CC-RX
Compiler

Applicable Revision
V2.00.00 to V3.05.00

Target Device
RX Family

Target CPU Cores:
RXv1, RXv2, RXv3

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How to Use This Manual

This manual describes the role of the CC-RX compiler for developing applications and systems for RX family, and provides an outline of its features.

Readers
This manual is intended for users who wish to understand the functions of the CC-RX and design software and hardware application systems.

Purpose
This manual is intended to give users an understanding of the functions of the CC-RX to use for reference in developing the hardware or software of systems using these devices.

Organization
This manual can be broadly divided into the following units.
1. GENERAL
2. COMMAND REFERENCE
3. OUTPUT FILES
4. COMPILER LANGUAGE SPECIFICATIONS
5. ASSEMBLY LANGUAGE SPECIFICATIONS
6. SECTION SPECIFICATIONS
7. LIBRARY FUNCTIONAL SPECIFICATION
8. STARTUP
9. FUNCTION CALL INTERFACE SPECIFICATIONS
10. MESSAGES
11. Usage Notes
A. QUICK GUIDE

How to Read This Manual
It is assumed that the readers of this manual have general knowledge of electricity, logic circuits, and microcontrollers.

Conventions
Data significance: Higher digits on the left and lower digits on the right
Active low representation: XXX (overscore over pin or signal name)
Note: Footnote for item marked with Note in the text
Caution: Information requiring particular attention
Remarks: Supplementary information
Numeric representation: Decimal ... XXX
Hexadecimal ... 0xXXXX
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1. GENERAL

This document is the user's manual for the RX family C/C++ compiler CC-RX V2.00 to V3.04. This chapter provides an overview of the processing of CC-RX and provides an example of program development.

1.1 Overview

The build tool is comprised of components provided by CC-RX. It enables various types of information to be configured via a GUI tool, enabling you to generate load module file or library file from your source files, according to your objectives. CC-RX is comprised of the four executable files listed below.

1. ccrx: Compile driver
2. asrx: Assembler Optimizer
3. rlink: Optimizing linkage editor
4. lbgrx: Library generator

Figure 1.1 illustrates the CC-RX processing flow.
Figure 1.1 CC-RX Processing Flow

- **C/C99 source file (.c)**
- **C++ source file (.cpp, .cc, .cp)**
- **Assembly language file (.src)**
- **Object module file (.obj)**
- **Load module file (.abs)**
- **Stack information file (.sni)**
- **Motorola S-format file (.mot)**
- **Intel hex-format file (.hex)**
- **Binary file (.bin)**

**Tools and Utilities:**
- **ccrx**
- **rcftr, rcbackrx**
- **asrx**
- **lbgrx**
- **rlink**
- **Debugger**
- **CallWalker**
- **Compiler** (Not executing directly)
- **Controller by the compile driver**
- **Library generator**
- **Optimizing linkage editor**
- **Stack display tool**

**File Output:**
- **File output after preprocessing (.p, .pp)**
- **Standard library file (.lib)**
- **User library file (.lib)**
- **Motorola S-format file (.mot)**
- **Intel hex-format file (.hex)**
- **Binary file (.bin)**
1.2 Copyrights

This software uses LLVM and Protocol Buffers.
- LLVM is copyright of University of Illinois at Urbana-Champaign.
- Protocol Buffers is copyright of Google Inc.

Other software components are copyright of Renesas Electronics Corporation.

1.3 Special Features

The RX family C/C++ compiler package (CC-RX) is equipped with the following special features.

1) Language specifications in accordance with ANSI standard
   The C, C99, and C++ language specifications conform to the ANSI standard. Coexistence with prior C language specifications (K&R specifications) is also provided.

2) Advanced optimization
   Code size and speed priority optimization for the C compiler are offered.

3) Improvement to description ability
   C language programming description ability has been improved due to enhanced language specifications.

4) High portability
   The single CC-RX supports all microcontrollers. This makes it possible to use a uniform language specification, and facilitates porting between microcontrollers. In addition, the industry-standard DWARF2/3 format is used for debugging information.

1.4 Limits

1.4.1 Limits of Compiler

Table 1.1 shows the translation limits of the compiler. Source programs must be created to fall within these translation limits.

Table 1.1 Translation Limits of Compiler

<table>
<thead>
<tr>
<th>No.</th>
<th>Classification</th>
<th>Item</th>
<th>Translation Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Startup</td>
<td>Total number of macro names that can be specified using the define option</td>
<td>Unlimited</td>
</tr>
<tr>
<td>2</td>
<td>Source program</td>
<td>Number of characters in one line</td>
<td>32768</td>
</tr>
<tr>
<td>3</td>
<td>Preprocessing</td>
<td>Nesting levels of files in an #include statement</td>
<td>Unlimited</td>
</tr>
<tr>
<td>4</td>
<td>Number of parameters that can be specified using a macro definition or macro call operation</td>
<td>Unlimited</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Nesting levels of conditional inclusion</td>
<td>Unlimited</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Total number of operators and operands that can be specified in an #if or #elif statement</td>
<td>Unlimited</td>
<td></td>
</tr>
</tbody>
</table>
### 1.4.2 Limits of Assembler

Table 1.2 shows the translation limits of the assembler. Source programs must be created to fall within these translation limits.

<table>
<thead>
<tr>
<th>No.</th>
<th>Classification</th>
<th>Item</th>
<th>Translation Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Declaration</td>
<td>Number of function definitions</td>
<td>Unlimited</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Number of external identifiers used for external linkage</td>
<td>Unlimited</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Number of valid internal identifiers used in one function</td>
<td>Unlimited</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Number of pointers, arrays, and function declarators that qualify the basic type</td>
<td>16</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Number of array dimensions</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Size of arrays and structures</td>
<td>2147483647 bytes</td>
</tr>
<tr>
<td>18</td>
<td>Statement</td>
<td>Nesting levels of compound statements</td>
<td>Unlimited</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>Nesting levels of statements in a combination of repeat (while, do, and for) and select (if and switch) statements</td>
<td>4096</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>Number of compound statements that can be written in one function</td>
<td>2048</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Number of goto labels that can be specified in one function</td>
<td>2147483646</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>Number of switch statements</td>
<td>2048</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>Nesting levels of switch statements</td>
<td>2048</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Number of case labels that can be specified in one switch statement</td>
<td>2147483646</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Nesting levels of for statements</td>
<td>2048</td>
</tr>
<tr>
<td>26</td>
<td>Expression</td>
<td>Number of characters in a string</td>
<td>32766</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>Number of parameters that can be specified using a function definition or function call operation</td>
<td>2147483646</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>Total number of operators and operands that can be specified in one expression</td>
<td>About 500</td>
</tr>
<tr>
<td>29</td>
<td>Standard library</td>
<td>Number of files that can be opened simultaneously in an open function</td>
<td>Variable*¹</td>
</tr>
<tr>
<td>30</td>
<td>Section</td>
<td>Length of section name*²</td>
<td>8146</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>Number of sections that can be specified in #pragma section in one file</td>
<td>2045</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>Maximum size of each section</td>
<td>4294967295 bytes</td>
</tr>
<tr>
<td>33</td>
<td>Output files</td>
<td>Maximum number of characters per line of assembly source code that can be output</td>
<td>8190</td>
</tr>
</tbody>
</table>

Notes 1. For details, refer to section 8.3.2 Initial Setting.

Notes 2. Since the assembler's limit of number of characters in one line is applied to the length of a section name when generating an object, the length that can be specified in #pragma section or the section option is shorter than this limit.
1.5 License

A license manager manages licenses to the compilers. If you have a license, the compiler will operate as the Standard or Professional edition depending on the license you are using. Refer to section 1.6, Standard and Professional Editions, for more on the Standard and Professional editions. If the license manager is not able to recognize a Standard or Professional license, the compiler operates as the free evaluation edition. Refer to section 1.7, Free Evaluation Editions, for more on the free evaluation edition. For details of the licenses and the license manager, refer to the User's Manual of the License Manager. Use V2.00 or later versions of the license manager for V2.06 and later versions of CC-RX.

1.6 Standard and Professional Editions

There are two editions of the compilers, the Standard and the Professional editions. The Standard editions support an ANSI-compliant C-language specification, and also provide the essential features for writing programs for embedded systems. As well as the features of the Standard editions, the Professional editions have additional features which help to improve the quality of the customer's programs and shorten development periods. The additional features of Professional editions are available through compiler options, #pragma directives and libraries. For descriptions of the options only available for the Professional editions, refer to section 2.5, Options, or the descriptions of the individual options. For descriptions of the #pragma directives that only the Professional editions support, refer to section 4.2.3, #pragma Directive.

1.7 Free Evaluation Editions

The free evaluation editions have a trial period of 60 days from the day of the first building by the compiler over which you can use features equivalent to those of the Professional editions. After that period, the additional features of the Professional editions are no longer available, and a restriction becomes applicable to the sizes produced by linkage.
- The restriction on the section sizes which can be allocated to the ROM area is up to 128 Kbytes in total. A linker error occurs when the size exceeds 128 Kbytes.

The version number of the optimizing linkage editor is prefixed by W while a compiler is operating as an evaluation edition and by V when it is operating as a commercial edition. Examples are given below.

- Version of a free evaluation edition:
  Renesas Optimizing Linker W1.01.01 [25 Apr 2014]

- Version of a commercial edition:
  Renesas Optimizing Linker V1.01.01 [25 Apr 2014]

We do not supply the following services for the evaluation editions. Consider purchasing a commercial edition if you require them.

- Technical support
- E-mail delivery of items such as information on revisions
2. COMMAND REFERENCE

This appendix describes the detailed specifications of each command included in the build tool.

2.1 Overview

The RX family C/C++ compiler generates a file executable in the target system from the source program written in C language, C99 language, C++ language, or assembly language.
In this compiler, a single driver controls multiple phases from preprocessing to linkage.
The following describes processing in each phase.

1. Compiler
This processes preprocessing directives, comments, and optimization for the C source program and generates an assembly-language source file.

2. Preprocessor
This processes the preprocessing directives in the source program. Only when the -P option is specified, it outputs the preprocessed file.

3. Parsing section
This parses the C source program and then converts it to the internal data representation for the compiler.

4. Optimizing section
This optimizes the internal data representation converted from the C source program.

5. Code generating section
This converts the internal data representation to an assembly-language source program.

6. Assembler
This converts the assembly-language source program to machine-language instructions and generates a relocatable object module file.

7. Optimizing linkage editor
This links object module files, link directive files, and library files and generates an object file (load module file) executable in the target system.

2.2 Input/Output Files

The following shows the files input to and output from the RX family C/C++ compiler.

Table 2.1 Input/Output Files for the RX Family C/C++ Compiler

<table>
<thead>
<tr>
<th>File Type</th>
<th>Extension</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C source program file</td>
<td>.c</td>
<td>Input</td>
<td>A source file written in C99 language. This file is created by the user.</td>
</tr>
<tr>
<td>C++ source program file</td>
<td>.cpp, .cp, and .cc</td>
<td>Input</td>
<td>A source file written in C++ language. This file is created by the user.</td>
</tr>
<tr>
<td>Include file</td>
<td>Optional</td>
<td>Input</td>
<td>A file referenced by the source file and written in C, C99, C++, or assembly language. This file is created by the user.</td>
</tr>
<tr>
<td>Preprocessor expansion file for the C program</td>
<td>.p</td>
<td>Output</td>
<td>A file output as a result of preprocessing applied to an input C-language or the C99-language source program. An ASCII image file. This is output when the -output=prep option is specified.</td>
</tr>
<tr>
<td>Preprocessor expansion file for the C++ program</td>
<td>.pp</td>
<td>Output</td>
<td>A file output as a result of preprocessing applied to an input C++-language source program. An ASCII image file. This is output when the -output=prep option is specified.</td>
</tr>
<tr>
<td>File Type</td>
<td>Extension</td>
<td>I/O</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------</td>
<td>-----</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Assembly-source program file</td>
<td>.src</td>
<td>Output</td>
<td>An assembly-language file generated from a C, C99, or C++ source file through compilation.</td>
</tr>
<tr>
<td></td>
<td>.src</td>
<td>Input</td>
<td>A source file written in assembly language.</td>
</tr>
<tr>
<td>List file for the assembly program</td>
<td>.lst</td>
<td>Output</td>
<td>A list file containing the assembly result information. This is output when the -listfile option is specified. The output contents are selected with the -show option.</td>
</tr>
<tr>
<td>Relocatable object program file</td>
<td>.obj</td>
<td>Output</td>
<td>An ELF-format file that contains the machine-language information, the relocation information about the allocation addresses of machine-language instructions, and symbol information.</td>
</tr>
<tr>
<td>Absolute load module file</td>
<td>.abs</td>
<td>Output</td>
<td>An ELF-format file for the object code generated as a result of linkage. This is an input file when a hex file is output.</td>
</tr>
<tr>
<td>Linkage list file</td>
<td>.map</td>
<td>Output</td>
<td>A list file containing the linkage result information. This is output when the -list option is specified. The output contents are selected with the -show option.</td>
</tr>
<tr>
<td>Library file</td>
<td>.lib</td>
<td>Output</td>
<td>A file where multiple object module files are registered.</td>
</tr>
<tr>
<td>Library list file</td>
<td>.lbp</td>
<td>Output</td>
<td>A list file containing the result information of generation of the library. This is output when the -list option is specified. The output contents are selected with the -show option.</td>
</tr>
<tr>
<td>Library backup file</td>
<td>.lbk</td>
<td>Output</td>
<td>File type for saving the contents of original library files before they are overwritten by the library generator.</td>
</tr>
<tr>
<td>Hex file (Motorola S-format file)</td>
<td>.mot</td>
<td>Output</td>
<td>A Motorola S-format file in the hex format converted from the load module file.</td>
</tr>
<tr>
<td>Hex file (Intel (expansion) hex format file)</td>
<td>.hex</td>
<td>Output</td>
<td>An Intel (expansion) file in the hex format converted from the load module file.</td>
</tr>
<tr>
<td>Hex file (binary format file)</td>
<td>.bin</td>
<td>Output</td>
<td>A binary file in the hex format converted from the load module file.</td>
</tr>
<tr>
<td>Stack information file</td>
<td>.sni</td>
<td>Output</td>
<td>A stack information file. This is output when the -stack option is specified.</td>
</tr>
<tr>
<td>Debugging information file</td>
<td>.dbg</td>
<td>Output</td>
<td>A debugging information file. This is output when the -sdebug option is specified.</td>
</tr>
<tr>
<td>Object file including a definition specified with a file having extension td</td>
<td>.rti</td>
<td>Output</td>
<td>An object file including a definition specified with a file having extension td.</td>
</tr>
<tr>
<td>Calling information file</td>
<td>.cal</td>
<td>Output</td>
<td>A calling information file. This is output by CallWalker.</td>
</tr>
<tr>
<td>External symbol assignment informa</td>
<td>.bls</td>
<td>Output</td>
<td>An external symbol assignment information file. This is output at linkage when the -map option is specified.</td>
</tr>
<tr>
<td>tion file</td>
<td></td>
<td></td>
<td>This is specified as an input file for the -map option at compilation.</td>
</tr>
</tbody>
</table>
2.3 Environment Variables

Environment variables are listed below. Note that there might be the case where environment variables are set in the integrated development environment. Also refer to the user's manual of the integrated development environment.

<table>
<thead>
<tr>
<th>No.</th>
<th>Environment Variable</th>
<th>Description</th>
<th>Default When Specification is Omitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>path</td>
<td>Specifies a storage directory for the execution file.</td>
<td>Specification cannot be omitted.</td>
</tr>
<tr>
<td>2</td>
<td>BIN_RX</td>
<td>Specifies the directory in which ccrx is stored.</td>
<td>&lt;ccrx storage directory&gt; Specification cannot be omitted when the lbgrx command is used.</td>
</tr>
<tr>
<td>3</td>
<td>ISA_RX *1</td>
<td>Selects an instruction-set architecture.</td>
<td>No value is set when the specification is omitted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Instruction-set architectures&gt; RXV1 RXV2 RXV3 [V3.00.00 or later]</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>INC_RX</td>
<td>Specifies a directory in which an include file of the compiler is stored.</td>
<td>&lt;ccrx storage directory&gt; \..\include</td>
</tr>
<tr>
<td>5</td>
<td>INC_RXA</td>
<td>Specifies a directory in which an include file of the assembler is stored.</td>
<td>No value is set when the specification is omitted.</td>
</tr>
<tr>
<td>6</td>
<td>TMP_RX</td>
<td>Specifies a directory in which a temporary file is generated.</td>
<td>%TEMP% when the ccrx command is used.</td>
</tr>
<tr>
<td>7</td>
<td>HLNK_LIBRARY1 HLNK/Library2 HLNK_LIBRARY3</td>
<td>Specifies a default library name for the optimizing linkage editor. Libraries which are specified by a library option are linked first. Then, if there is an unresolved symbol, the default libraries are searched in the order of 1, 2, 3.</td>
<td>No value is set when the specification is omitted.</td>
</tr>
</tbody>
</table>
### 2.4 Operating Instructions

This section describes how to operate the RX family C/C++ compiler.

The commands will take options from left to right on the command-line. When two or more options with conflicted meanings are selected and it will take neither error nor warning, the right-side option will be enabled. This results are different according to each options. For more details, please confirm each options’ descriptions.

1) **Operating Tools**

   (a) **Compiler (ccrx)**

   The startup command for the compile driver.

   Compilation, assemble, and linkage can be performed using this command.

   When the extension of an input file is "s", "src", "S", or "SRC", the compiler interprets the file as an assembly-language file (.src, .s) and initiates the assembler.

   A file with an extension other than those above is compiled as a C/C++ source file (.c, .cpp).

   Two or more input files can be specified at the same time. Cases where two or more C/C++ language source files are specified as input files at the same time are referred to as "batch compilation."

   [Command description format]

   ```
   ccrx [\<option> ...][\<file name>\[\<option> ...] ...]
   <option>: <-\<option>=[\<suboption\>=[\<suboption\>]][, ...]
   ```

   [ ] : Can be omitted

   ... : Pattern in proceeding [ ] can be repeated

   {} : Select from items delimited by the pipe symbol ("|")

   Δ : One or more spaces

   (b) **Assembler (asrx)**

   The startup command for the assembler.

   [Command description format]
2. Command Reference

(c) Optimizing Linkage Editor (rlink)

**rlink** is the startup command for the optimizing linkage editor.
The optimizing linkage editor has the following functions as well as the linkage processing.
- Optimizes relocatable files at linkage
- Generates and edits library files
- Converts files into Motorola S type files, Intel hex type files, and binary files

**Command description format**

```
[<command> [<option> ...] [<file name>] [=<<option> ...]] ...]
```

```
<rlink> [<option> ...] [<file name>] [=<<option> ...]] ...]
```

(d) Library Generator (lbgrx)

**lbgrx** is the startup command for the library generator.

**Command description format**

```
[lbgrx] [<option> ...]
```

```
<lbgx> [<option> ...] [=<<option> ...]] ...
```

(2) Command Description Examples

(a) Compilation, Assemble, and Linkage by One Command

Perform all steps below by a single command.
- Compile C/C++ source files (tp1.c and tp2.c) in **ccrx**.
- After compilation, assemble the files in **asrx**.
- After assemble, link the files in **rlink** to generate an absolute file (tp.abs).

**Command description**

```
ccrx -isa=rxv1 -output=abs=tp.abs tp1.c tp2.c
```

Remarks 1. When the output type specification of the **output** option is changed to **-output= sty**, the file after linkage will be generated as a Motorola S type file.

Remarks 2. An intermediate file generated during the absolute file generation process (assembly-language file or relocatable file) is not saved. Only a file of the type specified by the **output** option is to be generated.

Remarks 3. In order to specify assemble options and linkage options that are valid for only the assembler and optimizing linkage editor in **ccrx**, use the **-asmcmd**, **-lnkcmd**, **-asmopt**, and **-lnkopt** options.

Remarks 4. Object files that are to be linked are allocated from address 0. The order of the sections is not guaranteed. In order to specify the allocation address or section allocation order, specify options for the optimizing linkage editor using the **-lnkcmd** and **-lnkopt** options.

(b) Compilation and Assemble by One Command

Perform all steps below by a single command, and initiate the linker with another command to generate tp.abs.
- Compile C/C++ source files (tp1.c and tp2.c) in **ccrx**.
- After compilation, assemble the files in **asrx** to generate relocatable files (tp1.obj and tp2.obj).

**Command description**

```
ccrx -isa=rxv1 -output=obj tp1.c tp2.c
```

```
rlink -form=abs -output=tp.abs -subcommand=cmd.sub tp1.obj tp2.obj
```

Remarks 1. When the **-output=obj** option is specified in **ccrx**, **ccrx** generates relocatable files.

Remarks 2. In order to change relocatable file names, their C/C++ source files have to be input in **ccrx**, one file each.
Remarks 3. When the form option in rlink is changed to -form=sty, the file after linkage will be generated as a Motorola S type file.

(c) Compilation, Assemble, and Linkage by Separate Commands
Individually perform each step below by a single command.
- Compile C/C++ source files (tp1.c and tp2.c) in ccrx to generate assembly-language files (tp1.src and tp2.src).
- Assemble the assembly-language files (tp1.src and tp2.src) in asrx to generate relocatable files (tp1.obj and tp2.obj).
- Link the relocatable files (tp1.obj and tp2.obj) in rlink to generate an absolute file (tp.abs).

[Command description]

```
crx -isa=rxv1 -output=src tp1.c tp2.c
asrx tp1.src tp2.src
rlink -form=abs -output=tp.abs -subcommand=cmd.sub tp1.obj tp2.obj
```  

Remark When the -output=src option is specified in ccrx, ccrx generates assembly-language files.

(d) Assemble and Linkage by One Command
Perform all steps below by a single command.
- Assemble assembly-language files (tp1.src and tp2.src) in asrx.
- After assemble, link the files in rlink to generate an absolute file (tp.abs).

[Command description]

```
crx -isa=rxv1 -output=abs=tp.abs tp1.src tp2.src
```  

Remark Object files that are to be linked are allocated from address 0. The order of the sections is not guaranteed. In order to specify the allocation address or section allocation order, specify options for the optimizing linkage editor using the -lnkcmd and -lnkopt options.

(e) Assemble and Linkage by Separate Commands
Individually perform each step below by a single command.
- Assemble assembly-language files (tp1.src and tp2.src) in asrx to generate relocatable files (tp1.obj and tp2.obj).
- Link the relocatable files (tp1.obj and tp2.obj) in rlink to generate an absolute file (tp.abs).

[Command description 1]

```
crx -isa=rxv1 -output=obj tp1.src tp2.src
rlink -form=abs -output=tp.abs -subcommand=cmd.sub tp1.obj tp2.obj
```  

[Command description 2]

```
asrx -isa=rxv1 tp1.src tp2.src
rlink -form=abs -output=tp.abs -subcommand=cmd.sub tp1.obj tp2.obj
```  

(f) Create a List File of Existing Libraries
Create a list of lib1.lib with the name of lib1.lbp.

[Command description]

```
rlink -form=library -list -library=lib1.lib
```
### 2.5 Options

This section describes the options for the RX family C/C++ compiler in each processing phase.

- Compile phase: Refer to **2.5.1 Compile Options**.
- Assembly phase: Refer to **2.5.2 Assembler Command Options**.
- Link phase: Refer to **2.5.3 Optimizing Linkage Editor (rlink) Options**.
- Library generation phase: Refer to **2.5.4 Library Generator Options**.

#### 2.5.1 Compile Options

The types and explanations for options of the compile phase are shown below.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Options</td>
<td>-lang</td>
<td>Specifies the language to assume in compiling the source file.</td>
</tr>
<tr>
<td></td>
<td>-include</td>
<td>Specifies the names of folders that hold include files.</td>
</tr>
<tr>
<td></td>
<td>-preinclude</td>
<td>Specifies the names of files to be included at the head of each compiling unit.</td>
</tr>
<tr>
<td></td>
<td>-define</td>
<td>Specifies macro definitions.</td>
</tr>
<tr>
<td></td>
<td>-undefine</td>
<td>Specifies disabling of predefined macros.</td>
</tr>
<tr>
<td></td>
<td>-message</td>
<td>Information-level messages are output.</td>
</tr>
<tr>
<td></td>
<td>-nomessage</td>
<td>Specifies the numbers of information-level messages to be disabled.</td>
</tr>
<tr>
<td></td>
<td>-change_message</td>
<td>Changes the levels of compiler output messages.</td>
</tr>
<tr>
<td></td>
<td>-no_warning [V2.08.00 or later]</td>
<td>Disables the output of warnings and information-level messages.</td>
</tr>
<tr>
<td></td>
<td>-file_inline_path</td>
<td>Specifies the names of folders that hold files for inter-file inline expansion.</td>
</tr>
<tr>
<td></td>
<td>-comment</td>
<td>Selects permission for comment (/ * */ ) nesting.</td>
</tr>
<tr>
<td></td>
<td>-truncated_address_initializer [V3.01.00 or later]</td>
<td>Allows 1-byte or 2-byte type external variables in C source files to be initialized by address values.</td>
</tr>
<tr>
<td></td>
<td>-check</td>
<td>Checks compatibility with an existing program.</td>
</tr>
<tr>
<td></td>
<td>-misra2012 [Professional Edition only] [V2.04.00 or later]</td>
<td>Checks the source code against the MISRA-C: 2012 rules.</td>
</tr>
<tr>
<td></td>
<td>-ignore_files_misra [Professional Edition only]</td>
<td>Selects files that will not be checked against the MISRAC: 2004 rules or MISRA-C: 2012 rules.</td>
</tr>
<tr>
<td></td>
<td>-check_language_extension [Professional Edition only]</td>
<td>Enables complete checking against the MISRA-C: 2004 rules or MISRA-C: 2012 rules for parts of the code where this would otherwise be suppressed due to use of an extended specification.</td>
</tr>
<tr>
<td></td>
<td>-misra_intermodule [Professional Edition only] [V3.01.00 or later]</td>
<td>Checks the source code in multiple files against the MISRA-C:2012 rules.</td>
</tr>
<tr>
<td>Classification</td>
<td>Option</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Object Options</strong></td>
<td>-output</td>
<td>Selects the output file type.</td>
</tr>
<tr>
<td></td>
<td>-noline</td>
<td>Selects the non-output of #line in preprocessor expansion.</td>
</tr>
<tr>
<td></td>
<td>-debug</td>
<td>Debugging information is output to the object files.</td>
</tr>
<tr>
<td></td>
<td>-nodebug</td>
<td>Debugging information is not output to the object files.</td>
</tr>
<tr>
<td></td>
<td>-g_line [V3.02.00 or later]</td>
<td>Enhances source debugging information during optimization.</td>
</tr>
<tr>
<td></td>
<td>-section</td>
<td>Changes section names to be changed.</td>
</tr>
<tr>
<td></td>
<td>-stuff</td>
<td>Variables are allocated to sections that match their alignment values.</td>
</tr>
<tr>
<td></td>
<td>-nostuff</td>
<td>Alignment values of variables are ignored in allocating the variables to sections.</td>
</tr>
<tr>
<td></td>
<td>-instalign4</td>
<td>Instructions at branch destinations are aligned with 4-byte boundaries.</td>
</tr>
<tr>
<td></td>
<td>-instalign8</td>
<td>Instructions at branch destinations are aligned with 8-byte boundaries.</td>
</tr>
<tr>
<td></td>
<td>-noinstalign</td>
<td>Instructions at branch destinations have no specific alignment.</td>
</tr>
<tr>
<td></td>
<td>-nouse_div_inst</td>
<td>Generates code in which no DIV, DIVU, FDIV or DDIV instructions are used for division and modular division.</td>
</tr>
<tr>
<td></td>
<td>-create_unfilled_area [V2.03.00 or later]</td>
<td>[To be supported by V2.03 and later versions] Makes spaces created by .OFFSET unfilled.</td>
</tr>
<tr>
<td></td>
<td>-stack_protector/ -stack_protector_all [Professional Edition only] [V2.04.00 or later]</td>
<td>This option generates a code for detection of stack smashing.</td>
</tr>
<tr>
<td></td>
<td>-avoid_cross_boundary_pretch [V2.07.00 or later]</td>
<td>Prevents the reading of data across 4-byte boundaries in prefetching for string manipulation instructions.</td>
</tr>
<tr>
<td></td>
<td>-insert_nop_with_label [V2.08.00 or later]</td>
<td>This option inserts a local label and nop instruction.</td>
</tr>
<tr>
<td></td>
<td>-control_flow_integrity [Professional Edition only] [V2.08.00 or later]</td>
<td>This option generates code for the detection of illegal indirect function calls.</td>
</tr>
<tr>
<td><strong>List Options</strong></td>
<td>-listfile</td>
<td>A source list file is output.</td>
</tr>
<tr>
<td></td>
<td>-nolistfile</td>
<td>A source list file is not output.</td>
</tr>
<tr>
<td></td>
<td>-show</td>
<td>Specifies the contents of the source list file.</td>
</tr>
</tbody>
</table>
### Optimize Options

<table>
<thead>
<tr>
<th>Classification</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize Options</td>
<td>-optimize</td>
<td>Selects the optimization level.</td>
</tr>
<tr>
<td></td>
<td>-goptimize</td>
<td>Outputs additional information for inter-module optimization.</td>
</tr>
<tr>
<td></td>
<td>-speed</td>
<td>Optimization is with emphasis on execution performance.</td>
</tr>
<tr>
<td></td>
<td>-size</td>
<td>Optimization is with emphasis on code size.</td>
</tr>
<tr>
<td></td>
<td>-loop</td>
<td>Specifies a maximum number for loop-expansion.</td>
</tr>
<tr>
<td></td>
<td>-inline</td>
<td>Inline expansion is processed automatically.</td>
</tr>
<tr>
<td></td>
<td>-noinline</td>
<td>Inline expansion is not processed automatically.</td>
</tr>
<tr>
<td></td>
<td>-file_inline</td>
<td>Specifies a file for inter-file inline expansion.</td>
</tr>
<tr>
<td></td>
<td>-case</td>
<td>Selects the method of expansion for switch statements.</td>
</tr>
<tr>
<td></td>
<td>-volatile</td>
<td>External variables are handled as if they are all volatile qualified.</td>
</tr>
<tr>
<td></td>
<td>-novolatile</td>
<td>External variables are handled as if none of them have been declared volatile.</td>
</tr>
<tr>
<td></td>
<td>-type_size_access_to_volatile [V3.04.00 or later]</td>
<td>A variable with volatile specified is accessed in the size of the variable type.</td>
</tr>
<tr>
<td></td>
<td>-const_copy</td>
<td>Enables constant propagation of const qualified external variables.</td>
</tr>
<tr>
<td></td>
<td>-noconst_copy</td>
<td>Disables constant propagation of const qualified external variables.</td>
</tr>
<tr>
<td></td>
<td>-const_div</td>
<td>Divisions and remainders of integer constants are converted into instruction sequences.</td>
</tr>
<tr>
<td></td>
<td>-noconst_div</td>
<td>Divisions and remainders of integer constants are not converted into instruction sequences.</td>
</tr>
<tr>
<td></td>
<td>-library</td>
<td>Selects the method for the execution of library functions.</td>
</tr>
<tr>
<td></td>
<td>-scope</td>
<td>Selects division of the ranges for optimization into multiple sections before compilation.</td>
</tr>
<tr>
<td></td>
<td>-noscope</td>
<td>Selects non-division of the ranges for optimization into multiple sections before compilation.</td>
</tr>
<tr>
<td></td>
<td>-schedule</td>
<td>Pipeline processing is considered in scheduling instructions.</td>
</tr>
<tr>
<td></td>
<td>-noschedule</td>
<td>Scheduling is not applied to instruction execution.</td>
</tr>
<tr>
<td></td>
<td>-map</td>
<td>All access to external variables is optimized.</td>
</tr>
<tr>
<td></td>
<td>-smap</td>
<td>Access to external variables is optimized as defined in the file to be compiled.</td>
</tr>
<tr>
<td></td>
<td>-nomap</td>
<td>Access to external variables is not optimized.</td>
</tr>
<tr>
<td></td>
<td>-approxdiv</td>
<td>Division of floating-point constants is converted into multiplication.</td>
</tr>
<tr>
<td></td>
<td>-enable_register</td>
<td>Variables with the register storage class specification are given preference for allocation to registers.</td>
</tr>
</tbody>
</table>
### Optimize Options

<table>
<thead>
<tr>
<th>Classification</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-simple_float_conv</td>
<td>Part of the type conversion processing between the floating-point type and the integer type is omitted.</td>
</tr>
<tr>
<td></td>
<td>-fpu</td>
<td>Single-precision floating-point processing instructions are used.</td>
</tr>
<tr>
<td></td>
<td>-nofpu</td>
<td>Single-precision floating-point processing instructions are not used.</td>
</tr>
<tr>
<td></td>
<td>-dpfpu [V3.01.00 or later]</td>
<td>Double-precision floating-point processing instructions are used.</td>
</tr>
<tr>
<td></td>
<td>-nodpfpu [V3.01.00 or later]</td>
<td>Double-precision floating-point processing instructions are not used.</td>
</tr>
<tr>
<td></td>
<td>-tfu [V3.01.00 or later]</td>
<td>Selects how the trigonometric function unit is to be used.</td>
</tr>
<tr>
<td></td>
<td>-tfu_version [V3.05.00 or later]</td>
<td>Selects the version of the trigonometric function unit.</td>
</tr>
<tr>
<td></td>
<td>-nosave_tfu [V3.05.00 or later]</td>
<td>A code for saving and restoring the output of the trigonometric function unit (v2) is not generated for interrupt functions.</td>
</tr>
<tr>
<td></td>
<td>-alias</td>
<td>Optimization is performed in consideration of the types of data indicated by pointers.</td>
</tr>
<tr>
<td></td>
<td>-float_order</td>
<td>The orders of operations in floating-point expressions are modified for optimization.</td>
</tr>
<tr>
<td></td>
<td>-branch_chaining [V3.03.00 or later]</td>
<td>The branch instruction size is reduced for optimization.</td>
</tr>
<tr>
<td></td>
<td>-nobranch_chaining [V3.03.00 or later]</td>
<td>The branch instruction size is not reduced for optimization.</td>
</tr>
<tr>
<td></td>
<td>-ip_optimize</td>
<td>Selects global optimization.</td>
</tr>
<tr>
<td></td>
<td>-merge_files</td>
<td>The results of compiling multiple source files are output to a single object file.</td>
</tr>
<tr>
<td></td>
<td>-whole_program</td>
<td>Makes the compiler perform optimization on the assumption that all source files have been input.</td>
</tr>
<tr>
<td>Classification</td>
<td>Option</td>
<td>Description</td>
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<td>Microcontroller Options</td>
<td>-isa</td>
<td>Selects the instruction-set architecture.</td>
</tr>
<tr>
<td></td>
<td>-cpu</td>
<td>Selects the microcontroller type.</td>
</tr>
<tr>
<td></td>
<td>-endian</td>
<td>Selects the endian type.</td>
</tr>
<tr>
<td></td>
<td>-round</td>
<td>Selects the rounding method for floating-point constant operations.</td>
</tr>
<tr>
<td></td>
<td>-denormalize</td>
<td>Selects the operation when denormalized numbers are used to describe floating-point constants.</td>
</tr>
<tr>
<td></td>
<td>-dbl_size</td>
<td>Selects the precision of the <code>double</code> and <code>long double</code> types.</td>
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<td></td>
<td>-int_to_short</td>
<td>Replaces the <code>int</code> type with the <code>short</code> type and the <code>unsigned int</code> type with the <code>unsigned short</code> type.</td>
</tr>
<tr>
<td></td>
<td>-signed_char</td>
<td>Variables of the <code>char</code> type are handled as <code>signed char</code>.</td>
</tr>
<tr>
<td></td>
<td>-unsigned_char</td>
<td>Variables of the <code>char</code> type are handled as <code>unsigned char</code>.</td>
</tr>
<tr>
<td></td>
<td>-signed_bitfield</td>
<td>The sign bits of bit-fields are taken as <code>signed</code>.</td>
</tr>
<tr>
<td></td>
<td>-unsigned_bitfield</td>
<td>The sign bits of bit-fields are taken as <code>unsigned</code>.</td>
</tr>
<tr>
<td></td>
<td>-auto_enum</td>
<td>Selects whether or not the sizes for enumerated types are automatically selected.</td>
</tr>
<tr>
<td></td>
<td>-bit_order</td>
<td>Selects the order of bit-field members.</td>
</tr>
<tr>
<td></td>
<td>-pack</td>
<td>Specifies one as the boundary alignment value for structure members and class members.</td>
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<tr>
<td></td>
<td>-unpack</td>
<td>Aligns structure members and class members to the alignment boundaries for the given data types.</td>
</tr>
<tr>
<td></td>
<td>-exception</td>
<td>Enables the exception handling function.</td>
</tr>
<tr>
<td></td>
<td>-noexception</td>
<td>Disables the exception handling function.</td>
</tr>
<tr>
<td></td>
<td>-rtti</td>
<td>Selects enabling or disabling of C++ runtime type information (<code>dynamic_cast</code> or <code>typeid</code>).</td>
</tr>
<tr>
<td></td>
<td>-fint_register</td>
<td>Selects a general register for exclusive use with the fast interrupt function.</td>
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<tr>
<td>Microcontroller Options</td>
<td>-branch</td>
<td>Selects the maximum size or no maximum size for branches.</td>
</tr>
<tr>
<td></td>
<td>-base</td>
<td>Specifies the base registers for ROM and RAM.</td>
</tr>
<tr>
<td></td>
<td>-patch</td>
<td>Selects avoidance or non-avoidance of a problem specific to the CPU type.</td>
</tr>
<tr>
<td></td>
<td>-pic</td>
<td>Enables the PIC function.</td>
</tr>
<tr>
<td></td>
<td>-pid</td>
<td>Enables the PID function.</td>
</tr>
<tr>
<td></td>
<td>-nouse_pid_register</td>
<td>The PID register is not used in code generation.</td>
</tr>
<tr>
<td></td>
<td>-save_acc</td>
<td>The contents of ACC are saved and restored in interrupt functions.</td>
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### Assemble and Linkage Options

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<th>Description</th>
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<td><code>-asmcmd</code></td>
<td>Specifies a subcommand file for <code>asrx</code> options.</td>
</tr>
<tr>
<td><code>-lnkcmd</code></td>
<td>Specifies a subcommand file for <code>rlink</code> options.</td>
</tr>
<tr>
<td><code>-asmopt</code></td>
<td>Specifies <code>asrx</code> options.</td>
</tr>
<tr>
<td><code>-lnkopt</code></td>
<td>Specifies <code>rlink</code> options.</td>
</tr>
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</table>

### Other Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
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<tr>
<td><code>-logo</code></td>
<td>Selects the output of copyright information.</td>
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<tr>
<td><code>-nologo</code></td>
<td>Selects the non-output of copyright information.</td>
</tr>
<tr>
<td><code>-euc</code></td>
<td>The character codes of input programs are interpreted as EUC codes.</td>
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<tr>
<td><code>-sjis</code></td>
<td>The character codes of input programs are interpreted as SJIS codes.</td>
</tr>
<tr>
<td><code>-latin1</code></td>
<td>The character codes of input programs are interpreted as ISO-Latin1 codes.</td>
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<tr>
<td><code>-utf8</code></td>
<td>The character codes of input programs are interpreted as UTF-8 codes.</td>
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<td><code>-big5</code></td>
<td>The character codes of input programs are interpreted as BIG5 codes.</td>
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<tr>
<td><code>-gb2312</code></td>
<td>The character codes of input programs are interpreted as GB2312 codes.</td>
</tr>
<tr>
<td><code>-outcode</code></td>
<td>Selects the character coding for an output assembly-language file.</td>
</tr>
<tr>
<td><code>-subcommand</code></td>
<td>Specifies a file for including command options.</td>
</tr>
</tbody>
</table>
Source Options

< Compile Options / Source Options >

The following source options are available.

- -lang
- -include
- -preinclude
- -define
- -undefine
- -message
- -nomessage
- -change_message
- -no_warning [V2.08.00 or later]
- -file_inline_path
- -comment
- -truncated_address_initializer [V3.01.00 or later]
- -check
- -misra2004 [Professional Edition only]
- -misra2012 [Professional Edition only] [V2.04.00 or later]
- -ignore_files_misra [Professional Edition only]
- -check_language_extension [Professional Edition only]
- -misra_intermodule [Professional Edition only] [V3.01.00 or later]
- **-lang**

  < Compile Options / Source Options >

  [Format]

  -lang= { c | cpp | ecpp | c99 }

  - [Default]
    If this option is not specified, the compiler will compile the program file as a C++ source file when the extension is `cpp`, `cc`, or `cp`, and as a C (C89) source file for any other extensions. However, if the extension is `src` or `s`, the program file is handled as an assembly-language file regardless of whether this option is specified.

  [Description]

    - This option specifies the language of the source file.
    - When the `lang=c` option is specified, the compiler will compile the program file as a C (C89) source file.
    - When the `lang=cpp` option is specified, the compiler will compile the program file as a C++ source file.
    - When the `lang=ecpp` option is specified, the compiler will compile the program file as an Embedded C++ source file.
    - When the `lang=c99` option is specified, the compiler will compile the program file as a C (C99) source file.

  [Remarks]

    - The Embedded C++ language specification does not support a `catch`, `const_cast`, `dynamic_cast`, `explicit`, `mutable`, `namespace`, `reinterpret_cast`, `static_cast`, `template`, `throw`, `try`, `typeid`, `typename`, `using`, `multiple inheritance`, or `virtual base class`. If one of these classes is written in the source file, the compiler will display an error message.
    - Always specify the `lang=ecpp` option when using an EC++ library.
    - In batch compilation (when multiple C/C++ language source files are input to the compiler at the same time), the individual C or C++ language source files must be in the same language. Thus, separate the C and C++ language source files in accord with the languages to be specified and then perform batch compilation by specifying this option for the group in each of the languages.
**-include**

< Compile Options / Source Options >

**Format**

```
-includem=path_name{,...}
```

**Description**

- This option specifies the name of the path to the folder that stores the include file.
- Multiple path names can be specified by separating them with a comma (,).
- Searching for files with names enclosed in "<" and ">" proceeds in order of the folders specified by the include option, the folders specified by environment variable INC_RX.
- Searching for files with names enclosed in double quotation marks (") proceeds in order of the storage folder of the file for which the #include statement is made, the folders specified by the include option, the folders specified by environment variable INC_RX.
- If two or more folders are specified in the include option, searching proceeds in order of specifications of the path-names for the folders on the command line (from left to right).

**Remarks**

- If this option is specified for more than one time, all specified path names are valid.
- **`-preinclude`**

  `< Compile Options / Source Options >`

  **[Format]**

  `-preinclude=<file name>[,...]`

  **[Description]**

  - This option includes the specified file contents at the head of the compiling unit.
  - If the file name is specified by its relative path, the folder is searched in the following order:
    - [V3.01.00 or earlier]
      - Folder with the compilation unit
      - Folder specified by the include option
      - Folder specified by environment variable `INC_RX`
    - [V3.02.00 or later]
      - Folder that started the compiler
  - Multiple file names can be specified by separating them with a comma (,).

  **[Remarks]**

  - If this option is specified for more than one time, all specified files will be included.
-define

< Compile Options / Source Options >

[Format]

-define=<sub>[,...]
    <sub>: <macro name> [= <string>]

[Description]
- This option provides the same function as `#define` specified in the source file.
- `<string>` can be defined as a macro name by specifying `<macro name>=<string>`.
- When only `<macro name>` is specified as a suboption, the macro name is assumed to be defined. Names or integer constants can be written in `<string>`.

[Remarks]
- If the macro name specified by this option has already been defined in the source file by `#define`, `#define` takes priority.
- If this option is specified for more than one time, all specified macro names are valid.
-undefined

< Compile Options / Source Options >

[Format]

-undefined=<sub>[,...]
  <sub>: <macro name>

[Description]

- This option invalidates the predefined macro of <macro name>.
- Multiple macro names can be specified by separating them with a comma (,).

[Remarks]

- Refer to the Macro Names section, in the COMPILER LANGUAGE SPECIFICATIONS chapter, for specifiable pre-defined macros of the compiler.
- If this option is specified for more than one time, all specified macro names will be undefined.
-message

< Compile Options / Source Options >

[Format]

```plaintext
-message
```

- [Default]
  No information-level messages will be output.

[Description]

- This option outputs the information-level messages.

[Remarks]

- Message output from the assembler or optimizing linkage editor cannot be controlled by this option. Message output from the optimizing linkage editor can be controlled by using the `lnkcmd` option to specify the `message` or `nomessages` option of the optimizing linkage editor.
-nomessage

< Compile Options / Source Options >

[Format]

-nomessage [= <error number> [- <error number>]][,...]

[Description]

- With no sub-options, this disables the output of information-level messages.
- When error numbers are specified as sub-options, only the output of the information-level messages with the specified numbers will be disabled. Other information-level messages will be output.
- A range of error numbers to be disabled can be specified by using a hyphen (-), that is, in the form of <error number>-<error number>.
- Error numbers are specified by the five lower-order digits (i.e. five digits from the right) of message numbers without the prefix "M" (information). Example: To change the level of information message M0523009
  -nomessage=23009

[Remarks]

- Message output from the assembler or optimizing linkage editor cannot be controlled by this option. Message output from the optimizing linkage editor can be controlled by using the lnkcmd option to specify the message or nomessage option of the optimizing linkage editor.
- If the nomessage option is specified for more than one time, output for all specified error numbers will be disabled.
- This option is only specifiable for messages with number 0510000 to 0549999 (including the component number).
- This option can also be used to suppress the output of warnings in the range from 0520000 to 0529999. Specify the numbers of the warnings that you wish to suppress. To suppress the output of other warnings, use -change_message to change them to information-level messages.
-change_message

< Compile Options / Source Options >

[Format]

-change_message = <sub>[,...]
  <sub>: <error level>="<error number>[= <error number>[,...]]
  <error level>: { information | warning | error }

[Description]

- This option changes the message level of information-level and warning-level messages.
- Multiple error numbers can be specified by separating them with a comma (,).
- Error numbers are specified by the five lower-order digits (i.e. five digits from the right) of the message numbers without the prefix "M" (information) or "W" (warning).
  Example: To change the level of information message M0523009
  -change_message=error=23009
- Although this option may change the types of some messages (e.g. error (E) or warning (W)), the meaning of the message indicated by the component or message number remains the same.

[Example]

- Warning-level messages with the specified error numbers are changed to information-level messages.
  change_message=warning=error number

- Information-level messages with the specified error numbers are changed to warning-level messages.
  change_message=information=error number

- Information-level and warning-level messages with the specified error numbers are changed to error-level messages.
  change_message=error=error number

- All warning-level messages are changed to information-level messages.
  change_message=warning=information

- All information-level messages are changed to warning-level messages.
  change_message=warning

- All information-level and warning-level messages are changed to error-level messages.
  change_message=error

[Remarks]

- The output of messages which have been changed to information-level messages can be disabled by the nomessage option.
- Message output from the assembler or optimizing linkage editor cannot be controlled by this option. Message output from the optimizing linkage editor can be controlled by using the lnkcmd option to specify the message or nomessage option of the optimizing linkage editor.
- If this option is specified for more than one time, all specified error numbers are valid.
- Only the levels of warning and information messages can be controlled by this option. Specification of the option for a message not at these levels is ignored.

- This option is not usable to control the level of MISRA2004 detection messages (labeled M) that appear when the misra2004 option has been specified.
-no_warning [V2.08.00 or later]

< Compile Options / Source Options >

[Format]

-no_warning={ <number> | <number>-<number> }[, { <number> | <number>-<number> }]

[Description]

- This option is used to suppress the output of warnings or information-level messages with the numbers specified by <number>. You cannot use this option to suppress the output of any messages by the assembler or optimizing link-age editor.

- You can specify this option more than once. Each specification will be effective.

- Separate all parameters with commas (,). Do not enter any white space before or after a comma.

- Entering white space before or after a comma, omitting parameters, or entering characters that are not numbers will lead to a compilation error.

- The values specifiable as parameters are the last five digits of message numbers of warnings and information-level messages (51000 to 54999). Any other specified numbers, including those that are not actually message numbers, will be ignored.

  - Specification of the numbers of error messages will be ignored because the output of error messages cannot be suppressed. This applies to any messages at the error level, including those having levels changed by the -change_message=error option.

- This option is also usable in combination with the -nomessage option. In such cases, both options are effective, even if they include specifications of the same message.
- **file_inline_path**

  `< Compile Options / Source Options >`

  **[Format]**

  `-file_inline_path=<path name>[,...]`

  **[Description]**

  - This option is not available in V.2.00. Any specification of this option will simply be ignored and will not lead to an error due to compatibility with former versions.
**-comment**

< Compile Options / Source Options >

**[Format]**

```
-frame -comment = ( nest | nonest )
```

**[Description]**

- When `comment=nest` is specified, nested comments are allowed to be written in the source file.
- When `comment=nonest` is specified, writing nested comments will generate an error.
- The default for this option is `comment=nonest`.

**[Example]**

- When `comment=nest` is specified, the compiler handles the above line as a nested comment; however, when `comment=nonest` is specified, the compiler assumes (1) as the end of the comment.

```c
/* This is an example of /* nested */ comment */
(1)
```
-truncated_address_initializer [V3.01.00 or later]

< Compile Options / Source Options >

[Format]

-truncated_address_initializer

[Description]

- The warning message W0520069 is output instead of error E0520069 in response to detection of a code that initial-
izes a 1-byte type or 2-byte type external variable or static variable by an address value. This is only applicable to
C-language source files.

[Remarks]

- The upper bytes of an address are truncated. Therefore, the original address value will not be retained when the
upper bytes are not 0.
- If casting into 1-byte or 2-byte type is followed by casting into a larger type, an error will occur.
- If the variable to be initialized is a bit field member, an error will occur.
- This option is invalid when code is in the C++ language or Embedded C++ language.
-check

< Compile Options / Source Options >

[Format]

- check = { nc | ch38 | shc }

[Description]

- This option checks the specified options and source file parts which will affect the compatibility when this compiler uses a C/C++ source file that has been coded for the R8C and M16C family C compilers, H8, H8S, and H8SX family C/C++ compilers, and SuperH family C/C++ compilers.
- For check=nc, the compatibility with the R8C and M16C family C compilers is checked. Checking will be for the following options and types:
  - Options: signed_char, signed_bitfield, bit_order=left, endian=big, and dbl_size=4
  - inline, enum type, #pragma BITADDRESS, #pragma ROM, #pragma PARAMETER, and asm()
  - Assignment of a constant outside the signed short range to the int or signed int type or assignment of a constant outside the unsigned short range to the int or unsigned int type while -int_to_short is not specified
  - Assignment of a constant outside both of the signed short and unsigned short ranges to the long or long long type
  - Comparison expression between a constant outside the signed short range and the int, short, or char type (except the signed char type)
- For check=ch38, the compatibility with the H8, H8S, and H8SX family C/C++ compilers is checked. Checking will be for the following options and types:
  - Options: unsigned_char, unsigned_bitfield, bit_order=right, endian=little, and dbl_size=4
  - __asm and #pragma unpack
  - Comparison expression with a constant greater than the maximum value of signed long
  - Assignment of a constant outside the signed short range to the int or signed int type or assignment of a constant outside the unsigned short range to the int or unsigned int type while -int_to_short is not specified
  - Assignment of a constant outside both of the signed short and unsigned short ranges to the long or long long type
  - Comparison expression between a constant outside the signed short range and the int, short, or char type (except the signed char type)
- For check=shc, the compatibility with the SuperH family C/C++ compilers is checked. Checking will be for the following options and types:
  - Options: unsigned_char, unsigned_bitfield, bit_order=right, endian=little, dbl_size=4, and round=nearest
  - #pragma unpack
  - volatile qualified variables
- Confirm the following notes for the displayed items.
  - Options: The settings which are not defined in the language specification and depend on implementation differ in each compiler. Confirm the settings of the options that were output in a message.
  - Extended specifications: There is a possibility that extended specifications will affect program operation. Confirm the descriptions on the extended specifications that were output in a message.
[Remarks]

- When `dbl_size=4` is enabled, the results of type conversion related to floating-point numbers and the results of library calculation may differ from those in the R8C and M16C family C compilers, H8, H8S, and H8SX family C/C++ compilers, and SuperH family C/C++ compilers. When `dbl_size=4` is specified, this compiler handles `double` type and `long double` type as 32 bits, but the R8C and M16C family C compilers (`fdouble_32`), H8, H8S, and H8SX family C/C++ compilers (`double=float`), and SuperH family C/C++ compilers (`double=float`) handle only `double` type as 32 bits.

- The result of a binary operation (addition, subtraction, multiplication, division, comparison, etc.) with `unsigned int` type and `long` type operands may differ from that in the SuperH family C/C++ compilers. In this compiler, the types of the operands are converted to the `unsigned long` type before operation. However, in the SuperH family C/C++ compilers (only when `strict Ansi` is not specified), the types of the operands are converted to the `signed long long` type before operation.

- The data size of reading from and writing to a `volatile` qualified variable may differ from that in the SuperH family C/C++ compilers. This is because a `volatile` qualified bit field may be accessed in a size smaller than that of the declaration type in this compiler. However, in the SuperH family C/C++ compilers, a `volatile` qualified bit field is accessed in the same size as that of the declaration type.

- This option does not output a message regarding allocation of structure members and bit field members. When an allocation-conscious declaration is made, refer to the Internal Data Representation and Areas section of the COMPILER LANGUAGE SPECIFICATIONS chapter.

- In the R8C and M16C family C compilers (`fextend_to_int` is not specified), the generated code has been evaluated without performing generalized integer promotion by a conditional expression. Accordingly, operation of such a code may differ from a code generated by this compiler.
-misra2004 [Professional Edition only]

< Compile Options / Source Options >

[Format]

```c
-misra2004 = {
  all
  | apply=<rule number>[,...]
  | ignore=<rule number>[,...]
  | required
  | required_add=<rule number>[,...]
  | required_remove=<rule number>[,...]
  | <filename> }
```

[Description]
- This option enables checking against the MISRA-C:2004 rules and to select specific rules to be used.
  - When `misra2004=all`, the compiler checks the source code against all of the rules that are supported.
  - When `misra2004=apply=<rule number>[,<rule number>,...]`, the compiler checks the source code against the rules with the selected numbers.
  - When `misra2004=ignore=<rule number>[,<rule number>,...]`, the compiler checks the source code against the rules other than those with the selected numbers.
  - When `misra2004=required`, the compiler checks the source code against the rules of the "required" type.
  - When `misra2004=required_add=<rule number>[,<rule number>,...]`, the compiler checks the source code against the rules of the "required" type and the rules with the selected numbers.
  - When `misra2004=required_remove=<rule number>[,<rule number>,...]`, the compiler checks the source code against the rules other than those with the selected numbers among the rules of the "required" type.
  - When `misra2004=<filename>`, the compiler checks the source code against the rules with the numbers written in the specified file. One rule number is written per line in the file. Each rule number must be specified by using decimal values and a period (".").
  - When checking of a line of code against the MISRA-C:2004 rules leads to detection of a violation, a message in the following format will appear.
    `<Filename> (<line number>): M0523028 <Rule number>: <Message>`
  - When `misra2004=<filename>` is used more than once, only the last specification is valid.

[Remarks]
- The `-misra2004` option can be specified more than once. However, if multiple types exist, only the type written last and consecutive specifications of the same type are valid.
  ... `misra2004=ignore=2.2` `-misra2004=apply=2.3`
  `-misra2004=required_add=4.1` `-misra2004=apply=4.2`
  `-misra2004=apply=5.2` ...
  In this example, `ignore`, `apply`, and `required_add` are specified, but only `apply` (used in the last two cases) is valid. The compiler will check the source code against rules 4.2 and 5.2.
- When the number of an unsupported rule is specified for `<rule number>`, the compiler detects error F0523031 and stops the processing.
- When the file specified in `misra2004=<filename>` cannot be opened, the compiler detects error F0523029. When rule numbers are not extractable from the specified file, the compiler detects error F0523030. Processing by the compiler stops in both cases.
- This option is ignored when `cpp`, `c99`, or `ecpp` is selected for the `lang` option or when `output=prep` is specified at the same time.
- This option supports the MISRA-C: 2004 rules listed below.
- For source programs that use extended functions such as `#pragma`, checking against these rules will be suppressed under some conditions. For details, refer to the section on the `check_language_extension` option.

- MISRA diagnostic messages displayed by the `misra2004` option cannot be controlled by the `change_message` option.

- The source code cannot be simultaneously checked against the MISRA-C: 2012 rules.
-misra2012 [Professional Edition only] [V2.04.00 or later]

< Compile Options / Source Options >

[Format]

-misra2012 = {
  all
  | apply=<rule number>[,...]
  | ignore=<rule number>[,...]
  | required
  | required_add=<rule number>[,...]
  | required_remove=<rule number>[,...]
  | <filename> }

[Description]
- This option enables checking against the MISRA-C:2012 rules and to select specific rules to be used.
- When misra2012=all, the compiler checks the source code against all of the rules that are supported.
- When misra2012=apply=<rule number>[,<rule number>,...], the compiler checks the source code against the rules with the selected numbers.
- When misra2012=ignore=<rule number>[,<rule number>,...], the compiler checks the source code against the rules other than those with the selected numbers.
- When misra2012=required, the compiler checks the source code against the rules of the "mandatory" and "required" types.
- When misra2012=required_add=<rule number>[,<rule number>,...], the compiler checks the source code against the rules of the "mandatory" and "required" types and the rules with the selected numbers.
- When misra2012=required_remove=<rule number>[,<rule number>,...], the compiler checks the source code against the rules other than those with the selected numbers among the rules of the "required" type.
- When misra2012=<filename>, the compiler checks the source code against the rules with the numbers written in the specified file. One rule number is written per line in the file. Each rule number must be specified by using decimal values and a period (".").
- When checking of a line of code against the MISRA-C:2012 rules leads to detection of a violation, a message in the following format will appear.
  <Filename> (<line number>): M0523086 <Rule number>: <Message>
- When -misra2012=<filename> is used more than once, only the last specification is valid.

[Remarks]
- The -misra2012 option can be specified more than once. However, if multiple types exist, only the type written last and consecutive specifications of the same type are valid.
  ... -misra2012=ignore=3.1
  -misra2012=required_add=4.1 -misra2012=apply=4.2
  -misra2012=apply=5.2 ...
  In this example, ignore, apply, and required_add are specified, but only apply (used in the last two cases) is valid. The compiler will check the source code against rules 4.2 and 5.2.
- When the number of an unsupported rule is specified for <rule number>, the compiler detects error F0523031 and stops the processing.
- When the file specified in misra2012=<filename> cannot be opened, the compiler detects error F0523029. When rule numbers are not extractable from the specified file, the compiler detects error F0523030. Processing by the compiler stops in both cases.
- This option is ignored when cpp or ecpp is selected for the lang option or when output=prep is specified at the same time.
- If this option is specified together with `lang=c99`, checking against C90/C99 common rules is performed in the scope of C99.
- For source programs that use extended functions such as `#pragma`, checking against these rules are suppressed under some conditions. For details, refer to the section on the `check_language_extension` option.
- MISRA diagnostic messages displayed by the `misra2012` option cannot be controlled by the `change_message` option.
- Checking the source code cannot be simultaneously checked against the MISRA-C:2004 rules.
- In V3.02.00 and later versions, this option supports the MISRA-C: 2012 rules listed below.

\[
\begin{align*}
2.2 & \quad 2.6 \quad 2.7 \\
3.1 & \quad 3.2 \\
4.1 & \quad 4.2 \\
5.1 \quad 5.2 & \quad 5.3 \quad 5.4 \quad 5.5 \quad 5.6 & \quad 5.7 \quad 5.8 \quad 5.9 \\
6.1 & \quad 6.2 \\
7.1 & \quad 7.2 \quad 7.3 \quad 7.4 \\
8.1 & \quad 8.2 \quad 8.3 \quad 8.4 \quad 8.5 \quad 8.6 \quad 8.8 \quad 8.9 \quad 8.11 \quad 8.12 \quad 8.13 \quad 8.14 \\
9.1 & \quad 9.2 \quad 9.3 \quad 9.4 \quad 9.5 \\
10.1 & \quad 10.2 \quad 10.3 \quad 10.4 \quad 10.5 \quad 10.6 \quad 10.7 \quad 10.8 \\
11.1 & \quad 11.2 \quad 11.3 \quad 11.4 \quad 11.5 \quad 11.6 \quad 11.7 \quad 11.8 \quad 11.9 \\
12.1 & \quad 12.2 \quad 12.3 \quad 12.4 \quad 12.5 \\
13.1 & \quad 13.2 \quad 13.3 \quad 13.4 \quad 13.5 \quad 13.6 \\
14.2 & \quad 14.3 \quad 14.4 \\
15.1 & \quad 15.2 \quad 15.3 \quad 15.4 \quad 15.5 \quad 15.6 \quad 15.7 \\
16.1 & \quad 16.2 \quad 16.3 \quad 16.4 \quad 16.5 \quad 16.6 \quad 16.7 \\
17.1 & \quad 17.3 \quad 17.4 \quad 17.5 \quad 17.6 \quad 17.7 \quad 17.8 \\
18.4 & \quad 18.5 \quad 18.7 \\
19.2 \\
20.1 & \quad 20.2 \quad 20.3 \quad 20.4 \quad 20.5 \quad 20.6 \quad 20.7 \quad 20.8 \quad 20.9 \quad 20.10 \quad 20.11 \quad 20.12 \quad 20.13 \quad 20.14 \\
21.1 & \quad 21.2 \quad 21.3 \quad 21.4 \quad 21.5 \quad 21.6 \quad 21.7 \quad 21.8 \quad 21.9 \quad 21.10 \quad 21.11 \quad 21.12
\end{align*}
\]

*1) Checking is in accord with to MISRA C:2012, Amendment 1 (getenv is not checked).

*2) If the `-misra_intermodule` option is specified, analysis can be performed over multiple files.

*3) This rule is valid only when the `-misra_intermodule` option is specified.

**Example**

- In this example, tree types of `-misra2012` option (ignore, apply, and required_add) are specified, but only apply in the last two consecutive specifications is valid. As a result, the compiler checks the source code against rules 4.2 and 5.2.

```
-misra2012=ignore=3.1
-misra2012=required_add=4.1  -misra2012=apply=4.2
-misra2012=apply=5.2
```
-ignore_files_misra [Professional Edition only]

< Compile Options / Source Options >

[Format]

-ignore_files_misra=<filename>[,<filename>,...]

[Description]

- This option selects source files that will not be checked against the MISRA-C:2004 rules or MISRA-C:2012 rules.

[Remarks]

- If the option is specified more than once in the command line, all specifications are valid.
- This option is ignored when the misra2004 or misra2012 option has not been specified.
- <filename> is ignored when the specified file is not to be compiled.
-check_language_extension [Professional Edition only]

< Compile Options / Source Options >

[Format]

-check_language_extension

[Description]
- This option enables complete checking against the MISRA-C: 2004 rules or MISRA-C: 2012 rules for parts of the code where they would otherwise be suppressed due to proprietary extensions from the C language specification.
- With the default misra2004 option and misra2012 option, the compiler does not proceed with checking against the MISRA-C: 2004 rules and MISRA-C: 2012 rules under the condition given below. To enable complete checking, specify the check_language_extension option when specifying the misra2004 option or misra2012 option.
  - A function has no prototype declaration (MISRA-C:2004 rule 8.1, MISRA-C:2012 rule 8.4 ) and #pragma entry or #pragma interrupt is specified for it.

[Example]

```c
#pragma interrupt vfunc
extern void service(void);
void vfunc(void)
{
  service();
}
```

- A function vfunc, for which #pragma interrupt is specified, has no prototype declaration. The message on rule 8.1 is not displayed unless the check_language_extension option is specified.

[Remarks]
This option is ignored when the misra2004 or misra2012 option has not been specified.
-misra_intermodule [Professional Edition only] [V3.01.00 or later]

< Compile Options / Source Options >

[Format]

-misra_intermodule=<file name>

- Interpretation when omitted
  None (checking of source code in multiple files against the MISRA-C:2012 rules is disabled)

[Description]

- This option saves symbol information of multiple files in <file name> and checks source code in these files against the MISRA-C:2012 rules. If <file name> does not exist, a new file will be created. If <file name> exists, symbol information will be added to the file.

- This option is only valid when the -misra2012 option is specified. A warning is output and this option will be ignored if the -misra2012 option is not specified.

- An error will occur if <file name> is omitted.

- This option is applied to rules whose valid range of analysis is the system. Source code will be checked against the following MISRA-C:2012 rules.
  5.1 5.6 5.7 5.8 5.9
  8.3 8.5 8.6

[Example]

- To check source code in multiple files a.c, b.c, and c.c against the MISRA-C:2012 rules, describe as:

  > ccrx -isa=rxv3 -misra2012=all -misra_intermodule=test.mi a.c b.c c.c

[Remarks]

- .{c|a|f} cannot be specified as the extension of <file name>. If specified, an error will occur. Correct operation is not guaranteed if <file name> is same as the name of another input or output file.

- If there are many files to be checked and the symbol information to be stored in <file name> is huge, the compilation speed gets slower.

- If any of the source files is modified after <file name> was created, recompilation will update the information of <file name>. If any of the source files is deleted or its file name is changed, delete <file name> and recheck source code against the MISRA-C:2012 rules because the information of <file name> cannot be updated.

- An error will occur if this option is specified in the Standard edition of the compiler.
Object Options

< Compile Options / Object Options >

The following object options are available.

- -output
- -noline
- -debug
- -nodebug
- -g_line [V3.02.00 or later]
- -section
- -stuff
- -nostuff
- -instalign4
- -instalign8
- -noinstalign
- -nouse_div_inst
- -create_unfilled_area [V2.03.00 or later]
- -stack_protector/-stack_protector_all [Professional Edition only] [V2.04.00 or later]
- -avoid_cross_boundary_prefetch [V2.07.00 or later]
- -insert_nop_with_label [V2.08.00 or later]
- -control_flow_integrity [Professional Edition only] [V2.08.00 or later]
- **-output**

< Compile Options / Object Options >

### Format

```
-output = <sub> [=<file name>]  
   <sub>: { prep | src | obj | abs | hex | sty }
```

- [Default]
The default for this option is **output=obj**.

### Description

- This option specifies the output file type.
- The suboptions and output files are shown in the following table.
- If no `<file name>` is specified, a file will be generated with an extension, that is shown in the following table, appended to the source file name input at the beginning.

<table>
<thead>
<tr>
<th>Suboption</th>
<th>Output File Type</th>
<th>Extension When File Name is Not Specified</th>
</tr>
</thead>
</table>
| prep      | Source file after preprocessed | C (C89, C99) source file: p  
C++ source file: pp  |
| src       | Assembly-language file | src                                     |
| obj       | Relocatable file   | obj                                     |
| abs       | Absolute file     | abs                                     |
| hex       | Intel hex type file | hex                                     |
| sty       | Motorola S type file | mot                                     |

**Note** Relocatable files are files output from the assembler. Absolute files, Intel hex type files, and Motorola S type files are files output from the optimizing linkage editor.

### Remarks

- An intermediate file used to generate a file of the specified type is not generated.
-noline

< Compile Options / Object Options >

[Format]

-noline

[Description]

- This option disables #line output during preprocessor expansion.

[Remarks]

- This option is validated when the output=prep option has not been specified.
-debug

< Compile Options / Object Options >

[Format]

-debug

- [Default]
The default for this option is -nodebug.

[Description]
- When the debug option is specified, debugging information necessary for C-source debugging is output. The debug option is valid even when an optimize option is specified.
-nodebug

< Compile Options / Object Options >

[Format]

- nodebug

- [Default]
The default for this option is -nodebug.

[Description]

- When the nodebug option is specified, no debugging information is output.
-g_line [V3.02.00 or later]

< Compile Options / Object Options >

[Format]

-g_line

[Description]

- This option is valid only when the -debug option is specified at the same time.
- This option enhances debugging information to enable more accurate single-step execution at the source level during debugging when optimization is performed.
- An increase in debugging information might cause a delay in single-step execution.

[Example]

ccrx a.c -isa=rxv3 -debug -g_line
-section

< Compile Options / Object Options >

[Format]

```
-sectioan = <sub>[,...]
  <sub>: { P = <section name> | C = <section name> | D = <section name> | B = <section name> | L = <section name> | W = <section name> }
```

[Description]

- This option specifies the section name.
- `section=P=<section name>` specifies the section name of a program area.
- `section=C=<section name>` specifies the section name of a constant area.
- `section=D=<section name>` specifies the section name of an initialized data area.
- `section=B=<section name>` specifies the section name of an uninitialized data area.
- `section=L=<section name>` specifies the section name of a literal area.
- `section=W=<section name>` specifies the section name of a switch statement branch table area.
- `<section name>` must be alphabetic, numeric, underscore (_), or $. The first character must not be numeric.

[Remarks]

- The default for this option is `section=P=P,C=C,D=D,B=B,L=L,W=W`.
- In the same way as in V. 1.00, if you want to output the literal area in the C section rather than output a separate L section, select `section=L=C`.
- Except for changing the L section to the same section name as that of the C section, the same section name cannot be specified for the sections for different areas.
- For the translation limit of the section name length, refer to Translation Limits.
-stuff

< Compile Options / Object Options >

[Format]

-stuff

[Description]

- When the stuff option is specified, all variables are allocated to 4-byte, 2-byte, or 1-byte boundary alignment sections depending on the alignment value (see Table 2.4).

- [V3.01.00 or later] When the dpfpu option is specified, double type and long double type variables are allocated to 8-byte boundary alignment sections.

Table 2.4 Correspondences between Variables and Their Output Sections When stuff Option is Specified

<table>
<thead>
<tr>
<th>Variable Type</th>
<th>Alignment Value for Variable</th>
<th>Section to Which Variable Belongs</th>
</tr>
</thead>
<tbody>
<tr>
<td>const qualified variables</td>
<td>4</td>
<td>C_8&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>C_2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>C_1</td>
</tr>
<tr>
<td>Initialized variables</td>
<td>4</td>
<td>D_8&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>D_2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>D_1</td>
</tr>
<tr>
<td>Uninitialized variables</td>
<td>4</td>
<td>B_8&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>B_2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>B_1</td>
</tr>
<tr>
<td>switch statement branch table</td>
<td>4</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>W_2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>W_1</td>
</tr>
</tbody>
</table>

Notes 1. When the variable type is double or long double with the dpfpu option specified.
Notes 2. Cases other than note 1

- C, D, and B are the section names specified by the section option or #pragma section. W is the section name specified by the section option. The data contents allocated to each section are output in the order they were defined.
[Example]

```c
int a;
char b=0;
const short c=0;
struct {
    char x;
    char y;
} ST;
```

[Remarks]

- The `-stuff` option has no effect for sections other than B, D, C, and W.
-nostuff

< Compile Options / Object Options >

[Format]

-nostuff [= <section type>[,...]]
  <section type>: { B | D | C | W }

[Description]

- When the nostuff option is specified, the compiler allocates the variables belonging to the specified <section type> to 4-byte boundary alignment sections. When <section type> is omitted, variables of all section types are applicable.
- C, D, and B are the section names specified by the section option or #pragma section. W is the section name specified by the section option. The data contents allocated to each section are output in the order they were defined.

[Example]

```c
int a;
char b=0;
const short c=0;
struct {
    char x;
    char y;
} ST;
```

```asm
.SECTION               C,ROMDATA,ALIGN=4
.glb        _c
    .word                   0000H

.SECTION                D,ROMDATA,ALIGN=4
.glb        _b
    .byte                   00H

.SECTION                B,DATA,ALIGN=4
.glb        _a
    .blkl        1

.glb        _ST
    .blkb        2
```

[Remarks]

- The nostuff option cannot be specified for sections other than B, D, C, and W.
-instalign4

< Compile Options / Object Options >

[Format]

- $\text{instalign4}\{=\{\text{loop}\mid\text{inmostloop}\}\}$

[Description]

- This option aligns instructions at branch destinations.
- When the $\text{instalign4}$ option is specified, the instruction at the location address is aligned to the 4-byte boundary.
- Instruction alignment is performed only when the instruction at the specified location exceeds the address which is a multiple of the alignment value $(4)^{1}$. 
- The following three types of branch destination can be selected by specifying the suboptions of $\text{instalign4}^{2}$. 
  - No specification: Head of function and case and default labels of switch statement
  - $\text{inmostloop}$: Head of each inmost loop, head of function, and case and default labels of switch statement
  - $\text{loop}$: Head of each loop, head of function, and case and default labels of switch statement
- When this option is selected, the alignment value of the program section is changed from 1 to 4 (for $\text{instalign4}$) or 8 (for $\text{instalign8}$).
- This option aims to efficiently operate the instruction queues of the RX CPU and improve the speed of program execution by aligning the addresses of branch destination instructions.
  - $\text{instalign4}$: When attempting to improve the speed of CPUs with a 32-bit instruction queue (mainly RX200 Series)

Notes

1. This is when the instruction size is equal to or smaller than the alignment value. If the instruction size is greater than the alignment value, alignment is performed only when the number of exceeding points is two or more.

2. Alignment is adjusted only for the branch destinations listed above; alignment of the other destinations is not adjusted. For example, when $\text{loop}$ is selected, alignment of the head of a loop is adjusted but alignment is not adjusted at the branch destination of an if statement that is used in the loop but does not generate a loop.

- If an object module file or a standard library that has been generated through compilation without using this option is specified for linkage, the warning W0561322 will be output at linkage but program execution will have no problem.
-instalign8

< Compile Options / Object Options >

[Format]

-instalign8={loop|inmostloop}

[Description]
- This option aligns instructions at branch destinations.
- When the instalign8 option is specified, the instruction at the location address is aligned to the 8-byte boundary.
- Instruction alignment is performed only when the instruction at the specified location exceeds the address which is a multiple of the alignment value (8)\(^1\).
- The following three types of branch destination can be selected by specifying the suboptions of -instalign4 and -instalign8\(^2\).
  - No specification: Head of function and case and default labels of switch statement
  - instalign8: Head of each inmost loop, head of function, and case and default labels of switch statement
    - inmostloop: Head of each inmost loop, head of function, and case and default labels of switch statement
    - loop: Head of each loop, head of function, and case and default labels of switch statement
- When these options are selected, the alignment value of the program section is changed from 1 to 4 (for instalign4) or 8 (for instalign8).
- These options aim to efficiently operate the instruction queues of the RX CPU and improve the speed of program execution by aligning the addresses of branch destination instructions.
This option has specifications targeting the following usage.
- instalign8: When attempting to improve the speed of CPUs with a 64-bit instruction queue (mainly RX600 Series)

Notes 1. This is when the instruction size is equal to or smaller than the alignment value. If the instruction size is greater than the alignment value, alignment is performed only when the number of exceeding points is two or more.

Notes 2. Alignment is adjusted only for the branch destinations listed above; alignment of the other destinations is not adjusted. For example, when loop is selected, alignment of the head of a loop is adjusted but alignment is not adjusted at the branch destination of an if statement that is used in the loop but does not generate a loop.

- If an object module file or a standard library that has been generated through compilation without using this option is specified for linkage, the warning W0561322 will be output at linkage but program execution will have no problem.

[Example]
- <C source file>

```c
  dlong a;
  int f1(int num)
  {
    return (num+1);
  }
  void f2(void)
  {
    a = 0;
  }
  void f3(void)
  {
  }
```
When compiling with -instalign8 specified

In the example shown below, the head of each function is aligned so that the instruction does not exceed the 8-byte boundary.

In 8-byte boundary alignment of instructions, the address will not be changed unless the target instruction exceeds the 8-byte boundary. Therefore, only the address of function f2 is actually aligned.

```
.SECTI0N P, CODE, ALIGN=8
.INSTALIGN 8
_f1:                     ; Function f1, address = 0000H
  ADD     #01H, R1     ; 2 bytes
  RTS

_f2:                     ; Function f2, address = 0008H
  ; Note: Alignment is performed.
  ; When a 6-byte instruction is placed at 0003H, it exceeds the 8-byte boundary.
  ; Thus, alignment is performed.
  MOV.L   #_a, R4      ; 6 bytes
  MOV.L   #0, [R4]     ; 3 bytes
  RTS

_f3:                     ; Function f3, address = 0012H
  RTS

.END
```
-noinstalign

< Compile Options / Object Options >

[Format]

-noinstalign

[Description]

- This option does not aligns instructions at branch destinations.
-nouse_div_inst

< Compile Options / Object Options >

[Format]

- `nouse_div_inst`

[Description]

- This option generates code in which no DIV, DIVU, FDIV, or DDIV instructions are used for division and modular division operations in the program.

[Remarks]

- This option calls the equivalent runtime functions instead of DIV, DIVU, FDIV, or DDIV instructions. This may lower code efficiency in terms of required ROM capacity and speed of execution.
-create_unfilled_area [V2.03.00 or later]

< Compile Options / Object Options >

[Format]

-create_unfilled_area

[Description]

- When a Motorola S-record file (<name>.mot) or Hex file (<name>.hex) is output, this option blocks spaces created by .OFFSET directives in the assembly language being filled with output data.
- When using this option, specify it when using the ccrx or asrx command to create an object file (<name>.obj) as well as when using the rlink command to create a Motorola S-record file or Hex file.

[Remarks]

- This option is available in V2.03 and later versions of this compiler.
- When this option is used, symbols in the format shown below*1 will be added for each .OFFSET directive.

__$_<FileName>_<SectionName>_<IDNumber>s__unfilled_area
__$_<FileName>_<SectionName>_<IDNumber>e__unfilled_area

Here, the name of the source file, section, and a number in a sequence starting from 1 are entered as <FileName>, <SectionName>, and <IDNumber>, respectively.

Note

*1) Since symbols in this format are reserved, they cannot be directly included in your source code.
-stack_protector/-stack_protector_all [Professional Edition only] [V2.04.00 or later]

< Compile Options / Object Options >

[Format]

-stack_protector[=<numeric value>]
-stack_protector_all[=<numeric value>]

[Description]

- This option generates a code for detection of stack smashing at the entry and the end of a function. A code for detection of stack smashing consists of instructions executing the three processes shown below.
  (1) A 4-byte area is allocated just before (in the direction towards address 0xFFFFFFFF) the local variable area at the entry to a function, and the value specified by <number> is stored in the allocated area.
  (2) At the end of the function, whether the 4-byte area in which <number> was stored has been rewritten is checked.
  (3) If the 4-byte area has been rewritten in (2), the __stack_chk_fail function is called as the stack has been smashed.

- A decimal number from 0 to 4294967295 should be specified in <number>. If the specification of <number> is omitted, the compiler automatically select the number.

- The __stack_chk_fail function needs to be defined by the user. It should contain postprocesses for the detected stack smashing.

- Note the following items when defining the __stack_chk_fail function.
  - The only possible type of return value is void and any formal parameters not allowed.
  - It is prohibited to call the __stack_chk_fail function as a normal function.
  - The __stack_chk_fail function is not subject to generating a code for detection of stack smashing due to the -stack_protector and -stack_protector_all options and #pragma stack_protector.
  - In a C++ program, add extern "C" to the definition or the declaration for __stack_chk_fail function.
  - Prevent returning to the caller (the function where stack smashing was detected) by taking measures such as calling abort() in __stack_chk_fail function and terminating the program.
  - Do not define the function as static.

- If -stack_protector is specified, this option generates a code for detection of stack smashing for only functions having a structure, union, or array that exceeds eight bytes as a local variable. If -stack_protector_all is specified, this option generates a code for detection of stack smashing for all functions.

- If these options are used simultaneously with #pragma stack_protector, the specification by #pragma stack_protector becomes valid.

- Even though these options are specified, a code for detection of stack smashing is not generated for a functions for which one of the following #pragma directives is specified.
  #pragma inline, #pragma inline_asm, #pragma entry, #pragma no_stack_protector
[Example]

- C source file

```c
#include <stdio.h>
#include <stdlib.h>

void f1()  // Sample program in which the stack is smashed
{
    volatile char str[10];
    int i;
    for (i = 0; i <= 10; i++){
        str[i] = i;  // Stack is smashed when i=10
    }
}

#ifdef __cplusplus
extern "C" {
#endif
void __stack_chk_fail(void)
{
    printf("stack is broken!");
    abort();
}
#ifdef __cplusplus
}
#endif

#endif __cplusplus

```
When compilation is performed with -stack_protector=0 specified

```assembly
.glob _test
.glob __stack_chk_fail
.glob _printf
.glob _abort

.SECTION P, CODE

_test:
.STACK _test=20
MOV.L #00000000H, R14 ; The specified <number> 0 is stored in the stack area.
PUSH.L R14
SUB #0CH, R0
MOV.L #00000000H, R14
MOV.L #0000000BH, R15
ADD #02H, R0, R5
L12:    ; parse_bb
MOV.B R14, [R5+] 
ADD #01H, R14
SUB #01H, R15
BNE L12
L13:    ; return
MOV.L 0CH[R0], R14 ; Data is loaded from the location where <number> was
CMP #00H, R14 ; stored at the entry to a function and it is compared
; with the specified <number> 0.
BNE L15 ; If they do not match, the program branches to L15.
L14:    ; return
RTSD #10H
L15:    ; return
BRA __stack_chk_fail ; __stack_chk_fail is called.

__stack_chk_fail:
.STACK __stack_chk_fail=8
SUB #04H, R0
MOV.L #_L10, R14
MOV.L R14, [R0]
BSR _printf
ADD #04H, R0
BRA _abort

.SECTION L,ROMDATA,ALIGN=4
_L10:
.byte "stack is broken!"
.byte 00H
.END
```
-avoid_cross_boundary_prefetch [V2.07.00 or later]

< Compile Options / Object Options >

[Format]

-avoid_cross_boundary_prefetch

[Description]

- When both of the conditions given below are satisfied, using this option allows the compiler to expand library functions for handling strings as two units of code that include string manipulation instructions: one for manipulating data at the address where reading of the string starts up to the next 4-byte boundary and the other for manipulating data from that 4-byte boundary up to the last address.
  - Files of source code include calls of library functions for string handling, i.e. memchr(), strlen(), strcpy(), strncpy(), strcmp(), strncmp(), strcat(), or strncat().
  - library=intrinsic has been specified to select the expansion of library functions.

[Remarks]

- The aim of this option is to prevent the reading of data across 4-byte boundaries in prefetching for string manipulation instructions.
- If this option is selected, the code size increases when library functions for string handling, i.e. memchr(), strlen(), strcpy(), strncpy(), strcmp(), strncmp(), strcat(), or strncat(), are compiled with library=intrinsic specified.
- Using this option allows the library generator to expand library functions for string handling, i.e. memchr(), strlen(), strcpy(), strncpy(), strcmp(), strncmp(), strcat(), or strncat(), as two units of code that include string manipulation instructions: one for manipulating data at the address where reading of the string starts up to the next 4-byte boundary and the other for manipulating data from that 4-byte boundary up to the last address.
-`insert_nop_with_label` [V2.08.00 or later]

< Compile Options / Object Options >

[Format]

```
-insert_nop_with_label=<file>,<line>,<label>
```

- Interpretation when omitted
  A local label and nop instruction are not inserted.

[Description]

- This option inserts a local label and nop instruction at the specified location based on the information for source debugging.
- When this option is specified, the `-debug` option also becomes valid.
- This function is assumed to be used via CS+ or e²studio and should not be used directly by the user.
-control_flow_integrity [Professional Edition only] [V2.08.00 or later]

< Compile Options / Object Options >

[Format]

-control_flow_integrity

- Interpretation when omitted
  Code for the detection of illegal indirect function calls is not generated.

[Description]

- This option generates code for the detection of illegal indirect function calls. When this option is specified, code for the following processing is generated in the C/C++ source program.
  
  1. The __control_flow_integrity checking function is called with an indirect calling address as an argument immediately before indirect function calls.
  2. Within the checking function, the address given as the argument is checked against a list of the addresses of functions (hereafter referred to as the function list) which may be indirectly called. If the list does not include the address, the __control_flow_chk_fail function will be called since this is regarded as an illegal indirect function call.

The correctness of processing to change the flow of the program, such as through indirect function calls, is referred to as control flow integrity (CFI), and CFI techniques are used to verify this.

- A checking function is defined as follows and provided as library functions.

  void __control_flow_integrity(void *addr);

  Calling the checking function in the same way as normal functions is prohibited.

- The compiler automatically extracts the information on the functions which may be indirectly called from the C/C++ source program. The linker consolidates that information in creating the function list. For the linker to create a function list, the -cfi link option must be specified.

  For details, refer to section 2.5.3 Optimizing Linkage Editor (rlink) Options.

- The __control_flow_chk_fail function contains code for the processing which is to be executed when an illegal indirect function call is detected. The user must define this function.

  Note the following when defining the __control_flow_chk_fail function.

  - Specify void as the type of the return value and parameter.
  - Do not define the function as static.
  - Calling the __control_flow_chk_fail function in the same way as a normal function is prohibited.
  - The __control_flow_chk_fail function is not for the creation of code for detecting illegal indirect function calls.
  - In the __control_flow_chk_fail function, note that execution must not be returned to the checking function, for example, by calling abort() to terminate the program.
  - When defining the __control_flow_chk_fail function in a C++ program, add "extern "C"."
  - If the -pic option is specified at the same time, an error will occur.
[Example]

- <C source code>

```c
#include <stdlib.h>

int glb;

void __control_flow_chk_fail(void) {
  abort();
}

void func1(void) // Added to the function list.
{
  ++glb;
}

void func2(void) // Not added to the function list.
{
  --glb;
}

void (*pf)(void) = func1;

void main(void)
{
  pf(); // Indirect call of the function func1.
  func2();
}
```
- <Output code>

When `isa=rxv2 -output=src -control_flow_integrity` is specified for compilation

```
***control_flow_chk_fail:
  .STACK ***control_flow_chk_fail=4
  BRA _abort
_func1:
  .STACK _func1=4
  MOV.L #_glb, R14
  MOV.L [R14], R15
  ADD #01H, R15
  MOV.L R15, [R14]
  RTS
_func2:
  .STACK _func2=4
  MOV.L #_glb, R14
  MOV.L [R14], R15
  SUB #01H, R15
  MOV.L R15, [R14]
  RTS
_main:
  .STACK _main=8
  PUSH.L R6
  MOV.L #_pf, R6
  MOV.L [R6], R1
  BSR ***control_flow_integrity ; Call the checking function.
  MOV.L [R6], R1
  JSR R14 ; Indirect call of the function func1.
  BSR _func2 ; Direct call of the function func2.
  RTSD #04H, R6-R6
.SECTION D,ROMDATA,ALIGN=4
_pf:
  .lword _func1
.SECTION B,DATA,ALIGN=4
_glbl:
  .blkl 1
.END
```
List Options

< Compile Options / List Options >

The following list options are available.

