</td>
<td>47</td>
</tr>
<tr>
<td>pointer, cray</td>
<td>114, 229</td>
</tr>
<tr>
<td>pointer, disassociated</td>
<td>229</td>
</tr>
<tr>
<td>pointer, status</td>
<td>175, 215</td>
</tr>
<tr>
<td>POPCNT</td>
<td>232</td>
</tr>
<tr>
<td>POPPAR</td>
<td>233</td>
</tr>
<tr>
<td>positive difference</td>
<td>157</td>
</tr>
<tr>
<td>PRECISION</td>
<td>233</td>
</tr>
<tr>
<td>Preprocessing</td>
<td>2</td>
</tr>
<tr>
<td>preprocessing, assertion</td>
<td>14</td>
</tr>
<tr>
<td>preprocessing, define macros</td>
<td>14</td>
</tr>
<tr>
<td>preprocessing, include path</td>
<td>13</td>
</tr>
<tr>
<td>preprocessing, keep comments</td>
<td>14</td>
</tr>
<tr>
<td>preprocessing, no linemarkers</td>
<td>15</td>
</tr>
<tr>
<td>preprocessing, undefine macros</td>
<td>15</td>
</tr>
<tr>
<td>preprocessor</td>
<td>12</td>
</tr>
<tr>
<td>preprocessor, debugging</td>
<td>12</td>
</tr>
<tr>
<td>preprocessor, disable</td>
<td>12</td>
</tr>
<tr>
<td>preprocessor, enable</td>
<td>12</td>
</tr>
<tr>
<td>preprocessor, include file handling</td>
<td>2</td>
</tr>
</tbody>
</table>

### Q

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q exponent-letter</td>
<td>45</td>
</tr>
</tbody>
</table>

### R

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>radix, real</td>
<td>246</td>
</tr>
<tr>
<td>RADIAX</td>
<td>235</td>
</tr>
<tr>
<td>random number generation</td>
<td>198, 236</td>
</tr>
<tr>
<td>random number generation, seeding</td>
<td>237, 256</td>
</tr>
<tr>
<td>RAND</td>
<td>236</td>
</tr>
<tr>
<td>RANDOM_NUMBER</td>
<td>236</td>
</tr>
<tr>
<td>RANDOM_SEED</td>
<td>237</td>
</tr>
<tr>
<td>range checking</td>
<td>24</td>
</tr>
<tr>
<td>rank</td>
<td>238</td>
</tr>
<tr>
<td>RAN</td>
<td>236</td>
</tr>
<tr>
<td>RANGE</td>
<td>238</td>
</tr>
<tr>
<td>RANK</td>
<td>238</td>
</tr>
<tr>
<td>re-association of parenthesized expressions</td>
<td>27</td>
</tr>
<tr>
<td>read character, stream mode</td>
<td>169, 170</td>
</tr>
<tr>
<td>READONLY</td>
<td>59</td>
</tr>
<tr>
<td>real kind</td>
<td>246</td>
</tr>
<tr>
<td>real number, exponent</td>
<td>168</td>
</tr>
<tr>
<td>real number, fraction</td>
<td>175</td>
</tr>
<tr>
<td>real number, nearest different</td>
<td>226</td>
</tr>
<tr>
<td>real number, relative spacing</td>
<td>241, 254</td>
</tr>
<tr>
<td>real number, scale</td>
<td>243</td>
</tr>
<tr>
<td>real number, set exponent</td>
<td>247</td>
</tr>
<tr>
<td>Reallocate the LHS in assignments</td>
<td>27</td>
</tr>
<tr>
<td>Reallocate the LHS in assignments, notification</td>
<td>114, 229</td>
</tr>
<tr>
<td>REAL</td>
<td>239</td>
</tr>
<tr>
<td>REALPART</td>
<td>239</td>
</tr>
<tr>
<td>RECORD</td>
<td>51</td>
</tr>
<tr>
<td>Reduction, XOR</td>
<td>231</td>
</tr>
<tr>
<td>remainder</td>
<td>223</td>
</tr>
<tr>
<td>RENAME</td>
<td>240</td>
</tr>
<tr>
<td>repacking arrays</td>
<td>25</td>
</tr>
<tr>
<td>REPEAT</td>
<td>240</td>
</tr>
<tr>