- -listfile
- -nolistfile
- -show
-listfile

< Compile Options / List Options >

[Format]

-\-listfile\[=\langle file name\rangle|\langle path name\rangle\]

[Description]

- These options specify whether to output a source list file.
- When the listfile option is specified, a source list file is output. <file name> can also be specified.
- An existing folder can also be specified as <path name> instead of <file name>. In such a case, a source list file with the file extension .lst and the name of the source file being compiled or assembled is output to the folder selected as <path name>.

[Remarks]

- A linkage list cannot be output by this option. In order to output a linkage list, specify the list option of the optimizing linkage editor by using the lnkcmd option.
- Information output from the compiler is written to the source list. For the source list file format, refer to Assemble List File.
- When you use <path name>, create the folder in advance. If the folder specified as <path name> does not exist, the compiler will assume that <file name> is selected.
**-nolistfile**

< Compile Options / List Options >

**Format**

```
-nolistfile
```

**Description**

- When the **nolistfile** option is specified, no source list file is output.
-show

< Compile Options / List Options >

[Format]

-show=<sub>[,...]
  <sub>: ( source | conditionals | definitions | expansions )

[Description]

- This option sets the source list file contents.
- The suboptions and specified contents are shown in the following table.

Table 2.5 Suboption Specifications

<table>
<thead>
<tr>
<th>Suboption</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>source</td>
<td>Outputs the C/C++ source file.</td>
</tr>
<tr>
<td>conditionals</td>
<td>Outputs also the statements for which the specified condition is not satisfied in conditional assembly.</td>
</tr>
<tr>
<td>definitions</td>
<td>Outputs the information before .DEFINE replacement.</td>
</tr>
<tr>
<td>expansions</td>
<td>Outputs the assembler macro expansion statements.</td>
</tr>
</tbody>
</table>

[Remarks]

- This option is valid only when the listfile option has been specified.
- Information output from the compiler is written to the source list. For the source list file format, refer to Assemble List File.
Optimize Options

< Compile Options / Optimize Options >

The following optimize options are available.

- -optimize
- -goptimize
- -speed
- -size
- -loop
- -inline
- -noinline
- -file_inline
- -case
- -volatile
- -novolatile
- -type_size_access_to_volatile [V3.04.00 or later]
- -const_copy
- -noconst_copy
- -const_div
- -noconst_div
- -library
- -scope
- -noscope
- -schedule
- -noschedule
- -map
- -smap
- -nomap
- -approxdiv
- -enable_register
- -simple_float_conv
- -fpu
- -nofpu
- -dpfpu [V3.01.00 or later]
- -nodpfpu [V3.01.00 or later]
- -tfu [V3.01.00 or later]
- -tfu_version [V3.05.00 or later]
- -nosave_tfu [V3.05.00 or later]
- -alias
- -float_order
- -branch_chaining [V3.03.00 or later]
- -nobranch_chaining [V3.03.00 or later]
- -ip_optimize
- -merge_files
- -whole_program
-optimize

< Compile Options / Optimize Options >

[Format]

-optimize = { 0 | 1 | 2 | max }

[Description]

- This option specifies the optimization level.
- When optimize=0 is specified, the compiler does not optimize the program. Accordingly, the debugging information may be output with high precision and source-level debugging is made easier.
- When optimize=1 is specified, the compiler partially optimizes the program by automatically allocating variables to registers, integrating the function exit blocks, integrating multiple instructions which can be integrated, etc. Accordingly, the code size may become smaller than when compiled with the optimize=0 specification.
- When optimize=2 is specified, the compiler performs overall optimization. However, the optimization contents to be performed slightly differ depending on whether the size option or speed option has been selected.
- When optimize=max is specified, the compiler performs optimization as much as possible. For example, the optimization scope is expanded to its maximum extent, and if the speed option is specified, loop expansion is possible on a large scale. Though the advantages of optimization can be expected, there may be side effects, such as longer compilation time, and if the speed option is specified, significantly increased code size.

[Remarks]

- If the default is not included in the description of an optimize option, this means that the default varies depending on the optimize option and speed or size option specifications. For details on the default, refer to the speed or size option.
-goptimize

< Compile Options / Optimize Options >

[Format]

-goptimize

[Description]

- This option generates the additional information for inter-module optimization in the output file.
- At linkage, inter-module optimization is applied to files for which this option has been specified.
**-speed**

< Compile Options / Optimize Options >

### [Format]

```
-speed
```

- **[Default]**
  Optimization is with emphasis on size.

### [Description]

- When the `speed` option is specified, optimization will be performed with emphasis on execution performance.

### [Remarks]

- When the `speed` option is specified, the following options are automatically specified based on the `optimize` option specification.
- The processing for optimization in response to the optimization level selected for the `optimize` option includes the fine adjustment of many items other than those that can be specified through compiler options. Code produced with different levels of optimization will differ in the ways set by the compiler options listed in the tables below, but will also not match in other ways.

<table>
<thead>
<tr>
<th>Optimization item</th>
<th>optimize=0</th>
<th>optimize=1</th>
<th>optimize=2</th>
<th>optimize=max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Expansion</td>
<td>loop=1</td>
<td></td>
<td>loop=2</td>
<td>loop=8</td>
</tr>
<tr>
<td>Inline Expansion</td>
<td>noninline</td>
<td>inline=100</td>
<td>inline=250</td>
<td></td>
</tr>
<tr>
<td>Converting Constant Division into Multiplication</td>
<td>const_div</td>
<td>const_div</td>
<td>const_div</td>
<td></td>
</tr>
<tr>
<td>Scheduling Instructions</td>
<td>noschedule</td>
<td>schedule</td>
<td>schedule</td>
<td></td>
</tr>
<tr>
<td>Constant Propagation of const Qualified Variables</td>
<td>noconst_copy</td>
<td>const_copy</td>
<td>const_copy</td>
<td></td>
</tr>
<tr>
<td>Dividing Optimizing Ranges</td>
<td>scope</td>
<td></td>
<td>scope</td>
<td>noscope</td>
</tr>
<tr>
<td>Optimizing External Variable Accesses</td>
<td>nomap</td>
<td></td>
<td>nomap</td>
<td>map* nomap*</td>
</tr>
<tr>
<td>Optimization Considering the Type of the Data Indicated by the Pointer</td>
<td>alias=noansi</td>
<td>alias=noansi</td>
<td>alias=ansi</td>
<td></td>
</tr>
<tr>
<td>Optimization by Reducing the Branch Instruction Size</td>
<td>nobranch_chaining</td>
<td>nobranch_chaining</td>
<td>nobranch_chaining</td>
<td></td>
</tr>
</tbody>
</table>

**Note**

The default is `map` when a C/C++ source program has been specified for input and `output=abs` or `output=mot` has been specified for output. For any other case, the default is `nomap`. 
-size

< Compile Options / Optimize Options >

[Format]

-size

- [Default]
   Optimization is with emphasis on size.

[Description]

- When the size option is specified, optimization will be performed with emphasis on code size.

[Remarks]

- When the size option is specified, the following options are automatically specified based on the optimize option specification. Note however that if one of the following options is specified otherwise explicitly, that specified option becomes valid.

- The processing for optimization in response to the optimization level selected for the optimize option includes the fine adjustment of many items other than those that can be specified through compiler options. Code produced with different levels of optimization will differ in the ways set by the compiler options listed in the tables below, but will also not match in other ways.

<table>
<thead>
<tr>
<th>Optimization item</th>
<th>optimize=0</th>
<th>optimize=1</th>
<th>optimize=2</th>
<th>optimize=max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Expansion</td>
<td>loop=1</td>
<td>loop=1</td>
<td>loop=1</td>
<td>loop=1</td>
</tr>
<tr>
<td>Inline Expansion</td>
<td>noinline</td>
<td>noinline</td>
<td>inline=0</td>
<td></td>
</tr>
<tr>
<td>Converting Constant Division into Multiplication</td>
<td>noconst_div</td>
<td>noconst_div</td>
<td>noconst_div</td>
<td></td>
</tr>
<tr>
<td>Scheduling Instructions</td>
<td>noschedule</td>
<td>schedule</td>
<td>schedule</td>
<td></td>
</tr>
<tr>
<td>Constant Propagation of const Qualified Variables</td>
<td>noconst_copy</td>
<td>const_copy</td>
<td>const_copy</td>
<td></td>
</tr>
<tr>
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<td>scope</td>
<td>scope</td>
<td>noscope</td>
<td></td>
</tr>
<tr>
<td>Optimizing External Variable Accesses</td>
<td>nomap</td>
<td>nomap</td>
<td>map*</td>
<td>nomap*</td>
</tr>
<tr>
<td>Optimization Considering the Type of the Data Indicated by the Pointer</td>
<td>alias=noansi</td>
<td>alias=noansi</td>
<td>alias=ansi</td>
<td></td>
</tr>
<tr>
<td>Optimization by Reducing the Branch Instruction Size</td>
<td>nobranch_chaining</td>
<td>branch_chaining</td>
<td>branch_chaining</td>
<td></td>
</tr>
</tbody>
</table>

Note: The default is map when a C/C++ source program has been specified for input and output=abs or output=mot has been specified for output. For any other case, the default is nomap.
-loop

< Compile Options / Optimize Options >

[Format]

-loop[=<numeric value>]

- [Default]
The default for this option is loop=2.

[Description]
- This option specifies whether to optimize loop expansion.
- When the loop option is specified, the compiler expands loop statements (for, while, and do-while).
- The maximum expansion factor can be specified by <numeric value>. An integer from 1 to 32 can be specified for <numeric value>. If no <numeric value> is specified, 2 will be assumed.
- The default for this option is determined based on the optimize option and speed or size option specifications. For details, refer to the speed or size option.

[Remarks]
- This option is invalid when optimize=0 or optimize=1.
-inline

< Compile Options / Optimize Options >

[Format]

```
-inline[=<numeric value>]
```

- [Default]
  The default for this option is inline=100.

[Description]
- These options specify whether to automatically perform inline expansion of functions.
- A value from 0 to 65535 is specifiable as `<numeric value>`.
- When the `inline` option is specified, the compiler automatically performs inline expansion. However, inline expansion is not performed for the functions specified by `#pragma noinline`. The user is able to use `inline=<numeric value>`, to specify the allowed increase in the function's size due to the use of inline expansion. For example, when `inline=100` is specified, inline expansion will be performed until the function size has increased by 100% (size is doubled).
- The default for this option is determined based on the `optimize` option and `speed` or `size` option specifications. For details, refer to the `speed` or `size` option.

[Remarks]
- Expansion is attempted for the functions with `#pragma inline` specified regardless of the specification of this option. The inline function specifier (C99) is effective only when this option is valid.
- To perform inline expansion for a function for certain, specify `#pragma inline` for the function.
- Even though this option has been selected or an `inline` specifier has been specified for the function, if the compiler judges that the efficiency is degraded by inline expansion, it will not perform it in some cases.
-noinline

< Compile Options / Optimize Options >

[Format]

-noinline

[Description]
- When the **noinline** option is specified, automatic inline expansion is not performed.

[Remarks]
- Expansion is attempted for the functions with **#pragma inline** specified regardless of the specification of this option. The **inline** function specifier (C99) is effective only when this option is invalid.
- **file_inline**

  **< Compile Options / Optimize Options >**

  **[Format]**

  ```
  -file_inline=<file name>[,...]
  ```

  **[Description]**

  - This option is not available in V.2.00. Any specification of this option will simply be ignored and will not lead to an error due to compatibility with former versions.

  **[Remarks]**

  - For C (C99) source files, **-merge_files** can be used instead of **-file_inline**. Add the file that was used with **-file_inline** (including the file path if **-file_inline_path** was used together with it) as one of the source files to be merged.
  - There are some points to be noted regarding **-merge_files**. Refer to [Remarks] of the **-merge_files** option.
-case

< Compile Options / Optimize Options >

[Format]

-case={ ifthen | table | auto }

- [Default]
The default for this option is case=auto.

[Description]

- This option specifies the expansion method of the switch statement.
  - When case=ifthen is specified, the switch statement is expanded using the if_then method, which repeats, for each case label, comparison between the value of the evaluation expression in the switch statement and the case label value. If they match, execution jumps to the statement of the case label. This method increases the object code size depending on the number of case labels in the switch statement.
  - When case=table is specified, the switch statement is expanded by using the table method, where the case label jump destinations are stored in a branch table so that a jump to the statement of the case label that matches the expression for evaluation in the switch statement is made through a single access to the branch table. With this method, the size of the branch table increases with the number of case labels in the switch statement, but the performance in execution remains the same. The branch table is output to a section for areas holding switch statements for branch tables.
  - When case=auto is specified, the compiler automatically selects the if_then method or table method.

[Remarks]

- The branch table created when case=table has been specified will be output to section W when the nostuff option is specified and will be output to section W, W_2, or W_1 according to the size of the switch statement when the nostuff option is not specified.
-volatile

< Compile Options / Optimize Options >

[Format]

- volatile

[Description]
- When volatile is specified, all external variables are handled as if they were volatile qualified. Accordingly, the access count and access order for external variables are exactly the same as those written in the C/C++ source file.

[Remarks]
- Debugging tools for RX do not display the volatile declaration added to individual variables by this option.
-novolatile

< Compile Options / Optimize Options >

[Format]

```
-novolatile
```

[Description]

- When `novolatile` is specified, the external variables which are not `volatile` qualified are optimized. Accordingly, the access count and access order for external variables may differ from those written in the C/C++ source file.
-type_size_access_to_volatile [V3.04.00 or later]

< Compile Options / Optimize Options >

[Format]

```
-type_size_access_to_volatile
```

- [Default]
  A variable with `volatile` specified might be accessed in a different size from the size of the variable type.

[Description]
- A variable with `volatile` specified is accessed in the size of the variable type.
- This option also takes effect on the volatile specification by the `-volatile` option.
- Specifying this option more than once has the same effect as specifying it once only. No warning is output in this case.
- For semantic rules for variables with `volatile` specified, this option can only change the access width. Other semantic rules such as the number of accesses cannot be changed.
- If you want to access a variable in the size of its type without this option specified, specify the `__evenaccess` keyword when declaring the variable.

[Remarks]
- When this option is specified, the access size is guaranteed for 4-byte or smaller scalar types.

[Example]

```
> ccrx a.c -isa=rxv3 -type_size_access_to_volatile
```
-const_copy

< Compile Options / Optimize Options >

[Format]

-const_copy

- [Default]
The default for this option is const_copy when the optimize=2 or optimize=max option has been specified.

[Description]
- When const_copy is specified, constant propagation is performed even for const qualified global variables.
- The default for this option is const_copy when the optimize=2 or optimize=max option has been specified.

[Remarks]
- const qualified variables in a C++ source file cannot be controlled by this option (constant propagation is always performed).
-noconst_copy

< Compile Options / Optimize Options >

[Format]

- [Default] The default for this option is noconst_copy when the optimize=1 or optimize=0 option has been specified.

[Description]

- When noconst_copy is specified, constant propagation is disabled for const qualified global variables.

[Remarks]

- const qualified variables in a C++ source file cannot be controlled by this option (constant propagation is always performed).
-const_div

< Compile Options / Optimize Options >

[Format]

-const_div

- [Default]
The default for this option is const_div when the speed option has been specified.

[Description]
- When const_div is specified, calculations for division and remainders of integer constants in the source file are converted into sequences of multiplication or bitwise operation (shift or bitwise AND operations) instructions.

[Remarks]
- Constant multiplication that can be performed through only shift operations and division and residue that can be performed through only bitwise AND operations cannot be controlled by the const_div option.
-noconst_div

< Compile Options / Optimize Options >

[Format]

-noconst_div

- [Default]
  The default for this option is noconst_div when the size option has been specified.

[Description]

- When noconst_div is specified, the corresponding division and remainder instructions are used for calculating division and remainders of integer constants in the source file (except divisions and remainders of unsigned integers by powers of two).

[Remarks]

- Constant multiplication that can be performed through only shift operations and division and residue that can be performed through only bitwise AND operations cannot be controlled by the noconst_div option.
-library

< Compile Options / Optimize Options >

[Format]

-library = { function | intrinsic }

- [Default]
The default for this option is library=intrinsic.

[Description]
- When -library=function is specified, all library functions are called by calling subroutines provided by standard library.
- When -library=intrinsic is specified, a call for any of the following library functions is replaced with the RX instruction that has the corresponding facility.
  - abs
  - fabsf/fabs/1/fabsl/1
  - sqrtf/sqrt/1/3/sqrtl/1/3
  - memchr/strlen/strcpy/strncpy/strcmp/strncmp/strcat/strncat

Notes 1. When -dbl_size=4 or the -dpfpu option is specified
Notes 2. When the -isa option is specified with a value other than rxv1 in combination with the -fpu option
Notes 3. When the -isa option is specified with a value other than rxv1 in combination with the -fpu -dbl_size=4, or when the -dpfpu option is specified

[Remarks]
- The value of variable errno is not changed by the call of a library function that was replaced with an instruction.
**-scope**

< Compile Options / Optimize Options >

**[Format]**

```
-scope
```

- [Default]
The default for this option is **scope** when the **optimize=max** option has been specified.

**[Description]**

- When the **scope** option is specified, the optimizing ranges of the large-size function are divided into many sections before compilation.
- Use this option at performance tuning because it affects the object performance depending on the program.
-noscope

< Compile Options / Optimize Options >

[Format]

```
-noscope
```

- [Default]
The default for this option is `noscope` when the `optimize=max` option has been specified.

[Description]

- When the `noscope` option is specified, the optimizing ranges are not divided before compilation. When the optimizing range is expanded, the object performance is generally improved although the compilation time is delayed. However, if registers are not sufficient, the object performance may be lowered. Use this option at performance tuning because it affects the object performance depending on the program.
-schedule

< Compile Options / Optimize Options >

[Format]

-schedule

- [Default]
The default for this option is schedule when the optimize=2 or optimize=max option has been specified.

[Description]
- When the schedule option is specified, instructions are scheduled taking into consideration pipeline processing.
-noschedule

< Compile Options / Optimize Options >

[Format]

- -noschedule

[Default]
The default for this option is noschedule when the optimize=1 or optimize=0 option has been specified.

[Description]

- When the noschedule option is specified, instructions are not scheduled. Basically, processing is performed in the same order the instructions have been written in the C/C++ source file.
### -map

< Compile Options / Optimize Options >

#### Format

```bash
-map=[= <file name>]
```

- [Default]
The default for this option is map when the optimize=max option has been specified.

#### Description

- This option optimizes accesses to global variables.
- When the map option is specified, a base address is set by using an external symbol-allocation information file created by the optimizing linkage editor, and a code that uses addresses relative to the base address for accesses to global or static variables is generated.
- When accesses to external variables are to be optimized by the map option, how the map option is used differs according to the specification of the output option.
  - [output=abs, output=sty, or output=hex is specified]
    Specify only map. The compiler automatically performs compilation and linkage twice, and a code in which the base address is set based on external symbol allocation information is generated. Note that when output=abs, output=sty, or output=hex is specified simultaneously with optimize=max, map will be specified implicitly.
  - [output=obj is specified]
    Compile the source file once without specifying these options, create an external symbol-allocation information file by specifying map=<file name> at linkage by the optimizing linkage editor, and then compile the source file again by specifying map=<file name> in ccrx.

#### Example

- <C source file>

```c
long A,B,C;
void func()
{
  A = 1;
  B = 2;
  C = 3;
}
```

- <Output code>

```assembly
_func:
  MOV.L    #_A,R4     ; Sets the address of A as the base address.
  MOV.L    #1,[R4]
  MOV.L    #2,4[R4]   ; Accesses B using the address of A as the base.
  MOV.L    #3,8[R4]   ; Accesses C using the address of A as the base.
```

#### Remarks

- When the order of the definitions of global variables or static variables has been changed, a new external symbol-allocation information file must be created. If any option other than the map option in the previous compilation differs from the one in the current compilation, or if any contents of a function are changed, correct operation is not guaranteed. In such a case, a new external symbol-allocation information file must be created.
- This option is only valid for the compilation of C/C++ source programs. It does not apply to programs that have been compiled with the output=src specification or to programs written in assembly language.

- When the map option and smap option are specified simultaneously, the map option is valid.

- When continuous data sections are allocated after a program section, optimization of external variable accesses may be disabled or may not be performed sufficiently. For performing optimization to a maximum extent in a case in which multiple sections are allocated continuously, allocate the program section at the end. An example is shown below.

<table>
<thead>
<tr>
<th>Address 0x100</th>
<th>Address 0x400</th>
</tr>
</thead>
<tbody>
<tr>
<td>P C1 C2</td>
<td>C3</td>
</tr>
</tbody>
</table>

Note:
P: Program section
C1, C2, C3: Data section

- In the above example, section P is allocated from address 0x100, sections C1 and C2 are allocated immediately after section P, and section C3 is allocated from address 0x400. Since sections C1 and C2 are allocated continuously after section P, section P should be allocated behind section C2. Section C3 is not involved because it is not allocated continuously.
- **smap**

  < Compile Options / Optimize Options >

[Format]

```plaintext
-smap
```

[Description]

- When the `smap` option is specified, a base address is set for global or static variables defined in the file to be compiled, and a code that uses addresses relative to the base address for accesses to those variables is generated.

[Example]

- `<C source file>`

```c
long A,B,C;
void func()
{
    A = 1;
    B = 2;
    C = 3;
}
```

- `<Output code>`

```assembly
_func:
    MOV.L #_A,R4 ; Sets the address of A as the base address.
    MOV.L #1,[R4]
    MOV.L #2,4[R4] ; Accesses B using the address of A as the base.
    MOV.L #3,8[R4] ; Accesses C using the address of A as the base.
```

[Remarks]

- This option is only valid for the compilation of C/C++ source programs. It does not apply to programs that have been compiled with the `output=src` specification or to programs written in assembly language.

- When the `map` option and `smap` option are specified simultaneously, the `map` option is valid.
-nomap

< Compile Options / Optimize Options >

[Format]

-nomap

- [Default]
The default for this option is nomap when the optimize=0, optimize=1, or optimize=2 option has been specified.

[Description]

- When the nomap option is specified, accesses to external variables are not optimized.

[Example]

- <C source file>

```c
long A,B,C;
void func()
{
    A = 1;
    B = 2;
    C = 3;
}
```

- <Output code>

```assembly
_func:
    MOV.L   #_A,R4
    MOV.L   #1,[R4]
    MOV.L   #_B,R4
    MOV.L   #2,[R4]
    MOV.L   #_C,R4
    MOV.L   #3,[R4]
```
-approxdiv

< Compile Options / Optimize Options >

[Format]

-approxdiv

- [Default]
  When this option is omitted, division of floating-point constants into multiplications of the corresponding reciprocals as constants is not performed.

[Description]

- When there is an expression of (variable ÷ constant), this option generates a code with the expression converted into (variable × reciprocal of constant).

[Remarks]

- When this option is specified, the execution performance of floating-point constant division will be improved. The precision and order of operations may, however, be changed, so take care on this point.
-enable_register

< Compile Options / Optimize Options >

[Format]

-enable_register

[Description]
- This option is not available in V.2.00. Any specification of this option will simply be ignored and will not lead to an error due to compatibility with former versions.
- **simple_float_conv**

< Compile Options / Optimize Options >

**[Format]**

- `simple_float_conv`

**[Description]**

- This option omits part of the type conversion processing for the floating type.
- When this option is selected, the generation code that performs type conversion of the next floating-point number changes.
  - a) Type conversion from 32-bit floating type to unsigned integer type
  - b) Type conversion from unsigned integer type to 32-bit floating type
  - c) Type conversion from integer type to 64-bit floating type via 32-bit floating type

**[Example]**

- **< a) Type conversion from 32-bit floating type to unsigned integer type>**

  ```c
  unsigned long func1(float f)
  {
      return ((unsigned long)f);
  }
  
  When this option is not specified:
  _func1:
      FCMP  #4F000000H,R1
      BLT   L12
      FADD  #0CF800000H,R1
  L12:
      FTOI  R1,R1
      RTS
  ```

- **< b) Type conversion from unsigned integer type to 32-bit floating type>**

  ```c
  float func2(unsigned long u)
  {
      return ((float)u);
  }
  
  When this option is not specified:
  _func2:
      BTST  #31,R1
      BEQ   L15
      SHLR  #1,R1,R14
      AND   #1,R1
      OR    R14,R1
      ITOF  R1,R1
      FADD  R1,R1
      BRA   L16
  L15:
      ITOF  R1,R1
  L16:
      RTS
  ```

- **< c) Type conversion from integer type to 64-bit floating type via 32-bit floating type>**
Does not apply when the dbl_size=8 specification is not valid.

```c
double func3(long l)
{
    return (double)(float)l;
}
```

When this option is not specified:

```c
_func3:
    ITOF   R1,R1
    BRA    __COM_CONVfd
```

When this option is specified:

```c
    BRA    __COM_CONV32sd
```

[Remarks]
- When this option is specified, code performance of the relevant type conversion processing is improved. The conversion result may, however, differ from C/C++ language specifications, so take care on this point.
- This option of c) is invalid when optimize=0.
-fpu

< Compile Options / Optimize Options >

[Format]

- [Default]
  The default for this option is fpu when the instruction-code set as the ISA *1.
  The default for this option is nofpu (when RX200 is selected as the target CPU *2) or fpu (in other cases).

Note
  *1) This means a selection by the -isa option or the ISA_RX environment variable.
  *2) This means a selection by the -cpu option or the CPU_RX environment variable.

[Description]

- When the fpu option is specified, a code using single-precision floating-point processing instructions is generated.

[Remarks]

- For details of the single-precision floating-point processing instructions, refer to the RX Family Software Manual.
- When RX200 is selected as the CPU, an error will occur if fpu is specified.
-nofpu

< Compile Options / Optimize Options >

[Format]

-nofpu

- [Default]
The default for this option is fpu when the instruction-code set as the ISA *1. The default for this option is nofpu (when RX200 is selected as the target CPU *2) or fpu (in other cases).

Note

*1) This means a selection by the -isa option or the ISA_RX environment variable.
*2) This means a selection by the -cpu option or the CPU_RX environment variable.

[Description]

- When the nofpu option is specified, a code not using single-precision floating-point processing instructions is generated.
-dpfpu [V3.01.00 or later]

< Compile Options / Optimize Options >

[Format]

- Interpretation when omitted

nodpfpu is assumed to be specified.

[Description]

- When the dpfpu option is specified, a code using double-precision floating-point processing instructions is generated.

[Remarks]

- For details of the double-precision floating-point processing instructions, refer to the RX Family Software Manual.
- When the CPU*1 is selected or RXv1 or RXv2 is selected as ISA*2, an error will occur if dpfpu is specified.
- When nofpu has been specified, an error will occur if dpfpu is specified.

Note

*1) This means a selection by the cpu option or the CPU_RX environment variable.
*2) This means a selection by the isa option or the ISA_RX environment variable.
-nodpfpu [V3.01.00 or later]

< Compile Options / Optimize Options >

[Format]

```
-nodpfpu
```

- Interpretation when omitted
  nodpfpu is assumed to be specified.

[Description]

- When the nodpfpu option is specified, a code not using double-precision floating-point processing instructions is generated.
-tfu [V3.01.00 or later]

< Compile Options / Optimize Options >

[Format]

-tfu=intrinsic[,mathlib]

[Description]

- When -tfu=intrinsic is specified, the following intrinsic functions which use the trigonometric function unit are available.

  - __sincosf
  - __atan2hypotf
  - __init_tfuf (for initialization)
  - __sincosfx [V3.05.00 or later]
  - __sinf [V.05.00 or later]
  - __cosf [V.05.00 or later]
  - __atan2fx [V3.05.00 or later]
  - __hypotfx [V3.05.00 or later]
  - __atan2hypotfx [V3.05.00 or later]

  For details on the listed intrinsic functions, refer to section 4.2.6 Intrinsic Functions.

- When -tfu=intrinsic,mathlib is specified, the above intrinsic functions are available and calls of relevant mathematics library functions are replaced with code that uses the trigonometric function unit. The following are the mathematics library functions to be replaced.

  - sinf / sin^1 / sinl^1
  - cosf / cos^1 / cosl^1
  - atan2f / atan2^1 / atan2l^1
  - hypotf / hypot^1 / hypotl^1
  - asinf *2 / asin *1*2 / asinl *1*2 [V3.02.00 or later]
  - acost *2 / acos *1*2 / acosl *1*2 [V3.02.00 or later]
  - atanf / atan^1 / atanl^1 [V3.02.00 or later]
  - tanf / tan^1 / tanl^1 [V3.02.00 or later]

  *1: This is only the case when -dbl_size=4 is specified.
  *2: This is the case when -isa=rxv2|rxv3 and -fpu are specified.

- [V3.05.00 or later] When -tfu_version=v2 is specified at the same time, interrupt specifications tfuf and no_tfuf specified in #pragma interrupt are available.
[Remarks]

- [Earlier than V3.05.00] Code for operations that use the trigonometric function unit is not reentrant.

- [V3.05.00 or later] Code for operations that use the trigonometric function unit is not reentrant if `-tfu_version=v1` is specified. When `-tfu_version=v2` is specified, the default code is reentrant. However, it is not reentrant if any of the following applies:
  - When `-nosave_tfu` is specified. For details, refer to the description of `-nosave_tfu` in section 2.5.1 Compile Options.
  - When interrupt specification `no_tfu` is specified in `#pragma interrupt` for any interrupt function that uses the trigonometric function unit. For details, refer to the description of `#pragma interrupt` in section 4.2.3 #pragma Directive.
  - When `-tfu=intrinsic,mathlib` is specified, replacement of the mathematics library functions means that only code from the relevant function calls is replaced and code in the library is not affected. Accordingly, if an indirect call via a pointer is made, the trigonometric function unit will not be used.
  - If calls of mathematics library functions are replaced with code that uses the trigonometric function unit, the values of variable `errno` will not be modified.
  - Use or non-use of the trigonometric function unit affects the precision of operations.
  - When `TFUv1` is used, before using the trigonometric function unit, initialize the unit from the startup program by calling the `__init_tfu()` intrinsic function. If you do not do so, correct operation is not guaranteed.
  - When `TFUv2` is used, there is no need to initialize the trigonometric function unit. Calling the `__init_tfu` intrinsic function causes an error.
  - Do not specify this option for a device that does not include a trigonometric function unit.
-tfu_version [V3.05.00 or later]

< Compile Options / Optimize Options >

[Format]

-tfu_version=(v1|v2)

- Interpretation when omitted
  If the -tfu option is not specified, nothing is assumed to be specified. If the -tfu option is specified, v1 is assumed to be specified.

[Description]

- Selects the version of the trigonometric function unit. When v1 is specified, TFUv1 is selected. When v2 is specified, TFUv2 is selected.
- If this option is specified with the -tfu option not specified, an error (E0511152) occurs.
-nosave_tfu [V3.05.00 or later]

< Compile Options / Optimize Options >

[Format]

-losave_tfu

- Interpretation when omitted
  A code for saving and restoring the output of the trigonometric function unit (v2) is generated for all interrupt functions.

[Description]

- A code for saving and restoring the output of the trigonometric function unit (v2) is not generated for any interrupt function. As a result, code for operations that use the trigonometric function unit is not reentrant.
- If -tfu_version=v2 is not specified, specifying this option causes an error.

[Remarks]

- The code for saving and restoring that is generated when this option is omitted is the same code generated when interrupt specification tfu is selected in #pragma interrupt. For the actual code for saving and restoring, refer to the description of #pragma interrupt in section 4.2.3 #pragma Directive.
-alias

< Compile Options / Optimize Options >

[Format]

-alias = { noansi | ansi }

- [Default]
The default for this option is alias=noansi.

[Description]

- This option selects whether to perform optimization with consideration for the type of the data indicated by the pointer.
- When alias=ansi is specified, based on the ANSI standard, optimization considering the type of the data indicated by the pointer is performed. Although the performance of object code is generally better than when alias=noansi is specified, the results of execution may differ according to whether alias=ansi or alias=noansi is specified.
- In the same way as in V. 1.00, ANSI-standard based optimization in consideration of the type of data indicated by pointers is not performed when alias=noansi is specified.

[Example]

```c
long x;
long n;
void func(short * ps)
{
    n = 1;
    *ps = 2;
    x = n;
}
```

- [When alias=noansi is specified]
The value of n is reloaded at (A) since it is regarded that there is a possibility of the value of n being rewritten by *ps = 2.

```assembly
<Func:

    MOV.L  #_n, R4
    MOV.L  #1, [R4]  ; n = 1;
    MOV.W  #2, [R1]  ; *ps = 2;
    MOV.L  [R4], R5    ; (A) n is reloaded
    MOV.L  #x, R4
    MOV.L  R5, [R4]
    RTS

<Func:

    MOV.L  #_n, R4
    MOV.L  #1, [R4]  ; n = 1;
    MOV.W  #2, [R1]  ; *ps = 2;
    MOV.L  #x, R4
    MOV.L  #1, [R4]  ; (B) Value used in assignment at n = 1 is reused
    RTS
```
- [When alias=ansi is specified]
The value used in assignment at n = 1 is reused at (B) because it is regarded that the value of n will not change at *ps = 2 since *ps and n have different types.
(If the value of n is changed by *ps = 2, the result is also changed.)
[Remarks]

- When `optimize=0` or `optimize=1` is valid and the `alias` option is specified, the `alias=ansi` specification will be ignored and code will always be generated as if `alias=noansi` has been selected.
-float_order

< Compile Options / Optimize Options >

[Format]

-float_order

- [Default]
  If this option is omitted, optimization of modification of the operation order in a floating-point expression is not performed.

[Description]

- This option is not available in V.2.00. Any specification of this option will simply be ignored and will not lead to an error due to compatibility with former versions.
-branch_chaining [V3.03.00 or later]

< Compile Options / Optimize Options >

[Format]

-branch_chaining

[Description]

- This option uses a branch instruction whose code size is small. To use a branch instruction whose code size is small, another branch instruction which shares the same destination may be specified as the branch destination, not a direct branch to the final destination.
- If this option is not selected, the specification for the optimize, speed, and size options is followed.
- For details, see the sections for the speed and size options.

[Remarks]

- Although this option reduces the code size, it also lowers the execution speed.
- Note that using this optimization without specifying the -g_line option may affect the behavior of single-step execution.
- If the -speed option is specified, this option is ignored.
- If -optimize=0 or 1 is specified, this option is ignored.
-nobranch_chaining [V3.03.00 or later]

< Compile Options / Optimize Options >

[Format]

-­nobranch_chaining

[Description]

- This option suppresses the optimization that reduces the branch instruction size.
- If this option is not specified, the specification for the optimize, speed, and size options is followed.
- For details, see the sections for the speed and size options.
- **ip_optimize**

*< Compile Options / Optimize Options >*

### [Format]

```
-ip_optimize
```

### [Description]

- This option applies global optimization including
  - optimization that utilizes interprocedural alias analysis and
  - propagation of constant parameters and return values.

### [Example]

**Examples 1.**

- **<C source code>**

```c
static int func1(int *a, int *b) {
    *a=0;
    *b=1;
    return *a;
}
int x[2];
int func2() {
    return func1(x, x+1);
}
```

- **<Output assembly code without ip_optimize>**

```
; -optimize=2 -size
$_func1:
    MOV.L #00000000H, [R1]
    MOV.L #00000001H, [R2]
    MOV.L [R1], R1
    RTS
$_func2:
    MOV.L #_x,R1
    ADD #04H, R1, R2
    BRA __$_func1
```

- **<Output assembly code with ip_optimize>**

```
; -optimize=2 -size
$_func1:
    MOV.L #00000000H, [R1]
    MOV.L #00000001H, [R2]
    MOV.L #00000000H, R1
    RTS
$_func2:
    MOV.L #_x,R1
    ADD #04H, R1, R2
    BRA __$_func1
```

**Examples 2.**

- **<C source code>**

```c
static int func(int x, int y, int z) {
    return x-y+z;
}
int func2() {
    return func(3,4,5);
}

- <Output assembly code without ip_optimize>

__$func:
    ADD R3, R1
    SUB R2, R1
    RTS
_func2:
    MOV.L #00000005H, R3
    MOV.L #00000004H, R2
    MOV.L #00000003H, R1
    BRA __$func

- <Output assembly code with ip_optimize>

__$func:
    MOV.L #00000004H, R1
    RTS
_func2:
    MOV.L #00000005H, R3
    MOV.L #00000004H, R2
    MOV.L #00000003H, R1
    BRA __$func

[Remarks]
- Inter-file optimization is also applied when this option is used with **merge_files**.
**-merge_files**

< Compile Options / Optimize Options >

**Format**

-merge_files

**Description**

- This option allows the compiler to compile multiple C source files and output the results to a single object file.
- The name of the object file is specified by the output option. If no name is specified, the filename will be that of the first source file plus a filename extension that corresponds to the selected output format.
- If `src` or `obj` is selected as the output format, the compiler also generates blank files that have the names of the other source files with the given filename extension attached.

**Example**

```
ccrx -merge_files -output=obj=files.obj file1.c file2.c file3.c
```

*files.obj* is the object file. Blank files *file1.obj*, *file2.obj*, and *file3.obj* are also generated.

**Remarks**

- This option is invalid when only one source file is to be compiled or when the `output` option has been used to specify `prep` as the output format.
- Inter-file in-line expansion is applied when this option is used with the `inline` option.
- This option is not available for files to be compiled in C++ or EC++.
- The following restrictions apply to programs that include static functions or static variables.
  - If you wish to use the [Watch] window of the debugger to view a static variable that has the same name as a variable in another file, specify the variable name as well as the filename. The debugger cannot identify the variable without a filename.
  - When two or more files contain static variables with the same name and `rlink` is used to overlay sections to which the files belong, the debugger's facility to display overlay sections taking precedence over other sections is not available.
  - The names of static variables and static functions written in the link map file (.map) are those converted by the compiler (i.e., not original ones).
  - Any differences (e.g. type specifier) in declarations of the same variable may lead to an error in compilation.
-whole_program

< Compile Options / Optimize Options >

[Format]

-whole_program

[Description]
- This option makes the compiler perform optimization on the assumption that all source files have been input.

[Remarks]
- When this option is specified, do not include C++ language source files among the input files.
- When this option is specified, do not specify -lang=cpp or -lang=ecpp.
- Specifying this option also makes the ip_optimize option effective, and if multiple source files are input, the merge_files option is also effective.
- When this option is specified, compilation is on the assumption that the conditions listed below are satisfied. Correct operation is not guaranteed otherwise.
  - Values and addresses of extern variables defined in the target source files will not be modified or referred to by other files.
  - Functions within the target source file will not be called from within other files, although functions in other files can be called from within the target source files.
[Example]

```c
extern void g(void);
int func(void)
{
    static int a = 0;
    a++;      // (1) Write a value to a.
    g();      // (2) Call g().
    return a; // (3) Call a.
}
```

[Without whole_program]
The compiler assumes that (2) will change the value of a since function g() may call function func(), and generates a code to read the value of a in (3).

```
_func:
PUSH.L R6
MOV.L ____$a$1,R6
MOV.L [R6],R14
ADD #1,R14
MOV.L R14,[R6] ; (1)
BSR _g ; (2)
MOV.L [R6],R1 
RTSD #4,R6-R6
```

[With whole_program]
The compiler assumes that function g() will not call function func() and thus (2) will not change the value of a. As a result, the compiler does not read the value of a in (3) and instead generates a code to use the value written to a in (1).

```
_func:
PUSH.L R6
MOV.L ____$a$1,R14
MOV.L [R14],R6
ADD #1,R6
MOV.L R6,[R14] ; (1)
BSR _g ; (2)
MOV.L R6,R1 ; (3)
RTSD #4,R6-R6
```
The following microcontroller options are available.

- -isa
- -cpu
- -endian
- -round
- -denormalize
- -dbl_size
- -int_to_short
- -signed_char
- -unsigned_char
- -signed_bitfield
- -unsigned_bitfield
- -auto_enum
- -bit_order
- -pack
- -unpack
- -exception
- -noexception
- -rtti
- -fint_register
- -branch
- -base
- -patch
- -pic
- -pid
- -nouse_pid_register
- -save_acc
-isa

< Compile Options / Microcontroller Options >

[Format]

-isa={ rxv1 | rxv2 | rxv3 }

- [Default]
The default for this option is determined based on the environment variable ISA_RX.

[Description]
- This option specifies an instruction-set architecture for use in generating object files.

[Remarks]
- When neither the -nofpu nor -fpu option has been selected, specifying this option automatically selects the -fpu option.
- Omitting this option when neither the -cpu option nor one of the environment variables (CPU_RX or ISA_RX) is specified will lead to an error.
- When the -cpu option and this option are specified simultaneously, an error will occur.
- **cpu**

< Compile Options / Microcontroller Options >

**Format**

```
-cpu={ rx600 | rx200 }
```

- **[Default]**
  The default for this option is determined based on the environment variable **CPU_RX**.

**Description**

- This option specifies the microcontroller type for the instruction code to be generated.
- When `cpu=rx600` is specified, an instruction code for the RX600 Series is generated.
- When `cpu=rx200` is specified, an instruction code for the RX200 Series is generated.

**Remarks**

- This option is for compatibility with earlier products.
- For upcoming RX-family MCUs, the isa option will be used instead of the cpu option to select an instruction-set architecture. In developing new applications, use the isa option where possible.
- The cpu option can be replaced by the -isa, -fpu and -nofpu option as follows.
  - -cpu=rx600 ==> -isa=rxv1 -fpu
  - -cpu=rx200 ==> -isa=rxv1 -nofpu
- When `cpu=rx200` is specified, the **nofpu** option is automatically selected.
- `cpu=rx200` and the **fpu** option cannot be specified at the same time.
- When `cpu=rx600` is specified while neither the **nofpu** option nor the **fpu** option has been specified, the **fpu** option is automatically selected.
- Omitting the cpu option will lead to an error if neither the -isa option nor one of the environment variables (CPU_RX or ISA_RX) is specified.
- The cpu and isa options cannot be specified at the same time.
-endian

< Compile Options / Microcontroller Options >

[Format]

- endian={ big | little }

- [Default]
The default for this option is endian=little.

[Description]
- When endian=big is specified, data bytes are arranged in big endian.
- When endian=little is specified, data bytes are arranged in little endian.
- The mode for arranging data bytes can also be specified by the #pragma endian directive. If both this option and a #pragma directive are specified, the #pragma specification takes priority.
-round

< Compile Options / Microcontroller Options >

[Format]

-round={ zero | nearest }

[Default]
The default for this option is round=nearest.

[Description]
- This option specifies the rounding method for floating-point constant operations.
- When round=zero is specified, values are rounded to zero.
- When round=nearest is specified, values are rounded to the nearest value.

[Remarks]
- This option does not affect the method of rounding for floating-point operations during program execution.
- The default selection of this option does not affect the selection of the fpu and nofpu options.
-denormalize

< Compile Options / Microcontroller Options >

[Format]

- -denormalize=( off | on )

- [Default]
  The default for this option is denormalize=off.

[Description]
- This option specifies the operation when denormalized numbers are used to describe floating-point constants.
- When denormalize=off is specified, denormalized numbers are handled as zero.
- When denormalize=on is specified, denormalized numbers are handled as they are.

[Remarks]
- This option does not affect the handling of denormalized numbers in floating-point operations during program execution.
- This option is not automatically enabled by the selection of the fpu and nofpu options.
-dbl_size

< Compile Options / Microcontroller Options >

[Format]

-dbl_size={ 4 | 8 }

- [Default]
The default for this option is \texttt{dbl\_size=8} when the \texttt{-dpfpu} option is specified. Otherwise, it is \texttt{dbl\_size=4}.

[Description]

- This option controls how the \texttt{double} type and \texttt{long double} type are handled.
  - When \texttt{dbl\_size=4} is specified, they are handled as the single-precision floating-point type.
  - When \texttt{dbl\_size=8} is specified, they are handled as the double-precision floating-point type.

[Remarks]

- When \texttt{-dbl\_size=4} is selected, among the standard functions, the \texttt{mathf.h} and \texttt{math.h} functions having the same specifications as each other (e.g., \texttt{sqrtf} and \texttt{sqrt}) are integrated to configure a standard library. Because of this, phenomena, such as the following example will occur when \texttt{-dbl\_size=4} is selected. When the RX simulator or emulator traces (single-step execution) the calling of \texttt{sqrtf} which is a \texttt{mathf.h} header function, it appears as if not \texttt{sqrtf} but \texttt{sqrt}, which is a \texttt{math.h} header function with the same specifications, has been called.
**-int_to_short**

*< Compile Options / Microcontroller Options >*

**[Format]**

```
-int_to_short
```

- **[Default]**
  Before compilation, the `int` type is not replaced with the `short` type and the `unsigned int` type is not replaced with the `unsigned short` type in the source file.

**[Description]**

- Before compilation, the `int` type is replaced with the `short` type and the `unsigned int` type is replaced with the `unsigned short` type in the source file.

**[Remarks]**

- `INT_MAX`, `INT_MIN`, and `UINT_MAX` of `limits.h` are not converted by this option.
- This option is invalid during C++ and EC++ program compilation. If an external name of a C program may be referred to by a C++, EC++ program, message W0523041 will be output for the external name.
- When the `-int_to_short` option is specified and a file including a C standard header is compiled as C++ or EC++, the compiler may show the W0523041 message. In this case, simply ignore the message because it does not indicate a problem.
- Data that are shared between C and C++ (EC++) programs must be declared as the `long` or `short` type rather than as the `int` type.
- When an input function having a format such as that of `scanf` in the standard library is called while this option is enabled, be sure to pass the addresses of the variables of the long and unsigned long types as parameters for use in `%d` and `%u` conversion. If the address of the int-type or unsigned-type variables not declared as long is passed, the program might not handle related operations correctly.
-signed_char

< Compile Options / Microcontroller Options >

[Format]

```
-signed_char
```

- [Default]
  When `-signed_char` is omitted, `char` type values are handled as unsigned.

[Description]

- When `-signed_char` is specified, `char` type values are handled as signed.

[Remarks]

- The bit-field members of the `char` type are not controlled by this option; control them using the `-signed_bitfield` and `-unsigned_bitfield` options.
-unsigned_char

< Compile Options / Microcontroller Options >

[Format]

-unsigned_char

- [Default]
  When -unsigned_char is omitted, char type values are handled as unsigned.

[Description]

- When -unsigned_char is specified, char type values are handled as unsigned.

[Remarks]

- The bit-field members of the char type are not controlled by this option; control them using the signed_bitfield and unsigned_bitfield options.
-signed_bitfield

< Compile Options / Microcontroller Options >

[Format]

```
signed_bitfield
```

- [Default]
  When signed_bitfield is omitted, the value is handled as unsigned.

[Description]

- When signed_bitfield is specified, the value is handled as signed.
-unsigned_bitfield

< Compile Options / Microcontroller Options >

[Format]

-unsigned_bitfield

- [Default]
  When unsigned_bitfield is omitted, the value is handled as unsigned.

[Description]

- When unsigned_bitfield is specified, the value is handled as unsigned.
- **-auto_enum**

< Compile Options / Microcontroller Options >

**[Format]**

- `-auto_enum`

- **[Default]**
  The default for this option is to process the enumeration type size as the **signed long** type.

**[Description]**

- This option processes the enumerated data qualified by `enum` as the minimum data type with which the enumeration value can fit in.
- The possible enumeration values correspond to the data types as shown in the following table.

<table>
<thead>
<tr>
<th>Enumerator Data Type</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
<th>When -unsigned_char is selected</th>
<th>When -signed_char is selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>-128</td>
<td>127</td>
<td>signed char</td>
<td>char</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>255</td>
<td>char</td>
<td>unsigned char</td>
<td></td>
</tr>
<tr>
<td>-32768</td>
<td>32767</td>
<td>signed short</td>
<td>signed short</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>65535</td>
<td>unsigned short</td>
<td>unsigned short</td>
<td></td>
</tr>
<tr>
<td>Other than above</td>
<td>int *1</td>
<td>int *1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note**

*1) When the **-int_to_short** option has been selected, the signed 4-byte integer type will be selected.
-bit_order

< Compile Options / Microcontroller Options >

[Format]

```
-bit_order = ( left | right )
```

- [Default]
The default for this option is bit_order=right.

[Description]
- This option specifies the order of bit-field members.
- When bit_order=left is specified, members are allocated from the upper bit.
- When bit_order=right is specified, members are allocated from the lower bit.
- The order of bit-field members can also be specified by the #pragma bit_order extension. If both this option and a #pragma extension are specified, the #pragma specification takes priority.
-pack

< Compile Options / Microcontroller Options >

[Format]

```plaintext
-pack
```

- [Default]
  The default for this option is unpack. That is, the structure members and class members have boundary alignment values appropriate for their types. The boundary alignment value for structures and classes equals the maximum boundary alignment value for members.

[Description]

- This option sets the boundary alignment value for structure members and class members to 1.
- The boundary alignment value for structure members can also be set to 1 by using the `#pragma pack` directive. If this option and `#pragma` are specified together, the `#pragma` specification takes priority.

[Remarks]

- The boundary alignment values for structure members and class members when these options are specified are shown in the following table.

<table>
<thead>
<tr>
<th>Member Type</th>
<th>pack specified</th>
<th>pack not specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>char/signed char/unsigned char/bool Note 1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>signed short/unsigned short</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>signed int Note 2 /unsigned int Note 2 /signed long/unsigned long/signed long long/unsigned long long/float/double/long double/pointer type</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes 1. Becomes the same as `unsigned long` when the `-lang=c` option is specified.
Notes 2. Becomes the same as `signed short/unsigned short` when the `int_to_short` option is specified.
-**unpack**

< Compile Options / Microcontroller Options >

**[Format]**

```
-unpack
```

- **[Default]**
  The default for this option is unpack. That is, the structure members and class members have boundary alignment values appropriate for their types. The boundary alignment value for structures and classes equals the maximum boundary alignment value for members.

**[Description]**

- The structure members and class members have boundary alignment values appropriate for their types.
- The boundary alignment value for structures and classes equals the maximum boundary alignment value for members.

**[Remarks]**

- The boundary alignment values for structure members and class members when these options are specified are shown in the following table.

Table 2.8 Boundary Alignment Values for Structure Members and Class Members When the **unpack** Option is Specified

<table>
<thead>
<tr>
<th>Member Type</th>
<th>unpack specified</th>
<th>unpack not specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>char/signed char/unsigned char/bool Note 1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>signed short/unsigned short</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>signed int Note 2/unsigned int Note 2/signed long/unsigned long/signed long long/unsigned long long/float/double/long double/pointer type</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes 1. Becomes the same as **unsigned long** when the **-lang=c** option is specified.

Notes 2. Becomes the same as **signed short/unsigned short** when the **int_to_short** option is specified.
-exception

< Compile Options / Microcontroller Options >

[Format]

-exception

- [Default]
The C++ exceptional handling function (try, catch, throw) is disabled.

[Description]
- The C++ exceptional handling function (try, catch, throw) is enabled.
- The code performance may be lowered.

[Remarks]
- In order to use the C++ exceptional handling function among files, perform the following:
  - Specify rtti=on.
  - Do not specify the noprelink option in the optimizing linkage editor.
- The exception option can be specified only at C++ compilation. The exception option is ignored when lang=cpp has not been specified and the input file extension is .c or .p.
-noexception

< Compile Options / Microcontroller Options >

[Format]

-noexception

- [Default]
The C++ exceptional handling function (try, catch, throw) is disabled.

[Description]
- The C++ exceptional handling function (try, catch, throw) is disabled.

[Remarks]
- In order to use the C++ exceptional handling function among files, perform the following:
  - Specify rtti=on.
  - Do not specify the noprelink option in the optimizing linkage editor.
- The noexception option can be specified only at C++ compilation. The noexception option cannot be specified when lang=cpp has not been specified and the input file extension is .c or .p. If specified, an error will occur.
-rtti

< Compile Options / Microcontroller Options >

[Format]

-rtti={on | off}

- [Default]
The default for this option is rtti=off.

[Description]

- This option enables or disables runtime type information.
- When rtti=on is specified, dynamic_cast and typeid are enabled.
- When rtti=off is specified, dynamic_cast and typeid are disabled.

[Remarks]

- Do not define relocatable files (.obj) that were created by this option in a library, and do not output files in the relocatable format (.rel) through the optimizing linkage editor. A symbol double definition error or symbol undefined error may occur.
- rtti=on can be specified only at C++ compilation. rtti=on is ignored when lang=cpp has not been specified and the input file extension is .c or .p.
-fint_register

< Compile Options / Microcontroller Options >

[Format]

-\[ -fint\_register = \{0 | 1 | 2 | 3 | 4 \} \]

- [Default]
The default for this option is \texttt{fint\_register=0}.

[Description]

- This option specifies the general registers which are to be used only in fast interrupt functions (functions that have the fast interrupt setting \texttt{fint} in their interrupt specification defined by \texttt{#pragma interrupt}). The specified registers cannot be used in functions other than the fast interrupt functions. Since the general registers specified by this option can be used without being saved or restored in fast interrupt functions, the execution speed of fast interrupt functions will most likely be improved. Then again, since the number of usable general registers in other functions is reduced, the efficiency of register allocation in the entire program is degraded.

- The options correspond to the registers as shown in the following table.

Table 2.9 Correspondences between Options and Registers

<table>
<thead>
<tr>
<th>Option</th>
<th>Registers for Fast Interrupts Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>fint_register=0</td>
<td>None</td>
</tr>
<tr>
<td>fint_register=1</td>
<td>R13</td>
</tr>
<tr>
<td>fint_register=2</td>
<td>R12, R13</td>
</tr>
<tr>
<td>fint_register=3</td>
<td>R11, R12, R13</td>
</tr>
<tr>
<td>fint_register=4</td>
<td>R10, R11, R12, R13</td>
</tr>
</tbody>
</table>

[Remarks]

- Correct operation is not guaranteed when a register specified by this option is used in a function other than the fast interrupt functions. If a register specified by this option has been specified by the \texttt{base} option, an error will occur.
-branch

< Compile Options / Microcontroller Options >

[Format]

-branch = { 16 | 24 | 32 }

- [Default]
  The default for this option is **branch=24**.

[Description]

- This option specifies the branch width.
- When **branch=16** is specified, the program is compiled with a branch width within 16 bits.
- When **branch=24** is specified, the program is compiled with a branch width within 24 bits.
- When **branch=32** is specified, the branch width is not specified.
- base

< Compile Options / Microcontroller Options >

[Format]

- base = { rom=<register> |
  ram=<register> |
  <address value> = <register> }
  <register> := { R8 to R13 }

[Description]

- This option specifies the general register used as a fixed base address throughout the program.
- When base=rom=<register A> is specified, accesses to const variables are performed relative to the specified register A. Note, however, that the difference between the address closest to 0 and the address closest to 0xFFFFFFF is within the range from 64 Kbytes to 256 Kbytes*1 in the constant area section. The constant area section includes the sections (before renamed) shown below; C_1, C_2, C, C_8, C$VECT, C$INIT, C$VTBL, W, W_1, W_2, L
- When base=ram=<register B> is specified, accesses to initialized variables and uninitialized variables are performed relative to the specified register B. Note, however, that the difference between the address closest to 0 and the address closest to 0xFFFFFFF is within the range from 64 Kbytes to 256 Kbytes*1 in the RAM data area section. The RAM data area section includes the sections (before renamed) shown below; D_1, D_2, D, D_8, B_1, B_2, B, B_8
- When <address value>=<register C> is specified, accesses to an area within 64Kbytes to 256 bytes from the address value, among the areas whose addresses are already determined at the time of compilation, are performed relative to the specified register C.

Note
*1) This value is in the range from 64 to 256 Kbytes and depends on the total size of variables to be accessed.

[Remarks]

- The same register cannot be specified for different areas.
- Only a single register can be specified for each area. If a register specified by the fint_register option is specified by this option, an error will occur.
- When the pid option is selected, base=rom=<register> cannot be selected. If selected, message W0523039 is output as a warning and the selection of base=rom=<register> is disabled.
### -patch

< Compile Options / Microcontroller Options >

<table>
<thead>
<tr>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-patch = { rx610 }</code></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>- This option is used to avoid a problem specific to the CPU type.</td>
</tr>
<tr>
<td>- When <code>-patch=rx610</code> is specified, the <code>MVTIPL</code> instruction which causes a problem in the RX610 Group is not used in the generated code. Unless <code>-patch=rx610</code> is specified, the code generated in response to the call by the intrinsic function <code>set_ipl</code> will contain the <code>MVTIPL</code> instruction.</td>
</tr>
</tbody>
</table>
-pic

< Compile Options / Microcontroller Options >

[Format]

- -pic

- [Default]
  This option does not generate code with the program section as PIC (position independent code).

[Description]

- This option generates code with the program section as PIC (position independent code).
- In PIC, all function calls are performed with BSR or BRA instructions. When acquiring the address of a function, a relative address from the PC should be used. This allows PIC to be located at a desired address after linkage.

[Example]

- Calling a function (only for branch=32)

```c
void func()
{
    sub();
}
```

- Acquiring a function address

```c
void func1(void);
void (*f_ptr)(void);
void func2(void)
{
    f_ptr = func1;
}
```
- In C++ or EC++ compilation, the `pic` option cannot be selected. If selected, message W0511171 is output as a warning and the selection of the `pic` option is disabled.

- The address of a function which is PIC should not be used in the initialization expression used for static initialization. If used, error E0523026 will occur.

- <Example of using a PIC address for static initialization>

```c
void pic_func1(void), pic_func2(int), pic_func3(int); /* Becomes PIC */
void (*fptr1_for_pic) = pic_func1; /* Uses PIC address in static initialization: Error */
struct PIC_funcs{ int code; void (*fptr)(int); };    
struct PIC_funcs pic_funcs[] = {
    { 2, pic_func2 }, /* Uses PIC address in static initialization: Error */
    { 3, pic_func3 }, /* Uses PIC address in static initialization: Error */
};
```

- When creating a code for startup of the application program using the PIC function, refer to the Application Startup section of the STARTUP chapter.

- For the PIC function, also refer to the Usage of PIC/PID Function of the STARTUP section.
- **-pid**

*< Compile Options / Microcontroller Options >*

### [Format]

```
-pid={ 16 | 32 }
```

- **[Default]**
  The constant area sections C_8, C, C_2, and C_1, the literal section L, and the switch statement branch table sections W, W_2, and W_1 are not handled as PID (position independent data).

### [Description]

- The constant area sections C_8, C, C_2, and C_1, the literal section L, and the switch statement branch table sections W, W_2, and W_1 are handled as PID (position independent data).
- PID can be accessed through a relative address from the PID register. This allows PID to be located at a desired address after linkage.
- A single general register is used to implement the PID function.
- **<PID register>**
  - Based on the rules in the following table, one register from among R9 to R13 is selected according to the specification of the fint_register option. If the fint_register option is not specified, R13 is selected.

<table>
<thead>
<tr>
<th>fint_register Option</th>
<th>PID Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fint_register specification</td>
<td>R13</td>
</tr>
<tr>
<td>fint_register = 0</td>
<td>R12</td>
</tr>
<tr>
<td>fint_register = 1</td>
<td>R11</td>
</tr>
<tr>
<td>fint_register = 2</td>
<td>R10</td>
</tr>
<tr>
<td>fint_register = 3</td>
<td>R9</td>
</tr>
</tbody>
</table>

- The PID register can be used only for the purpose of PID access.

- **<Parameters>**
  - The parameter selects the maximum bit width of the offset when accessing the constant area section from the PID register as 16 bits or 32 bits.
  - The default for this option when the offset width is omitted is pid=16. When pid=16 is specified, the size of the constant area section that can be accessed by the PID register is limited to 64 Kbytes to 256 Kbytes (varies depending on the access width). When pid=32 is specified, there is no limitation of the size of the constant area section that can be accessed by the PID register, but the size of the code accessing PID is increased.
  - Note that when pid=32 and the map option with valid external symbol-allocation information are specified at the same time, the allocation information causes code the same as if pid=16 was specified to be generated if access by the PID register is possible.
[Examples]

- Accessing an externally referenced symbol that is `const` qualified

```c
extern const int pid;
int work;
void func1()
{
    work = pid;
}
```

- Acquiring the address of an externally defined symbol that is `const` qualified

```c
extern const int pid = 1000;
const int *ptr;
void func2()
{
    ptr = &pid;
}
```

[Remarks]

- The address of an area which is PID should not be used in the initialization expression used for static initialization. If used, error E0523027 will occur.
- <Example of using a PID address for static initialization>

```c
extern const int pid_data1; /* Becomes PID */
const int *ptr1_for_pid = &pid_data1; /* Uses PID address in static initialization: Error */
const int pid_data4[] = {1,2,3,4}; /* Becomes PID */
const int *ptr2_for_pid = pid_data4; /* Uses PID address in static initialization: Error */
```

- When creating a code for startup of the application program using the PID function, refer to Application Startup, instead of Startup.

- When the `pid` option is selected, the same external variables in different files all have to be `const` qualified. This is because the `pid` option is used to specify `const` qualified variables as PID. The `pid` option (PID function) should not be used when there may be an external variable that is not `const` qualified.

- If the `map=<file name>` option is enabled while the `pid` option is selected, warning W0530809 may be output when there is an externally referenced variable that is not `const` qualified but used in different files as the same external variable. In the case, the displayed variable is handled as PID.

- In C++ or EC++ compilation, the `pid` option cannot be selected. If selected, message W0511171 is output as a warning and the selection of the `pid` option is disabled.

- When the `pid` option is selected, `base=rom=<register>` cannot be selected. If selected, message W0551149 is output as a warning and the selection of `base=rom=<register>` is disabled.

- If a PID register selected by the `pid` option is also specified by the `base` option, warning W0511149 will occur.

- If the `pid` option and `nouse_pid_register` option are selected simultaneously, error E0511150 will occur.

- For details of the application and PID function, refer to Usage of PIC/PID Function.
- `nouse_pid_register`

  < Compile Options / Microcontroller Options >

[Format]

```
-nouse_pid_register
```

[Description]

- When this option is specified, the generated code does not use the PID register.

- Selection of the PID register according to the settings of the `fint_register` option is based on the same rule as for the `pid` option.

- A master program called by an application program in which the PID function is enabled needs to be compiled with this option. At this time, if the `fint_register` option is selected in the application program, the same parameter `fint_register` should also be selected in the master program.

[Remarks]

- If the `nouse_pid_register` option and `pid` option are selected simultaneously, error E0511150 will occur.

- A register selected as the PID register also being specified for the `base` option leads to warning W0511149.

- For details of the PID function, refer to Usage of PIC/PID Function.
**-save_acc**

< Compile Options / Microcontroller Options >

**[Format]**

```
-save_acc
```

- [Default]
  When this option is omitted, it does not generate the saved and restored code of the accumulator (ACC, ACC0, ACC1) for interrupt functions.

**[Description]**

- This option generates the saved and restored code of the accumulator (ACC, ACC0, ACC1) for interrupt functions.
- The code for saving and restoring the ACC is generated when RXv1 is selected for ISA¹ or the microcomputer type is selected by the CPU².
- The code for saving and restoring ACC0 and ACC1 is generated when a value other than RXv1 is selected for ISA¹.

**Note**

*¹) This means a selection by the -isa option or the ISA_RX environment variable.
*²) This means a selection by the -cpu option or the CPU_RX environment variable.

**[Remarks]**

- The generated code for saving and restoring is the same code generated when interrupt specification "acc" is selected in #pragma interrupt. For the actual code for saving and restoring, refer to the description of #pragma interrupt in section 4.2.3 #pragma Directive.
- Since the value of the accumulator is retained even at interrupt occurrence if this option has been specified, a code using DSP instructions, such as the MACLO instruction, may be generated for C/C++ arithmetic expressions.
Assemble and Linkage Options

< Compile Options / Assemble and Linkage Options >

The following assemble and linkage options are available.

- -asmcmd
- -lnkcmd
- -asmopt
- -lnkopt
-asmcmd

< Compile Options / Assemble and Linkage Options >

[Format]

```
-aspmcmd=<file name>
```

[Description]

- This option specifies the assembler options to pass to `asrx` with a subcommand file.

[Example]

```
crxx -isa=rxv1 -asmcmd=file.sub sample.c
```

The above description has the same meaning as the following two command lines:

```
crxx -isa=rxv1 -output=src sample.c
asrx -isa=rxv1 -subcommand=file.sub sample.src
```

[Remarks]

- If this option is specified for more than one time, all specified subcommand files are valid.
**-lnkcmd**

< Compile Options / Assemble and Linkage Options >

**[Format]**

```-lnkcmd=<file name>```

**[Description]**

- This option specifies the linkage options to pass to `rlink` with a subcommand file.

**[Example]**

```ccrx -isa=rxv1 -output=abs=tp.abs -lnkcmd=file.sub tp1.c tp2.c
ccrx -isa=rxv1 -output=src tp1.c tp2.c
asrx -isa=rxv1 tp1.src tp2.src
rlink -subcommand=file.sub -form=abs -output=tp tp1.obj tp2.obj```

The above description has the same meaning as the following three command lines:

```c
ccrx -isa=rxv1 -output=abs=tp.abs -lnkcmd=file.sub tp1.c tp2.c
asrx -isa=rxv1 tp1.src tp2.src
rlink -subcommand=file.sub -form=abs -output=tp tp1.obj tp2.obj```

**[Remarks]**

- If this option is specified for more than one time, all specified subcommand files are valid.
- Refer to the `-subcommand` option of the optimizing linkage editor for the contents of the subcommand file passed to the `-lnkcmd` option.
- **asmopt**

**< Compile Options / Assemble and Linkage Options >**

**[Format]**

```
-asmopt=""<assembler option>"
```

**[Description]**

- This option specifies the assembler options to pass to `asrx` with a string.
- Multiple options can be specified by enclosing them with double-quote marks (".

**[Example]**

```
ccrx -isa=rxv1 -asmopt="-chkpm" sample.c
```

The above description has the same meaning as the following two command lines:

```
ccrx -isa=rxv1 -output=src sample.c
asrx -isa=rxv1 -chkpm sample.src
```

**[Remarks]**

- If this option is specified for more than one time, all specified assembler options are valid.
-lnkopt

< Compile Options / Assemble and Linkage Options >

[Format]

-\lnkopt=\""<linkage option>\"\"

[Description]

- This option specifies the linkage options to pass to rlink with a string.
- Multiple options can be specified by enclosing them with double-quote marks (").

[Example]

ccrx -isa=rxv1 -output=abs=tp.abs -lnkopt="-start=P,C,D/100,B/8000" tp1.c tp2.c

The above description has the same meaning as the following three command lines:

ccrx -isa=rxv1 -output=src tp1.c tp2.c
asrx -isa=rxv1 tpl.src tp2.src
rlink -start=P,C,D/100,B/8000 -form=abs -output=tp tpl1.obj tp2.obj

[Remarks]

- If this option is specified for more than one time, all specified linkage options are valid.
- A single -lnkopt option can only take a single linkage option. To pass multiple linkage options, specify -lnkopt options as many times as the number of linkage options you require.
Other Options

< Compile Options / Other Options >

The following other options are available.
- -logo
- -nologo
- -euc
- -sjis
- -latin1
- -utf8
- -big5
- -gb2312
- -outcode
- -subcommand
-logo

< Compile Options / Other Options >

[Format]

- logo

  - [Default]
    The copyright notice is output.

[Description]

- The copyright notice is output.
-nologo

< Compile Options / Other Options >

[Format]

```
-nologo
```

- [Default]
  The copyright notice is output.

[Description]

- When the `nologo` option is specified, output of the copyright notice is disabled.
-euc

< Compile Options / Other Options >

[Format]

-euc

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in EUC code.
-sjis

< Compile Options / Other Options >

[Format]

```
-sjis
```

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in **SJIS** code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in **SJIS** code.
-latin1

< Compile Options / Other Options >

[Format]

-latin1

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in ISO-Latin1 code.
-utf8

< Compile Options / Other Options >

[Format]

-utf8

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in UTF-8 code.
-big5

< Compile Options / Other Options >

[Format]

-big5

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in Big5 code.

[Remarks]

- When big5 is specified, the same character coding must be selected for the outcode option.
-gb2312

< Compile Options / Other Options >

[Format]

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in GB2312 code.

[Remarks]

- When gb2312 is specified, the same character coding must be selected for the outcode option.
- **outcode**

< Compile Options / Other Options >

[Format]

```
-outcode = { euc | sjis | utf8 | big5 | gb2312 }
```

- [Default]
  The default for this option is `outcode=sjis`.

[Description]

- This option specifies the character code to output characters in strings and character constants.
- The options correspond to the character codes as shown in the following table.

Table 2.11 Correspondences between Options and Character Codes (outcode)

<table>
<thead>
<tr>
<th>Option</th>
<th>Character Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>euc</td>
<td>EUC code</td>
</tr>
<tr>
<td>sjis</td>
<td>SJIS code</td>
</tr>
<tr>
<td>utf8</td>
<td>UTF-8 code</td>
</tr>
<tr>
<td>big5</td>
<td>Big5 code</td>
</tr>
<tr>
<td>gb2312</td>
<td>GB2312 code</td>
</tr>
</tbody>
</table>

[Remarks]

- When `outcode=big5` or `outcode=gb2312`, the `big5` or `gb2312` option must also be specified.
-subcommand

< Compile Options / Other Options >

[Format]

-subcommand=<subcommand file name>

[Description]
- When the subcommand option is specified, the compiler options specified in a subcommand file are used at compiler startup. Specify options in a subcommand file in the same format as in the command line.

[Remarks]
- If this option is specified for more than one time, all specified subcommand files are valid.
### 2.5.2 Assembler Command Options

<table>
<thead>
<tr>
<th>Classification</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source Options</strong></td>
<td>-include</td>
<td>Specifies the names of folders that hold include files.</td>
</tr>
<tr>
<td></td>
<td>-define</td>
<td>Specifies macro definitions.</td>
</tr>
<tr>
<td></td>
<td>-chkpm</td>
<td>Checks whether a privileged instruction is written.</td>
</tr>
<tr>
<td></td>
<td>-chkfpu</td>
<td>Checks whether a single-precision floating-point processing instruction is written.</td>
</tr>
<tr>
<td></td>
<td>-chkdsp</td>
<td>Checks whether a DSP instruction is written.</td>
</tr>
<tr>
<td></td>
<td>-chkdpfpu [V3.01.00 or later]</td>
<td>Checks whether a double-precision floating-point processing instruction is written.</td>
</tr>
<tr>
<td><strong>Object Options</strong></td>
<td>-output</td>
<td>Specifies the relocatable file name.</td>
</tr>
<tr>
<td></td>
<td>-debug</td>
<td>Debugging information is output to the object files.</td>
</tr>
<tr>
<td></td>
<td>-nodebug</td>
<td>Debugging information is not output to the object files.</td>
</tr>
<tr>
<td></td>
<td>-goptimize</td>
<td>Outputs additional information for inter-module optimization.</td>
</tr>
<tr>
<td></td>
<td>-fpu</td>
<td>Enables writing of a single-precision floating-point processing instruction.</td>
</tr>
<tr>
<td></td>
<td>-nofpu</td>
<td>Generates an error when a single-precision floating-point processing instruction is written.</td>
</tr>
<tr>
<td></td>
<td>-dpfpu [V3.01.00 or later]</td>
<td>Enables writing of a double-precision floating-point processing instruction.</td>
</tr>
<tr>
<td></td>
<td>-nodpfpu [V3.01.00 or later]</td>
<td>Generates an error when a double-precision floating-point processing instruction is written.</td>
</tr>
<tr>
<td></td>
<td>-bank [V3.01.00 or later]</td>
<td>Enables writing of the SAVE and RSTR instructions dedicated to the register bank save function.</td>
</tr>
<tr>
<td></td>
<td>-nobank [V3.01.00 or later]</td>
<td>Generates an error when the SAVE or RSTR instruction dedicated to the register bank save function is written.</td>
</tr>
<tr>
<td></td>
<td>-create_unfilled_area [V2.03.00 or later]</td>
<td>[To be supported by V2.03 and later versions] Makes spaces created by .OFFSET unfilled.</td>
</tr>
<tr>
<td><strong>List Options</strong></td>
<td>-listfile</td>
<td>An assembler list file is output.</td>
</tr>
<tr>
<td></td>
<td>-nolistfile</td>
<td>An assembler list file is not output.</td>
</tr>
<tr>
<td></td>
<td>-show</td>
<td>Specifies the contents of the source list file.</td>
</tr>
<tr>
<td>Classification</td>
<td>Option</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Microcontroller Options</td>
<td>-isa</td>
<td>Selects the instruction-set architecture.</td>
</tr>
<tr>
<td></td>
<td>-cpu</td>
<td>Selects the microcontroller type.</td>
</tr>
<tr>
<td></td>
<td>-endian</td>
<td>Selects the endian type.</td>
</tr>
<tr>
<td></td>
<td>-fint_register</td>
<td>Selects a general register for exclusive use with the fast interrupt function.</td>
</tr>
<tr>
<td></td>
<td>-base</td>
<td>Specifies the base registers for ROM and RAM.</td>
</tr>
<tr>
<td></td>
<td>-patch</td>
<td>Selects avoidance or non-avoidance of a problem specific to the CPU type.</td>
</tr>
<tr>
<td></td>
<td>-pic</td>
<td>Enables the PIC function.</td>
</tr>
<tr>
<td></td>
<td>-pid</td>
<td>Enables the PID function.</td>
</tr>
<tr>
<td></td>
<td>-nouse_pid_register</td>
<td>The PID register is not used in code generation.</td>
</tr>
<tr>
<td>Other Options</td>
<td>-logo</td>
<td>Selects the output of copyright information.</td>
</tr>
<tr>
<td></td>
<td>-nologo</td>
<td>Selects the non-output of copyright information.</td>
</tr>
<tr>
<td></td>
<td>-subcommand</td>
<td>Specifies a file for including command options.</td>
</tr>
<tr>
<td></td>
<td>-euc</td>
<td>The character codes of input programs are interpreted as EUC codes.</td>
</tr>
<tr>
<td></td>
<td>-sjis</td>
<td>The character codes of input programs are interpreted as SJIS codes.</td>
</tr>
<tr>
<td></td>
<td>-latin1</td>
<td>The character codes of input programs are interpreted as ISO-Latin1 codes.</td>
</tr>
<tr>
<td></td>
<td>-big5</td>
<td>The character codes of input programs are interpreted as BIG5 codes.</td>
</tr>
<tr>
<td></td>
<td>-gb2312</td>
<td>The character codes of input programs are interpreted as GB2312 codes.</td>
</tr>
<tr>
<td></td>
<td>-utf8 [V2.04.00 or later]</td>
<td>The character codes of input programs are interpreted as UTF-8 codes.</td>
</tr>
</tbody>
</table>
The following source options are available.

- -include
- -define
- -chkpm
- -chkfpu
- -chkdsp
- -chkdpfpu [V3.01.00 or later]
-include

< Assembler Command Options / Source Options >

[Format]

-include=<path_name>{,...}

- [Default]
The include file is searched for in the order of the current folder and the folders specified by environment variable INC_RXA.

[Description]
- This option specifies the name of the path to the folder that stores the include file.
- Multiple path names can be specified by separating them with a comma (,).
- The include file is searched for in the order of the current folder, the folders specified by the include option, and the folders specified by environment variable INC_RXA.

[Example]
- Folders c:\usr\inc and c:\usr\rxc are searched for the include file.

   asrx -include=c:\usr\inc,c:\usr\rxc test.src
-define

< Assembler Command Options / Source Options >

[Format]

-define=<sub>[,...]
   <sub>: <macro name> = <string>

[Description]
- This option replaces the macro name with the specified string.
  (This provides the same function as writing the .DEFINE directive at the beginning of the source file.)

[Remarks]
- .DEFINE takes priority over the define option if both are specified.
-chkpm

< Assembler Command Options / Source Options >

[Format]

-chkpm

[Description]
- This option outputs warning W0551011 when a privileged instruction is written in the source file.

[Remarks]
- For details of the privileged instructions, refer to the RX Family Software Manual.
-chkfpu

< Assembler Command Options / Source Options >

[Format]

-chkfpu

[Description]
- This option outputs warning W0551012 when a single-precision floating-point processing instruction is written in the source file.

[Remarks]
- For details of the single-precision floating-point processing instructions, refer to the RX Family Software Manual.
-chkdsp

< Assembler Command Options / Source Options >

[Format]

-chkdsp

[Description]
- This option outputs warning W0551013 when a DSP instruction is written in the source file.

[Remarks]
- For details of the DSP instructions, refer to the RX Family Software Manual.
-chkdpfpu [V3.01.00 or later]

< Assembler Command Options / Source Options >

[Format]

-chkdpfpu

[Description]
- This option outputs warning W0551017 when a double-precision floating-point processing instruction is written in the source file.

[Remarks]
- For details of the double-precision floating-point processing instructions, refer to the RX Family Software Manual.
The following object options are available.

- `-output`
- `-debug`
- `-nodebug`
- `-goptimize`
- `-fpuse`
- `-nofpuse`
- `-dpfpuse` [V3.01.00 or later]
- `-nodedpfpuse` [V3.01.00 or later]
- `-bank` [V3.01.00 or later]
- `-nobank` [V3.01.00 or later]
- `-create_unfilled_area` [V2.03.00 or later]
-output

< Assembler Command Options / Object Options >

[Format]

- output=<output file name>

- [Default]
  This option outputs a relocatable file having the same name as that of the source file with extension .obj.

[Description]

- When the specified output file name does not have an extension, the file name appended with extension .obj is used for the output relocatable file name. When it has an extension, the extension is replaced with .obj.
-debug

< Assembler Command Options / Object Options >

[Format]

```
-debug
```

- [Default]
  If this option is not specified, no debugging information is output to the relocatable file.

[Description]

- When the `debug` option is specified, debugging information is output to the relocatable file.
nodebug

[Format]

`-nodebug`

- [Default]
  If this option is not specified, no debugging information is output to the relocatable file.

[Description]

- When the `nodebug` option is specified, no debugging information is output to the relocatable file.
-goptimize

< Assembler Command Options / Object Options >

[Format]

```
-goptimize
```

- [Default]
  If this option is not specified, additional information for the inter-module optimization is not output.

[Description]

- This option outputs the additional information for the inter-module optimization.
- At linkage, inter-module optimization is applied to the file specified with this option.
-fpu

< Assembler Command Options / Object Options >

[Format]

```
-fpu
```

- [Default]
The default for this option is fpu when the instruction-code set as the ISA *1.
The default for this option is nofpu (when RX200 is selected as the target CPU *2) or fpu (in other cases).

Note
*1) This means a selection by the -isa option or the ISA_RX environment variable.
*2) This means a selection by the -cpu option or the CPU_RX environment variable.

[Description]
- This option enables writing of a single-precision floating-point processing instruction.

[Remarks]
- Specifying fpu will lead to an error when the RX200 is selected as the target CPU.
- For details of the single-precision floating-point processing instructions, refer to the RX Family Software Manual.
-nofpu

< Assembler Command Options / Object Options >

[Format]

-fpu

- [Default]
  The default for this option is fpu when the instruction-code set as the ISA *1.
  The default for this option is nofpu (when RX200 is selected as the target CPU *2) or fpu (in other cases).

Note
  *1) This means a selection by the -isa option or the ISA_RX environment variable.
  *2) This means a selection by the -cpu option or the CPU_RX environment variable.

[Description]
- This option generates an error when a single-precision floating-point processing instruction is written.

[Remarks]
- For details of the single-precision floating-point processing instructions, refer to the RX Family Software Manual.
- When this option is specified, a code including single-precision floating-point processing instructions or control register FPSW will cause an error.
-dpfpu [V3.01.00 or later]

< Assembler Command Options / Object Options >

[Format]

- Interpretation when omitted
  nodpfpu is assumed to be specified.

[Description]
- This option enables writing of a double-precision floating-point processing instruction.

[Remarks]
- When the CPU*1 is selected or RXv1 or RXv2 is selected as ISA*2, an error will occur if dpfpu is specified.
- For details of the double-precision floating-point processing instructions, refer to the RX Family Software Manual.
- When nofpu has been specified, an error will occur if dpfpu is specified.

Note
  *1) This means a selection by the cpu option or the CPU_RX environment variable.
  *2) This means a selection by the isa option or the ISA_RX environment variable.
-nodpfpu [V3.01.00 or later]

< Assembler Command Options / Object Options >

[Format]

- nodpfpu

- Interpretation when omitted
  nodpfpu is assumed to be specified.

[Description]

- This option generates an error when a double-precision floating-point processing instruction is written.

[Remarks]

- For details of the double-precision floating-point processing instructions, refer to the RX Family Software Manual.
- When this option is specified, a code including double-precision floating-point processing instructions, double-precision floating-point data registers (DR0 to DR15), or double-precision floating-point control registers (DPSW, DMCR, DECNT, and DEPC) will cause an error.
-bank [V3.01.00 or later]

< Assembler Command Options / Object Options >

[Format]

- bank

- Interpretation when omitted
  When the CPU*1 is selected or RXv1 or RXv2 is selected as ISA*2, -nobank is assumed to be specified. In other cases, -bank is assumed to be specified.

Note
  *1) This means a selection by the cpu option or the CPU_RX environment variable.
  *2) This means a selection by the isa option or the ISA_RX environment variable.

[Description]

- This option enables writing of the SAVE and RSTR instructions dedicated to the register bank save function.
-nobank [V3.01.00 or later]

< Assembler Command Options / Object Options >

[Format]

- nobank

- Interpretation when omitted
  When the CPU\(^1\) is selected or RXv1 or RXv2 is selected as ISA\(^2\), -nobank is assumed to be specified.
  In other cases, -bank is assumed to be specified.

  Note
  *1) This means a selection by the cpu option or the CPU_RX environment variable.
  *2) This means a selection by the isa option or the ISA_RX environment variable.

[Description]

- This option generates an error when the SAVE or RSTR instruction dedicated to the register bank save function is written.
-create_unfilled_area [V2.03.00 or later]

< Assembler Command Options / Object Options >

[Format]

-create_unfilled_area

[Description]

- When a Motorola S-record file (<name>.mot) or Hex file (<name>.hex) is output, this option blocks spaces created by .OFFSET directives in the assembly language being filled with output data.
- When using this option, specify it when using the ccrx or asrx command to create an object file (<name>.obj) as well as when using the rlink command to create a Motorola S-record file or Hex file.

[Remarks]

- This option is available in V2.03 and later versions of this compiler.
- When this option is used, symbols in the format shown below*1 will be added for each .OFFSET directive.

__$_<FileName>_<SectionName>_<IDNumber>s__unfilled_area
__$_<FileName>_<SectionName>_<IDNumber>e__unfilled_area

Here, the name of the source file, section, and a number in a sequence starting from 1 are entered as <FileName>, <SectionName>, and <IDNumber>, respectively.

Note

*1) Since symbols in this format are reserved, they cannot be directly included in your source code.
List Options

< Assembler Command Options / List Options >

The following list options are available.

- -listfile
- -nolistfile
- -show
-listfile

< Assembler Command Options / List Options >

[Format]

```
-listfile[=<file name>]
```

- [Default]
  If this option is not specified, no assemble list file is output.

[Description]

- When the listfile option is specified, an assemble list file is output. The name of the file can also be specified.
- <file name> should be specified according to the rules described in the Naming Files section.
- If <file name> is not specified in the listfile option, the source file name with the extension replaced with .lst is used as the source list file name.
-nolistfile

< Assembler Command Options / List Options >

[Format]

- `nolistfile`

- [Default]
  If this option is not specified, no assemble list file is output.

[Description]

- When the `nolistfile` option is specified, no assemble list file is output.
-show

< Assembler Command Options / List Options >

[Format]

-show=<sub>[,...]
  <sub>: ( conditionals | definitions | expansions )

[Description]

This option specifies the contents of the list file to be output by the assembler. The following output types can be specified as <sub>.

Table 2.12  Output Types Specifiable for show Option

<table>
<thead>
<tr>
<th>Output Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>conditionals</td>
<td>The statements for which the specified condition is not satisfied in conditional assembly are also output to a source list file.</td>
</tr>
<tr>
<td>definitions</td>
<td>The information before replacement specified by .DEFINE is output to a source list file.</td>
</tr>
<tr>
<td>expansions</td>
<td>The macro expansion statements are output to a source list file.</td>
</tr>
</tbody>
</table>
Microcontroller Options

< Assembler Command Options / Microcontroller Options >

The following microcontroller options are available.

- -isa
- -cpu
- -endian
- -fint_register
- -base
- -patch
- -pic
- -pid
- -nouse_pid_register
-isa

< Assembler Command Options / Microcontroller Options >

[Format]

-isa={ rxv1 | rxv2 | rxv3 }

- [Default]
The default for this option is determined based on the environment variable ISA_RX.

[Description]
- This option specifies an instruction-set architecture for use in generating object files.

[Remarks]
- When neither the -nofpu nor -fpu option has been selected, specifying this option automatically selects the -fpu option.
- Omitting this option when neither the -cpu option nor one of the environment variables (CPU_RX or ISA_RX) is specified will lead to an error.
- When the -cpu option and this option are specified simultaneously, an error will occur.
-cpu

< Assembler Command Options / Microcontroller Options >

[Format]

-cpu={ rx600 | rx200 }

- [Default]
The default for this option is determined based on the environment variable CPU_RX.

[Description]
- This option specifies the CPU type for the instruction code to be generated.
- When -cpu=rx600 is specified, a relocatable file for the RX600 Series is generated.
- When -cpu=rx200 is specified, a relocatable file for the RX200 Series is generated.

[Remarks]
- This option is for compatibility with earlier products.
- For upcoming RX-family MCUs, the isa option will be used instead of the cpu option to select an instruction-set architecture. In developing new applications, use the isa option where possible.
- The cpu option can be replaced by the -isa, -fpu and -nofpu options as follows.
  - -cpu=rx600 ==> -isa=rxv1 -fpu
  - -cpu=rx200 ==> -isa=rxv1 -nofpu
- Omitting the cpu option will lead to an error if neither the -isa option nor one of the environment variables (CPU_RX or ISA_RX) is specified.
- The -cpu and -isa options cannot be specified at the same time.
-endian

< Assembler Command Options / Microcontroller Options >

[Format]

- endian={ big | little }

- [Default]
The default for this option is endian=little.

[Description]

- When endian=big is specified, data bytes are arranged in big endian.
  When endian=little is specified, data bytes are arranged in little endian.
-fint_register

< Assembler Command Options / Microcontroller Options >

[Format]

-fint_register = \{ 0 | 1 | 2 | 3 | 4 \}

- [Default]
The default for this option is fint_register=0.