<td>RESHAPE</td>
<td>241</td>
</tr>
<tr>
<td>REVIND</td>
<td>51</td>
</tr>
<tr>
<td>right shift, combined</td>
<td>160</td>
</tr>
<tr>
<td>root</td>
<td>255</td>
</tr>
<tr>
<td>rounding, ceiling</td>
<td>111, 138</td>
</tr>
<tr>
<td>rounding, floor</td>
<td>107, 171</td>
</tr>
<tr>
<td>Keyword</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>rounding, nearest whole number</td>
<td>227</td>
</tr>
<tr>
<td>RRS_PACING</td>
<td>241</td>
</tr>
<tr>
<td>RSHIFT</td>
<td>242</td>
</tr>
<tr>
<td>run-time checking</td>
<td>24</td>
</tr>
<tr>
<td>S</td>
<td></td>
</tr>
<tr>
<td>SAME_TYPE_AS</td>
<td>242</td>
</tr>
<tr>
<td>SAVE statement</td>
<td>22</td>
</tr>
<tr>
<td>SCALE</td>
<td>243</td>
</tr>
<tr>
<td>SCAN</td>
<td>243</td>
</tr>
<tr>
<td>search path</td>
<td>20</td>
</tr>
<tr>
<td>search paths, for included files</td>
<td>20</td>
</tr>
<tr>
<td>SECONDS</td>
<td>244</td>
</tr>
<tr>
<td>SECOND</td>
<td>244</td>
</tr>
<tr>
<td>seeding a random number generator</td>
<td>237, 256</td>
</tr>
<tr>
<td>SELECTED_CHAR_KIND</td>
<td>245</td>
</tr>
<tr>
<td>SELECTED_INT_KIND</td>
<td>245</td>
</tr>
<tr>
<td>SELECTED_REAL_KIND</td>
<td>246</td>
</tr>
<tr>
<td>SET_EXPONENT</td>
<td>247</td>
</tr>
<tr>
<td>SHAPE</td>
<td>248</td>
</tr>
<tr>
<td>SHARED</td>
<td>59</td>
</tr>
<tr>
<td>shift, left</td>
<td>159, 249</td>
</tr>
<tr>
<td>shift, right</td>
<td>248</td>
</tr>
<tr>
<td>shift, right with fill</td>
<td>248</td>
</tr>
<tr>
<td>SHIFTL</td>
<td>249</td>
</tr>
<tr>
<td>SHIFTR</td>
<td>249</td>
</tr>
<tr>
<td>SHORT</td>
<td>196</td>
</tr>
<tr>
<td>sign copying</td>
<td>249</td>
</tr>
<tr>
<td>SIGN</td>
<td>249</td>
</tr>
<tr>
<td>SIGNAL</td>
<td>250</td>
</tr>
<tr>
<td>SIN</td>
<td>251</td>
</tr>
<tr>
<td>SIND</td>
<td>251</td>
</tr>
<tr>
<td>sine</td>
<td>251</td>
</tr>
<tr>
<td>sine, degrees</td>
<td>251</td>
</tr>
<tr>
<td>sine, hyperbolic</td>
<td>252</td>
</tr>
<tr>
<td>sine, hyperbolic, inverse</td>
<td>252</td>
</tr>
<tr>
<td>sine, inverse</td>
<td>112</td>
</tr>
<tr>
<td>sine, inverse, degrees</td>
<td>252</td>
</tr>
<tr>
<td>SINH</td>
<td>132</td>
</tr>
<tr>
<td>size of a variable, in bits</td>
<td>137, 253</td>
</tr>
<tr>
<td>size of an expression</td>
<td>253</td>
</tr>
<tr>
<td>SIZE</td>
<td>253</td>
</tr>
<tr>
<td>SIZEOF</td>
<td>253</td>
</tr>
<tr>
<td>SLEEP</td>
<td>254</td>
</tr>
<tr>
<td>SNGL</td>
<td>239</td>
</tr>
<tr>
<td>SPACING</td>
<td>254</td>
</tr>
<tr>
<td>SPREAD</td>
<td>255</td>
</tr>
<tr>
<td>SQRT</td>
<td>255</td>
</tr>
<tr>
<td>square-root</td>
<td>255</td>
</tr>
<tr>
<td>BRAND</td>
<td>256</td>
</tr>
<tr>
<td>Standards</td>
<td>4</td>
</tr>
<tr>
<td>statement, ENUN</td>
<td>36</td>
</tr>
<tr>
<td>statement, ENUMERATOR</td>
<td>36</td>
</tr>
<tr>
<td>statement, FLUSH</td>
<td>36</td>
</tr>
<tr>
<td>statement, IMPORT</td>
<td>36</td>
</tr>
<tr>
<td>statement, ISO_FORTRAN_ENV</td>
<td>36</td>
</tr>
<tr>
<td>statement, PROTECTED</td>
<td>36</td>
</tr>
<tr>
<td>statement, SAVE</td>
<td>22</td>
</tr>
<tr>
<td>statement, USE, INTRINSIC</td>
<td>36</td>
</tr>
<tr>
<td>statement, VALUE</td>
<td>36</td>
</tr>
<tr>
<td>statement, VOLATILE</td>
<td>36</td>
</tr>
<tr>
<td>STAT</td>
<td>256</td>
</tr>
<tr>
<td>STATIC</td>
<td>57</td>
</tr>
<tr>
<td>storage size</td>
<td>258</td>
</tr>
<tr>
<td>STORAGE_SIZE</td>
<td>258</td>
</tr>
<tr>
<td>stream mode, read character</td>
<td>169, 170</td>
</tr>
<tr>
<td>stream mode, write character</td>
<td>173, 174</td>
</tr>
<tr>
<td>STREAM I/O</td>
<td>36</td>
</tr>
<tr>
<td>string, adjust left</td>
<td>106</td>
</tr>
<tr>
<td>string, adjust right</td>
<td>106</td>
</tr>
<tr>
<td>string, comparison</td>
<td>206, 207, 208, 209</td>
</tr>
<tr>
<td>string, concatenate</td>
<td>240</td>
</tr>
<tr>
<td>string, find missing set</td>
<td>270</td>
</tr>
<tr>
<td>string, find non-blank character</td>
<td>209</td>
</tr>
<tr>
<td>string, find subset</td>
<td>243</td>
</tr>
<tr>
<td>string, find substring</td>
<td>195</td>
</tr>
<tr>
<td>string, length</td>
<td>205</td>
</tr>
<tr>
<td>string, length, without trailing whitespace</td>
<td>206</td>
</tr>
<tr>
<td>string, remove trailing whitespace</td>
<td>267</td>
</tr>
<tr>
<td>string, repeat</td>
<td>240</td>
</tr>
<tr>
<td>strings, varying length</td>
<td>4</td>
</tr>
<tr>
<td>structure packing</td>
<td>25</td>
</tr>
<tr>
<td>STRUCTURE</td>
<td>51</td>
</tr>
<tr>
<td>subscript checking</td>
<td>24</td>
</tr>
<tr>
<td>substring position</td>
<td>195</td>
</tr>
<tr>
<td>sum array elements</td>
<td>258</td>
</tr>
<tr>
<td>SUN</td>
<td>258</td>
</tr>
<tr>
<td>suppressing warnings</td>
<td>15</td>
</tr>
<tr>
<td>symbol names</td>
<td>9</td>
</tr>
<tr>
<td>symbol names, transforming</td>
<td>22, 23</td>
</tr>
<tr>
<td>symbol names, underscores</td>
<td>22, 23</td>
</tr>
<tr>
<td>SYMLNK</td>
<td>259</td>
</tr>
<tr>
<td>syntax checking</td>
<td>15</td>
</tr>
<tr>
<td>system, error handling</td>
<td>178, 194, 232</td>
</tr>
<tr>
<td>system, group ID</td>
<td>183</td>
</tr>
<tr>
<td>system, host name</td>
<td>185</td>
</tr>
<tr>
<td>system, login name</td>
<td>183</td>
</tr>
<tr>
<td>system, process ID</td>
<td>184</td>
</tr>
<tr>
<td>system, signal handling</td>
<td>250</td>
</tr>
<tr>
<td>system, system call</td>
<td>166, 259</td>
</tr>
<tr>
<td>system, terminal</td>
<td>200, 267</td>
</tr>
<tr>
<td>system, user ID</td>
<td>184</td>
</tr>
<tr>
<td>system, working directory</td>
<td>139, 181</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>259</td>
</tr>
<tr>
<td>SYSTEM_CLOCK</td>
<td>260</td>
</tr>
<tr>
<td>T</td>
<td></td>
</tr>
<tr>
<td>tabulators</td>
<td>18</td>
</tr>
<tr>
<td>TAND</td>
<td>261</td>
</tr>
<tr>
<td>tangent</td>
<td>261</td>
</tr>
<tr>
<td>tangent, degrees</td>
<td>261</td>
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