[Description]
- This option outputs to the relocatable file the information about the general registers that are specified to be used only for fast interrupts through the same-name option in the compiler.

[Remarks]
- Be sure to set this option to the same value for all assembly processes in the project. If a different setting is made, correct operation is not guaranteed.
- Do not use a general register dedicated to fast interrupts for other purposes in assembly-language files. If such a register is used for any other purpose, correct operation is not guaranteed.
- If a register specified by this option is also specified by the base option, an error will be output.
-base

< Assembler Command Options / Microcontroller Options >

[Format]

-base = {  rom = <register>
             | ram = <register>
             | <address> = <register>}
        <register> = {R8 to R13}

[Description]

- This option outputs to the relocatable file the information about the general register that is specified to be used only as a base address register through the same-name option in the compiler.

[Remarks]

- Be sure to set this option to the same value for all assembly processes in the project. If a different setting is made, correct operation is not guaranteed.
- Do not use a general register specified by this option for other purposes than a base address register. If such a register is used for any other purpose, correct operation is not guaranteed.
- If a single general register is specified for different areas, an error will be output.
- If a general register specified by the fint_register option is also specified by this option, an error will be output.
-patch

< Assembler Command Options / Microcontroller Options >

[Format]

-patch = { rx610 }

[Description]

- This option is used to avoid a problem specific to the CPU type.
- When -patch=rx610 is specified, the MVTIPL instruction which causes a problem in the RX610 Group is handled as an undefined instruction. The MVTIPL instruction will not be recognized as an instruction and the error message E0552113 will be output.
-pic

< Assembler Command Options / Microcontroller Options >

[Format]

```
-pic
```

- [Default]
  This option generates a relocatable object indicating that code was generated with the PIC function disabled.

[Description]

- This option generates a relocatable object indicating that code was generated with the PIC function enabled.

[Remarks]

- Even if code conflicting with this option is written in the assembly code, it will not be checked.
- A relocatable object with the PIC function enabled cannot be linked with a relocatable object with the PIC function disabled.
- For the PIC function, also refer to Usage of PIC/PID Function.
**-pid**

< Assembler Command Options / Microcontroller Options >

**[Format]**

```
-pid[={ 16 | 32 }]
```

- [Default]
  This option generates a relocatable object indicating that code was generated with the PID function disabled.

**[Description]**

- This option generates a relocatable object indicating that code was generated with the PID function enabled.
- <PID register>
  - Based on the rules in the following table, one register from among R9 to R13 is selected according to the specification of the `fint_register` option. If the `fint_register` option is not specified, R13 is selected.

<table>
<thead>
<tr>
<th>fint_register Option</th>
<th>PID Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>No <code>fint_register</code> specification</td>
<td>R13</td>
</tr>
<tr>
<td><code>fint_register</code> = 0</td>
<td></td>
</tr>
<tr>
<td><code>fint_register</code> = 1</td>
<td>R12</td>
</tr>
<tr>
<td><code>fint_register</code> = 2</td>
<td>R11</td>
</tr>
<tr>
<td><code>fint_register</code> = 3</td>
<td>R10</td>
</tr>
<tr>
<td><code>fint_register</code> = 4</td>
<td>R9</td>
</tr>
</tbody>
</table>

- The PID register can be used only for the purpose of PID access.
- <Parameters>
  - The meaning of a parameter is the same as that for the compiler option with the same name.

**[Remarks]**

- Even if code conflicting with PID is written in the assembly code, it will not be checked.
- A relocatable object with the PID function enabled cannot be linked with a relocatable object with the PID function disabled.
- If a PID register specified by the `pid` option is also specified by the `base` option, error F0553111 will be output.
- If the `pid` option and `nouse_pid_register` option are selected simultaneously, error F0553103 will be output.
- For the PID function, also refer to Usage of PIC/PID Function.
-nouse_pid_register

< Assembler Command Options / Microcontroller Options >

[Format]

-nouse_pid_register

[Description]

- This option generates a relocatable object that was generated without using the PID register.
- If the PID register is used in the assembly-language source file, error message E0552058 will be output. Specifying this option, however, does not lead to an error if a substitute register defined in the assembler specifications is used as the PID register.
- A master program called by an application program in which the PID function is enabled needs to be assembled with this option. At this time, if the fint_register option is selected in the application program, the same parameter fint_register should also be selected in the master program.

[Remarks]

- If the nouse_pid_register option and pid option are selected simultaneously, error F0553103 will be output.
- If a register specified by the nouse_pid_register option is also specified by the base option, error F0553112 will be output.
- For the PID function, also refer to Usage of PIC/PID Function.
Other Options

< Assembler Command Options / Other Options >

The following other options are available.

- -logo
- -nologo
- -subcommand
- -euc
- -sjis
- -latin1
- -big5
- -gb2312
- -utf8 [V2.04.00 or later]
-logo

< Assembler Command Options / Other Options >

[Format]

- [Default]
  The copyright notice is output.

[Description]

- The copyright notice is output.
-nologo

< Assembler Command Options / Other Options >

[Format]

-nologo

- [Default]
The copyright notice is output.

[Description]

- When the **nologo** option is specified, output of the copyright notice is disabled.
-**subcommand**

< Assembler Command Options / Other Options >

**[Format]**

```
-subcommand=<subcommand file name>
```

**[Description]**

- When the **subcommand** option is specified, the assembler options specified in a subcommand file are used at assembler startup. Specify options in a subcommand file in the same format as in the command line.

**[Example]**

- Contents of subcommand file **opt.sub**:

  ```
  -listfile
  -debug
  ```

- Command line specifications:

- When options are specified in the command line as shown (1) below, the assembler interprets them as shown in (2).

  ```
  (1) asrx -endian=big -subcommand=opt.sub test.src
  (2) asrx -endian=big -listfile -debug test.src
  ```
-euc

< Assembler Command Options / Other Options >

[Format]

-euc

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in EUC code.
-sjis

< Assembler Command Options / Other Options >

[Format]

-sjis

- [Default]
This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]
- This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.
-\texttt{latin1}

\begin{itemize}
  \item \texttt{-latin1}
\end{itemize}

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

- [Description]
  This option specifies the character code to handle the characters in strings, character constants, and comments in ISO-Latin1 code.
-big5

< Assembler Command Options / Other Options >

[Format]

```
-big5
```

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in Big5 code.
-gb2312

< Assembler Command Options / Other Options >

[Format]

-`-gb2312`

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in GB2312 code.
-utf8 [V2.04.00 or later]

< Assembler Command Options / Other Options >

[Format]

```
-utf8
```

- [Default]
  This option specifies the character code to handle the characters in strings, character constants, and comments in SJIS code.

[Description]

- This option specifies the character code to handle the characters in strings, character constants, and comments in UTF-8 code.
## 2.5.3 Optimizing Linkage Editor (rlink) Options

<table>
<thead>
<tr>
<th>Classification</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Options</td>
<td>-Input</td>
<td>Specifies relocatable files.</td>
</tr>
<tr>
<td></td>
<td>-library</td>
<td>Specifies library files.</td>
</tr>
<tr>
<td></td>
<td>-binary</td>
<td>Specifies binary files.</td>
</tr>
<tr>
<td></td>
<td>-define</td>
<td>Specifies symbol definitions.</td>
</tr>
<tr>
<td></td>
<td>-entry</td>
<td>Specifies an entry symbol or entry address.</td>
</tr>
<tr>
<td></td>
<td>-noprelink</td>
<td>Selects non-initiation of the prelinker.</td>
</tr>
<tr>
<td></td>
<td>-allow_duplicate_module_name[V3.02.00 or later]</td>
<td>This option allows multiple same module names to be specified.</td>
</tr>
</tbody>
</table>
### Output Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-form</td>
<td>Selects the output file format.</td>
</tr>
<tr>
<td>-debug</td>
<td>Debugging information is output to load module files.</td>
</tr>
<tr>
<td>-sdebug</td>
<td>Debugging information is output to the .dbg file.</td>
</tr>
<tr>
<td>-nodebug</td>
<td>Debugging information is not output.</td>
</tr>
<tr>
<td>-record</td>
<td>Selects the record size.</td>
</tr>
<tr>
<td>-end_record [V2.07.00 or later]</td>
<td>This option specifies the end record.</td>
</tr>
<tr>
<td>-rom</td>
<td>Specifies the section mapping from ROM to RAM.</td>
</tr>
<tr>
<td>-output</td>
<td>Specifies the names of files to be output.</td>
</tr>
<tr>
<td>-map</td>
<td>Outputs an external symbol-allocation information file.</td>
</tr>
<tr>
<td>-space</td>
<td>Data are output to fill unused ranges of memory.</td>
</tr>
<tr>
<td>-message</td>
<td>Information-level messages are output.</td>
</tr>
<tr>
<td>-nomessage</td>
<td>The output of messages is disabled.</td>
</tr>
<tr>
<td>-msg_unused</td>
<td>Messages are output to indicate the presence of externally defined symbols to which there is no reference.</td>
</tr>
<tr>
<td>-byte_count</td>
<td>Specifies the number of bytes in a data record.</td>
</tr>
<tr>
<td>-fix_record_length_and_alignment [V2.08.00 or later]</td>
<td>Fixes the format of data records to be output.</td>
</tr>
<tr>
<td>-crc</td>
<td>Specifies the format for output of the CRC code.</td>
</tr>
<tr>
<td>-padding</td>
<td>Padding data are included at the end of each section.</td>
</tr>
<tr>
<td>-vectn</td>
<td>Assigns an address to the specified vector number in the variable vector table (for the RX Family and M16C Family).</td>
</tr>
<tr>
<td>-vect</td>
<td>Assigns an address to an unused area in the variable vector table (for the RX Family and M16C Family).</td>
</tr>
<tr>
<td>-split_vect [V3.00.00 or later]</td>
<td>Generates split vector table sections.</td>
</tr>
<tr>
<td>-jump_entries_for_pic</td>
<td>Outputs a jump table file (for the PIC function of the RX Family).</td>
</tr>
<tr>
<td>-cfi [Professional Edition only] [V2.08.00 or later]</td>
<td>Generates the function list for use in detecting illegal indirect function calls.</td>
</tr>
<tr>
<td>-cfi_add_func [V2.08.00 or later]</td>
<td>Specifies the symbol or address of a function to be added to the function list for use in detecting illegal indirect function calls.</td>
</tr>
<tr>
<td>-cfi_ignore_module [V2.08.00 or later]</td>
<td>Specifies modules which are to be exempted from checking against the function list for use in detecting illegal indirect function calls.</td>
</tr>
<tr>
<td>-create_unfilled_area [V2.03.00 or later]</td>
<td>[To be supported by V2.03 and later versions] Makes spaces created by OFFSET unfilled.</td>
</tr>
</tbody>
</table>

### List Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-list</td>
<td>A linkage list file is output.</td>
</tr>
<tr>
<td>-show</td>
<td>Selects the contents to be output in the linkage list file.</td>
</tr>
</tbody>
</table>
### Optimize Options
- **-optimize**
  Selects the items to be optimized at linkage.
- **-nooptimize**
  Selects no optimization at linkage.
- **-samesize**
  Specifies the minimum size for unification of the same codes.
- **-symbol_forbid**
  Specifies symbols for which unreferenced symbol deletion is disabled.
- **-samecode_forbid**
  Specifies symbols for which same code unification is disabled.
- **-section_forbid**
  Specifies a section where optimization is disabled.
- **-absolute_forbid**
  Specifies an address range where optimization is disabled.

### Section Options
- **-start**
  Specifies a section start address.
- **-fsymbol**
  Specifies the section where an external defined symbol will be placed in the output file.
- **-aligned_section**
  Specifies the section alignment value as 16 bytes.

### Verify Options
- **-cpu**
  Checks addresses for consistency.
- **-contiguous_section**
  Specifies sections that will not be divided.

### Other Options
- **-s9**
  Selects the output of an s9 record at the end of the file.
- **-stack**
  Selects the output of a stack information file.
- **-compress**
  Debugging information are compressed.
- **-nocompress**
  Debugging information are not compressed.
- **-memory**
  Selects the amount of memory to be used in linkage.
- **-rename**
  Specifies symbol names and section names to be modified.
- **-lib_rename [V3.01.00 or later]**
  Changes the name of a symbol or section that was input from a library.
- **-delete**
  Specifies symbol names and module names to be deleted.
- **-replace**
  Specifies library modules to be replaced.
- **-extract**
  Specifies modules to be extracted from library files.
- **-strip**
  Debugging information is deleted from absolute files and library files.
- **-change_message**
  Specifies changes to the levels of messages (information, warning, and error).
- **-hide**
  Name information on local symbols is deleted.
- **-total_size**
  The total sizes of sections after linkage are sent to standard output.
- **-verbose [V3.03.00 or later]**
  This option displays detailed information in the standard error output.

### Subcommand File Option
- **-subcommand**
  Specifies a file from which to include command options.

### Options Other Than Above
- **-logo**
  Selects the output of copyright information.
- **-nologo**
  Selects the non-output of copyright information.
- **-end**
  Selects the execution of option strings specified before **END**.
- **-exit**
  Specifies the end of option specification.
Input Options

< Optimizing Linkage Editor (rlink) Options / Input Options >

The following input options are available.

- -Input
- -library
- -binary
- -define
- -entry
- -noprelink
- -allow_duplicate_module_name [V3.02.00 or later]
**Input**

- **Input**

  < Optimizing Linkage Editor (rlink) Options / Input Options >

**[Format]**

-Input = <suboption>{, | A}...  
  <suboption>: <file name>[ (<module name>[,...] ) ]

**[Description]**

- Specifies an input file. Two or more files can be specified by separating them with a comma (,) or space.
- Wildcards (* or ?) can also be used for the specification. String literals specified with wildcards are expanded in alphabetical order. Expansion of numerical values precedes that of alphabetical letters. Uppercase letters are expanded before lowercase letters.
- Specifiable files are object files output from the compiler or the assembler, and relocatable or absolute files output from the optimizing linkage editor. A module in a library can be specified as an input file using the format of <library name>(<module name>). The module name is specified without an extension.
- If an extension is omitted from the input file specification, **obj** is assumed when a module name is not specified and **lib** is assumed when a module name is specified.

**[Examples]**

```
input=a.obj lib1(e)       ; Inputs a.obj and module e in lib1.lib.
input=c*.obj              ; Inputs all .obj files beginning with c.
```

**[Remarks]**

- When **form=object** or **extract** is specified, this option is unavailable.
- When an input file is specified on the command line, **input** should be omitted.
**-library**

< Optimizing Linkage Editor (rlink) Options / Input Options >

**[Format]**

```
-library = <file name>[,...]
```

**[Description]**

- Specifies an input library file. Two or more files can be specified by separating them with a comma (,).
- Wildcards (* or ?) can also be used for the specification. String literals specified with wildcards are expanded in the alphabetical order. Expansion of numerical values precedes that of alphabetical letters. Uppercase letters are expanded before lowercase letters.
- If an extension is omitted from the input file specification, **lib** is assumed.
- If **form=library** or **extract** is specified, the library file is input as the target library to be edited.
- Otherwise, after the linkage processing between files specified for the input files are executed, undefined symbols are searched in the library file.
- The symbol search in the library file is executed in the following order: user library files with the library option specification (in the specified order), the system library files with the library option specification (in the specified order), and then the default library (environment variable **HLNK_LIBRARY1,2,3**).

**[Examples]**

```
library=a.lib,b ; Inputs a.lib and b.lib.
library=c*.lib ; Inputs all files beginning with c with the extension .lib.
```
**-binary**

< Optimizing Linkage Editor (rlink) Options / Input Options >

### Format

```
-binary = <suboption>[,...]
   <suboption>: <file name>{<section name>
       [:<boundary alignment>][:<section attribute>]},<symbol name>]
   <section attribute>: CODE | DATA
   <boundary alignment>: 1 | 2 | 4 | 8 | 16 | 32 (default: 1)
```

### Description

- Specifies an input binary file. Two or more files can be specified by separating them with a comma (,).
- If an extension is omitted for the file name specification, **bin** is assumed.
- Input binary data is allocated as the specified section data. The section address is specified with the **start** option. That section cannot be omitted.
- When a symbol is specified, the file can be linked as a defined symbol. For a variable name referenced by a C/C++ program, add an underscore (_) at the head of the reference name in the program.
- The section specified with this option can have its section attribute and boundary alignment specified.
- **CODE** or **DATA** can be specified for the section attribute.
- When section attribute specification is omitted, the write, read, and execute attributes are all enabled by default.
- A boundary alignment value can be specified for the section specified by this option. A power of 2 can be specified for the boundary alignment; no other values should be specified.
- When the boundary alignment specification is omitted, 1 is used as the default.

### Examples

```
input=a.obj
start=P,D*/200
binary=b.bin(D1bin),c.bin(D2bin:4,_datab)
form=absolute
```

- Allocates **b.bin** from 0x200 as the **D1bin** section.
- Allocates **c.bin** after **D1bin** as the **D2bin** section (with boundary alignment = 4).
- Links **c.bin** data as the defined symbol **_datab**.

### Remarks

- When **form=(object | library)** or strip is specified, this option is unavailable.
- If no input object file is specified, this option cannot be specified.
-define

< Optimizing Linkage Editor (rlink) Options / Input Options >

[Format]

-define = <suboption>{[, ...]}
  <suboption>: <symbol name>=<symbol name> | <numerical value>

[Description]

- Defines an undefined symbol forcedly as an externally defined symbol or a numerical value.
- The numerical value is specified in the hexadecimal notation. If the specified value starts with a letter from A to F, symbols are searched first, and if no corresponding symbol is found, the value is interpreted as a numerical value. Values starting with 0 are always interpreted as numerical values.
- If the specified symbol name is a C/C++ variable name, add an underscore (_) at the head of the definition name in the program. If the symbol name is a C++ function name (except for the `main` function), enclose the definition name with the double-quotes including parameter strings. If the parameter is `void`, specify as "<function name>( )".

[Examples]

define=_sym1=data ; Defines _sym1 as the same value as the externally defined symbol data.
define=_sym2=4000 ; Defines _sym2 as 0x4000.

[Remarks]

- When form={object | relocate | library} is specified, this option is unavailable.
-entry

< Optimizing Linkage Editor (rlink) Options / Input Options >

[Format]

-entry = {<symbol name> | <address>}

[Description]

- Specifies the execution start address with an externally defined symbol or address.
- The address is specified in hexadecimal notation. If the specified value starts with a letter from A to F, symbols are
  searched first, and if no corresponding symbol is found, the value is interpreted as an address. Values starting with 0
  are always interpreted as addresses.
- For a C function name, add an underscore (_) at the head of the definition name in the program. For a C++ function
  name (except for the main function), enclose the definition name with double-quotes in the program including param-
  eter strings. If the parameter is void, specify as "<function name>()".
- If the entry symbol is specified at compilation or assembly, this option precedes the entry symbol.

[Examples]

entry=_main ; Specifies main function in C/C++ as the execution start address.
entry="init()" ; Specifies init function in C++ as the execution start address.
entry=100 ; Specifies 0x100 as the execution start address.

[Remarks]

- When form=(object | relocate | library) or strip is specified, this option is unavailable.
- When optimization with undefined symbol deletion (optimize=symbol_delete) is specified, the execution start
  address should be specified. If it is not specified, the specification of the optimization with undefined symbol deletion
  is unavailable. Optimization with undefined symbol deletion is not available when an address is specified with this
  option.
- If the address specified by the -entry option belongs to the list of sections for which the location address is specified
  by the -start option, optimization is disabled for the area from the location address specified by the -start option to the
  address specified by the -entry option.
-noprelink

< Optimizing Linkage Editor (rlink) Options / Input Options >

[Format]

-noprelink

- [Default]
  If this option is not specified, the prelinker is initiated.

[Description]

- Disables the prelinker initiation.
  - The prelinker supports the functions to generate the C++ template instance automatically and to check types at run time. When the C++ template function and the run-time type test function are not used, specify the noprelink option to reduce the link time.

[Remarks]

- When extract or strip is specified, this option is unavailable.
- If form=lib or form=rel is specified while the C++ template function and run-time type test are used, do not specify noprelink.
- Allow_duplicate_module_name [V3.02.00 or later]

< Optimizing Linkage Editor (rlink) Options / Input Options >

[Format]

-allow_duplicate_module_name

[Description]

- This option allows multiple input files with the same module name to be specified to generate a library.
- If the library already contains a module having the same name with other modules to be registered in the library, the other modules are renamed by adding a postfix number ".<N>".
- <N> is assigned a number as a unique module name in the generating library. If can't assigned a unique number, The linker will output the error message and quit.

[Examples]

- To generate a library a.lib from multiple input files having the same module name (mod), describe as:

  > rlink -allow_duplicate_module_name -form=lib -output=a.lib b\mod.obj c\mod.obj d\mod.obj

  The command line above leads to generate a library a.lib containing the following modules:
  - mod (originally b\mod.obj)
  - mod.1 (originally c\mod.obj)
  - mod.2 (originally d\mod.obj)

[Remarks]

- If the -form={ object|absolute|relocate|hexadecimal|stype|binary }, -strip, or -extract option is specified, this option will be invalid.
Output Options

< Optimizing Linkage Editor (rlink) Options / Output Options >

The following output options are available.
- -form
- -debug
- -sdebug
- -nodebug
- -record
- -end_record [V2.07.00 or later]
- -rom
- -output
- -map
- -space
- -message
- -nomessage
- -msg_unused
- -byte_count
- -fix_record_length_and_alignment [V2.08.00 or later]
- -crc
- -padding
- -vectn
- -vect
- -split_vect [V3.00.00 or later]
- -jump_entries_for_pic
- -cfi [Professional Edition only] [V2.08.00 or later]
- -cfi_add_func [V2.08.00 or later]
- -cfi_ignore_module [V2.08.00 or later]
- -create_unfilled_area [V2.03.00 or later]
-form

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-form = {Absolute | Relocate | Object | Library[{=S | U}] | Hexadecimal | S-type | Binary}

- [Default]
  When this option is omitted, the default is form=absolute.

[Description]

- Specifies the output format.
- Table 2.14 lists the suboptions.

Table 2.14 Suboptions of form Option

<table>
<thead>
<tr>
<th>No</th>
<th>Suboption</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>absolute</td>
<td>Outputs an absolute file</td>
</tr>
<tr>
<td>2</td>
<td>relocate</td>
<td>Outputs a relocatable file</td>
</tr>
<tr>
<td>3</td>
<td>object</td>
<td>Outputs an object file. This is specified when a module is extracted as an object file from a library with the extract option.</td>
</tr>
<tr>
<td>4</td>
<td>library</td>
<td>Outputs a library file. When library=s is specified, a system library is output. When library=u is specified, a user library is output. Default is library=u.</td>
</tr>
<tr>
<td>5</td>
<td>hexadecimal</td>
<td>Outputs a HEX file. For details of the HEX format, refer to HEX File Format.</td>
</tr>
<tr>
<td>6</td>
<td>stype</td>
<td>Outputs an S-type file. For details of the S-type format, refer to S-Type File Format.</td>
</tr>
<tr>
<td>7</td>
<td>binary</td>
<td>Outputs a binary file.</td>
</tr>
</tbody>
</table>

[Remarks]

Table 2.15 shows relations between output formats and input files or other options.
## Table 2.15 Relations Between Output Format and Input File or Other Options

<table>
<thead>
<tr>
<th>No</th>
<th>Output Format</th>
<th>Specified Option</th>
<th>Enabled File Format</th>
<th>Specifiable Option&lt;sup&gt;Note1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Absolute</td>
<td>strip specified</td>
<td>Absolute file</td>
<td>input, output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other than above</td>
<td>object file, binary, debug/nodebug, sdebug, cpu, start, rom, entry, output, map, hide, optimize/nooptimize, samesize, symbol_forbid, samecode_forbid, section_forbid, absolute_forbid, compress, rename, lib_rename, delete, define, fsymbol, stack, noprelink, memory, msg_unused, show=(symbol,reference,xreference,total_size, vector, relocation_attribute), jump_entries_for_pic, aligned_section, padding, vectn, vect, split_vect</td>
</tr>
<tr>
<td>2</td>
<td>Relocate</td>
<td>extract specified</td>
<td>Library file</td>
<td>library, output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other than above</td>
<td>object file, binary, debug/nodebug, output, hide, rename, lib_rename, delete, noprelink, msg_unused, show=(symbol,reference,xreference,total_size)</td>
</tr>
<tr>
<td>3</td>
<td>Object</td>
<td>extract specified</td>
<td>Library file</td>
<td>library, output</td>
</tr>
<tr>
<td>4</td>
<td>Hexadecimal</td>
<td>extract specified</td>
<td>Library file</td>
<td>input, output, memory&lt;sup&gt;Note4&lt;/sup&gt;, show=symbol, section</td>
</tr>
<tr>
<td></td>
<td>Stype</td>
<td></td>
<td>Other than above</td>
<td>object file, output, record, end_record, s9&lt;sup&gt;Note2&lt;/sup&gt;, byte_count&lt;sup&gt;Note3&lt;/sup&gt;, fix_record_length_and_align, memory, msg_unused, show=(symbol, reference, xreference, total_size, vector, jump_entries_for_pic, aligned_section, padding, vectn, vect, split_vect)</td>
</tr>
<tr>
<td></td>
<td>Binary</td>
<td></td>
<td>Absolute file</td>
<td>input, output, record, end_record, s9&lt;sup&gt;Note2&lt;/sup&gt;, byte_count&lt;sup&gt;Note3&lt;/sup&gt;, fix_record_length_and_align, show=(symbol, reference, xreference)</td>
</tr>
<tr>
<td>5</td>
<td>Library</td>
<td>strip specified</td>
<td>Library file</td>
<td>library, output, memory&lt;sup&gt;Note4&lt;/sup&gt;, show=symbol, section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>extract specified</td>
<td>Library file</td>
<td>library, output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other than above</td>
<td>object file, binary, hide, rename, delete, replace, noprelink, memory&lt;sup&gt;Note4&lt;/sup&gt;, show=symbol, section, allow_duplicate_module_name</td>
</tr>
</tbody>
</table>

<sup>Note1</sup> message/nomessage, change_message, logo/nologo, form, list, and subcommand can always be specified.

<sup>Note2</sup> s9 can be used only when form=stype is specified for the output format.

<sup>Note3</sup> byte_count can be used only when form=hexadecimal or form=stype is specified for the output format.

<sup>Note4</sup> memory cannot be used when hide is specified.
-debug

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-debug
```

- [Default]
  When this option is omitted, debugging information is output to the output file.

[Description]

- When debug is specified, debugging information is output to the output file.
- If debug is specified and if two or more files are specified to be output with output, they are interpreted as sdebug and debugging information is output to `<first output file name>.dbg`.

[Remarks]

- When form=object | library | hexadecimal | stype | binary, strip or extract is specified, this option is unavailable.
-sdebug

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-sdebug
```

- [Default]
  When this option is omitted, debugging information is output to the output file.

[Description]
- When sdebug is specified, debugging information is output to <output file name>.dbg file.
- If sdebug and form=relocate are specified, sdebug is interpreted as debug.

[Remarks]
- When form={object | library | hexadecimal | stype | binary}, strip or extract is specified, this option is unavailable.
-nodebug

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-nodebug
```

- [Default]
  When this option is omitted, debugging information is output to the output file.

[Description]
- When `nodebug` is specified, debugging information is not output.

[Remarks]
- When `form=(object | library | hexadecimal | stype | binary)`, `strip` or `extract` is specified, this option is unavailable.
-record

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-record = { H16 | H20 | H32 | S1 | S2 | S3 }

- [Default]
  When this option is omitted, various data records are output according to each address.

[Description]

- Outputs data with the specified data record regardless of the address range.
- If there is an address that is larger than the specified data record, the appropriate data record is selected for the address.

[Remarks]

- This option is available only when form=hexadecimal or stype is specified.
-end_record [V2.07.00 or later]

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-end_record = { S7 | S8 | S9 }
```

[Description]

- This option specifies the type of the end record of a Motorola S-record file.
- When the entry point address is larger than the specified address field, select the type of end record that suits the address of the entry point.
- When this option is omitted, the end record that is output will suit the address of the entry point.

[Example]

```
rlink a.obj b.obj -end_record=S7 -form=stype -output=c.mot
```

- An S-type end record that is interpreted as a 32-bit address (S7) is output regardless of the address range.

[Remarks]

- When -form={stype} is not also specified, an error message is output in response to this option and execution is terminated.
-rom

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-rom = <suboption>[,...]
  <suboption>:  <ROM section name>=<RAM section name>

[Description]

- Reserves ROM and RAM areas in the initialized data area and relocates a defined symbol in the ROM section with the specified address in the RAM section.
- Specifies a relocatable section including the initial value for the ROM section.
- Specifies a nonexistent section or relocatable section whose size is 0 for the RAM section.

[Examples]

rom=D=R
start=D/100,R/8000

- Reserves R section with the same size as D section and relocates defined symbols in D section with the R section addresses.

[Remarks]

- When form={object | relocate | library}or strip is specified, this option is unavailable.
-output

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-output = <suboption>[,...]
  <suboption>: {<file name> | <file name>=<output range> |<file name>=<output range>/<load address> |<file name>=/<load address>}
  <output range>: {<start address>-<end address> | <section name>[:...],}

- [Default] When this option is omitted, the default is <first input file name>.<default extension>. The default extensions are as follows:

[Description]

- Specifies an output file name. When form=absolute, hexadecimal, stype, or binary is specified, two or more files can be specified. An address is specified in the hexadecimal notation. If the specified data starts with a letter from A to F, sections are searched first, and if no corresponding section is found, the data is interpreted as an address. Data starting with 0 are always interpreted as addresses.
- [V3.00.00 or later] If a load address is specified, when outputting an Intel HEX file or Motorola S-record file, the first load address in the file is changed to the specified value.

[Examples]

```plaintext
output=file1.abs=0-ffff,file2.abs=10000-1ffff
```

- Outputs the range from 0 to 0xffff to file1.abs and the range from 0x10000 to 0x1ffff to file2.abs.

```plaintext
output=file1.abs=sec1:sec2,file2.abs=sec3
```

- Outputs the sec1 and sec2 sections to file1.abs and the sec3 section to file2.abs.

[Remarks]

- When a file is output in section units while the CPU type is RX Family in big endian, the section size should be a multiple of 4.
- [V3.00.00 or later] A load address can be specified only when form=hexadecimal or form=stype is specified.
-map

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-map [= <file name>]

[Description]

- Outputs the external-symbol-allocation information file that is used by the compiler in optimizing access to external variables.

- When <file name> is not specified, the file has the name specified by the output option or the name of the first input file, and the extension bls.

- If the order of the declaration of variables in the external-symbol-allocation information file is not the same as the order of the declaration of variables found when the object was read after compilations, an error will be output.

- In the following case, the linker outputs the external variable allocation information file and, when the -list option is specified, outputs the list file. After that, the linker terminates operation normally. Note that the linker does not output a load module file in this case.

  - When a program section allocation address exceeds the allowable address range:

    In the external variable allocation information file, information regarding only the symbols and sections allocated within the allowable areas are output. [V2.06 or later]

[Remarks]

- This option is valid only when form={absolute | hexadecimal | stype | binary} is specified.
-space

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-space [= {<numerical value> | Random}]
```

[Description]
- This option fills the vacant area of the output range with user-specified data.
- Fills the unused areas in the output ranges with random values or a user-specified hexadecimal value.
- The way of filling unused areas differs with the output range specification as follows.
  - When the output option is used to specify sections as the range for output:
  - The specified numerical value is output to unused areas between the specified sections.
  - When the output option is used to specify a range of addresses as the range for output:
  - The specified numerical value is output to unused areas within the specified address range.
  - When the fix_record_length_and_align option is specified:
    - The specified numerical value is output to an unused area at the top of a section, which starts at an address that can be divided by the alignment number.
    - The specified numerical value is output when the end of a section does not reach the specified record length.

[Remarks]
- When no suboption is specified by this option, unused areas are not filled with values.
- This option is only available when the form={ binary | stype | hexadecimal } or fix_record_length_and_align option is specified.
-message

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-message

[Description]
- When message is specified, information-level messages are output.
- When this option is omitted, the output of information-level messages is disabled.
-nomessage

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-nomessage [=<suboption>[,...]]
  <suboption>: <error number>[-<error number>]

- [Default]
  When this option is omitted, the output of information-level messages is disabled.

[Description]

- When nomessage is specified, the output of information-level messages is disabled. If an error number is specified, the output of the error message with the specified error number is disabled. A range of error message numbers to be disabled can be specified using a hyphen (-).

- Each error number consists of a component number (05), phase (6), and a four-digit value (e.g. 0004 in the case of M0560004). If the four-digit section has leading zeroes, e.g. before the 4 in the case of M0560004, these can be omitted.

- If a warning or error level message number is specified, the message output is disabled assuming that change_message has changed the specified message to the information level.

[Examples]

- Messages of L0004, L0200 to L0203, and L1300 are disabled to be output.

  nomessage=4,200-203,1300
-msg_unused

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-msg_unused
```

[Description]
- Notifies the user of the externally defined symbol which is not referenced during linkage through an output message.

[Examples]

```
rlink -msg_unused a.obj
```

[Remarks]
- When an absolute file is input, this option is invalid.
- To output a message, the message option must also be specified.
- The linkage editor may output a message for the function that was inline-expanded at compilation. To avoid this, add a static declaration for the function definition.
- In any of the following cases, references are not correctly analyzed so that information shown by output messages will be incorrect.
  - There are references to constant symbols within the same file.
  - There are branches to immediate subordinate functions when optimization is specified at compilation.
-byte_count

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

- byte_count=<numerical value>

- [Default]
The default values are FF (hexadecimal) for Intel HEX-format files and 10 (hexadecimal) for Motorola S-format files.

[Description]
- This option is used to specify the length of data records in Intel HEX-format files or Motorola S-format files to be generated.
- Values from 01 to FF (hexadecimal) are specifiable for Intel HEX-format files.
- The following ranges of values are specifiable for Motorola S-format files.
  - S1 records: 01 to FC (hexadecimal)
  - S2 records: 01 to FB (hexadecimal)
  - S3 records: 01 to FA (hexadecimal)

[Examples]
Specifying 16 bytes (10 in hexadecimal) as the length of data records

-byte_count=10

[Remarks]
- This option is invalid for file formats other than Intel HEX type (form=hex) or Motorola S-record type (form=stype).
- `fix_record_length_and_alignment` [V2.08.00 or later]

< Optimizing Linkage Editor (rlink) Options / Output Options >

**[Format]**

```
-fix_record_length_and_align=<alignment number>
```

**[Description]**

- This option is used to output an Intel HEX- or Motorola S-format file with records of a fixed length starting from the address that has alignment with the specified number.
- The address of the first record to be output should be less than or equal to the first address of a section and be the largest number that can be divided by the specified alignment number.
- The specified numerical value or default value for the parameter of the `byte_count` option will be used as the length of the records.
- Since the length of records is fixed, each record may include data for more than one section.
- In unused areas, the value specified by the `space` option will be output. If the `space` option is not specified, 0 (with the `crc` option not specified) or FF (with the `crc` option specified) as the default value will be output.

**[Examples]**

Starting the output of records from an address that can be divided by 8, with the length of each record fixed to 16 bytes (10 in hexadecimal)

```
rlink a.obj b.obj -form=hexadecimal -byte_count=10 -fix_record_length_and_align=8
```

**[Remarks]**

- This option is invalid for file formats other than Intel HEX type (`form=hex`) or Motorola S-record type (`form=stype`).
-crc

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

\[-\text{CRC} = \text{<suboption>}
\]
\[\text{<suboption>}: \text{<address where the result is output>=<target range>}
\]
\[\text{[/<Operation Method>], [All initial value] [/:<endianness>]}
\[\text{<address where the result is output>: <address>}
\]
\[\text{<target range>: } \{ \text{<start address>-<end address> |}
\]
\[\text{<section> }, [...]
\]
\[\text{<Operation Method>: } \{ \text{CCITT | 16-CCITT-MSB |}
\]
\[\text{16-CCITT-MSB-LITTLE-4 | 16-CCITT-MSB-LITTLE-2 | 16-CCITT-LSB |}
\]
\[\text{16 | SENT-MSB | 32-ETHERNET}\}
\]
\[\text{<initial value>: <initial value>}
\]
\[\text{<endianness>: } \{ \text{BIG | LITTLE} \}[<-\text{size}>-<-\text{offset}>]
\]

[Description]

- CRC (cyclic redundancy check) operation is done for the specified range of section data in the order from the lower to the higher addresses, and the operation result is output to the specified output address in the specified endian mode.

- Specify one of the following as the operation method. If the specification of the operation method is omitted, operation is performed assuming that CCITT has been specified.

Table 2.16 List of Operation Methods

<table>
<thead>
<tr>
<th>Operation Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCITT</td>
<td>The result of CRC-16-CCITT operation is obtained with the MSB first, an initial value of 0xFFFF, and inverse of XOR performed. The generator polynomial is (x^{16}+x^{12}+x^5+1).</td>
</tr>
<tr>
<td>16-CCITT-MSB [V2.04.00 or later]</td>
<td>The result of CRC-16-CCITT operation is obtained with the MSB first. The generator polynomial is (x^{16}+x^{12}+x^5+1).</td>
</tr>
<tr>
<td>16-CCITT-MSB-LITTLE-4 [V2.04.00 or later]</td>
<td>The input is handled in little endian in 4-byte units and the result of CRC-16-CCITT operation is obtained with the MSB first. The generator polynomial is (x^{16}+x^{12}+x^5+1).</td>
</tr>
<tr>
<td>16-CCITT-MSB-LITTLE-2 [V2.04.00 or later]</td>
<td>The input is handled in little endian in 2-byte units and the result of CRC-16-CCITT operation is obtained with the MSB first. The generator polynomial is (x^{16}+x^{12}+x^5+1).</td>
</tr>
<tr>
<td>16-CCITT-LSB [V2.04.00 or later]</td>
<td>The result of CRC-16-CCITT operation is obtained with the LSB first. The generator polynomial is (x^{16}+x^{12}+x^5+1).</td>
</tr>
<tr>
<td>16 [V2.04.00 or later]</td>
<td>The result of CRC-16 operation is obtained with the LSB first. The generator polynomial is (x^{16}+x^{15}+x^2+1).</td>
</tr>
<tr>
<td>SENT-MSB [V2.04.00 or later]</td>
<td>The input is handled in little endian in the lower 4-bit units of one byte and the result of SENT-compliant CRC operation is obtained with the MSB first and an initial value of 0x5. The generator polynomial is (x^{4}+x^{3}+x^{2}+1).</td>
</tr>
<tr>
<td>32-ETHERNET [V2.04.00 or later]</td>
<td>The result of CRC-32-ETHERNET operation is obtained with an initial value of 0xFFFFFFFF, inverse of XOR performed, and the bits reversed. The generator polynomial is (x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^8 +x^7+x^6+x^4+x^2+x+1).</td>
</tr>
</tbody>
</table>
- The range of values that can be specified for <initial value> is from 0x0 to 0xFFFFFFFF when the operation method is 32-ETHERNET, from 0x0 to 0xF when the operation method is SENT-MSB, and from 0x0 to 0xFFFF for the other cases.

- When <initial value> is omitted, operation is performed on the assumption that 0x5 has been specified for the operation method of SENT-MSB, 0xFFFF for CCITT, 0xFFFFFFFF for 32-ETHERNET, and 0x0 for other cases.

- The operation result is output to the specified output address by writing at the offset location from the beginning of the area allocated by size in the byte order specified with BIG or LITTLE. 0 is output from the beginning of the allocated area until immediately before the offset location.

- When the size and offset are omitted, the size is assumed to be 2 bytes and the offset is assumed to be 0.

- When the space option is not specified, space=FF is assumed for CRC operation for the unused areas in the operation range. Note that 0xFF is only assumed for CRC operation for the unused areas, but the areas are not actually filled with 0xFF.

- Operation is done from the lower to the higher addresses of the specified operation range.

- If this option is specified more than once, all the specified CRC operations will be output. [V3.05.00 or later]

[Example]

- \texttt{rlink *.obj -form=stype -start=P1,P2/1000,P3/2000}
  \texttt{-crc=2FFE=1000-2FFD -output=out.mot=1000-2FFF}

\begin{itemize}
  \item \texttt{crc} option: \texttt{-crc=2FFE=1000-2FFD}
    \begin{itemize}
      \item In this example, CRC will be calculated for the range from 0x1000 to 0x2FFD and the result will be output to address 0x2FFE.
      \item When the \texttt{space} option has not been specified, \texttt{space=0xFF} is assumed for calculation of free areas within the target range.
    \end{itemize}

  \item \texttt{output} option: \texttt{-output=out.mot=1000-2FFF}
    \begin{itemize}
      \item Since the \texttt{space} option has not been specified, the free areas are not output to the \texttt{out.mot} file. 0xFF is used in CRC for calculation of the free areas, but will not be filled into these areas.
    \end{itemize}

  \begin{notes}
    \item The address where the result of CRC will be output cannot be included in the target range.
    \item The address where the result of CRC will be output must be included in the output range specified with the \texttt{output} option.
  \end{notes}
\end{itemize}

- \texttt{rlink *.obj -form=stype -start=P1/1000,P2/1800,P3/2000}
  \texttt{-space=7F -crc=2FFE=1000-17FF,2000-27FF}
  \texttt{-output=out.mot=1000-2FFF}

\begin{itemize}
  \item \texttt{crc} option: \texttt{-crc=2FFE=1000-2FFD,2000-27FF}
    \begin{itemize}
      \item In this example, CRC will be calculated for the two ranges, 0x1000 to 0x17FF and 0x2000 to 0x27FF, and the result will be output to address 0x2FFE.
      \item Two or more non-contiguous address ranges can be selected as the target range for CRC.
    \end{itemize}

  \item \texttt{space} option: \texttt{-space=7F}
    \begin{itemize}
      \item The value of the \texttt{space} option (0x7F) is used for CRC in free areas within the target range.
    \end{itemize}

  \item \texttt{output} option: \texttt{-output=out.mot=1000-2FFF}
    \begin{itemize}
      \item Since the \texttt{space} option has been specified, the free areas are output to the \texttt{out.mot} file. 0x7F will be filled into the free areas.
    \end{itemize}

  \begin{notes}
    \item The order that CRC is calculated for the specified address ranges is not the order that the ranges have been specified. CRC proceeds from the lowest to the highest address.
    \item Even if you wish to use the \texttt{crc} and \texttt{space} options at the same time, the \texttt{space} option cannot be set as \texttt{random} or a value of 2 bytes or more. Only 1-byte values are valid.
  \end{notes}
\end{itemize}
  -crc=1FFE=1000-1FFD,2000-2FFF
  -output=flmem.mot=1000-1FFF

- **crc** option: -crc=1FFE=1000-1FFD,2000-2FFF
  - In this example, CRC will be calculated for the two ranges, 0x1000 to 0x1FFD and 0x2000 to 0x2FFF, and the result will be output to address 0x1FFE.
  - When the **space** option has not been specified, **space=0xFF** is assumed for calculation of free areas within the target range.

- **output** option: -output=flmem.mot=1000-1FFF
  - Since the **space** option has not been specified, the free areas are not output to the **flmem.mot** file.
  - 0xFF is used in CRC for calculation of the free areas, but will not be filled into these areas.

  -crc=2FFC=1000-1FFF -crc=2FFE=2000-2FFB

- **crc** option (1): -crc=2FFC=1000-1FFF
  - In this example, CRC will be calculated for the range from 0x1000 to 0x1FFF, and the result will be output to address 0x2FFC.

- **crc** option (2): -crc=2FFE=2000-2FFB
  - In this example, CRC will be calculated for the range from 0x2000 to 0x2FFB, and the result will be output to address 0x2FFE.

[Remarks]

- When multiple load module files are input, the compiler outputs a warning message and ignores this option.
- This option is valid when the output format is **form={hexadecimal | stype | bin}**. For any other cases, an error is output and execution is terminated.
- When the space option is not specified and the operation range includes an empty area that is not output, 0xFF is assumed to be stored in the unused area during CRC operation.
- An error is output and execution is terminated if the CRC operation range includes an overlaid area.
- The following can be specified for the size and offset when specifying the endian. For any other cases, an error is output and execution is terminated.
  - LITTLE
  - LITTLE-2-0
  - LITTLE-4-0
  - BIG
  - BIG-2-0
  - BIG-4-0

- Sample Code: The sample code shown below is provided to check the result of CRC figured out by the **crc** option. The sample code program should match the result of CRC by rlink.
- When the selected operation method is **CRC-CCITT**:
typedef unsigned char uint8_t;
typedef unsigned short uint16_t;
typedef unsigned long uint32_t;

uint16_t CRC_CCITT(uint8_t *pData, uint32_t iSize)
{
    uint32_t ui32_i;
    uint8_t *pui8_Data;
    uint16_t ui16_CRC = 0xFFFFu;
    pui8_Data = (uint8_t *)pData;
    for(ui32_i = 0; ui32_i < iSize; ui32_i++)
    {
        ui16_CRC  = (uint16_t)((ui16_CRC >> 8u) |
            ((uint16_t)((uint32_t)ui16_CRC << 8u)));
        ui16_CRC ^= pui8_Data[ui32_i];
        ui16_CRC ^= (uint16_t)((ui16_CRC & 0xFFu) >> 4u);
        ui16_CRC ^= (uint16_t)((ui16_CRC << 8u) << 4u);
        ui16_CRC ^= (uint16_t)(((ui16_CRC & 0xFFu) << 4u) << 1u);
    }
    ui16_CRC = (uint16_t)( 0x0000FFFFul &
        ((uint32_t)~(uint32_t)ui16_CRC) );
    return ui16_CRC;
}

#define POLYNOMIAL 0xa001 // Generated polynomial expression CRC-16

typedef unsigned char uint8_t;
typedef unsigned short uint16_t;
typedef unsigned long uint32_t;

uint16_t CRC16(uint8_t *pData, uint32_t iSize)
{
    uint16_t crcdData = (uint16_t)0;
    uint32_t data = 0;
    uint32_t i, cycLoop;
    for(i=0;i<iSize;i++){
        data = (uint32_t)pData[i];
        crcdData = crcdData ^ data;
        for (cycLoop = 0; cycLoop < 8; cycLoop++) {
            if (crcdData & 1) {
                crcdData = (crcdData >> 1) ^ POLYNOMIAL;
            } else {
                crcdData = crcdData >> 1;
            }
        }
    }
    return crcdData;
}
-padding

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-padding

[Description]

- Fills in padding data at the end of a section so that the section size is a multiple of the boundary alignment of the section.
- The file name is <output file>.jmp.

[Examples]

- -start=P,C/0 -padding
  - When the boundary alignment of section P is 4 bytes, the size of section P is 0x06 bytes, the boundary alignment of section C is 1 byte, and the size of section C is 0x03 bytes, two bytes of padding data is filled in section P to make its size become 0x08 bytes and then linkage is performed.

- -start=P/0,C/7 -padding
  - When the boundary alignment of section P is 4 bytes, the size of section P is 0x06 bytes, the boundary alignment of section C is 1 byte, and the size of section C is 0x03 bytes, if two bytes of padding data is filled in section P to make its size become 0x08 bytes and then linkage is performed, error L2321 will be output because section P overlaps with section C.

[Remarks]

- The value of the created padding data is 0x00.
- Since padding is not performed to an absolute address section, the size of an absolute address section should be adjusted by the user.
-vectn

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-vectn = <suboption>[,...]
   <suboption>: <vector number> = {<symbol> | <address>}

[Description]

- Assigns the specified address to the specified vector number in the variable vector table section.
- When this option is specified, a variable vector table section is created and the specified address is set in the table even if there is no interrupt function in the source code.
- Specify a decimal value from 0 to 255 for <vector number>.
- Specify the external name of the target function for <symbol>.
- Specify the desired hexadecimal address for <address>.
- [V3.00.00 or later] When split_vect is not specified, set a value in an unused area which is not specified with vectn according to the following priority.
  1. Value specified with the vect option
  2. If there is a defined symbol with the name (internal name) of "__dummy_int" in the link target, the address of that symbol
  3. If there is a defined symbol with the name (internal name) of "dummy_int" in the link target, the address of that symbol
  4. 0 for cases other than any of the above
When split_vect is specified, a section for each vector number is not generated for an unused area which is not specified with vectn.

[Examples]

-vectn=30=_f1,31=0000F100 ;Specifies the _f1 address for vector number 30 and 0x0f100 for vector number 31

[Remarks]

- This option is ignored when the user creates a variable vector table section in the source program because the variable vector table is not automatically created in this case.
-vect

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

-vect={<symbol>|<address>}

[Description]

- Assigns the specified address to the vector number to which no address has been assigned in the variable vector table section.
- When this option is specified, a variable vector table section is created by the linkage editor and the specified address is set in the table even if there is no interrupt function in the source code.
- Specify the external name of the target function for <symbol>.
- Specify the desired hexadecimal address for <address>.
- The file name is <output file>.jmp.

[Remarks]

- This option is ignored when the user creates a variable vector table section in the source program because the variable vector table is not automatically created in this case.
- When the {<symbol>|<address>} specification is started with 0, the whole specification is assumed as an address.
**-split_vect [V3.00.00 or later]**

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

| -split_vect |

[Description]

- This option generates vector table sections split by vector table number.
- A vector table section is not generated for an unused area of the vector table number.

[Example]

- To generate a vector table section "C$VECT14" for vector table number 14, code as:

  ```
  -vectn=14=__dummy -split_vect
  ```

[Remarks]

- This option is invalid when the -vect option, -form={object | relocate | library} option, -strip option, or -extract option is specified at the same time.
- **jump_entries_for_pic**

  `< Optimizing Linkage Editor (rlink) Options / Output Options >`

  **[Format]**

  ```
  -jump_entries_for_pic=<section name>[,...]
  ```

  **[Description]**

  - Outputs an assembly-language source for a jump table to branch to external definition symbols in the specified section.
  - The file name is `<output file>.jmp`.

  **[Examples]**

  - A jump table for branching to external definition symbols in the sections `sct2` and `sct3` is output to `test.jmp`.

    ```
    jump_entries_for_pic=sct2,sct3
    output=test.abs
    ```

  - [Example of a file output to `test.jmp`]

    ```
    ;OPTIMIZING LINKAGE EDITOR GENERATED FILE 2009.07.19
    .glob _func01
    .glob _func02
    .SECTION P,CODE
    _func01:
    MOV.L #1000H,R14
    JMP R14
    _func02:
    MOV.L #2000H,R14
    JMP R14
    .END
    ```

  **[Remarks]**

  - This option is invalid when `form={object | relocate| library}` or `strip` is specified.
  - The generated jump table is output to the `P` section.
  - Only the program section can be specified for the type of section in the section name.
- **cfi [Professional Edition only] [V2.08.00 or later]**

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

```
-cfi
```

- Interpretation when omitted
  The function list for use in detecting illegal indirect function calls is not generated.

[Description]

- This option selects generation of the function list for use in detecting illegal indirect function calls. For details on detecting illegal indirect function calls, refer to the item on the `-control_flow_integrity [Professional Edition only] [V2.08.00 or later]` compile option.

- Since the linker generates the function list for the C section, the C section must be specified with the `-start` option at the time of linking.

- When an object file is created with `-control_flow_integrity` specified at the time of compilation, the linker generates the function list according to information that the compiler has automatically extracted.

- When an object file is created without `-control_flow_integrity` specified at the time of compilation, the linker generates function lists for all symbols that were resolved for relocation in the object file.

- To add specific functions to the function list, specify the `-cfi_add_func` optimizing linkage editor (rlink) option. When a function in the specific object file is to be exempted from the function list, specify the `-cfi_ignore_module` optimizing linkage editor (rlink) option.
- **-cfi_add_func [V2.08.00 or later]**

  `< Optimizing Linkage Editor (rlink) Options / Output Options >`

  **[Format]**

  ```
  -cfi_add_func={ <function symbol> | <function address> ][{, { <function symbol> | <function address> }}]...
  ```

  **[Description]**

  - This option registers the symbol or address of functions in the function list for use in detecting illegal indirect function calls.
    For details on detecting illegal indirect function calls, refer to the item on the `-control_flow_integrity [Professional Edition only] [V2.08.00 or later]` compile option.
  - Specify addresses in hexadecimal.
  - If the specified symbol of a function is not included in the load module that was optimized by the linker, an error will occur.
  - If this option is specified more than once, all specified symbols or addresses of functions are registered in the function list.
  - When this option is used, the `-cfi` option must also be specified. If the `-cfi` option is not specified, an error will occur.

  **[Example]**

  - To register the sub1 function of the C source code, function address 0x100, and the function sub2 in the C source code in the function list, write this as:

    ```
    -cfi_add_func=_sub1,100 -cfi_add_func=_sub2
    ```
- `cfi_ignore_module` [V2.08.00 or later]

  < Optimizing Linkage Editor (rlink) Options / Output Options >

**[Format]**

- `cfi_ignore_module=<suboption>[,...]`
  - `<suboption>`: `<module>` | `<library file>`{(<library module>
    [,<library module>]...}[,...]}

**[Description]**

- This option specifies object files to be exempted from the function list for use in detecting illegal indirect function calls. For details on detecting illegal indirect function calls, refer to the item on the `-control_flow_integrity [Professional Edition only] [V2.08.00 or later]` compiler option.
- [V3.00.00 or later] This option specifies object files or library files to be exempted from the function list for use in detecting illegal indirect function calls. The module name can be used to specify a module in a library file.
- If the specified object file does not exist, an error will occur.
- If this option is specified more than once, the functions of all specified object files are exempted from the function list.
- When this option is used, the `-cfi` option must also be specified. If the `-cfi` option is not specified, an error will occur.

**[Example]**

- To remove functions in a.obj, b.obj, and the d module in c.lib from the function list, code as:

  ```
  -cfi_ignore_module=a.obj,b.obj -cfi_ignore_module=c.lib(d)
  ```
-create_unfilled_area [V2.03.00 or later]

< Optimizing Linkage Editor (rlink) Options / Output Options >

[Format]

`-create_unfilled_area`

[Description]

- This option is available in V2.03 and later versions of this compiler.
- When a Motorola S-record file `<name>.mot` or Hex file `<name>.hex` is output, this option blocks spaces created by `.OFFSET` directives in the assembly language being filled with output data.
- When using this option, specify it when using the `ccrx` or `asrx` command to create an object file `<name>.obj` as well as when using the `rlink` command to create a Motorola S-record file or Hex file.
List Options

< Optimizing Linkage Editor (rlink) Options / List Options >

The following list options are available.

- -list
- -show
-list

< Optimizing Linkage Editor (rlink) Options / List Options >

[Format]

- list [=<file name>]

[Description]

- Specifies list file output and a list file name.
- If no list file name is specified, a list file with the same name as the output file (or first output file) is created, with the extension lbp when form=library or extract is specified, or map in other cases.
- Even if the section allocation address exceeds the allowable address range, this option outputs the link map information and symbol information. In this case, ***OVER*** is output. [V2.06.00 or later]
-show

< Optimizing Linkage Editor (rlink) Options / List Options >

[Format]

```
-show [=<sub>({ symbol | reference | section | xreference | total_size | vector | struct | relocation_attribute | all})]
```

[Description]

- Specifies output contents of a list.
- Table 2.17 lists the suboptions.
- For details of list examples, refer to Linkage List, and Library List in the user's manual.

Table 2.17 Suboptions of show Option

<table>
<thead>
<tr>
<th>No</th>
<th>Output Format</th>
<th>Suboption Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>form=library</td>
<td>symbol</td>
<td>Outputs a symbol name list in a module (when extract is specified).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reference</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section</td>
<td>Outputs a section list in a module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>xreference</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total_size</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vector</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>relocation_attribute</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cfi</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>all</td>
<td>Not specifiable (when extract is specified). Outputs a symbol name list and a section list in a module (when form=library).</td>
</tr>
</tbody>
</table>
2. COMMAND REFERENCE

### Remarks

- The following table shows whether suboptions will be valid or invalid by all possible combinations of options `form`, `show`, and/or `show=all`.

<table>
<thead>
<tr>
<th>No</th>
<th>Output Format</th>
<th>Suboption Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Other than <code>form=library</code> is specified.</td>
<td>symbol</td>
<td>Outputs symbol address, size, type, and optimization contents.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reference</td>
<td>Outputs the number of symbol references.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>section</td>
<td>Not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>xreference</td>
<td>Outputs the cross-reference information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total_size</td>
<td>Shows the total sizes of sections allocated to the ROM and RAM areas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vector</td>
<td>Outputs vector information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>struct</td>
<td>Outputs structure/union member information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>relocation_attribute</td>
<td>When <code>-form=abs</code> is specified and <code>-strip</code> is not specified, the relocation attribute corresponding to the section is output. When <code>-form=hex/bin/stype</code> is specified and the input file format is not <code>absolute/hex/stype</code>, the relocation attribute corresponding to the section is output. Otherwise, <code>relocation_attribute</code> is not specified.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cfi</td>
<td>Outputs the function list for use in detecting illegal indirect function calls. <code>cfi</code> must be specified with <code>-cfi</code> option (Otherwise an error will occur). <code>cfi</code> is specifiable when <code>-form=abs</code> option is specified and <code>-strip</code> option is not specified, or <code>-form=hex/bin/stype</code> option is specified and input files are <code>absolute/hex/stype</code>. Otherwise, <code>cfi</code> is not specifiable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>all</td>
<td>If <code>form=rel</code> the linkage editor outputs the same information as when <code>show=symbol,xreference,total_size</code> is specified. If <code>form=rel,data_stuff</code> have been specified, the linkage editor outputs the same information as when <code>show=symbol,total_size</code> is specified. If <code>form=abs</code> the linkage editor outputs the same information as when <code>show=symbol,reference,xreference,total_size,struct</code> is specified. If <code>form=hex/stype/bin</code> the linkage editor outputs the same information as when <code>show=symbol,reference,xreference,total_size,struct</code> is specified. If <code>form=obj</code>, <code>all</code> is not specifiable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>form=abs</th>
<th>Symbol</th>
<th>Reference</th>
<th>Section</th>
<th>Xreference</th>
<th>Vector</th>
<th>Total_size</th>
<th>relocation_attribute</th>
<th>cfi</th>
</tr>
</thead>
<tbody>
<tr>
<td>show</td>
<td>Valid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td>show=all</td>
<td>Valid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Valid</td>
<td>Valid</td>
<td>Valid</td>
<td>Valid</td>
<td>Invalid</td>
</tr>
<tr>
<td>form=lib</td>
<td>show</td>
<td>Valid</td>
<td>Invalid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td>show=all</td>
<td>Valid</td>
<td>Invalid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td>form=rel</td>
<td>show</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td>show=all</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>ValidNote</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
</tbody>
</table>

[Remarks]

- The following table shows whether suboptions will be valid or invalid by all possible combinations of options `form`, `show`, and/or `show=all`.
### Note
The option is invalid if an absolute-format file is input.

- Note the following limitations on output of the cross-reference information.
  - When an absolute-format file is input, the referrer address information is not output.
  - Information about references to constant symbols within the same file is not output.
  - When optimization is specified at compilation, information about branches to immediate subordinate functions is not output.
  - When optimization of access to external variables is specified, information about references to variables other than base symbols is not output.
  - Both `show=total_size` and `total_size` output the same information.
  - When `show=reference` is valid, the number of references of the variable specified by `#pragma address` is output as 0.

<table>
<thead>
<tr>
<th>Form</th>
<th>Symbol</th>
<th>Reference</th>
<th>Section</th>
<th>Xreference</th>
<th>Vector</th>
<th>Total_size</th>
<th>reloc</th>
<th>cfi</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>form=obj</code></td>
<td>show</td>
<td>Valid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td></td>
<td>show=all</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td><code>form=hex/bin/sty</code></td>
<td>show</td>
<td>Valid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
<td>Invalid</td>
</tr>
<tr>
<td></td>
<td>show=all</td>
<td>Valid</td>
<td>Valid</td>
<td>Invalid</td>
<td>Valid</td>
<td>Valid (\text{Note})</td>
<td>Valid (\text{Note})</td>
<td>Invalid</td>
</tr>
</tbody>
</table>

### Form Validation

<table>
<thead>
<tr>
<th>Symbol Reference Section Xreference Vector Total_size reloc</th>
<th>cfi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>form=obj</strong> show</td>
<td>Valid</td>
</tr>
<tr>
<td>show=all</td>
<td>Valid</td>
</tr>
<tr>
<td><strong>form=hex/bin/sty</strong> show</td>
<td>Valid</td>
</tr>
<tr>
<td>show=all</td>
<td>Valid</td>
</tr>
</tbody>
</table>

Note: The option is invalid if an absolute-format file is input.

- When an absolute-format file is input, the referrer address information is not output.
- Information about references to constant symbols within the same file is not output.
- When optimization is specified at compilation, information about branches to immediate subordinate functions is not output.
- When optimization of access to external variables is specified, information about references to variables other than base symbols is not output.
- Both `show=total_size` and `total_size` output the same information.
- When `show=reference` is valid, the number of references of the variable specified by `#pragma address` is output as 0.
Optimize Options

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

The following optimize options are available.

- -optimize
- -nooptimize
- -samesize
- -symbol_forbid
- -samecode_forbid
- -section_forbid
- -absolute_forbid
-optimize

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

[Format]

-optimize [ = <suboption>[,...] ]

<suboption>: ( SYmbol_delete | SAME_code | SHort_format | Branch | SPeed | SAFe )

- [Default]
  When this option is omitted, the default is optimize.

[Description]

- When optimize is specified, optimization is performed for the file specified with the goptimize option at compilation or assembly.
- -optimize (no suboptions) executes all optimization. It has the same meaning as
  -optimize=symbol_delete,same_code,short_format,branch.
- -optimize=speed executes optimizations other than those reducing object speed. It has the same meaning as
  -optimize=symbol_delete,short_format,branch
- -optimize=safe executes optimization other than those limited by variable or function attributes. It has the same mean-
  ing as -optimize=short_format,branch
- Other suboptions mean optimization as the following table.

Table 2.18  Suboptions of optimize Option

<table>
<thead>
<tr>
<th>Suboption</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>symbol_delete</td>
<td>Deletes variables/functions that are not referenced. Always be sure to specify #pragma entry at compilation or the entry option in the optimizing linkage editor.</td>
</tr>
<tr>
<td>same_code</td>
<td>Creates a subroutine for the same instruction sequence.</td>
</tr>
<tr>
<td>short_format</td>
<td>Replaces an instruction having a displacement or an immediate value with a smaller-size instruction when the code size of the displacement or immediate value can be reduced.</td>
</tr>
<tr>
<td>branch</td>
<td>Optimizes branch instruction size according to program allocation information. Even if this option is not specified, it is performed when any other optimization is executed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Program to be OptimizedNote1</th>
</tr>
</thead>
<tbody>
<tr>
<td>RXC</td>
</tr>
<tr>
<td>symbol_delete</td>
</tr>
<tr>
<td>same_code</td>
</tr>
<tr>
<td>short_format</td>
</tr>
<tr>
<td>branch</td>
</tr>
</tbody>
</table>

Notes 1. R XC: C/C++ program for RX Family, RXA: Assembly program for RX Family

[Remarks]

- When form={object | relocate | library} or strip is specified, this option is unavailable.
- optimize=symbol_delete is invalid unless the execution start address is specified by using either #pragma entry or the entry option.
-nooptimize

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

[Format]

-  -nooptimize

-  [Default]
   When this option is omitted, the default is optimize.

[Description]

-  When pnooptimize is specified, optimization is not performed at linkage.
-samesize

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

[Format]

-samesize = <size>

- [Default]
  When this option is omitted, the default is samesize=1E.

[Description]

- Specifies the minimum code size for the optimization with the same-code unification (optimize=same_code). Specify a hexadecimal value from 8 to 7FF.

[Remarks]

- When optimize=same_code is not specified, this option is unavailable.
-symbol_forbid

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

[Format]

```
-symbol_forbid = <symbol name> [,..]
```

[Description]
- Disables optimization regarding unreferenced symbol deletion. For a C/C++ variable or C function name, add an underscore (_) at the head of the definition name in the program. For a C++ function, enclose the definition name in the program with double-quotes including the parameter strings. When the parameter is void, specify as "<function name>()".

[Remarks]
- If optimization is not applied at linkage, this option is ignored.
-samecode_forbid

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

[Format]

-samecode_forbid = <function name> [, ...]

[Description]
- Disables optimization regarding same-code unification. For a C/C++ variable or C function name, add an underscore (_.) at the head of the definition name in the program. For a C++ function, enclose the definition name in the program with double-quotes including the parameter strings. When the parameter is **void**, specify as "<function name>( )".

[Remarks]
- If optimization is not applied at linkage, this option is ignored.
-section_forbid

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

[Format]

-section_forbid = <sub>[,...]
   <sub>: [<file name>|<module name>](<section name>)[,...])

[Description]

- Disables optimization for the specified section. If an input file name or library module name is also specified, the optimization can be disabled for a specific file, not only the entire section.

[Remarks]

- If optimization is not applied at linkage, this option is ignored.
- To disable optimization for an input file with its path name, type the path with the file name when specifying section_forbid.
### -absolute_forbid

< Optimizing Linkage Editor (rlink) Options / Optimize Options >

#### [Format]

```plaintext
-absolute_forbid = <address> [+<size>] [, ...]
```

#### [Description]
- Disables optimization regarding address + size specification.

#### [Remarks]
- If optimization is not applied at linkage, this option is ignored.
< Optimizing Linkage Editor (rlink) Options / Section Options >

The following section options are available.

- -start
- -fsymbol
- -aligned_section
-start

< Optimizing Linkage Editor (rlink) Options / Section Options >

[Format]

```
-start = <sub> [,...]
   <sub>: [{<section name> [[: | ,] <section name> [,...] }][]} [,...] /<address>]
```

- [Default]
The section is allocated at 0.

[Description]
- Specifies the start address of the section. Specify an address as the hexadecimal.
- The section name can be specified with wildcards "*". Sections specified with wildcards are expanded according to the input order.
- Two or more sections can be allocated to the same address (i.e., sections are overlaid) by separating them with a colon ":".
- Sections specified at a single address are allocated in the specification order.
- Sections to be overlaid can be changed by enclosing them by parentheses "()".
- Objects in a single section are allocated in the specification order of the input file or the input library.
- If no address is specified, the section is allocated at 0.
- A section which is not specified with the start option is allocated after the last allocation address.

[Examples]

This example shows how sections are allocated when the objects are input in the following order (names enclosed by parentheses are sections in the objects).

- tp1.obj(A,D1,E) -> tp2.obj(B,D3,F)) -> tp3.obj(C,D2,E,G) -> lib.lib(E)
- -start=A,B,C,D1:D2,D3,E,F:G/8000

0x400

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>E(tp1)</th>
<th>E(tp3)</th>
<th>E(lib)</th>
</tr>
</thead>
</table>

0x8000

<table>
<thead>
<tr>
<th>C</th>
<th>D1</th>
<th>D3</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Sections C, F, and G separated by colons are allocated to the same address.
- Sections specified with wildcards "*" (in this example, the sections whose names start with D) are allocated in the input order.
- Objects in the sections having the same name (E in this example) are allocated in the input order.
- An input library's section having the same name (E in this example) as those of input objects is allocated after the input objects.

- -start=A,B,C,D1:D2,D3,E,F:G/400
- The sections that come immediately after the colons (A, D2, and G in this example) are selected as the start and allocated to the same address.

- -start=A,B,C,(D1:D2,D3),E,(F:G)/400

  0x400

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>D3</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

  - When the sections to be allocated to the same address are enclosed by parentheses, the sections within parentheses are allocated to the address immediately after the sections that come before the parentheses (C and E in this example).

  - The section that comes after the parentheses (E in this example) is allocated after the last of the sections enclosed by the parentheses.

[Remarks]

- When form={object | relocate | library} or strip is specified, this option is unavailable.

- Parentheses cannot be nested.

- One or more colons must be written within parentheses. Parentheses cannot be written without a colon.

- Colons cannot be written outside of parentheses.

- When this option is specified with parentheses, optimization with the linkage editor is disabled.
-fsymbol

< Optimizing Linkage Editor (rlink) Options / Section Options >

[Format]

- fsymbol = <section name> [...]

[Description]

- Outputs externally defined symbols in the specified section to a file in the assembler directive format.
- The file name is <output file>.fsy.

[Examples]

- Outputs externally defined symbols in sections sct2 and sct3 to test.fsy.

```
fsymbol = sct2, sct3
output=test.abs
```

- [Output example of test.fsy]

```
;RENESAS OPTIMIZING LINKER GENERATED FILE 2012.07.19
;fsymbol = sct2, sct3
;SECTION NAME = sct2
.glb_f
_f: .equ 00000000h
.glb_g
_g: .equ 00000016h
;SECTION NAME = sct3
.glb_main
_main: .equ 00000020h
.end
```

[Remarks]

- When form=(object | relocate | library) or strip is specified, this option is unavailable.
-aligned_section

< Optimizing Linkage Editor (rlink) Options / Section Options >

[Format]

- aligned_section = <section name>[,...]

[Description]
- Changes the alignment value for the specified section to 16 bytes.

[Remarks]
- When form={object | relocate | library}, extract, or strip is specified, this option is unavailable.
Verify Options

- -cpu
- -contiguous_section
-cpu

< Optimizing Linkage Editor (rlink) Options / Verify Options >

[Format]

-cpu={ <memory type> = <address range> [, ...] | STRIDE}
   <memory type> = { ROM | RAM | FIX }
   <address range> = <start address> - <end address>

[Description]

- When cpu=stride is not specified, a section larger than the specified range of addresses leads to an error.
- When cpu=stride is specified, a section larger than the specified range of addresses is allocated to the next area of the same memory type or the section is divided.

[Examples]

- When the stride suboption is not specified:

  start=D1,D2/100
  cpu=ROM=100-1FF,RAM=200-2FF

  - The result is normal when D1 and D2 are respectively allocated within the ranges from 100 to 1FF and from 200 to 2FF. If they are not allocated within the ranges, an error will be output.

- When the stride suboption is specified:

  start=D1,D2/100
  cpu=ROM=100-1FF,RAM=200-2FF,ROM=300-3FF
  cpu=stride

  - The result is normal when D1 and D2 are allocated within the ROM area (regardless of whether the section is divided). A linkage error occurs when they are not allocated within the ROM area even though the section is divided.

  - Specify an address range in which a section can be allocated in hexadecimal notation. The memory type attribute is used for the inter-module optimization.

  - FIX for <memory type> is used to specify a memory area where the addresses are fixed (e.g. I/O area).

  - If the address range of <start>-<end> specified for FIX overlaps with that specified for another memory type, the setting for FIX is invalid.

  - When <memory type> is ROM or RAM and the section size is larger than the specified memory range, sub-option STRIDE can be used to divide a section and allocate them to another area of the same memory type. Sections are divided in module units.

  cpu=ROM=0-FFFF,RAM=10000-1FFFF

  - Checks that section addresses are allocated within the range from 0 to FFFF or from 10000 to 1FFFF.

  - Object movement is not provided between different attributes with the inter-module optimization.

  cpu=ROM=100-1FF,ROM=400-4FF,RAM=500-5FF
  cpu=stride

  - When section addresses are not allocated within the range from 100 to 1FF, the linkage editor divides the sections in module units and allocates them to the range from 400 to 4FF.
[Remarks]

- When `form=(object | relocate | library)` or `strip` is specified, this option is unavailable.
- When `cpu=stride` and `memory=low` are specified, this option is unavailable.
- When section B is divided by `cpu=stride`, the size of section `C$BSEC` increases by 8 bytes × number of divisions because this amount of information is required for initialization.
-contiguous_section

< Optimizing Linkage Editor (rlink) Options / Verify Options >

[Format]

-<contiguous_section>=<section name>[, ...]

[Description]
- Allocates the specified section to another available area of the same memory type without dividing the section when cpu=stride is valid.

[Examples]

```
start=P,PA,PB/100
cpu=ROM=100-1FF,ROM=300-3FF,ROM=500-5FF
cpu=stride
contiguous_section=PA
```

- Section P is allocated to address 100.
- If section PA which is specified as contiguous_section is over address 1FF, section PA is allocated to address 300 without being divided.
- If section PB which is not specified as contiguous_section is over address 3FF, section PB is divided and allocated to address 500.

[Remarks]
- When cpu=stride is invalid, this option is unavailable.
Other Options

< Optimizing Linkage Editor (rlink) Options / Other Options >

The following other options are available.

- `-s9`
- `-stack`
- `-compress`
- `-nocompress`
- `-memory`
- `-rename`
- `-lib_rename` [V3.01.00 or later]
- `-delete`
- `-replace`
- `-extract`
- `-strip`
- `-change_message`
- `-hide`
- `-total_size`
- `-verbose` [V3.03.00 or later]
-s9

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

```
-s9
```

[Description]
- Outputs the S9 record at the end even if the entry address exceeds 0x10000.

[Remarks]
- When form=stype is not specified, this option is unavailable.
-stack

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

-stack

[Description]

- Outputs a stack information file.
- The file name is `<output file name>.sni`.

[Remarks]

- When `form={object | relocate | library}` or `strip` is specified, this option is unavailable.
-compress

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

```
-compress
```

- [Default]
  If this option is omitted, the debugging information is not compressed.

[Description]
- The debugging information is compressed.
- By compressing the debugging information, the debugger loading speed is improved.

[Remarks]
- When `form={object | relocate | library | hexadecimal | stype | binary}` or `strip` is specified, this option is unavailable.
-nocompress

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

```
-nocompress
```

- [Default]
  If this option is omitted, the debugging information is not compressed.

[Description]

- The debugging information is not compressed.
- If the **nocompress** option is specified, the link time is reduced.
- **-memory**

< Optimizing Linkage Editor (rlink) Options / Other Options >

**[Format]**

```
-memory = [ High | Low ]
```

- [Default]
The default for this option is **memory = high**.

**[Description]**

- Specifies the memory size occupied for linkage.
- When **memory = high** is specified, the processing is the same as usual.
- When **memory = low** is specified, the linkage editor loads the information necessary for linkage in smaller units to reduce the memory occupancy. This increases file accesses and processing becomes slower when the occupied memory size is less than the available memory capacity.
- **memory = low** is effective when processing is slow because a large project is linked and the memory size occupied by the linkage editor exceeds the available memory in the machine used.

**[Remarks]**

- When one of the following options is specified, the **memory=low** option is unavailable:
  - When **form=absolute, hexadecimal, stype, or binary** is specified:
    - **compress, delete, rename, map, stack, cpu=stride, or list** and **show=[{reference | xreference}]** are specified in combination.
  - When **form=library** is specified:
    - **delete, rename, extract, hide, replace, or allow_duplicate_module_name**
  - When **form=object or relocate** is specified:
    - **extract**
  - Some combinations of this option and the input or output file format are unavailable.
-rename

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

-renamer = <suboption> [, ...]
  <suboption>: [[<file>] (<name> = <name> [, ...])
  | [<module>] (<name> = <name> [, ...] ) ]}

[Description]
- Modifies an external symbol name or a section name.
- Symbol names or section names in a specific file or library in a module can be modified.
- For a C/C++ variable name, add an underscore (_) at the head of the definition name in the program.
- When a function name is modified, the operation is not guaranteed.
- If the specified name matches both section and symbol names, the symbol name is modified.
- If there are several files or modules of the same name, the priority depends on the input order.

[Examples]

rename=(_sym1=data) ; Modifies _sym1 to data.
rename=lib1(P=P1)   ; Modifies the section P to P1
                     ; in the library module lib1.

[Remarks]
- When extract or strip is specified, this option is unavailable.
- When form=absolute is specified, the section name of the input library cannot be modified.
- Operation is not guaranteed if this option is used in combination with compile option -merge_files.
### -lib_rename [V3.01.00 or later]

< Optimizing Linkage Editor (rlink) Options / Other Options >

#### [Format]

```plaintext
-lib_rename = <name1>=<name2>,...
-lib_rename = <file>({<name1>=<name2>,...})
-lib_rename = "<file>|<module>[|<module>...]{<name1>=<name2>,...})"
```

#### [Description]

- This option changes the name of global symbol or section included in a module within the library that was specified by the `-library` option.
- Specify the symbol name or section name to be changed as `<name 1>`. Specify the symbol name or section name after the change as `<name 2>`.
- When a C variable name is specified, add prefix "_" to the definition name in the program.
- If the specified name matches both section and symbol names, the symbol name is changed.
- If there are two or more files or modules with the same name, the priority depends on the input order.
- If this option is specified more than once, all specifications will be valid.
- An error will occur in any of the following cases.
  - When the specified `<name>`, `<file>`, or `<module>` cannot be found
  - When the parameter is omitted

#### [Examples]

- To change ",sym1" in b.lib and c.lib to ",data", describe as:
  ```plaintext
  > rlink a.obj -lib=b.lib,c.lib -lib_rename=(,sym1=,data)
  ```

- To change ",sym1" in all modules in b.lib to ",data", describe as:
  ```plaintext
  > rlink a.obj -lib=b.lib,c.lib -lib_rename=b.lib,(sym1=,data)
  ```

- To change ",sym1" in modules m1 and m2 in b.lib to ",data", describe as:
  ```plaintext
  > rlink a.obj -lib=b.lib,c.lib -lib_rename="b.lib|m1|m2,(sym1=,data)"
  ```

#### [Remarks]

- If this option is specified together with the `-form={object|library}, -extract, or -strip` option, an error will occur.
- When the `-form={absolute|hexadecimal|stype|binary}` option is specified, the `-show=struct` option cannot be specified together. Thus, the section name of the input library cannot be changed.
- Correct operation is not guaranteed if this option is used in combination with the compiler option `-merge_files`.
-delete

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

```
-delete = <suboption> [,...]
   <suboption>: [[<file>] (<name>[,...]) | <module>]
```

[Description]

- Deletes an external symbol name or library module.
- Symbol names or modules in the specified file can be deleted.
- For a C/C++ variable name or C function name, add an underscore (_) at the head of the definition name in the program. For a C++ function name, enclose the definition name in the program with double-quotes including the parameter strings. If the parameter is void, specify as "<function name>()". If there are several files or modules of the same name, the file that is input first is applied.
- When a symbol is deleted using this option, the object is not deleted but the attribute is changed to the internal symbol.

[Examples]

```
delete=(_sym1) ; Deletes the symbol _sym1 in all files.
delete=file1.obj(_sym2) ; Deletes the symbol _sym2 in the file file1.obj.
```

[Remarks]

- When extract or strip is specified, this option is unavailable.
- When form=library has been specified, this option deletes modules.
- When form={absolute|relocate|hexadecimal|stype|binary} has been specified, this option deletes external symbols.
- Operation is not guaranteed if this option is used in combination with compile option -merge_files.
-replace

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

-replace = <suboption> [,..]
  <suboption>: <file name> [ ( <module name> [,..] ) ]

[Description]

- Replaces library modules.
- Replaces the specified file or library module with the module of the same name in the library specified with the library option.

[Examples]

replace=file1.obj ; Replaces the module file1 with the module file1.obj.
replace=lib1.lib(mdl1) ; Replaces the module mdl1 with the module mdl1
                      ; in the input library file lib1.lib.

[Remarks]

- When form={object | relocate | absolute | hexadecimal | stype | binary}, extract, or strip is specified, this option is unavailable.
- Operation is not guaranteed if this option is used in combination with compile option -merge_files.
- `extract`

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

```
extract = <module name> [, ...]
```

[Description]
- Extracts library modules.
- Extracts the specified library module from the library file specified using the `library` option.

[Examples]

```
extract=file1 ; Extracts the module file1.
```

[Remarks]
- When `form=(absolute | hexadecimal | stype | binary)` or `strip` is specified, this option is unavailable.
- When `form=library` has been specified, this option deletes modules.
- When `form=(absolute|relocate|hexadecimal|stype|binary)` has been specified, this option deletes external symbols.
-strip

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

- strip

[Description]

- Deletes debugging information in an absolute file or library file.
- When the strip option is specified, one input file should correspond to one output file.

[Examples]

```
input=file1.abs file2.abs file3.abs
strip
```

- Deletes debugging information of file1.abs, file2.abs, and file3.abs, and outputs this information to file1.abs, file2.abs, and file3.abs, respectively. Files before debugging information is deleted are backed up in file1.abk, file2.abk, and file3.abk.

[Remarks]

- When form={object | relocate | hexadecimal | stype | binary} is specified, this option is unavailable.
- `change_message`

  `< Optimizing Linkage Editor (rlink) Options / Other Options >`

  **[Format]**

  ```
  - `change_message = <suboption> [,...]`
    <suboption>: `<error level> [= <error number> [-<error number>] [,...]]`
    <error level>: `{Information | Warning | Error}
  ```

  **[Description]**

  - Modifies the level of information, warning, and error messages.
  - Specifies the execution continuation or abort at the message output.
  - When a message number is specified, the error level of the message with the specified error number changes to the given level.
  - A range of error message numbers can be specified by using a hyphen (-).
  - Each error number must consist of a component number (05), phase (6), and a four-digit value (e.g. 2310 in the case of E0562310).
  - If no error number is specified, all messages will be changed to the specified level.

  **[Examples]**

  ```
  change_message=warning=2310
  ```

  - This changes E0562310 to a warning-level message so that linkage proceeds even if E0562310 is output.

  ```
  change_message=error
  ```

  - This changes all information and warning messages to error level messages. When a message is output, the execution is aborted.
-hide

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

```
-hide
```

[Description]

- Deletes local symbol name information from the output file. Since all the name information regarding local symbols is deleted, local symbol names cannot be checked even if the file is opened with a binary editor. This option does not affect the operation of the generated file.

- Use this option to keep the local symbol names secret.

- The following types of symbol names are hidden:

  - C source: Variable or function names specified with the static qualifiers
  - C source: Label names for the goto statements
  - Assembly source: Symbol names of which external definition (reference) symbols are not declared

  Note: The entry function name is not hidden.

[Examples]

- The following is a C source example in which this option is valid:

```c
int g1;
int g2=1;
const int g3=3;
static int s1;  //<- The static variable name will be hidden.
static int s2=1;  //<- The static variable name will be hidden.
static const int s3=2;  //<- The static variable name will be hidden.

static int sub1()  //<- The static function name will be hidden.
{
  static int s1;  //<- The static variable name will be hidden.
  int l1;
  s1 = l1; l1 = s1;
  return(l1);
}

int main()
{
  sub1();
  if (g1==1)
    goto L1;
  g2=2;
  L1:  //<- The label name of the goto statement will be hidden.
    return(0);
}
```
[Remarks]

- This option is available only when the output file format is specified as `absolute`, `relocate`, or `library`.

- When the input file was compiled or assembled with the `goptimize` option specified, this option is unavailable if the output file format is specified as `relocate` or `library`.

- To use this option with the external variable access optimization, do not use this option for the first linkage, and use it only for the second linkage.

- The symbol names in the debugging information are not deleted by this option.
-total_size

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

-total_size

[Description]
- Sends total sizes of sections after linkage to standard output. The sections are categorized as follows, with the overall size of each being output.
  - Executable program sections
  - Non-program sections allocated to the ROM area
  - Sections allocated to the RAM area
- This option makes it easy to see the total sizes of sections allocated to the ROM and RAM areas.

[Remarks]
- The show=total_size option must be used if total sizes of sections are to be output in the linkage listing.
- When the ROM-support function (rom option) has been specified for a section, the section will be used by both the source (ROM) and destination (RAM) of the transfer. The sizes of sections of this type will be added to the total sizes of sections in both ROM and RAM.
-verbose [V3.03.00 or later]

< Optimizing Linkage Editor (rlink) Options / Other Options >

[Format]

-verbose=<sub>[, ...]
sub : crc

[Description]
- This option displays the contents specified by the suboption in the standard error output.
- The suboption below can be specified.

| CRC         | This suboption displays the CRC operation result and its output address. Valid when the crc option is specified. |

[Example]
- To display the CRC operation result and its output address in the standard error output, describe as:

  > rlink a.obj -form=stype -start=.SEC1/1000 -crc=2000=1000-10ff/CCITT -verbose=crc
Subcommand File Option

< Optimizing Linkage Editor (rlink) Options / Subcommand File Option >

The following subcommand file option is available.
- -subcommand
-subcommand

< Optimizing Linkage Editor (rlink) Options / Subcommand File Option >

[Format]

-subcommand = <file name>

[Description]

- Specifies options with a subcommand file.
- The format of the subcommand file is as follows:
  <option> { = | Δ } [<suboption> [...]] [ Δ& ] [:<comment>]
- The option and suboption are separated by an "=" sign or a space.
- For the input option, suboptions are separated by a space.
- One option is specified per line in the subcommand file.
- If a subcommand description exceeds one line, the description can be allowed to overflow to the next line by using an ampersand (&).

[Examples]

- Command line specification:

  rlink file1.obj -sub=test.sub file4.obj

- Subcommand specification:

  input   file2.obj file3.obj ; This is a comment.
  library lib1.lib, & ; Specifies line continued.
  lib2.lib

- Option contents specified with a subcommand file are expanded to the location at which the subcommand is specified on the command line and are executed.
- The order of file input is file1.obj, file2.obj, file3.obj, and file4.obj.
Options Other Than Above

< Optimizing Linkage Editor (rlink) Options / Options Other Than Above >

The following options other than above are available.

- -logo
- -nologo
- -end
- -exit
-logo

< Optimizing Linkage Editor (rlink) Options / Options Other Than Above >

[Format]

- logo

- [Default]
  When this option is omitted, the copyright notice is output.

[Description]

- The copyright notice is output.
-nologo

< Optimizing Linkage Editor (rlink) Options / Options Other Than Above >

[Format]

-nologo

- [Default]
  When this option is omitted, the copyright notice is output.

[Description]

- Output of the copyright notice is disabled.
-end

< Optimizing Linkage Editor (rlink) Options / Options Other Than Above >

[Format]

-end

[Description]

- Executes option strings specified before END. After the linkage processing is terminated, option strings that are specified after END are input and the linkage processing is continued.
- This option cannot be specified on the command line.

[Examples]

input=a.obj,b.obj ; Processing (1)
start=P,C,D/100,B/8000 ; Processing (2)
output=a.abs ; Processing (3)
end
input=a.abs ; Processing (4)
form=stype ; Processing (5)
output=a.mot ; Processing (6)

- Executes the processing from (1) to (3) and outputs a.abs. Then executes the processing from (4) to (6) and outputs a.mot.
- **exit**

< Optimizing Linkage Editor (rlink) Options / Options Other Than Above >

### Format

```
-exit
```

### Description
- Specifies the end of the option specifications.
- This option cannot be specified on the command line.

### Examples
- Command line specification:

```
rlink -sub=test.sub -nodebug
```

- test.sub:

```
input=a.obj,b.obj ; Processing (1)
start=P,C,D/100,B/8000 ; Processing (2)
output=a.abs ; Processing (3)
exit
```

- Executes the processing from (1) to (3) and outputs **a.abs**.
- The **nodebug** option specified on the command line after **exit** is executed is ignored.
2.5.4 Library Generator Options

<table>
<thead>
<tr>
<th>Classification</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library Options</td>
<td>-head</td>
<td>Specifies a configuration library.</td>
</tr>
<tr>
<td></td>
<td>-output</td>
<td>Specifies an output library file name.</td>
</tr>
<tr>
<td></td>
<td>-nofloat</td>
<td>Creates a simple I/O function.</td>
</tr>
<tr>
<td></td>
<td>-reent [V2.03.00 or later]</td>
<td>[To be supported by V2.03 and later versions] Creates a reentrant library.</td>
</tr>
<tr>
<td></td>
<td>-lang</td>
<td>Selects the set of functions available from the C standard library.</td>
</tr>
<tr>
<td></td>
<td>-simple_stdio</td>
<td>Creates a functionally cut down version of the set of I/O functions.</td>
</tr>
<tr>
<td></td>
<td>-secure_malloc [Professional Edition only] [V2.05.00 or later]</td>
<td>Generates the calloc, free, malloc and realloc with security facility.</td>
</tr>
<tr>
<td></td>
<td>-logo</td>
<td>Outputs the copyright.</td>
</tr>
<tr>
<td></td>
<td>-nologo</td>
<td>Disables output of the copyright.</td>
</tr>
</tbody>
</table>
Library Options

< Library Generator Options / Library Options >

The following library options are available.
- -head
- -output
- -nofloat
- -reent [V2.03.00 or later]
- -lang
- -simple_stdio
- -secure_malloc [Professional Edition only] [V2.05.00 or later]
- -logo
- -nologo
**-head**

< Library Generator Options / Library Options >

[Format]

```
-\texttt{-head=\{all | runtime | ctype | math | mathf | stdarg | stdio | stdlib | string | ios | new | complex | cppstring | c99_complex | fenv | inttypes | wchar | wctype\}}
```

- [Default]
  The default for this option is \texttt{head=all}.

[Description]

- This option specifies a configuration file with a header file name.
- When \texttt{head=all} is specified, all header file names will be configured.
- The runtime library is always configured.
-output

< Library Generator Options / Library Options >

[Format]

-output=<file name>

- [Default]
The default for this option is output=stdlib.lib.

[Description]
- This option specifies an output file name.
-nofloat

< Library Generator Options / Library Options >

[Format]

```
-nofloat
```

[Description]

- This option creates simple I/O functions that do not support the conversion of floating-point numbers (%f, %e, %E, %g, %G).
- When inputting or outputting files that do not require the conversion of floating-point numbers, ROM can be saved. Target functions: fprintf, fscanf, printf, scanf, sprintf, sscanf, vfprintf, vprintf, and vsprintf

[Remarks]

- In a library created with this option specified, correct operation cannot be guaranteed when floating-point numbers are input to or output from the target functions.
-reent [V2.03.00 or later]

< Library Generator Options / Library Options >

[Format]

```
-reent
```

[Description]

- This option creates reentrant libraries.
- Note that the rand, srand and EC++ library functions are not reentrant libraries.

[Remarks]

- This option is available in V2.03 and later versions of this compiler.
- When reentrant libraries are linked, use `#define` to define the macro name of `__REENTRANT` before including standard include files in the program or use the `-define` option to define `__REENTRANT` at compilation.
-lang

< Library Generator Options / Library Options >

[Format]

- lang = { c | c99 }

- [Default]
The default for this option is lang=c.

[Description]

- This option selects which functions are to be usable in the C standard library.
- When lang=c is specified, only the functions conforming to the C89 standard are included in the C standard library, and the extended functions of the C99 standard are not included. When lang=c99 is specified, the functions conforming to the C89 standard and the functions conforming to the C99 standard are included in the C standard library.

[Remarks]

- There are no changes in the functions included in the C++ and EC++ standard libraries.
- When lang=c99 is specified, all functions including those specified by the C99 standard can be used. Since the number of available functions is greater than when lang=c is specified, however, generating a library may take a long time.
-simple_stdio

< Library Generator Options / Library Options >

[Format]

-skip_stdio

[Description]

- This option creates a functional cutdown version of I/O functions.
- The functional cutdown version does not include the conversion of floating-point numbers (same as the function not supported with the nofloat option), the conversion of long long type, and the conversion of 2-byte code. When inputting or outputting files that do not require these functions, ROM can be saved.
  Target functions: fprintf, fscanf, printf, scanf, sprintf, sscanf, vfprintf, vprintf, and vsprintf

[Remarks]

- In a library created with this option specified, correct operation cannot be guaranteed when a cutdown function is used in the target functions.
- This function is disabled during C++ and EC++ program compilation.
-secure_malloc [Professional Edition only] [V2.05.00 or later]

< Library Generator Options / Library Options >

[Format]

-secure_malloc

[Description]

This option creates the calloc, free, malloc, and realloc functions to which a security facility for detecting illegal operations to storage areas has been added.

When one of the following operations is performed, the __heap_chk_fail function is called.
- The pointer to an area other than that allocated by calloc, malloc, or realloc is passed to free or realloc.
- The pointer to an area released by free is passed again to free or realloc.
- A value is written to up to four bytes before and after the area allocated by calloc, malloc, or realloc and the pointer to that area is passed to free or realloc.

The same facility is also added to the new and delete operators in C++ programs.

The __heap_chk_fail function needs to be defined by the user and it describes the processing to be executed when an error occurs in management of dynamic memory.

Note the following points when defining the __heap_chk_fail function.
- The only possible type of return value is void and the __heap_chk_fail function does not have formal parameters.
- When defining the __heap_chk_fail function in a C++ program, add extern "C".
- Corruption of heap space should not be detected recursively in the __heap_chk_fail function.
- Do not define the function as static.

[Example]

```c
#include <stdlib.h>

void sub(int *ip) {
    ...
    free(ip);
}

int func(void) {
    int *ip;
    if ((ip = malloc(40 * sizeof(int))) == NULL)
        if ((ip = malloc(10 * sizeof(int))) == NULL) return(1);
    else sub(ip); /* First appearance of free */
    else
        ...
    free(ip); /* Second appearance of free */
    return(0);
}

#ifdef __cplusplus
extern "C" {
#endif

void __heap_chk_fail(void) {
    /* Processing when corruption of heap memory area is detected */
}

#ifdef __cplusplus
}
#endif
```
[Remarks]

The calloc, malloc, and realloc functions for the security facility allocate four extra bytes before and after each allocated area for the purpose of detecting writing to addresses outside the allocated area. This consumes more heap memory area than with the usual functions. Using the new operators in C++ programs will also consume more heap memory area.
-logo

< Library Generator Options / Library Options >

[Format]

- logo

- [Default]
  When this option is omitted, the copyright notice is output.

[Description]

- The copyright notice is output.
-nologo

< Library Generator Options / Library Options >

[Format]

- `nologo`

  - [Default]
    When this option is omitted, the copyright notice is output.

[Description]

- Output of the copyright notice is disabled.
In addition to the options in 2.5.4 Library Generator Options, the C/C++ compiler options can be specified in the library generator as options used for library compilation. However, the options listed below are invalid; they are not selected at library compilation.

Table 2.19 Invalid Options

<table>
<thead>
<tr>
<th>No.</th>
<th>Options that Become Invalid</th>
<th>Conditions for Invalidation</th>
<th>Library Configuration When Made Invalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>lang</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>include</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>define</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>undefined</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>message nomessage</td>
<td>Always invalid nomessage</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>change_message</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>file_inline_path</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>comment</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>check</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>output</td>
<td>Always invalid output=obj</td>
<td>None</td>
</tr>
<tr>
<td>11</td>
<td>noline</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>12</td>
<td>debug nodebug</td>
<td>Always invalid nodebug</td>
<td>None</td>
</tr>
<tr>
<td>13</td>
<td>listfile nolistfile show</td>
<td>Always invalid nolistfile</td>
<td>None</td>
</tr>
<tr>
<td>14</td>
<td>file_inline</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>15</td>
<td>asmcmd</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>16</td>
<td>lnkcmd</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>17</td>
<td>asmopt</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>18</td>
<td>lnkopt</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>19</td>
<td>logo nologo</td>
<td>Always invalid nologo</td>
<td>None</td>
</tr>
<tr>
<td>20</td>
<td>euc sjis latin1 utf8</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>21</td>
<td>outcode</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>22</td>
<td>subcommand</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>23</td>
<td>alias</td>
<td>Always invalid alias=noansi</td>
<td>None</td>
</tr>
<tr>
<td>24</td>
<td>pic pid</td>
<td>lang=cpp or at C++ source compilation None</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Options that Become Invalid</td>
<td>Conditions for Invalidation</td>
<td>Library Configuration When Made Invalid</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>25</td>
<td>ip_optimize</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>26</td>
<td>merge_files</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>27</td>
<td>whole_program</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>28</td>
<td>big5 gb2312</td>
<td>Always invalid Note2</td>
<td>None</td>
</tr>
<tr>
<td>29</td>
<td>map [V3.02.00 or later]</td>
<td>Always invalid Note3</td>
<td>smap</td>
</tr>
<tr>
<td>30</td>
<td>control_flow_integrity</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>31</td>
<td>create_unfilled_area [V3.00.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>32</td>
<td>stack_protector [V3.00.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>33</td>
<td>stack_protector_all [V3.00.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>34</td>
<td>misra2004 [V3.00.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>35</td>
<td>misra2012 [V3.00.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>36</td>
<td>misra_intermodule [V3.01.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>37</td>
<td>tfu [V3.01.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>38</td>
<td>truncated_address_initializer [V3.01.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>39</td>
<td>g_line [V3.02.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>40</td>
<td>tfu_version [V3.05.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
<tr>
<td>41</td>
<td>nosave_tfu [V3.05.00 or later]</td>
<td>Always invalid</td>
<td>None</td>
</tr>
</tbody>
</table>

Notes 1. Warning W0511171 is output.
Notes 2. Error F0593305 is output. (This library cannot be generated.)
Notes 3. Any specification of <file name> is ignored. Even if <file name> does not exist, no error is output.
3. OUTPUT FILES

This chapter describes the format and other aspects of files output by a build via each command.

3.1 Assemble List File

This section covers the contents and format of the assemble list file output by the assembler. The source list file contains the compilation and assembly results. Table 3.1 shows the structure and contents of the source list.

Table 3.1 Structure and Contents of Source List

<table>
<thead>
<tr>
<th>No</th>
<th>Output Information</th>
<th>Contents</th>
<th>Suboption Note</th>
<th>When -show Option is not Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Source information</td>
<td>C/C++ source code corresponding to assembly source code</td>
<td>-show=source</td>
<td>Not output</td>
</tr>
<tr>
<td>2</td>
<td>Object information</td>
<td>Machine code used in object programs and the assembly source code</td>
<td>None</td>
<td>Output</td>
</tr>
<tr>
<td>3</td>
<td>Statistics information</td>
<td>Total number of errors, number of source program lines, and size of each section</td>
<td>None</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>Command specification information</td>
<td>File names and options specified by the command</td>
<td>None</td>
<td>Output</td>
</tr>
</tbody>
</table>

Note Valid when the -listfile option is specified.

3.1.1 Source Information

The source information is included in the object information when the -show=source option is specified. For an example of source information, refer to the next section, Object Information.

3.1.2 Object Information

The following figure shows an example of object information output.

```
* RX FAMILY ASSEMBLER V2.00.00 [15 Feb 2013] * SOURCE LIST Mon Feb 18 20:15:19 2013
(1) (2) (3) (4)
LOC. OBJ. OXMDA SOURCE STATEMENT

;RX Family C/C++ Compiler (V2.00.00 [15 Feb 2013])
18-Feb-2013 20:15:19

;*** CPU TYPE ***
;-ISA=RXV1

;*** COMMAND PARAMETER ***
;-output=src=sample.src
;-listfile
;-show=source
;sample.c
.glb_x
```
### CC-RX

#### 3. OUTPUT FILES

```assembly
.glb_func02
.glb_func03
.glb_func01

;LineNo. C-SOURCE STATEMENT

"SECTIONP, CODE"

_func02:
.STACK_func02=12
; 1 #include "include.h"
; 2 int func01(int);
; 3 int func03(int);
; 4
; 5 int func02(int z)

PUSHM R6=R7
MOV.L R1, R6

; 6 {
; 7 x = func01(z);
; 8 if (z == 2) {
; 9 x++;
; 10 } else {
; 11 x = func03(x + 2);

ADD #02H, R1

; 12 };
; 13 return x;
; 14 }

RTSD #08H, R6-R7

<Func03:>
.STACK_func03=4
; 15
; 16 int func03(int p)
; 17 {
; 18 return p+1;

ADD #01H, R1
; 19 }

RTS

"SECTIOND, ROMDATA, ALIGN=4"

:y:

.word00000001H
.END
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Location information (LOC.) Location address of the object code that can be determined at assembly.</td>
</tr>
<tr>
<td>(2)</td>
<td>Object code information (OBJ.) Object code corresponding to the mnemonic of the source code.</td>
</tr>
</tbody>
</table>
3.1.3 Statistics Information

The following figure shows an example of statistics information output.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Numbers of error messages and warning messages, and total number of source lines</td>
</tr>
<tr>
<td>(2)</td>
<td>Section information (section attribute, size, and section name)</td>
</tr>
</tbody>
</table>

---

### Line Information (0XMDA)

Results of source code processing by the assembler. The following shows the meaning of each symbol.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>Shows the nesting level of include files.</td>
</tr>
<tr>
<td>X</td>
<td>Shows the line where the condition is false in conditional assembly when <code>-show=conditions</code> is specified.</td>
</tr>
<tr>
<td>M</td>
<td>Shows the line expanded from a macro instruction when <code>-show=expansions</code> is specified.</td>
</tr>
<tr>
<td>D</td>
<td>Shows the line that defines a macro instruction when <code>-show=definitions</code> is specified.</td>
</tr>
<tr>
<td>S</td>
<td>Shows that branch distance specifier S is selected.</td>
</tr>
<tr>
<td>B</td>
<td>Shows that branch distance specifier B is selected.</td>
</tr>
<tr>
<td>W</td>
<td>Shows that branch distance specifier W is selected.</td>
</tr>
<tr>
<td>A</td>
<td>Shows that branch distance specifier A is selected.</td>
</tr>
<tr>
<td>*</td>
<td>Shows that a substitute instruction is selected for a conditional branch instruction.</td>
</tr>
</tbody>
</table>

### Source Information (SOURCE STATEMENT)

Contents of the assembly-language source file.

### C/C++ Source Line Number (LineNo.)

### C/C++ Source Statement (C-SOURCE STATEMENT)

C/C++ source statement output when the `-show=source` option is specified.
### 3.1.4 Compiler Command Specification Information

The file names and options specified on the command line when the compiler is invoked are output. The compiler command specification information is output at the beginning of the list file. The following figure shows an example of command specification information output.

```
;*** CPU TYPE *** (1)
;*-ISA=RXV1
;*** COMMAND PARAMETER *** (2)
;*-output=src=C:\tmp\elp1894\sample.src
;*-nologo
;*-show=source
;*sample.c
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Selected microcomputer</td>
</tr>
<tr>
<td>(2)</td>
<td>File names and options specified for the compiler</td>
</tr>
</tbody>
</table>

### 3.1.5 Assembler Command Specification Information

The file names and options specified on the command line when the assembler is invoked are output. The assembler command specification information is output at the end of the list file. The following figure shows an example of command specification information output.

```
Cpu Type (1)
-ISA=RXV1
Command Parameter (2)
-output=sample.obj
-nologo
-listfile=sample.lst
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Microcomputer selected for the assembler</td>
</tr>
<tr>
<td>(2)</td>
<td>File names and options specified for the assembler</td>
</tr>
</tbody>
</table>

### 3.2 Link Map File

This section explains the link map file. The link map has information of the link result. It can be referenced for information such as the section's allocation addresses.

#### 3.2.1 Structure of Linkage List

Table 3.2 shows the structure and contents of the linkage list.

<table>
<thead>
<tr>
<th>No</th>
<th>Output Information</th>
<th>Contents</th>
<th>When -show Option is Specified</th>
<th>When -show Option is not Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Option information</td>
<td>Option strings specified by a command line or subcommand</td>
<td>None</td>
<td>Output</td>
</tr>
</tbody>
</table>
### 3.2.2 Option Information

The option strings specified by a command line or a subcommand file are output. The following figure shows an example of option information output when `rlink -subcommand=test.sub -list -show` is specified.

```
(test.sub contents)
INPUT test.obj

*** Options ***
-sub=test.sub    (1)
-input test.obj  (2)
-list             (1)
-show             (1)
```

<table>
<thead>
<tr>
<th>No</th>
<th>Output Information</th>
<th>Contents</th>
<th>When -show Option is Specified</th>
<th>When -show Option is not Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Error information</td>
<td>Error messages</td>
<td>None</td>
<td>Output</td>
</tr>
<tr>
<td>3</td>
<td>Linkage map information</td>
<td>Section name, start/end addresses, size, and type</td>
<td>None</td>
<td>Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-show=relocation_attribute</td>
<td>Not output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>is specified, the relocation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>attribute is output.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Symbol information</td>
<td>Static definition symbol name, address, size, and type in the order of</td>
<td>-show=symbol</td>
<td>Not output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-show=reference</td>
<td>Not output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Symbol deletion optimization information</td>
<td>Symbols deleted by optimization</td>
<td>-show=symbol</td>
<td>Not output</td>
</tr>
<tr>
<td>6</td>
<td>Cross-reference information</td>
<td>Symbol reference information</td>
<td>-show=xreference</td>
<td>Not output</td>
</tr>
<tr>
<td>7</td>
<td>Total section size</td>
<td>Total sizes of RAM, ROM, and program sections</td>
<td>-show=total_size</td>
<td>Not output</td>
</tr>
<tr>
<td>8</td>
<td>Vector information</td>
<td>Vector numbers and address information</td>
<td>-show=vector</td>
<td>Not output</td>
</tr>
<tr>
<td>9</td>
<td>CRC information</td>
<td>CRC calculation result and output addresses</td>
<td>None</td>
<td>Always output when the CRC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>option is specified</td>
</tr>
<tr>
<td>10</td>
<td>CFI information</td>
<td>Contents of the function list for use in detecting illegal indirect</td>
<td>-show=cfi</td>
<td>Not output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The `-show` option is valid when the `list` option is specified.
### 3.2.3 Error Information

Error messages are output. The following figure shows an example of error information output.

```
*** Error Information ***
** E0562310 (E) Undefined external symbol "strcmp" referred to in "test.obj" (1)
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Outputs an error message.</td>
</tr>
</tbody>
</table>

**Note**
As the number for the alignment of code sections whose address is determined after linkage, when **big endian** is selected, a multiple of 4 is indicated regardless of the actual number for alignment at the time of compiling and assembling.

### 3.2.4 Linkage Map Information

The start and end addresses, size, and type of each section are output in the order of address. The following figure shows an example of linkage map information output.

```
*** Mapping List ***
(1)                               (2)        (3)        (4)   (5)      (6)
SECTION                           START      END        SIZE   ALIGN   ATTRIBUTE
P                                  00001000  00001000 1 1       CODE
C                                  00001004  00001007 4 4       ROMDATA
D_2                                00001008  000014dd 4d6 2       ROMDATA
B_2                                000014de  000050b3 3bd6 2       DATA
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Section name</td>
</tr>
<tr>
<td>(2)</td>
<td>Start address <strong>OVER</strong> being displayed here indicates that the address exceeded the range that can be expressed by 32 bits.</td>
</tr>
<tr>
<td>(3)</td>
<td>End address <strong>OVER</strong> being displayed here indicates that the address exceeded the range that can be expressed by 32 bits.</td>
</tr>
<tr>
<td>(4)</td>
<td>Section size</td>
</tr>
<tr>
<td>(5)</td>
<td>Section boundary alignment value</td>
</tr>
<tr>
<td>(6)</td>
<td>The relocation attribute is output</td>
</tr>
</tbody>
</table>
Note: As the number for the alignment of code sections whose address is determined after linkage, when big endian is selected, a multiple of 4 is indicated regardless of the actual number for alignment at the time of compiling and assembling.

3.2.5 Symbol Information

When `-show=symbol` is specified, the addresses, sizes, and types of externally defined symbols or static internally defined symbols are output in the order of address. When `-show=reference` is specified, the symbol reference counts and optimization information are also output. The following figure shows an example of symbol information output.

```
*** Symbol List ***
SECTION=(1)
(2) (3) (4) (5)
FILE= START END SIZE
(6) (7) (8) (9) (10) (11)
SYMBOL ADDR SIZE INFO COUNTS OPT
SECTION=P
FILE=test.obj
  _main 00000000 00000428          428
  _malloc 00000000           2      func ,g                 0
FILE=mvn3
  $MVN#3 00000428 00000490           68
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Section name</td>
</tr>
<tr>
<td>(2)</td>
<td>File name</td>
</tr>
<tr>
<td>(3)</td>
<td>Start address of a section included in the file indicated by (2) above</td>
</tr>
<tr>
<td>(4)</td>
<td>End address of a section included in the file indicated by (2) above</td>
</tr>
<tr>
<td>(5)</td>
<td>Section size of a section included in the file indicated by (2) above</td>
</tr>
<tr>
<td>(6)</td>
<td>Symbol name</td>
</tr>
<tr>
<td>(7)</td>
<td>Symbol address <strong>OVER</strong> being displayed here indicates that the address exceeded the range that can be expressed by 32 bits.</td>
</tr>
<tr>
<td>(8)</td>
<td>Symbol size</td>
</tr>
<tr>
<td>(9)</td>
<td>Symbol type as shown below Data type: func: Function name data: Variable name entry: Entry function name none: Undefined (label, assembler symbol) Declaration type g: External definition l: Internal definition</td>
</tr>
<tr>
<td>(10)</td>
<td>Symbol reference count only when <code>-show=reference</code> is specified. * is output when show=reference is not specified.</td>
</tr>
</tbody>
</table>
When the -show=struct option is specified, the addresses for the structure and union members that are defined in the source file for which the -debug option was specified at compilation are output. The output example of the symbol information is shown below.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(11)</td>
<td>Optimization information as shown below. ch: Symbol modified by optimization cr: Symbol created by optimization mv: Symbol moved by optimization</td>
</tr>
</tbody>
</table>

*** Symbol List ***

<table>
<thead>
<tr>
<th>SECTION=</th>
<th>FILE=</th>
<th>SYMBOL</th>
<th>START</th>
<th>END</th>
<th>SIZE</th>
<th>INFO</th>
<th>COUNTS</th>
<th>OPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION=B</td>
<td>FILE=tp.obj</td>
<td>_st</td>
<td>00000000</td>
<td>0000000b</td>
<td>c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>struct</td>
<td></td>
<td>00000000</td>
<td>c</td>
<td>data ,g</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_st.mem1</td>
<td></td>
<td>00000000</td>
<td>1</td>
<td>char</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_st.mem2</td>
<td></td>
<td>00000004</td>
<td>4</td>
<td>int</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_st.mem3</td>
<td></td>
<td>00000008</td>
<td>2</td>
<td>short</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number Description

| (1) | struct is output for a structure or union is output for a union. |
| (2) | Total size of the structure or union. |
| (3) | The member name is concatenated after a symbol name with a dot (.). |
| (4) | The member address is output. |
| (5) | The member size is output. |
| (6) | The member type is output. |

3.2.6 Symbol Deletion Optimization Information

The size and type of symbols deleted by symbol deletion optimization (-optimize=symbol_delete) are output. The following figure shows an example of symbol deletion optimization information output.

*** Delete Symbols ***

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SIZE</th>
<th>INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>_Version</td>
<td>4</td>
<td>data ,g</td>
</tr>
</tbody>
</table>
### 3.2.7 Cross-Reference Information

The symbol reference information (cross-reference information) is output when `-show=xreference` is specified. The following figure shows an example of cross-reference information output.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Deleted symbol name</td>
</tr>
<tr>
<td>(2)</td>
<td>Deleted symbol size</td>
</tr>
<tr>
<td>(3)</td>
<td>Deleted symbol type as shown below</td>
</tr>
<tr>
<td></td>
<td>Data type</td>
</tr>
<tr>
<td></td>
<td>func: Function name</td>
</tr>
<tr>
<td></td>
<td>data: Variable name</td>
</tr>
<tr>
<td></td>
<td>Declaration type</td>
</tr>
<tr>
<td></td>
<td>g: External definition</td>
</tr>
<tr>
<td></td>
<td>l: Internal definition</td>
</tr>
</tbody>
</table>

```
*** Cross Reference List ***
(1)   (2)        (3)             (4)         (5)         
No   Unit Name  Global.Symbol   Location    External Information
0001 a _func                 00000100
    _func1                00000116
    _main                 0000012c
    _g                    00000136
SECTION=B
    _a     00000190      0001(00000140:P)  
          0002(00000178:P)  
          0003(0000018c:P)  
0002 b SECTION=P
    _func01               00000154      0001(00000148:P)  
    _func02               00000166      0001(00000150:P)  
0003 c SECTION=P
    _func03               00000184  
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Unit number, which is an identification number in object units</td>
</tr>
<tr>
<td>(2)</td>
<td>Object name, which specifies the input order at linkage</td>
</tr>
<tr>
<td>(3)</td>
<td>Symbol name output in ascending order of allocation addresses for every section</td>
</tr>
</tbody>
</table>
3.2.8 Total Section Size

The total sizes of ROM, RAM, and program sections are output. The following figure shows an example of total section size output.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Total size of RAM data sections</td>
</tr>
<tr>
<td>(2)</td>
<td>Total size of ROM data sections</td>
</tr>
<tr>
<td>(3)</td>
<td>Total size of program sections</td>
</tr>
</tbody>
</table>

3.2.9 Vector Information

The contents of the variable vector table are output when -show=vector is specified. The following figure shows an example of vector information output.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Vector number</td>
</tr>
<tr>
<td>(2)</td>
<td>Symbol. When no symbol is defined for the vector number, the address is output.</td>
</tr>
</tbody>
</table>
3.2.10 CRC Information

The CRC calculation result and output address are output when the CRC option is specified.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>CRC calculation result</td>
</tr>
<tr>
<td>(2)</td>
<td>Address where the CRC calculation result is output</td>
</tr>
</tbody>
</table>

### *** CRC Code ***

**CODE** : cb0b  (1)
**ADDRESS** : 00007ffe  (2)

3.2.11 CFI Information

If `-show=cfi` is specified, this option outputs the contents of the function list for use in detecting illegal indirect function calls. The output example is given below.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Outputs the symbol for the function.</td>
</tr>
<tr>
<td>(2)</td>
<td>Outputs the address of the function if a symbol for it has not been defined.</td>
</tr>
</tbody>
</table>

### *** CFI Function List ***

**SYMBOL/ADDRESS**

_func  (1)
0000F100  (2)
3.3 Library List

This section covers the contents and format of the library list output by the optimizing linkage editor.

3.3.1 Structure of Library List

Table 3.3 shows the structure and contents of the library list.

Table 3.3 Structure and Contents of Library List

<table>
<thead>
<tr>
<th>No</th>
<th>Output Information</th>
<th>Contents</th>
<th>SuboptionNote</th>
<th>When -show Option is not Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Option information</td>
<td>Option strings specified by a com-</td>
<td>-</td>
<td>Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mand line or subcommand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Error information</td>
<td>Error messages</td>
<td>-</td>
<td>Output</td>
</tr>
<tr>
<td>3</td>
<td>Library information</td>
<td>Library information</td>
<td>-</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>Information of modules, sections, and symbols within library</td>
<td>Module within the library</td>
<td>-</td>
<td>Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>when show=symbol is specified: List of symbol names in a module within the library</td>
<td>-show=symbol</td>
<td>Not output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>when show=section is specified: Lists of section names and symbol names in a module within the library</td>
<td>-show=section</td>
<td>Not output</td>
</tr>
</tbody>
</table>

Note: All options are valid when the -list option is specified.

3.3.2 Option Information

The option strings specified by a command line or a subcommand file are output.

The following figure shows an example of option information output when rlink -subcommand=test.sub -list -show is specified.

```
(sub.sub contents)
form library
in adhry.obj
output test.lib

*** Options ***
-sub=test.sub
form library
in adhry.obj
output test.lib
-list
-show
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Outputs option strings specified by a command line or a subcommand in the specified order.</td>
</tr>
<tr>
<td>(2)</td>
<td>Subcommand in the test.sub subcommand file.</td>
</tr>
</tbody>
</table>
3.3.3 Error Information

Messages for errors or warnings are output.
The following figure shows an example of error information output.

```
*** Error Information ***
** W0561200 (W) Backed up file "main.lib" into "main.lbk"  (1)
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Outputs a warning message.</td>
</tr>
</tbody>
</table>

3.3.4 Library Information

The library type is output.
The following figure shows an example of library information output.

```
*** Library Information ***
LIBRARY NAME =test.lib (1)
CPU=RX610               (2)
ENDIAN=Big              (3)
ATTRIBUTE=system        (4)
NUMBER OF MODULE =1     (5)
```

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Library name</td>
</tr>
<tr>
<td>(2)</td>
<td>CPU name</td>
</tr>
<tr>
<td>(3)</td>
<td>Endian type</td>
</tr>
<tr>
<td>(4)</td>
<td>Library file attribute: either system library or user library</td>
</tr>
<tr>
<td>(5)</td>
<td>Number of modules within the library</td>
</tr>
</tbody>
</table>

3.3.5 Module, Section, and Symbol Information within Library

A list of modules within the library is output.
When `-show=symbol` is specified, the symbol names in a module within the library are listed. When `-show=section` is specified, the section names and symbol names in a module within the library are listed.
The following figure shows an output example of module, section, and symbol information within a library.
### Library List

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Module name</td>
</tr>
<tr>
<td>(2)</td>
<td>Module definition date</td>
</tr>
<tr>
<td>(3)</td>
<td>Section name within a module</td>
</tr>
<tr>
<td>(4)</td>
<td>Symbol within a section</td>
</tr>
</tbody>
</table>

#### Module List

<table>
<thead>
<tr>
<th>MODULE</th>
<th>LAST UPDATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>adhry</td>
<td>29-Feb-2000 12:34:56</td>
</tr>
<tr>
<td>P</td>
<td>_main, _Proc0, _Proc1</td>
</tr>
<tr>
<td>C</td>
<td>_Version</td>
</tr>
<tr>
<td>D</td>
<td>_IntGlob, _CharGlob</td>
</tr>
</tbody>
</table>
3.4 S-Type and HEX File Formats

This section describes the S-type files and HEX files that are output by the optimizing linkage editor.

3.4.1 S-Type File Format

Figure 3.1 S-Type File Format

(a) Header record (S0 record)

(b) Data record (S1, S2, and S3 records)

(i) When the load address is 0 to FFFF

(ii) When the load address is 10000 to FFFFFF
Figure 3.2  S-Type File Format (cont)

(iii) When the load address is 1000000 to FFFFFFFF

<table>
<thead>
<tr>
<th>S</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>33</td>
</tr>
</tbody>
</table>

- Load address (4 bytes)
- Byte count [1]
- Record format
- Record header
- Checksum [2]
- Data (16 bytes max.)

Notes:

[1] The number of bytes from the load address (or the entry address) to the checksum.

[2] 1’s complement of the sum of the byte count and the data between the checksum and the byte count, in byte units.


(c) End record (S9, S8, and S7 records)

(i) When the entry address is 0 to FFFF

<table>
<thead>
<tr>
<th>S</th>
<th>9</th>
<th>0</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>39</td>
<td>30</td>
<td>33</td>
</tr>
</tbody>
</table>

- Entry address (2 bytes)
- Byte count [1]
- Record format
- Record header
- Checksum [2]

(ii) When the entry address is 10000 to FFFFFF

<table>
<thead>
<tr>
<th>S</th>
<th>8</th>
<th>0</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>38</td>
<td>30</td>
<td>34</td>
</tr>
</tbody>
</table>

- Entry address (3 bytes)
- Byte count [1]
- Record format
- Record header
- Checksum [2]

(iii) When the entry address is 1000000 to FFFFFFFF

<table>
<thead>
<tr>
<th>S</th>
<th>7</th>
<th>0</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>37</td>
<td>30</td>
<td>35</td>
</tr>
</tbody>
</table>

- Entry address (4 bytes)
- Byte count [1]
- Record format
- Record header
- Checksum [2]
3.4.2 HEX File Format

The execution address of each data record is obtained as described below.

1. Segment address
   (Segment base address << 4) + (Address offset of the data record)

2. Linear address
   (Linear base address << 16) + (Address offset of the data record)

Figure 3.3 HEX File Format

(a) Data record (00 record)

(b) End record (01 record)

(c) Expansion segment address record (02 record)
Figure 3.4  HEX File Format (cont)

(d) Start address record (03 record)

<table>
<thead>
<tr>
<th>0</th>
<th>4</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>3</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
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<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

- **Record type**: 03
- **Address offset**: 4
- **Byte count**: 5
- **Start mark**: 0
- **Checksum**: [2]
- **Start address**: 0

(e) Expansion linear address record (04 record)

<table>
<thead>
<tr>
<th>0</th>
<th>2</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>4</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
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<th>XX</th>
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<tbody>
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</tbody>
</table>

- **Record type**: 04
- **Address offset**: 2
- **Byte count**: 6
- **Start mark**: 0
- **Linear base address**: 4
- **Checksum**: [2]

(f) 32-bit start linear address record (05 record)

<table>
<thead>
<tr>
<th>0</th>
<th>4</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>5</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
<th>XX</th>
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</tr>
</tbody>
</table>

- **Record type**: 05
- **Address offset**: 4
- **Byte count**: 6
- **Start mark**: 0
- **Start address**: 5
- **Checksum**: [2]

Notes:

[1] The number of bytes from the byte following the record type to the previous byte of the checksum.

[2] 2's complement of the sum of the byte count and the data between the byte count and checksum, in hexadecimal (lower 8 bits are valid).

4. COMPLIER LANGUAGE SPECIFICATIONS

4.1 Basic Language Specifications

The RXC supports the language specifications stipulated by the ANSI standards. These specifications include items that are stipulated as processing definitions. This chapter explains the language specifications of the items dependent on the processing system of the RX microcontrollers.

For extended language specifications explicitly added by the RXC, refer to section 4.2 Extended Language Specifications.

4.1.1 Unspecified Behavior

This section describes behavior that is not specified by the ANSI standard.

(1) Execution environment - initialization of static storage
    Static data is output during compilation as a data section.

(2) Meanings of character displays - backspace (\b), horizontal tab (\t), vertical tab (\v)
    This is dependent on the design of the display device.

(3) Types - floating point
    Conforms to IEEE754*.
    Note: IEEE: Institute of Electrical and Electronics Engineers
    IEEE754 is a system for handling floating-point calculations, providing a uniform standard for data formats, numerical ranges, and the like handled.

(4) Expressions - evaluation order
    In general, expressions are evaluated from left to right. The behavior when optimization has been applied, however, is undefined. Options or other settings could change the order of evaluation, so please do not code expressions with side effects.

(5) Function calls - parameter evaluation order
    In general, function arguments are evaluated from first to last. The behavior when optimization has been applied, however, is undefined. Options or other settings could change the order of evaluation, so please do not code expressions with side effects.

(6) Structure and union specifiers
    These are adjusted so that they do not span bit field type alignment boundaries. If packing has been conducting using options or a #pragma, then bit fields are packed, and not adjusted to alignment boundaries.

(7) Function definitions - storage of formal parameters
    These are assigned to the stack and register. For details, refer to section 9.1.3 Rules Concerning Setting and Referencing Parameters.

(8) # operator
    These are evaluated left to right.

4.1.2 Undefined Behavior

This section describes behavior that is not defined by the ANSI standard.

(1) Character set
    A message is output if a source file contains a character not specified by the character set.

(2) Lexical elements
    A message is output if there is a single or double quotation mark (""') in the last category (a delimiter or a single non-whitespace character that does not lexically match another preprocessing lexical type).

(3) Identifiers
    Since all identifier characters have meaning, there are no meaningless characters.

(4) Identifier binding
    A message is output if both internal and external binding was performed on the same identifier within a translation unit.
(5) Compatible type and composite type
All declarations referencing the same object or function must be compatible. Otherwise, a message will be output.

(6) Character constants
Specific non-graphical characters can be expressed by means of extended notation, consisting of a backslash (\) followed by a lower-case letter. The following are available: \a, \b, \f, \n, \r, \t, and \v. There is no other extended notation; other letters following a backslash (\) become that letter.

(7) String literals - concatenation
When a simple string literal is adjacent to a wide string literal token, simple string concatenation is performed.

(8) String literals - modification
Users modify string literals at their own risk. Although the string will be changed if it is allocated to RAM, it will not be changed if it is allocated to ROM.

(9) Header names
If the following characters appear in strings between the delimiter characters < and >, or between two double quotation marks ("), then they are treated as part of the file name: characters, comma (,), double quote ("), two slashes (/), or slash-asterisk (*). The backslash (\) is treated as a folder separator.

(10) Floating point type and integral type
If a floating-point type is converted into an integral type, and the integer portion cannot be expressed as an integral type, then the value is truncated until it can.

(11)IVALUES and function specifiers
A message is output if an incomplete type becomes an ivalue.

(12) Function calls - number of arguments
If there are too few arguments, then the values of the formal parameters will be undefined. If there are too many arguments, then the excess arguments will be ignored when the function is executed, and will have no effect. A message will be output if there is a function declaration before the function call.

(13) Function calls - types of extended parameters
If a function is defined without a function prototype, and the types of the extended arguments do not match the types of the extended formal parameters, then the values of the formal parameters will be undefined.

(14) Function calls - incompatible types
If a function is defined with a type that is not compatible with the type specified by the expression indicating the called function, then the return value of the function will be invalid.

(15) Function declarations - incompatible types
If a function is defined in a form that includes a function prototype, and the type of an extended argument is not compatible with that of a formal parameter, or if the function prototype ends with an ellipsis, then it will be interpreted as the type of the formal parameter.

(16) Addresses and indirection operators
If an incorrect value is assigned to a pointer, then the behavior of the unary * operator will either obtain an undefined value or result in an illegal access, depending on the hardware design and the contents of the incorrect value.

(17) Cast operator - function pointer casts
If a typecast pointer is used to call a function with other than the original type, then it is possible to call the function. If the parameters or return value are not compatible, then it will be invalid.

(18) Cast operator - integral type casts
If a pointer is cast into an integral type, and the amount of storage is too small, then the storage of the cast type will be truncated.

(19) Multiplicative operators
A message will be output if a divide by zero is detected during compilation. During execution, a divide by zero will raise an exception. If an error-handling routine has been coded, it will be handled by this routine.

(20) Additive operators - non-array pointers
If addition or subtraction is performed on a pointer that does other than indicate elements in an array object, the behavior will be as if the pointer indicates an array element.

(21) Additive operators - subtracting a pointer from another array
If subtraction is performed using two pointers that do not indicate elements in the same array object, the behavior will be as if the pointers indicate array elements.
(22) Bitwise shift operators
If the value of the right operand is negative, or greater than the bit width of the extended left operand, then the result will be the shifted value of the right operand, masked by the bit width of the left operand.

(23) Relational operators - pointers
If the objects pointed to by the pointers being compared are not members of the same structure or union object, then the relational operation will be performed as if it were for pointers pointing to members of the same structure or union object.

(24) Simple assignment
If a value stored in an object is accessed via another object that overlaps that object's storage area in some way, then the overlapping portion must match exactly. Furthermore, the types of the two objects must have modified or non-modified versions with compatible types. Assignment to non-matching overlapping storage could cause the value of the assignment source to become corrupted.

(25) Structure and union specifiers
If the member declaration list does not include named members, then a message will be output warning that the list has no effect. Note, however, that the same message will be output accompanied by an error if the -Xansi option is specified.

(26) Type modifiers - const
A message will be output if an attempt is made to modify an object defined with a const modifier, using an lvalue that is the non-const modified version. Casting is also prohibited.

(27) Type modifiers - volatile
A message will be output if an attempt is made to modify an object defined with a volatile modifier, using an lvalue that is the non-volatile modified version.

(28) return statements
A message will be output if a return statement without an expression is executed, and the caller uses the return value of the function, and there is a declaration. If there is no declaration, then the return value of the function will be undefined.

(29) Function definitions
If a function taking a variable number of arguments is defined without a parameter type list that ends with an ellipsis, then the values of the formal parameters will be undefined.

(30) Conditional inclusion
If a replacement operation generates a "defined" token, or if the usage of the "defined" unary operator before macro replacement does not match one of the two formats specified in the constraints, then it will be handled as an ordinary "defined".

(31) Macro replacement - arguments not containing preprocessing tokens
A message is output if the arguments (before argument replacement) do not contain preprocessing tokens.

(32) Macro replacement - arguments with preprocessing directives
A message is output if an argument list contains a preprocessor token stream that would function as a processing directive in another circumstance.

(33) # operator
A message is output if the results of replacement are not a correct simple string literal.

(34) ## operator
A message is output if the results of replacement are not a correct simple string literal.

4.1.3 Implementation-defined behavior of C90

(1) How to identify diagnostic messages (5.1.1.3).
Refer to "10. MESSAGES".

(2) The semantics of the arguments to main (5.1.2.2.1).
Not defined.

(3) What constitutes an interactive device (5.1.2.3).
Not defined for the configuration of an interactive device.

(4) The number of significant initial characters (beyond 31) in an identifier without external linkage (6.1.2).
The first 8,189 characters are handled as significant characters.

(5) The number of significant initial characters (beyond 6) in an identifier with external linkage (6.1.2).
The first 8,191 characters are handled as significant characters.

6. Whether case distinctions are significant in an identifier with external linkage (6.1.2).
Characters in an identifier are case sensitive.

7. The members of the source and execution character sets, except as explicitly specified in the Standard (5.2.1).
The values of the members of the source and execution character sets are ASCII code, EUC, SJIS, UTF-8, big5, and gb2312. Japanese and Chinese descriptions in comments and strings are supported.

8. The shift states used for the encoding of multibyte characters (5.2.1.2).
A representation format that depends on the shift status is not supported.

9. The number of bits in a character in the execution character set (5.2.4.2.1).
A character consists of 8 bits. A multibyte character consists of 16 bits.

10. The mapping of members of the source character set (in character constants and string literals) to members of the execution character set (6.1.3.4).
The members of the source character set match the members of the execution character set.

11. The value of an integer character constant that contains a character or escape sequence not represented in the basic execution character set or the extended character set for a wide character constant (6.1.3.4).
Specific non-graphical characters can be represented by means of extended notation, consisting of a backslash (\) followed by a lower-case letter. The following are available: \a, \b, \f, \n, \r, \t, and \v. There is no other extended notation; other letters following a backslash (\) become that letter.

<table>
<thead>
<tr>
<th>Escape sequence</th>
<th>Value (ASCII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>\a</td>
<td>0x07</td>
</tr>
<tr>
<td>\b</td>
<td>0x08</td>
</tr>
<tr>
<td>\f</td>
<td>0x0C</td>
</tr>
<tr>
<td>\n</td>
<td>0x0A</td>
</tr>
<tr>
<td>\r</td>
<td>0x0D</td>
</tr>
<tr>
<td>\t</td>
<td>0x09</td>
</tr>
<tr>
<td>\v</td>
<td>0x0B</td>
</tr>
</tbody>
</table>

12. The value of an integer character constant that contains more than one character or a wide character constant that contains more than one multibyte character (6.1.3.4).
If an integer character constant contains four-byte characters (equivalent to four characters in ASCII), all the four bytes are valid values.
If the integer character constant contains five or more bytes, an error message is output.

13. The current locale used to convert multibyte characters into corresponding wide characters (codes) for a wide character constant (6.1.3.4).
No locale is supported.

14. Whether a "plain" char has the same range of values as signed char or unsigned char (6.2.1.1).
The char type has the same range of values, the same representation format, and the same behavior as those of the unsigned char type.
However, the char type can be switched to the signed char type by using the -signed_char option.

15. The representations and sets of values of the various types of integers (6.1.2.5).
Refer to "4.1.5 Internal Data Representation and Areas".

16. The result of converting an integer to a shorter signed integer, or the result of converting an unsigned integer to a signed integer of equal length, if the value cannot be represented (6.2.1.2).
If an integer is converted to an integer containing less bits, the resultant bit string is masked by the bit width of the less number of bits (with the upper bits deleted). If an unsigned integer is converted to a signed integer containing the same number of bits, the bit string is copied as is.

17. The results of bitwise operations on signed integers (6.3).
Arithmetic shift is performed for a shift operator. For other operators, a signed integer is calculated as an unsigned value (as a bit image).

18. The sign of the remainder on integer division (6.3.5).
If an operand has a negative value, the result of the "%" operator has the same sign as that of the first operand (dividend).

(19) The result of a right shift of a negative-valued signed integral type (6.3.7).
In the case of "E1 >> E2", if E1 is a negative-valued signed type, arithmetic shift is performed.

(20) The representations and sets of values of the various types of floating-point numbers (6.1.2.5).
Refer to "4.1.5 Internal Data Representation and Areas".

(21) The direction of truncation when an integral number is converted to a floating-point number that cannot exactly represent the original value (6.2.1.3). Rounded in the direction of the nearest value if any of these conditions is met:
- nofpu is specified.
- cpu=rx200 is specified.
- cpu=rx600 or -isa=rxv1 is specified, and the integer to be converted is unsigned.
In other cases, the result of conversion to the single-precision floating-point type is in accordance with the setting of the RM[0:1] bit in the FPSW.
[V3.01.00 or later] If -dpfpu is specified, the result of conversion to the double-precision floating-point type is in accordance with the setting of the DRM[0:1] bit in the DPSW.

(22) The direction of truncation or rounding when a floating-point number is converted to a narrower floating-point number (6.2.1.4).
Rounded to the nearest representable direction.

(23) The type of integer required to hold the maximum size of an array --- that is, the type of the sizeof operator, size_t (6.3.3.4, 7.1.1).
Unsigned long type

(24) The result of casting a pointer to an integer or vice versa (6.3.4).
- Integer-to-pointer conversion result
  If the size of an integer type is larger than or equal to that of a pointer type, the lower-byte value of the integer type is used. If the size of the integer type is smaller than that of the pointer type, the sign-extended value is used.
- Pointer-to-integer conversion result
  If the size of a pointer type is larger than or equal to that of an integer type, the lower-byte value of the pointer type is used. If the size of a pointer type is smaller than that of an integer type, the zero-extended value is used.

(25) The type of integer required to hold the difference between two pointers to members of the same array, ptrdiff_t (6.3.4, 7.1.1).
long type

(26) The extent to which objects can actually be placed in registers by use of the register storage-class specifier (6.5.1). Optimization is performed so that objects are accessed as fast as possible regardless of whether the register storage-class specifier is declared.

(27) A member of a union object is accessed using a member of a different type (6.3.2.3).
The internal data representation is determined by the type that is to be accessed.

(28) The padding and alignment of members of structures (6.5.2.1).
Refer to "4.1.5 Internal Data Representation and Areas".

(29) Whether a "plain" int bit-field is treated as a signed int bit-field or as an unsigned int bit-field (6.5.2.1).
A bit field that was declared without specifying a sign is treated as an unsigned int type.

(30) The order of allocation of bit-fields within an int (6.5.2.1).
The first declared bit-field is allocated from the lowest-order bit in the area with the size of the type when the bit-field was declared. This can be changed by the option.
Refer to "4.1.5 Internal Data Representation and Areas".

(31) Whether a bit-field can straddle a storage-unit boundary (6.5.2.1).
A bit-field is allocated to the next area instead of straddling a storage-unit boundary.
Refer to "4.1.5 Internal Data Representation and Areas".

(32) The integer type chosen to represent the values of an enumeration type (6.5.2.2).
Signed long type. If the -auto_enum option is specified, the minimum type that an enumerated type fits in is used.

(33) What constitutes an access to an object that has volatile-qualified type (6.5.3).
Not defined.

(34) The maximum number of declarators that may modify an arithmetic, structure, or union type (6.5.4).
The maximum number of case values in a switch statement (6.6.4.2).
There are no limits.

Whether the value of a single-character character constant in a constant expression that controls conditional inclusion matches the value of the same character constant in the execution character set. Whether such a character constant may have a negative value (6.8.1).
The value for the character constant specified in conditional inclusion matches the character constant value that appears in other expressions.
Such a character constant does not have a negative value.

The method for locating includable source files (6.8.2).
Files are searched in the following order, and a file having the same name in the folder is identified as the header:
1. Folder specified by the path (if it is full-path). If full-path is not specified:
   2. Folder having the source file
   3. Folder specified by the -include option
   4. Standard include file folder specified in the INC_RXA environment variable

The support for quoted names for includable source files (6.8.2).
Files are searched in the following order:
1. Folder specified by the path (if it is full-path). If full-path is not specified:
   2. Folder having the source file
   3. Folder specified by the -include option
   4. Standard include file folder specified in the INC_RXA environment variable

The mapping of source file character sequences (6.8.2).
A preprocessing token string enclosed in < and > or in double quotation marks (") is mapped to the header name as is. If the preprocessing token string is converted to the <character string> or "character string" format by expanding a macro, the content is mapped to the header name.

The behavior on each recognized #pragma directive (6.8.6).
Refer to "4.2.3 #pragma Directive".

The definitions for __DATE__ and __TIME__ when respectively, the date and time of translation are not available (6.8.8).
A date and time are always obtained.

The null pointer constant to which the macro NULL expands (7.1.6).
0

The diagnostic printed by and the termination behavior of the assert function (7.2).
The display varies depending on the -lang option specified at compilation.
If -lang=c99 is not specified (for C/C89, C++, or EC++ language):
ASSERTION FAILED: Expression FILE file-name,LINE line-number
If -lang=c99 is specified (for C/C99 language):
ASSERTION FAILED: Expression FILE file-name.LINE line-number FUNCNAME function-name
The behavior when the assert function ends is not defined. As per low-level interface routine specifications.

The sets of characters tested for by the isalnum, isalpha, iscntrl, islower, isprint, and isupper functions (7.3.1).
Unsigned char type (0 to 255) and EOF (-1)

The values returned by the mathematics functions on domain errors (7.5.1).
A NaN is returned.
Refer to "(5) Floating-Point Number Specifications" in "4.1.5 Internal Data Representation and Areas".

Whether the mathematics functions set the integer expression errno to the value of the macro ERANGE on underflow range errors (7.5.1).
For details about the functions that set ERANGE in errno when an underflow occurs, refer to "10.5.6 Standard Library Error Messages". Other functions do not set ERANGE in errno.

Whether a domain error occurs or zero is returned when the fmod function has a second argument of zero (7.5.6.4).
A domain error occurs. For details, see the description about the fmod function group.

The set of signals for the signal function (7.7.1.1).
The signal function is not supported.

The semantics for each signal recognized by the signal function (7.7.1.1).
The signal function is not supported.
(50) The default handling and the handling at program startup for each signal recognized by the signal function (7.7.1.1).
The signal function is not supported.

(51) If the equivalent of signal(sig, SIG_DFL); is not executed prior to the call of a signal handler, the blocking of the signal that is performed (7.7.1.1).
The signal function is not supported.

(52) Whether the default handling is reset if the SIGILL signal is received by a handler specified to the signal function (7.7.1.1).
The signal function is not supported.

(53) Whether the last line of a text stream requires a terminating new-line character (7.9.2).
Not defined. As per low-level interface routine specifications.

(54) Whether space characters that are written out to a text stream immediately before a new-line character appear when read in (7.9.2).
Not defined. As per low-level interface routine specifications.

(55) The number of null characters that may be appended to data written to a binary stream (7.9.2).
Not defined. As per low-level interface routine specifications.

(56) Whether the file position indicator of an append mode stream is initially positioned at the beginning or end of the file (7.9.3).
Not defined. As per low-level interface routine specifications.

(57) Whether a write on a text stream causes the associated file to be truncated beyond that point (7.9.3).
Not defined. As per low-level interface routine specifications.

(58) The characteristics of file buffering (7.9.3).
Not defined. As per low-level interface routine specifications.

(59) Whether a zero-length file actually exists (7.9.3).
Not defined. As per low-level interface routine specifications.

(60) The rules for composing valid file names (7.9.3).
Not defined. As per low-level interface routine specifications.

(61) Whether the same file can be open multiple times (7.9.3).
Not defined. As per low-level interface routine specifications.

(62) The effect of the remove function on an open file (7.9.4.1).
The remove function is not supported.

(63) The effect if a file with the new name exists prior to a call to the rename function (7.9.4.2).
The rename function is not supported.

(64) The output for %p conversion in the fprintf function (7.9.6.1).
Hexadecimal output

(65) The input for %p conversion in the fscanf function (7.9.6.2).
Hexadecimal input

(66) The interpretation of a - character that is neither the first nor the last character in the scan list for %[ conversion in the fscanf function (7.9.6.2).
The - character indicates the range between the previous character and the next character unless the previous character is a ^ character.

(67) The value to which the macro errno is set by the fgetpos or ftell function on failure (7.9.9.1, 7.9.9.4).
The fgetpos function is not supported.
Not defined for the ftell function. As per low-level interface routine specifications.

(68) The messages generated by the perror function (7.9.10.4).
Refer to "7.4 Library Function".

(69) The behavior of the calloc, malloc, or realloc function if the size requested is zero (7.10.3).
NULL is returned.

(70) The behavior of the abort function with regard to open and temporary files (7.10.4.1).
Not defined. As per low-level interface routine specifications.

(71) The status returned by the exit function if the value of the argument is other than zero, EXIT_SUCCESS, or EXIT_FAILURE (7.10.4.3).
The exit function is not supported.
(72) The set of environment names and the method for altering the environment list used by the getenv function (7.10.4.4).
The getenv function is not supported.

(73) The contents and mode of execution of the string by the system function (7.10.4.5).
The system function is not supported.

(74) The contents of the error message strings returned by the strerror function (7.11.6.2).
Refer to "10.5.6 Standard Library Error Messages".

(75) The local time zone and Daylight Saving Time (7.12.1).
The time.h is not supported.

(76) The era for the clock function (7.12.2.1).
The clock function is not supported.

4.1.4 Implementation-defined behavior of C99

(1) How a diagnostic is identified (3.10, 5.1.1.3).
Refer to "10. MESSAGES".

(2) Whether each non-empty sequence of white-space characters other than new-line is retained or replaced by one space character in translation phase 3 (5.1.1.2).
Retained as they are.

(3) The mapping between physical source file multi-byte characters and the source character set in translation phase 1 (5.1.1.2).
Multibyte characters are mapped to the corresponding source character set according to the compile option.

(4) The name and type of the function called at program startup in a freestanding environment (5.1.2.1).
Not defined. Depends on the startup implementation.

(5) The effect of program termination in a freestanding environment (5.1.2.1).
Depends on startup in a normal termination. Create an exit processing routine if the program needs to terminate abnormally.

(6) An alternative manner in which the main function may be defined (5.1.2.2.1).
Not defined because of a freestanding environment.

(7) The values given to the strings pointed to by the argv argument to main (5.1.2.2.1).
Not defined because of a freestanding environment.

(8) What constitutes an interactive device (5.1.2.3).
Not defined for the configuration of an interactive device.

(9) The set of signals, their semantics, and their default handling (7.14).
The signal handling functions are not supported.

(10) Signal values other than SIGFPE, SIGILL, and SIGSEGV that correspond to a computational exception (7.14.1.1).
The signal handling functions are not supported.

(11) Signals for which the equivalent of signal(sig, SIG_IGN); is executed at program startup (7.14.1.1).
The signal handling functions are not supported.

(12) The set of environment names and the method for altering the environment list used by the getenv function (7.20.4.5).
The getenv function is not supported.

(13) The manner of execution of the string by the system function (7.20.4.6).
The system function is not supported.

(14) Which additional multibyte characters may appear in identifiers and their correspondence to universal character names (6.4.2).
Multibyte characters cannot be used as identifiers.

(15) The number of significant initial characters in an identifier (5.2.4.1.1, 6.4.2).
The entire identifier is handled as meaningful. The length of an identifier is unlimited.

(16) The number of bits in a byte (3.6).
8 bits.

(17) The values of the members of the execution character set (5.2.1).
The element values of the execution character set are ASCII code, EUC, SJIS, UTF-8, big5 and gb2312 values.

(18) The unique value of the member of the execution character set produced for each of the standard alphabetic escape sequences (5.2.2).

<table>
<thead>
<tr>
<th>Escape Sequence</th>
<th>Value (ASCII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;\a&quot;</td>
<td>0x07</td>
</tr>
<tr>
<td>&quot;\b&quot;</td>
<td>0x08</td>
</tr>
<tr>
<td>&quot;\f&quot;</td>
<td>0x0C</td>
</tr>
<tr>
<td>&quot;\n&quot;</td>
<td>0x0A</td>
</tr>
<tr>
<td>&quot;\r&quot;</td>
<td>0x0D</td>
</tr>
<tr>
<td>&quot;\t&quot;</td>
<td>0x09</td>
</tr>
<tr>
<td>&quot;\v&quot;</td>
<td>0x0B</td>
</tr>
</tbody>
</table>

(19) The value of a char object into which has been stored any character other than a member of the basic execution character set (6.2.5).
Value that is type-converted to char type.

(20) Which of signed char or unsigned char has the same range, representation, and behavior as "plain" char (6.2.5, 6.3.1.1).
The char type has the same range of values, the same representation format and the same behavior as the unsigned char type. However, it can be switched to the signed char type by the -signed_char option.

(21) The mapping of members of the source character set (in character constants and string literals) to members of the execution character set (6.4.4.4, 5.1.1.2).
When the character code selection of the input program is the same as the character code selection of the output file according to an option specification, association with the element having the same value is performed. If they are different according to the option specification, the value of the corresponding character code is used.

(22) The value of an integer character constant containing more than one character or containing a character or escape sequence that does not map to a single-byte execution character (6.4.4.4).
A integer character constant consisting of up to four characters has a four-byte value with the lower byte being the last character and the upper byte being the first character. A character constant having five or more characters results in an error. A character which is not represented by basic execution environment character set is regarded as a integer character constant having that value. In an invalid escape sequence, the backslash is ignored and the next character is regarded as a integer character constant.

(23) The value of a wide character constant containing more than one multibyte character, or containing a multibyte character or escape sequence not represented in the extended execution character set (6.4.4.4).
Left-most character value as a multibyte character.

(24) The current locale used to convert a wide character constant consisting of a single multi-byte character that maps to a member of the extended execution character set into a corresponding wide character code (6.4.4.4).
Locale is not supported.

(25) The current locale used to convert a wide string literal into corresponding wide character codes (6.4.5).
Locale is not supported.

(26) The value of a string literal containing a multi-byte character or escape sequence not represented in the execution character set (6.4.5).
Corresponding byte value for escape sequence or corresponding each byte value for a multibyte character.

(27) Any extended integer types that exist in the implementation (6.2.5).
No extended integer types are provided.

(28) Whether signed integer types are represented using sign and magnitude, two’s complement, or one’s complement, and whether the extraordinary value is a trap representation or an ordinary value (6.2.6.2).
The signed integer type is represented in two's complement, and there are no trap representations.

(29) The rank of any extended integer type relative to another extended integer type with the same precision (6.3.1.1).
No extended integer types are provided.

(30) The result of, or the signal raised by, converting an integer to a signed integer type when the value cannot be represented in an object of that type (6.3.1.3).
Bit string masked by the width of the conversion target type (with the upper bits truncated).

(31) The results of some bit-wise operations on signed integers (6.5).
   Arithmetic shift is performed for a shift operator. For other operators, a signed integer is calculated as an unsigned
   value (as a bit image).

(32) The accuracy of the floating-point operations and of the library functions in <math.h> and <complex.h> that return
   floating-point results (5.2.4.2.2).
   Unknown.

(33) The rounding behaviors characterized by non-standard values of FLT_ROUNDS (5.2.4.2.2).
   No nonstandard value is defined for FLT_ROUNDS.

(34) The evaluation methods characterized by non-standard negative values of FLT_EVAL_METHOD (5.2.4.2.2).
   No nonstandard value is defined for FLT_EVAL_METHOD.

(35) The direction of rounding when an integer is converted to a floating-point number that cannot exactly represent the
   original value (6.3.1.4).
   Rounded to the nearest direction if any of these conditions is met:
   -nofpu is specified.
   -cpu=rx200 is specified.
   -cpu=rx600 or isa=rxv1 is specified and the integer to be converted is unsigned.
   Otherwise, the setting in the RMI[0:1] bits in FPSW is followed.
[V3.01.00 or later] When -dpfu is specified, the result of conversion to the double-precision floating-point type is
   in accord with the setting of the DRM[0:1] bits in the DPSW.

(36) The direction of rounding when a floating-point number is converted to a narrower floating-point number (6.3.1.5).
   As per the option (-round) specification and microcomputer settings.

(37) How the nearest representable value or the larger or smaller representable value immediately adjacent to the
   nearest representable value is chosen for certain floating constants (6.4.4.2).
   As per the option (-round) specification.

(38) Whether and how floating expressions are contracted when not disallowed by the FP_CONTRACT pragma (6.5).
   Contraction of expressions depends on each option specification.
   The FP_CONTRACT pragma does not work.
   #pragma STDC FP_CONTRACT is ignored even if it is specified.

(39) The default state for the FENV_ACCESS pragma (7.6.1).
   The default state of the FENV_ACCESS pragma is ON.
   #pragma STDC FENV_ACCESS is ignored even if it is specified.

(40) Additional floating-point exceptions, rounding modes, environments, and classifications, and their macro names
   (7.6, 7.12).
   As per the math.h and fenv.h libraries provided by the compiler. There are no additional definitions.

(41) The default state for the FP_CONTRACT pragma (7.12.2).
   The default state of the FP_CONTRACT pragma is ON.

(42) Whether the "inexact" floating-point exception can be raised when the rounded result actually does equal the
   mathematical result in an IEC 60559 conformant implementation (F.9).
   No "inexact" floating-point exception is generated for the nearbyint, nearbyintf or nearbyintl function. An "inexact"
   floating-point exception may be generated for the rint, rintf or rintl function.

(43) Whether the underflow (and inexact) floating-point exception can be raised when a result is tiny but not inexact in
   an IEC 60559 conformant implementation (F.9).
   As per the option (-round) specification and microcomputer settings.

(44) The result of converting a pointer to an integer or vice versa (6.3.2.3).
   - Integer-to-pointer conversion result
     If the size of an integer type is larger than that of a pointer type, the lower-byte value of the integer type is used.
     If the size of the integer type is equal to that of the pointer type, the bit pattern of the integer type is retained as
     is. If the size of the integer type is smaller than that of the pointer type, the resultant value of an extension to a
     long type is retained as is.
   - Pointer-to-integer conversion result
     If the size of a pointer type is larger than that of an integer type, the lower-byte value of the pointer type is used.
     If the size of the pointer type is equal to that of the integer type, the bit pattern of the pointer type is retained as
     is. If the size of a pointer type is smaller than that of an integer type, the zero-extended value of the pointer type
     is used.

(45) The size of the result of subtracting two pointers to elements of the same array (6.5.6).
The resultant type is the signed long type.

(46) The extent to which suggestions made by using the register storage-class specifier are effective (6.7.1). User requests for register variables are not honored.

(47) The extent to which suggestions made by using the inline function specifier are effective (6.7.4). Expansion is attempted only when the -inline option is valid. In addition, expansion may not be performed depending on the condition.

(48) Whether a "plain" int bit-field is treated as signed int bit-field or as an unsigned int bit-field (6.7.2, 6.7.2.1). Treated as an unsigned int type. However, this can be changed by the -signed_bitfield option.

(49) Allowable bit-field types other than _Bool, signed int, and unsigned int (6.7.2.1). All integer types are allowed.

(50) Whether a bit-field can straddle a storage-unit boundary (6.7.2.1). When structure type packing is not specified, a bit-field cannot straddle a strage-unit boundary, but it is allocated to the next area. When structure type packing is specified, a bit-field may straddle a strage-unit boundary.

(51) The order of allocation of bit-fields within a unit (6.7.2.1). Allocated from the lower order. Selectable by the -bit_order option or #pragma bit_order.

(52) The alignment of non-bit-field members of structures (6.7.2.1). Refer to "4.1.5 Internal Data Representation and Areas".

(53) The integer type compatible with each enumerated type (6.7.2.2). Signed long type. However, the minimum type that an enumerated type fits in if the -auto_enum option is specified.

(54) What constitutes an access to an object that has volatile-qualified type (6.7.3). Although the order and number of accesses are as described in the C source, this does not apply to those accesses to a type for which the microcomputer does not have a corresponding instruction. An object qualified as volatile might be accessed in a smaller size than a declaration type.

(55) How sequences in both forms of header names are mapped to headers or external source file names (6.4.7). A character string described in the #include is interpreted as the character code specified as the source character set and is associated with a header name or an external source file name.

(56) Whether the value of a character constant in a constant expression that controls conditional inclusion matches the value of the same character constant in the execution character set (6.10.1). A value for the character constant specified in conditional inclusion is equal to the character constant value that appears in other expressions.

(57) Whether the value of a single-character character constant in a constant expression that controls conditional inclusion may have a negative value (6.10.1).

(58) The places that are searched for an included < > delimited header, and how the places are specified other header is identified (6.10.2). Folders are searched in this order and a file having the same name in the folder is identified as the header.
1. Folder specified by the path (if it is full-path)
2. Folder specified by the -include option
3. Standard include file folder (..\inc folder with a relative path from the bin folder where the compiler is placed)

(59) How the named source file is searched for in an included " " delimited header (6.10.2). Search in this order:
1. Folder specified by the path (if it is full-path)
2. Folder having the source file
3. Folder specified by the -include option
4. Standard include file folder (..\inc folder with a relative path from the bin folder where the compiler is placed)

(60) The method by which preprocessing tokens (possibly resulting from macro expansion) in a #include directive are combined into a header name (6.10.2). Treated as a preprocessing token of a single header or file name only in a macro that replaces preprocessing tokens with a single <character string> or "character string" format.

(61) The nesting limit for #include processing (6.10.2). There are no limits.

(62) Whether the # operator inserts a \ character before the \ character that begins a universal character name in a character constant or string literal (6.10.3.2). A \ character is not inserted in front of the first \ character.
(63) The behavior on each recognized non-STDC #pragma directive (6.10.6).
Refer to “4.2.3 #pragma Directive”.

(64) The definitions for ___DATE___ and ___TIME___ when respectively, the date and time of translation are not available
(6.10.8).
A date and time are always obtained.

(65) Any library facilities available to a freestanding program, other than the minimal set required by clause 4 (5.1.2.1).
Refer to ”7. LIBRARY FUNCTIONAL SPECIFICATION”.

(66) The format of the diagnostic printed by the assert macro (7.2.1.1).
As follows:
Assertion failed: Expression FILE file-name,LINE line-number FUNCNAME function-name

(67) The representation of the floating-point status flags stored by the fegetexceptflag function (7.6.2.2).
One or combination of the following:
  _FE_DIVBYZERO  0x04
  _FE_INEXACT   0x10
  _FE_INVALID   0x01
  _FE_OVERFLOW  0x02
  _FE_UNDERFLOW 0x08

(68) Whether the feraiseexcept function raises the "inexact" floating-point exception in addition to the "overflow" or
"underflow" floating-point exception (7.6.2.3).
An "inexact" floating-point exception may be generated if the E0 flag is set to 0 when an "overflow" floating-point
exception is generated. Otherwise, no "inexact" floating-point exception is generated.

(69) Strings other than "C" and "" that may be passed as the second argument to the setlocale function (7.11.1.1).
The setlocale function is not supported.

(70) The types defined for float_t and double_t when the value of the FLT_EVAL_METHOD macro is less than zero or
greater than two (7.12).
float_t is defined as the float type and double_t as the double type.

(71) Domain errors for the mathematics functions, other that those required by this International Standard (7.12.1).
Refer to (72).

(72) The values returned by the mathematics functions on domain errors (7.12.1).

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>acosh function</td>
<td>The argument is x. If x &lt; 1 is true, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td>atanh function</td>
<td>The argument is x. If -1 &lt; x &lt; 1 is true, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td>ccosh function</td>
<td>The argument is x. - If the real part of x is 0 and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is NaN + 0 × i. - If the real part of x is ±∞ and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is -∞ + NaN × i. - If the real part of x is a finite value and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is NaN + NaN × i.</td>
</tr>
<tr>
<td>cexp function</td>
<td>The argument is x. - If the real part of x is ±∞ and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is NaN + NaN × i.</td>
</tr>
<tr>
<td>csinh function</td>
<td>The argument is x. - If the real part of x is ±∞ and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is NaN + NaN × i.</td>
</tr>
<tr>
<td>Function Group</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| **fma function group** | The first argument is x1, the second argument is x2, and the third argument is x3.  
- If x1 is ±∞, x2 is 0, and x3 is not a NaN, a domain error occurs. In this case, the return value is a NaN.  
- If x1 is 0, x2 is ±∞, and x3 is not a NaN, a domain error occurs (no definition). In this case, the return value is a NaN.  
- If x1, x2, and x3 are ±∞ and the sign of x1 and x2 is different from that of x3, (that is, subtraction between ∞ occurs), a domain error occurs. In this case, the return value is a NaN. |
| **llrint function group** | The argument is x.  
- If x is a finite value that cannot be represented in the longlong type, a domain error occurs. In this case, the return value is 0.  
- If x is a NaN or ±∞, a domain error occurs. In this case, the return value is 0. |
| **llround function group** | The argument is x.  
- If x is a finite value that cannot be represented in the longlong type, a domain error occurs. In this case, the return value is 0.  
- If x is a NaN or ±∞, a domain error occurs. In this case, the return value is 0. |
| **log1p function group** | The argument is x. If x satisfies x < -1, a domain error occurs. In this case, the return value is a NaN. |
| **lrint function group** | The argument is x.  
- If x is a finite value that cannot be represented in the long type, a domain error occurs. In this case, the return value is 0.  
- If x is a NaN or ±∞, a domain error occurs. In this case, the return value is 0. |
| **lround function group** | The argument is x.  
- If x is a finite value that cannot be represented in the long type, a domain error occurs. In this case, the return value is 0.  
- If x is a NaN or ±∞, a domain error occurs. In this case, the return value is 0. |
| **remquo function group** | The first argument is x1, the second argument is x2, and the third argument is x3.  
- If x1 is ±∞ and x2 is not a NaN, a domain error occurs. In this case, the return value is a NaN. Note that x3 points to 0.  
- If x1 is not a NaN and x2 is 0, a domain error occurs. In this case, the return value is a NaN. Note that x3 points to 0. |
| **tgamma function group** | The argument is x. If x is -∞ or a negative integer, a domain error occurs. In this case, the return value is a NaN. |
| **carg function group** | The argument is x. If the real part and imaginary part of x are 0, a domain error occurs. In this case, the return value is a NaN. |
| **ccos function group** | The argument is x.  
- If the real part of x is ±∞ and the imaginary part of x is 0, a domain error occurs. In this case, the return value is NaN + 0 × i.  
- If the real part of x is ±∞ and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is ±∞ + NaN × i.  
- If the real part of x is ±∞ and the imaginary part of x is a finite value, a domain error occurs. In this case, the return value is NaN + NaN × i. |
<p>| <strong>clog function group</strong> | The argument is x. If the real part of x is ±∞ and the imaginary part of x is ±∞, a domain error occurs. In this case, the return value is ±∞ + NaN × i. |</p>
<table>
<thead>
<tr>
<th>Function Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>cpow function group</strong></td>
<td>The first argument is x1 and the second argument is x2.</td>
</tr>
<tr>
<td>- If the imaginary part of x1 is 0 and, as a result of multiplying x2 by the real part of x1, the real part is $+\infty$ and the imaginary part is $\pm\infty$, a domain error occurs. In this case, the return value is $+\infty$ + NaN × i.</td>
<td></td>
</tr>
<tr>
<td>- If the imaginary part of x1 is 0 and, as a result of multiplying x2 by the real part of x1, the real part is $\pm\infty$, a domain error occurs. In this case, the return value is NaN × NaN × i.</td>
<td></td>
</tr>
<tr>
<td>- If the real part of x1 or x2 is a NaN and the imaginary parts of x1 and x2 are 0, a domain error occurs. In this case, the return value is NaN × 0 × i.</td>
<td></td>
</tr>
<tr>
<td>- If the real part of x1 is 0, the real part of x2 is 0 or smaller, and the imaginary parts of x1 and x2 are 0, a domain error occurs. In this case, the return value is NaN × 0 × i.</td>
<td></td>
</tr>
<tr>
<td>- If the real part of x1 is a negative number, the real part of x2 is a noninteger, and the imaginary parts of x1 and x2 are 0, a domain error occurs. In this case, the return value is NaN + 0 × i.</td>
<td></td>
</tr>
<tr>
<td><strong>remainder function group</strong></td>
<td>The first argument is x1 and the second argument is x2.</td>
</tr>
<tr>
<td>- If x1 is $\pm\infty$ and x2 is not a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td>- If x1 is not a NaN and x2 is 0, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td><strong>acos function group</strong></td>
<td>The argument is x.</td>
</tr>
<tr>
<td>- If x satisfies $x &lt; -1$ or $1 &lt; x$, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td>- If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td><strong>asin function group</strong></td>
<td>The argument is x.</td>
</tr>
<tr>
<td>- If x satisfies $x &lt; -1$ or $1 &lt; x$, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td>- If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td><strong>atan function group</strong></td>
<td>The argument is x. If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td><strong>cosh function group</strong></td>
<td>The argument is x. If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td><strong>exp function group</strong></td>
<td>The argument is x. If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td><strong>frexp function group</strong></td>
<td>The first argument is x1 and the second argument is x2. If x1 is a NaN, a domain error occurs. In this case, the return value is a NaN. Note that the pointing target of x2 does not change.</td>
</tr>
<tr>
<td><strong>log10 function group</strong></td>
<td>The argument is x.</td>
</tr>
<tr>
<td>- If $x &lt; 0$ is true, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td>- If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td><strong>log function group</strong></td>
<td>The argument is x.</td>
</tr>
<tr>
<td>- If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td>- If $x &lt; 0$ is true, a domain error occurs. In this case, the return value is a NaN.</td>
<td></td>
</tr>
<tr>
<td><strong>sin function group</strong></td>
<td>The argument is x. If x is $\pm\infty$ or NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td><strong>cos function group</strong></td>
<td>The argument is x. If x is $\pm\infty$ or NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td><strong>sinh function group</strong></td>
<td>The argument is x. If x is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
<tr>
<td><strong>tan function group</strong></td>
<td>The argument is x. If x is $\pm\infty$ or NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
</tbody>
</table>
**4. COMPILER LANGUAGE SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Function Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>tanh function group</strong></td>
<td>The argument is (x). If (x) is a NaN, a domain error occurs. In this case, the return value is a NaN.</td>
</tr>
</tbody>
</table>
| **atan2 function group** | The first argument is \(x_1\) and the second argument is \(x_2\).  
- If \(x_1\) and \(x_2\) are 0, a domain error occurs. In this case, the return value is a NaN.  
- If \(x_1\) or \(x_2\) is a NaN, a domain error occurs. In this case, the return value is a NaN.  
- If \(x_1\) and \(x_2\) are ±\(\infty\), a domain error occurs. In this case, the return value is a NaN. |
| **ceil function group** | The argument is \(x\). If \(x\) is a NaN, a domain error occurs. In this case, the return value is a NaN. |
| **floor function group** | The argument is \(x\). If \(x\) is a NaN, a domain error occurs. In this case, the return value is a NaN. |
| **fmod function group** | The first argument is \(x_1\) and the second argument is \(x_2\).  
- If \(x_2\) is 0, a domain error occurs. In this case, the return value is a NaN.  
- If \(x_1\) or \(x_2\) is a NaN, a domain error occurs. In this case, the return value is a NaN.  
- If \(x_1\) is ±\(\infty\), a domain error occurs. In this case, the return value is a NaN. |
| **ldexp function group** | The first argument is \(x_1\) and the second argument is \(x_2\). If \(x_1\) is a NaN, a domain error occurs. In this case, the return value is a NaN. |
| **modf function group** | The first argument is \(x_1\) and the second argument is \(x_2\). If \(x_1\) is a NaN, a domain error occurs. In this case, the return value is a NaN. Note that \(x_2\) points to the NaN. |
| **pow function group** | The first argument is \(x_1\) and the second argument is \(x_2\).  
- If \(x_1\) or \(x_2\) is a NaN, a domain error occurs. In this case, the return value is a NaN.  
- If \(x_1\) is 0 and \(x_2\) is 0 or smaller, a domain error occurs. In this case, the return value is a NaN.  
- If \(x_1\) satisfies \(x_1 < 0\) and \(x_2\) is not an integer, a domain error occurs. In this case, the return value is a NaN. |
| **sqrt function group** | The argument is \(x\).  
- If \(x\) satisfies \(x < 0\), a domain error occurs. In this case, the return value is a NaN.  
- If \(x\) is a NaN, a domain error occurs. In this case, the return value is a NaN. |

(73) The values returned by the mathematics functions on underflow range errors, whether errno is set to the value of the macro ERANGE when the integer expression math_errno & MATH_ERRNO is nonzero, and whether the “underflow” floating-point exception is raised when the integer expression math_errno & MATH_ERREXCEPT is nonzero. (7.12.1).

The return value is 0. ERANGE is set in errno in case of an underflow. An "underflow" floating-point exception is generated.

(74) Whether a domain error occurs or zero is returned when an fmod function has a second argument of zero (7.12.10.1).

A domain error is generated. For details, see the description about the fmod function group.

(75) The base-2 logarithm of the modulus used by the remquo functions in reducing the quotient (7.12.10.3).

31.

(76) Whether the equivalent of signal(sig, SIG_DFL); is executed prior to the call of a signal handler, and, if not, the blocking of signals that is performed (7.14.1.1).

The signal handling functions are not supported.

(77) The null pointer constant to which the macro NULL expands (7.17).

0.

(78) Whether the last line of a text stream requires a terminating new-line character (7.19.2).

As per low-level interface routine specifications.
(79) Whether space characters that are written out to a text stream immediately before a new-line character appear when read in (7.19.2).  
As per low-level interface routine specifications.

(80) The number of null characters that may be appended to data written to a binary stream (7.19.2).  
As per low-level interface routine specifications.

(81) Whether the file position indicator of an append-mode stream is initially positioned at the beginning or end of the file (7.19.3).  
As per low-level interface routine specifications.

(82) Whether a write on a text stream causes the associated file to be truncated beyond that point (7.19.3).  
As per low-level interface routine specifications.

(83) The characteristics of file buffering (7.19.3).  
As per low-level interface routine specifications.

(84) Whether a zero-length file actually exists (7.19.3).  
As per low-level interface routine specifications.

(85) The rules for composing valid file names (7.19.3).  
As per low-level interface routine specifications.

(86) Whether the same file can be simultaneously open multiple times (7.19.3).  
As per low-level interface routine specifications.

(87) The nature and choice of encodings used for multibyte characters in files (7.19.3).  
The shift state is not supported as the representation form of multibyte characters.

(88) The effect of the remove function on an open file (7.19.4.1).  
The remove function is not supported.

(89) The effect if a file with the new name exists prior to a call to the rename function (7.19.4.2).  
The rename function is not supported.

(90) Whether an open temporary file is removed upon abnormal program termination (7.19.4.3).  
The tmpfile function is not supported.

(91) Which changes of mode are permitted (if any), and under what circumstances (7.19.5.4).  
If filename is a null pointer, it changes the mode of the current stream to the specified mode.

(92) The style used to print an infinity or NaN, and the meaning of any n-char or n-wchar sequence printed for a NaN (7.19.6.1, 7.24.2.1).  
++++++ is output for the positive infinity, ------ for a negative infinity, and ****** for a NaN.  
n character strings or n wide character strings are not supported when a NaN is written.

(93) The output for %p conversion in the printf or fprintf function (7.19.6.1, 7.24.2.1).  
Hexadecimal notation.

(94) The interpretation of a - character that is neither the first nor the last character, nor the second where a ^ character is the first, in the scanlist for %[ conversion in the fscanf() or fwsanf() function (7.19.6.2, 7.24.2.1).  
Indicates a range between the previous character and the next character.

(95) The set of sequences matched by a %p conversion and the interpretation of the corresponding input item in the fscanf() or fwsanf() function (7.19.6.2, 7.24.2.2).  
Hexadecimal number.

(96) The value to which the macro errno is set by the fgetpos, fsetpos, or ftell functions on failure (7.19.9.1, 7.19.9.3, 7.19.9.4).  
The ftell function conforms with the low-level interface routine specifications.  
The fgetpos and fsetpos functions are not supported.

(97) The meaning of any n-char or n-wchar sequence in a string representing a NaN that is converted by the strtod(), strtof(), strtold(), wcstod(), wcstof(), or wcstold() function (7.20.1.3, 7.24.4.1.1).  
Interpreted as qNaN in case of the strtof, strtold, wcstod, wcstof, or wcstold function. Interpreted as a value other than a number of floating-point type in case of the strtod function.

(98) Whether or not the strtod, strtof, strtold, wcstod, wcstof, or wcstold function sets errno to ERANGE when underflow occurs (7.20.1.3, 7.24.4.1.1).  
The strtod, strtof, strtold, wcstod, wcstof and wcstold functions set ERANGE in global variable errno.

(99) Whether the calloc, malloc, and realloc functions return a null pointer or a pointer to an allocated object when the size requested is zero (7.20.3).
NULL is returned.

(100) Whether open streams with unwritten buffered data are flushed, open streams are closed, or temporary files are
removed when the abort or _Exit function is called (7.20.4.1, 7.20.4.4).
As per low-level interface routine specifications.

(101) The termination status returned to the host environment by the abort, exit, or _Exit function (7.20.4.1, 7.20.4.3,
7.20.4.4).
The abort, exit and _Exit functions are not supported.

(102) The value returned by the system function when its argument is not a null pointer (7.20.4.6).
The system function is not supported.

(103) The local time zone and Daylight Saving Time (7.23.1).
time.h is not supported.

(104) The range and precision of times representable in clock_t and time_t (7.23).
time.h is not supported.

(105) The era for the clock function (7.23.2.1).
time.h is not supported.

(106) The replacement string for the %Z specifier to the strftime, and wcsftime functions in the "C" locale (7.23.3.5,
7.24.5.1).
time.h is not supported.

(107) Whether or when the trigonometric, hyperbolic, base-e exponential, base-e logarithmic, error, and log gamma
functions raise the "inexact" floating-point exception in an IEC 60559 conformant implementation (F.9).
An "inexact" floating-point exception may be generated if the hypot, ldexp, lgamma, tgamma, erfc, pow, scalbln,
tan, exp, or nexttoward function group resulted in an overflow or underflow.

(108) Whether the functions in <math.h> honor the rounding direction mode in an IEC 60559 conformant implementa-
tion (F.9).
The lround function group may not follow the rounding direction mode.

(109) The values or expressions assigned to the macros specified in the headers <float.h>, <limits.h>, and <stdint.h>
(5.2.4.2, 7.18.2, 7.18.3).
Refer to each header and file in "7. LIBRARY FUNCTIONAL SPECIFICATION".

(110) The number, order, and encoding of bytes in any object (when not explicitly specified in this International Stan-
dard) (6.2.6.1).
Refer to "4.1.5 Internal Data Representation and Areas".

(111) The value of the result of the sizeof operator (6.5.3.4).
Refer to "4.1.5 Internal Data Representation and Areas".

Translation limits
The table below shows the translation limits of CC-RX.
The upper limit depends on the memory situation of the host environment for the item "No limit".

<table>
<thead>
<tr>
<th>Item</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nesting levels of blocks</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of nesting levels of conditional inclusion</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of pointers, arrays, and function declarators (in any combinations) qualifying an arithmetic, structure, union, or incomplete type in a declaration</td>
<td>128</td>
</tr>
<tr>
<td>Number of nesting levels of parenthesized declarators within a full declarator</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of nesting levels of parenthesized expressions within a full expression</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of significant initial characters in an internal identifier or a macro name</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of significant initial characters in an external identifier</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of external identifiers in one translation unit</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of identifiers with block scope declared in one block</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of macro identifiers simultaneously defined in one preprocessing translation unit</td>
<td>No limit</td>
</tr>
</tbody>
</table>
4.1.5 Internal Data Representation and Areas

This section explains the data type and the internal data representation. The internal data representation is determined according to the following four items:

- **Size**
  Shows the memory size necessary to store the data.

- **Boundary alignment**
  Restricts the addresses to which data is allocated. There are three types of alignment; 1-byte alignment in which data can be allocated to any address, 2-byte alignment in which data is allocated to even byte addresses, and 4-byte alignment in which data is allocated to addresses of multiples of four bytes.

- **Data range**
  Shows the range of data of scalar type (C) or basic type (C++).

- **Data allocation example**
  Shows an example of assignment of element data of compound type (C) or class type (C++).

### (1) Scalar Type (C), Basic Type (C++)

Table 4.1 shows internal representation of scalar type data in C and basic type data in C++.

<table>
<thead>
<tr>
<th>No</th>
<th>Data Type</th>
<th>Size (bytes)</th>
<th>Alignment (bytes)</th>
<th>Signed/Unsigned</th>
<th>Data Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Minimum Value</td>
</tr>
<tr>
<td>1</td>
<td>char *1</td>
<td>1</td>
<td>1</td>
<td>Unsigned</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>signed char</td>
<td>1</td>
<td>1</td>
<td>Signed</td>
<td>−2^7 (~128)</td>
</tr>
<tr>
<td>3</td>
<td>unsigned char</td>
<td>1</td>
<td>1</td>
<td>Unused</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>short</td>
<td>2</td>
<td>2</td>
<td>Signed</td>
<td>−2^15 (~32768)</td>
</tr>
<tr>
<td>5</td>
<td>signed short</td>
<td>2</td>
<td>2</td>
<td>Signed</td>
<td>−2^15 (~32768)</td>
</tr>
<tr>
<td>6</td>
<td>unsigned short</td>
<td>2</td>
<td>2</td>
<td>Unsigned</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>int *2</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>−2^31 (~2147483648)</td>
</tr>
<tr>
<td>No</td>
<td>Data Type</td>
<td>Size (bytes)</td>
<td>Alignment (bytes)</td>
<td>Signed/Unsigned</td>
<td>Data Range</td>
</tr>
<tr>
<td>----</td>
<td>-------------------</td>
<td>--------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>signed int</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{31}) (–2147483648)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unsinged</td>
<td>2(^{31})–1 (2147483647)</td>
</tr>
<tr>
<td>9</td>
<td>unsigned int</td>
<td>4</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{32})–1 (4294967295)</td>
</tr>
<tr>
<td>10</td>
<td>long</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{31}) (–2147483648)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{31})–1 (2147483647)</td>
</tr>
<tr>
<td>11</td>
<td>signed long</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{31}) (–2147483648)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{31})–1 (2147483647)</td>
</tr>
<tr>
<td>12</td>
<td>unsigned long</td>
<td>4</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{32})–1 (4294967295)</td>
</tr>
<tr>
<td>13</td>
<td>long long</td>
<td>8</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{63}) (–9223372036854775808)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{63})–1 (9223372036854775807)</td>
</tr>
<tr>
<td>14</td>
<td>signed long, long</td>
<td>8</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{63}) (–9223372036854775808)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{63})–1 (9223372036854775807)</td>
</tr>
<tr>
<td>15</td>
<td>unsigned long, long</td>
<td>8</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{64})–1 (18446744073709551615)</td>
</tr>
<tr>
<td>16</td>
<td>float</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>–(\infty)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ (\infty)</td>
</tr>
<tr>
<td>17</td>
<td>double, long double</td>
<td>4 (^{3})</td>
<td>4</td>
<td>Signed</td>
<td>–(\infty)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ (\infty)</td>
</tr>
<tr>
<td>18</td>
<td>size_t</td>
<td>4</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{32})–1 (4294967295)</td>
</tr>
<tr>
<td>19</td>
<td>ptrdiff_t</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{31}) (–2147483648)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{31})–1 (2147483647)</td>
</tr>
<tr>
<td>20</td>
<td>enum</td>
<td>4</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{31}) (–2147483648)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{31})–1 (2147483647)</td>
</tr>
<tr>
<td>21</td>
<td>Pointer</td>
<td>4</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{32}}–1 (4294967295)</td>
</tr>
<tr>
<td>22</td>
<td>bool , _Bool</td>
<td>1 (^{5})</td>
<td>1</td>
<td>Signed</td>
<td>–2(^{9})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–2(^{9})</td>
</tr>
<tr>
<td>23</td>
<td>Reference</td>
<td>4</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{32})–1 (4294967295)</td>
</tr>
<tr>
<td>24</td>
<td>Pointer to a data member</td>
<td>4 (^{6})</td>
<td>4</td>
<td>Unsinged</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2(^{32}}–1 (4294967295)</td>
</tr>
<tr>
<td>25</td>
<td>Pointer to a function member</td>
<td>12 (^{7})</td>
<td>4</td>
<td>Signed</td>
<td>–2(^{10})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–2(^{10})</td>
</tr>
</tbody>
</table>

Notes 1. When the `signed_char` option is specified, the `char` type has the same value range as the `signed char` type.

Notes 2. When the `int_to_short` option is specified, the `int` type has the same value range as the `short` type, the `signed int` type has the same value ranges as the `signed short` type, and the `unsigned int` type has the same value range as the `unsigned short` type.

Notes 3. When the `auto_enum` option is specified, the smallest type that holds enumeration values is selected.

Notes 4. When `dbl_size=8` is specified, the size of the `double` type and `long double` type is 8 bytes.

Notes 5. This data type is only valid for compilation of C++ programs or C programs including `stdbool.h`.

Notes 6. These data types are only valid for compilation of C++ programs.

Notes 7. Pointers to function and virtual function members are represented in the following data structure.

Notes 8. This data type is only valid when compiling a `C99` program or C program in which `stdbool.h` has been included.
Notes 9. When C89 is used for compiling, the size, number of bytes for alignment, and sign are the same as for the **unsigned long** type.

Notes 10. This data type does not include a concept of sign.

(2) Compound Type (C), Class Type (C++)

This section explains internal representation of array type, structure type, and union type data in C and class type data in C++.

Table 4.2 shows internal representation of compound type and class type data.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Alignment (bytes)</th>
<th>Size (bytes)</th>
<th>Data Allocation Example</th>
</tr>
</thead>
</table>
| Array     | Array element alignment | Number of array elements × element size | char a[10];  
Alignment: 1 byte  
Size: 10 bytes |
| Structure | Maximum structure member alignment | Total size of members. Refer to (a) Structure Data Allocation, below. | struct {
char a,b;
};  
Alignment: 1 byte  
Size: 2 bytes |
| Union     | Maximum union member alignment | Maximum size of member. Refer to (b) Union Data Allocation, below. | union {
char a,b;
};  
Alignment: 1 byte  
Size: 1 byte |
| Class     | 1. Always 4 if a virtual function is included  
2. Other than 1 above: maximum member alignment | Sum of data members, pointer to the virtual function table, and pointer to the virtual base class. Refer to (c) Class Data Allocation, below. | class B:public A {
virtual void f();
};  
Alignment: 4 bytes  
Size: 8 bytes  
class A {
char a;
};  
Alignment: 1 byte  
Size: 1 byte |

In the following examples, a rectangle (□) indicates four bytes. The diagonal line (\_/) represents an unused area for alignment. The address increments from right to left (the left side is located at a higher address).

(a) Structure Data Allocation

When structure members are allocated, an unused area may be generated between structure members to align them to boundaries.

Example

```c
struct {
    char a;
    int b;
} obj
```

If a structure has 4-byte alignment and the last member ends at an 1-, 2-, or 3-byte address, the following three, two, or one byte is included in this structure.

Example

```c
struct {
    char a;
    int b;
} obj;
```
(b) Union Data Allocation
When an union has 4-byte alignment and its maximum member size is not a multiple of four, the remaining
bytes up to a multiple of four is included in this union.

Example

```cpp
union {
    int a;
    char b[7];
} o;
```

(c) Class Data Allocation
For classes having no base class or virtual functions, data members are allocated according to the allocation
rules of structure data.

Example

```cpp
class A{
    char data1;
    int data2;
public:
    A();
    int getData1(){return data1;}
} obj;
```

If a class is derived from a base class of 1-byte alignment and the start member of the derived class is 1-byte
data, data members are allocated without unused areas.

Example

```cpp
struct {
    int a;
    char b;
} obj
```
For a class having a virtual base class, a pointer to the virtual base class is allocated.

Example

```cpp
class A{
    char data1;
};
class B:public A{
    char data2;
    short data3;
} obj;
```

For a class having virtual functions, the compiler creates a virtual function table and allocates a pointer to the virtual function table.

Example

```cpp
class A{
    short data1;
};
class B: virtual protected A{
    char data2;
} obj;
```

An example is shown for a class having virtual base class, base class, and virtual functions.

Example
For an empty class, a 1-byte dummy area is assigned.

Example

```cpp
class A{
    void fun();
} obj;
```
For an empty class having an empty class as its base class, the dummy area is one byte.

Example

class A{
    void fun();
};
class B: A{
    void sub();
} obj;

For an empty class having an empty class as its base class, the dummy area is one byte.

Example

class A{
    void fun();
};
class B: A{
    char data1;
} obj;

Dummy areas shown in the above two examples are allocated only when the class size is 0. No dummy area is allocated if a base class or a derived class has a data member or has a virtual function.

Example

class A{
    void fun();
};
class B: A{
    char data1;
} obj;

(3) Bit Fields
A bit field is a member allocated with a specified size in a structure, a union, or a class. This section explains how bit fields are allocated.

(a) Bit Field Members
Table 4.3 shows the specifications of bit field members.

Table 4.3  Bit Field Member Specifications

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type specifier allowed for bit fields</td>
<td>(unsigned) char, signed char, bool(^1), _Bool(^5), (unsigned) short, signed short, enum, (unsigned) int, signed int, (unsigned) long, signed long, (unsigned) long long, signed long long</td>
</tr>
<tr>
<td>2</td>
<td>How to treat a sign when data is extended to the declared type(^2)</td>
<td>Unsigned: Zero extension(^3) Signed: Sign extension(^4)</td>
</tr>
<tr>
<td>3</td>
<td>Sign type for the type without sign specification</td>
<td>Unsigned. When the signed bitfield option is specified, the signed type is selected.</td>
</tr>
<tr>
<td>4</td>
<td>Sign type for enum type</td>
<td>Signed. When the auto_enum option is specified, the resultant type is selected.</td>
</tr>
</tbody>
</table>
Notes 1. The `bool` type is only valid for compilation of C++ programs or C programs including `stdbool.h`

Notes 2. To use a bit field member, data in the bit field is extended to the declared type. One-bit field data declared with a sign is interpreted as the sign, and can only indicate 0 and −1.

Notes 3. Zero extension: Zeros are written to the upper bits to extend data.

Notes 4. Sign extension: The most significant bit of a bit field is used as a sign and the sign is written to the upper bits to extend data.

Notes 5. This data type is only valid for programs in C99. The `_Bool` type is treated as the `bool` type in compilation.

(b) Bit Field Allocation

Bit field members are allocated according to the following five rules:

- Bit field members are placed in an area beginning from the right, that is, the least significant bit.

Example

```c
struct b1 {  
    int a:2;  
    int b:3;  
} x;
```

![Diagram of bit field allocation example x](image)

- Consecutive bit field members having type specifiers of the same size are placed in the same area as much as possible.

Example

```c
struct b1 {  
    long a:2;  
    unsigned int b:3;  
} y;
```

![Diagram of bit field allocation example y](image)

- Bit field members having type specifiers with different sizes are allocated to separate areas.

Example

```c
struct b1 {  
    int a:5;  
    char b:4;  
} z;
```
If the number of remaining bits in an area is less than the next bit field size, even though the type specifiers indicate the same size, the remaining area is not used and the next bit field is allocated to the next area.

Example

```c
struct b2 {
    char a:5;
    char b:4;
} v;
```

- If a bit field member with a bit field size of 0 is declared, the next member is allocated to the next area.

Example

```c
struct b2 {
    char a:5;
    char :0;
    char c:3;
} w;
```

Note It is also possible to place bit field members from the upper bit. For details, refer to the description on the `bit_order` option in Compiler Options, and the description on `#pragma bit_order` in 4.2 Extended Language Specifications.

(4) Memory Allocation in Big Endian

In big endian, data are allocated in the memory as follows:

(a) One-Byte Data (char, signed char, unsigned char, bool, and _Bool types)

The order of bits in one-byte data for the little endian and the big endian is the same.

Notes 1. When C89 is used for compiling, the size and the number of bytes for alignment are 4.

(b) Two-Byte Data ((signed) short and unsigned short types)

The upper byte and the lower byte will be reversed in two-byte data between the little endian and the big endian.

Example When two-byte data 0x1234 is allocated at address 0x00:

Little Endian: Address 0x010: 0x34
              Address 0x010: 0x12

Big Endian: Address 0x100: 0x12
            Address 0x100: 0x34

(c) Four-Byte Data ((signed) int, unsigned int, (signed) long, unsigned long, and float types)

The order of bytes will be reversed in four-byte data between the little endian and the big endian.
Notes 2. When the \texttt{int\textunderscore to\textunderscore short} option is specified, the \texttt{signed int} and \texttt{unsigned int} types have the same size and number of bytes for alignment as the \texttt{signed short} and \texttt{unsigned short} types, respectively.

Example When four-byte data 0x12345678 is allocated at address 0x100:

\begin{verbatim}
Little Endian: Address 0x100: 0x78
  Address 0x101: 0x56
  Address 0x102: 0x34
  Address 0x103: 0x12

Big Endian:  Address 0x100: 0x12
  Address 0x101: 0x34
  Address 0x102: 0x56
  Address 0x103: 0x78
\end{verbatim}

(d) Eight-Byte Data (\texttt{(signed) long}, \texttt{unsigned long}, and \texttt{double} types)
The order of bytes will be reversed in eight-byte data between the little endian and the big endian.

Example When eight-byte data 0x123456789abc def is allocated at address 0x100:

\begin{verbatim}
Little Endian: Address 0x100: 0xef
  Address 0x101: 0xcd
  Address 0x102: 0xab
  Address 0x103: 0x89
  Address 0x104: 0x67
  Address 0x105: 0x45
  Address 0x106: 0x23
  Address 0x107: 0x01

Big Endian:  Address 0x100: 0x01
  Address 0x101: 0x23
  Address 0x102: 0x45
  Address 0x103: 0x67
  Address 0x104: 0x89
  Address 0x105: 0x56
  Address 0x106: 0x78
  Address 0x107: 0xef
\end{verbatim}

(e) Compound-Type and Class-Type Data
Members of compound-type and class-type data will be allocated in the same way as that of the little endian. However, the order of byte data of each member will be reversed according to the rule of data size.

Example When the following function exists at address 0x100:

\begin{verbatim}
struct {
  short a;
  int b;
}z= {0x1234, 0x56789abc};
\end{verbatim}

\begin{verbatim}
Little Endian: Address 0x100: 0x34
  Address 0x101: 0x12
  Address 0x102: Unused area
  Address 0x103: Unused area
  Address 0x104: 0xbc
  Address 0x105: 0x9a
  Address 0x106: 0x78
  Address 0x107: 0x56

Big Endian:  Address 0x100: 0x12
  Address 0x101: 0x34
  Address 0x102: Unused area
  Address 0x103: Unused area
  Address 0x104: 0x56
  Address 0x105: 0x78
  Address 0x106: 0x9a
  Address 0x107: 0xbc
\end{verbatim}

(f) Bit Field
Bit fields will be allocated in the same way as that of the little endian. However, the order of byte data in each area will be reversed according to the rule of data size.

Example When the following function exists at address 0x100:

\begin{verbatim}
struct {
  long a:16;
  unsigned int b:15;
  short c:5;
}y= {1,1,1};
\end{verbatim}

\begin{verbatim}
Little Endian: Address 0x100: 0x01
  Address 0x101: 0x00
  Address 0x102: 0x01
  Address 0x103: 0x00
  Address 0x104: 0x01
  Address 0x105: 0x00
  Address 0x106: Unused area
  Address 0x107: Unused area

Big Endian:  Address 0x100: 0x00
  Address 0x101: 0x01
  Address 0x102: 0x00
  Address 0x103: 0x01
  Address 0x104: 0x00
  Address 0x105: 0x01
  Address 0x106: Unused area
  Address 0x107: Unused area
\end{verbatim}

(5) Floating-Point Number Specifications

(a) Internal Representation of Floating-Point Numbers
Floating-point numbers handled by this compiler are internally represented in the standard IEEE format. This section outlines the internal representation of floating-point numbers in the IEEE format. This section assumes that the `dbl_size=8` option is specified. When the `dbl_size=4` option is specified, the internal representation of the `double` type and `long double` type is the same as that of the `float` type.

(b) Format for Internal Representation

`float` types are represented in the IEEE single-precision (32-bit) format, while `double` types and `long double` types are represented in the IEEE double-precision (64-bit) format.

(c) Structure of Internal Representation

Figure 4.1 shows the structure of the internal representation of `float`, `double`, and `long double` types.

![Figure 4.1](image_url)

Figure 4.1 Structure of Internal Representation of Floating-Point Numbers

- **`float` type**
  
  ![Mantissa (23 bits) Exponent (8 bits) Sign (1 bit)]

  - Mantissa (23 bits)
  - Exponent (8 bits)
  - Sign (1 bit)

- **`double` type and `long double` type**
  
  ![Mantissa (53 bits) Exponent (11 bits) Sign (1 bit)]

  - Mantissa (53 bits)
  - Exponent (11 bits)
  - Sign (1 bit)

The internal representation format consists of the following parts:

i. **Sign**
   
   Shows the sign of the floating-point number. 0 is positive, and 1 is negative.

ii. **Exponent**
   
   Shows the exponent of the floating-point number as a power of 2.

iii. **Mantissa**
   
   Shows the data corresponding to the significant digits (fraction) of the floating-point number.

(d) Types of Values Represented as Floating-Point Numbers

In addition to the normal real numbers, floating-point numbers can also represent values such as infinity. The following describes the types of values represented by floating-point numbers.

i. **Normalized number**
   
   Represents a normal real value; the exponent is not 0 or not all bits are 1.

ii. **Denormalized number**
   
   Represents a real value having a small absolute number; the exponent is 0 and the mantissa is other than 0.

iii. **Zero**
   
   Represents the value 0.0; the exponent and mantissa are 0.

iv. **Infinity**
   
   Represents infinity; all bits of the exponent are 1 and the mantissa is 0.

v. **Not-a-number**
   
   Represents the result of operation such as "0.0/0.0", "\infty/\infty", or "\infty-\infty", which does not correspond to a number or infinity; all bits of the exponents are 1 and the mantissa is other than 0.

Table 4.4 shows the types of values represented as floating-point numbers.
Table 4.4  Types of Values Represented as Floating-Point Numbers

<table>
<thead>
<tr>
<th>Mantissa</th>
<th>Exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other than 0</td>
<td>Denormalized number</td>
</tr>
</tbody>
</table>

Note: Denormalized numbers are floating-point numbers of small absolute values that are outside the range represented by normalized numbers. There are fewer valid digits in a denormalized number than in a normalized number. Therefore, if the result or intermediate result of a calculation is a denormalized number, the number of valid digits in the result cannot be guaranteed. When `denormalize=off` is specified, denormalized numbers are processed as 0. When `denormalize=on` is specified, denormalized numbers are processed as denormalized numbers.
(e) **float Type**

The **float** type is internally represented by a 1-bit sign, an 8-bit exponent, and a 23-bit mantissa.

i. **Normalized numbers**

The sign indicates the sign of the value, either 0 (positive) or 1 (negative). The exponent is between 1 and 254 \((2^8 - 2)\). The actual exponent is gained by subtracting 127 from this value. The range is between −126 and 127. The mantissa is between 0 and \(2^{23} - 1\). The actual mantissa is interpreted as the value of which \(2^{23}\)rd bit is 1 and this bit is followed by the decimal point. Values of normalized numbers are as follows:

\[
(–1)^{\text{sign}} \times 2^{\text{exponent}–127} \times (1 + \text{mantissa} \times 2^{–23})
\]

**Example**

<table>
<thead>
<tr>
<th>31</th>
<th>30</th>
<th>23</th>
<th>22</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1100000000000000000000000000000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sign: –

Exponent: 1000000000\(_{(2)}\) – 127 = 1, where \(_{(2)}\) indicates binary

Mantissa: 1.11\(_{(2)}\) = 1.75

Value: \(-1.75 \times 2^1 = -3.5\)

ii. **Denormalized numbers**

The sign indicates the sign of the value, either 0 (positive) or 1 (negative). The exponent is 0 and the actual exponent is −126. The mantissa is between 1 and \(2^{23}–1\), and the actual mantissa is interpreted as the value of which \(2^{23}\)rd bit is 0 and this bit is followed by the decimal point. Values of denormalized numbers are as follows:

\[
(–1)^{\text{sign}} \times 2^{–126} \times ((\text{mantissa}) \times 2^{–23})
\]

**Example**

<table>
<thead>
<tr>
<th>31</th>
<th>30</th>
<th>23</th>
<th>22</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1100000000000000000000000000000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sign: +

Exponent: −126

Mantissa: 0.11\(_{(2)}\) = 0.75, where \(_{(2)}\) indicates binary

Value: \(0.75 \times 2^{-126}\)

iii. **Zero**

The sign is 0 (positive) or 1 (negative), indicating +0.0 or −0.0, respectively. The exponent and mantissa are both 0.

+0.0 and −0.0 are both the value 0.0.

iv. **Infinity**

The sign is 0 (positive) or 1 (negative), indicating \(+\infty\) or \(–\infty\), respectively.

The exponent is 255 \((2^8–1)\).

The mantissa is 0.

v. **Not-a-number**

The exponent is 255 \((2^8–1)\).

The mantissa is a value other than 0.

**Note**

A not-a-number is called a quiet NaN when the MSB of the mantissa is 1, or a signaling NaN when the MSB of the mantissa is 0. There are no stipulations regarding the values of the rest of the mantissa and of the sign.

(f) **double Types and long double Types**

The **double** and **long double** types are internally represented by a 1-bit sign, an 11-bit exponent, and a 52-bit mantissa.

i. **Normalized numbers**

The sign indicates the sign of the value, either 0 (positive) or 1 (negative). The exponent is between 1 and 2046 \((2^{11}–2)\). The actual exponent is gained by subtracting 1023 from this value. The range is between −1022 and 1023. The mantissa is between 0 and \(2^{52}–1\). The actual mantissa is interpreted as the value of which \(2^{52}\)nd bit is 1 and this bit is followed by the decimal point. Values of normalized numbers are as follows:

\[
(–1)^{\text{sign}} \times 2^{\text{exponent}–1023} \times (1 + \text{mantissa} \times 2^{–52})
\]

**Example**

<table>
<thead>
<tr>
<th>63</th>
<th>62</th>
<th>52</th>
<th>51</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1110000000000000000000000000000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sign: +

Exponent: 1111111111\(_{(2)}\) − 1023 = 0, where \(_{(2)}\) indicates binary
ii. Denormalized numbers
The sign indicates the sign of the value, either 0 (positive) or 1 (negative). The exponent is 0 and the actual
exponent is \(-1022\). The mantissa is between 1 and \(2^{52} - 1\), and the actual mantissa is interpreted as the value
of which \(2^{52}\)nd bit is 0 and this bit is followed by the decimal point. Values of denormalized numbers are as
follows:
\((-1)^{\text{sign}} \times 2^{-1022} \times ((\text{mantissa}) \times 2^{-52})\)

Example

\[
\begin{array}{cccc}
63 & 62 & 52 & 51 & 0 \\
1 & 0000000000 & 1110000000000000000000000000000000000000000000000001
\end{array}
\]

Sign: \(-\)
Exponent: \(-1022\)
Mantissa: \(0.111(2) = 0.875\), where \((2)\) indicates binary
Value: \(0.875 \times 2^{-1022}\)

iii. Zero
The sign is 0 (positive) or 1 (negative), indicating \(+0.0\) or \(–0.0\), respectively. The exponent and mantissa are
both 0. \(+0.0\) and \(–0.0\) are both the value 0.0.

iv. Infinity
The sign is 0 (positive) or 1 (negative), indicating \(+\infty\) or \(–\infty\), respectively. The exponent is 2047 (\(2^{11}–1\)).
The mantissa is 0.

v. Not-a-number
The exponent is 2047 (\(2^{11}–1\)). The mantissa is a value other than 0.

Note A not-a-number is called a quiet NaN when the MSB of the mantissa is 1, or signaling NaN when
the MSB of the mantissa is 0. There are no specifications regarding the values of other mantissa
fields or the sign.

4.1.6 Operator Evaluation Order

When an expression includes multiple operators, the evaluation order of these operators is determined according to the
precedence and the associativity indicated by right or left.

Table 4.5 shows each operator precedence and associativity.

<table>
<thead>
<tr>
<th>Precedence</th>
<th>Operators</th>
<th>Associativity</th>
<th>Applicable Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>++ -- (postfix) ( ) [ ] -&gt; .</td>
<td>Left</td>
<td>Postfix expression</td>
</tr>
<tr>
<td>2</td>
<td>++ -- (prefix) ! ~ + - * &amp; sizeof</td>
<td>Right</td>
<td>Unary expression</td>
</tr>
<tr>
<td>3</td>
<td>(Type name)</td>
<td>Right</td>
<td>Cast expression</td>
</tr>
<tr>
<td>4</td>
<td>* / %</td>
<td>Left</td>
<td>Multiplicative expression</td>
</tr>
<tr>
<td>5</td>
<td>+ -</td>
<td>Left</td>
<td>Additive expression</td>
</tr>
<tr>
<td>6</td>
<td>&lt;&lt; &gt;&gt;</td>
<td>Left</td>
<td>Bitwise shift expression</td>
</tr>
<tr>
<td>7</td>
<td>&lt; &lt;= &gt; &gt;=</td>
<td>Left</td>
<td>Relational expression</td>
</tr>
<tr>
<td>8</td>
<td>== !=</td>
<td>Left</td>
<td>Equality expression</td>
</tr>
<tr>
<td>9</td>
<td>&amp;</td>
<td>Left</td>
<td>Bitwise AND expression</td>
</tr>
<tr>
<td>10</td>
<td>^</td>
<td>Left</td>
<td>Bitwise exclusive OR expression</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>Left</td>
</tr>
</tbody>
</table>
4. COMPILER LANGUAGE SPECIFICATIONS

4.1.7 Conforming Language Specifications

(1) C Language Specifications (When the lang=c Option is Selected)
   ANSI/ISO 9899-1990 American National Standard for Programming Languages -C

(2) C Language Specifications (When the lang=c99 Option is Selected)
   ISO/IEC 9899:1999 INTERNATIONAL STANDARD Programming Languages - C

(3) C++ Language Specifications (When the lang=cpp Option is Selected)
   Based on the language specifications compatible with Microsoft® Visual C/C++ 6.0

<table>
<thead>
<tr>
<th>Precedence</th>
<th>Operators</th>
<th>Associativity</th>
<th>Applicable Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>&amp;&amp;</td>
<td>Left</td>
<td>Logical AND operation</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>?:</td>
<td>Right</td>
<td>Conditional expression</td>
</tr>
<tr>
<td>15</td>
<td>= += -= *= /= %= &lt;&lt;= &gt;&gt;= &amp;=</td>
<td>= ^=</td>
<td>Right</td>
</tr>
<tr>
<td>16</td>
<td>,</td>
<td>Left</td>
<td>Comma expression</td>
</tr>
</tbody>
</table>
4.2  Extended Language Specifications

This section explains the extended language specifications supported by the CCRX.
The compiler supports the following extended specifications:
- **#pragma** extension specifiers and keywords
- Intrinsic functions
- Section address operators

4.2.1  Macro Names

The following shows supported macro names.

<table>
<thead>
<tr>
<th>No.</th>
<th>Option</th>
<th>Predefined Macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>DATE</strong></td>
<td>Date of translating source file</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(character string constant in the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>form of &quot;Mmm dd yyyy.&quot;.) Here,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the name of the month is the same</td>
</tr>
<tr>
<td></td>
<td></td>
<td>as that created by the asctime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>function stipulated by ANSI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>standards (3 alphabetic characters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with only the first character is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>capital letter) (The first</td>
</tr>
<tr>
<td></td>
<td></td>
<td>character of dd is blank if its</td>
</tr>
<tr>
<td></td>
<td></td>
<td>value is less than 10).</td>
</tr>
<tr>
<td>2</td>
<td><strong>FILE</strong></td>
<td>Name of assumed source file</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(character string constant).</td>
</tr>
<tr>
<td>3</td>
<td><strong>LINE</strong></td>
<td>Line number of source line at that</td>
</tr>
<tr>
<td></td>
<td></td>
<td>point (decimal).</td>
</tr>
<tr>
<td>4</td>
<td><strong>STDC</strong></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>lang=c99</td>
<td><strong>STDC_HOSTED</strong> 1</td>
</tr>
<tr>
<td>6</td>
<td>lang=c99</td>
<td><strong>STDC_VERSION</strong> 199409L (lang = c</td>
</tr>
<tr>
<td></td>
<td>lang=c99</td>
<td>199901L (lang = c99)</td>
</tr>
<tr>
<td>7</td>
<td>lang=c99</td>
<td><strong>STDC_IEC_559</strong> 1</td>
</tr>
<tr>
<td>8</td>
<td>lang=c99</td>
<td><strong>STDC_IEC_559_COMPLEX</strong> 1</td>
</tr>
<tr>
<td>9</td>
<td>lang=c99</td>
<td><strong>STDC_ISO_10646</strong> 199712L</td>
</tr>
<tr>
<td>10</td>
<td>lang=cpp</td>
<td>__cplusplus 1</td>
</tr>
<tr>
<td></td>
<td>lang=ecpp</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td><strong>TIME</strong></td>
<td>Translation time of source file</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(character string constant having</td>
</tr>
<tr>
<td></td>
<td></td>
<td>format &quot;hh:mm:ss&quot;).</td>
</tr>
<tr>
<td>12</td>
<td>isa=rxv1</td>
<td>#define __RXV1 1</td>
</tr>
<tr>
<td></td>
<td>isa=rxv2</td>
<td>#define __RXV2 1</td>
</tr>
<tr>
<td></td>
<td>isa=rxv3</td>
<td>#define __RXV3 [V3.00.00 or later]</td>
</tr>
<tr>
<td>13</td>
<td>endian=big</td>
<td>#define __BIG 1</td>
</tr>
<tr>
<td></td>
<td>endian=little</td>
<td>#define __LIT 1</td>
</tr>
<tr>
<td>14</td>
<td>dbl_size=4</td>
<td>#define __DBL4 1</td>
</tr>
<tr>
<td></td>
<td>dbl_size=8</td>
<td>#define __DBL8 1</td>
</tr>
<tr>
<td>15</td>
<td>int_to_short</td>
<td>#define __INT_SHORT 1</td>
</tr>
<tr>
<td>No.</td>
<td>Option</td>
<td>Predefined Macro</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>------------------</td>
</tr>
</tbody>
</table>
| 16  | signed_char
    unsigned_char | #define __SCHAR
    #define __UCHAR |
| 17  | signed_bitfield
    unsigned_bitfield | #define __SBIT
    #define __UBIT |
| 18  | round=zero
    round=nearest | #define __ROZ
    #define __RON |
| 19  | denormalize=off
    denormalize=on | #define __DOFF
    #define __DON |
| 20  | bit_order=left
    bit_order=right | #define __BITLEFT
    #define __BITRIGHT |
| 21  | auto_enum | #define __AUTO_ENUM |
| 22  | library=function
    library=intrinsic | #define __FUNCTION_LIB
    #define __INTRINSIC_LIB |
| 23  | fpu | #define __FPU |
| 24  | - | #define __RENEASAS__ ^3 |
| 25  | - | #define __RENEASAS_VERSION__ ^3 0xXXYYYZZ00 ^4 |
| 26  | - | #define __RX ^3 |
| 27  | pic | #define __PIC |
| 28  | pid | #define __PID |
| 29  | cpu=rx600
    cpu=rx200 | #define __RX600
    #define __RX200 |
| 30  | - | #define __CCRX__ ^3 [V2.03.00 or later] |
| 31  | isa=rxv1
    isa=rxv2
    isa=rxv3 | #define __RX_ISA_VERSION__ [V3.00.00 or later] |
| 32  | dpfpu | #define __DPFPU [V3.01.00 or later] |
| 33  | tfu=intrinsic
    tfu=intrinsic,mathlib | #define __TFU [V3.01.00 or later] |
| 34  | tfu=intrinsic,mathlib | #define __TFU_MATHLIB [V3.01.00 or later] |

Notes 1. Includes cases where a file with the .c extension is compiled without specifying the -lang option.

Notes 2. Includes cases where a file with the .cpp, .cp, or .cc extension is compiled without specifying the -lang option.

Notes 3. Always defined regardless of the option.

Notes 4. When the Compiler version is VXX.YY.ZZ, the value of __RENEASAS_VERSION__ is 0xXXYYYZZ00. Example
   For V3.01.00: #define __RENEASAS_VERSION__ 0x03010000
4.2.2 Keywords

The CCRX adds the following characters as a keyword to implement the extended function. These words are similar to the ANSI C keywords, and cannot be used as a label or variable name.

Keywords that are added by the CCRX are listed below.

__evenaccess, far, _far, near, and _near

Table 4.7 Keywords

<table>
<thead>
<tr>
<th>No.</th>
<th>Keyword</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>#pragma STDC CX_LIMITED_RANGE #pragma STDC FENV_ACCESS #pragma STDC FP_CONTRACT</td>
<td>Reserved keywords that are only valid when C99 is selected (these are only for grammatical checking and not for checking the correctness of the code).</td>
</tr>
<tr>
<td>2</td>
<td>#pragma keywords</td>
<td>Provides language extensions. For details, refer to 4.2.3 #pragma Directive.</td>
</tr>
<tr>
<td>3</td>
<td>__evenaccess</td>
<td>Guarantees access in the size of the variable type.</td>
</tr>
<tr>
<td>4</td>
<td>far _far near _near</td>
<td>Reserved keywords (these are ignored even though they are recognized as type names)</td>
</tr>
<tr>
<td>5</td>
<td>_RAM_BASE</td>
<td>Reserved keyword. (Only in -base=ram specified.)</td>
</tr>
<tr>
<td>6</td>
<td>_ROM_BASE</td>
<td>Reserved keyword. (Only in -base=rom specified.)</td>
</tr>
<tr>
<td>7</td>
<td>_PID_TOP</td>
<td>Reserved keyword. (Only in -pid specified.)</td>
</tr>
<tr>
<td>8</td>
<td>_builtin_xxx</td>
<td>Reserved keyword. This means all functions those names begin with <em>builtin</em>.</td>
</tr>
</tbody>
</table>

4.2.3 #pragma Directive

The following extended specifications can also be used with the _Pragma operator in C99.

(1) Section Switch
This extension changes the section name to be output by the compiler.
For details on the description, refer to (1) Section Switch.

```
#pragma section [<section type>] [D<new section name>]
<section type>: { P | C | D | B }
```

(2) Stack Section Creation
This extension creates the stack section.
For details on the description, refer to (2) Stack Section Creation.

```
#pragma stacksize { si=<constant> | su=<constant> }
```

(3) Interrupt Function Creation
This extension creates the interrupt function.
For details on the description, refer to (3) Interrupt Function Creation.

```
#pragma interrupt [[(]<function name>[(<interrupt specification>[,...][,...][,...])]]]
```

(4) Inline Expansion of Function
This extension expands a function.
For details on the description, refer to (4) Inline Expansion of Function.
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(5) Cancellation of Inline Expansion of Function
This extension cancels expansion of a function.
For details on the description, refer to (4) Inline Expansion of Function.

#pragma inline [([function name> [...]])]

#pragma noinline [([function name> [...]])]

(6) Inline Expansion of Assembly-Language Function
This extension creates the assembly-language inline functions.
For details on the description, refer to (5) Inline Expansion of Assembly-Language Function.

#pragma inline_asm([([function name> [...]])]

(7) Entry Function Specification
This extension specifies the entry function.
For details on the description, refer to (6) Entry Function Specification.

#pragma entry([([function name> [...]])]

(8) Bit Field Order Specification
This extension specifies the order of the bit field.
For details on the description, refer to (7) Bit Field Order Specification.

#pragma bit_order ([left | right])

(9) 1-Byte Alignment Specification for Structure Members and Class Members
This extension specifies the boundary alignment value of structure members and class members as 1 byte.
For details on the description, refer to (8) Alignment Value Specification for Structure Members and Class Members.

#pragma pack

#pragma unpack

(10) Default Alignment Specification for Structure Members and Class Members
This extension specifies the boundary alignment value for structure members and class members as the value for members.
For details on the description, refer to (8) Alignment Value Specification for Structure Members and Class Members.

#pragma unpack

(11) Option Alignment Specification for Structure Members and Class Members
This extension specifies the option of the boundary alignment value for structure members and class members.
For details on the description, refer to (8) Alignment Value Specification for Structure Members and Class Members.

#pragma packoption

(12) Allocation of a Variable to the Absolute Address
This extension allocates the specified variable to the specified address.
For details on the description, refer to (9) Allocation of a Variable to the Absolute Address.

#pragma address ([([variable name>=<absolute address> [...]])]

(13) Endian Specification for Initial Values
This extension specifies an endian for initial values.
For details on the description, refer to (10) Endian Specification for Initial Values.

#pragma endian ([big | little])

(14) Specification of Function in which Instructions at Branch Destinations are Aligned to 4-Byte Boundaries
This extension specifies the function in which instructions at branch destinations are aligned to 4-byte boundaries.
For details on the description, refer to (11) Specification of Function in which Instructions at Branch Destinations are Aligned for Execution.

```
#pragma instalign4 [(<function name>)(<branch destination type>)[,...][)]
```

(15) Specification of Function in which Instructions at Branch Destinations are Aligned to 8-Byte Boundaries
This extension specifies the function in which instructions at branch destinations are aligned to 8-byte boundaries. For details on the description, refer to (11) Specification of Function in which Instructions at Branch Destinations are Aligned for Execution.

```
#pragma instalign8 [(<function name>)(<branch destination type>)[,...][)]
```

(16) Specification of Function in which Instructions at Branch Destinations are not Aligned
This extension specifies the function in which instructions at branch destinations are not aligned. For details on the description, refer to (11) Specification of Function in which Instructions at Branch Destinations are Aligned for Execution.

```
#pragma noinstalign [(<function name>)[,...][)]
```

(17) Specification of Function for generating a code for detection of stack smashing [Professional Edition only] [V2.04.00 or later]
This extension generates a code for detection of stack smashing. For details on the description, refer to (12) Specification of Function for generating a code for detection of stack smashing [Professional Edition only] [V2.04.00 or later].

```
#pragma stack_protector [(<function name>)(<integer value>)]
```

(18) Specification of not generating a code for detection of stack smashing [Professional Edition only] [V2.04.00 or later]
This extension suppresses generating a code for detection of stack smashing. For details on the description, refer to (12) Specification of Function for generating a code for detection of stack smashing [Professional Edition only] [V2.04.00 or later].

```
#pragma no_stack_protector [(<function name>)]
```

### 4.2.4 Using Extended Specifications

This section explains using the following extended specifications.

- Section switch
- Stack section creation
- Interrupt function creation
- Inline expansion of function
- Inline expansion of assembly-language function
- Entry function specification
- Bit field order specification
- Alignment value specification for structure members and class members
- Allocation of a variable to the absolute address
- Endian specification for initial values
- Specification of function in which instructions at branch destinations are aligned for execution
- Specification of function for generating a code for detection of stack smashing

(1) **Section Switch**

```
#pragma section [<section type>] [D<new section name>]
<section type>: { P | C | D | B }
```
This extension changes the section name to be output by the compiler.
When both a section type and a new section name are specified, the section names for all functions written after
the `#pragma` declaration are changed if the specified section type is P. If the section type is C, D, or B, the names
of all sections defined after the `#pragma` declaration are changed.
When only a new section name is specified, the section names for the program, constant, initialized data, and
uninitialized data areas after the `#pragma` declaration are changed. In this case, the default section name post-
fixed with the string specified by <new section name> is used as the new section name.
When neither a section type nor a new section name is specified, the section names for the program, constant, ini-
tialized data, and uninitialized data areas after the `#pragma` declaration are restored to the default section names.
The default section name for each section type is determined by the `section` option when specified. If the default
section name is not specified by the `section` option, the section type name is used instead.

[Earlier than V3.02.00] `#pragma section` must be specified outside function definitions.

[V3.02.00 or later] `#pragma section` can be specified within function definitions. The opening and closing paren-
theses of a function do not affect the valid range of `#pragma`.

[V3.02.00 or later] `#pragma section` has effect on the name of the section containing static variables within the
function, static data members, and their initial values. However, there is no effect on the names of the following
sections:
- Section that contains static variables within the function and their initial values specified in a function template
  (not specialized)
- Section that contains static data members and their initial values specified in a class template

Examples 1. When a section name and a section type are specified

```c
#pragma section B Ba
int i; // Allocated to the Ba section
void func(void)
{
    (omitted)
}

#pragma section B Bb
int j; // Allocated to the Bb section
void sub(void)
{
    (omitted)
}
```

Examples 2. When the section type is omitted

```c
#pragma section abc
int a; // Allocated to the Babc section
const int c=1; // Allocated to the Cabc section
void f(void) // Allocated to the Pabc section
{
    a=c;
}

#pragma section
int b; // Allocated to the B section
void g(void) // Allocated to the P section
{
    b=c;
}
Examples 3. Specification for static class members

```
/*
** Class member declaration
*/

class A {
    private:
        // No initial value specified
        #pragma section DATA
        static int data_;  
        #pragma section
        // Initial value specified
        #pragma section TABLE
        static int table_[2];
        #pragma section
    }

    class member definition
*/

    // No initial value specified
    #pragma section DATA
    int A::data_;  
    #pragma section
    // Initial value specified
    #pragma section TABLE
    int A::table_[2] = { 0, 1 }; 
    #pragma section
```

Examples 4. Specification of a section for static variables within the function [V3.02.00 or later]

```
void test1(void) {
    #pragma section B B1
    static int b1; // B1
    #pragma section B B2
    static int b2; // B2
}

// The valid range is not affected by the parentheses of the function definition.
int b3; // B2

void test2(void) {
    static int b4; // B2
    #pragma section
    static int b5; // B
}
```

The section name of the following items cannot be changed by this extension. The section option needs to be used.
(1) String literal and initializers for use in the dynamic initialization of aggregates
(2) Branch table of switch statement
Up to 2045 sections can be specified by #pragma section in one file.
When specifying the section for static class member variables, be sure to specify #pragma section for both the class member declaration and definition.
Example

```c
/*
 ** Class member declaration
 */

class A
{
 private:

 // No initial value specified
 #pragma section DATA
 static int data_;  
 #pragma section

 // Initial value specified
 #pragma section TABLE
 static int table_[2];
 #pragma section
};

/*
 ** Class member definition
 */

// No initial value specified
 #pragma section DATA
 int A::data_;  
 #pragma section

 // Initial value specified
 #pragma section TABLE
 int A::table_[2]={0, 1};
 #pragma section

#pragma stacksize { si=<constant> | su=<constant> }
```

(2) Stack Section Creation

```c
#pragma stacksize { si=<constant> | su=<constant> }
```

When `si=<constant>` is specified, a data section is created to be used as the stack of size `<constant>` with section name `SI`.

When `su=<constant>` is specified, a data section is created to be used as the stack of size `<constant>` with section name `SU`.

C source description:

```c
#pragma stacksize si=100
#pragma stacksize su=200
```

Example of expanded code:

```c
.SECION    SI,DATA,ALIGN=4
.BLKB       100
.SECION    SU,DATA,ALIGN=4
.BLKB       200
```

`si` and `su` can each be specified only once in a file.

A value from 4 to 2147483644(0x7ffffffc) is specifiable for `<constant>`. 

<constant> must always be specified as a multiple of four.
(3) Interrupt Function Creation

```c
#pragma interrupt [(<function name>)[(<<interrupt specification>[],...)[,...][)])
```

This extension declares an interrupt function. A global function or a static function member can be specified for the function name. Table 4.8 lists the interrupt specifications.

### Table 4.8 Interrupt Specifications

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Form</th>
<th>Options</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vector table</td>
<td>vect=</td>
<td>&lt;vector number&gt;</td>
<td>Specifies the vector number for which the interrupt function address is stored.</td>
</tr>
<tr>
<td>2</td>
<td>Fast interrupt</td>
<td>fint</td>
<td>None</td>
<td>Specifies the function used for fast interrupts. This RTFI instruction is used to return from the function.</td>
</tr>
<tr>
<td>3</td>
<td>Limitation on registers in interrupt function</td>
<td>save</td>
<td>None</td>
<td>Limits the number of registers used in the interrupt function to reduce save and restore operations.</td>
</tr>
<tr>
<td>4</td>
<td>Nested interrupt enable</td>
<td>enable</td>
<td>None</td>
<td>Sets the I flag in PSW to 1 at the beginning of the function to enable nested interrupts.</td>
</tr>
<tr>
<td>5</td>
<td>Accumulator saving</td>
<td>acc</td>
<td>None</td>
<td>Saves and restores Accumulator in the interrupt function.</td>
</tr>
<tr>
<td>6</td>
<td>Accumulator non-saving</td>
<td>no_acc</td>
<td>None</td>
<td>Does not save and restore Accumulator in the interrupt function.</td>
</tr>
<tr>
<td>7</td>
<td>Enable the register bank save function</td>
<td>bank=</td>
<td>&lt;bank number&gt;</td>
<td>Enables the register bank save function. Specify the number of the bank in which the values of registers will be saved.</td>
</tr>
<tr>
<td>8</td>
<td>Saving output of the trigonometric function unit</td>
<td>tfu</td>
<td>None</td>
<td>Saves and restores the output of the trigonometric function unit in the interrupt function.</td>
</tr>
<tr>
<td>9</td>
<td>Not saving output of the trigonometric function unit</td>
<td>no_tfu</td>
<td>None</td>
<td>Does not save or restore output of the trigonometric function unit in the interrupt function.</td>
</tr>
</tbody>
</table>

An interrupt function declared by `#pragma interrupt` guarantees register values before and after processing (all registers used by the function are pushed onto and popped from the stack when entering and exiting the function). The RTE instruction directs execution to return from the function in most cases. An interrupt function with no interrupt specifications is processed as a simple interrupt function.

When use of the vector table is specified (`vect=`), the interrupt function address is stored in the specified vector table number location in the C$VECT section. [V3.00.00 or later] When the `-split_vect` option is specified in the optimizing linkage editor, the C$VECT section is split by vector table number and each section has the name of "C$VECT<vector table number>".

When use of fast interrupt processing is specified (`fint`), the RTFI instruction is used to return from the function. When the `fint_register` option is also specified, the registers specified through the option are used by the interrupt function without being saved or restored.
When a limitation on registers in interrupt function is specified (save), the registers that can be used in the interrupt function are limited to R1 to R5 and R14 to R15. R6 to R13 are not used and the instructions for saving and restoring them are not generated.

When enable is specified, the I flag in PSW is set to 1 at the beginning of the function to enable nested interrupts.

When Accumulator saving (acc) is specified, if another function is called from a function specified with #pragma interrupt or the function uses an instruction that modifies the ACC, an instruction to save and restore the ACC is generated. When RXv1 is selected as ISA\(^1\), the ACC is saved and restored. When a value other than RXv1 is selected as ISA\(^1\), ACC0 and ACC1 are saved and restored.

When Accumulator non-saving is specified (no_acc), an instruction to save and restore the ACC is not generated. If neither acc nor no_acc is specified, the result depends on the setting of the compiler option -save_acc.

[V3.01.00 or later] When bank = <bank number> is specified, the CC-RX enables the use of the register bank save function (for which the SAVE and RSTR instructions are provided) in cases where it is considered necessary. The destination for saving data is the save register bank with the number specified in <bank number>. Refer to the User’s Manual: Hardware for the target MCU and specify a bank number that is actually available. When this facility is enabled, the values of ACC0 and ACC1 are also saved and restored even if the -save_acc option is not specified or no_acc (not saving accumulator values) is specified. Specifying bank = <bank number> when RXv1 or RXv2 is selected as ISA\(^1\) will lead to an error. When you specify bank = <bank number>, also specify the assembler option -bank. If you are using an integrated development environment from Renesas, -bank is specified automatically upon selection of an MCU that has save register banks.

[V3.05.00 or later] When tfu (saving output of the trigonometric function unit) is specified, if another function is called from a function specified with #pragma interrupt or the function uses the trigonometric function unit, instructions to save and restore the output (DTSR0, DTSR1) of the trigonometric function unit are generated. When no_tfu (not saving output of the trigonometric function unit) is specified, instructions to save and restore output of the trigonometric function unit are not generated. Interrupt specifications tfu and no_tfu can be specified only when tfu_version=v2 is specified. If neither tfu nor no_tfu is specified, the result depends on the setting of the -nosave_tfu compile option.

**Note**

*1) This means a selection by the -isa option or the ISA_RX environment variable.

The function must return only void data. No return value can be specified for the return statement. If attempted, an error will be output.

**Examples 1.** Correct declaration and wrong declaration

```c
#pragma interrupt (f1, f2)
void f1(){...}// Correct declaration.
int f2(){...}// An error will be output
// because the return value is not
// void data.
```

**Examples 2.** General interrupt function

C source description:

```c
#pragma interrupt func
void func(){ .... }
```

Output code:
Examples 3. Interrupt function that calls another function

In addition to the registers used in the interrupt function, the registers that are not guaranteed before and after a function call are also saved at the entry and restored at the exit.

C source description:

```c
#pragma interrupt func
void func(){
   ...
   sub();
   ...
}
```
Examples 4. Use of interrupt specification fint
C source description: Compiles with the fint_register=2 option specified

```c
#pragma interrupt func1(fint)
void func1(){ a=1; }    //  Interrupt function
void func2(){ a=2; }    //  General function
```

Output code:

```
_func1:
  _func:
    PUSHM R14-R15
    PUSHM R1-R5
    ...
    BSR _sub
    ...
    POPM R1-R5
    POPM R14-R15
    RTE
```

Examples 5. Use of interrupt specification acc
C source description:

```c
void func5(void);
#pragma interrupt accsaved_ih(acc)      /* Specifies acc */
void accsaved_ih(void)
{
  func5();
}
```
Output code:

```c
#include <rx.h>

#pragma interrupt func(bank=3) /* Specifies "bank=3" */
void func(void)
{
    ...
}
```

Output code:

```c
#include <rx.h>

#pragma interrupt func(bank=3) /* Specifies "bank=3" */
void func(void)
{
    ...
}
```

[Remarks]
Due to the specifications of the RX instruction set, if rxv1 is specified for ISA*1, only the upper 48 bits of ACC can be saved and restored with the acc flag. The lower 16 bits of ACC are not saved or restored.
Each interrupt specification can be specified only with alphabetical lowercase letters. When specified with upper-case letters, an error will occur.

When vect is used as an interrupt specification, the address of empty vectors for which there is no specification is 0. You can specify a desired address value or symbol for an address with the optimizing linkage editor. For details, refer to the descriptions on the VECT and VECTN options.
Parameters are not definable for #pragma interrupt functions. Although defining parameters for such functions does not lead to an error, values read out from the parameters are undefined.

Note *1) ISA indicates the selection by using the isa option or ISA_RX environment variable.

Purpose of acc and no_acc:
acc and no_acc take into account the following purposes:
- Solution for decrease in the interrupt response speed when compensation of ACC is performed by save_acc (no_acc)
  Though the save_acc option is valid for compensation of ACC in an existing interrupt function, the interrupt response speed is degraded in some cases. Therefore, no_acc is provided as a means to disable saving and restoring of unnecessary ACC for each function independently.
- Control of saving and restoring of ACC through source code
  Explicitly selecting acc or no_acc for an interrupt function for which saving and restoring of ACC has already been considered allows saving and restoring of ACC to be defined in the source program without using the save_acc option.

Examples 6. Use of interrupt specification bank
C source description:

```c
#include <rx.h>

#pragma interrupt func(bank=3) /* Specifies "bank=3" */
void func(void)
{
    ...
}
```

Output code:

```c
#include <rx.h>

#pragma interrupt func(bank=3) /* Specifies "bank=3" */
void func(void)
{
    ...
}
```

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Examples 7. Use of interrupt specification `vect` and `bank` in combination

C source description:

```c
#pragma interrupt func(vect=64, bank=4) /* Specifies "vect=64" and "bank=4" */
void func(void)
{
    ...
}
```

Output code:

```c
_func:
    .RVVECTOR 64,_func; Vector table number registration
    SAVE #04H ; Instruction for saving values in save register bank 4
    ...
    RSTR #04H ; Instruction for restoring values from save register bank 4
    RTE
```

(4) Inline Expansion of Function

```c
#pragma inline []<function name>[],...
#pragma noinline []<function name>[],...
```

`#pragma inline` declares a function for which inline expansion is performed.

Even when the `noinline` option is specified, inline expansion is done for the function specified by `#pragma inline`. `#pragma noinline` declares a function for which the inline option effect is canceled.

A global function or a static function member can be specified as a function name.

When inline expansion is performed for a function specified by `#pragma inline` or a function with the `inline` function specifier (C++ and C (C99), the body of the function is expanded where the function is called.

Example Source file:

```c
#pragma inline(func)
static int func (int a, int b)
{
    return (a+b)/2;
}
int x;
main()
{
    x=func(10,20);
}
```

Inline expansion image:

```c
int x;
main()
{
    int func_result;
    {
        int a_1=10, b_1=20;
        func_result=(a_1+b_1)/2;
    }
    x=func_result;
}
```

Inline expansion will not be applied in the following functions even when `#pragma inline` is specified.
- The function has variable parameters.
- Another function is called by using the address of the function to be expanded.

```c
#pragma inline
```
does not guarantee inline expansion; inline expansion might not be applied due to restrictions on increasing compilation time or memory size. If inline expansion is canceled, try specifying the `noscope` option; inline expansion may be applied in some cases.

Specify `#pragma inline` before defining a function.

An external definition is generated for a function specified by `#pragma inline`.

When `#pragma inline` is specified for a `static` function, the function definition is deleted after inline expansion.

The C++ compiler does not create external definitions for inline-specified functions.

The C (C99) does not create external definitions for inline-specified functions unless they include `extern` declarations.

### (5) Inline Expansion of Assembly-Language Function

This extension declares an assembly-language function for which inline expansion is performed.

The general function calling rules are also applied to the calls of assembly-language inline functions.

**C source description:**

```c
#pragma inline_asm(func)
static int func(int a, int b){
  ADD R2,R1; Assembly-language description
}
main(int *p){
  *p = func(10,20);
}
```

**Output code:**

```c
main:
  PUSH.L R6
  MOV.L R1, R6
  MOV.L #20, R2
  MOV.L #10, R1
  ADD R2,R1; Assembly-language description
  MOV.L R1, [R6]
  MOV.L #0, R1
  RTSD #04H, R6-R6
```

Specify `#pragma inline_asm` before defining a function.

An external definition is generated for a function which is not a `static` function but for which `#pragma inline_asm` is specified.

When the registers whose values are saved and restored at the entry and exit of a function (see Table 9.1 Rules to Use Registers) are used in an assembly-language inline function, these registers must be saved and restored at the start and end of the function.

**Remarks**

- In an assembly-language inline function, use only the RX Family instruction and temporary labels. Other labels cannot be defined and assembler directives cannot be used.
- Do not use `RTS` at the end of an assembly-language inline function.
- Function members cannot be specified as function names.
- When `#pragma inline_asm` is specified for a `static` function, the function definition is deleted after inline expansion.
- Assembly-language descriptions are processed by the preprocessor; take special care when defining through `#define` a macro with the same name as an instruction or a register used in the assembly language (such as `MOV` or `R5`).
A stack information file handles the assembly code for a `#pragma inline_asm` directive as not consuming stack area. Be careful when the assembly code includes an instruction with R0 as an operand.

**Entry Function Specification**

```c
#pragma entry[()]<function name>()
```

This specifies that the function specified as `function name` is handled as an entry function. The entry function is created without any code to save and restore the contents of registers. When `#pragma stacksize` is declared, the code that makes the initial setting of the stack pointer will be output at the beginning of the function. When the `base` option is specified, the base register specified by the option is set up.

Example C source description: `-base=rom=R13` is specified

```c
#pragma stacksize su=100
#pragma entry INIT
void INIT() {
  :
}
```

Output code:

```
.SECTIO8s SU,DATA,ALIGN=4
.BLKB 100
.SECTIO8s P,CODE
  _INIT:
  MVTC (TOPOF SU + SIZEOF SU),USP
  MOV.L #__ROM_TOP,R13
```

Be sure to specify `#pragma entry` before declaring a function. Do not specify more than one entry function in a load module.

**Bit Field Order Specification**

This extension switches the order of bit field assignment. When `left` is specified, bit field members are assigned from the upper-bit side. When `right` is specified, members are assigned from the lower-bit side. The default is `right`. If `left` or `right` is omitted, the order is determined by the option specification.

Example

<table>
<thead>
<tr>
<th>C Source</th>
<th>Bit Assignment</th>
</tr>
</thead>
</table>
| #pragma bit_order right
struct tbl_r{
    unsigned char a:2;
    unsigned char b:3;
} x; | Unused area |
| #pragma bit_order left
struct tbl_l{
    unsigned char a:2;
    unsigned char b:3;
} y; | x.a x.b |
(8) Alignment Value Specification for Structure Members and Class Members

```
// Different-size members
#pragma pack bit_order right
struct tbl_r {
    unsigned short a:4;
    unsigned char b:3;
} x

// Larger than the size of the type
#pragma pack bit_order right
struct tbl_r {
    unsigned char a:4;
    unsigned char b:5;
} x;
```

Table 4.9 #pragma pack Specifications and Corresponding Member Alignment Values

<table>
<thead>
<tr>
<th>Member Type</th>
<th>#pragma pack</th>
<th>#pragma unpack</th>
<th>#pragma packoption or No Extension Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>(signed) char</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(unsigned) short</td>
<td>1</td>
<td>2</td>
<td>Determined by the pack option</td>
</tr>
<tr>
<td>(unsigned) int *, (unsigned) long, (unsigned) long long, floating-point type, and pointer type</td>
<td>1</td>
<td>4</td>
<td>Determined by the pack option</td>
</tr>
</tbody>
</table>

Example

```
#pragma pack
struct S1 {
    char a;/* Byte offset = 0*/
    int b;/* Byte offset = 1*/
    char c;/* Byte offset = 5*/
} ST1;/* Total size: 6 bytes*/

#pragma unpack
struct S2 {
    char a;/* Byte offset = 0*/
    /* 3-byte empty area*/
    int b;/* Byte offset = 4*/
    char c;/* Byte offset = 8*/
    /* 3-byte empty area*/
} ST2;/* Total size: 12 bytes*/
```
The boundary alignment value for structure and class members can also be specified by the `pack` option. When both the option and `#pragma` extension specifier are specified together, the `#pragma` specification takes priority.

(9) Allocation of a Variable to the Absolute Address

```
#pragma address [ ()<variable name>=<absolute address> [, ... ] ]
```

This extension allocates the specified variable to the specified address. The compiler assigns a section for each specified variable, and the variable is allocated to the specified absolute address during linkage. If variables are specified for contiguous addresses, these variables are assigned to a single section.

Example C source description:

```
#pragma address X=0x7f00
int X;
main(){
    X=0;
}
```

Output code:

```
.main:
    MOV.L #0, R5
    MOV.L #7F00H, R14;
    MOV.L R5, [R14]
    RTS

_SECTION $ADDR_B_7F00
.ORG 7F00H
.glb _X
_X; static: X
.blkl 1
```

[Remarks]
- Specify `#pragma address` before declaring a variable.
- If an object that is neither a structure/union member nor a variable is specified, an error will be output.
- If `#pragma address` is specified for a single variable more than one time, an error will be output.
- A static variable that is validated by `#pragma address` and not referred from the source file may be removed by a compiler optimization.
- We recommend not applying `#pragma address` to a variable which has an initial value but does not have the const qualifier. If this case applies for any variables, take note of the restrictions below.
  - The -rom option (RAMization of the ROM area) of the optimizing linkage editor (rlink) cannot be applied to sections containing such variables.
  - Error messages or warnings will not be displayed for code that includes such a variable.
  - When a section containing such variables is allocated to the RAM, all initial values must be written to the corresponding RAM areas when starting up the program or in advance of that.
    - In addition to an "=" sign, a white-space character can also be used as a separator between a variable name and an absolute address.

(10) Endian Specification for Initial Values

```
#pragma endian [{big | little}]
```

This extension specifies the endian for the area that stores static objects.

The specification of this extension is applied from the line containing `#pragma endian` to the end of the file or up to the line immediately before the line containing the next `#pragma endian`. 
big specifies big endian. When the endian=little option is specified, data is assigned to the section with the section name postfixed with _B.
little specifies little endian. When the endian=big option is specified, data is assigned to the section with the section name postfixed with _L.

When big or little is omitted, endian is determined by the option specification.

Example

When the endian=little option is specified (default state)
C source description:

```c
#pragma endian big
int A=100;/* D_B section */
#pragma endian
int B=200;/* D section */
```

Output code:

```assembly
.glb _A
.glb _B
.SECTION D,ROMDATA,ALIGN=4
_B:
    .lword 200
.SECTION D_B,ROMDATA,ALIGN=4
.ENDIAN BIG
_A:
    .lword 100
```

If areas of the long long type, double type (when the dbl_size=8 option is specified), and long double type (when the dbl_size=8 option is specified) are included in objects to which #pragma endian (differed from the endian option) is applied, do not make indirect accesses to these areas using addresses or pointers. In such a case, correct operation will not be guaranteed. If a code that acquires an address in such an area is included, a warning message is displayed.

If bit fields of the long long type are included in objects to which #pragma endian (differed from the endian option) is applied, do not make writes to these areas. In such a case, correct operation will not be guaranteed.

The endian of the following items cannot be changed by this extension. The endian option needs to be used.

1. String literal and initializers for use in the dynamic initialization of aggregates
2. Branch table of switch statement
3. Objects declared as external references (objects declared through extern without initialization expression)
4. Objects specified as #pragma address
5. Specification of Function in which Instructions at Branch Destinations are Aligned for Execution

```c
#pragma instalign4 [(<function name>[(<branch destination type>)][,...]])
#pragma instalign8 [(<function name>[(<branch destination type>)][,...]])
#pragma noinstalign [(<function name>][,...])]
```

Specifies the function in which instructions at branch destinations are aligned for execution.

Instruction allocation addresses in the specified function are adjusted to be aligned to 4-byte boundaries when #pragma instalign4 is specified or to 8-byte boundaries when #pragma instalign8 is specified.

In the function specified with #pragma noinstalign, alignment of allocation addresses is not adjusted.

The branch destination type should be selected from the following*:

- No specification: Head of function and case and default labels of switch statement
- inmostloop: Head of each inmost loop, head of function, and case and default labels of switch statement
- loop: Head of each loop, head of function, and case and default labels of switch statement

Note

Alignment is adjusted only for the branch destinations listed above; alignment of the other destinations is not adjusted. For example, when loop is selected, alignment of the head of a loop is adjusted but alignment is not adjusted at the branch destination of an if statement that is used in the loop but does not generate a loop.

Except that each #pragma extension specification is valid only in the specified function, these specifiers work in the same way as the instalign4, instalign8, and noinstalign options. When both the options and #pragma extension specifiers are specified together, the #pragma specifications take priority.
In the code section that contains a function specified with `instalign4` or `instalign8`, the alignment value is changed to 4 (`instalign4` is specified) or 8 (`instalign8` is specified). If a single code section contains both a function specified with `instalign4` and that specified with `instalign8`, the alignment value in the code section is set to 8.

The other detailed functions of these `#pragma` extension specifiers are the same as those of the `instalign4`, `instalign8`, and `noinstalign` options; refer to the description of each option.

(12) Specification of Function for generating a code for detection of stack smashing [Professional Edition only]
[V2.04.00 or later]

`#pragma stack_protector [() function name [([num=<integer value>]) [...]]]`  
`#pragma no_stack_protector [() function name [...]]`

Generates a code for detection of stack smashing at the entry and the end of a function. A code for detection of stack smashing consists of instructions executing the three processes shown below.

1. A 4-byte area is allocated just before (in the direction towards address 0xFFFFFFFF) the local variable area at the entry to a function, and the value specified by `<number>` is stored in the allocated area.
2. At the end of the function, whether the 4-byte area in which `<number>` was stored has been rewritten is checked.
3. If the 4-byte area has been rewritten in (2), the `__stack_chk_fail` function is called as the stack has been smashed.

A decimal number from 0 to 4294967295 should be specified in `<number>`. If the specification of `<number>` is omitted, the compiler automatically selects the number.

The `__stack_chk_fail` function needs to be defined by the user. It should contain postprocesses for the detected stack smashing.

Note the following items when defining the `__stack_chk_fail` function.

- The only possible type of return value is void and any formal parameters not allowed.
- It is prohibited to call the `__stack_chk_fail` function as a normal function.
- The `__stack_chk_fail` function does not generate a code for detection of stack smashing regardless of the `-stack_protector` and `-stack_protector_all` options, and `#pragma stack_protector`.
- In a C++ program, add extern “C” to the definition or the declaration for `__stack_chk_fail` function.
- Prevent returning to the caller (the function where stack smashing was detected) by taking measures such as calling `abort()` in `__stack_chk_fail` function and terminating the program.
- Do not define the function as `static`.

A code for detection of stack smashing is not generated for a function for which `#pragma no_stack_protector` has been specified regardless of the `-stack_protector` option and `-stack_protector_all` option.

If these options are used simultaneously with `#pragma stack_protector`, the `-stack_protector` option, or the `-stack_protector_all` option, the specification by `#pragma` becomes valid.

An error will occur when `#pragma stack_protector` and `#pragma no_stack_protector` are specified simultaneously for the same function within a single translation unit.

When the function specified by `#pragma stack_protector` is specified as any one of the following functions, an error message is output.

`#pragma inline`  
`#pragma inline_asm`  
`#pragma entry`
4.2.5 Using a Keyword

This section explains using the following keyword.

- Description of access in specified size

(1) Description of Access in Specified Size

__evenaccess <type specifier> <variable name>
__type specifier__ __evenaccess <variable name>

A variable is accessed in the declared or defined size.
This extension guarantees access in the size of the target variable.
This keyword is applicable to 4-byte or smaller scalar types.

Example C source description:

```c
#pragma address A=0xff0178
unsigned long __evenaccess A;
void test(void)
{
    A &= ~0x20;
}
```

Output code (__evenaccess not specified):

```assembly
_test:
    MOV.L #16712056,R1
    BCLR #5,[R1] ; Memory access in 1 byte
    RTS
```

Output code (__evenaccess specified):

```assembly
_test:
    MOV.L #16712056,R1
    MOV.L [R1],R5 ; Memory access in 4 bytes
    BCLR #5,R5
    MOV.L R5,[R1] ; Memory access in 4 bytes
    RTS
```

The __evenaccess is invalid to the case of accessing of members by a lump of these structure and union frame. When __evenaccess is specified for a structure or a union, __evenaccess is applied to all members. In this case, the access size is guaranteed for 4-byte or smaller scalar integer types, but the size of access in structure or union units is not guaranteed.
### 4.2.6 Intrinsic Functions

In the CCRX, some of the assembler instructions can be described in C source as "Intrinsic Functions". However, it is not described "as assembler instruction", but as a function format set in the CCRX. When an intrinsic function is used, the compiler inserts the corresponding code into the program.

#### Table 4.10 Intrinsic Functions

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Specifications</th>
<th>Function</th>
<th>Restriction in User Mode*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maximum value and minimum value</td>
<td>signed long max(signed long data1, signed long data2)</td>
<td>Selects the maximum value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>signed long __max(signed long data1, signed long data2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>signed long min(signed long data1, signed long data2)</td>
<td>Selects the minimum value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>signed long __min(signed long data1, signed long data2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Byte switch</td>
<td>unsigned long revl(unsigned long data)</td>
<td>Reverses the byte order in longword data.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __revl(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>unsigned long revw(unsigned long data)</td>
<td>Reverses the byte order in longword data in word units.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __revw(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Data exchange</td>
<td>void xchg(signed long *data1, signed long *data2)</td>
<td>Exchanges data.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __xchg(signed long *data1, signed long *data2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Multiply-and-accumulate operation</td>
<td>long long rmpab(long long init, unsigned long count, signed char *addr1, signed char *addr2)</td>
<td>Multiply-and-accumulate operation (byte).</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>long long __rmpab(long long init, unsigned long count, signed char *addr1, signed char *addr2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>long long rmpaw(long long init, unsigned long count, short *addr1, short *addr2)</td>
<td>Multiply-and-accumulate operation (word).</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>long long __rmpaw(long long init, unsigned long count, short *addr1, short *addr2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>long long rmpal(long long init, unsigned long count, long *addr1, long *addr2)</td>
<td>Multiply-and-accumulate operation (longword).</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>long long __rmpal(long long init, unsigned long count, long *addr1, long *addr2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Item</td>
<td>Specifications</td>
<td>Function</td>
<td>Restriction in User Mode</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>----------------</td>
<td>----------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Rotation</td>
<td>unsigned long rolc(unsigned long data)</td>
<td>Rotates data including the carry to left by one bit.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __rolc(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>unsigned long rorc(unsigned long data)</td>
<td>Rotates data including the carry to right by one bit.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __rorc(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>unsigned long rotl(unsigned long data, unsigned long num)</td>
<td>Rotates data to left.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __rotl(unsigned long data, unsigned long num) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>unsigned long rotr(unsigned long data, unsigned long num)</td>
<td>Rotates data to right.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __rotr(unsigned long data, unsigned long num) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Special instructions</td>
<td>void brk(void)</td>
<td>BRK instruction exception.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __brk(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>void int_exception(signed long num)</td>
<td>INT instruction exception.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __int_exception(signed long num) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>void wait(void)</td>
<td>Stops program execution.</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __wait(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>void nop(void)</td>
<td>Expanded to a NOP instruction.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __nop(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Processor interrupt priority level (IPL)</td>
<td>void set_ipl(signed long level)</td>
<td>Sets the interrupt priority level.</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_ipl(signed long level) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>unsigned char get_ipl(void)</td>
<td>Refers to the interrupt priority level.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned char __get_ipl(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Processor status word (PSW)</td>
<td>void set_psw(unsigned long data)</td>
<td>Sets a value for PSW.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_psw(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>unsigned long get_psw(void)</td>
<td>Refers to PSW value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __get_psw(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Item</td>
<td>Specifications</td>
<td>Function</td>
<td>Restriction in User Mode*</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>----------------</td>
<td>----------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>21</td>
<td>Floating-point status word (FPSW)</td>
<td>void set_fpsw(unsigned long data)</td>
<td>Sets a value for FPSW.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_fpsw(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>unsigned long get_fpsw(void)</td>
<td>Refers to FPSW value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __get_fpsw(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>User stack pointer (USP)</td>
<td>void set_usp(void *data)</td>
<td>Sets a value for USP.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_usp(void *data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>void *get_usp(void)</td>
<td>Refers to USP value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void *__get_usp(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Interrupt stack pointer (ISP)</td>
<td>void set_isp(void *data)</td>
<td>Sets a value for ISP.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_isp(void *data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>void *get_isp(void)</td>
<td>Refers to ISP value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void *__get_isp(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Interrupt table register (INTB)</td>
<td>void set_intb(void *data)</td>
<td>Sets a value for INTB.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_intb(void *data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>void *get_intb(void)</td>
<td>Refers to INTB value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void *__get_intb(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Backup PSW (BPSW)</td>
<td>void set_bpsw(unsigned long data)</td>
<td>Sets a value for BPSW.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_bpsw(unsigned long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>unsigned long get_bpsw(void)</td>
<td>Refers to BPSW value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long __get_bpsw(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Backup PC (BPC)</td>
<td>void set_bpc(void *data)</td>
<td>Sets a value for BPC.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_bpc(void *data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>void *get_bpc(void)</td>
<td>Refers to BPC value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void *__get_bpc(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Fast interrupt vector register (FINTV)</td>
<td>void set_fintv(void *data)</td>
<td>Sets a value for FINTV.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_fintv(void *data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>void *get_fintv(void)</td>
<td>Refers to FINTV value.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void *__get_fintv(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Item</td>
<td>Specifications</td>
<td>Function</td>
<td>Restriction in User Mode*</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>----------------</td>
<td>----------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>35</td>
<td>Significant 64-bit multiplication</td>
<td>signed long long __emul(signed long data1, signed long data2) [V2.05.00 or later]</td>
<td>Signed multiplication of significant 64 bits.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>signed long long __emul(signed long data1, signed long data2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Unsigned multiplication</td>
<td>unsigned long long __emulu(unsigned long data1, unsigned long data2)</td>
<td>Unsigned multiplication of significant 64 bits.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unsigned long long __emulu(unsigned long data1, unsigned long data2) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Processor mode (PM)</td>
<td>void chg_pmusr(void)</td>
<td>Switches to user mode.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __chg_pmusr(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Accumulator (ACC)</td>
<td>void set_acc(signed long long data)</td>
<td>Sets the ACC.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_acc(signed long long data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>signed long long get_acc(void)</td>
<td>signed long long get_acc(void) [V2.05.00 or later]</td>
<td>Refers to the ACC.</td>
<td>O</td>
</tr>
<tr>
<td>40</td>
<td>Control of the interrupt enable bits</td>
<td>void setpsw_i(void)</td>
<td>Sets the interrupt enable bit to 1.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __setpsw_i(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>void clrpsw_i(void)</td>
<td>void clrpsw_i(void) [V2.05.00 or later]</td>
<td>Clears the interrupt enable bit to 0.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __clrpsw_i(void) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Multiply-and-accumulate operation</td>
<td>long mac(short *data1, short *data2, unsigned long count)</td>
<td>Multiply-and-accumulate operation of 2-byte data.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>long __mac(short *data1, short *data2, unsigned long count) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>short macw1(short *data1, short *data2, unsigned long count)</td>
<td>short macw1(short *data1, short *data2, unsigned long count) [V2.05.00 or later]</td>
<td>Multiply-and-accumulate operation of fixed-point data.</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>short macw2(short *data1, short *data2, unsigned long count)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>short __macw1(short *data1, short *data2, unsigned long count) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>short __macw2(short *data1, short *data2, unsigned long count) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Exception vector table register (EXTB)</td>
<td>void set_extb(void *data)</td>
<td>Sets a value for EXTB.</td>
<td>Δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>void __set_extb(void *data) [V2.05.00 or later]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>void *get_extb(void)</td>
<td>void *get_extb(void) [V2.05.00 or later]</td>
<td>Refers to EXTB value.</td>
<td>O</td>
</tr>
<tr>
<td>No.</td>
<td>Item</td>
<td>Specifications</td>
<td>Function</td>
<td>Restriction in User Mode*</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>46</td>
<td>Bit manipulation</td>
<td>void _bclr(unsigned char *data, unsigned long bit) [V2.05.00 or later]</td>
<td>Clears one bit.</td>
<td>O</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td>void _bset(unsigned char *data, unsigned long bit) [V2.05.00 or later]</td>
<td>Sets one bit.</td>
<td>O</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>void _bnot(unsigned char *data, unsigned long bit) [V2.05.00 or later]</td>
<td>Reverses one bit.</td>
<td>O</td>
</tr>
<tr>
<td>49</td>
<td>Double-precision floating-point status word (DPSW)</td>
<td>void _set_dpsw(unsigned long data) [V3.01.00 or later]</td>
<td>Sets a value in DPSW.</td>
<td>O</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>unsigned long _get_dpsw(void) [V3.01.00 or later]</td>
<td>Refers to the DPSW value.</td>
<td>O</td>
</tr>
<tr>
<td>51</td>
<td>Double-precision floating-point exception handling operation control register (DECNT)</td>
<td>void _set_decnt(unsigned long data) [V3.01.00 or later]</td>
<td>Sets a value in DECNT.</td>
<td>O</td>
</tr>
<tr>
<td>52</td>
<td></td>
<td>unsigned long _get_decnt(void) [V3.01.00 or later]</td>
<td>Refers to the DECNT value.</td>
<td>O</td>
</tr>
<tr>
<td>53</td>
<td>Double-precision floating-point exception program counter (DEPC)</td>
<td>void *_get_depc(void) [V3.01.00 or later]</td>
<td>Refers to the DEPC value.</td>
<td>O</td>
</tr>
<tr>
<td>No.</td>
<td>Item</td>
<td>Specifications</td>
<td>Function</td>
<td>Restriction in User Mode*</td>
</tr>
<tr>
<td>-----</td>
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<td>----------------</td>
<td>----------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>54</td>
<td>Trigonometric function unit</td>
<td>void __init_tfu(void) [V3.01.00 or later]</td>
<td>Initializes the trigonometric function unit.</td>
<td>O</td>
</tr>
<tr>
<td>55</td>
<td>void __sincosf(float f, float *sin, float *cos) [V3.01.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the sine and cosine of an angle at the same time (single precision).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>void __atan2hypotf(float y, float x, float *atan2, float *hypot) [V3.01.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the arc tangent of x and y and the square root of the sum of squares of these values ($\sqrt{x^2 + y^2}$) at the same time (single precision).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>void __sincosfx(signed long fx, signed long *sin, signed long *cos) [V3.05.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the sine and cosine of an angle at the same time (fixed-point number).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>signed long __sinfx(signed long fx) [V3.05.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the sine of an angle (fixed-point number).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>signed long __cosfx(signed long fx) [V3.05.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the cosine of an angle (fixed-point number).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>void __atan2hypotfx(signed long y, signed long x, signed long *atan2, signed long *hypot) [V3.05.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the arc tangent of x and y and the square root of the sum of squares of these values ($\sqrt{x^2 + y^2}$) at the same time (fixed-point number).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>signed long __atan2fx(signed long y, signed long x) [V3.05.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the arc tangent of x and y (fixed-point number).</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>signed long __hypotfx(signed long x, signed long y) [V3.05.00 or later]</td>
<td>Uses the trigonometric function unit to calculate the square root of the sum of squares of x and y ($\sqrt{x^2 + y^2}$) (fixed-point number).</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

Note: * Indicates whether the function is limited when the RX processor mode is user mode.

O: Has no restriction.

X: Must not be used in user mode because a privileged instruction exception occurs.

Δ: Has no effect when executed in user mode.
signed long max(signed long data1, signed long data2)
signed long __max(signed long data1, signed long data2) [V2.05.00 or later]

[Description]
Selects the greater of two input values (this function is expanded into a MAX instruction).

[Header]
<machine.h>

[Parameters]
data1    Input value 1
data2    Input value 2

[Return value]
The greater value of data1 and data2

[Example]

```c
#include <machine.h>
extern signed long ret,in1,in2;
void main(void)
{
    ret = max(in1,in2);// Stores the greater value of in1 and in2 in ret.
}
```

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.

signed long min(signed long data1, signed long data2)
signed long __min(signed long data1, signed long data2) [V2.05.00 or later]

[Description]
Selects the smaller of two input values (this function is expanded into a MIN instruction).

[Header]
<machine.h>

[Parameters]
data1    Input value 1
data2    Input value 2

[Return value]
The smaller value of data1 and data2

[Example]

```c
#include <machine.h>
extern signed long ret,in1,in2;
void main(void)
{
    ret = min(in1,in2);// Stores the smaller value of in1 and in2 in ret.
}
```

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.
Reverses the byte order in 4-byte data (this function is expanded into a REVL instruction).

```c
#include <machine.h>
extern unsigned long ret, indata = 0x12345678;
void main(void)
{
    ret = revl(indata);// ret = 0x78563412
}
```

The header does not have to be included when using an intrinsic function whose name starts with __.

Reverses the byte order within each of the upper and lower two bytes of 4-byte data (this function is expanded into a REVW instruction).

```c
#include <machine.h>
extern unsigned long ret; indata = 0x12345678;
void main(void)
{
    ret = revw(indata);// ret = 0x34127856
}
```

The header does not have to be included when using an intrinsic function whose name starts with __.
void xchg(signed long *data1, signed long *data2)
void __xchg(signed long *data1, signed long *data2) [V2.05.00 or later]

[Description]
Exchanges the contents of the areas indicated by parameters (this function is expanded into an XCHG instruction).

[Header]
<machine.h>

[Parameters]
*data1 Input value 1
*data2 Input value 2

[Example]

```c
#include <machine.h>
extern signed long *in1,*in2;
void main(void)
{
    xchg (in1,in2); // Exchanges data at address in1 and address in2.
}
```

[Remarks]
The XCHG instruction to be generated has a memory operand with a location indicated by data2.
The header does not have to be included when using an intrinsic function whose name starts with __.

long long rmpab(long long init, unsigned long count, signed char *addr1, signed char *addr2)
long long __rmpab(long long init, unsigned long count, signed char *addr1, signed char *addr2) [V2.05.00 or later]

[Description]
Performs a multiply-and-accumulate operation with the initial value specified by init, the number of multiply-and-accumulate operations specified by count, and the start addresses of values to be multiplied specified by addr1 and addr2 (this function is expanded into a RMPA.B instruction).

[Header]
<machine.h>

[Parameters]
init Initial value
count Count of multiply-and-accumulate operations
*addr1 Start address of values 1 to be multiplied
*addr2 Start address of values 2 to be multiplied

[Return value]
Lower 64 bits of the init + Σ(data1[n] * data2[n]) result (n = 0, 1, ..., const - 1)

[Example]

```c
#include <machine.h>
extern signed char data1[8],data2[8];
long long sum;
void main(void)
{
    sum=rmpab(0, 8, data1, data2);  
    // Specifies 0 as the initial value, adds the result  
    // of multiplication of arrays data1 and data2,  
    // and stores the result in sum.
}
```

[Remark]
The RMPA instruction obtains a result in a maximum of 80 bits, but this intrinsic function handles only 64 bits.
The header does not have to be included when using an intrinsic function whose name starts with __.
**Description**
Performs a multiply-and-accumulate operation with the initial value specified by init, the number of multiply-and-accumulate operations specified by count, and the start addresses of values to be multiplied specified by addr1 and addr2 (this function is expanded into a RMPA.W instruction).

**Header**
<machine.h>

**Parameters**
- **init** Initial value
- **count** Count of multiply-and-accumulate operations
- **addr1** Start address of values 1 to be multiplied
- **addr2** Start address of values 2 to be multiplied

**Return value**
Lower 64 bits of the init + \( \sum (\text{data1}[n] \times \text{data2}[n]) \) result (\( n = 0, 1, ..., \text{const} - 1 \))

**Example**
```c
#include <machine.h>
extern signed short data1[8], data2[8];
long long sum;
void main(void)
{
    sum = rmpaw(0, 8, data1, data2);
    // Specifies 0 as the initial value, adds the result
    // of multiplication of arrays data1 and data2,
    // and stores the result in sum.
}
```

**Remark**
The RMPA instruction obtains a result in a maximum of 80 bits, but this intrinsic function handles only 64 bits. The header does not have to be included when using an intrinsic function whose name starts with `__`. 

```c
long long rmpaw(long long init, unsigned long count, short *addr1, short *addr2)
long long __rmpaw(long long init, unsigned long count, short *addr1, short *addr2) [V2.05.00 or later]
```
Performs a multiply-and-accumulate operation with the initial value specified by init, the number of multiply-and-accumulate operations specified by count, and the start addresses of values to be multiplied specified by addr1 and addr2 (this function is expanded into a RMPA.L instruction).

**Header**
<machine.h>

**Parameters**
- init    Initial value
- count   Count of multiply-and-accumulate operations
- *addr1  Start address of values 1 to be multiplied
- *addr2  Start address of values 2 to be multiplied

**Return value**
Lower 64 bits of the init + \[\sum (\text{data1}[\text{n}] \times \text{data2}[\text{n}])\] result (n = 0, 1, ..., const - 1)

**Example**

```c
#include <machine.h>
extern signed long data1[8],data2[8];
long long sum;

void main(void)
{
    sum=rmpal(0, 8, data1, data2);
    // Specifies 0 as the initial value, adds the result
    // of multiplication of arrays data1 and data2,
    // and stores the result in sum.
}
```

**Remarks**
The RMPA instruction obtains a result in a maximum of 80 bits, but this intrinsic function handles only 64 bits. The header does not have to be included when using an intrinsic function whose name starts with __.
Rotates data including the C flag to left by one bit (this function is expanded into a ROLC instruction). The bit pushed out of the operand is set to the C flag.

**Header**
<machine.h>

**Parameters**
data Data to be rotated to left

**Return value**
Result of 1-bit left rotation of data including the C flag

**Example**
```c
#include <machine.h>
extern unsigned long ret, indata;
void main(void)
{
    ret = rolc(indata);// Rotates indata including the C flag
    // to left by one bit and stores the result
    // in ret.
}
```

**Remarks**
The header does not have to be included when using an intrinsic function whose name starts with __.

Rotates data including the C flag to right by one bit (this function is expanded into a RORC instruction). The bit pushed out of the operand is set to the C flag.

**Header**
<machine.h>

**Parameters**
data Data to be rotated to right

**Return value**
Result of 1-bit right rotation of data including the C flag

**Example**
```c
#include <machine.h>
extern unsigned long ret, indata;
void main(void)
{
    ret = rorc(indata);// Rotates indata including the C flag
    // to right by one bit and stores the result
    // in ret.
}
```

**Remarks**
The header does not have to be included when using an intrinsic function whose name starts with __.
[Description]
Rotates data to left by the specified number of bits (this function is expanded into a ROTL instruction).
The bit pushed out of the operand is set to the C flag.

[Header]
<machine.h>

[Parameters]
data    Data to be rotated to left
num    Number of bits to be rotated

[Return value]
Result of num-bit left rotation of data

[Example]

```c
#include <machine.h>
extern unsigned long ret, indata;
void main(void)
{
    ret = rotl(indata, 31); // Rotates indata to left by 31 bits
    // and stores the result in ret.
}
```

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.

---

[Description]
Rotates data to right by the specified number of bits (this function is expanded into a ROTR instruction).
The bit pushed out of the operand is set to the C flag.

[Header]
<machine.h>

[Parameters]
data    Data to be rotated to right
num    Number of bits to be rotated

[Return value]
Result of num-bit right rotation of data

[Example]

```c
#include <machine.h>
extern unsigned long ret, indata;
void main(void)
{
    ret = rotr(indata, 31); // Rotates indata to right by 31 bits
    // and stores the result in ret.
}
```

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.
void brk(void)
void __brk(void) [V2.05.00 or later]

[Description]
This function is expanded into a BRK instruction.
[Header]
<machine.h>
[Parameters]
-
[Return value]
-
[Example]
#include <machine.h>
void main(void)
{
    brk(); // BRK instruction
}

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.

void int_exception(signed long num)
void __int_exception(signed long num) [V2.05.00 or later]

[Description]
This function is expanded into an INT num instruction.
[Header]
<machine.h>
[Parameters]
    num    INT instruction number
[Return value]
-
[Example]
#include <machine.h>
void main(void)
{
    int_exception(10); // INT #10 instruction
}

[Remarks]
Only an integer from 0 to 255 can be specified as num.
The header does not have to be included when using an intrinsic function whose name starts with __.
**void wait(void)**

**void __wait(void) [V2.05.00 or later]**

**[Description]**
This function is expanded into a WAIT instruction.

**[Header]**
<machine.h>

**[Parameters]**
-

**[Return value]**
-

**[Example]**

```c
#include <machine.h>
void main(void)
{
    wait(); // WAIT instruction
}
```

**[Remarks]**
This function must not be executed when the RX processor mode is user mode. If executed, a privileged instruction exception of the RX occurs due to the specifications of the WAIT instruction.

The header does not have to be included when using an intrinsic function whose name starts with __.

---

**void nop(void)**

**void __nop(void) [V2.05.00 or later]**

**[Description]**
This function is expanded into a NOP instruction.

**[Header]**
<machine.h>

**[Parameters]**
-

**[Return value]**
-

**[Example]**

```c
#include <machine.h>
void main(void)
{
    nop(); // NOP instruction
}
```

**[Remarks]**
The header does not have to be included when using an intrinsic function whose name starts with __.
void set_ipl(signed long level)  
void __set_ipl(signed long level) [V2.05.00 or later]

[Description]  
Changes the interrupt mask level.  

[Header]  
<machine.h>

[Parameters]  
-  

[Return value]  
level Interrupt mask level to be set

[Example]

```c
#include <machine.h>
void main(void)  
{  
    set_ipl(7); // Sets PSW.IPL to 7.
}
```

[Remarks]  
A value from 0 to 15 can be specified for level by default, and a value from 0 to 7 can be specified when -patch=rx610 is specified.  
If a value outside the above range is specified when level is a constant, an error will be output.  
This function must not be executed when the RX processor mode is user mode. If executed, a privileged instruction exception of the RX occurs due to the specifications of the MVTIPL instruction.  
The header does not have to be included when using an intrinsic function whose name starts with __.

unsigned char get_ipl(void)  
unsigned char __get_ipl(void) [V2.05.00 or later]

[Description]  
Refers to the interrupt mask level.  

[Header]  
<machine.h>

[Parameters]  
-  

[Return value]  
Interrupt mask level

[Example]

```c
#include <machine.h>
extern unsigned char level;
void main(void)  
{  
    level=get_ipl();  // Obtains the PSW.IPL value and  
    // stores it in level.
}
```

[Remarks]  
If a value smaller than 0 or greater than 7 is specified as level, an error will be output.  
The header does not have to be included when using an intrinsic function whose name starts with __.
### set_psw(unsigned long data)
void __set_psw(unsigned long data) [V2.05.00 or later]

**Description**
Sets a value to PSW.

**Header**
<machine.h>

**Parameters**
- data    Value to be set

**Return value**
-

**Example**
```
#include <machine.h>
extern unsigned long data;
void main(void)
{
    set_psw(data); // Sets PSW to the value specified by data.
}
```

**Remarks**
Due to the specifications of the RX instruction set, a write to the PM bit of PSW is ignored. In addition, a write to PSW is ignored when the RX processor mode is user mode. The header does not have to be included when using an intrinsic function whose name starts with __.

### get_psw(void)
unsigned long __get_psw(void) [V2.05.00 or later]

**Description**
Refers to the PSW value.

**Header**
<machine.h>

**Parameters**
-

**Return value**
PSW value

**Example**
```
#include <machine.h>
extern unsigned long ret;
void main(void)
{
    ret=get_psw(); // Obtains the PSW value and stores it in ret.
}
```

**Remarks**
In some cases, the timing at which the PSW value is obtained differs from the timing at which get_psw was called, due to the effect of optimization. Therefore when a code using the C, Z, S, or O flag included in the return value of this function is written after some sort of operation, correct operation will not be guaranteed. The header does not have to be included when using an intrinsic function whose name starts with __.
### set_fpsw

```
void set_fpsw(unsigned long data)
void __set_fpsw(unsigned long data) [V2.05.00 or later]
```

**[Description]**
Sets a value to FPSW.

**[Header]**
<machine.h>

**[Parameters]**
- `data` Value to be set

**[Return value]**
- 

**[Example]**

```c
#include <machine.h>
extern unsigned long data;
void main(void)
{
    set_fpsw(data); // Sets FPSW to the value specified by data.
}
```

**[Remarks]**
The header does not have to be included when using an intrinsic function whose name starts with `__`.

### get_fpsw

```
unsigned long get_fpsw(void)
unsigned long __get_fpsw(void) [V2.05.00 or later]
```

**[Description]**
Refers to the FPSW value.

**[Header]**
machine.h

**[Parameters]**
- 

**[Return value]**
FPSW value

**[Example]**

```c
#include <machine.h>
extern unsigned long ret;
void main(void)
{
    ret=get_fpsw(); // Obtains the FPSW value and stores it
                     // in ret.
}
```

**[Remarks]**
In some cases, the timing at which the FPSW value is obtained differs from the timing at which `get_fpsw` was called, due to the effect of optimization. Therefore when a code using the CV, CO, CZ, CU, CX, CE, FV, FO, FZ, FU, FX, or FS flag included in the return value of this function is written after some sort of operation, correct operation will not be guaranteed.
The header does not have to be included when using an intrinsic function whose name starts with `__`. 
### set_usp

```c
void set_usp(void *data)
void __set_usp(void *data) [V2.05.00 or later]
```

**[Description]**
Sets a value to USP.

**[Header]**
`<machine.h>`

**[Parameters]**
- `data` Value to be set

**[Return value]**
- `-`

**[Example]**
```c
#include <machine.h>
extern void * data;
void main(void)
{
  set_usp(data); // Sets USP to the value specified by data.
}
```

**[Remarks]**
A 4-byte boundary address should be specified as `data`.
Program operation is not guaranteed when a 1-byte boundary address or 2-byte boundary address is specified.
The header does not have to be included when using an intrinsic function whose name starts with `__`.

### get_usp

```c
void *get_usp(void)
void *__get_usp(void) [V2.05.00 or later]
```

**[Description]**
Refers to the USP value.

**[Header]**
`<machine.h>`

**[Parameters]**
- `-`

**[Return value]**
- `USP value`

**[Example]**
```c
#include <machine.h>
extern void * ret;
void main(void)
{
  ret=get_usp(); // Obtains the USP value and stores it in ret.
}
```

**[Remarks]**
The header does not have to be included when using an intrinsic function whose name starts with `__`. 
### void set_isp(void *data)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>Value to be set</td>
</tr>
</tbody>
</table>

- **Return value**

```c
#include <machine.h>
extern void * data;
void main(void)
{
    set_isp(data);// Sets ISP to the value specified by data.
}
```

**Remarks**

Due to the specifications of the MVTC instruction used in this function, a write to ISP is ignored when the RX processor mode is user mode.

A 4-byte boundary address should be specified as `data`.

Program operation is not guaranteed when a 1-byte boundary address or 2-byte boundary address is specified.

The header does not have to be included when using an intrinsic function whose name starts with `__`.

### void *get_isp(void)

- **Return value**

```c
#include <machine.h>
extern void * ret;
void main(void)
{
    ret=get_isp();// Obtains the ISP value and stores it in ret.
}
```

**Remarks**

The header does not have to be included when using an intrinsic function whose name starts with `__`. 
void set_intb (void *data)
void __set_intb(void *data) [V2.05.00 or later]

[Description]
Sets a value to INTB.

[Header]
<machine.h>

[Parameters]
data Value to be set

[Return value]
-

[Example]
#include <machine.h>
extern void * data;
void main(void)
{
    set_intb (data); // Sets INTB to the value specified by data.
}

[Remarks]
Due to the specifications of the MVTC instruction used in this function, a write to INTB is ignored when the RX processor mode is user mode.
The header does not have to be included when using an intrinsic function whose name starts with __.

void *get_intb(void)
void *__get_intb(void) [V2.05.00 or later]

[Description]
Refers to the INTB value.

[Header]
<machine.h>

[Parameters]
-

[Return value]
INTB value

[Example]
#include <machine.h>
extern void * ret;
void main(void)
{
    ret=get_intb(); // Obtains the INTB value and stores it in ret.
}

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.
### void set_bpsw(unsigned long data)
### void __set_bpsw(unsigned long data) [V2.05.00 or later]

**[Description]**
Sets a value to BPSW.

**[Header]**
<machine.h>

**[Parameters]**
data Value to be set

**[Return value]**
-

**[Example]**
```c
#include <machine.h>
extern unsigned long data;
void main(void)
{
    set_bpsw (data);// Sets BPSW to the value specified by data.
}
```

**[Remarks]**
Due to the specifications of the MVTC instruction used in this function, a write to BPSW is ignored when the RX processor mode is user mode.
The header does not have to be included when using an intrinsic function whose name starts with __.

### unsigned long get_bpsw(void)
### unsigned long __get_bpsw(void) [V2.05.00 or later]

**[Description]**
Refers to the BPSW value.

**[Header]**
<machine.h>

**[Parameters]**
-

**[Return value]**
BPSW value

**[Example]**
```c
#include <machine.h>
extern unsigned long ret;
void main(void)
{
    ret=get_bpsw ();// Obtains the BPSW value and stores it
    // in ret.
}
```

**[Remarks]**
The header does not have to be included when using an intrinsic function whose name starts with __.
void set_bpc(void *data)  
void __set_bpc(void *data) [V2.05.00 or later]

[Description]
Sets a value to BPC.

[Header]
<machine.h>

[Parameters]
data Value to be set

[Return value]
-

[Example]
#include <machine.h>
extern void * data;
void main(void)  
{  
  set_bpc(data);// Sets BPC to the value specified by data.
  
}

[Remarks]
Due to the specifications of the MVTC instruction used in this function, a write to BPC is ignored when the RX processor mode is user mode.
The header does not have to be included when using an intrinsic function whose name starts with __.

void *get_bpc(void)  
void *__get_bpc(void) [V2.05.00 or later]

[Description]
Refers to the BPC value.

[Header]
<machine.h>

[Parameters]
-

[Return value]
BPC value

[Example]
#include <machine.h>
extern void * ret;
void main(void)  
{  
  ret=get_bpc();// Obtains the BPC value and stores it in ret.
  
}

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.
### set_fintv

**Declaration**

```c
void set_fintv(void *data)
void __set_fintv(void *data) [V2.05.00 or later]
```

**Description**
Sets a value to FINTV.

**Header**

```c
<machine.h>
```

**Parameters**

- `data` Value to be set

**Return value**

**Example**

```c
#include <machine.h>
extern void * data;
void main(void)
{
    set_fintv(data);// Sets FINTV to the value specified by data.
}
```

**Remarks**

Due to the specifications of the **MVTC** instruction used in this function, a write to FINTV is ignored when the RX processor mode is user mode.

The header does not have to be included when using an intrinsic function whose name starts with `__`.

### get_fintv

**Declaration**

```c
void *get_fintv(void)
void *__get_fintv(void) [V2.05.00 or later]
```

**Description**
Refers to the FINTV value.

**Header**

```c
<machine.h>
```

**Parameters**

- 

**Return value**

**Example**

```c
#include <machine.h>
extern void * ret;
void main(void)
{
    ret=get_fintv(); // Obtains the FINTV value and stores it
                     // in ret.
}
```

**Remarks**

The header does not have to be included when using an intrinsic function whose name starts with `__`. 
signed long long emul(signed long data1, signed long data2)
signed long long __emul(signed long data1, signed long data2) [V2.05.00 or later]

[Description]
Performs signed multiplication of significant 64 bits.
[Header]
<machine.h>
[Parameters]
data 1 Input value 1
data 2 Input value 2
[Return value]
Result of signed multiplication (signed 64-bit value)
[Example]
#include <machine.h>
extern signed long long ret;
extern signed long data1, data2;
void main(void)
{
  ret=emul(data1, data2);// Calculates the value of
  // "data1 * data2" and stores it in ret.
}

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.

unsigned long long emulu(unsigned long data1, unsigned long data2)
unsigned long long __emulu(unsigned long data1, unsigned long data2) [V2.05.00 or later]

[Description]
Performs unsigned multiplication of significant 64 bits.
[Header]
<machine.h>
[Parameters]
data 1 Input value 1
data 2 Input value 2
[Return value]
Result of unsigned multiplication (unsigned 64-bit value)
[Example]
#include <machine.h>
extern unsigned long long ret;
extern unsigned long data1, data2;
void main(void)
{
  ret=emulu(data1, data2);// Calculates the value of
  // "data1 * data2" and stores it in ret.
}

[Remarks]
The header does not have to be included when using an intrinsic function whose name starts with __.
### chg_pmusr(void)

Switches the RX processor mode to user mode.

**Header**

```
<machine.h>
```

**Parameters**

- 

**Return value**

- 

**Example**

```c
#include <machine.h>

void main(void);
void Do_Main_on_UserMode(void)
{
    chg_pmusr(); // Switches the RX processor mode to user mode.
    main(); // Executes the main function.
}
```

**Remarks**

This function is provided for a reset processing function or interrupt function. Usage in any other function is not recommended.

The processor mode is not switched when the RX processor mode is user mode.

Since the stack is switched from the interrupt stack to the user stack when this function is executed, the following conditions must be met in a function that is calling this function. If the conditions are not met, code does not operate correctly because the stack is not the same before and after this function has been executed.

- Execution cannot be returned to the calling function.
- The `auto` variable cannot be declared.
- Parameters cannot be declared.

The header does not have to be included when using an intrinsic function whose name starts with `__`.

#### set_acc(signed long long data)

Sets a value to ACC.

**Header**

```
<machine.h>
```

**Parameters**

- data Value to be set to ACC

**Return value**

- 

**Example**

```c
#include <machine.h>

void main(void)
{
    signed long long data = 0x123456789ab0000LL;
    set_acc(data); // Sets ACC to the value specified by data.
}
```

**Remarks**

The header does not have to be included when using an intrinsic function whose name starts with `__`. 
signed long long get_acc(void)
signed long long __get_acc(void) [V2.05.00 or later]

[Description]
Refers to the ACC value.

[Header]
<machine.h>

[Parameters]
-

[Return value]
ACC value

[Example]

/* Example of program using the function to save and restore ACC by*/
/* get_acc and set_acc*/
#include <machine.h>
signed long a, b, c;
void func(void)
{
    signed long long bak_acc = get_acc();
    // Obtains the ACC value and saves it
    // in bak acc.
    c = a * b; // Multiplication (ACC is damaged).
    set_acc(bak_acc); // Restores ACC with a value saved by
    // bak_acc.
}

[Remarks]
Due to the specifications of the RX instruction set, contents in the lower 16 bits of ACC cannot be obtained. This function returns the value of 0 for these bits.
The header does not have to be included when using an intrinsic function whose name starts with __.

void setpsw_i(void)
void __setpsw_i(void) [V2.05.00 or later]

[Description]
Sets the interrupt enable bit (I bit) in PSW to 1.

[Header]
<machine.h>

[Parameters]
-

[Return value]
-

[Example]

#include <machine.h>
void main(void)
{
    setpsw_i(); // Sets the interrupt enable bit to 1.
}

[Remarks]
Due to the specifications of the SETPSW instruction used by this function, writing to the interrupt enable bit is ignored when the RX processor mode is set to user mode.
The header does not have to be included when using an intrinsic function whose name starts with __.
void clrpsw_i(void)
void __clrpsw_i(void) [V2.05.00 or later]

[Description]
Clears the interrupt enable bit (I bit) in PSW to 0.

[Header]
<machine.h>

[Parameters]
-

[Return value]
-

[Example]
```
#include <machine.h>
void main(void)
{
    clrpsw_i(); // Clears the interrupt enable bit to 0.
}
```

[Remarks]
Due to the specifications of the CLRPSW instruction used by this function, writing to the interrupt enable bit is ignored when the RX processor mode is set to user mode.
The header does not have to be included when using an intrinsic function whose name starts with __.
long macl(short *data1, short *data2, unsigned long count)
long __macl(short *data1, short *data2, unsigned long count) [V2.05.00 or later]

[Description]
Performs a multiply-and-accumulate operation between data of two bytes each and returns the result as four bytes. The multiply-and-accumulate operation is executed with DSP functional instructions (MULLO, MACLO, and MACHI). Data in the middle of the multiply-and-accumulate operation is retained in ACC as 48-bit data. After all multiply-and-accumulate operations have finished, the contents of ACC are fetched by the MVFACMI instruction and used as the return value of the intrinsic function. Usage of this intrinsic function enables fast multiply-and-accumulate operations to be expected compared to as when writing multiply-and-accumulate operations without using this intrinsic function. This intrinsic function can be used for multiply-and-accumulate operations of 2-byte integer data. Saturation and rounding are not performed to the results of multiply-and-accumulate operations.

[Header]
<machine.h>

[Parameters]
data1 Start address of values 1 to be multiplied
data2 Start address of values 2 to be multiplied
count Count of multiply-and-accumulate operations

[Return value]
\(\sum(data1[n] \times data2[n])\) result

[Example]
#include <machine.h>
short data1[3] = {a1, b1, c1};
short data2[3] = {a2, b2, c2};
void mac_calc()
{
    result = macl(data1, data2, 3);
    /* Obtains the result of "a1*a2+b1*b2+c1*c2". */
}

[Remarks]
Refer to the programming manual to confirm the detailed contents of the various DSP functional instructions used in multiply-and-accumulate operations.
When the multiplication count is 0, the return value of the intrinsic function is 0.
When using this intrinsic function, save and restore ACC in an interrupt processing in which the ACC value is rewritten.
For the function to save and restore ACC, refer to the compiler option save_acc or the extended language specifications #pragma interrupt.
The header does not have to be included when using an intrinsic function whose name starts with __.
Performs a multiply-and-accumulate operation between data of two bytes each and returns the result as two bytes. The multiply-and-accumulate operation is executed with DSP functional instructions (MULLO, MACLO, and MACHI).
Data in the middle of the multiply-and-accumulate operation is retained in ACC as 48-bit data. After all multiply-and-accumulate operations have finished, rounding is applied to the multiply-and-accumulate operation result of ACC.
The macw1 function performs rounding with the "RACW #1" instruction while the macw2 function performs rounding with the "RACW #2" instruction.
Rounding is performed with the following procedure.
- The contents of ACC are left-shifted by one bit with the macw1 function and by two bits with the macw2 function.
- The MSB of the lower 32 bits of ACC is rounded off (binary).
- The upper 32 bits of ACC are saturated with the upper limit as 0x00007FFF and the lower limit as 0xFFFF8000.
Finally, the contents of ACC are fetched by the MVFACHI instruction and used as the return value of these intrinsic functions.
Normally, the decimal point position of the multiplication result needs to be adjusted when fixed-point data is multiplied with each other. For example, in a case of multiplication of two Q15-format fixed-point data items, the multiplication result has to be left-shifted by one bit to make the multiplication result have the Q15 format. This left-shifting to adjust the decimal point position is achieved by the left-shift operation of the RACW instruction. Accordingly, in a case of multiply-and-accumulate operation of 2-byte fixed-point data, using these intrinsic functions facilitate multiply-and-accumulate processing. Note however that since the rounding mode of the operation result differs in macw1 and macw2, the intrinsic function to be used should be selected according to the desired accuracy for the operation result.

[Header]
#include <machine.h>

[Parameters]
data1 Start address of values 1 to be multiplied
data2 Start address of values 2 to be multiplied
count Count of multiply-and-accumulate operations

[Return value]
Value obtained by rounding the multiply-and-accumulate operation result with the RACW instruction

[Example]
#include <machine.h>
short data1[3] = {a1, b1, c1};
short data2[3] = {a2, b2, c2};
void mac_calc()
{
  result = macw1(data1, data2, 3);
  /* Obtains the value of rounding the result of "a1*a2+b1*b2+c1*c2"*/
  /* with the "RACW #1" instruction. */
}

[Remarks]
Refer to the programming manual to confirm the detailed contents of the various DSP functional instructions used in multiply-and-accumulate operations.
When the multiplication count is 0, the return value of the intrinsic function is 0.
When using this intrinsic function, save and restore ACC in an interrupt processing in which the ACC value is rewritten.
For the function to save and restore ACC, refer to the compiler option save_acc or the extended language specifications #pragma interrupt.
The header does not have to be included when using an intrinsic function whose name starts with __.
### void set_extb(void *data)
void __set_extb(void *data) [V2.05.00 or later]

**[Description]**
Sets a value for EXTB.

**[Header]**
<machine.h>

**[Parameters]**
- data Value to be set

**[Return value]**
-

**[Example]**
```c
#include <machine.h>
extern void * data;
void main(void)
{
    set_extb(data); // Sets EXTB to the value specified by data.
}
```

**[Remarks]**
This function is only usable when a value other than RXv1 is specified for the isa option or the environment variable ISA_RX. In other cases, this option will lead to an error at compilation. Due to the specifications of the MVTC instruction used in this function, a write to EXTB is ignored when the RX processor mode is user mode. The header does not have to be included when using an intrinsic function whose name starts with __.

### void *get_extb(void)
void *__get_extb(void) [V2.05.00 or later]

**[Description]**
Refers to the EXTB value.

**[Header]**
<machine.h>

**[Parameters]**
-

**[Return value]**
EXTB value

**[Example]**
```c
#include <machine.h>
extern void * ret;
void main(void)
{
    ret=get_extb(); // Obtains the EXTB value and stores it in ret.
}
```

**[Remarks]**
This function is only usable when a value other than RXv1 is specified for the isa option or the environment variable ISA_RX. In other cases, this option will lead to an error at compilation. The header does not have to be included when using an intrinsic function whose name starts with __.
### void __bclr(unsigned char *data, unsigned long bit) [V2.05.00 or later]

**Description**
Sets the specified one bit in the specified 1-byte area to 0 (this function is expanded into a BCLR instruction).

**Header**

- **Parameters**
  - data Address of the target 1-byte area
  - bit Position of the bit to be manipulated

**Return value**

- 

**Example**

```c
void __bclr(unsigned char *data, unsigned long bit) 
unsigned char *data;
void main(void)
{
  __bclr(data, 0);  // Sets the least significant bit in the 1-byte area indicated
                    // by address data to 0.
}
```

**Remarks**
Only an integer constant from 0 to 7 can be specified as parameter bit.
This function is expanded into a BCLR instruction which directly modifies the bit specified by the parameter to 0 in memory.

### void __bset(unsigned char *data, unsigned long bit) [V2.05.00 or later]

**Description**
Sets the specified one bit in the specified 1-byte area to 1 (this function is expanded into a BSET instruction).

**Header**

- 

**Parameters**
  - data Address of the target 1-byte area
  - bit Position of the bit to be manipulated

**Return value**

- 

**Example**

```c
void __bset(unsigned char *data, unsigned long bit) 
unsigned char *data;
void main(void)
{
  __bset(data, 0);  // Sets the least significant bit in the 1-byte area indicated
                    // by address data to 1.
}
```

**Remarks**
Only an integer constant from 0 to 7 can be specified as parameter bit.
This function is expanded into a BSET instruction which directly modifies the bit specified by the parameter to 1 in memory.
### void __bnot(unsigned char *data, unsigned long bit) [V2.05.00 or later]

**[Description]**
Reverses the value of the specified one bit in the specified 1-byte area (this function is expanded into a BNOT instruction).

**[Parameters]**
- data    Address of the target 1-byte area
- bit    Position of the bit to be manipulated

**[Return value]**

**[Example]**

```c
unsigned char *data;
void main(void)
{
    __bnot(data, 0);  // Sets the least significant bit in the 1-byte area indicated
                    // by address data to 0 if the value is 1 or to 1 if the value
                    // is 0.
}
```

**[Remarks]**
Only an integer constant from 0 to 7 can be specified as parameter bit.
This function is expanded into a BNOT instruction which directly reverses the bit specified by the parameter in memory.

### void __set_dpsw(unsigned long data) [V3.01.00 or later]

**[Description]**
Sets a value in DPSW.

**[Parameters]**
- data    Value to be set

**[Return value]**

**[Example]**

```c
unsigned long data;
void main(void)
{
    __set_dpsw(data);  // Sets DPSW to the value specified by data.
}
```

**[Remarks]**
This function is only usable when the dpfu option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.
unsigned long __get_dpsw(void) [V3.01.00 or later]

[Description]
Refers to the DPSW value.

[Header]
-

[Parameters]
-

[Return value]
DPSW value

[Example]

```c
unsigned long ret;
void main(void)
{
    ret=__get_dpsw();   // Obtains the DPSW value and stores it in ret.
}
```

[Remarks]
This function is only usable when the dpfpu option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.

void __set_decnt(unsigned long data) [V3.01.00 or later]

[Description]
Sets a value in DECNT.

[Header]
-

[Parameters]
data  Value to be set

[Return value]
-

[Example]

```c
unsigned long data;
void main(void)
{
    __set_decnt(data);  // Sets DECNT to the value specified by data.
}
```

[Remarks]
This function is only usable when the dpfpu option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.
**Description**
Refers to the DECNT value.

**Header**

**Parameters**

**Return value**
DECNT value

**Example**

```c
unsigned long __get_decnt(void) [V3.01.00 or later]

void main(void)
{
    ret=__get_decnt();// Obtains the DECNT value and stores it in ret.
}
```

**Remarks**
This function is only usable when the **dpfpu** option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.

---

**Description**
Refers to the DEPC value.

**Header**

**Parameters**

**Return value**
DEPC value

**Example**

```c
void *__get_depc(void) [V3.01.00 or later]

void main(void)
{
    ret=__get_depc();// Obtains the DEPC value and stores it in ret.
}
```

**Remarks**
This function is only usable when the **dpfpu** option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.
void __init_tfu(void) [V3.01.00 or later]

[Description]
Initializes the trigonometric function unit (v1).

[Header]
-

[Parameters]
-

[Return value]
-

[Example]
```c
void main(void)
{
#if __TFU == 1
    __init_tfu();
#endif
}
```

[Remarks]
This function is only available when the `tfu` option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.

When TFUv1 is used, initialize the trigonometric function unit by calling this function before use of the unit, at the startup program for example. If you do not initialize the unit, correct operation is not guaranteed.

When TFUv2 is used, there is no need to initialize the trigonometric function unit. Calling this function will lead to an error at the time of compilation.
CC-RX 4. COMPILER LANGUAGE SPECIFICATIONS

void __sincosf(float f, float *sin, float *cos) [V3.01.00 or later]

[Description]
Uses the trigonometric function unit to calculate the sine and cosine of an angle at the same time (single precision).

[Header]
-

[Parameters]
- f Value in radians from which to calculate the sine and cosine
- sin Address for storing the result of the sine operation
- cos Address for storing the result of the cosine operation

[Return value]
-

[Example]
float f, *sin, *cos;
void main(void)
{
    #if __TFU == 1
        __init_tfu(); // The trigonometric function unit must be initialized in advance.
    #endif

    __sincosf(f, sin, cos);
}

[Remarks]
This function is only available when the tfu option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.

When TFUv1 is used, you must initialize the trigonometric function unit by calling the __init_tfu() intrinsic function before calling this function. This function is not reentrant.

When TFUv2 is used, there is no need to initialize the trigonometric function unit (calling __init_tfu() will lead to an error at the time of compilation). This function is reentrant by default, but is not reentrant if any of the following applies:
- When -nosave_tfu is specified.
- When interrupt specification no_tfu is specified in #pragma interrupt for any interrupt function that uses the trigonometric function unit.
void __atan2hypotf(float y, float x, float *atan2, float *hypot) [V3.01.00 or later]

[Description]
Uses the trigonometric function unit to calculate the arc tangent of x and y and the square root of the sum of squares of these values ($\sqrt{x^2 + y^2}$) at the same time (single precision).

[Header]

[Parameters]
- y Coordinate y (the numerator of the tangent)
- x Coordinate x (the denominator of the tangent)
- atan2 Address for storing the result of the arc tangent operation for y/x
- hypot Address for storing the result of the square root of the sum of squares of x and y ($\sqrt{x^2 + y^2}$)

[Return value]

[Example]

```c
float y, x, *a, *h;
void main(void)
{
    #if __TFU == 1
        __init_tfu(); // The trigonometric function unit must be initialized in advance.
    #endif
    __atan2hypotf(y, x, a, h);
}
```

[Remarks]
This function is only available when the tfu option is specified. If this call is attempted with the option not specified, an error will occur at the time of compilation.

When TFUv1 is used, you must initialize the trigonometric function unit by calling the __init_tfu() intrinsic function before calling this function. This function is not reentrant.

When TFUv2 is used, there is no need to initialize the trigonometric function unit (calling __init_tfu() will lead to an error at the time of compilation). This function is reentrant by default, but is not reentrant if any of the following applies:
- When -nosave_tfu is specified.
- When interrupt specification no_tfu is specified in #pragma interrupt for any interrupt function that uses the trigonometric function unit.

The result of the arc tangent operation is returned as a value in radians from $-\pi$ to $\pi$. 
### __sincosfx__

**Description**
Uses the trigonometric function unit to calculate the sine and cosine of an angle at the same time (fixed-point number).

**Header**

- __sincosfx__(signed long fx, signed long *sin, signed long *cos)

**Parameters**
- **fx** Angle used to calculate the sine and cosine
- **sin** Address for storing the result of the sine operation
- **cos** Address for storing the result of the cosine operation

**Return value**

- None

**Example**

```c
void __sincosfx(signed long fx, signed long *sin, signed long *cos) { 
    // Implementation...
}
```

**Remarks**

This function is available when the `-tfu` option is specified and TFUv2 is used. If either of these conditions is not met, an error occurs at the time of compilation. This function is reentrant by default, but is not reentrant if any of the following applies:
- When `-nosave_tfu` is specified.
- When interrupt specification `no_tfu` is specified in `#pragma interrupt` for any interrupt function that uses the trigonometric function unit.

The input format, input unit, and output format of the operation result depend on the FXSCIOC register settings. For details, refer to the hardware manual.

### __sinfx__

**Description**
Uses the trigonometric function unit to calculate the sine of an angle (fixed-point number).

**Header**

- __sinf__(signed long fx)

**Parameters**
- **fx** Angle used to calculate the sine

**Return value**

- Result of the sine operation

**Example**

```c
signed long __sinfx(signed long fx) {
    // Implementation...
}
```

**Remarks**

This function is available when the `-tfu` option is specified and TFUv2 is used. If either of these conditions is not met, an error occurs at the time of compilation. This function is reentrant by default, but is not reentrant if any of the following applies:
- When `-nosave_tfu` is specified.
- When interrupt specification `no_tfu` is specified in `#pragma interrupt` for any interrupt function that uses the trigonometric function unit.

The input format, input unit, and output format of the operation result depend on the FXSCIOC register settings. For details, refer to the hardware manual.
signed long __cosfx(signed long fx) [V3.05.00 or later]

[Description]
Uses the trigonometric function unit to calculate the cosine of an angle (fixed-point number).

[Header]

[Parameters]
fx Angle used to calculate the cosine

[Return value]
Result of the cosine operation

[Example]
signed long fx, c;
void main(void) {
    c = __cosfx(fx);
}

[Remarks]
This function is available when the -tfu option is specified and TFUv2 is used. If either of these conditions is not met, an error occurs at the time of compilation.

This function is reentrant by default, but is not reentrant if any of the following applies:
- When -nosave_tf is specified.
- When interrupt specification no_tf is specified in #pragma interrupt for any interrupt function that uses the trigonometric function unit.

The input format, input unit, and output format of the operation result depend on the FXSCIOC register settings. For details, refer to the hardware manual.
void __atan2hypotfx(signed long y, signed long x, signed long *atan2, signed long *hypot) [V3.05.00 or later]

[Description]
Uses the trigonometric function unit to calculate the arc tangent of x and y and the square root of the sum of squares of these values ($\sqrt{x^2+y^2}$) at the same time (fixed-point number).

[Header]

[Parameters]
- y Coordinate y (the numerator of the tangent)
- x Coordinate x (the denominator of the tangent)
- atan2 Address for storing the result of the arc tangent operation for y/x
- hypot Address for storing the result of the square root of the sum of squares of x and y ($\sqrt{x^2+y^2}$)

[Return value]

[Example]

```c
signed long y, x, *a, *h;
void main(void) {
    __atan2hypotfx(y, x, a, h);
}
```

[Remarks]
This function is available when the -tfu option is specified and TFUv2 is used. If either of these conditions is not met, an error occurs at the time of compilation.

This function is reentrant by default, but is not reentrant if any of the following applies:
- When -nosave_tfu is specified.
- When interrupt specification no_tfu is specified in #pragma interrupt for any interrupt function that uses the trigonometric function unit.

The output format and output unit of the result of the arc tangent operation depend on the FXATIOC register settings. For details, refer to the hardware manual.

The output format of the result of the square root of the sum of squares of x and y ($\sqrt{x^2+y^2}$) is fixed to Q3.29.
演算結果の出力形式はQ3.29固定です。

[Description]
Uses the trigonometric function unit to calculate the arc tangent of x and y (fixed-point number).

[Header]
-

[Parameters]
y Coordinate y (the numerator of the tangent)
x Coordinate x (the denominator of the tangent)

[Return value]
Result of the arc tangent operation for y/x

[Example]
signed long y, x, a;
void main(void) {
    a = __atan2fx(y, x);
}

[Remarks]
This function is available when the -tfu option is specified and TFUv2 is used. If either of these conditions is not met, an error occurs at the time of compilation.
This function is reentrant by default, but is not reentrant if any of the following applies:
  - When -nosave_tfu is specified.
  - When interrupt specification no_tfu is specified in #pragma interrupt for any interrupt function that uses the trigonometric function unit.
The output format and output unit of the operation result depend on the FXATIOC register settings. For details, refer to the hardware manual.

signed long __hypotfx(signed long x, signed long y) [V3.05.00 or later]

[Description]
Uses the trigonometric function unit to calculate the square root of the sum of squares of x and y (\(\sqrt{x^2 + y^2}\)) (fixed-point number).

[Header]
-

[Parameters]
x Coordinate x
y Coordinate y

[Return value]
Result of the square root of the sum of squares of x and y (\(\sqrt{x^2 + y^2}\))

[Example]
signed long x, y, h;
void main(void) {
    h = __hypotfx(x, y);
}

[Remarks]
This function is available when the -tfu option is specified and TFUv2 is used. If either of these conditions is not met, an error occurs at the time of compilation.
This function is reentrant by default, but is not reentrant if any of the following applies:
  - When -nosave_tfu is specified.
  - When interrupt specification no_tfu is specified in #pragma interrupt for any interrupt function that uses the trigonometric function unit.
The output format of the operation result is fixed to Q3.29.
4.2.7 Section Address Operators

Table 4.11 lists the section address operators.

Table 4.11  Section Address Operators

<table>
<thead>
<tr>
<th>No.</th>
<th>Section Address Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>__sectop(&quot;&lt;section name&gt;&quot;)</td>
<td>Refers to the start address of &lt;section name&gt;.</td>
</tr>
<tr>
<td>2</td>
<td>__secend(&quot;&lt;section name&gt;&quot;)</td>
<td>Refers to the sum of the size of &lt;section name&gt; and the address where &lt;section name&gt; starts.</td>
</tr>
<tr>
<td>3</td>
<td>__secsize(&quot;&lt;section name&gt;&quot;)</td>
<td>Refers to the size of &lt;section name&gt;.</td>
</tr>
</tbody>
</table>

[Return value type]
The return value type of __sectop is void *.
The return value type of __secend is void *.
The return value type of __secsize is unsigned long.

[Example]

(1) __sectop, __secend

```c
#include <machine.h>
#pragma section $DSEC
static const struct {
    void *rom_s; /* Start address of the initialized data section in ROM */
    void *rom_e; /* End address of the initialized data section in ROM */
    void *ram_s; /* Start address of the initialized data section in RAM */
} DTBL[]={__sectop("D"), __secend("D"), __sectop("R")};

#pragma section $BSEC
static const struct {
    void *b_s; /* Start address of the uninitialized data section */
    void *b_e; /* End address of the uninitialized data section */
} BTBL[]={__sectop("B"), __secend("B")};

#pragma stacksize si=0x100
#pragma entry INIT
void main(void);
void INIT(void)
{
    _INITSCT();
    main();
    sleep();
}
```

(2) __secsize

```c
/* size of section B */
unsigned int size_of_B = __secsize("B");
```

[Remarks]
In an application that enables the PIC/PID function, __sectop and __secend is processed as the addresses determined at linkage.
For details of the PIC/PID function, refer to the descriptions of the pic and pid options in Usage of PIC/PID Function.
5. ASSEMBLY LANGUAGE SPECIFICATIONS

This chapter describes the assembly language specifications supported by the RX assembler. For information on registers, instructions, and data types that are usable in the assembly source code, refer to the RX Family Software Manual.

5.1 Description of Source

This section explains description of source, expressions, and operators.

5.1.1 Description

The following shows the mnemonic line format.

[label][operation][operand(s)][comment]

Coding example:

LABEL1: MOV.L [R1], R2 ; Example of a mnemonic.

<table>
<thead>
<tr>
<th>Label</th>
<th>Operation</th>
<th>Operands</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>Operation</td>
<td>Operands</td>
<td>Comment</td>
</tr>
</tbody>
</table>

(1) Label
Define a name for the address of the mnemonic line.

(2) Operation
Write a mnemonic or a directive.

(3) Operand(s)
Write the object(s) of the operation. The number of operands and their types depend on the operation. Some operations do not require any operands.

(4) Comment
Write notes or explanations that make the program easier to understand.

5.1.2 Names

Desired names can be defined and used in assembly-language files. Names are classified into the following types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label name</td>
<td>A name having an address as its value.</td>
</tr>
<tr>
<td>Symbol name</td>
<td>A name having a constant as its value (the name of a label is also included).</td>
</tr>
<tr>
<td>Section name</td>
<td>The name of a section that is defined through the .SECTION directive.</td>
</tr>
<tr>
<td>Location symbol name</td>
<td>The start address of the operation in a line including a location symbol ($).</td>
</tr>
<tr>
<td>Macro name</td>
<td>Macro definition name</td>
</tr>
</tbody>
</table>

Rules for Names:
- There is no limitation on the number of characters in a name.
- Names are case-sensitive; "LAB" and "Lab" are handled as different names.
- An underscore (_) and a dollar sign ($) can be used in names.
- The first character in a name must not be a digit.
- Any reserved word must not be used as a name.

Note Flag names (U, I, O, S, Z, and C), which are reserved words, can be used only for section names.
5.1.3 Coding of Labels

Be sure to append a colon (:) to the end of a label.

Example

LABEL1:

Defining a symbol name which is the same as that of an existing section is not possible. If a section and symbol with the same name are defined, the section name will be effective, but the symbol name will lead to an A2118 error.

5.1.4 Coding of Operation

- Format

   mnemonic [size specifier (branch distance specifier)]

- Description

   An instruction consists of the following two elements.
   (1) Mnemonic: Specifies the operation of the instruction.
   (2) Size specifier: Specifies the size of the data which undergoes the operation.

(1) Mnemonic

   A mnemonic specifies the operation of the instruction.
   Example:
   MOV: Transfer instruction
   ADD: Arithmetic instruction (addition instruction)

(2) Size Specifier

   A size specifier specifies the size of the operand(s) in the instruction code.
   - Format
     .size
   - Description
     A size specifier specifies the operation size of the operand(s). More exactly, it specifies the size of data to be read to execute the instruction. The following can be specified as size.

<table>
<thead>
<tr>
<th>size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Byte (8 bits)</td>
</tr>
<tr>
<td>W</td>
<td>Word (16 bits)</td>
</tr>
<tr>
<td>L</td>
<td>Longword (32 bits)</td>
</tr>
</tbody>
</table>

A size specifier can be written in either uppercase or lowercase.
Example: MOV, B #0, R3 ... Specifies the byte size.
Size specifiers can be and must be used for the instructions whose mnemonics are suffixed with ".size" in the Instruction Format description of the RX Family Software Manual.

(3) Branch Distance Specifier

   Branch distance specifiers are used in branch and relative subroutine branch instructions.
   - Format
     .length
   - Description
     The following can be specified as length.
Table 5.3 Branch Distance Specifiers

<table>
<thead>
<tr>
<th>length</th>
<th>Description</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>3-bit PC forward relative</td>
<td>(+3 to +10)</td>
</tr>
<tr>
<td>B</td>
<td>8-bit PC relative</td>
<td>(–128 to +127)</td>
</tr>
<tr>
<td>W</td>
<td>16-bit PC relative</td>
<td>(–32768 to +32767)</td>
</tr>
<tr>
<td>A</td>
<td>24-bit PC relative</td>
<td>(–8388608 to +8388607)</td>
</tr>
<tr>
<td>L</td>
<td>Register relative</td>
<td>(–2147483648 to +2147183647)</td>
</tr>
</tbody>
</table>

A distance specifier can be written either in uppercase or lowercase.

Examples:
- BRA.W label ... Specifies 16-bit relative.
- BRA.L R1 ... Specifies register relative.

This specifier can be omitted. When the specifier is omitted, the assembler automatically selects the distance from among S, B, W, and A to generate the smallest opcode when the following conditions are all satisfied.

1. The operand is not a register.
2. The operand specifies the destination for which the branch distance is determined at assembly.
   Examples:
   - Label + value determined at assembly
   - Value determined at assembly + label
3. The label of the operand is defined within the same section.
   Note that when a register is specified as the operand, branch distance specifier L is selected.

For a conditional branch instruction, if the branch distance is beyond the allowed range, a code is generated by inverting the branch condition.

The following shows the branch distance specifiers that can be used in each instruction.

Table 5.4 Branch Distance Specifiers for Each Branch Instruction

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BCnd</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Cnd = EQ/Z)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Cnd = NE/NZ)</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Cnd = others)</td>
<td>-</td>
<td>Allowed</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BRA</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
</tr>
<tr>
<td>BSR</td>
<td>-</td>
<td>-</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
</tr>
</tbody>
</table>

5.1.5 Coding of Operands

(1) Numeric Value

Five types of numeric values described below can be written in programs.

The written values are handled as 32-bit signed values (except floating-point values).

(a) Binary Number

Use digits 0 and 1, and append B or b as a suffix.

- Examples
  - 1011000B
  - 1011000b

(b) Octal Number

Use digits 0 to 7, and append O or o as a suffix.

- Examples
  - 607020
  - 607020o
(c) **Decimal Number**
Use digits 0 to 9.
- Example
  9243

(d) **Hexadecimal Number**
Use digits 0 to 9 and letters A to F and a to f, and append H or h as a suffix.
When starting with a letter, append 0 as a prefix.
- Examples
  0A5FH
  5FH
  0a5fh
  5fh

(e) **Floating-Point Number**
A floating-point number can be written only as the operand of the `.FLOAT` or `.DOUBLE` directive.
No floating-point number can be used in expressions.
The following range of values can be written as floating-point numbers.
**FLOAT** (32 bits): $1.17549435 \times 10^{-38}$ to $3.40282347 \times 10^{38}$
**DOUBLE** (64 bits): $2.2250738585072014 \times 10^{-308}$ to $1.7976931348623157 \times 10^{308}$
- Format
  (mantissa)E(exponent)
  (mantissa)e(exponent)
- Examples
  3.4E35 ; $3.4 \times 10^{35}$
  3.4e-35 ; $3.4 \times 10^{-35}$
  -.5E20 ; $-0.5 \times 10^{20}$
  5e-20 ; $5.0 \times 10^{-20}$

(2) **Addressing Mode**
The following three types of addressing mode can be specified in operands.
(a) **General Instruction Addressing**
  - Register direct
    The specified register is the object of operation. R0 to R15 and SP can be specified. DR0 to DR15, DRL0 to DRL15, and DRH0 to DRH15 can also be used when `-dpfpu` is specified. SP is assumed as R0 (R0 = SP).
    \[
    Rn \ (Rn=R0 \text{ to } R15, \ SP)
    \]
  - Example:
    \[
    \text{ADD} \ R1, R2
    \]
  - Immediate
    
    - `#imm` indicates an immediate integer.
    - `#uimm` indicates an immediate unsigned integer.
    - `#simm` indicates an immediate signed integer.
    - `#imm:n`, `#uimm:n`, and `#simm:n` indicate an n-bit immediate value.

    \[
    \text{#imm:8, #uimm:8, #simm:8, #imm:16, #simm:16, #simm:24, #imm:32}
    \]
  
  Note: The value of `#uimm:8` in the `RTSD` instruction must be determined.
  - Example:
    \[
    \text{MOV.L} \ #-100, R2; \ #simm:8
    \]
- Register indirect
  The value in the register indicates the effective address of the object of operation. The effective address range is 00000000h to FFFFFFFFh.

  \[ \text{[Rn]} \ (\text{Rn=R0 to R15, SP}) \]

- Example:

  \[
  \text{ADD} \ [R1], R2
  \]

- Register relative
  The effective address of the object of operation is the sum of the displacement (\( \text{dsp} \)) after zero-extension to 32 bits and the register value. The effective address range is 00000000h to FFFFFFFFh. \( \text{dsp}:n \) represents an \( n \)-bit displacement.
  Specify a \( \text{dsp} \) value scaled with the following rules. The assembler restores it to the value before scaling and embeds it into the instruction bit pattern.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer instruction using a size specifier</td>
<td>Multiply by 1, 2, or 4 according to the size specifier (( \text{.B}, \text{.W}, \text{or .L} ))</td>
</tr>
<tr>
<td>Arithmetic/logic instruction using a size extension specifier</td>
<td>Multiply by 1, 1, 2, 2, or 4 according to the size extension specifier (( \text{.B}, \text{.UB}, \text{.W}, \text{.UW}, \text{or .L} ))</td>
</tr>
<tr>
<td>Bit manipulation instruction</td>
<td>Multiply by 1</td>
</tr>
<tr>
<td>Others</td>
<td>Multiply by 4</td>
</tr>
</tbody>
</table>

\( \text{dsp}:8[Rn], \text{dsp}:16[Rn] \ (\text{Rn=R0 to R15, SP}) \)

- Example:

  \[
  \text{ADD} \ 400[R1], R2; \text{dsp}:8[Rn] \ (400/4 = 100)
  \]

When the size specifier is \( \text{W} \) or \( \text{L} \) but the address is not a multiple of 2 or 4:
  if the value is determined at assembly: Error at assembly
  if the value is not determined at assembly: Error at linkage

(b) Extended Instruction Addressing

- Short immediate
  The immediate value specified by \( \#\text{imm} \) is the object of operation. When the immediate value is not determined at assembly, an error will be output.
  \( \#\text{imm}:1 \)
  This addressing mode is used only for \( \text{src} \) in the DSP function instruction (\( \text{RACW} \)). 1 or 2 can be specified as an immediate value.
  Example:

  \[
  \text{RACW} \ \#1; \text{RACW} \ \#\text{imm}:1
  \]

  \( \#\text{imm}:2 \)
  The 2-bit immediate value specified by \( \#\text{imm} \) is the object of operation. This addressing mode is only used to specify the coprocessor number in coprocessor instructions (\( \text{MVFCP}, \text{MVTCP}, \text{and OPECp} \)).
  Example:

  \[
  \text{MVTCP} \ \#3, R1, \#4:16; \text{MVTCP} \ \#\text{imm}:2, Rn, \#\text{imm}:16
  \]

  \( \#\text{imm}:3 \)
  The 3-bit immediate value specified by \( \#\text{imm} \) is the object of operation. This addressing mode is used to specify the bit number in bit manipulation instructions (\( \text{BCLR}, \text{BMCnd}, \text{BNOT}, \text{BSET}, \text{and BTST} \)).
  Example:

  \[
  \text{BSET} \ \#7, R10; \text{BSET} \ \#\text{imm}:3, Rn
  \]
When using this addressing mode in the source statements of the ADD, AND, CMP, MOV, MUL, OR, and SUB instructions, the object of operation is obtained by zero-extension of the 4-bit immediate value specified by \texttt{#imm} to 32 bits.

When using this addressing mode to specify the interrupt priority level in the MVTIPL instruction, the object of operation is the 4-bit immediate value specified by \texttt{#imm}.

Example:

\begin{verbatim}
ADD  #15, R8; ADD  #imm:4, Rn
\end{verbatim}

\texttt{#imm:5}

The 5-bit immediate value specified by \texttt{#imm} is the object of operation. This addressing mode is used to specify the bit number in bit manipulation instructions (BCLR, BMCnd, BNOT, BSET, and BTST), the number of bits shifted in shift instructions (SHAR, SHLL, and SHLR), and the number of bits rotated in rotate instructions (ROTL and ROTR).

Example:

\begin{verbatim}
BSET  #31, R10; BSET  #imm:5, Rn
\end{verbatim}

- Short register relative

The effective address of the object of operation is the sum of the 5-bit displacement (\texttt{dsp}) after zero-extension to 32 bits and the register value. The effective address range is 00000000h to FFFFFFFFh.

Specify a \texttt{dsp} value respectively multiplied by 1, 2, or 4 according to the size specifier (.B, .W, or .L). The assembler restores it to the value before scaling and embeds it into the instruction bit pattern. When the \texttt{dsp} value is not determined at assembly, an error will be output. This addressing mode is used only in the MOV and MOVU instructions.

\begin{verbatim}
mov.L  R3,124[R1]; dsp:5[Rn] (124/4 = 31)
\end{verbatim}

Note The other operand (src or dest) should also be R0 to R7.

- Post-increment register indirect

1, 2, or 4 is respectively added to the register value according to the size specifier (.B, .W, or .L). The register value before increment is the effective address of the object of operation. The effective address range is 00000000h to FFFFFFFFh. This addressing mode is used only in the MOV and MOVU instructions.

\begin{verbatim}
[Rn+](Rn=R0 to R15, SP)
\end{verbatim}

Example:

\begin{verbatim}
MOV.L [R3+],R1
\end{verbatim}

- Pre-decrement register indirect

1, 2, or 4 is respectively subtracted from the register value according to the size specifier (.B, .W, or .L). The register value after decrement is the effective address of the object of operation. The effective address range is 00000000h to FFFFFFFFh. This addressing mode is used only in the MOV and MOVU instructions.

\begin{verbatim}
[-Rn](Rn=R0 to R15, SP)
\end{verbatim}

Example:

\begin{verbatim}
MOV.L [-R3],R1
\end{verbatim}

- Indexed register indirect

The effective address of the object of operation is the least significant 32 bits of the sum of the value in the index register (Ri) after multiplication by 1, 2, or 4 according to the size specifier (.B, .W, or .L) and the value in the base register (Rb). The effective address range is 00000000h to FFFFFFFFh. This addressing mode is used only in the MOV and MOVU instructions.

\begin{verbatim}
[Ri,Rb](Ri=R0 to R15, SP) (Rb=R0 to R15, SP)
\end{verbatim}
Examples:

MOV.L [R3,R1],R2
MOV.L R3, [R1,R2]

(c) Specific Instruction Addressing

- Control register direct
  The specified control register is the object of operation. This addressing mode is used only in the MVTC, POPC, PUSHC, and MVFC instructions.

PSW, FPSW, USP, ISP, INTB, EXTB, BPSW, BPC, FINTV, PC

This addressing mode is also used for the DPUSHM, DPOPM, MVTDC, and MVFDC instructions when -dpfpu is specified.

DPSW, DCMR, DECNT, DEPC

Example:

STC PSW,R2

- PSW direct
  The specified flag or bit is the object of operation. This addressing mode is used only in the CLRPSW and SETPSW instructions.

U, I, O, S, Z, C

Example:

CLRPW U

- Program counter relative
  This addressing mode is used to specify the branch destination in the branch instruction.

Rn (Rn=R0 to R15, SP)

The effective address is the signed sum of the program counter value and the Rn value. The range of the Rn value is –2147483648 to 2147483647. The effective address range is 00000000h to FFFFFFFFh. This addressing mode is used in the BRA(L) and BSR(L) instructions.

label(PC + pcdsp:3)

This specifies the destination address of a branch instruction. The specified symbol or value indicates the effective address.

The assembler subtracts the program counter value from the specified branch destination address and embeds it into the instruction bit pattern as a displacement (pcdsp).

When the branch distance specifier is .S, the effective address is the least significant 32 bits of the unsigned sum of the program counter value and the displacement value.

The range of pcdsp is 3 ≤ pcdsp:3 ≤ 10.

The effective address range is 0000000h to FFFFFFFFh. This addressing mode is used only in the BRA and BCnd (only for Cnd == EQ, NE, Z, or NZ) instructions.

label(PC + pcdsp:8/pcdsp:16/pcdsp:24)

This specifies the destination address of a branch instruction. The specified symbol or value indicates the effective address.

The assembler subtracts the program counter value from the specified branch destination address and embeds it into the instruction bit pattern as a displacement (pcdsp).

When the branch distance specifier is .B, .W, or .A, the effective address is the least significant 32 bits of the signed sum of the program counter value and the displacement value. The range of pcdsp is as follows.

For .B: –128 ≤ pcdsp:8 ≤ +127
(3) Bit Length Specifier
A bit length specifier specifies the size of the immediate value or displacement in the operand.

- Format

:width

- Description
This specifier should be appended immediately after the immediate value or displacement specified in the operand.
The assembler selects an addressing mode according to the specified size.
When this specifier is omitted, the assembler selects the optimum bit length for code efficiency.
When specified, the assembler does not select the optimum size but uses the specified size.
This specifier must not be used for operands of assembler directives.
One or more space characters can be inserted between an immediate value or a displacement and this specifier.
When a size specified for an instruction is not allowed for that instruction, an error will be output.
The following can be specified as width.
2: Indicates an effective length of one bit.
#imm:2
3: Indicates an effective length of three bits.
#imm:3
4: Indicates an effective length of four bits.
#imm:4
5: Indicates an effective length of five bits.
#imm:5, dsp:5
8: Indicates an effective length of eight bits.
#uimm:8, #simm:8, dsp:8
16: Indicates an effective length of 16 bits.
#uimm:16, #simm:16, dsp:16
24: Indicates an effective length of 24 bits.
#simm:24
32: Indicates an effective length of 32 bits.
#imm:32

(4) Size Extension Specifier
A size extension specifier specifies the size of a memory operand and the type of extension when memory is specified as the source operand of an arithmetic/logic instruction.

- Format

.memex

- Description
This specifier should be appended immediately after a memory operand and no space character should be inserted between them.
Size extension specifiers are valid only for combinations of specific instructions and memory operands; if a size extension specifier is used for an invalid combination of instruction and operand, an error will be output.
Valid combinations are indicated by ".memex" appended after the source operands in the Instruction Format description of the RX Family Software Manual.
When this specifier is omitted, the assembler assumes B for bit manipulation instructions or assumes L for other instructions.
The following shows available size extension specifiers and their function.

Table 5.6 Size Extension Specifiers

<table>
<thead>
<tr>
<th>Size Extension Specifier</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Sign extension of 8-bit data into 32 bits</td>
</tr>
<tr>
<td>UB</td>
<td>Zero extension of 8-bit data into 32 bits</td>
</tr>
</tbody>
</table>
5.1.6 Expression

A combination of numeric values, symbols, and operators can be written as an expression.

- A space character or a tab can be inserted between an operator and a numeric value.
- Multiple operators can be used in combination.
- When using an expression as a symbol value, make sure that the value of the expression is determined at assembly.
- A character constant must not be used as a term of an expression.
- The expression value as a result of operation must be within the range from –2147483648 to 2147483647. The assembler does not check if the result is outside this range.

(a) Operator

The following is a list of the operators that can be written in programs.

- Unary operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Handles the value that follows the operator as a positive value.</td>
</tr>
<tr>
<td>-</td>
<td>Handles the value that follows the operator as a negative value.</td>
</tr>
<tr>
<td>~</td>
<td>Logically negates the value that follows the operator.</td>
</tr>
<tr>
<td>SIZEOF</td>
<td>Handles the size (bytes) of the section specified in the operand as a value.</td>
</tr>
<tr>
<td>TOPOF</td>
<td>Handles the start address of the section specified in the operand as a value.</td>
</tr>
</tbody>
</table>

Be sure to insert a space character or a tab between the operand and SIZEOF or TOPOF.

Example: SIZEOF program

- Binary operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Adds the lvalue and rvalue.</td>
</tr>
<tr>
<td>-</td>
<td>Subtracts the rvalue from the lvalue.</td>
</tr>
<tr>
<td>*</td>
<td>Multiplies the lvalue and rvalue.</td>
</tr>
<tr>
<td>/</td>
<td>Divides the lvalue by the rvalue.</td>
</tr>
<tr>
<td>%</td>
<td>Obtains the remainder by dividing the lvalue by the rvalue.</td>
</tr>
<tr>
<td>&gt;&gt;=</td>
<td>Shifts the lvalue to the right by the number of bits specified by the rvalue.</td>
</tr>
<tr>
<td>&lt;&lt;</td>
<td>Shifts the lvalue to the left by the number of bits specified by the rvalue.</td>
</tr>
</tbody>
</table>
- Conditional operators
A conditional operator can be used only in the operand of the .IF or .ELIF directive.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp;</td>
<td>Logically ANDs the lvalue and rvalue in bitwise.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>^</td>
<td>Exclusively ORs the lvalue and rvalue in bitwise.</td>
</tr>
</tbody>
</table>

Table 5.9  Conditional Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;</td>
<td>Evaluates if the lvalue is greater than the rvalue.</td>
</tr>
<tr>
<td>&lt;</td>
<td>Evaluates if the lvalue is smaller than the rvalue.</td>
</tr>
<tr>
<td>&gt;=</td>
<td>Evaluates if the lvalue is equal to or greater than the rvalue.</td>
</tr>
<tr>
<td>&lt;=</td>
<td>Evaluates if the lvalue is equal to or smaller than the rvalue.</td>
</tr>
<tr>
<td>==</td>
<td>Evaluates if the lvalue is equal to the rvalue.</td>
</tr>
<tr>
<td>!=</td>
<td>Evaluates if the lvalue is not equal to the rvalue.</td>
</tr>
</tbody>
</table>

- Precedence designation operator

Table 5.10  Precedence Designation Operator

<table>
<thead>
<tr>
<th>Operator</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>()</td>
<td>An operation enclosed within ( ) takes precedence. If multiple pairs of parentheses are used in an expression, the left pair is given precedence over the right pair. Parentheses can be nested.</td>
</tr>
</tbody>
</table>

(b) Order of Expression Evaluation
The expression in an operand is evaluated in accordance with the following precedence and the resultant value is handled as the operand value.

- The operators are evaluated in the order of their precedence. The operator precedence is shown in the following table.
- Operators having the same precedence are evaluated from left to right.
- An operation enclosed within parentheses takes the highest precedence.

Table 5.11  Order of Expression Evaluation

<table>
<thead>
<tr>
<th>Precedence</th>
<th>Operator Type</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Precedence designation operator</td>
<td>()</td>
</tr>
<tr>
<td>2</td>
<td>Unary operator</td>
<td>+, -, ~, SIZEOF, TOPOF</td>
</tr>
<tr>
<td>3</td>
<td>Binary operator 1</td>
<td>*, /, %</td>
</tr>
<tr>
<td>4</td>
<td>Binary operator 2</td>
<td>+, -</td>
</tr>
<tr>
<td>5</td>
<td>Binary operator 3</td>
<td>&gt;&gt;, &lt;&lt;</td>
</tr>
<tr>
<td>6</td>
<td>Binary operator 4</td>
<td>&amp;</td>
</tr>
<tr>
<td>7</td>
<td>Binary operator 5</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Conditional operator</td>
<td>&gt;, &lt;, &gt;=, &lt;=, ==, !=</td>
</tr>
</tbody>
</table>
5.1.7 Coding of Comments
A comment is written after a semicolon (;). The assembler regards all characters from the semicolon to the end of the line as a comment.

Example:

```
ADD R1, R2 ; Adds R1 to R2.
```

5.1.8 Selection of Optimum Instruction Format
Some of the RX Family microcontroller instructions provide multiple instruction formats for an identical single processing. The assembler selects the optimum instruction format that generates the shortest code according to the instruction and addressing mode specifications.

(1) Immediate Value
For an instruction having an immediate value as an operand, the assembler selects the optimum one of the available addressing modes according to the range of the immediate value specified as the operand. The following shows the immediate value ranges in the order of priority.

<table>
<thead>
<tr>
<th>#imm</th>
<th>Decimal Notation</th>
<th>Hexadecimal Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>#imm:1</td>
<td>1 to 2</td>
<td>1H to 2H</td>
</tr>
<tr>
<td>#imm:2</td>
<td>0 to 3</td>
<td>0H to 3H</td>
</tr>
<tr>
<td>#imm:3</td>
<td>0 to 7</td>
<td>0H to 7H</td>
</tr>
<tr>
<td>#imm:4</td>
<td>0 to 15</td>
<td>0H to 0FH</td>
</tr>
<tr>
<td>#imm:5</td>
<td>0 to 31</td>
<td>0H to 1FH</td>
</tr>
<tr>
<td>#imm:8</td>
<td>–128 to 255</td>
<td>–80H to 0FFH</td>
</tr>
<tr>
<td>#uimm:8</td>
<td>0 to 255</td>
<td>0H to 0FFH</td>
</tr>
<tr>
<td>#simm:8</td>
<td>–128 to 127</td>
<td>–80H to 7FH</td>
</tr>
<tr>
<td>#imm:16</td>
<td>–32768 to 65535</td>
<td>–8000H to 0FFFFH</td>
</tr>
<tr>
<td>#simm:16</td>
<td>–32768 to 32767</td>
<td>–8000H to 7FFFFH</td>
</tr>
<tr>
<td>#simm:24</td>
<td>–8388608 to 8388607</td>
<td>–800000H to 7FFFFFFH</td>
</tr>
<tr>
<td>#imm:32</td>
<td>–2147483648 to 4294967295</td>
<td>–80000000H to 0xFFFFFFFF</td>
</tr>
</tbody>
</table>

Notes 1. Hexadecimal values can also be written in 32 bits. Example: Decimal “–127” = hexadecimal “–7FH” can be written as “0FFFFFF81H”.

Notes 2. The #imm range for src in the INT instruction is 0 to 255.

Notes 3. The #imm range for src in the RTSD instruction is four times the #uimm:8 range.

(2) ADC and SBB Instructions
The following shows the ADC and SBB instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

Note The following table does not show the instruction formats and operands for which code selection is not optimized. When the processing size is not shown in the table, L is assumed.
Table 5.13 Instruction Formats of ADC and SBB Instructions

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>src</td>
<td>src2</td>
</tr>
<tr>
<td>ADC src,dest</td>
<td>#simm:8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#simm:16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#simm:24</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#imm:32</td>
<td>-</td>
</tr>
<tr>
<td>ADC/SBB src,dest</td>
<td>dsp:8[Rs].L</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>dsp:16[Rs].L</td>
<td>-</td>
</tr>
</tbody>
</table>

In the SBB instruction, an immediate value is not allowed for src.

(3) ADD Instruction
The following shows the ADD instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

Table 5.14 Instruction Formats of ADD Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>src</td>
<td>src2</td>
</tr>
<tr>
<td>(1) ADD src,dest</td>
<td>#uimm:4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#simm:8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#simm:16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#simm:24</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>#imm:32</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>dsp:8[Rs].memex</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>dsp:16[Rs].memex</td>
<td>-</td>
</tr>
<tr>
<td>(2) ADD src,src2,dest</td>
<td>#simm:8</td>
<td>Rs</td>
</tr>
<tr>
<td></td>
<td>#simm:16</td>
<td>Rs</td>
</tr>
<tr>
<td></td>
<td>#simm:24</td>
<td>Rs</td>
</tr>
<tr>
<td></td>
<td>#imm:32</td>
<td>Rs</td>
</tr>
</tbody>
</table>

(4) AND, OR, SUB, and MUL Instructions
The following shows the AND, OR, SUB, and MUL instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.
Table 5.15 Instruction Formats of AND, OR, SUB, and MUL Instructions

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>src</td>
<td>src2</td>
</tr>
<tr>
<td>AND/OR/SUB/MUL src,dest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#uimm:4</td>
<td>Rd</td>
<td></td>
</tr>
<tr>
<td>#simm:8</td>
<td>Rd</td>
<td></td>
</tr>
<tr>
<td>#simm:16</td>
<td>Rd</td>
<td></td>
</tr>
<tr>
<td>#simm:24</td>
<td>Rd</td>
<td></td>
</tr>
<tr>
<td>#imm:32</td>
<td>Rd</td>
<td></td>
</tr>
<tr>
<td>dsp:8[Rs].memex</td>
<td>Rd</td>
<td></td>
</tr>
<tr>
<td>dsp:16[Rs].memex</td>
<td>Rd</td>
<td></td>
</tr>
</tbody>
</table>

In the **SUB** instruction, **#simm:8/16/24** and **#imm:32** are not allowed for **src**.

(5) **BMCnd Instruction**

The following shows the **BMCnd** instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

Table 5.16 Instruction Formats of BMCnd Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>src</td>
<td>src2</td>
<td>dest</td>
</tr>
<tr>
<td>BMCnd src,dest</td>
<td>B</td>
<td>#imm:3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>#imm:3</td>
<td>-</td>
</tr>
</tbody>
</table>

(6) **CMP Instruction**

The following shows the **CMP** instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

Table 5.17 Instruction Formats of CMP Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>src</td>
<td>src2</td>
<td>dest</td>
</tr>
<tr>
<td>CMP src,src2</td>
<td>L</td>
<td>#uimm:4</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>#uimm:8</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>#simm:8</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>#simm:16</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>#simm:24</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>#imm:32</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>dsp:8[Rs].memex</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>dsp:16[Rs].memex</td>
<td>Rd</td>
</tr>
</tbody>
</table>

(7) **DIV, DIVU, EMUL, EMULU, ITOF, MAX, MIN, TST, and XOR Instructions**

The following shows the **DIV, DIVU, EMUL, EMULU, ITOF, MAX, MIN, MUL, TST, and XOR** instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.
### Table 5.18 Instruction Formats of DIV, DIVU, EMUL, EMULU, ITOF, MAX, MIN, TST, and XOR Instructions

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIV/DIVU/EMUL/EMULU/ITOF/MAX/MIN/TST/XOR</td>
<td>#simm:8 - Rd</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>#simm:16 - Rd</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>#simm:24 - Rd</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>#imm:32 - Rd</td>
<td>7</td>
</tr>
<tr>
<td>src,dest</td>
<td>dsp:8[Rs].memex - Rd</td>
<td>4 (memex = UB), 5 (memex ≠ UB)</td>
</tr>
<tr>
<td></td>
<td>dsp:16[Rs].memex - Rd</td>
<td>5 (memex = UB), 6 (memex ≠ UB)</td>
</tr>
</tbody>
</table>

In the ITOF instruction, #simm:8/16/24 and #imm:32 are not allowed for src.

(8) **FADD, FCMP, FDIV, FMUL, and FTOI Instructions**

The following shows the FADD, FCMP, FDIV, FMUL, and FTOI instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

#### Table 5.19 Instruction Formats of FADD, FCMP, FDIV, FMUL, and FTOI Instructions

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FADD/FCMP/FDIV/FMUL/FTOI</td>
<td>#imm:32 - Rd</td>
<td>7</td>
</tr>
<tr>
<td>src,dest</td>
<td>dsp:8[Rs].L - Rd</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>dsp:16[Rs].L - Rd</td>
<td>5</td>
</tr>
</tbody>
</table>

In the FTOI instruction, #imm:32 is not allowed for src.

(9) **MVTC, STNZ, and STZ Instructions**

The following shows the MVTC, STNZ, and STZ instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

#### Table 5.20 Instruction Formats of MVTC, STNZ, and STZ Instructions

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVTC/STNZ/STZ</td>
<td>#simm:8 - Rd</td>
<td>4</td>
</tr>
<tr>
<td>src,dest</td>
<td>#simm:16 - Rd</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>#simm:24 - Rd</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>#imm:32 - Rd</td>
<td>7</td>
</tr>
</tbody>
</table>

(10) **MOV Instruction**

The following shows the MOV instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.
### Table 5.21 Instruction Formats of MOV Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>size</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOV(.size) src,dest</td>
<td></td>
<td></td>
<td>src src2 dest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>Rs (Rs=R0-R7)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>L</td>
<td>dsp:5[Rs] (Rs=R0-R7)</td>
<td>Rd (Rd=R0-R7)</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>L</td>
<td>#uimm:8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#uimm:4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#uimm:8</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#simm:8</td>
<td>Rd</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B</td>
<td>#imm:8</td>
<td>[Rd]</td>
</tr>
<tr>
<td></td>
<td>W/L</td>
<td>W/L</td>
<td>#simm:8</td>
<td>[Rd]</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>W</td>
<td>#imm:16</td>
<td>[Rd]</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#simm:16</td>
<td>[Rd]</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#simm:24</td>
<td>[Rd]</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:32</td>
<td>[Rd]</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B</td>
<td>#imm:8</td>
<td>dsp:8[Rd]</td>
</tr>
<tr>
<td></td>
<td>W/L</td>
<td>W/L</td>
<td>#simm:8</td>
<td>dsp:8[Rd]</td>
</tr>
</tbody>
</table>
(11) **MOVU Instruction**

The following shows the MOVU instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>size</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOVU(.size) src,dest</td>
<td>W</td>
<td>W</td>
<td>#imm:16 - dsp:8[Rd]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:16 - dsp:8[Rd]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:24 - dsp:8[Rd]</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:32 - dsp:8[Rd]</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B</td>
<td>#imm:8 - dsp:16[Rd]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>W/L</td>
<td>W/L</td>
<td>#imm:8 - dsp:16[Rd]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>W</td>
<td>#imm:16 - dsp:16[Rd]</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:16 - dsp:16[Rd]</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:24 - dsp:16[Rd]</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>L</td>
<td>#imm:32 - dsp:16[Rd]</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>L</td>
<td>dsp:8[Rs] - Rd</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>L</td>
<td>dsp:16[Rs] - Rd</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>Rs - dsp:8[Rd]</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>Rs - dsp:16[Rd]</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>[Rs] - dsp:8[Rd]</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>[Rs] - dsp:16[Rd]</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>dsp:8[Rs] - [Rd]</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>dsp:16[Rs] - [Rd]</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>dsp:8[Rs] - dsp:16[Rd]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>dsp:16[Rs] - dsp:8[Rd]</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>size</td>
<td>dsp:16[Rs] - dsp:16[Rd]</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 5.22 Instruction Formats of MOVU Instruction

(12) **PUSH Instruction**

The following shows the PUSH instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>size</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSH(.size) src,dest</td>
<td>B/W</td>
<td>L</td>
<td>dsp:5[Rs] (Rs=R0-R7) - Rd (Rd=R0-R7)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B/W</td>
<td>L</td>
<td>dsp:8[Rs] - Rd</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>B/W</td>
<td>L</td>
<td>dsp:16[Rs] - Rd</td>
<td>4</td>
</tr>
</tbody>
</table>
### Table 5.23 Instruction Formats of PUSH Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSH src</td>
<td>dspl8[Rs]</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>dspl16[Rs]</td>
<td>4</td>
</tr>
</tbody>
</table>

(13) **ROUND Instruction**
The following shows the ROUND instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

### Table 5.24 Instruction Formats of ROUND Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROUND src,dest</td>
<td>dspl8[Rd]</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>dspl16[Rd]</td>
<td>5</td>
</tr>
</tbody>
</table>

(14) **SCCnd Instruction**
The following shows the SCCnd instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

### Table 5.25 Instruction Formats of SCCnd Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCCnd(.size) src,dest</td>
<td>B/W/L</td>
<td>dspl8[Rd]</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B/W/L</td>
<td>dspl16[Rd]</td>
<td>5</td>
</tr>
</tbody>
</table>

(15) **XCHG Instruction**
The following shows the XCHG instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.

### Table 5.26 Instruction Formats of XCHG Instruction

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>XCHG src,dest</td>
<td>L</td>
<td>dspl8[Rs].memex</td>
<td>4(memex = UB), 5(memex ≠ UB)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>dspl16[Rs].memex</td>
<td>5(memex = UB), 6(memex ≠ UB)</td>
</tr>
</tbody>
</table>

(16) **BCLR, BNOT, BSET, and BTST Instructions**
The following shows the BCLR, BNOT, BSET, and BTST instruction formats and operands for which the assembler selects the optimum code, in the order of selection priority.
Table 5.27 Instruction Formats of BCLR, BNOT, BSET, and BTST Instructions

<table>
<thead>
<tr>
<th>Instruction Format</th>
<th>Processing Size</th>
<th>Target of Optimum Selection</th>
<th>Code Size [Bytes]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>src</td>
<td>src2</td>
<td>dest</td>
</tr>
<tr>
<td>BCLR/BNOT/BSET/BTST src,dest</td>
<td>B</td>
<td>#imm:3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>#imm:3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Rs</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Rs</td>
<td>-</td>
</tr>
</tbody>
</table>

5.1.9 Selection of Optimum Branch Instruction

(1) Unconditional Relative Branch (BRA) Instruction

(a) Specifiable Branch Distance Specifiers
- \( .S \) 3-bit PC relative (PC + pcdsp:3, \( 3 \leq \text{pcdsp:}3 \leq 10 \))
- \( .B \) 8-bit PC relative (PC + pcdsp:8, \( -128 \leq \text{pcdsp:}8 \leq 127 \))
- \( .W \) 16-bit PC relative (PC + pcdsp:16, \( -32768 \leq \text{pcdsp:}16 \leq 32767 \))
- \( .A \) 24-bit PC relative (PC + pcdsp:24, \( -8388608 \leq \text{pcdsp:}24 \leq 8388607 \))
- \( .L \) Register relative (PC + Rs, \( -2147483648 \leq \text{Rs} \leq 2147483647 \))

Note: The register relative distance is selected only when a register is specified as an operand; it is not used automatically through optimum selection.

(b) Optimum Selection
- The assembler selects the shortest branch distance when the operand of an unconditional relative branch instruction satisfies the conditions for optimum branch selection. For the conditions, refer to section 5.1.4 (3) Branch Distance Specifier.
- When the operand does not satisfy the conditions, the assembler selects the 24-bit PC relative distance (\( .A \)).

(2) Relative Subroutine Branch (BSR) Instruction

(a) Specifiable Branch Distance Specifiers
- \( .W \) 16-bit PC relative (PC + pcdsp:16, \( -32768 \leq \text{pcdsp:}16 \leq 32767 \))
- \( .A \) 24-bit PC relative (PC + pcdsp:24, \( -8388608 \leq \text{pcdsp:}24 \leq 8388607 \))
- \( .L \) Register relative (PC + Rs, \( -2147483648 \leq \text{Rs} \leq 2147483647 \))

Note: The register relative distance is selected only when a register is specified as an operand; it is not used automatically through optimum selection.

(b) Optimum Selection
- The assembler selects the shortest branch distance when the operand of a relative subroutine branch instruction satisfies the conditions for optimum branch selection. For the conditions, refer to section 5.1.4 (3) Branch Distance Specifier.
- When the operand does not satisfy the conditions, the assembler selects the 24-bit PC relative distance (\( .A \)).

(3) Conditional Branch (BCond) Instruction

(a) Specifiable Branch Distance Specifiers
- \( \text{BEQ.S} \) 3-bit PC relative (PC + pcdsp:3, \( 3 \leq \text{pcdsp:}3 \leq 10 \))
- \( \text{BNE.S} \) 3-bit PC relative (PC + pcdsp:3, \( 3 \leq \text{pcdsp:}3 \leq 10 \))
- \( \text{BCond.B} \) 8-bit PC relative (PC + pcdsp:8, \( -128 \leq \text{pcdsp:}8 \leq 127 \))
- \( \text{BEQ.W} \) 16-bit PC relative (PC + pcdsp:16, \( -32768 \leq \text{pcdsp:}16 \leq 32767 \))
- \( \text{BNE.W} \) 16-bit PC relative (PC + pcdsp:16, \( -32768 \leq \text{pcdsp:}16 \leq 32767 \))

(b) Optimum Selection
- When the operand of a conditional branch instruction satisfies the conditions for optimum branch selection, the assembler generates the optimum code for the conditional branch instruction by replacing it with a combination of a conditional branch instruction with an inverted logic (condition) and an unconditional relative branch instruction with an optimum branch distance.
- When the operand does not satisfy the conditions, the assembler selects the 8-bit PC relative distance (\( .B \)) or 16-bit PC relative distance (\( .W \)).
### Conditional Branch Instructions to Be Replaced and Corresponding Instruction Replacements

#### Table 5.28 Replacement Rules of Conditional Branch Instructions

<table>
<thead>
<tr>
<th>Conditional Branch Instruction</th>
<th>Instruction Replacement</th>
<th>Conditional Branch Instruction</th>
<th>Instruction Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNC/BLTU dest</td>
<td>BC ..xx</td>
<td>BC/BGEU dest</td>
<td>BNC ..xx</td>
</tr>
<tr>
<td></td>
<td>BRA.A dest</td>
<td></td>
<td>BRA.A dest</td>
</tr>
<tr>
<td></td>
<td>..xx:</td>
<td></td>
<td>..xx:</td>
</tr>
<tr>
<td>BLEU dest</td>
<td>BGTU ..xx</td>
<td>BGTU dest</td>
<td>BLEU ..xx</td>
</tr>
<tr>
<td></td>
<td>BRA.A dest</td>
<td></td>
<td>BRA.A dest</td>
</tr>
<tr>
<td></td>
<td>..xx:</td>
<td></td>
<td>..xx:</td>
</tr>
<tr>
<td>BNZ/BNE dest</td>
<td>BZ ..xx</td>
<td>BZ/BEQ dest</td>
<td>BNZ ..xx</td>
</tr>
<tr>
<td></td>
<td>BRA.A dest</td>
<td></td>
<td>BRA.A dest</td>
</tr>
<tr>
<td></td>
<td>..xx:</td>
<td></td>
<td>..xx:</td>
</tr>
<tr>
<td>BPZ dest</td>
<td>BN ..xx</td>
<td>BO dest</td>
<td>BNO ..xx</td>
</tr>
<tr>
<td></td>
<td>BRA.A dest</td>
<td></td>
<td>BRA.A dest</td>
</tr>
<tr>
<td></td>
<td>..xx:</td>
<td></td>
<td>..xx:</td>
</tr>
<tr>
<td>BGT dest</td>
<td>BLE ..xx</td>
<td>BLE dest</td>
<td>BGT ..xx</td>
</tr>
<tr>
<td></td>
<td>BRA.A dest</td>
<td></td>
<td>BRA.A dest</td>
</tr>
<tr>
<td></td>
<td>..xx:</td>
<td></td>
<td>..xx:</td>
</tr>
<tr>
<td>BGE dest</td>
<td>BLT ..xx</td>
<td>BLT dest</td>
<td>BGE ..xx</td>
</tr>
<tr>
<td></td>
<td>BRA.A dest</td>
<td></td>
<td>BRA.A dest</td>
</tr>
<tr>
<td></td>
<td>..xx:</td>
<td></td>
<td>..xx:</td>
</tr>
</tbody>
</table>

**Note**

In this table, the branch distance in unconditional relative branch instructions is a 24–bit PC relative value. The "..xx" label and the unconditional relative branch instruction are processed within the assembler; only the resultant code is output to the source list file.

#### 5.1.10 Substitute Register Names (for the PID Function)

The substitute register names listed below can be used instead of the names of general-purpose registers.

#### Table 5.29 Substitute Register Names

<table>
<thead>
<tr>
<th>Substitute Register Name</th>
<th>Corresponding General-Purpose Register Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>__PID_R0</td>
<td>R0</td>
</tr>
<tr>
<td>__PID_R1</td>
<td>R1</td>
</tr>
<tr>
<td>__PID_R2</td>
<td>R2</td>
</tr>
<tr>
<td>__PID_R3</td>
<td>R3</td>
</tr>
<tr>
<td>__PID_R4</td>
<td>R4</td>
</tr>
<tr>
<td>__PID_R5</td>
<td>R5</td>
</tr>
<tr>
<td>__PID_R6</td>
<td>R6</td>
</tr>
<tr>
<td>__PID_R7</td>
<td>R7</td>
</tr>
<tr>
<td>__PID_R8</td>
<td>R8</td>
</tr>
<tr>
<td>__PID_R9</td>
<td>R9</td>
</tr>
<tr>
<td>__PID_R10</td>
<td>R10</td>
</tr>
<tr>
<td>__PID_R11</td>
<td>R11</td>
</tr>
</tbody>
</table>
Note *1) This indicates the name of the register selected as the PID register when the -pid or -nouse_pid_register option is specified. For details on the rules for selecting the PID register, refer to the descriptions of the -pid and -nouse_pid_register assembler options.

In assembly-language code that constitutes a master program in which the PID function is enabled, the names of all registers that may be selected as the PID register must be represented by the corresponding substitute register names (rather than the actual names of general-purpose registers such as R13).

When a substitute register name is selected as the PID register, assembling the program with nouse_pid_register enabled will not lead to an error.

[Remark]
Substitute register names are usable even when neither -nouse_pid_register nor the -pid option has been selected.

5.2 Directives

This chapter explains the directives.
Directives are instructions that direct all types of instructions necessary for the assembler.

5.2.1 Outline

Instructions are translated into object codes (machine language) as a result of assembling, but directives are not converted into object codes in principle.

Directives contain the following functions mainly:
- To facilitate description of source programs
- To initialize memory and reserve memory areas
- To provide the information required for assemblers and linkers to perform their intended processing

The following table shows the types of directives.

<table>
<thead>
<tr>
<th>Type</th>
<th>Directives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link directives</td>
<td>.SECTION, .GLB, .RVECTOR</td>
</tr>
<tr>
<td>Assembler directives</td>
<td>.EQU, .END, .INCLUDE</td>
</tr>
<tr>
<td>Address directives</td>
<td>.ORG, .OFFSET, .ENDIAN, .BLKB, .BLKW, .BLKL, .BLKD, .BYTE, .WORD, .LWORD, .FLOAT, .DOUBLE, .ALIGN</td>
</tr>
<tr>
<td>Macro directives</td>
<td>.MACRO, .EXITM, .LOCAL, .ENDM, .MREPEAT, .ENDR, .MACPARA, .MACREP, .LEN, .INSTR, .SUBSTR</td>
</tr>
<tr>
<td>Specific compiler directives</td>
<td>.LINE_TOP, .LINE_END, .SWSECTION, .SWMOV, .SWITCH, .INSTALIGN</td>
</tr>
</tbody>
</table>

The following sections explain the details of each directive.
5.2.2 Link Directives

These directives are used for relocatable assembly that enables a program to be written in multiple separate files.

This directive declares or restarts a section.

**Format**

```
.SECTION
```

[Description]

- **Declaration**
  - This directive defines the beginning of a section with a section name and a section attribute specified.

- **Restart**
  - This directive specifies restart of a section that has already been declared in the source program. Specify an existing section name to restart it. The section attribute and alignment value declared before are used without change.

- The alignment value in the section can be changed through the `ALIGN` specification.

- The `ALIGN` directive can be used in relative-addressing sections defined by the `.SECTION` directive including the `ALIGN` specification or in absolute-addressing sections.

- When `ALIGN` is not specified, the boundary alignment value in the section is 1.

**Examples**

```
.SECTION program, CODE
NOP
.SECTION ram, DATA
.BLKB10
.SECTION tbl1, ROMDATA
.BYTE "abcd"
.SECTION tbl2, ROMDATA, ALIGN=8
.LWORD 11111111H, 22222222H
.END
```

**Remarks**

- Be sure to specify a section name.
- To use assembler directives that allocate memory areas or store data in memory areas, be sure to define a section through this directive.
- To write mnemonics, be sure to define a section through this directive.
- A section attribute and `ALIGN` should be specified after a section name.
- A section attribute and `ALIGN` should be specified with them separated by a comma.
- A section attribute and `ALIGN` can be specified in any order.
- Select `CODE, ROMDATA, or DATA` for the section attribute.
- The section attribute can be omitted. In this case, the assembler assumes `CODE` as the section attribute.
- When `-endian=big` is specified, only a multiple of 4 can be specified for the start address of an absolute-addressing `CODE` section.

  - If an absolute-addressing `CODE` section is declared when `-endian=big` is specified, a warning message will be output.
  - In this case, the assembler appends `NOP (0x03)` at the end of the section to adjust the section size to a multiple of 4.
  - Defining a symbol name which is the same as that of an existing section is not possible. If a section and symbol with the same name are defined, the section name will be effective, but the symbol name will lead to an A2118 error.
  - The section name `$lo$` is reserved and cannot be defined. If this is attempted, an A2049 error will be reported.

This directive declares that the specified labels and symbols are global.

**Format**

```
.GLB
```

### GLB

\[
\text{GLB} <\text{name}> \\
\text{GLB} <\text{name}> [, <\text{name}> ?]
\]

**Description**
This directive declares that the specified labels and symbols are global. When any label or symbol specified through this directive is not defined within the current file, the assembler processes it assuming that it is defined in an external file. When a label or symbol specified through this directive is defined within the current file, the assembler processes it so that it can be externally referenced.

**Examples**

```
.GLBO name1,name2,name3
.GLBO name4
.SECTION program
MOV.L #name1,R1
```

**Remarks**
Be sure to insert a space character or a tab between this directive and the operand. Specify a label name to be a global label as the operand. Specify a symbol name to be a global symbol as the operand. To specify multiple symbol names as operands, separate them by commas (,).

### .RVECTOR

This directive registers the specified label or name as a variable vector.

**Format**

```
.RVECTOR <number>,<name>
```

**Description**
This directive registers the specified label or name as a variable vector. A constant from 0 to 255 can be entered in <number> of this directive as the vector number. A label or symbol defined within the current file can be specified as <name> of this directive. The registered variable vectors are gathered into a single $C$VECT section by the optimizing linkage editor.

[V3.00.00 or later] When the -split_vect option is specified in the optimizing linkage editor, the $C$VECT section is split by vector table number and each section has the name of "$C$VECT<vector table number>".

**Examples**

```
.RVECTOR 50,_rvfunc
._rvfunc:
MOV.L #0,R1
RTE
```

**Remark**
Be sure to insert a space character or a tab between this directive and the operand.

#### 5.2.3 Assembler Directives

These directives do not generate data corresponding to themselves but controls generation of machine code for instructions. They do not modify addresses.

### .EQU

This directive defines a symbol for a 32-bit signed integer value (–2147483648 to 2147483647).

**Format**

```
<name>.EQU <numeric value>
```

**Description**
This directive defines a symbol for a 32-bit signed integer value (–2147483648 to 2147483647).
The symbolic debugging function can be used after symbol definition through this directive.
[Examples]

symbol  .EQU 1
symbol1 .EQU symbol+symbol
symbol2 .EQU 2

[Remarks]
The value assigned for a symbol should be determined at assembly.
Be sure to insert a space character or a tab between this directive and the operand.
A symbol can be specified as the operand of symbol definition. Note that forward-reference symbol names must not be
specified.
An expression can be specified in the operand.
Symbols can be declared as global.
When this directive and the .DEFINE directive declare the same symbol name, the directive to make the declaration first
is given priority.

.END

This directive declares the end of an assembly-language file.
[Format]

.END

[Description]
This directive declares the end of an assembly-language file.
The source file contents after the line where this directive is written are only output to the source list file; the code corre-
sponding to them is not generated.
[Examples]

.END

[Remarks]
One .END directive should be written in each assembly-language file.

.INCLUDE

This directive inserts the contents of the specified include file to the line where this directive is written in the assem-
bl y-language file.
[Format]

.INCLUDE <include file name>

[Description]
This directive inserts the contents of the specified include file to the line where this directive is written in the assem-
bl y-language file.
The include file contents are processed together with the contents of the assembly-language file as a single assem-
bl y-language file.
File inclusion can be nested up to 30 levels.
When an absolute path is specified as an include file name, the include file is searched for in the specified directory.
If a file is not found, an error will be output.
When the specified include file name is not an absolute path, the file is searched for in the following order.
(1) When no directory information is included in the assembly-language file name specified in the command line at
assembler startup, the include file is searched for with the name specified in the .INCLUDE directive. When directory infor-
mation is included in the assembly-language file name, the include file is searched for with the specified directory name
added to the file name specified in the .INCLUDE directive.
(2) The directory specified through the -include assembler option is searched.
(3) The directory specified in the INC_RXA environment variable is searched.
[Examples]

.INCLUDE initial.src
.INCLUDE ../FILE@.inc
[Remarks]
Be sure to insert a space character or a tab between this directive and the operand.
Be sure to add a file extension to the include file name in the operand.
The `.FILE` directive and a string including @ can be specified as the operand.
A space character can be included in a file name, except for at the beginning of a file name.
Do not enclose a file name within double-quotes (".
The assembly-language file containing this directive cannot be specified as the include file.

5.2.4 Address Directives

These directives control address specifications in the assembler.
The assembler handles relocatable address values except for the addresses in absolute-addressing sections.

```
.ORG
```

This directive applies the absolute addressing mode to the section containing this directive.

[Format]
```
.ORG \<numeric value>
```

[Description]
This directive applies the absolute addressing mode to the section containing this directive.
All addresses in the section containing this directive are handled as absolute values.
This directive determines the address for storing the mnemonic code written in the line immediately after this directive.
It also determines the address of the memory area to be allocated by the area allocation directive written in the line immediately after this directive.

[Examples]
```
.SECTION value,ROMDATA
.ORG 0FF00H
.BYTE "abcdefghijklmnopqrstuvwxyz"
.ORG 0FF80H
.BYTE "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
.END
```
```
.SECTION value,ROMDATA
.BYTE "abcdefghijklmnopqrstuvwxyz"
.ORG 0FF00H
.BYTE "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
.END
```

The following example will generate an error because `.ORG` is not written immediately after `.SECTION`.
```
.SECTION value,ROMDATA
.BYTE "abcdefghijklmnopqrstuvwxyz"
.ORG 0FF80H
.BYTE "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
.END
```

[Remarks]
When using this directive, be sure to place it immediately after a `.SECTION` directive.
When `.ORG` is not written immediately after `.SECTION`, the section is handled as a relative-addressing section.
Be sure to insert a space character or a tab between this directive and the operand.
The operand should be a value from 0 to 0FFFFFFFH.
An expression or a symbol can be specified as the operand. Note that the value of the expression or symbol should be determined at assembly.
This directive must not be used in a relative-addressing section.
This directive can be used multiple times in an absolute-addressing section. Note that if the value specified as the operand is smaller than the address of the line where this directive is written, an error will be output.
This directive embeds 0 or more bytes that indicate disabling (03H) for the number of addresses preceding the location specified by the offset.

```
.OFFSET
```

This directive specifies an offset from the beginning of the section.

[Format]
OFFSET Δ<numeric value>

[Description]
This directive specifies an offset from the beginning of the section.
This directive determines the offset from the beginning of the section to the area that stores the mnemonic code written in the line immediately after this directive.
It also determines the offset from the beginning of the section to the memory area to be allocated by the area allocation directive written in the line immediately after this directive.

[Examples]
The following example will generate an error because the value specified in the second .OFFSET line is smaller than the offset to that line.

```
.SECTION value,ROMDATA
.BYTE "abcdefghijklmnopqrstuvwxyz"
.OFFSET 80H
.BYTE "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
.END

.SECTION value,ROMDATA
.OFFSET 80H
.BYTE "abcdefghijklmnopqrstuvwxyz"
.OFFSET 70H
.BYTE "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
.END
```

[Remarks]
Be sure to insert a space character or a tab between this directive and the operand.
The operand should be a value from 0 to 0FFFFFFFFH.
An expression or a symbol can be specified as the operand. Note that the value of the expression or symbol should be determined at assembly.
This directive must not be used in an absolute-addressing section.
This directive can be used multiple times in a relative-addressing section. Note that if the value specified as the operand is smaller than the offset to the line where this directive is written, an error will be output.
This directive embeds 0 or more bytes that indicate disabling (03H) for the number of addresses preceding the location specified by the offset.

.ENDIAN

This directive specifies the endian for the section containing this directive.

[Format]
.ENDIAN ΔBIG
.ENDIAN ΔLITTLE

[Description]
This directive specifies the endian for the section containing this directive.
When .ENDIAN BIG is written in a section, the byte order in the section is set to big endian.
When .ENDIAN LITTLE is written in a section, the byte order in the section is set to little endian.
When the directive is not written in a section, the byte order in the section depends on the -endian option setting.

[Examples]
```
.SECTION value,ROMDATA
.ORG 0FF00H
.ENDIAN BIG
.BYTE "abcdefghijklmnopqrstuvwxyz"
```

The following example will generate an error because .ENDIAN is not written immediately after .SECTION or .ORG.
This directive allocates a RAM area with the size specified in 1-byte units.

**Description**
This directive allocates a RAM area with the size specified in 1-byte units. A label name can be defined for the address of the allocated RAM area.

**Examples**
```
symbol.EQU 1
.SECTION area,DATA
work1:.BLKB 1
work2:.BLKB symbol
.BLKB symbol+1
```

**Remarks**
Be sure to write this directive in DATA sections. In section definition, write ",DATA" after a section name to specify a DATA section. Be sure to insert a space character or a tab between this directive and the operand. A numeric value, a symbol, or an expression can be specified as the operand. The operand value should be determined at assembly. Write a label name before this directive to define the label name for the allocated area. Be sure to append a colon (:) to the label name. The maximum value that can be specified for the operand is 7FFFFFFFH.

This directive allocates 2-byte RAM areas for the specified number.

**Description**
This directive allocates 2-byte RAM areas for the specified number. A label name can be defined for the address of the allocated RAM area.

**Examples**
```
symbol.EQU 1
.SECTION area,DATA
work1:.BLKW 1
work2:.BLKW symbol
.BLKW symbol+1
```

**Remarks**
Be sure to write this directive immediately after a .SECTION or .ORG directive. Be sure to insert a space character or a tab between this directive and the operand. This directive must not be used in CODE sections.
Be sure to write this directive in DATA sections. In section definition, write ",DATA" after a section name to specify a DATA section.

Be sure to insert a space character or a tab between this directive and the operand. A numeric value, a symbol, or an expression can be specified as the operand. The operand value should be determined at assembly. Write a label name before this directive to define the label name for the allocated area. Be sure to append a colon (:) to the label name. The maximum value that can be specified for the operand is 3FFFFFFFH.

```
.BLKL
```

This directive allocates 4-byte RAM areas for the specified number.

**[Format]**

\[.BLKL\langle operand\rangle\]
\[\langle label name:\rangle .BLKL\langle operand\rangle\]

**[Description]**

This directive allocates 4-byte RAM areas for the specified number.
A label name can be defined for the address of the allocated RAM area.

**[Examples]**

symbol.EQU 1
.SECTION area,DATA
work1:.BLKL 1
work2:.BLKL symbol
.BLKL symbol+1

**[Remarks]**

Be sure to write this directive in DATA sections. In section definition, write ",DATA" after a section name to specify a DATA section.

Be sure to insert a space character or a tab between this directive and the operand. A numeric value, a symbol, or an expression can be specified as the operand. The operand value should be determined at assembly. Write a label name before this directive to define the label name for the allocated area. Be sure to append a colon (:) to the label name. The maximum value that can be specified for the operand is 1FFFFFFFH.

```
.BLKD
```

This directive allocates 8-byte RAM areas for the specified number.

**[Format]**

\[.BLKD\langle operand\rangle\]
\[\langle label name:\rangle .BLKD\langle operand\rangle\]

**[Description]**

This directive allocates 8-byte RAM areas for the specified number.
A label name can be defined for the address of the allocated RAM area.

**[Examples]**

symbol.EQU 1
.SECTION area,DATA
work1:.BLKD 1
work2:.BLKD symbol
.BLKD symbol+1

**[Remarks]**

Be sure to write this directive in DATA sections. In section definition, write ",DATA" after a section name to specify a DATA section.

Be sure to insert a space character or a tab between this directive and the operand. A numeric value, a symbol, or an expression can be specified as the operand.
The operand value should be determined at assembly. Write a label name before this directive to define the label name for the allocated area. Be sure to append a colon (:) to the label name. The maximum value that can be specified for the operand is 0xFFFFFFFF.

```plaintext
.BYTE
```

This directive stores 1-byte fixed data in ROM.

### Format

```plaintext
\.BYTE\.\<operand>
\.\<label name:\>\.BYTE\.\<operand>
```

### Description
This directive stores 1-byte fixed data in ROM. A label name can be defined for the address of the area for storing the data.

### Examples

**<When endian=little is specified>**

```
.SECTON value,ROMDATA
.BYTE 1
.BYTE "data"
.BYTE symbol
.BYTE symbol+1
.BYTE 1,2,3,4,5
.END
```

**<When endian=big is specified>**

```
.SECTON program,CODE,ALIGN=4
MOV.L R1,R2
.ALIGN 4
.BYTE 080H,00H,00H,00H
.END
```

### Remarks
Be sure to use this directive in a ROMDATA section. To specify attribute ROMDATA for a section, add ,ROMDATA after the section name when defining the section. Be sure to insert a space character or a tab between this directive and the operand. A numeric value, a symbol, or an expression can be specified as the operand. To specify a character or a string for the operand, enclose it within single-quotes (') or double-quotes ("). In this case, the ASCII code for the specified characters is stored. Write a label name before this directive to define the label name for the area storing the data. Be sure to append a colon (:) to the label name. When the endian=big option is specified, this directive can be used only in the sections that satisfy the following conditions. An error will be output if this directive is used in a section that does not satisfy the conditions.

1. ROMDATA section
   ```plaintext
   .SECTION data,ROMDATA
   ```

2. Relative-addressing CODE section for which the address alignment value is set to 4 or 8 in section definition
   ```plaintext
   .SECTION program,CODE,ALIGN=4
   ```

3. Absolute-addressing CODE section
   ```plaintext
   .SECTION program,CODE
   .OEG 0ffffff0H
   ```

To use a .BYTE directive in a CODE section while the endian=big option is specified, be sure to write an address correction directive (.ALIGN 4) in the line immediately before the .BYTE directive so that the data is aligned to a 4-byte
boundary. If this address correction directive is not written, the assembler outputs a warning message and automatically aligns the data to a 4-byte boundary.

When the \texttt{endian=big} option is specified, the data area size in a \texttt{CODE} section must be specified to become a multiple of 4. If the data area size in a \texttt{CODE} section is not a multiple of 4, the assembler outputs a warning message and writes \texttt{NOP} (0x03) to make the data area size become a multiple of 4.

### \texttt{.WORD}

This directive stores 2-byte fixed data in ROM.

**[Format]**

\begin{verbatim}
  .WORD\langle operand\rangle
  \langle label name:\rangle .WORD\langle operand\rangle
\end{verbatim}

**[Description]**

This directive stores 2-byte fixed data in ROM.

A label name can be defined for the address of the area for storing the data.

**[Examples]**

\begin{verbatim}
  .SECTION value,ROMDATA
  .WORD1
  .WORDsymbol
  .WORDsymbol+1
  .WORD1,2,3,4,5
  .END
\end{verbatim}

**[Remarks]**

Be sure to use this directive in a \texttt{ROMDATA} section. To specify attribute \texttt{ROMDATA} for a section, add \texttt{,ROMDATA} after the section name when defining the section.

Be sure to insert a space character or a tab between this directive and the operand.

A numeric value, a symbol, or an expression can be specified as the operand.

Neither a character nor a string can be specified for an operand.

Write a label name before this directive to define the label name for the area storing the data.

Be sure to append a colon (:) to the label name.

### \texttt{.LWORD}

This directive stores 4-byte fixed data in ROM.

**[Format]**

\begin{verbatim}
  .LWORD\langle operand\rangle
  \langle label name:\rangle .LWORD\langle operand\rangle
\end{verbatim}

**[Description]**

This directive stores 4-byte fixed data in ROM.

A label name can be defined for the address of the area for storing the data.

**[Examples]**

\begin{verbatim}
  .SECTION value,ROMDATA
  .LWORD1
  .LWORDsymbol
  .LWORDsymbol+1
  .LWORD1,2,3,4,5
  .END
\end{verbatim}

**[Remarks]**

Be sure to use this directive in a \texttt{ROMDATA} section. To specify attribute \texttt{ROMDATA} for a section, add \texttt{,ROMDATA} after the section name when defining the section.

Be sure to insert a space character or a tab between this directive and the operand.

A numeric value, a symbol, or an expression can be specified as the operand.

Neither a character nor a string can be specified for an operand.

Write a label name before this directive to define the label name for the area storing the data.

Be sure to append a colon (:) to the label name.
This directive stores 4-byte fixed data in ROM.

**[Format]**

```
.FLOAT

<numeric value>
```

- `<label name>:>`
- `<numeric value>`

**[Description]**

This directive stores 4-byte fixed data in ROM. A label name can be defined for the address of the area for storing the data.

**[Examples]**

```
.FLOAT 5E2
constant: .FLOAT 5e2
```

**[Remarks]**

Be sure to use this directive in a `ROMDATA` section. To specify attribute `ROMDATA` for a section, add `,ROMDATA` after the section name when defining the section. Specify a floating-point number as the operand. Be sure to insert a space character or a tab between this directive and the operand. Write a label name before this directive to define the label name for the area storing the data. Be sure to append a colon (:) to the label name.

This directive stores 8-byte fixed data in ROM.

**[Format]**

```
.DOUBLE

<numeric value>
```

- `<label name>:>`
- `<numeric value>`

**[Description]**

This directive stores 8-byte fixed data in ROM. A label name can be defined for the address of the area for storing the data.

**[Examples]**

```
.DOUBLE 5E2
constant: .DOUBLE 5e2
```

**[Remarks]**

Be sure to use this directive in a `ROMDATA` section. To specify attribute `ROMDATA` for a section, add `,ROMDATA` after the section name when defining the section. Specify a floating-point number as the operand. Be sure to insert a space character or a tab between this directive and the operand. Write a label name before this directive to define the label name for the area storing the data. Be sure to append a colon (:) to the label name.

This directive corrects the address for storing the code written in the line immediately after this directive to a multiple of two, four, or eight bytes.

**[Format]**

```
.ALIGN

<alignment value>
```

- `<alignment value>`: [2|4|8]

**[Description]**

This directive corrects the address for storing the code written in the line immediately after this directive to a multiple of two, four, or eight bytes.
In a **CODE** or **ROMDATA** section, **NOP** code (03H) is written to the empty space generated as a result of address correction. In a **DATA** section, only address correction is performed.

[Examples]

```
.SEC\tion program,\CODE,ALIGN=4
MOV.L R1, R2
.ALIGN 4; Corrects the address to a multiple of 4
RTS
.END
```

[Remarks]

This directive can be used in the sections that satisfy the following conditions.

1. Relative-addressing section for which address correction is specified in section definition
   
   ```
   .SEC\tion program,\CODE,ALIGN=4
   ```

2. Absolute-addressing section
   
   ```
   .SEC\tion program,\CODE
   .ORG 0fff0000H
   ```

A warning message will be output if this directive is used for a relative-addressing section in which **ALIGN** is not specified in the **.SEC\ION** directive line.

A warning message will be output if the specified value is larger than the boundary alignment value specified for the section.

### 5.2.5 Macro Directives

These directives do not generate data corresponding to themselves but controls generation of machine code for instructions. They do not modify addresses. These directives define macro functions and repeat macro functions.

<table>
<thead>
<tr>
<th>Directive</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>.MACRO</code></td>
<td>Defines a macro name and the beginning of a macro body.</td>
</tr>
<tr>
<td><code>.EXITM</code></td>
<td>Terminates macro body expansion.</td>
</tr>
<tr>
<td><code>.LOCAL</code></td>
<td>Declares a local label in a macro.</td>
</tr>
<tr>
<td><code>.ENDM</code></td>
<td>Specifies the end of a macro body.</td>
</tr>
<tr>
<td><code>.MREPEAT</code></td>
<td>Specifies the beginning of a repeat macro body.</td>
</tr>
<tr>
<td><code>.ENDR</code></td>
<td>Specifies the end of a repeat macro body.</td>
</tr>
<tr>
<td><code>..MACPARA</code></td>
<td>Indicates the number of arguments in a macro call.</td>
</tr>
<tr>
<td><code>..MACREP</code></td>
<td>Indicates the count of repeat macro body expansions.</td>
</tr>
<tr>
<td><code>.LEN</code></td>
<td>Indicates the number of characters in a specified string.</td>
</tr>
<tr>
<td><code>.INSTR</code></td>
<td>Indicates the start position of a specified string in another specified string.</td>
</tr>
<tr>
<td><code>.SUBSTR</code></td>
<td>Extracts a specified number of characters from a specified position in a specified string.</td>
</tr>
</tbody>
</table>

| `.MACRO` |

This directive defines a macro name.

[Format]
5. ASSEMBLY LANGUAGE SPECIFICATIONS

[macro definition]
\[<macro name>\].MACRO\[<parameter>[,...]]
.body
.ENDM

[macro call]
\[<macro name>\[<argument>[,...]]

[Description]
This directive defines a macro name.
It also specifies the beginning of a macro definition.

[Examples: Example 1]
[Macro definition example]

    name.MACRO string
    .BYTE 'string'
    .ENDM

[Macro call example 1]

    name"name,address"
    .BYTE 'name,address'

[Macro call example 2]

    name(name,address)
    .BYTE '(name,address)'

[Example 2]

    mac .MACROp1,p2,p3
    .IF  ..MACPARA == 3
    .IF  'p1' == 'byte'
    MOV.B #p2,[p3]
    .ELSE
    MOV.W #p2,[p3]
    .ENDIF
    .ELIF ..MACPARA == 2
    .IF  'p1' == 'byte'
    MOV.B #p2,[R3]
    .ELSE
    MOV.W #p2,[R3]
    .ENDIF
    .ELSE
    MOV.W R3,R1
    .ENDIF
    .ENDM

    macword,10,R3; Macro call
    .IF  3 == 3; Macro-expanded code
    .ELSE
    MOV.W #10,[R3]
    .ENDIF

[Remarks]
Be sure to specify a macro name.
For the macro name and parameter name format, refer to the Rules for Names in section 4.1.2, Names.
Use a unique name for defining each parameter, including the nested macro definitions.
To define multiple parameters, separate them by commas (,).
Make sure that all parameters specified as operands of a .MACRO directive are used in the macro body.
Be sure to insert a space character or a tab between a macro name and an argument.
Write a macro call so that the arguments correspond to the parameters on a one-to-one basis.

To use a special character in an argument, enclose it within double-quotes.

A label, a global label, and a symbol can be used in an argument.

An expression can be used in an argument.

Parameters are replaced with arguments from left to right in the order they appear.

If no argument is specified in a macro call while the corresponding parameter is defined, the assembler does not generate code for this parameter.

If there are more parameters than the arguments, the assembler does not generate code for the parameters that do not have the corresponding arguments.

When a parameter in the body is enclosed within single-quotes ('), the assembler encloses the corresponding argument within single-quotes when outputting it.

When an argument contains a comma (,) and the argument is enclosed within parentheses (( )), the assembler converts the argument including the parentheses.

If there are more arguments than the parameters, the assembler does not process the arguments that do not have the corresponding parameters.

The string enclosed within double-quotes is processed as a string itself. Do not enclose parameters within double-quotes.

Up to 80 parameters can be specified within the maximum allowable number of characters for one line.

If the number of arguments differs from that of the parameters, the assembler outputs a warning message.

```asm
.EXITM
```

This directive terminates expansion of a macro body and passes control to the nearest `.ENDM`.

[Format]

```
<macro name> .MACRO
  .body
  .EXITM
  .body
  .ENDM
```

[Description]

This directive terminates expansion of a macro body and passes control to the nearest `.ENDM`.

[Examples]

```asm
data1 .MACROvalue
  .IF value == 0
    .EXITM
  .ELSE
  .BLKBvalue
  .ENDIF
  .ENDM
```

data1 0 ; Macro call

```asm
  .IF 0 == 0; Macro-expanded code
  .EXITM
  .ENDIF
```

[Remarks]

Write this directive in the body of a macro definition.

```asm
.LOCAL
```

This directive declares that the label specified as an operand is a macro local label.

[Format]

```
.LOCAL <label name> [...]
```

[Description]

This directive declares that the label specified as an operand is a macro local label.
Macro local labels can be specified multiple times with the same name as long as they are specified in different macro definitions or outside macro definitions.

[Examples]

```
name.MACRO
 .LOCAL m1; 'm1' is macro local label
 m1:     
nop
 bra m1
 .ENDM
```

[Remarks]
Write this directive in a macro body.
Be sure to insert a space character or a tab between this directive and the operand.
Make sure that a macro local label is declared through this directive before the label name is defined.
For the macro local name format, refer to the Rules for Names in section 10.1.2, Names.
Multiple labels can be specified as operands of this directive by separating them by commas. Up to 100 labels can be specified in this manner.
When macro definitions are nested, a macro local label in a macro that is defined within another macro definition (outer macro) cannot use the same name as that used in the outer macro.
Up to 65,535 macro local labels can be written in one assembly source file including those used in the include files.

```
.ENDM
```

This directive specifies the end of a macro definition.

[Format]

```
<macro name> .MACRO
 \body
 .ENDM
```

[Description]
This directive specifies the end of a macro definition.

[Examples]

```
lda .MACRO
 MOV.L #value,R3
 .ENDM
lda 0     ; Expanded to MOV.L #0,R3.
```

```
.MREPEAT
```

This directive specifies the beginning of a repeat macro.

[Format]

```
[<label>:] .MREPEAT <numeric value>
 \body
 .ENDR
```

[Description]
This directive specifies the beginning of a repeat macro.
The assembler repeatedly expands the body the specified number of times.
The repetition count can be specified within the range of 1 to 65,535.
 Repeat macros can be nested up to 65,535 levels.
The macro body is expanded at the line where this directive is written.

[Examples]
This directive specifies the end of a repeat macro.

**Format**

```
[<label>:]<MREPEAT><numeric value>
AMERA
.ENDR
```

**Description**
This directive specifies the end of a repeat macro.

**Remarks**
Make sure this directive corresponds to a `.MREPEAT` directive.

This directive indicates the number of arguments in a macro call.

**Format**

```
..MACPARA
```

**Description**
This directive indicates the number of arguments in a macro call.

This directive can be used in the body in a macro definition through `.MACRO`.

**Examples**
This example executes conditional assembly according to the number of macro arguments.

```assembly
rep .MACRO num
 .MREPEAT num
 .IF num > 49
 .EXITM
 .ENDIF
 nop
 .ENDR
 .ENDM

rep 3 ; Macro call

nop ; Macro-expanded code
nop
nop
```

Be sure to specify an operand.
Be sure to insert a space character or a tab between this directive and the operand.
A label can be specified at the beginning of this directive line.
A symbol can be specified as the operand.
Forward reference symbols must not be used.
An expression can be used in the operand.
Macro definitions and macro calls can be used in the body.
The `.EXITM` directive can be used in the body.
### .GLBmem

**name**.MACRO f1,f2
..MACRO ..MACREPEAT value,reg
  .MREPEAT value
  MOV.B#0,..MACREP[reg]
  .ENDR
  .ENDM

mac.MACRO value,reg
  .MREPEAT value
  MOV.B#0,..MACREP[reg]
  .ENDR
  .ENDM

mac3,R3; Macro call
  .MREPEAT3; Macro-expanded code
  MOV.B#0,1[R3]
  MOV.B#0,2[R3]
  MOV.B#0,3[R3]
  .ENDR
  .ENDM

### Remarks
This directive can be used as a term of an expression.
If this directive is written outside a macro body defined through .MACRO, its value becomes 0.

### .MACREP

This directive indicates the count of repeat macro expansions.

#### Format

```
..MACREP
```

#### Description
This directive indicates the count of repeat macro expansions.
This directive can be used in the body in a macro definition through .MREPEAT.
This directive can be specified in an operand of conditional assembly.

#### Examples

```
MACRO value,reg
  .MREPEAT value
  MOV.B#0,..MACREP[reg]
  .ENDR
  .ENDM

mac3,R3; Macro call
  .MREPEAT3; Macro-expanded code
  MOV.B#0,1[R3]
  MOV.B#0,2[R3]
  MOV.B#0,3[R3]
  .ENDR
  .ENDM
```

### Remarks
This directive can be used as a term of an expression.
If this directive is written outside a macro body defined through .MACRO, its value becomes 0.

### .LEN

This directive indicates the length of the string specified as the operand.

#### Format

```
.LEN
```

#### Description
This directive indicates the length of the string specified as the operand.
[Examples]

bufset.MACRO f1
buffer:.BLKB .LEN{f1}
.ENDM

bufset Sample ; Macro call
buffer:.BLKB 6 ; Macro-expanded code

[Remarks]
Be sure to enclose the operand within {}.
A space character or a tab can be inserted between this directive and the operand.
Characters including spaces and tabs can be specified in a string.
Be sure to enclose a string within single-quotes or double-quotes.
This directive can be used as a term of an expression.
To count the length of the macro argument, enclose the parameter name within single-quotes. When the name is
enclosed within double-quotes, the length of the string specified as the parameter is counted.

.INSTR

This directive indicates the start position of a search string within a specified string.
[Format]

.INSTR["<string>","<search string>",<search start position> ]

[Description]
This directive indicates the start position of a search string within a specified string.
The position from which search is started can be specified.
[Examples]
This example detects the position (7) of string "se", counted from the beginning (top) of a specified string (japanese):

top .EQU 1
point_set.MACRO source,dest,top
point.EQU .INSTR["source","dest",top]
.ENDM
point_set japanese,se,1 ; Macro call

point .EQU 7 ; Macro-expanded code

[Remarks]
Be sure to enclose the operand within {}.
Be sure to specify all of a string, a search string, and a search start position.
Separate the string, search string, and search start position by commas.
Neither space character nor tab can be inserted before or after a comma.
A symbol can be specified as a search start position.
When 1 is specified as the search start position, it indicates the beginning of a string.
This directive can be used as a term of an expression.
This directive is replaced with 0 when the search string is longer than the string, the search string is not found in the
string, or the search start position value is larger than the length of the string.
To expand a macro by using a macro argument as the condition for detection, enclose the parameter name within single-quotes. When the name is
enclosed within double-quotes, the macro is expanded by using the enclosed string as the condition for detection.

.SUBSTR

This directive extracts a specified number of characters from a specified position in a specified string.
[Format]
[Description]
This directive extracts a specified number of characters from a specified position in a specified string.

[Examples]
The following example passes the length of the string given as an argument of a macro to the operand of .MREPEAT.
The ..MACREP value is incremented as 1 -> 2 -> 3 -> 4 every time the .BYTE line is expanded. Consequently, the characters in the string given as an argument of the macro is passed to the operand of .BYTE one by one starting from the beginning of the string.

name MACRO data
.MREPEAT LEN('data')
.BYTE SUBSTR('data',..MACREP,1)
.ENDR
.ENDM

name ABCD  ; Macro call

.BYTE "A"  ; Macro-expanded code
.BYTE "B"
.BYTE "C"
.BYTE "D"

[Remarks]
Be sure to enclose the operand within {}.
Be sure to specify all of a string, an extraction start position, and an extraction character length.
Separate the string, extraction start position, and extraction character length by commas.
Symbols can be specified as an extraction start position and an extraction character length. When 1 is specified as the extraction start position, it indicates the beginning of a string.
Characters including spaces and tabs can be specified in a string.
Be sure to enclose a string within single-quotes or double-quotes.
This directive is replaced with 0 when the extraction start position value is larger than the string, the extraction character length is larger than the length of the string, or the extraction character length is set to 0.
To expand a macro by using the macro argument as the condition for extraction, enclose the parameter name within single-quotes. When the name is enclosed within double-quotes, the macro is expanded by using the enclosed string as the condition for extraction.

5.2.6 Specific Compiler Directives

The following directives are output in some cases so that the assembler can appropriately process C language functions when the compiler generates assembly-language files.
When using the assembly-language files generated by the compiler, these directives should be used without changing the settings. These directives should not be used when creating user-created assembly-language files.

Table 5.31 Specific Compiler Directives

<table>
<thead>
<tr>
<th>Directive</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>_LINE_TOP</td>
<td>These directives are output when the functions specified by #pragma inline_asm have been expanded.</td>
</tr>
<tr>
<td>_LINE_END</td>
<td>These directives are output when the branch table is used in the switch statement.</td>
</tr>
<tr>
<td>SWSECTION</td>
<td>These directives are output when the branch table is used in the switch statement.</td>
</tr>
<tr>
<td>SWMOV</td>
<td>This directive is output when the #pragma instalign4 option, the instalign8 option, #pragma instalign4, or #pragma instalign8 is used.</td>
</tr>
<tr>
<td>SWITCH</td>
<td>This directive is output when the instalign4 option, the instalign8 option, #pragma instalign4, or #pragma instalign8 is used.</td>
</tr>
</tbody>
</table>
5.3 Control Instructions

This chapter describes control instructions. Control Instructions provide detailed instructions for assembler operation.

5.3.1 Outline

Control instructions provide detailed instructions for assembler operation and so are written in the source. Control instructions do not become the target of object code generation. The following table shows the types of control instructions.

<table>
<thead>
<tr>
<th>Type</th>
<th>Control Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembler list directive</td>
<td>.LIST</td>
</tr>
<tr>
<td>Conditional assembly directives</td>
<td>.IF, .ELIF, .ELSE, .ENDIF</td>
</tr>
<tr>
<td>Extended function directives</td>
<td>.ASSERT, ?, @, ..FILE, .STACK, .LINE, .DEFINE</td>
</tr>
</tbody>
</table>

The following sections explain the details of each control instruction.

5.3.2 Assembler List Directive

This directive controls the output information and format of the assembler list file. It does not affect code generation.

```
.LIST
```

This directive can stop (OFF) outputting lines to the assembler list file.

[Format]

```
.LIST.[ON|OFF]
```

[Description]
This directive can stop (OFF) outputting lines to the assembler list file. Even in the range where line output is stopped, error lines are output to the assembler list file. This directive can start (ON) outputting lines to the assembler list file. When this directive is not specified, all lines are output to the assembler list file.

[Examples]

```
.LIST ON
.LIST OFF
```

[Remarks]
Be sure to insert a space character or a tab between this directive and the operand. Specify OFF as the operand to stop outputting lines. Specify ON as the operand to start outputting lines.

5.3.3 Conditional Assembly Directives

These directives specify whether to assemble a specified range of lines.

<table>
<thead>
<tr>
<th>Directive</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>.IF</td>
<td>Specifies the beginning of a conditional assembly block and evaluates the condition.</td>
</tr>
<tr>
<td>.ELIF</td>
<td>Evaluates the second or later conditions when multiple conditional blocks are written.</td>
</tr>
<tr>
<td>.ELSE</td>
<td>Specifies the beginning of a block to be assembled when all conditions are false.</td>
</tr>
<tr>
<td>.ENDIF</td>
<td>Specifies the end of a conditional assembly block.</td>
</tr>
</tbody>
</table>
The assembler controls assembly of the blocks according to the conditions specified through `.IF` and `.ELIF`. The assembler evaluates the condition specified in the operand of `.IF` or `.ELIF`, and assembles the body in the subsequent lines when the condition is true. In this case, the lines before the `.ELIF`, `.ELSE`, or `.ENDIF` directive are assembled.

Any directives that can be used in an assembly-language file can be written in a conditional assembly block. Conditional assembly is done according to the result of conditional expression evaluation.

**Examples**

<Example of conditional expressions>

```assembly
sym < 1
sym+2 < data1
sym+2 < data1+2
'smp1' == name
```

<Example of conditional assembly specification>

```assembly
.IF  TYPE==0
 .byte "Proto Type Mode"
 .ELSE
 .byte "Mass Production Mode"
 .ENDIF
```

**Remarks**

Be sure to write a conditional expression in an `.IF` or `.ELIF` directive.

Be sure to insert a space character or a tab between the `.IF` or `.ELIF` directive and the operand.

Only one conditional expression can be specified for the operand of the `.IF` or `.ELIF` directive.

Be sure to use a conditional operator in a conditional expression. The following operators can be used.

### Table 5.33 Conditional Operators of `.IF` and `.ELIF` Directives

<table>
<thead>
<tr>
<th>Conditional Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&gt;</code></td>
<td>The condition is true when the lvalue is greater than the rvalue</td>
</tr>
<tr>
<td><code>&lt;</code></td>
<td>The condition is true when the lvalue is smaller than the rvalue</td>
</tr>
<tr>
<td><code>&gt;=</code></td>
<td>The condition is true when the lvalue is equal to or greater than the rvalue</td>
</tr>
<tr>
<td><code>&lt;=</code></td>
<td>The condition is true when the lvalue is equal to or smaller than the rvalue</td>
</tr>
<tr>
<td><code>==</code></td>
<td>The condition is true when the lvalue is equal to the rvalue</td>
</tr>
<tr>
<td><code>!=</code></td>
<td>The condition is true when the lvalue is not equal to the rvalue</td>
</tr>
</tbody>
</table>

A conditional expression is evaluated in signed 32 bits.
Symbols can be used in the left and right sides of a conditional operator.
Expressions can be used in the left and right sides of a conditional operator. For the expression format, refer to the rules described in (2) Expression in section 4.1.5, Coding of Operands.

Strings can be used in the left and right sides of a conditional operator. Be sure to enclose a string within single-quotes (`'`) or double-quotes (`"`). Strings are compared in character code values.
Examples:
"ABC" < "CBA" -> 414243 < 434241; this condition is true.
"C" < "A" -> 43 < 41; this condition is false.
Space characters and tabs can be written before and after conditional operators.
Conditional expressions can be specified in the operands of the .IF and .ELIF directives.
The assembler does not check if the evaluation result is outside the allowed range.
Forward reference symbols (reference to a symbol that is defined after this directive line) must not be specified.
If a forward reference symbol or an undefined symbol is specified, the assembler assumes the symbol value as 0 when evaluating the expression.

5.3.4 Extended Function Directives

These directives do not affect code generation.

Table 5.34  Extended Function Directives

<table>
<thead>
<tr>
<th>Directive</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>.ASSERT</td>
<td>Outputs a string specified in an operand to the standard error output or a file.</td>
</tr>
<tr>
<td>?</td>
<td>Defines and references a temporary label.</td>
</tr>
<tr>
<td>@</td>
<td>Concatenates strings specified before and after @ so that they are handled as one string.</td>
</tr>
<tr>
<td>..FILE</td>
<td>Indicates the name of the assembly-language file being processed by the assembler.</td>
</tr>
<tr>
<td>.STACK</td>
<td>Defines a stack value for a specified symbol.</td>
</tr>
<tr>
<td>.LINE</td>
<td>Changes line number.</td>
</tr>
<tr>
<td>.DEFINE</td>
<td>Defines a replacement symbol.</td>
</tr>
</tbody>
</table>

### .ASSERT

This directive outputs a string specified in the operand to the standard error output at assembly.

**[Format]**

```
ASSERT:s"<string>"  
ASSERT:s"<string>" delta <file name>  
ASSERT:s"<string>" delta <file name>
```

**[Description]**

This directive outputs a string specified in the operand to the standard error output at assembly.

When a file name is specified, the assembler outputs the string written in the operand to the file.

When an absolute path is specified as a file name, the assembler creates a file in the specified directory.

When no absolute path is specified as a file name:

1. if no directory information is included in the file name specified by the `output` option, the assembler creates the file specified by this directive in the current directory.
2. if directory information is included in the file name specified by the `output` option, the assembler creates the file specified by this directive and adds the directory information for the file specified by the `output` option.
3. if the `output` option is not specified, the assembler creates the file in the same directory containing the file specified in the command line at assembler startup.

When the ..FILE directive is specified as a file name, the assembler creates a file in the same directory as the file specified in the command line at assembler startup.

**[Examples]**

To output a message to the sample.dat file:

```
ASSERT "string" > sample.dat
```

To add a message to the sample.dat file:

```
ASSERT "string" >> sample.dat
```

To output a message to a file with the same name as the current processing file but without a file extension:

```
ASSERT "string" > ..FILE
```
Be sure to insert a space character or a tab between the directive and the operand.
Be sure to enclose the string in the operand within double-quotes.
To output a string to a file, specify the file name after > or >>. The symbol > directs the assembler to create a new file and output a message to the file. If a file with the same name exists, the file is overwritten. The symbol >> directs the assembler to add the message to the contents of the specified file. If the specified file is not found, the assembler creates a new file. Space characters or tabs can be specified before and after > and >>.
The ..FILE directive can be specified as a file name.

This directive defines a temporary label. [Format]

`?:`<em>mnemonic</em>`?+`<em>mnemonic</em>`?-`

[Description]
This directive defines a temporary label. It also references the temporary label defined immediately before or after an instruction. Definitions and references are allowed within the same file. Up to 65,535 temporary labels can be defined in a file. In this case, if .INCLUDE is used in the file, the maximum number (65,535) of temporary files includes the labels in the include file. The temporary labels converted by the assembler are output to the source list file. [Examples]

```
?: <mnemonic> ?+
\text{\textarrow}{BRA} <mnemonic> ?-

?: \text{\textarrow}{BRA} ?-
```
References temporary labels indicated by arrows.

[Remarks]
Write "?:" in the line that is to be defined as a temporary label. To reference the temporary label defined immediately before an instruction, write "?-+" as an operand of the instruction. To reference the temporary label defined immediately after an instruction, write "?-?+" as an operand of the instruction. Only the label defined immediately before or after an instruction can be referenced from the instruction.

This directive concatenates macro arguments, macro variables, reserved symbols, an expanded file name of directive ..FILE, and specified strings. [Format]

`<string>@<string>[@<string> ...]`

[Description]
This directive concatenates macro arguments, macro variables, reserved symbols, an expanded file name of directive ..FILE, and specified strings. [Examples]

Example of file name concatenation: When the name of the currently processed file is sample1.src, a message is output to the sample.dat file in the following example.

```
.ASEERT "sample" > ..FILE@.dat
```
Example of string concatenation:

```assembly
mov_nibble .MACRO p1,src,dest
MOV.@p1 src,dest
.ENDM

mov_nibble W,R1,R2; Macro call
MOV.W R1,R2 ;Macro-expanded code
```

[Remarks]
Space characters and tabs inserted before and after this directive are concatenated as a string.
Strings can be written before and after this directive.
To use `@` as character data (40H), enclose it within double-quotes ("."). When a string including `@` is enclosed within single-quotes (".), the strings before and after `@` are concatenated.
This directive can be used multiple times in one line.
To use the concatenated string as a name, do not insert space characters or tabs before or after this directive.

```
..FILE
```

This directive is expanded to the name of the file that the assembler is currently processing (assembly-language file name or include file name).

[Format]
```
..FILE
```

[Description]
This directive is expanded to the name of the file that the assembler is currently processing (assembly-language file name or include file name).

[Examples]
When the assembly-language file name is `sample.src`, a message is output to the `sample` file in the following example.

```
..FILE
```

When the assembly-language file name is `sample.src`, the `sample.inc` file is included in the following example.

```
..FILE@.inc
```

When the above line is written in the `incl.inc` file included in the `sample.src` file, a string is output to the `incl.mes` file in most cases.

```
..FILE@.mes
```

[Remarks]
This directive can be used in the operand of the `.ASSERT` and `.INCLUDE` directives.
Only the file name body with neither file extension nor path is used for replacement.

```
.STACK
```

This directive defines the stack size to be used for a specified symbol referenced through the Call Walker.

[Format]
```
.STACK<name>=<numeric value>
```

[Description]
This directive defines the stack size to be used for a specified symbol referenced through the Call Walker.

[Examples]
```
.STACK SYMBOL=100H
```

[Remarks]
The stack value for a symbol can be defined only once; any later definitions for the same symbol are ignored. A multiple of 4 in the range from 0H to 0xFFFFFFCH can be specified for a stack value, and a definition with any other value is ignored.

<numeric value> must be a constant specified without using a forward reference symbol, an externally referenced symbol, or a relative address symbol.

**.LINE**

This directive changes the line number and file name referred to in assembler error messages or at debugging.

**[Format]**

```
.LINE <file name>,<line number>
.LINE <line number>
```

**[Description]**

This directive changes the line number and file name referred to in assembler error messages or at debugging. The line number and the file name specified with **.LINE** are valid until the next **.LINE** in a program. The compiler generates **.LINE** corresponding to the line in the C source file when the assembly source program is output with the debugging option specified. When the file name is omitted, the file name is not changed, but only the line number is changed.

**[Examples]**

```
.LINE "C:\asm\test.c",5
```

**.DEFINE**

This directive defines a symbol for a string.

**[Format]**

```
<symbol name>.DEFINE <string>
```

**[Description]**

This directive defines a symbol for a string. Defined symbols can be redefined.

**[Examples]**

```
X_HI.DEFINE R1
MOV L #0, X_HI
```

**[Remarks]**

To define a symbol for a string including a space character or a tab, be sure to enclose it within single-quotes (') or double-quotes (""). The symbols defined through this directive cannot be declared as external references. When this directive and the **.EQU** directive declare the same symbol name, the directive to make the declaration first is given priority.

### 5.4 Macro Names

The following predefined macros are defined according to the option specification and version.

**Table 5.35  Predefined Macros of Assembler**

<table>
<thead>
<tr>
<th>Option</th>
<th>Predefined Macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cpu=rx600</td>
<td>__RX600 .DEFINE 1</td>
</tr>
<tr>
<td>cpu=rx200</td>
<td>__RX200 .DEFINE 1</td>
</tr>
<tr>
<td>2 endian=big</td>
<td>__BIG .DEFINE 1</td>
</tr>
<tr>
<td>endian=little</td>
<td>__LITTLE .DEFINE 1</td>
</tr>
<tr>
<td>3 -</td>
<td>__RENESAS_VERSION  &quot;1&quot; .DEFINE XXYYZZ00H &quot;2&quot;</td>
</tr>
</tbody>
</table>
5.5 Reserved Words

The assembler handles the same strings as assembler directives and mnemonics as reserved words. These reserved words have special functions and they cannot be used as label names or symbol names in assembly-language files. They are not case-sensitive; for example, "ABS" and "abs" are the same reserved word.

Reserved words are classified into the following types.

1. Assembler directives
   All assembler directives and all strings that begin with a period (.)

2. Mnemonics
   All mnemonics of the RX Family

3. Register and flag names
   All register and flag names of the RX family

4. Operators
   All operators described in this section

5. System labels
   A system label is a name that begins with two periods and is generated by the assembler. All system labels are handled as reserved words

### Notes

1. Always defined regardless of the option.
2. When the Assembler version is VXX.YY.ZZ, the value of __RENESAS_VERSION__ is XXYYZZ00H.
   For V3.00.00: __RENESAS_VERSION__.DEFINE 03010000H.
6. SECTION SPECIFICATIONS

6.1 List of Section Names

This section describes the sections for CCRX.
Each of the regions for execution instructions and data of the relocatable files output by the assembler comprises a section. A section is the smallest unit for data placement in memory. Sections have the following properties.

- Section attributes
  - code
    Stores execution instructions
  - data
    Stores data that can be changed
  - romdata
    Stores fixed data

- Format type
  - Relative-address format:A section that can be relocated by the optimizing linkage editor.
  - Absolute-address format:A section of which the address has been determined; it cannot be relocated by the optimizing linkage editor.

- Initial values
  Specifies whether there are initial values at the start of program execution. Data which has initial values and data which does not have initial values cannot be included in the same section. For example, if the initialization list for an array contains elements less than the number of elements for that array, elements without initial values specified in the initialization list are handled as if 0 is specified for the initial value.

- Write operations
  Specifies whether write operations are or are not possible during program execution.

- Boundary alignment number
  Values to correct the addresses of the sections. The optimizing linkage editor corrects addresses of the sections so that they are multiples of each of the boundary alignment numbers.

6.1.1 C/C++ Program Sections

The correspondence between memory areas and sections for C/C++ programs and the standard library is described in Table 6.1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Section Format</th>
<th>Type</th>
<th>Initial Value</th>
<th>Alignement Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Program area</td>
<td>P <em>1</em>6 code Relative</td>
<td>Yes</td>
<td>Not possible</td>
<td>1 byte *7</td>
<td>Stores machine code</td>
</tr>
<tr>
<td>2</td>
<td>Constant area</td>
<td>C_8 <em>1</em>2<em>6</em>8 romdata Relative</td>
<td>Yes</td>
<td>Not possible</td>
<td>8 bytes</td>
<td>Stores const type data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C_8 <em>1</em>2<em>6</em>8 romdata Relative</td>
<td>Yes</td>
<td>Not possible</td>
<td>4 bytes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C_2 <em>1</em>2<em>6</em>8 romdata Relative</td>
<td>Yes</td>
<td>Not possible</td>
<td>2 bytes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C_1 <em>1</em>2<em>6</em>8 romdata Relative</td>
<td>Yes</td>
<td>Not possible</td>
<td>1 byte</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Name</td>
<td>Section</td>
<td>Format Type</td>
<td>Initial Value</td>
<td>Alignment Number</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>---------</td>
<td>-------------</td>
<td>---------------</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>3</td>
<td>Initialized data area</td>
<td>D_8</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Possible</td>
<td>8 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D_2</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D_1</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Possible</td>
<td>2 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B_8</td>
<td>data</td>
<td>Relative</td>
<td>No Possible</td>
<td>8 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B_2</td>
<td>data</td>
<td>Relative</td>
<td>No Possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B_1</td>
<td>data</td>
<td>Relative</td>
<td>No Possible</td>
<td>2 bytes</td>
</tr>
<tr>
<td>5</td>
<td>switch statement branch table area</td>
<td>W</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Not Possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W_2</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Not Possible</td>
<td>2 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W_1</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Not Possible</td>
<td>1 byte</td>
</tr>
<tr>
<td>6</td>
<td>C++ initial processing/ post-processing data area</td>
<td>C$INIT</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Not possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td>7</td>
<td>C++ virtual function table area</td>
<td>C$VTBL</td>
<td>romdata</td>
<td>Relative</td>
<td>Yes Not possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td>8</td>
<td>User stack area</td>
<td>SU</td>
<td>data</td>
<td>Relative</td>
<td>No Possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td>9</td>
<td>Interrupt stack area</td>
<td>SI</td>
<td>data</td>
<td>Relative</td>
<td>No Possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td>10</td>
<td>Heap area</td>
<td>-</td>
<td>-</td>
<td>Relative</td>
<td>No Possible</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Absolute address variable area</td>
<td>$ADDR_&lt;section&gt;_&lt;address&gt;</td>
<td>data</td>
<td>Absolute</td>
<td>Yes/No Possible/Not possible</td>
<td>-</td>
</tr>
</tbody>
</table>
### 6. SECTION SPECIFICATIONS

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Section</th>
<th>Format Type</th>
<th>Initial Value/Write Operation</th>
<th>Alignment Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Variable vector area</td>
<td>C$VECT</td>
<td>romdata</td>
<td>Relative</td>
<td>4 bytes</td>
<td>Variable vector table</td>
</tr>
<tr>
<td>13</td>
<td>Literal area</td>
<td>L &quot;s&quot;</td>
<td>romdata</td>
<td>Relative</td>
<td>4 bytes</td>
<td>Stores string literals and initializers used for dynamic initialization of aggregates</td>
</tr>
</tbody>
</table>

Notes 1. Section names can be switched using the `section` option.

Notes 2. Specifying a section with a boundary alignment of 4 when switching the section names also changes the section name of sections with a boundary alignment of 1, 2, or 8.

Notes 3. `<section>` is a C, D, or B section name, and `<address>` is an absolute address (hexadecimal).

Notes 4. The initial value and write operation depend on the attribute of `<section>`.

Notes 5. The section name can be changed by using the `section` option. In this case, the C section can be selected as the changed name.

Notes 6. The section name can be changed through `#pragma section`.

Notes 7. Specifying the `instalign4` or `instalign8` option, `#pragma instalign4`, or `#pragma instalign8` changes the boundary alignment to 4 or 8.

Notes 8. If an endian not matching the `endian` option has been specified in `#pragma endian`, a dedicated section is created to store the relevant data. At the end of the section name, _B is added for `#pragma endian big`, and _L is added for `#pragma endian little`.

Notes 9. Using these functions requires the allocation of at least 16 bytes of memory as a heap area.

Notes 10. This section is for storing double-precision floating-point data when the `dpfpu` option is specified.

Examples 1. A program example is used to demonstrate the correspondence between a C program and the compiler-generated sections.

C program

```c
int a=1;
char b;
const short c=0;
void main()
{
    ...
}
```

<table>
<thead>
<tr>
<th>Areas generated by the compiler and stored data</th>
<th>Section name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program area (main(){...})</td>
<td>P</td>
</tr>
<tr>
<td>Constant area (c)</td>
<td>C_2</td>
</tr>
<tr>
<td>Initialized data area (a)</td>
<td>D</td>
</tr>
<tr>
<td>Uninitialized data area (b)</td>
<td>B_1</td>
</tr>
</tbody>
</table>
Examples 2. A program example is used to demonstrate the correspondence between a C++ program and the compiler-generated sections.

C++ program

```cpp
class A{
    int m;
    A(int p);
    ~A();
};
A a(1);
char b;
extern const char c='a';
short d=1;
void f(){...}
```

<table>
<thead>
<tr>
<th>Areas generated by the compiler and stored data</th>
<th>Section name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program area (f(){...})</td>
<td>P</td>
</tr>
<tr>
<td>Constant area (c)</td>
<td>C_1</td>
</tr>
<tr>
<td>Initialized data area (d)</td>
<td>D_2</td>
</tr>
<tr>
<td>Uninitialized data area (a)</td>
<td>B</td>
</tr>
<tr>
<td>Uninitialized data area (b)</td>
<td>B_1</td>
</tr>
<tr>
<td>Initial processing/postprocessing data areas</td>
<td>C $\text{INT}$</td>
</tr>
</tbody>
</table>
6.2 Assembly Program Sections

In assembly programs, the `.SECTION` control directive is used to begin sections and declare their attributes, and the `.ORG` control directive is used to declare the format types of sections. For details on the control directives, refer to section 5.2, Directives.

Example

An example of an assembly program section declaration is shown below.

```assembly
; Declares a code section with section name A, boundary alignment 4, and relative address format.
.SECTION A, CODE, ALIGN=4 ; (1)
START:
  MOV.L #CONST, R4
  MOV.L [R4], R5
  ADD #10, R5, R3
  MOV.L #100, R4
  MOV.L #ARRAY, R5
LOOP:
  MOV.L R3, [R5+]
  SUB #1, R4
  CMP #0, R4
  BNE LOOP
EXIT:
  RTS

; Declares a romdata section with section name B, allocated address 2000H, and absolute address format.
.SECTION B, ROMDATA ; (2)
.ORG 02000H
.glb CONST
CONST:
  .LWORD 05H
;
; Declares a data section with section name C, boundary alignment 4, and relative address format.
.SECTION C, DATA, ALIGN=4 ; (3)
.glb BASE
BASE:
  .blkl 100
.END
```

(1) Declares a code section with section name A, boundary alignment 4, and relative address format.
(2) Declares a romdata section with section name B, allocated address 2000H, and absolute address format.
(3) Declares a data section with section name C, boundary alignment 4, and relative address format.
6.3 Linking Sections

The optimizing linkage editor links the same sections within input relocatable files, and allocates addresses specified by the `start` option.

1. The same section names in different files are allocated continuously in the order of file input.

```
"file1.obj"  "file2.obj"  "file3.obj"

Section A  Section D  Section C
Section B  Section A  Section B
Section C
```

```
input file1.obj file2.obj file3.obj
start A,B/1000, C,D/8000
```

```
0x1000
file1.section A
file2.section A
file1.section B
file3.section B
```

```
0x8000
file1.section C
file3.section C
file2.section D
```

2. Sections with the same name but different boundary alignments are linked after alignment. Section alignment uses the larger of the section alignments.

```
"file1.obj"  "file2.obj"

Section A  (align=2,size=0x6D)  Section A  (align=4,size=0x100)
```

```
input file1.obj file2.obj
start A/1000
```

```
0x1000
file1.section A
```

```
0x1070
file1.section A
Alignment = 4
Size = 0x170
```
(3) When sections with the same name include both absolute-address and relative-address formats, relative-address sections are linked following absolute-address sections.
6. SECTION SPECIFICATIONS

(4) Rules for the order of linking sections with the same name are based on their priorities as follows.
- Order specified by the input option or input files on the command line
- Order specified for the user library by the library option and order of input of modules within the library
- Order specified for the system library by the library option and order of input of modules within the library
- Order specified for libraries by environment variables (HLNK_LIBRARY1 to HLNK_LIBRARY3) and order of input of modules within the library

```
"file1.obj"  "usr1.lib"  "syslib1.lib"
    Section A        Module 1 (Section A)        Module 5 (Section A)
    Module 2 (Section A)        Module 6 (Section A)
    Module 3 (Section A)        Module 7 (Section A)
    Module 4 (Section A)        Module 8 (Section A)
```

```
"file2.obj"
    Section A
    Module 1.section A
    Module 2.section A
    Module 5.section A
    Module 6.section A
    Module 7.section A
    Module 8.section A
    Module 3.section A
    Module 4.section A
```

Options specified at linkage

```
input  file1.obj  file2.obj
library  syslib1.lib  usr1.lib
start  A/1000
```

Environment variables

```
HLNK_LIBRARY1=syslib2.lib
HLNK_LIBRARY2=usr2.lib
```

```
0x1000
file1.section A
file2.section A
Module 1.section A
Module 2.section A
Module 5.section A
Module 6.section A
Module 7.section A
Module 8.section A
Module 3.section A
Module 4.section A
```
7. LIBRARY FUNCTIONAL SPECIFICATION

This chapter provides library functions supplied with the CCRX.

7.1 Supplied Libraries

The CCRX provides the standard C, standard C99, and EC++ libraries.

7.1.1 Terms Used in Library Function Descriptions

(1) Stream input/output

In data input/output, it would lead to poor efficiency if each call of an input/output function, which handles a single character, drove the input/output device and the OS functions. To solve this problem, a storage area called a buffer is normally provided, and the data in the buffer is input or output at one time.

From the viewpoint of the program, on the other hand, it is more convenient to call input/output functions for each character.

Using the library functions, character-by-character input/output can be performed efficiently without awareness of the buffer status within the program by automatically performing buffer management.

Those library functions enable a programmer to write a program considering the input/output as a single data stream, making the programmer be able to implement data input/output efficiently without being aware of the detailed procedure. Such capability is called stream input/output.

(2) FILE structure and file pointer

The buffer and other information required for the stream input/output described above are stored in a single structure, defined by the name FILE in the <stdio.h> standard include file.

In stream input/output, all files are handled as having a FILE structure data structure. Files of this kind are called stream files. A pointer to this FILE structure is called a file pointer, and is used to specify an input/output file.

The file pointer is defined as

FILE *fp;

When a file is opened by the fopen function, etc., the file pointer is returned. If the open processing fails, NULL is returned. Note that if a NULL pointer is specified in another stream input/output function, that function will end abnormally. After opening a file, be sure to check the file pointer value to see whether the open processing has been successful.

(3) Functions and macros

There are two library function implementation methods: functions and macros.

A function has the same interface as an ordinary user-written function, and is incorporated during linkage. A macro is defined using a #define statement in the standard include file relating to the function.

The following points must be noted concerning macros:

- Macros are expanded automatically by the preprocessor, and therefore a macro expansion cannot be invalidated even if the user declares a function with the same name.
- If an expression with a side effect (assignment expression, increment, decrement) is specified as a macro parameter, its result is not guaranteed.

Example Macro definition of MACRO that calculates the absolute value of a parameter is as follows:

If the following definition is made:

#define MACRO(a)  ((a) >= 0 ? (a) : -(a))

and if

X=MACRO(a++)

is in the program, the macro will be expanded as follows:

X = ((a++) >= 0 ? (a++) : -(a++))

a will be incremented twice, and the resultant value will be different from the absolute value of the initial value of a.

(4) EOF

In functions such as getc, getchar, and fgetc, which input data from a file, EOF is the value returned at end-of-file. The name EOF is defined in the <stdio.h> standard include file.

(5) NULL

This is the value indicating that a pointer is not pointing at anything. The name NULL is defined in the <stddef.h> standard include file.
(6) Null character
The end of a string in C/C++ is indicated by the characters \0. String parameters in library functions must also conform to this convention. The characters \0 indicating the end of a string are called null characters.

(7) Return code
With some library functions, a return value is used to determine the result (such as whether the specified processing succeeded or failed). In this case, the return value is called the return code.

(8) Text files and binary files
Many systems have special file formats to store data. To support this facility, library functions have two file formats: text files and binary files.

- Text files
  A text file is used to store ordinary text, and consists of a collection of lines. In text file input, the new-line character (\n) is input as a line separator. In output, output of the current line is terminated by outputting the new-line character (\n). Text files are used to input/output files that store standard text for each system. With text files, characters input or output by a library function do not necessarily correspond to a physical stream of data in the file.

- Binary files
  A binary file is configured as a row of byte data. Data input or output by a library function corresponds to a physical list of data in the file.

(9) Standard input/output files
Files that can be used as standard by input/output library functions by default without preparations such as opening file are called standard input/output files. Standard input/output files comprise the standard input file (stdin), standard output file (stdout), and standard error output file (stderr).

- Standard input file (stdin)
  Standard file to be input to a program.

- Standard output file (stdout)
  Standard file to be output from a program.

- Standard error output file (stderr)
  Standard file for storing output of error messages, etc., from a program.

(10) Floating-point numbers
Floating-point numbers are numbers represented by approximation of real numbers. In a C source program, floating-point numbers are represented by decimal numbers, but inside the computer they are normally represented by binary numbers.

In the case of binary numbers, the floating-point representation is as follows:

\[2^n \times m\]

Here, \(n\) is called the exponent of the floating-point number, and \(m\) is called the mantissa. The numbers of bits to represent \(n\) and \(m\) are normally fixed so that a floating-point number can be represented using a specific data size.

Some terms relating to floating-point numbers are explained below.

- Radix
  An integer value indicating the number of distinct digits in the number system used by a floating-point number (10 for decimal, 2 for binary, etc.). The radix is normally 2.

- Rounding
  Rounding is performed when an intermediate result of an operation of higher precision than a floating-point type is stored as that floating-point type. There is rounding up, rounding down, and half-adjust rounding (i.e., in binary representation, rounding down 0 and rounding up 1).

- Normalization
  When a floating-point number is represented in the form \(2^n \times m\), the same number can be represented in different ways.

  \[2^5 \times 1.0\]
  \[2^5 \times 0.1\]

  Usually, a representation in which the leading digit is not 0 is used, in order to secure the number of valid digits. This is called a normalized floating-point number, and the operation that converts a floating-point number to this kind of representation is called normalization.
- Guard bit
  When saving an intermediate result of a floating-point operation, data one bit longer than the actual floating-point number is normally provided in order for rounding to be carried out. However, this alone does not permit an accurate result to be achieved in the event of digit dropping, etc. For this reason, the intermediate result is saved with an extra bit, called a guard bit.

(11) File access mode
  This is a string that indicates the kind of processing to be carried out on a file when it is opened. There are 12 different modes, as shown in Table 7.1.

Table 7.1  File Access Modes

<table>
<thead>
<tr>
<th>Access Mode</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>'r'</td>
<td>Opens text file for reading</td>
</tr>
<tr>
<td>'w'</td>
<td>Opens text file for writing</td>
</tr>
<tr>
<td>'a'</td>
<td>Opens text file for addition</td>
</tr>
<tr>
<td>'rb'</td>
<td>Opens binary file for reading</td>
</tr>
<tr>
<td>'wb'</td>
<td>Opens binary file for writing</td>
</tr>
<tr>
<td>'ab'</td>
<td>Opens binary file for appending</td>
</tr>
<tr>
<td>'r+'</td>
<td>Opens text file for reading and updating</td>
</tr>
<tr>
<td>'w+'</td>
<td>Opens text file for writing and updating</td>
</tr>
<tr>
<td>'a+'</td>
<td>Opens text file for appending and updating</td>
</tr>
<tr>
<td>'r+b'</td>
<td>Opens binary file for reading and updating</td>
</tr>
<tr>
<td>'w+b'</td>
<td>Opens binary file for writing and updating</td>
</tr>
<tr>
<td>'a+b'</td>
<td>Opens binary file for appending and updating</td>
</tr>
</tbody>
</table>

(12) implementation defined
  Definitions differ for each compiler.

(13) Error indicator and end-of-file indicator
  The following two data items are held for each stream file: (1) an error indicator that indicates whether or not an error has occurred during file input/output, and (2) an end-of-file indicator that indicates whether or not the input file has ended.
  These data items can be referenced by the `ferror` function and the `feof` function, respectively.
  With some functions that handle stream files, error occurrence and end-of-file information cannot be obtained from the return value alone. The error indicator and end-of-file indicator are useful for checking the file status after execution of such functions.

(14) File position indicator
  Stream files that can be read or written at any position within the file, such as disk files, have an associated data item called a file position indicator that indicates the current read/write position within the file.
  File position indicators are not used with stream files that do not permit the read/write position within the file to be changed, such as terminals.

7.1.2 Notes on Use of Libraries

The contents of macros defined in a library differ for each compiler.
When a library is used, the behavior is not guaranteed if the contents of these macros are redefined.
With libraries, errors are not detected in all cases. The behavior is not guaranteed if library functions are called in a form other than those shown in the descriptions in the following sections.
7.2 Header Files

The list of header files required for using the libraries of the RX are listed below.
The macro definitions and function declarations are described in each file.

Table 7.2  Library Types and Corresponding Standard Include Files

<table>
<thead>
<tr>
<th>Library Type</th>
<th>Description</th>
<th>Standard Include File</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program diagnostics</td>
<td>Outputs program diagnostic information.</td>
<td>&lt;assert.h&gt;</td>
</tr>
<tr>
<td>Character handling</td>
<td>Handles and checks characters.</td>
<td>&lt;ctype.h&gt;</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Performs numerical calculations such as trigonometric functions.</td>
<td>&lt;math.h&gt; &lt;mathf.h&gt;</td>
</tr>
<tr>
<td>Non-local jumps</td>
<td>Supports transfer of control between functions.</td>
<td>&lt;setjmp.h&gt;</td>
</tr>
<tr>
<td>Variable arguments</td>
<td>Supports access to variable arguments for functions with such arguments.</td>
<td>&lt;stdarg.h&gt;</td>
</tr>
<tr>
<td>Input/output</td>
<td>Performs input/output handling.</td>
<td>&lt;stdio.h&gt;</td>
</tr>
<tr>
<td>General utilities</td>
<td>Performs C program standard processing such as storage area management.</td>
<td>&lt;stdlib.h&gt;</td>
</tr>
<tr>
<td>String handling</td>
<td>Performs string comparison, copying, etc.</td>
<td>&lt;string.h&gt;</td>
</tr>
<tr>
<td>Complex arithmetic</td>
<td>Performs complex number operations.</td>
<td>&lt;complex.h&gt;</td>
</tr>
<tr>
<td>Floating-point environment</td>
<td>Supports access to floating-point environment.</td>
<td>&lt;fenv.h&gt;</td>
</tr>
<tr>
<td>Integer type format conversion</td>
<td>Manipulates greatest-width integers and converts integer format.</td>
<td>&lt;inttypes.h&gt;</td>
</tr>
<tr>
<td>Multibyte and wide characters</td>
<td>Manipulates multibyte characters.</td>
<td>&lt;wchar.h&gt; &lt;wctype.h&gt;</td>
</tr>
</tbody>
</table>

In addition to the above standard include files, standard include files consisting solely of macro name definitions, shown in Table 7.3, are provided to improve programming efficiency.

Table 7.3  Standard Include Files Comprising Macro Name Definitions

<table>
<thead>
<tr>
<th>Standard Include File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;stddef.h&gt;</td>
<td>Defines macro names used in common by the standard include files.</td>
</tr>
<tr>
<td>&lt;limits.h&gt;</td>
<td>Defines various limit values relating to compiler internal processing.</td>
</tr>
<tr>
<td>&lt;errno.h&gt;</td>
<td>Defines the value to be set in errno when an error is generated in a library function.</td>
</tr>
<tr>
<td>&lt;float.h&gt;</td>
<td>Defines various limit values relating to the limits of floating-point numbers.</td>
</tr>
<tr>
<td>&lt;iso646.h&gt;</td>
<td>Defines alternative spellings of macro names.</td>
</tr>
<tr>
<td>&lt;stdbool.h&gt;</td>
<td>Defines macros relating to logical types and values.</td>
</tr>
<tr>
<td>&lt;stdint.h&gt;</td>
<td>Declares integer types with specified width and defines macros.</td>
</tr>
<tr>
<td>&lt;tgmath.h&gt;</td>
<td>Defines type-generic macros.</td>
</tr>
</tbody>
</table>
## 7.3 Reentrant Library

Functions of libraries created by using the standard library generator with the `--reent` option specified can be executed as reentrant except for the rand and srand functions and the functions of the EC++ library.

Table 7.4 and Table 7.5 indicate which functions of libraries are reentrant even when the `--reent` option is not specified.

In the tables, functions for which "D" is indicated set the `errno` variable, so execution as reentrant is only possible as long as the program does not refer to the `errno` variable.

Reentrant column O: Reentrant  X: Non-reentrant  D: Sets the `errno` variable.

### Table 7.4  C(C89) Reentrant Library Function List

<table>
<thead>
<tr>
<th>Standard Include File</th>
<th>Function Name</th>
<th>Reentrant</th>
<th>Standard Include File</th>
<th>Function Name</th>
<th>Reentrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>stddef.h</td>
<td>offsetof</td>
<td>O</td>
<td>math.h</td>
<td>frexp</td>
<td>D</td>
</tr>
<tr>
<td>assert.h</td>
<td>assert</td>
<td>X</td>
<td>math.h</td>
<td>log</td>
<td>D</td>
</tr>
<tr>
<td>ctype.h</td>
<td>isalnum</td>
<td>O</td>
<td>math.h</td>
<td>log10</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>isalpha</td>
<td>O</td>
<td>math.h</td>
<td>modf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>iscntrl</td>
<td>O</td>
<td>math.h</td>
<td>pow</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>isdigit</td>
<td>O</td>
<td>math.h</td>
<td>sqrt</td>
<td>D *1</td>
</tr>
<tr>
<td></td>
<td>isgraph</td>
<td>O</td>
<td>math.h</td>
<td>ceil</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>islower</td>
<td>O</td>
<td>math.h</td>
<td>fabs</td>
<td>D *1</td>
</tr>
<tr>
<td></td>
<td>isprint</td>
<td>O</td>
<td>math.h</td>
<td>floor</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>ispunct</td>
<td>O</td>
<td>math.h</td>
<td>fmod</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>isspace</td>
<td>O</td>
<td>math.h</td>
<td>isupper</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>isxdigit</td>
<td>O</td>
<td>math.f</td>
<td>acosf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>tolower</td>
<td>O</td>
<td>math.h</td>
<td>asinf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>toupper</td>
<td>O</td>
<td>math.h</td>
<td>atanf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>math.h</td>
<td>atan2f</td>
<td>D *2</td>
</tr>
<tr>
<td>math.h</td>
<td>acos</td>
<td>D</td>
<td>math.h</td>
<td>cosf</td>
<td>D *2</td>
</tr>
<tr>
<td></td>
<td>asin</td>
<td>D</td>
<td>math.h</td>
<td>sinf</td>
<td>D *2</td>
</tr>
<tr>
<td></td>
<td>atan</td>
<td>D</td>
<td>math.h</td>
<td>tanf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>atan2</td>
<td>D *2</td>
<td>math.h</td>
<td>coshf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>cos</td>
<td>D *2</td>
<td>math.h</td>
<td>sinhf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>sin</td>
<td>D *2</td>
<td>math.h</td>
<td>tanhf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>tan</td>
<td>D</td>
<td>math.h</td>
<td>expf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>cosh</td>
<td>D</td>
<td>math.h</td>
<td>frexp</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>sinh</td>
<td>D</td>
<td>math.h</td>
<td>ldexpf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>tanh</td>
<td>D</td>
<td>math.h</td>
<td>logf</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>exp</td>
<td>D</td>
<td>math.h</td>
<td>log10f</td>
<td>D</td>
</tr>
<tr>
<td>Standard Include File</td>
<td>Function Name</td>
<td>Reentrant</td>
<td>Standard Include File</td>
<td>Function Name</td>
<td>Reentrant</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------</td>
<td>-----------</td>
<td>-----------------------</td>
<td>---------------</td>
<td>-----------</td>
</tr>
<tr>
<td>mathf.h</td>
<td>modff</td>
<td>D</td>
<td>stdio.h</td>
<td>puts</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>powf</td>
<td>D</td>
<td></td>
<td>getc</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>sqrtf</td>
<td>D ++1</td>
<td></td>
<td>getchar</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>ceilf</td>
<td>D</td>
<td></td>
<td>gets</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>fabsf</td>
<td>O</td>
<td></td>
<td>putc</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>fabsl</td>
<td>D ++1</td>
<td></td>
<td>putchar</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>floorf</td>
<td>D</td>
<td></td>
<td>puts</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>fmodf</td>
<td>D</td>
<td></td>
<td>ungetc</td>
<td>X</td>
</tr>
<tr>
<td>setjmp.h</td>
<td>setjmp</td>
<td>O</td>
<td></td>
<td>fread</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>longjmp</td>
<td>O</td>
<td></td>
<td>fwrite</td>
<td>X</td>
</tr>
<tr>
<td>stdarg.h</td>
<td>va_start</td>
<td>O</td>
<td></td>
<td>fseek</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>va_arg</td>
<td>O</td>
<td></td>
<td>ftell</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>va_end</td>
<td>O</td>
<td></td>
<td>rewind</td>
<td>X</td>
</tr>
<tr>
<td>stdio.h</td>
<td>fclose</td>
<td>X</td>
<td></td>
<td>clearerr</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>flush</td>
<td>X</td>
<td></td>
<td>feof</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>fopen</td>
<td>X</td>
<td></td>
<td>ferror</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>freopen</td>
<td>X</td>
<td></td>
<td>perror</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>setbuf</td>
<td>X</td>
<td>stdlib.h</td>
<td>atof</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>setvbuf</td>
<td>X</td>
<td></td>
<td>atoi</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>fprintf</td>
<td>X</td>
<td></td>
<td>atol</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>fscanf</td>
<td>X</td>
<td></td>
<td>atoll</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>printf</td>
<td>X</td>
<td></td>
<td>strtod</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>scanf</td>
<td>X</td>
<td></td>
<td>strtol</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>sprintf</td>
<td>X</td>
<td></td>
<td>strtoul</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>sscanf</td>
<td>D</td>
<td></td>
<td>strtoull</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>vfprintf</td>
<td>X</td>
<td></td>
<td>rand</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>vprintf</td>
<td>X</td>
<td></td>
<td>srand</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>vsprintf</td>
<td>X</td>
<td></td>
<td>calloc</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>fgetc</td>
<td>X</td>
<td></td>
<td>free</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>fgets</td>
<td>X</td>
<td></td>
<td>malloc</td>
<td>X</td>
</tr>
</tbody>
</table>
Notes 1. If the function call is replaced by an instruction, the entry in the column for "Reentrant" in the table would become O (i.e. reentrance is possible) since the instruction does not update the \texttt{errno} variable. Refer to the item on `-library` in the section on compiler options for the conditions under which calls are replaced by instructions.

Notes 2. If the function call is replaced by code that uses a trigonometric function unit, the entry in the column for "Reentrant" in the table might become X (i.e. non-reentrant). For details, refer to the item about `-tfu` in the section on compile options.

Table 7.5 C99 Reentrant Library Functions List

<table>
<thead>
<tr>
<th>Standard Include File</th>
<th>Function Name</th>
<th>Reentrant</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>stdlib.h</code></td>
<td>realloc</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td><code>bsearch</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>qsort</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>abs</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>div</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>labs</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>llabs</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>ldiv</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>lldiv</code></td>
<td>O</td>
</tr>
<tr>
<td><code>string.h</code></td>
<td><code>memcpy</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strncpy</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strcat</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strncat</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memcmp</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memmove</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strncpy</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strcat</code></td>
<td>O</td>
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<tr>
<td></td>
<td><code>strncat</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memcmp</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memmove</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strncpy</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strcat</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strncat</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memcmp</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memmove</code></td>
<td>O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Include File</th>
<th>Function Name</th>
<th>Reentrant</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>string.h</code></td>
<td><code>strcmp</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strncpy</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memchr</code></td>
<td>O</td>
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<tr>
<td></td>
<td><code>strstr</code></td>
<td>O</td>
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<td></td>
<td><code>strrchr</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strspn</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strpbrk</code></td>
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</tr>
<tr>
<td></td>
<td><code>strtok</code></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td><code>strerror</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strlen</code></td>
<td>O</td>
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<tr>
<td></td>
<td><code>memmove</code></td>
<td>O</td>
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<tr>
<td></td>
<td><code>strerror</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strlen</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memmove</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strerror</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>strlen</code></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td><code>memmove</code></td>
<td>O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Include File</th>
<th>Function Name</th>
<th>Reentrant</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>math.h</code></td>
<td><code>frexpl</code></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td><code>idexpl</code></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td><code>log1fl</code></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td><code>log10fl</code></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td><code>modfl</code></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td><code>powl</code></td>
<td>D</td>
</tr>
<tr>
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<td>putwchar</td>
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</tr>
<tr>
<td></td>
<td>ungetwc</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes 1. If the function call is replaced by an instruction, the entry in the column for “Reentrant” in the table would become O (i.e. reentrance is possible) since the instruction does not update the errno variable. Refer to the item on `-library` in the section on compiler options for the conditions under which calls are replaced by instructions.

Notes 2. If the function call is replaced by code that uses a trigonometric function unit, the entry in the column for "Reentrant" in the table might become X (i.e. non-reentrant). For details, refer to the item about `-tfu` in the section on compile options.
7.4 Library Function

This section explains library functions.

Some of the C99-language-expanded keywords (functions, macros, variable names, etc.) must be used in when the C99-language is selected. Such keywords are displayed by the mark of "<-lang=c99>" at the tables each the header-files in these sections. When you use these keywords in your program, at the time of compilations and library generations, please turn on the -lang=c99 option.
7.4.1 <stddef.h>

Defines macro names used in common in the standard include files.
The following macro names are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (typedef)</td>
<td>ptdiff_t</td>
<td>Indicates the type of the result of subtraction between two pointers.</td>
</tr>
<tr>
<td></td>
<td>size_t</td>
<td>Indicates the type of the result of an operation using the <code>sizeof</code> operator.</td>
</tr>
<tr>
<td>Constant (macro)</td>
<td>NULL</td>
<td>Indicates the value when a pointer is not pointing at anything. This value is such that the result of a comparison with 0 using the equality operator (==) is true.</td>
</tr>
<tr>
<td>Variable (macro)</td>
<td>errno</td>
<td>If an error occurs during library function processing, the error code defined in the respective library is set in <code>errno</code>. By setting 0 in <code>errno</code> before calling a library function and checking the error code set in <code>errno</code> after the library function processing has ended, it is possible to check whether an error occurred during the library function processing.</td>
</tr>
<tr>
<td>Function (macro)</td>
<td>offsetof</td>
<td>Obtains the offset in bytes from the beginning of a structure to a structure member.</td>
</tr>
<tr>
<td>Type (typedef)</td>
<td>wchar_t</td>
<td>Type that indicates an extended character.</td>
</tr>
</tbody>
</table>

### Implementation-Defined Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Compiler Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of macro <code>NULL</code></td>
<td>Value 0.</td>
</tr>
<tr>
<td>Type equivalent to macro ptdiff_t</td>
<td><code>long</code> type</td>
</tr>
<tr>
<td>Type equivalent to wchar_t</td>
<td><code>unsigned short</code> type</td>
</tr>
</tbody>
</table>
7.4.2  `<assert.h>`

Adds diagnostics into programs.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function (macro)</td>
<td>assert</td>
<td>Adds diagnostics into programs.</td>
</tr>
</tbody>
</table>

To invalidate the diagnostics defined by `<assert.h>`, define macro name `NDEBUG` with a `#define` statement (`#define NDEBUG`) before including `<assert.h>`.

Note: If an `#undef` statement is used for macro name `assert`, the result of subsequent `assert` calls is not guaranteed.
CC-RX 7. LIBRARY FUNCTIONAL SPECIFICATION

assert

Adds diagnostics into programs.

[Format]

#include <assert.h>
void assert (long expression);

[Parameters]

expression  Expression to be evaluated.

[Remarks]

When expression is true, the assert macro terminates processing without returning a value. If expression is false, it outputs diagnostic information to the standard error file in the form defined by the compiler, and then calls the abort function.

The diagnostic information includes the parameter's program text, source file name, and source line numbers.

Implementation define:

The following message is output when expression is false in assert (expression):

The message depends on the lang option setting at compilation.

(1) When -lang=c99 is not specified (C (C89), C++, or EC++ language):

ASSERTION FAILED:expressionFILE<file name>,LINE<line number>

(2) When -lang=c99 is specified (C (C99) language):

ASSERTION FAILED:expressionFILE<file name>,LINE<line number>FUNCNAME<function name>
### 7.4.3 `<ctype.h>`

Checks and converts character types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>isalnum</td>
<td>Tests for a letter or a decimal digit.</td>
</tr>
<tr>
<td></td>
<td>isalpha</td>
<td>Tests for a letter.</td>
</tr>
<tr>
<td></td>
<td>iscntrl</td>
<td>Tests for a control character.</td>
</tr>
<tr>
<td></td>
<td>isdigit</td>
<td>Tests for a decimal digit.</td>
</tr>
<tr>
<td></td>
<td>isgraph</td>
<td>Tests for a printing character except space.</td>
</tr>
<tr>
<td></td>
<td>islower</td>
<td>Tests for a lowercase letter.</td>
</tr>
<tr>
<td></td>
<td>isprint</td>
<td>Tests for a printing character including space.</td>
</tr>
<tr>
<td></td>
<td>ispunct</td>
<td>Tests for a special character.</td>
</tr>
<tr>
<td></td>
<td>isspace</td>
<td>Tests for a white-space character.</td>
</tr>
<tr>
<td></td>
<td>isupper</td>
<td>Tests for an uppercase letter.</td>
</tr>
<tr>
<td></td>
<td>isxdigit</td>
<td>Tests for a hexadecimal digit.</td>
</tr>
<tr>
<td></td>
<td>tolower</td>
<td>Converts an uppercase letter to lowercase.</td>
</tr>
<tr>
<td></td>
<td>toupper</td>
<td>Converts a lowercase letter to uppercase.</td>
</tr>
<tr>
<td></td>
<td>isblank</td>
<td>Tests for a space character or a tab character.</td>
</tr>
</tbody>
</table>

In the above functions, if the input parameter value is not within the range that can be represented by the `unsigned char` type and is not `EOF`, the operation of the function is not guaranteed.

Character types are listed in Table 7.6.

#### Table 7.6 Character Types

<table>
<thead>
<tr>
<th>Character Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uppercase letter</td>
<td>Any of the following 26 characters</td>
</tr>
<tr>
<td>Lowercase letter</td>
<td>Any of the following 26 characters</td>
</tr>
<tr>
<td></td>
<td>'a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'j', 'k', 'l', 'm', 'n', 'o', 'p', 'q', 'r', 's', 't', 'u', 'v', 'w', 'x', 'y', 'z'</td>
</tr>
<tr>
<td>Letter</td>
<td>Any uppercase or lowercase letter</td>
</tr>
<tr>
<td>Decimal digit</td>
<td>Any of the following 10 characters</td>
</tr>
<tr>
<td></td>
<td>'0', '1', '2', '3', '4', '5', '6', '7', '8', '9'</td>
</tr>
<tr>
<td>Printing character</td>
<td>A character, including space (' ') that is displayed on the screen (corresponding to ASCII codes 0x20 to 0x7E)</td>
</tr>
<tr>
<td>Control character</td>
<td>Any character except a printing character</td>
</tr>
<tr>
<td>White-space character</td>
<td>Any of the following 6 characters</td>
</tr>
<tr>
<td></td>
<td>Space (' '), form feed ('\f'), new-line ('\n'), carriage return ('\r'), horizontal tab ('\t'), vertical tab ('\v')</td>
</tr>
<tr>
<td>Hexadecimal digit</td>
<td>Any of the following 22 characters</td>
</tr>
<tr>
<td></td>
<td>'0', '1', '2', '3', '4', '5', '6', '7', '8', '9', 'A', 'B', 'C', 'D', 'E', 'F', 'a', 'b', 'c', 'd', 'e', 'f'</td>
</tr>
<tr>
<td>Special character</td>
<td>Any printing character except space (''), a letter, or a decimal digit</td>
</tr>
</tbody>
</table>
## Implementation-Defined Specifications

<table>
<thead>
<tr>
<th>Character Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank character</td>
<td>Either of the following 2 characters</td>
</tr>
<tr>
<td></td>
<td>Space (&quot; &quot;), horizontal tab (&quot;\t&quot;)</td>
</tr>
</tbody>
</table>

### Table 7.7 True Character

<table>
<thead>
<tr>
<th>Function Name</th>
<th>True Characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>isalnum</td>
<td>'0' to '9', 'A' to 'Z', 'a' to 'z'</td>
</tr>
<tr>
<td>isalpha</td>
<td>'A' to 'Z', 'a' to 'z'</td>
</tr>
<tr>
<td>iscntrl</td>
<td>'\x00' to '\x1f', '\x7f'</td>
</tr>
<tr>
<td>islower</td>
<td>'a' to 'z'</td>
</tr>
<tr>
<td>isprint</td>
<td>'\x20' to '\x7E'</td>
</tr>
<tr>
<td>isupper</td>
<td>'A' to 'Z'</td>
</tr>
</tbody>
</table>
isalnum

Tests for a letter or a decimal digit.

[Format]

```c
#include <ctype.h>
long isalnum (long c);
```

[Parameters]

- c Character to be tested

[Return values]

- If character c is a letter or a decimal digit: Nonzero
- If character c is not a letter or a decimal digit: 0
isalpha

Tests for a letter.

[Format]

#include <ctype.h>
long isalpha(long c);

Parameters

- c Character to be tested

Return values

- If character c is a letter: Nonzero
- If character c is not a letter: 0
iscntrl

Tests for a control character.

[Format]

```c
#include <ctype.h>
long iscntrl (long c);
```

[Parameters]

- c  Character to be tested

[Return values]

- If character c is a control character: Nonzero
- If character c is not a control character: 0
isdigit

Tests for a decimal digit.

[Format]

```c
#include <ctype.h>
long isdigit (long c);
```

[Parameters]

c  Character to be tested

[Return values]

If character c is a decimal digit: Nonzero
If character c is not a decimal digit: 0
isgraph

Tests for any printing character except space (‘ ’).

[Format]

```c
#include <ctype.h>
long isgraph (long c);
```

[Parameters]

c  Character to be tested

[Return values]

- If character c is a printing character except space: Nonzero
- If character c is not a printing character except space: 0
islower

Tests for a lowercase letter.

[Format]

```c
#include <ctype.h>
long islower (long c);
```

[Parameters]

- `c` Character to be tested

[Return values]

- If character `c` is a lowercase letter: Nonzero
- If character `c` is not a lowercase letter: 0
isprint

Tests for a printing character including space (‘’).

[Format]

```c
#include <ctype.h>
long isprint(long c);
```

[Parameters]

- `c` Character to be tested

[Return values]

- If character `c` is a printing character including space: Nonzero
- If character `c` is not a printing character including space: 0
ispunct

Tests for a special character.

[Format]

```c
#include <ctype.h>
long ispunct (long c);
```

[Parameters]

c  Character to be tested

[Return values]

- If character `c` is a special character: Nonzero
- If character `c` is not a special character: 0
isspace

Tests for a white-space character.

[Format]

```c
#include <ctype.h>
long isspace (long c);
```

[Parameters]

- `c`  Character to be tested

[Return values]

- If character `c` is a white-space character: Nonzero
- If character `c` is not a white-space character: 0
isupper

Tests for an uppercase letter.

[Format]

```c
#include <ctype.h>
long isupper (long c);
```

[Parameters]

- c Character to be tested

[Return values]

- If character c is an uppercase letter: Nonzero
- If character c is not an uppercase letter: 0
Tests for a hexadecimal digit.

[Format]

```c
#include <ctype.h>
long isxdigit (long c);
```

[Parameters]

- `c` Character to be tested

[Return values]

- If character `c` is a hexadecimal digit: Nonzero
- If character `c` is not a hexadecimal digit: 0
tolower

Converts an uppercase letter to the corresponding lowercase letter.

[Format]

```c
#include <ctype.h>
long tolower (long c);
```

[Parameters]

- c Character to be converted

[Return values]

- If character c is an uppercase letter: Lowercase letter corresponding to character c
- If character c is not an uppercase letter: Character c
toupper

Converts a lowercase letter to the corresponding uppercase letter.

[Format]

```
#include <ctype.h>
long toupper (long c);
```

[Parameters]

- c  Character to be converted

[Return values]

- If character c is a lowercase letter: Uppercase letter corresponding to character c
- If character c is not a lowercase letter: Character c
isblank

Tests for a space character or a tab character.

[Format]

#include <ctype.h>
long isblank (long c);

[Parameters]

  c  Character to be tested

[Return values]

  If character c is a space character or a tab character: Nonzero
  If character c is neither a space character nor a tab character: 0
7.4.4 `<float.h>`

Defines various limits relating to the internal representation of floating-point numbers. The following macro names are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Definition Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>FLT_RADIX</td>
<td>2</td>
<td>Indicates the radix in exponent representation.</td>
</tr>
<tr>
<td></td>
<td>FLT_ROUNDS</td>
<td>1</td>
<td>Indicates whether or not the results of addition are rounded off.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 means that rounding of the results of operation is enabled.</td>
</tr>
<tr>
<td></td>
<td>FLT_MAX</td>
<td>3.4028235677973364e+38F</td>
<td>Indicates the maximum value that can be represented as a float type floating-point value.</td>
</tr>
<tr>
<td></td>
<td>DBL_MAX</td>
<td>1.7976931348623158e+308</td>
<td>Indicates the maximum value that can be represented as a double type floating-point value.</td>
</tr>
<tr>
<td></td>
<td>LDBL_MAX</td>
<td>1.7976931348623158e+308</td>
<td>Indicates the maximum value that can be represented as a long double type floating-point value.</td>
</tr>
<tr>
<td></td>
<td>FLT_MAX_EXP</td>
<td>128</td>
<td>Using powers of the radix two to represent the range of float type floating-point numbers, FLT_MAX_EXP indicates the maximum value of the exponent plus 1.</td>
</tr>
<tr>
<td></td>
<td>DBL_MAX_EXP</td>
<td>1024</td>
<td>Using powers of the radix two to represent the range of double type floating-point numbers, DBL_MAX_EXP indicates the maximum value of the exponent plus 1.</td>
</tr>
<tr>
<td></td>
<td>LDBL_MAX_EXP</td>
<td>1024</td>
<td>Using powers of the radix two to represent the range of long double type floating-point numbers, LDBL_MAX_EXP indicates the maximum value of the exponent plus 1.</td>
</tr>
<tr>
<td></td>
<td>FLT_MAX_10_EXP</td>
<td>38</td>
<td>Using powers of 10 to represent the range of float type floating point positive numbers, FLT_MAX_10_EXP indicates the exponent of the maximum integer.</td>
</tr>
<tr>
<td></td>
<td>DBL_MAX_10_EXP</td>
<td>308</td>
<td>Using powers of 10 to represent the range of double type floating point positive numbers, DBL_MAX_10_EXP indicates the exponent of the maximum integer.</td>
</tr>
<tr>
<td></td>
<td>LDBL_MAX_10_EXP</td>
<td>308</td>
<td>Using powers of 10 to represent the range of long double type floating point positive numbers, LDBL_MAX_10_EXP indicates the exponent of the maximum integer.</td>
</tr>
<tr>
<td></td>
<td>FLT_MIN</td>
<td>1.175494351e−38F</td>
<td>Indicates the minimum positive value that can be represented as a float type floating-point value.</td>
</tr>
<tr>
<td></td>
<td>DBL_MIN</td>
<td>2.2250738585072014e−308</td>
<td>Indicates the minimum positive value that can be represented as a double type floating-point value.</td>
</tr>
<tr>
<td></td>
<td>LDBL_MIN</td>
<td>2.2250738585072014e−308</td>
<td>Indicates the minimum positive value that can be represented as a long double type floating-point value.</td>
</tr>
</tbody>
</table>
Using powers of the radix two to represent the range of float type floating-point numbers, FLT_MIN_EXP indicates the minimum value of the exponent plus 1.

Using powers of the radix two to represent the range of double type floating-point numbers, DBL_MIN_EXP indicates the minimum value of the exponent plus 1.

Using powers of the radix two to represent the range of long double type floating-point numbers, LDBL_MIN_EXP indicates the minimum value of the exponent plus 1.

Using powers of 10 to represent the range of float type floating point positive numbers, FLT_MIN_10_EXP indicates the exponent of the minimum integer.

Using powers of 10 to represent the range of double type floating point positive numbers, DBL_MIN_10_EXP indicates the exponent of the minimum integer.

Using powers of 10 to represent the range of long double type floating point positive numbers, LDBL_MIN_10_EXP indicates the exponent of the minimum integer.

Indicates the maximum number of digits in float type floating-point value decimal-precision.

Indicates the maximum number of digits in double type floating-point value decimal-precision.

Indicates the maximum number of digits in long double type floating-point value decimal-precision.

Indicates the maximum number of mantissa digits when a float type floating-point value is represented in the radix.

Indicates the maximum number of mantissa digits when a double type floating-point value is represented in the radix.

Indicates the maximum number of mantissa digits when a long double type floating-point value is represented in the radix.

Indicates the maximum number of digits of a floating-point value represented in decimal precision.

Indicates the difference between 1 and the minimum value greater than 1 that can be represented in float type.
<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Definition Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (macro)</td>
<td>DBL_EPSILON</td>
<td>2.2204460492503131e-16</td>
<td>Indicates the difference between 1 and the minimum value greater than 1 that can be represented in <strong>double</strong> type.</td>
</tr>
<tr>
<td></td>
<td>LDBL_EPSILON</td>
<td>2.2204460492503131e-16</td>
<td>Indicates the difference between 1 and the minimum value greater than 1 that can be represented in <strong>long double</strong> type.</td>
</tr>
</tbody>
</table>
### 7.4.5 <limits.h>

Defines various limits relating to the internal representation of integer type data.
The following macro names are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Definition Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>CHAR_BIT</td>
<td>8</td>
<td>Indicates the number of bits in a char type value.</td>
</tr>
<tr>
<td></td>
<td>CHAR_MAX</td>
<td>127</td>
<td>Indicates the maximum value that can be represented by a char type variable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>255^1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHAR_MIN</td>
<td>−128</td>
<td>Indicates the minimum value that can be represented by a char type variable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0^1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCHAR_MAX</td>
<td>127</td>
<td>Indicates the maximum value that can be represented by a signed char type variable.</td>
</tr>
<tr>
<td></td>
<td>SCHAR_MIN</td>
<td>−128</td>
<td>Indicates the minimum value that can be represented by a signed char type variable.</td>
</tr>
<tr>
<td></td>
<td>UCHAR_MAX</td>
<td>255U</td>
<td>Indicates the maximum value that can be represented by an unsigned char type variable.</td>
</tr>
<tr>
<td></td>
<td>SHRT_MAX</td>
<td>32767</td>
<td>Indicates the maximum value that can be represented by a short type variable.</td>
</tr>
<tr>
<td></td>
<td>SHRT_MIN</td>
<td>−32768</td>
<td>Indicates the maximum value that can be represented by a short type variable.</td>
</tr>
<tr>
<td></td>
<td>USHRT_MAX</td>
<td>65535U</td>
<td>Indicates the maximum value that can be represented by an unsigned short type variable.</td>
</tr>
<tr>
<td></td>
<td>INT_MAX</td>
<td>217483647</td>
<td>Indicates the maximum value that can be represented by an int type variable.</td>
</tr>
<tr>
<td></td>
<td>INT_MIN</td>
<td>−2147483647−1</td>
<td>Indicates the minimum value that can be represented by an int type variable.</td>
</tr>
<tr>
<td></td>
<td>UINT_MAX</td>
<td>4294967295U</td>
<td>Indicates the maximum value that can be represented by an unsigned int type variable.</td>
</tr>
<tr>
<td></td>
<td>LONG_MAX</td>
<td>217483647L</td>
<td>Indicates the maximum value that can be represented by a long type variable.</td>
</tr>
<tr>
<td></td>
<td>LONG_MIN</td>
<td>−2147483647L−1L</td>
<td>Indicates the minimum value that can be represented by a long type variable.</td>
</tr>
<tr>
<td></td>
<td>ULONG_MAX</td>
<td>4294967295U</td>
<td>Indicates the maximum value that can be represented by an unsigned long type variable.</td>
</tr>
<tr>
<td></td>
<td>LLONG_MAX</td>
<td>9223372036854775807LL</td>
<td>Indicates the maximum value that can be represented by a long long type variable.</td>
</tr>
<tr>
<td></td>
<td>LONGLONG_MIN</td>
<td>−9223372036854775807L−1LL</td>
<td>Indicates the minimum value that can be represented by a long long type variable.</td>
</tr>
<tr>
<td></td>
<td>ULLONG_MAX</td>
<td>18446744073709551615U LL</td>
<td>Indicates the maximum value that can be represented by an unsigned long long type variable.</td>
</tr>
</tbody>
</table>

Notes 1. Indicates the value that can be represented by a variable when the signed_char option is specified.
### 7.4.6 `<errno.h>`

Defines the value to be set in `errno` when an error is generated in a library function. The following macro names are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>errno</td>
<td>int type variable. An error number is set when an error is generated in a library function.</td>
</tr>
<tr>
<td>Constant</td>
<td>ERANGE</td>
<td>Refer to section 10.5.6, Standard Library Error Messages.</td>
</tr>
<tr>
<td></td>
<td>EDOM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ESTRN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PTRERR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECBASE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ETLN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEXP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEXPN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EFLOATO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EFLOATU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EDBLO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EDBLU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ELDBLO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ELDBLU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NOTOPN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EBADF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECSPEC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EFIXEDO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EFIXEDU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EACCUMO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EACCUMU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EILSEQ</td>
<td></td>
</tr>
</tbody>
</table>
7.4.7 \texttt{<math.h>}

Performs various mathematical operations. The following constants (macros) are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (macro)</td>
<td>EDOM</td>
<td>Indicates the value to be set in \texttt{errno} if the value of a parameter input to a function is outside the range of values defined in the function.</td>
</tr>
<tr>
<td></td>
<td>ERANGE</td>
<td>Indicates the value to be set in \texttt{errno} if the result of a function cannot be represented as a \texttt{double} type value, or if an overflow or an underflow occurs.</td>
</tr>
<tr>
<td></td>
<td>HUGE_VAL</td>
<td>Indicates the value for the function return value if the result of a function overflows.</td>
</tr>
<tr>
<td></td>
<td>HUGE_VALF</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>HUGE_VALL</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>INFINITY</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>NAP</td>
<td>Defined when float-type \texttt{qNaN} is supported.</td>
</tr>
<tr>
<td></td>
<td>FP_INFINITE</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_NAN</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_NORMAL</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_SUBNORMAL</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_ZERO</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_FAST_FMA</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_FAST_FMAF</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FFP_FAST_FMAFL</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_ILOGBO</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>FP_ILOGBNAN</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>MATH_ERRNO</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>MATH_ERREXCEPT</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>math_errhandling</td>
<td>lang=c99</td>
</tr>
<tr>
<td>Type</td>
<td>float_t</td>
<td>lang=c99</td>
</tr>
<tr>
<td></td>
<td>double_t</td>
<td>lang=c99</td>
</tr>
</tbody>
</table>

These indicate exclusive types of floating-point values.

Defined when the \texttt{fma} function is executed at the same or higher speed than a multiplication and an addition with \texttt{double}-type operands.

These are expanded to an integer constant expression of the value returned by \texttt{ilogb} when they are 0 or not-a-number, respectively.

These are expanded to integer constants 1 and 2, respectively.

Expanded to an int-type expression whose value is a bitwise logical OR of \texttt{MATH_ERRNO} and \texttt{MATH_ERREXCEPT}.

These are floating-point types having the same width as float and double, respectively.
### Function (macro)

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fpclassify  &lt;lang=c99&gt;</td>
<td>Classifies argument values into not-a-number, infinity, normalized number,</td>
</tr>
<tr>
<td></td>
<td>isfinite       &lt;lang=c99&gt;</td>
<td>Determines whether the argument is a finite value.</td>
</tr>
<tr>
<td></td>
<td>isinf          &lt;lang=c99&gt;</td>
<td>Determines whether the argument is infinity.</td>
</tr>
<tr>
<td></td>
<td>isnan         &lt;lang=c99&gt;</td>
<td>Determines whether the argument is a not-a-number.</td>
</tr>
<tr>
<td></td>
<td>isnormal      &lt;lang=c99&gt;</td>
<td>Determines whether the argument is a normalized number.</td>
</tr>
<tr>
<td></td>
<td>signbit       &lt;lang=c99&gt;</td>
<td>Determines whether the sign of the argument is negative.</td>
</tr>
<tr>
<td></td>
<td>isgreater      &lt;lang=c99&gt;</td>
<td>Determines whether the first argument is greater than the second argument.</td>
</tr>
<tr>
<td></td>
<td>isgreaterequal &lt;lang=c99&gt;</td>
<td>Determines whether the first argument is equal to or greater than the second</td>
</tr>
<tr>
<td></td>
<td>isless         &lt;lang=c99&gt;</td>
<td>Determines whether the first argument is smaller than the second argument.</td>
</tr>
<tr>
<td></td>
<td>islessequal    &lt;lang=c99&gt;</td>
<td>Determines whether the first argument is equal to or smaller than the second</td>
</tr>
<tr>
<td></td>
<td>islessgreater  &lt;lang=c99&gt;</td>
<td>Determines whether the first argument is smaller or greater than the second</td>
</tr>
<tr>
<td></td>
<td>isunordered    &lt;lang=c99&gt;</td>
<td>Determines whether the arguments are not ordered.</td>
</tr>
</tbody>
</table>

### Function

<p>|          | acos / acosf / acosl              | Calculates the arc cosine of a floating-point number.                        |
|          | asin / asinf / asinl              | Calculates the arc sine of a floating-point number.                           |
|          | atan / atanf / atanl              | Calculates the arc tangent of a floating-point number.                        |
|          | atan2 / atan2f / atan2l            | Calculates the arc tangent of the result of a division of two floating-point  |
|          | cos / cosf / cosl                  | Calculates the cosine of a floating-point radian value.                       |
|          | sin / sinf / sinl                  | Calculates the sine of a floating-point radian value.                         |
|          | tan / tanf / tanl                  | Calculates the tangent of a floating-point radian value.                      |
|          | cosh / coshf / coshl               | Calculates the hyperbolic cosine of a floating-point number.                 |
|          | sinh / sinhf / sinhl                | Calculates the hyperbolic sine of a floating-point number.                   |
|          | tanh / tanhf / tanhl                | Calculates the hyperbolic tangent of a floating-point number.                |
|          | exp / expf / expl                  | Calculates the exponential function of a floating-point number.              |
|          | frexp / frexpf / frexpl             | Breaks a floating-point number into a [0.5, 1.0) value and a power of 2.      |
|          | ldexp / ldexpf / ldexpl            | Multiplies a floating-point number by a power of 2.                           |
|          | log / logf / logl                  | Calculates the natural logarithm of a floating-point number.                 |
|          | log10 / log10f / log10l             | Calculates the base-ten logarithm of a floating-point number.                |
|          | modf / modff / modfl                | Breaks a floating-point number into integral and fractional parts.           |
|          | pow / powf / powl                  | Calculates a power of a floating-point number.                               |
|          | sqrt / sqrtf / sqrtl               | Calculates the positive square root of a floating-point number.              |</p>
<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>ceil / ceilf / ceill</td>
<td>Calculates the smallest integral value not less than or equal to the given floating-point number.</td>
</tr>
<tr>
<td></td>
<td>fabs / fabsf / fabsl</td>
<td>Calculates the absolute value of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>floor / floorf / floorl</td>
<td>Calculates the largest integral value not greater than or equal to the given floating-point number.</td>
</tr>
<tr>
<td></td>
<td>fmod / fmodf / fmodl</td>
<td>Calculates the remainder of a division of two floating-point numbers.</td>
</tr>
<tr>
<td></td>
<td>acosh / acoshf / acoshl</td>
<td>Calculates the hyperbolic arc cosine of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>asinh / asinhf / asinhl</td>
<td>Calculates the hyperbolic arc sine of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>atanh / atanhf / atanhl</td>
<td>Calculates the hyperbolic arc tangent of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>exp2 / exp2f / exp2l</td>
<td>Calculates the value of 2 raised to the power (x).</td>
</tr>
<tr>
<td></td>
<td>expm1 / expm1f / expm1l</td>
<td>Calculates the natural logarithm raised to the power (x) and subtracts 1 from the result.</td>
</tr>
<tr>
<td></td>
<td>ilogb / ilogbf / ilogbl</td>
<td>Extracts the exponent of (x) as a signed int value.</td>
</tr>
<tr>
<td></td>
<td>log1p / log1pf / log1pl</td>
<td>Calculates the natural logarithm of the argument + 1.</td>
</tr>
<tr>
<td></td>
<td>log2 / log2f / log2l</td>
<td>Calculates the base-2 logarithm.</td>
</tr>
<tr>
<td></td>
<td>logb / logbf / logbl</td>
<td>Extracts the exponent of (x) as a signed integer.</td>
</tr>
<tr>
<td></td>
<td>scalbn / scalbnf / scalbln / scalbnf / scalblnl</td>
<td>Calculates (x \times \text{FLT_RADXn}).</td>
</tr>
<tr>
<td></td>
<td>cbrt / cbrtf / cbrtl</td>
<td>Calculates the cube root of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>hypot / hypotf / hypotl</td>
<td>Calculates the square root of the sum of squares of two parameters (\sqrt{x^2 + y^2}).</td>
</tr>
<tr>
<td></td>
<td>erf / erff / erfl</td>
<td>Calculates the error function.</td>
</tr>
<tr>
<td></td>
<td>erfc / erfcf / erfcfl</td>
<td>Calculates the complementary error function.</td>
</tr>
<tr>
<td></td>
<td>lgamma / lgammaf / lgammal</td>
<td>Calculates the natural logarithm of the absolute value of the gamma function.</td>
</tr>
<tr>
<td></td>
<td>tgamma / tgammaf / tgammal</td>
<td>Calculates the gamma function.</td>
</tr>
<tr>
<td></td>
<td>nearbyint / nearbyintf / nearbyintl</td>
<td>Rounds a floating-point number to an integer in the floating-point representation according to the current rounding direction.</td>
</tr>
<tr>
<td></td>
<td>rint / rintf / rintl</td>
<td>Equivalent to \texttt{nearbyint} except that this function group may generate floating-point exception.</td>
</tr>
</tbody>
</table>
Operation in the event of an error is described below.

1. **Domain error**
   A domain error occurs if the value of a parameter input to a function is outside the domain over which the mathematical function is defined. In this case, the value of `EDOM` is set in `errno`. The function return value in implementation-defined.

2. **Range error**
   A range error occurs if the result of a function cannot be represented as a value of the double type. In this case, the value of `ERANGE` is set in `errno`. If the result overflows, the function returns the value of `HUGE_VAL`, `HUGE_VALF`, or `HUGE_VALL` with the same sign as the correct value of the function. If the result underflows, 0 is returned as the return value.

**Notes**

1. If there is a possibility of a domain error resulting from a `<math.h>` function call, it is dangerous to use the resultant value directly. The value of `errno` should always be checked before using the result in such cases.

---

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>lrint / lrintf / lrintl / lrintf / lrintl</td>
<td>ROUNDS A FLOATING-POINT NUMBER TO THE NEAREST INTEGER ACCORDING TO THE ROUNDING DIRECTION.</td>
</tr>
<tr>
<td></td>
<td>round / roundf / roundl</td>
<td>ROUNDS A FLOATING-POINT NUMBER TO THE NEAREST INTEGER IN THE FLOATING-POINT REPRESENTATION.</td>
</tr>
<tr>
<td></td>
<td>lround / lroundf / lroundl / lroundf / lround</td>
<td>ROUNDS A FLOATING-POINT NUMBER TO THE NEAREST INTEGER.</td>
</tr>
<tr>
<td></td>
<td>trunc / truncf / truncl</td>
<td>ROUNDS A FLOATING-POINT NUMBER TO THE NEAREST INTEGER IN THE FLOATING-POINT REPRESENTATION.</td>
</tr>
<tr>
<td></td>
<td>remainder / remainderf / remainderl</td>
<td>CALCULATES REMAINDER X REM Y SPECIFIED IN THE IEEE60559 STANDARD.</td>
</tr>
<tr>
<td></td>
<td>copysign / copysignf / copysignl</td>
<td>GENERATES A VALUE CONSISTING OF THE GIVEN ABSOLUTE VALUE AND SIGN.</td>
</tr>
<tr>
<td></td>
<td>nan / nanf / nanl</td>
<td>nan(“n string”) IS EQUIVALENT TO (“NAN(n string)”, (char**) NULL).</td>
</tr>
<tr>
<td></td>
<td>nextafter / nextafterf / nextafterl</td>
<td>CONVERTS A FLOATING-POINT NUMBER TO THE TYPE OF THE FUNCTION AND CALCULATES THE REPRESENTABLE VALUE FOLLOWING THE CONVERTED NUMBER ON THE REAL AXIS.</td>
</tr>
<tr>
<td></td>
<td>nexttoward / nexttowardf / nexttowardl</td>
<td>EQUIVALENT TO THE NEXTAFTER FUNCTION GROUP EXCEPT THAT THE SECOND ARGUMENT IS OF TYPE LONG DOUBLE AND RETURNS THE SECOND ARGUMENT AFTER CONVERSION TO THE TYPE OF THE FUNCTION.</td>
</tr>
<tr>
<td></td>
<td>fdim / fdimf / fdiml</td>
<td>CALCULATES THE POSITIVE DIFFERENCE.</td>
</tr>
<tr>
<td></td>
<td>fmax / fmaxf / fmaxl</td>
<td>OBTAINS THE GREATER OF TWO VALUES.</td>
</tr>
<tr>
<td></td>
<td>fmin / fminf / fminl</td>
<td>OBTAINS THE SMALLER OF TWO VALUES.</td>
</tr>
<tr>
<td></td>
<td>fma / fmaf / faml</td>
<td>CALCULATES (D1 * D2) + D3 AS A SINGLE TERNARY OPERATION.</td>
</tr>
</tbody>
</table>
In line 1, the arc sine value is computed using the `asin` function. If the value of argument `a` is outside the `asin` function domain [–1.0, 1.0], the `EDOM` value is set in `errno`. Line 2 determines whether a domain error has occurred. If a domain error has occurred, `error` is output in line 3. If there is no domain error, the arc sine value is output in line 5.

**Notes 2.** Whether or not a range error occurs depends on the internal representation format of floating-point types determined by the compiler. For example, if an internal representation format that allows an infinity to be represented as a value is used, `<math.h>` library functions can be implemented without causing range errors.

### Implementation-Defined Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Compiler Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value returned by a mathematical function if an input argument is out of the range</td>
<td>A not-a-number is returned. For details on the format of not-a-numbers, refer to section &quot;(5) Floating-Point Number Specifications&quot; in &quot;4.1.5 Internal Data Representation and Areas&quot;.</td>
</tr>
<tr>
<td>Whether <code>errno</code> is set to the value of macro <code>ERANGE</code> if an underflow error occurs in a mathematical function</td>
<td>For the functions that set <code>errno</code> to the value of <code>ERANGE</code>, see &quot;10.5.6 Standard Library Error Messages&quot;. The other functions do not set <code>errno</code> to <code>ERANGE</code>.</td>
</tr>
<tr>
<td>Whether a range error occurs if the second argument in the <code>fmod</code> function is 0</td>
<td>A range error occurs. For details of the return value from <code>fmod</code>, see &quot;fmod / fmodf / fmodl&quot; in &quot;7.4.7 &lt;math.h&gt;&quot;.</td>
</tr>
</tbody>
</table>
acos / acosl

Calculates the arc cosine of a floating-point number.

[Format]

#include <math.h>
double acos (double d);
float acosf (float d);
long double acosl (long double d);

[Parameters]

d  Floating-point number for which arc cosine is to be computed

[Return values]

Normal: Arc cosine of d
Abnormal: Domain error: Returns not-a-number.

[Remarks]

A domain error occurs for a value of d not in the range [–1.0, +1.0].
The acos function returns the arc cosine in the range [0, π] by the radian.
### asin / asinf / asinl

Calculates the arc sine of a floating-point number.

**[Format]**

```c
#include <math.h>
double asin (double d);
float asinf (float d);
long double asinl (long double);
```

**[Parameters]**

- **d**: Floating-point number for which arc sine is to be computed

**[Return values]**

- **Normal**: Arc sine of d
- **Abnormal**: Domain error: Returns not-a-number.

**[Remarks]**

A domain error occurs for a value of d not in the range \([-1.0, +1.0]\).
The asin function returns the arc sine in the range \([-\pi/2, +\pi/2]\) by the radian.
Calculates the arc tangent of a floating-point number.

[Format]
#include <math.h>
double atan (double d);
float atanf (float d);
long double atanl (long double d);

[Parameters]
d Floating-point number for which arc tangent is to be computed

[Return values]
Arc tangent of d

[Remarks]
The atan function returns the arc tangent in the range (–π/2, +π/2) by the radian.
atan2 / atan2f / atan2l

Calculates the arc tangent of the division of two floating-point numbers.

[Format]

#include <math.h>
double atan2 (double y, double x);
float atan2f (float y, float x);
long double atan2l (long double y, long double x);

[Parameters]

x  Divisor
y  Dividend

[Return values]

Normal: Arc tangent value when y is divided by x
Abnormal: Domain error: Returns not-a-number.

[Remarks]

A domain error occurs if the values of both x and y are 0.0.
The atan2 function returns the arc tangent in the range (–π, +π) by the radian. The meaning of the atan2 function is illustrated in Figure 7.1. As shown in the figure, the result of the atan2 function is the angle between the X-axis and a straight line passing through the origin and point (x, y).
If y = 0.0 and x is negative, the result is π. If x = 0.0, the result is ±π/2, depending on whether y is positive or negative.

Figure 7.1  Meaning of atan2 Function

![Diagram of atan2 function](image-url)
Calculates the cosine of a floating-point radian value.

[Format]
```
#include <math.h>
double cos (double d);
float cosf (float d);
long double cosl (long double d);
```

[Parameters]
- `d` Radian value for which cosine is to be computed

[Return values]
- Cosine of `d`
**sin / sinf / sinl**

Calculates the sine of a floating-point radian value.

**[Format]**

```c
#include <math.h>
double sin (double d);
float sinf (float d);
long double sinl (long double d);
```

**[Parameters]**

- `d` Radian value for which sine is to be computed

**[Return values]**

- Sine of `d`
Calculates the tangent of a floating-point radian value.

[Format]

```
#include <math.h>
double tan (double d);
float tanf (float d);
long double tanl (long double d);
```

[Parameters]

d  Radian value for which tangent is to be computed

[Return values]

Tangent of d
cosh / coshf / coshl

Calculates the hyperbolic cosine of a floating-point number.

[Format]

```c
#include <math.h>
double cosh (double d);
float coshf (float d);
long double coshl (long double d);
```

[Parameters]

- `d` Floating-point number for which hyperbolic cosine is to be computed

[Return values]

- Hyperbolic cosine of `d`
Calculates the hyperbolic sine of a floating-point number.

**Format**

```c
#include <math.h>
double sinh (double d);
float sinhf (float d);
long double sinhl (long double d);
```

**Parameters**

- `d` Floating-point number for which hyperbolic sine is to be computed

**Return values**

Hyperbolic sine of `d`
Calculates the hyperbolic tangent of a floating-point number.

[Format]
#include <math.h>
double tanh (double d);
float tanhf (float d);
long double tanhl (long double d);

[Parameters]

d  Floating-point number for which hyperbolic tangent is to be computed

[Return values]

Hyperbolic tangent of d
exp / expf / expl

Calculates the exponential function of a floating-point number.

[Format]
#include <math.h>
double exp (double d);
float expf (float d);
long double expl (long double d);

[Parameters]
 d Floating-point number for which exponential function is to be computed

[Return values]
 Exponential function value of d
frexp / frexpf / frexpl

Breaks a floating-point number into a [0.5, 1.0) value and a power of 2.

[Format]

```
#include <math.h>
double frexp (double value, long *exp);
float frexpf (float value, long * exp);
long double frexpl (long double value, long *exp);
```

[Parameters]

- value  Floating-point number to be broken into a [0.5, 1.0) value and a power of 2
- exp  Pointer to storage area that holds power-of-2 value

[Return values]

- If value is 0.0: 0.0
- If value is not 0.0: Value of ret defined by ret \( \times 2^{\text{value pointed to by exp}} \) = value

[Remarks]

- The frexp function breaks value into a [0.5, 1.0) value and a power of 2. It stores the resultant power-of-2 value in the area pointed to by exp.
- The frexp function returns the return value ret in the range [0.5, 1.0) or as 0.0.
- If value is 0.0, the contents of the int storage area pointed to by exp and the value of ret are both 0.0.
Multiplies a floating-point number by a power of 2.

**[Format]**

```
#include <math.h>
double ldexp (double e, long f);
float ldexpf (float e, long f);
long double ldexpl (long double e, long f);
```

**[Parameters]**

- e  Floating-point number to be multiplied by a power of 2
- f  Power-of-2 value

**[Return values]**

Result of e * 2^f operation
Calculates the natural logarithm of a floating-point number.

[Format]

```c
#include <math.h>
double log (double d);
float logf (float d);
long double logl (long double d);
```

[Parameters]

- **d**  Floating-point number for which natural logarithm is to be computed

[Return values]

- Normal: Natural logarithm of d
- Abnormal: Domain error: Returns not-a-number.

[Remarks]

- A domain error occurs if d is negative.
- A range error occurs if d is 0.0.
Calculates the base-ten logarithm of a floating-point number.

[Format]
```c
#include <math.h>
double log10 (double d);
float log10f(float d);
long double log10l(long double d);
```

[Parameters]
- d  Floating-point number for which base-ten logarithm is to be computed

[Return values]
- Normal: Base-ten logarithm of d
- Abnormal: Domain error: Returns not-a-number.

[Remarks]
- A domain error occurs if d is negative.
- A range error occurs if d is 0.0.
modf / modff / modfl

Breaks a floating-point number into integral and fractional parts.

[Format]

```c
#include <math.h>
double modf (double a, double *b);
float modff (float a, float *b);
long double modfl (long double a, long double *b);
```

[Parameters]

- `a` Floating-point number to be broken into integral and fractional parts
- `b` Pointer indicating storage area that stores integral part

[Return values]

- Fractional part of `a`
 Calculates a power of floating-point number.

[Format]

#include <math.h>
double pow (double x, double y);
float powf (float x, float y);
long double powl (long double x, long double y);

[Parameters]

  x  Value to be raised to a power
  y  Power value

[Return values]

  Normal: Value of x raised to the power y
  Abnormal: Domain error: Returns not-a-number.

[Remarks]

  A domain error occurs if x is 0.0 and y is 0.0 or less, or if x is negative and y is not an integer.
Calculates the positive square root of a floating-point number.

[Format]

#include <math.h>

double sqrt (double d);
float sqrtf (float d);
long double sqrtl (long double d);

[Parameters]

d  Floating-point number for which positive square root is to be computed

[Return values]

Normal: Positive square root of d
Abnormal: Domain error: Returns not-a-number.

[Remarks]

A domain error occurs if d is negative.
Returns the smallest integral value not less than or equal to the given floating-point number.

[Format]

```c
#include <math.h>
double ceil (double d);
float ceilf (float d);
long double ceill (long double d);
```

[Parameters]

- **d**  Floating-point number for which smallest integral value not less than that number is to be computed

[Return values]

- Smallest integral value not less than or equal to **d**

[Remarks]

The `ceil` function returns the smallest integral value not less than or equal to **d**, expressed as a double type value. Therefore, if **d** is negative, the value after truncation of the fractional part is returned.
Calculates the absolute value of a floating-point number.

**[Format]**

```c
#include <math.h>
double fabs (double d);
float fabsf (float d);
long double fabsl (long double d);
```

**[Parameters]**

d  Floating-point number for which absolute value is to be computed

**[Return values]**

Absolute value of d
Returns the largest integral value not greater than or equal to the given floating-point number.

**[Format]**

```c
#include <math.h>
double floor (double d);
float floorf (float d);
long double floorl (long double d);
```

**[Parameters]**

- `d` Floating-point number for which largest integral value not greater than that number is to be computed

**[Return values]**

Largest integral value not greater than or equal to `d`

**[Remarks]**

The `floor` function returns the largest integral value not greater than or equal to `d`, expressed as a double type value. Therefore, if `d` is negative, the value after rounding-up of the fractional part is returned.
fmod / fmodf / fmodl

Calculates the remainder of a division of two floating-point numbers.

[Format]

#include <math.h>
double fmod (double x, double y);
float fmodf (float x, float y);
long double fmodl (long double x, long double y);

[Parameters]

x  Dividend
y  Divisor

[Return values]

When y is 0.0: x
When y is not 0.0: Remainder of division of x by y
When y is ±∞: Returns x.
When x is ±∞ or y is 0: Returns not-a-number and sets global variable errno to the value of macro EDOM.

[Remarks]

In the fmod function, the relationship between parameters x and y and return value ret is as follows:

x = y \times i + ret (where i is an integer)

The sign of return value ret is the same as the sign of x.
If the quotient of x/y cannot be represented, the value of the result is not guaranteed.
Calculates the hyperbolic arc cosine of a floating-point number.

**[Format]**

```c
#include <math.h>
double acosh(double d);
float acoshf(float d);
long double acoshl(long double d);
```

**[Parameters]**

- `d` Floating-point number for which hyperbolic arc cosine is to be computed

**[Return values]**

- **Normal:** Hyperbolic arc cosine of `d`
- **Abnormal:** Domain error: Returns NaN.

Error conditions: A domain error occurs when `d` is smaller than 1.0.

**[Remarks]**

The `acosh` function returns the hyperbolic arc cosine in the range `[0, +∞]`. 
asinh / asinhf / asinhl

Calculates the hyperbolic arc sine of a floating-point number.

[Format]
#include <math.h>
double asinh(double d);
float asinhf(float d);
long double asinhl(long double d);

[Parameters]
  d  Floating-point number for which hyperbolic arc sine is to be computed

[Return values]
  Hyperbolic arc sine of d
Calculates the hyperbolic arc tangent of a floating-point number.

[Format]

```c
#include <math.h>
double atanh(double d);
float atanhf(float d);
long double atanhl(long double d);
```

[Parameters]

d  Floating-point number for which hyperbolic arc tangent is to be computed

[Return values]

Normal: Hyperbolic arc tangent of d
Abnormal: Domain error: Returns HUGE_VAL, HUGE_VALF, or HUGE_VALL depending on the function.
Range error: Returns not-a-number.

[Remarks]

A domain error occurs for a value of d not in the range [–1, +1]. A range error may occur for a value of d equal to –1 or 1.
## exp2 / exp2f / exp2l

Calculates the value of 2 raised to the power d.

### Format

```c
#include <math.h>
double exp2(double d);
float exp2f(float d);
long double exp2l(long double d);
```

### Parameters

- `d` Floating-point number for which exponential function is to be computed

### Return values

- **Normal**: Exponential function value of 2
- **Abnormal**: Range error: Returns 0, or returns +HUGE_VAL, +HUGE_VALF, or +HUGE_VALL depending on the function

### Remarks

A range error occurs if the absolute value of d is too large.
expm1 / expm1f / expm1l

Calculates the value of natural logarithm base e raised to the power d and subtracts 1 from the result.

[Format]

#include <math.h>
double expm1(double d);
float expm1f(float d);
long double expm1l(long double d);

[Parameters]

d  Power value to which natural logarithm base e is to be raised

[Return values]

Normal: Value obtained by subtracting 1 from natural logarithm base e raised to the power d
Abnormal: Range error: Returns -HUGE_VAL, -HUGE_VALF, or -HUGE VALL depending on the function.

[Remarks]

expm1(d) provides more accurate calculation than exp(x) – 1 even when d is near to 0.
**ilogb / ilogbf / ilogbl**

Extracts the exponent of d.

**[Format]**

```c
#include <math.h>
long ilogb(double d);
long ilogbf(float d);
long ilogbl(long double d);
```

**[Parameters]**

- `d`  Value of which exponent is to be extracted

**[Return values]**

- Normal: Exponential function value of d
  - `d` is \( \infty \): INT_MAX
  - `d` is not-a-number: FP_ILOGBNAN
  - `d` is 0: FP_ILOGBNAN
- Abnormal: `d` is 0 and a range error has occurred: FP_ILOGB0

**[Remarks]**

A range error may occur if `d` is 0.
**log1p / log1pf / log1pl**

Calculates the natural logarithm (base e) of d + 1.

**[Format]**

```c
#include <math.h>
double log1p(double d);
float log1pf(float d);
long double log1pl(long double d);
```

**[Parameters]**

- **d** Value for which the natural logarithm of this parameter + 1 is to be computed

**[Return values]**

- Normal: Natural logarithm of d + 1
- Abnormal: Domain error: Returns not-a-number.
  - Range error: Returns –HUGE_VAL, –HUGE_VALF, or –HUGE_VALL depending on the function.

**[Remarks]**

- A domain error occurs if d is smaller than –1.
- A range error occurs if d is –1.
- `log1p(d)` provides more accurate calculation than `log(1+d)` even when d is near to 0.
Calculates the base-2 logarithm of d.

**[Format]**

```c
#include <math.h>
double log2(double d);
float log2f(float d);
long double log2l(long double d);
```

**[Parameters]**

- `d` Value of which logarithm is to be calculated

**[Return values]**

- Normal: Base-2 logarithm of d
- Abnormal: Domain error: Returns not-a-number.

**[Remarks]**

A domain error occurs if d is a negative value.
logb / logbf / logbl

Extracts the exponent of d in internal floating-point representation, as a floating-point value.

[Format]

#include <math.h>
double logb(double d);
float logbf(float d);
long double logbl(long double d);

[Parameters]

d  Value of which exponent is to be extracted

[Return values]

Normal: Signed exponent of d
Abnormal: Range error: Returns –HUGE_VAL, –HUGE_VALF, or –HUGE_VALL depending on the function.

[Remarks]

A range error may occur if d is 0.
d is always assumed to be normalized.
Calculates a floating-point number multiplied by a power of radix, which is an integer.

[Format]

```c
#include <math.h>
double scalbn(double d, long e);
float scalbnf(float d, long e);
long double scalbnl(long double d, long e);
double scalbln(double d, long e);
float scalblnf(float d, long int e);
long double scalblnl(long double d, long int e);
```

[Parameters]

- `d`: Value to be multiplied by FLT_RADIX raised to the power `e`
- `e`: Exponent used to compute a power of FLT_RADIX

[Return values]

- Normal: Value equal to `d` multiplied by FLT_RADIX
- Abnormal: Range error: Returns –HUGE_VAL, –HUGE_VALF, or –HUGE_VALL depending on the function.

[Remarks]

- A range error may occur if `d` is 0.
- FLT_RADIX raised to the power `e` is not actually calculated.
Calculates the cube root of a floating-point number.

[Format]

```c
#include <math.h>
double cbrt(double d);
float cbrtf(float d);
long double cbrtl(long double d);
```

[Parameters]

- `d` Value for which a cube root is to be computed

[Return values]

Cube root of `d`
Calculates the square root of the sum of squares of floating-point values \( \sqrt{x^2 + y^2} \).

[Format]

```c
#include <math.h>
double hypot(double x, double y);
float hypotf(float x, float y);
long double hypotl(long double x, long double y);
```

[Parameters]

\(x, y\) Values for which the square root of the sum of squares of two parameters \(\sqrt{x^2 + y^2}\) is to be calculated.

[Return values]

Normal: Square root of the sum of squares of two parameters \(\sqrt{x^2 + y^2}\)
Abnormal: Range error: Returns HUGE_VAL, HUGE_VALF, or HUGE_VALL depending on the function.

[Remarks]

A range error may occur if the result overflows.
erf / erff / erfl

Calculates the error function value of a floating-point number.

[Format]

```c
#include <math.h>
double erf(double d);
float erff(float d);
long double erfl(long double d);
```

[Parameters]

- d Value for which the error function value is to be computed

[Return values]

- Error function value of d
erfc / erfcf / erfcl

Calculates the complementary error function value of a floating-point number.

[Format]

#include <math.h>
double erfc(double d);
float erfcf(float d);
long double erfcl(long double d);

[Parameters]

d Value for which the complementary error function value is to be computed

[Return values]

Complementary error function value of d

[Remarks]

A range error occurs if the absolute value of d is too large.
Calculates the logarithm of the gamma function of a floating-point number.

[Format]

```c
#include <math.h>
double lgamma(double d);
float lgammaf(float d);
long double lgammal(long double d);
```

[Parameters]

- `d` Value for which the logarithm of the gamma function is to be computed

[Return values]

- Normal: Logarithm of gamma function of `d`
- Abnormal: Domain error: Returns HUGE_VAL, HUGE_VALF, or HUGE_VALL with the mathematically correct sign.
- Range error: Returns +HUGE_VAL, +HUGE_VALF, or +HUGE_VALL.

[Remarks]

A range error is set if the absolute value of `d` is too large or small.
A domain error occurs if `d` is a negative integer or 0 and the calculation result is not representable.
tgamma / tgammaf / tgammal

Calculates the gamma function of a floating-point number.

[Format]
#include <math.h>
double tgamma(double d);
float tgammaf(float d);
long double tgammal(long double d);

[Parameters]
d Value for which the gamma function value is to be computed

[Return values]
Normal: Gamma function value of d
Abnormal: Domain error: Returns HUGE_VAL, HUGE_VALF, or HUGE_VALL with the same sign as that of d.
Range error: Returns 0, or returns +HUGE_VAL, +HUGE_VALF, or +HUGE_VALL with the mathematically correct sign depending on the function.

[Remarks]
A range error is set if the absolute value of d is too large or small.
A domain error occurs if d is a negative integer or 0 and the calculation result is not representable.
Rounds a floating-point number to an integer in the floating-point representation according to the current rounding direction.

[Format]

```c
#include <math.h>
double nearbyint(double d);
float nearbyintf(float d);
long double nearbyintl(long double d);
```

[Parameters]

- **d** Value to be rounded to an integer in the floating-point format

[Return values]

- **d** rounded to an integer in the floating-point format

[Remarks]

The nearbyint function group does not generate "inexact" floating-point exceptions.
**rint / rintf / rintl**

Rounds a floating-point number to an integer in the floating-point representation according to the current rounding direction.

**[Format]**

```c
#include <math.h>
double rint(double d);
float rintf(float d);
long double rintl(long double d);
```

**[Parameters]**

- `d` Value to be rounded to an integer in the floating-point format

**[Return values]**

- `d` rounded to an integer in the floating-point format

**[Remarks]**

The `rint` function group differs from the `nearbyint` function group only in that the `rint` function group may generate "inexact" floating-point exceptions.
Rounds a floating-point number to the nearest integer according to the current rounding direction.

[Format]

```c
#include <math.h>
long int lrint(double d);
long int lrintf(float d);
long int lrintl(long double d);
long long int llrint(double d);
long long int llrintf(float d);
long long int llrintl(long double d);
```

[Parameters]

- `d`: Value to be rounded to an integer

[Return values]

- Normal: `d` rounded to an integer
- Abnormal: Range error: Returns an undetermined value.

[Remarks]

A range error may occur if the absolute value of `d` is too large.
The return value is unspecified when the rounded value is not in the range of the return value type.
round / roundf / roundl

Rounds a floating-point number to the nearest integer in the floating-point representation.

[Format]

#include <math.h>
double round(double d);
float roundf(float d);
long double roundl(long double d);

[Parameters]

d  Value to be rounded to an integer

[Return values]

Normal: d rounded to an integer
Abnormal: Range error: Returns an undetermined value.

[Remarks]

A range error may occur if the absolute value of d is too large.
**lround / lroundf / lroundl / llround / llroundf / llroundl**

Rounds a floating-point number to the nearest integer.

**[Format]**

```c
#include <math.h>
long int lround(double d);
long int lroundf(float d);
long int lroundl(long double d);
long long int llround(double d);
long long int llroundf(float d);
long long int llroundl(long double d);
```

**[Parameters]**

- `d` Value to be rounded to an integer

**[Return values]**

- Normal: `d` rounded to an integer
- Abnormal: Range error: Returns an undetermined value.

**[Remarks]**

A range error may occur if the absolute value of `d` is too large.
When `d` is at the midpoint between two integers, the lround function group selects the integer farther from 0 regardless of the current rounding direction. The return value is unspecified when the rounded value is not in the range of the return value type.
trunc / truncf / truncl

Rounds a floating-point number to the nearest integer in the floating-point representation.

[Format]

```c
#include <math.h>
double trunc(double d);
float truncf(float d);
long double truncfl(long double d);
```

[Parameters]

- `d` Value to be rounded to an integer in the floating-point representation

[Return values]

- `d` truncated to an integer in the floating-point format

[Remarks]

The trunc function group rounds `d` so that the absolute value after rounding is not greater than the absolute value of `d`. 
Calculates the remainder of a division of two floating-point numbers.

[Format]

```c
#include <math.h>
double remainder(double d1, double d2);
float remainderf(float d1, float d2);
long double remainderl(long double d1, long double d2);
```

[Parameters]

d1, d2  Values for which remainder of a division is to be computed (d1 / d2)

[Return values]

Remainder of division of d1 by d2

[Remarks]

The remainder calculation by the remainder function group conforms to the IEEE 60559 standard.
remquo / remquof / remquol

Calculates the remainder of a division of two floating-point numbers.

[Format]

#include <math.h>
double remquo(double d1, double d2, long *q);
float remquof(float d1, float d2, long *q);
long double remquol(long double d1, long double d2, long *q);

[Parameters]

d1, d2  Values for which remainder of a division is to be computed (d1 / d2)
q  Value pointing to the location to store the quotient obtained by remainder calculation

[Return values]

Remainder of division of d1 by d2

[Remarks]

The value stored in the location indicated by q has the same sign as the result of x/y and the integral quotient of modulo-2n x/y (n is an implementation-defined integer equal to or greater than 3).
Generates a value consisting of the absolute value of \( d_1 \) and the sign of \( d_2 \).

**[Format]**

```c
#include <math.h>
double copysign(double d1, double d2);
float copysignf(float d1, float d2);
long double copysignl(long double d1, long double d2);
```

**[Parameters]**

- \( d_1 \) Value of which absolute value is to be used in the generated value
- \( d_2 \) Value of which sign is to be used in the generated value

**[Return values]**

- Normal: Value consisting of absolute value of \( d_1 \) and sign of \( d_2 \)
- Abnormal: Range error: Returns an undetermined value.

**[Remarks]**

When \( d_1 \) is a not-a-number, the `copysign` function group generates a not-a-number with the sign bit of \( d_2 \).
nan / nanf / nanl

Returns not-a-number.

[Format]

#include <math.h>
double nan(const char *c);
float nanf(const char *c);
long double nanl(const char *c);

[Parameters]

c  Pointer to a string

[Return values]

qNaN with the contents of the location indicated by c or 0 (when qNaN is not supported)

[Remarks]

The nan("c string") call is equivalent to strtod("NAN(c string)", (char**) NULL). The nanf and nanl calls are equivalent to the corresponding strtof and strtold calls, respectively.
Calculates the next floating-point representation following \(d_1\) in the direction to \(d_2\) on the real axis.

**[Format]**

```c
#include <math.h>
double nextafter(double d1, double d2);
float nextafterf(float d1, float d2);
long double nextafterl(long double d1, long double d2);
```

**[Parameters]**

- \(d_1\)  Floating-point value on the real axis
- \(d_2\)  Value indicating the direction viewed from \(d_1\), in which a representable floating-point value is to be found

**[Return values]**

- **Normal**: Representable floating-point value
- **Abnormal**: Range error: Returns HUGE_VAL, HUGE_VALF, or HUGE_VALL with the mathematically correct sign depending on the function.

**[Remarks]**

A range error may occur if \(d_1\) is the maximum finite value that can be represented in its type and the return value is an infinity or cannot be represented in its type.

The nextafter function group returns \(d_2\) when \(d_1\) is equal to \(d_2\).
nexttoward / nexttowardf / nexttowardl

Calculates the next floating-point representation following d1 in the direction to d2 on the real axis.

[Format]

```
#include <math.h>

double nexttoward(double d1, long double d2);
float nexttowardf(float d1, long double d2);
long double nexttowardl(long double d1, long double d2);
```

[Parameters]

- **d1** Floating-point value on the real axis
- **d2** Value indicating the direction viewed from d1, in which a representable floating-point value is to be found

[Return values]

- Normal: Representable floating-point value
- Abnormal: Range error: Returns HUGE_VAL, HUGE_VALF, or HUGE_VALL with the mathematically correct sign depending on the function

[Remarks]

A range error may occur if d1 is the maximum finite value that can be represented in its value and the return value is an infinity or cannot be represented in its type.

The nexttoward function group is equivalent to the nextafter function group except that d2 is of type long double and returns d2 after conversion depending of the function when d1 is equal to d2.
Calculates the positive difference between two arguments.

[Format]

```c
#include <math.h>
double fdim(double d1, double d2);
float fdimf(float d1, float d2);
long double fdiml(long double d1, long double d2);
```

[Parameters]

- `d1, d2` Values of which difference is to be computed (`|d1 - d2|`)

[Return values]

- Normal: Positive difference between two arguments
- Abnormal: Range error: HUGE_VAL, HUGE_VALF, or HUGE_VALL

[Remarks]

A range error may occur if the return value overflows.
Obtains the greater of two arguments.

[Format]

```
#include <math.h>
double fmax(double d1, double d2);
float fmaxf(float d1, float d2);
long double fmaxl(long double d1, long double d2);
```

[Parameters]

d1, d2  Values to be compared

[Return values]

Greater of two arguments

[Remarks]

The fmax function group recognizes a not-a-number as a lack of data. When one argument is a not-a-number and the other is a numeric value, the function returns the numeric value.
Obtains the smaller of two arguments.

**[Format]**

```c
#include <math.h>
double fmin(double d1, double d2);
float fminf(float d1, float d2);
long double fminl(long double d1, long double d2);
```

**[Parameters]**

- `d1, d2` Values to be compared

**[Return values]**

- Smaller of two arguments

**[Remarks]**

The `fmin` function group recognizes a not-a-number as a lack of data. When one argument is a not-a-number and the other is a numeric value, the function returns the numeric value.
fma / fmaf / fmal

Calculates \((d_1 \times d_2) + d_3\) as a single ternary operation.

[Format]

```c
#include <math.h>
double fma(double d1, double d2, double d3);
float fmaf(float d1, float d2, float d3);
long double fmal(long double d1, long double d2, long double d3);
```

[Parameters]

- d1, d2, d3  Floating-point values

[Return values]

Result of \((d_1 \times d_2) + d_3\) calculated as ternary operation

[Remarks]

The fma function group performs calculation as if infinite precision is available and rounds the result only one time in the rounding mode indicated by FLT_ROUNDS.
7.4.8 `<mathf.h>`

Performs various mathematical operations. `<mathf.h>` declares mathematical functions and defines macros in single-precision format. The mathematical functions and macros used here do not follow the ANSI specifications. Each function receives float-type arguments and returns a float-type value.

The following constants (macros) are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (macro)</td>
<td>EDOM</td>
<td>Indicates the value to be set in errno if the value of a parameter input to a function is outside the range of values defined in the function.</td>
</tr>
<tr>
<td></td>
<td>ERANGE</td>
<td>Indicates the value to be set in errno if the result of a function cannot be represented as a float type value, or if an overflow or an underflow occurs.</td>
</tr>
<tr>
<td></td>
<td>HUGE_VALF</td>
<td>Indicates the value for the function return value if the result of a function overflows.</td>
</tr>
<tr>
<td></td>
<td>HUGE_VAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HUGE_VALL</td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>acosf</td>
<td>Calculates the arc cosine of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>asinf</td>
<td>Calculates the arc sine of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>atanf</td>
<td>Calculates the arc tangent of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>atan2f</td>
<td>Calculates the arc tangent of the result of a division of two floating-point numbers.</td>
</tr>
<tr>
<td></td>
<td>cosf</td>
<td>Calculates the cosine of a floating-point radian value.</td>
</tr>
<tr>
<td></td>
<td>sinf</td>
<td>Calculates the sine of a floating-point radian value.</td>
</tr>
<tr>
<td></td>
<td>tanf</td>
<td>Calculates the tangent of a floating-point radian value.</td>
</tr>
<tr>
<td></td>
<td>coshf</td>
<td>Calculates the hyperbolic cosine of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>sinhf</td>
<td>Calculates the hyperbolic sine of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>tanhf</td>
<td>Calculates the hyperbolic tangent of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>expf</td>
<td>Calculates the exponential function of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>frexpf</td>
<td>Breaks a floating-point number into a ([0.5, 1.0)) value and a power of 2.</td>
</tr>
<tr>
<td></td>
<td>ldexpf</td>
<td>Multiplies a floating-point number by a power of 2.</td>
</tr>
<tr>
<td></td>
<td>logf</td>
<td>Calculates the natural logarithm of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>log10f</td>
<td>Calculates the base-ten logarithm of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>modff</td>
<td>Breaks a floating-point number into integral and fractional parts.</td>
</tr>
<tr>
<td></td>
<td>powf</td>
<td>Calculates a power of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>sqrtf</td>
<td>Calculates the positive square root of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>ceilf</td>
<td>Calculates the smallest integral value not less than or equal to the given floating-point number.</td>
</tr>
<tr>
<td></td>
<td>fabsf</td>
<td>Calculates the absolute value of a floating-point number.</td>
</tr>
<tr>
<td></td>
<td>floorf</td>
<td>Calculates the largest integral value not greater than or equal to the given floating-point number.</td>
</tr>
<tr>
<td></td>
<td>fmodf</td>
<td>Calculates the remainder of a division of two floating-point numbers.</td>
</tr>
</tbody>
</table>
Operation in the event of an error is described below.

(1) Domain error
A domain error occurs if the value of a parameter input to a function is outside the domain over which the mathematical function is defined. In this case, the value of **EDOM** is set in **errno**. The function return value in implementation-defined.

(2) Range error
A range error occurs if the result of a function cannot be represented as a **float** type value. In this case, the value of **ERANGE** is set in **errno**. If the result overflows, the function returns the value of **HUGE_VALF**, with the same sign as the correct value of the function. If the result underflows, 0 is returned as the return value.

Notes 1. If there is a possibility of a domain error resulting from a `<mathf.h>` function call, it is dangerous to use the resultant value directly. The value of **errno** should always be checked before using the result in such cases.

[Format]

```c
1  x=asinf(a);
2  if (errno==EDOM)
3      printf("error\n");
4  else
5      printf("result is : %f\n",x);
```

In line 1, the arc sine value is computed using the **asinf** function. If the value of argument **a** is outside the **asinf** function domain [−1.0, 1.0], the **EDOM** value is set in **errno**. Line 2 determines whether a domain error has occurred. If a domain error has occurred, error is output in line 3. If there is no domain error, the arc sine value is output in line 5.

Notes 2. Whether or not a range error occurs depends on the internal representation format of floating-point types determined by the compiler. For example, if an internal representation format that allows an infinity to be represented as a value is used, `<mathf.h>` library functions can be implemented without causing range errors.

### Implementation-Defined Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Compiler Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value returned by a mathematical function if an input argument is out of the range</td>
<td>A not-a-number is returned. For details on the format of not-a-numbers, refer to section 4.1.6 (5) Floating-Point Number Specifications.</td>
</tr>
<tr>
<td>Whether <strong>errno</strong> is set to the value of macro <strong>ERANGE</strong> if an underflow error occurs in a mathematical function</td>
<td>Not specified</td>
</tr>
<tr>
<td>Whether a range error occurs if the second argument in the <strong>fmodf</strong> function is 0</td>
<td>A range error occurs.</td>
</tr>
</tbody>
</table>
Calculates the arc cosine of a floating-point number.

[Format]

```c
#include <mathf.h>
float acosf (float f);
```

[Parameters]

- f Floating-point number for which arc cosine is to be computed

[Return values]

- Normal: Arc cosine of f
- Abnormal: Domain error: Returns not-a-number.

[Remarks]

A domain error occurs for a value of f not in the range [-1.0, +1.0]
The acosf function returns the arc cosine in the range [0, π] by the radian.
asinf

Calculates the arc sine of a floating-point number.

[Format]

```c
#include <mathf.h>
float asinf(float f);
```

[Parameters]

- f  Floating-point number for which arc sine is to be computed

[Return values]

- Normal: Arc sine of f
- Abnormal: Domain error: Returns not-a-number.

[Remarks]

- A domain error occurs for a value of f not in the range [-1.0, +1.0].
- The asinf function returns the arc sine in the range [-π/2, +π/2] by the radian.
Calculates the arc tangent of a floating-point number.

[Format]

```c
#include <mathf.h>
float atanf (float f);
```

[Parameters]

- f  Floating-point number for which arc tangent is to be computed

[Return values]

- Arc tangent of f

[Remarks]

The atanf function returns the arc tangent in the range \((-\pi/2, +\pi/2)\) by the radian.
**atan2f**

Calculates the arc tangent of the division of two floating-point numbers.

**[Format]**

```c
#include <mathf.h>
float atan2f (float y, float x);
```

**[Parameters]**

- **x** Divisor
- **y** Dividend

**[Return values]**

- **Normal**: Arc tangent value when `y` is divided by `x`
- **Abnormal**: Domain error: Returns not-a-number.
- **Error conditions**: A domain error occurs if the values of both `x` and `y` are 0.0.

**[Remarks]**

A domain error occurs if the values of both `x` and `y` are 0.0.

The `atan2f` function returns the arc tangent in the range (–π, +π) by the radian. The meaning of the `atan2f` function is illustrated in **Figure 7.2**. As shown in the figure, the result of the `atan2f` function is the angle between the X-axis and a straight line passing through the origin and point `(x, y)`.

If `y = 0.0` and `x` is negative, the result is π. If `x = 0.0`, the result is ±π/2, depending on whether `y` is positive or negative.

**Figure 7.2** Meaning of `atan2f` Function

![Diagram of atan2f function](image-url)
Calculates the cosine of a floating-point radian value.

**[Format]**

```c
#include <mathf.h>
float cosf(float f);
```

**[Parameters]**

- `f` Radian value for which cosine is to be computed

**[Return values]**

Cosine of `f`
Calculates the sine of a floating-point radian value.

[Format]
#include <math.h>
float sinf (float f);

[Parameters]
  f  Radian value for which sine is to be computed

[Return values]
  Sine of f
Calculates the tangent of a floating-point radian value.

[Format]
#include <mathf.h>
float tanf (float f);

[Parameters]
f  Radian value for which tangent is to be computed

[Return values]
Tangent of f
coshf

Calculates the hyperbolic cosine of a floating-point number.

[Format]

```
#include <mathf.h>
float coshf (float f);
```

[Parameters]

- `f` Floating-point number for which hyperbolic cosine is to be computed

[Return values]

Hyperbolic cosine of `f`
sinhf

Calculates the hyperbolic sine of a floating-point number.

[Format]
#include <mathf.h>
float sinhf (float f);

[Parameters]
  f  Floating-point number for which hyperbolic sine is to be computed

[Return values]
  Hyperbolic sine of f
tanhf

Calculates the hyperbolic tangent of a floating-point number.

[Format]

```c
#include <mathf.h>
float tanhf (float f);
```

[Parameters]

- `f` Floating-point number for which hyperbolic tangent is to be computed

[Return values]

Hyperbolic tangent of `f`
expf

Calculates the exponential function of a floating-point number.

[Format]
#include <mathf.h>
float expf (float f);

[Parameters]

f  Floating-point number for which exponential function is to be computed

[Return values]

Exponential function value of f
frexp

Breaks a floating-point number into a \([0.5, 1.0)\) value and a power of 2.

[Format]

```c
#include <mathf.h>
float frexpf (float value, float long *exp);
```

[Parameters]

- `value`  Floating-point number to be broken into a \([0.5, 1.0)\) value and a power of 2
- `exp` Pointer to storage area that holds power-of-2 value

[Return values]

- If value is 0.0: 0.0
- If value is not 0.0: Value of ret defined by \(ret \times 2^{value}\) pointed to by `exp` = value

[Remarks]

The `frexp` function breaks value into a \([0.5, 1.0)\) value and a power of 2. It stores the resultant power-of-2 value in the area pointed to by `exp`.

The `frexp` function returns the return value `ret` in the range \([0.5, 1.0)\) or as 0.0.

If value is 0.0, the contents of the int storage area pointed to by `exp` and the value of `ret` are both 0.0.
ldexpf

Multiplies a floating-point number by a power of 2.

[Format]

```c
#include <mathf.h>
float ldexpf (float e, long f);
```

[Parameters]

- `e` Floating-point number to be multiplied by a power of 2
- `f` Power-of-2 value

[Return values]

Result of `e * 2^f` operation
Calculates the natural logarithm of a floating-point number.

[Format]
#include <mathf.h>
float logf (float f);

[Parameters]

f  Floating-point number for which natural logarithm is to be computed

[Return values]
Normal: Natural logarithm of f
Abnormal: Domain error: Returns not-a-number.

[Remarks]
A domain error occurs if f is negative.
A range error occurs if f is 0.0.
Calculates the base-ten logarithm of a floating-point number.

[Format]
#include <mathf.h>
float log10f (float f);

[Parameters]
  f  Floating-point number for which base-ten logarithm is to be computed

[Return values]
  Normal: Base-ten logarithm of f
  Abnormal: Domain error: Returns not-a-number.

[Remarks]
  A domain error occurs if f is negative.
  A range error occurs if f is 0.0.
modff

Breaks a floating-point number into integral and fractional parts.

[Format]

```c
#include <mathf.h>
float modff (float a, float *b);
```

[Parameters]

a Floating-point number to be broken into integral and fractional parts
b Pointer indicating storage area that stores integral part

[Return values]

Fractional part of a
powf

Calculates a power of a floating-point number.

[Format]

```c
#include <mathf.h>
float powf(float x, float y);
```

[Parameters]

- x  Value to be raised to a power
- y  Power value

[Return values]

- Normal: Value of x raised to the power y
- Abnormal: Domain error: Returns not-a-number.

[Remarks]

A domain error occurs if x is 0.0 and y is 0.0 or less, or if x is negative and y is not an integer.
Calculates the positive square root of a floating-point number.

**[Format]**

```c
#include <mathf.h>
float sqrtf (float f);
```

**[Parameters]**

- `f` Floating-point number for which positive square root is to be computed

**[Return values]**

- Normal: Positive square root of `f`
- Abnormal: Domain error: Returns not-a-number.

**[Remarks]**

A domain error occurs if `f` is negative.
Returns the smallest integral value not less than or equal to the given floating-point number.

**[Format]**

```c
#include <mathf.h>
float ceilf (float f);
```

**[Parameters]**

- `f` Floating-point number for which smallest integral value not less than that number is to be computed

**[Return values]**

- Smallest integral value not less than or equal to f

**[Remarks]**

The `ceilf` function returns the smallest integral value not less than or equal to f, expressed as a float type value. Therefore, if f is negative, the value after truncation of the fractional part is returned.
calculates the absolute value of a floating-point number.

[Format]

```c
#include <mathf.h>
float fabsf (float f);
```

[Parameters]

- `f` Floating-point number for which absolute value is to be computed

[Return values]

- Absolute value of f
Returns the largest integral value not greater than or equal to the given floating-point number.

[Format]

```c
#include <mathf.h>
float floorf (float f);
```

[Parameters]

- f  Floating-point number for which largest integral value not greater than that number is to be computed

[Return values]

Largest integral value not greater than or equal to f

[Remarks]

The floorf function returns the largest integral value not greater than or equal to f, expressed as a float type value. Therefore, if f is negative, the value after rounding-up of the fractional part is returned.
fmodf

Calculates the remainder of a division of two floating-point numbers.

[Format]
#include <mathf.h>
float fmodf (float x, float y);

[Parameters]
  x  Dividend
  y  Divisor

[Return values]
  When y is 0.0: x
  When y is not 0.0: Remainder of division of x by y

[Remarks]
  In the fmodf function, the relationship between parameters x and y and return value ret is as follows:
  x = y * i + ret (where i is an integer)
  The sign of return value ret is the same as the sign of x.
  If the quotient of x/y cannot be represented, the value of the result is not guaranteed.
7.4.9 <setjmp.h>

Supports transfer of control between functions.
The following macros are implementation-defined.

<table>
<thead>
<tr>
<th>Type (macro)</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (macro)</td>
<td>jmp_buf</td>
<td>Indicates the type name corresponding to a storage area for storing information that enables transfer of control between functions.</td>
</tr>
<tr>
<td>Function</td>
<td>setjmp</td>
<td>Saves the execution environment defined by jmp_buf of the currently executing function in the specified storage area.</td>
</tr>
<tr>
<td></td>
<td>longjmp</td>
<td>Restores the function execution environment saved by the setjmp function, and transfers control to the program location at which the setjmp function was called.</td>
</tr>
</tbody>
</table>

The setjmp function saves the execution environment of the current function. The location in the program that called the setjmp function can subsequently be returned to by calling the longjmp function.

An example of how transfer of control between functions is supported using the setjmp and longjmp functions is shown below.

```
[Format]
1    #include <stdio.h>
2    #include <setjmp.h>
3    jmp_buf env;
4    void sub( );
5    void main( )
6    {
7        if (setjmp(env)!=0){
8            printf("return from longjmp\n");
9            exit(0);
10            sub( );
11        }
12         sub( );
13     }
14    void sub( )
15    {
16        printf("subroutine is running \n");
17        longjmp(env, 1);
18    }

Explanation:
The setjmp function is called in line 8. At this time, the environment in which the setjmp function was called is saved in jmp_buf type variable env. The return value in this case is 0, and therefore function sub is called next.
The environment saved in variable env is restored by the longjmp function called within function sub. As a result, the program behaves just as if a return had been made from the setjmp function in line 8. However, the return value at this time is 1 specified by the second argument of the longjmp function. As a result, execution proceeds to line 9.
**setjmp**

Saves the execution environment of the currently executing function in the specified storage area.

**[Format]**

```c
#include <setjmp.h>
long setjmp (jmp_buf env);
```

**[Parameters]**

- `env` Pointer to storage area in which execution environment is to be saved

**[Return values]**

- When `setjmp` function is called: 0
- On return from `longjmp` function: Nonzero

**[Remarks]**

The execution environment saved by the `setjmp` function is used by the `longjmp` function. The return value is 0 when the function is called as the `setjmp` function, but the return value on return from the `longjmp` function is the value of the second parameter specified by the `longjmp` function.

If the `setjmp` function is called from a complex expression, part of the current execution environment, such as the intermediate result of expression evaluation, may be lost. The `setjmp` function should only be used in the form of a comparison between the result of the `setjmp` function and a constant expression, and should not be called within a complex expression.

Do not call the `setjmp` function indirectly using a pointer.
Restores the function execution environment saved by the `setjmp` function, and transfers control to the program location at which the `setjmp` function was called.

[Format]

```c
#include <setjmp.h>
void longjmp (jmp_buf env, long ret);
```

[Parameters]

- `env` Pointer to storage area in which execution environment was saved
- `ret` Return code to `setjmp` function

[Remarks]

From the storage area specified by the first parameter `env`, the `longjmp` function restores the function execution environment saved by the most recent invocation of the `setjmp` function in the same program, and transfers control to the program location at which that `setjmp` function was called. The value of the second parameter `ret` of the `longjmp` function is returned as the `setjmp` function return value. However, if `ret` is 0, the value 1 is returned to the `setjmp` function as a return value.

If the `setjmp` function has not been called, or if the function that called the `setjmp` function has already executed a return statement, the operation of the `longjmp` function is not guaranteed.
7.4.10 <stdarg.h>

Enables referencing of variable arguments for functions with such arguments. The following macros are implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (macro)</td>
<td>va_list</td>
<td>Indicates the types of variables used in common by the va_start, va_arg, and va_end macros in order to reference variable arguments.</td>
</tr>
<tr>
<td>Function (macro)</td>
<td>va_start</td>
<td>Executes initialization processing for performing variable argument referencing.</td>
</tr>
<tr>
<td></td>
<td>va_arg</td>
<td>Enables referencing of the argument following the argument currently being referenced for a function with variable arguments.</td>
</tr>
<tr>
<td></td>
<td>va_end</td>
<td>Terminates referencing of the arguments of a function with variable arguments.</td>
</tr>
<tr>
<td></td>
<td>va_copy  &lt;lang=c99&gt;</td>
<td>Copies variable arguments.</td>
</tr>
</tbody>
</table>

An example of a program using the macros defined by this standard include file is shown below.

[Format]
```
1   #include <stdio.h>
2   #include <stdarg.h>
3
4   extern void prlist(int count, ...);
5
6   void main( )
7   {
8       prlist(1, 1);
9       prlist(3, 4, 5, 6);
10      prlist(5, 1, 2, 3, 4, 5);
11   }
12
13   void prlist(int count, ...)
14   {
15     va_list ap;
16     int i;
17
18     va_start(ap, count);
19     for(i=0; i<count; i++)
20         printf("%d", va_arg(ap, int));
21     putchar('
');
22     va_end(ap);
23   }
```

Explanation:
This example implements function prlist, in which the number of data items to be output is specified in the first argument and that number of subsequent arguments are output.

In line 18, the variable argument reference is initialized by va_start. Each time an argument is output, the next argument is referenced by the va_arg macro (line 20). In the va_arg macro, the type name of the argument (in this case, int type) is specified in the second argument.

When argument referencing ends, the va_end macro is called (line 22).
**va_start**

Executes initialization processing for referencing variable arguments.

**[Format]**

```c
#include <stdarg.h>
void va_start(va_list ap, parmN);
```

**[Parameters]**

- `ap` Variable for accessing variable arguments
- `parmN` Identifier of rightmost argument

**[Remarks]**

The `va_start` macro initializes `ap` for subsequent use by the `va_arg` and `va_end` macros. The argument `parmN` is the identifier of the rightmost argument in the argument list in the external function definition (the one just before the `, ...`). To reference variable unnamed arguments, the `va_start` macro call must be executed first of all.
va_arg

Allows a reference to the argument following the argument currently being referred to in the function with variable arguments.

[Format]

#include <stdarg.h>
type va_arg (va_list ap, type);

[Parameters]

ap  Variable for accessing variable arguments
type  Type of arguments to be accessed

[Return values]

Argument value

[Remarks]

Specify a variable of the va_list type initialized by the va_start macro as the first argument. The value of ap is updated each time va_arg is used, and, as a result, a sequence of variable arguments is returned by sequential calls of this macro.

Specify the type to refer to as the second argument type.

The ap argument must be the same as the ap initialized by va_start.

It will not be possible to refer to arguments correctly if argument type is set to a type of which size is changed by type conversion when it is used as a function argument, i.e., if char type, unsigned char type, short type, unsigned short type, or float type is specified as type. If such a type is specified, correct operation is not guaranteed.
Terminates referencing of the arguments of a function with variable arguments.

[Format]
```
#include <stdarg.h>
void va_end (va_list ap);
```

[Parameters]
ap  Variable for referencing variable arguments

[Remarks]
The ap argument must be the same as the ap initialized by va_start. If the va_end macro is not called before the return from a function, the operation of that function is not guaranteed.
va_copy

Makes a copy of the argument currently being referenced for a function with variable arguments.

[Format]

```c
#include <stdarg.h>
void va_copy (va_list dest, va_list src);
```

[Parameters]

- `dest`  Copy of variable for referencing variable arguments
- `src`   Variable for referencing variable arguments

[Remarks]

A copy is made of the second argument src which is one of the variable arguments that have been initialized by the `va_start` macro and used by the `va_arg` macro, and the copy is saved in the first argument dest.

The `src` argument must be the same as the `src` initialized by `va_start`.

The `dest` argument can be used as an argument that indicates the variable arguments in the subsequent `va_arg` macros.
7.4.11 `<stdio.h>`

Performs processing relating to input/output of stream input/output file.
The following constants (macros) are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>FILE</td>
<td>Indicates a structure type that stores various control information including a pointer to the buffer, an error indicator, and an end-of-file indicator, which are required for stream input/output processing.</td>
</tr>
<tr>
<td></td>
<td>_IOFBF</td>
<td>Indicates full buffering of input/output as the buffer area usage method.</td>
</tr>
<tr>
<td></td>
<td>_IOLBF</td>
<td>Indicates line buffering of input/output as the buffer area usage method.</td>
</tr>
<tr>
<td></td>
<td>_IONBF</td>
<td>Indicates non-buffering of input/output as the buffer area usage method.</td>
</tr>
<tr>
<td></td>
<td>BUFSIZ</td>
<td>Indicates the buffer size required for input/output processing.</td>
</tr>
<tr>
<td></td>
<td>EOF</td>
<td>Indicates end-of-file, that is, no more input from a file.</td>
</tr>
<tr>
<td></td>
<td>L_tmpnam</td>
<td>Indicates the size of an array large enough to store a string of a temporary file name generated by the <code>tmpnam</code> function.</td>
</tr>
<tr>
<td></td>
<td>SEEK_CUR</td>
<td>Indicates a shift of the current file read/write position to an offset from the current position.</td>
</tr>
<tr>
<td></td>
<td>SEEK_END</td>
<td>Indicates a shift of the current file read/write position to an offset from the end-of-file position.</td>
</tr>
<tr>
<td></td>
<td>SEEK_SET</td>
<td>Indicates a shift of the current file read/write position to an offset from the beginning of the file.</td>
</tr>
<tr>
<td></td>
<td>SYS_OPEN</td>
<td>Indicates the number of files for which simultaneous opening is guaranteed by the implementation.</td>
</tr>
<tr>
<td></td>
<td>TMP_MAX</td>
<td>Indicates the maximum number of unique file names that shall be generated by the <code>tmpnam</code> function.</td>
</tr>
<tr>
<td></td>
<td>stderr</td>
<td>Indicates the file pointer to the standard error file.</td>
</tr>
<tr>
<td></td>
<td>stdin</td>
<td>Indicates the file pointer to the standard input file.</td>
</tr>
<tr>
<td></td>
<td>stdout</td>
<td>Indicates the file pointer to the standard output file.</td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>Function</td>
<td>fclose</td>
<td>Closes a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>fflush</td>
<td>Outputs stream input/output file buffer contents to the file.</td>
</tr>
<tr>
<td></td>
<td>fopen</td>
<td>Opens a stream input/output file under the specified file name.</td>
</tr>
<tr>
<td></td>
<td>freopen</td>
<td>Closes a currently open stream input/output file and reopens a new file under the specified file name.</td>
</tr>
<tr>
<td></td>
<td>setbuf</td>
<td>Defines and sets a stream input/output buffer area on the user program side.</td>
</tr>
<tr>
<td></td>
<td>setvbuf</td>
<td>Defines and sets a stream input/output buffer area on the user program side.</td>
</tr>
<tr>
<td></td>
<td>fprintf</td>
<td>Outputs data to a stream input/output file according to a format.</td>
</tr>
<tr>
<td></td>
<td>vfprintf</td>
<td>Outputs a variable parameter list to the specified stream input/output file according to a format.</td>
</tr>
<tr>
<td></td>
<td>printf</td>
<td>Converts data according to a format and outputs it to the standard output file (stdout).</td>
</tr>
<tr>
<td></td>
<td>vprintf</td>
<td>Outputs a variable parameter list to the standard output file (stdout) according to a format.</td>
</tr>
<tr>
<td></td>
<td>scanf</td>
<td>Inputs data from the standard input file (stdin) and converts it according to a format.</td>
</tr>
<tr>
<td></td>
<td>vsprintf</td>
<td>Outputs a variable parameter list to the specified area according to a format.</td>
</tr>
<tr>
<td></td>
<td>fgetc</td>
<td>Inputs one character from a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>fgets</td>
<td>Inputs a string from a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>fputc</td>
<td>Outputs one character to a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>fputs</td>
<td>Outputs a string to a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>getc</td>
<td>(macro) Inputs one character from a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>getchar</td>
<td>(macro) Inputs one character from the standard input file.</td>
</tr>
<tr>
<td></td>
<td>gets</td>
<td>Inputs a string from the standard input file.</td>
</tr>
<tr>
<td></td>
<td>putc</td>
<td>(macro) Outputs one character to a stream input/output file.</td>
</tr>
<tr>
<td></td>
<td>putchar</td>
<td>(macro) Outputs one character to the standard output file.</td>
</tr>
<tr>
<td></td>
<td>puts</td>
<td>Outputs a string to the standard output file.</td>
</tr>
<tr>
<td></td>
<td>ungetc</td>
<td>Returns one character to a stream input/output file.</td>
</tr>
</tbody>
</table>
### Implementation-Defined Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Compiler Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whether the last line of the input text requires a new-line character indicating the end</td>
<td>Not specified. Depends on the low-level interface routine specifications.</td>
</tr>
<tr>
<td>Whether the space characters written immediately before the new-line character are read</td>
<td></td>
</tr>
<tr>
<td>Number of null characters added to data written in the binary file</td>
<td></td>
</tr>
<tr>
<td>Initial value of file position indicator in the append mode</td>
<td></td>
</tr>
<tr>
<td>Whether file data is lost after output to a text file</td>
<td></td>
</tr>
<tr>
<td>File buffering specifications</td>
<td></td>
</tr>
<tr>
<td>Whether a file with file length 0 exists</td>
<td></td>
</tr>
<tr>
<td>File name configuration rule</td>
<td></td>
</tr>
<tr>
<td>Whether the same file is opened simultaneously</td>
<td></td>
</tr>
<tr>
<td>Output data representation of the %p format conversion in the fprintf function</td>
<td>Hexadecimal representation.</td>
</tr>
<tr>
<td>Input data representation of the %p format conversion in the fscanf function.</td>
<td>Hexadecimal representation. If ‘-' is not the first or last character or ‘-’ does not follow ‘\n’, the range from the previous character to the following character is indicated.</td>
</tr>
<tr>
<td>The meaning of conversion specifier ‘-’ in the fscanf function</td>
<td></td>
</tr>
<tr>
<td>Value of errno specified by the fgetpos or ftell function</td>
<td>The fgetpos function is not supported. The errno value for the ftell function is not specified. It depends on the low-level interface routine specifications.</td>
</tr>
</tbody>
</table>
(a) The output format of perror function is
<string>:<error message for the error number specified in error>

(b) Table 7.8 shows the format when displaying the floating-point infinity and not-a-number in printf and fprintf functions.

<table>
<thead>
<tr>
<th>Value</th>
<th>Display Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive infinity</td>
<td>++++++</td>
</tr>
<tr>
<td>Negative infinity</td>
<td>------</td>
</tr>
<tr>
<td>Not-a-number</td>
<td>*****</td>
</tr>
</tbody>
</table>

An example of a program that performs a series of input/output processing operations for a stream input/output file is shown in the following.

```
#include <stdio.h>

void main()
{
    int c;
    FILE *ifp, *ofp;

    if ((ifp=fopen("INPUT.DAT","r"))==NULL) {
        fprintf(stderr,"cannot open input file\n");
        exit(1);
    }

    if ((ofp=fopen("OUTPUT.DAT","w"))==NULL) {
        fprintf(stderr,"cannot open output file\n");
        exit(1);
    }
    while ((c=getc(ifp))!=EOF)
    {
        putc(c, ofp);
    }
    fclose(ifp);
    fclose(ofp);
}
```

Explanation:
This program copies the contents of file INPUT.DAT to file OUTPUT.DAT.
Input file INPUT.DAT is opened by the fopen function in line 8, and output file OUTPUT.DAT is opened by the fopen function in line 12. If opening fails, NULL is returned as the return value of the fopen function, an error message is output, and the program is terminated.

If the fopen function ends normally, the pointer to the data (FILE type) that stores information on the opened files is returned; these are set in variables ifp and ofp.
After successful opening, input/output is performed using these FILE type data.
When file processing ends, the files are closed with the fclose function.
fclose

Closes a stream input/output file.

[Format]

```c
#include <stdio.h>
long fclose (FILE *fp);
```

[Parameters]

- fp  File pointer

[Return values]

- Normal: 0
- Abnormal: Nonzero

[Remarks]

The fclose function closes the stream input/output file indicated by file pointer fp. If the output file of the stream input/output file is open and data that is not output remains in the buffer, that data is output to the file before it is closed. If the input/output buffer was automatically allocated by the system, it is released.
flush

Outputs the stream input/output file buffer contents to the file.

[Format]

```c
#include <stdio.h>
long fflush (FILE *fp);
```

[Parameters]

- fp  File pointer

[Return values]

- Normal: 0
- Abnormal: Nonzero

[Remarks]

When the output file of the stream input/output file is open, the fflush function outputs the contents of the buffer that is not output for the stream input/output file specified by file pointer fp to the file. When the input file is open, the ungetc function specification is invalidated.
Opens a stream input/output file under the specified file name.

**[Format]**

```c
#include <stdio.h>
FILE *fopen (const char *fname, const char *mode);
```

**[Parameters]**

- `fname`  Pointer to string indicating file name
- `mode`  Pointer to string indicating file access mode

**[Return values]**

- Normal: File pointer indicating file information on opened file
- Abnormal: NULL

**[Remarks]**

The `fopen` function opens the stream input/output file whose file name is the string pointed to by `fname`. If a file that does not exist is opened in write mode or append mode, a new file is created wherever possible. When an existing file is opened in write mode, writing processing is performed from the beginning of the file, and previously written file contents are erased.

When a file is opened in append mode, write processing is performed from the end-of-file position. When a file is opened in update mode, both input and output processing can be performed on the file. However, input cannot directly follow output without intervening execution of the `fflush`, `fseek`, or `rewind` function. Similarly, output cannot directly follow input without intervening execution of the `fflush`, `fseek`, or `rewind` function.

A string indicating the opening method may be added after the string indicating the file access mode.
Closes a currently open stream input/output file and reopens a new file under the specified file name.

**[Format]**

```c
#include <stdio.h>
FILE *freopen (const char *fname, const char *mode, FILE *fp);
```

**[Parameters]**

- `fname`  Pointer to string indicating new file name
- `mode`  Pointer to string indicating file access mode
- `fp`  File pointer to currently open stream input/output file

**[Return values]**

- Normal: `fp`
- Abnormal: `NULL`

**[Remarks]**

The `freopen` function first closes the stream input/output file indicated by file pointer `fp` (the following processing is carried out even if this close processing is unsuccessful). Next, the `freopen` function opens the file indicated by file name `fname` for stream input/output, reusing the FILE structure pointed to by `fp`.

The `freopen` function is useful when there is a limit on the number of files being opened at one time.
The `freopen` function normally returns the same value as `fp`, but returns `NULL` when an error occurs.
setbuf

Defines and sets a stream input/output buffer area by the user program.

[Format]

```c
#include <stdio.h>
void setbuf (FILE *fp, char buf[BUFSIZ]);
```

[Parameters]

- fp  File pointer
- buf  Pointer to buffer area

[Remarks]

The setbuf function defines the storage area pointed to by buf so that it can be used as an input/output buffer area for the stream input/output file indicated by file pointer fp. As a result, input/output processing is performed using a buffer area of size BUFSIZ.
setvbuf

Defines and sets a stream input/output buffer area by the user program.

[Format]

#include <stdio.h>
long setvbuf(FILE *fp, char *buf, long type, size_t size);

[Parameters]

fp  File pointer  
buf  Pointer to buffer area  
type Buffer management method  
size Size of buffer area

[Return values]

Normal: 0  
Abnormal: Nonzero

[Remarks]

The setvbuf function defines the storage area pointed to by buf so that it can be used as an input/output buffer area for the stream input/output file indicated by file pointer fp.

There are three ways of using this buffer area, as follows:

(a) When _IOFBF is specified as type  
Input/output is fully buffered.

(b) When _IOLBF is specified as type  
Input/output is line buffered; that is, input/output data is fetched from the buffer area when a new-line character is written, when the buffer area is full, or when input is requested.

(c) When _IONBF is specified as type  
Input/output is unbuffered. The setvbuf function usually returns 0. However, when an illegal value is specified for type or size, or when the request on how to use the buffer could not be accepted, a value other than 0 is returned.

The buffer area must not be released before the open stream input/output file is closed. In addition, the setvbuf function must be used between opening of the stream input/output file and execution of input/output processing.
`fprintf`

Outputs data to a stream input/output file according to the format.

**[Format]**

```c
#include <stdio.h>
long fprintf (FILE *fp, const char *control[, arg]...);
```

**[Parameters]**

- `fp` File pointer
- `control` Pointer to string indicating format
- `arg`... List of data to be output according to format

**[Return values]**

- Normal: Number of characters converted and output
- Abnormal: Negative value

**[Remarks]**

The `fprintf` function converts and edits parameter `arg` according to the string that represents the format pointed to by `control`, and outputs the result to the stream input/output file indicated by file pointer `fp`.

The `fprintf` function returns the number of characters converted and output when the function is terminated successfully, or a negative value if an error occurs.

The format specifications are shown below.

**Overview of Formats**

The string that represents the format is made up of two kinds of string.

- Ordinary characters
  - A character other than a conversion specification shown below is output unchanged.
- Conversion specifications
  - A conversion specification is a string beginning with `%` that specifies the conversion method for the following parameter. The conversion specifications format conforms to the following rules:

  ```
  [%[Flag...]] [Field width] [Precision] [Parameter size specification] 
  ```

  When there is no parameter to be actually output according to this conversion specification, the behavior is not guaranteed. In addition, when the number of parameters to be actually output is greater than the conversion specification, the excess parameters are ignored.

**Description of Conversion Specifications**

(a) **Flags**

Flags specify modifications to the data to be output, such as addition of a sign. The types of flag that can be specified and their meanings are shown in Table 7.9.

<table>
<thead>
<tr>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>If the number of converted data characters is less than the field width, the data will be output left-justified within the field.</td>
</tr>
<tr>
<td>+</td>
<td>A plus or minus sign will be prefixed to the result of a signed conversion.</td>
</tr>
</tbody>
</table>

Table 7.9 Flag Types and Their Meanings
(b) Field width
The number of characters in the converted data to be output is specified as a decimal number.
If the number of converted data characters is less than the field width, the data is prefixed with spaces up to the field width. (However, if '-' is specified as a flag, spaces are suffixed to the data.)
If the number of converted data characters exceeds the field width, the field width is extended to allow the converted result to be output.
If the field width specification begins with 0, the output data is prefixed with characters "0", not spaces.

(c) Precision
The precision of the converted data is specified according to the type of conversion, as described in table 6.10. The precision is specified in the form of a period (.) followed by a decimal integer. If the decimal integer is omitted, 0 is assumed to be specified.
If the specified precision is incompatible with the field width specification, the field width specification is ignored.
The precision specification has the following meanings according to the conversion type.
- For d, i, o, u, x, and X conversions
  The minimum number of digits in the converted data is specified.
- For e, E, and f conversions
  The number of digits after the decimal point in the converted data is specified.
- For g and G conversions
  The maximum number of significant digits in the converted data is specified.
- For s conversion
  The maximum number of printed digits is specified.

(d) Parameter size specification
For d, i, o, u, x, X, e, E, f, g, and G conversions (see Table 7.10), the size (short type, long type, long long type, or long double type) of the data to be converted is specified. In other conversions, this specification is ignored. Table 7.10 shows the types of size specification and their meanings.

<table>
<thead>
<tr>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>hh</td>
</tr>
<tr>
<td>2</td>
<td>h</td>
</tr>
<tr>
<td>3</td>
<td>l</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
</tr>
</tbody>
</table>

Table 7.10 Parameter Size Specification Types and Meanings
(e) Conversion specifier

The format into which the data is to be converted is specified. If the data to be converted is structure or array type, or is a pointer pointing to those types, the behavior is not guaranteed except when a character array is converted by `s` conversion or when a pointer is converted by `p` conversion. Table 7.11 shows the conversion specifier and conversion methods. If a letter which is not shown in this table is specified as the conversion specifier, the behavior is not guaranteed. The behavior, if a character that is not a letter is specified, depends on the compiler.

Table 7.11 Conversion Specifiers and Conversion Methods

<table>
<thead>
<tr>
<th>Conversion Specifier</th>
<th>Conversion Type</th>
<th>Conversion Method</th>
<th>Type Subject to Conversion</th>
<th>Notes Related to Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 d</td>
<td>d conversion</td>
<td>int type data is converted to a signed decimal string. <code>d</code> conversion and <code>i</code> conversion have the same specification.</td>
<td>int type</td>
<td>The precision specification indicates the minimum number of characters output. If the number of converted data characters is less than the precision specification, the string is prefixed with zeros. If the precision is omitted, 1 is assumed. If conversion and output of data with a value of 0 is attempted with 0 specified as the precision, nothing will be output.</td>
</tr>
<tr>
<td>2 i</td>
<td>i conversion</td>
<td>int type data is converted to an unsigned octal string.</td>
<td>int type</td>
<td></td>
</tr>
<tr>
<td>3 o</td>
<td>o conversion</td>
<td>int type data is converted to an unsigned decimal string.</td>
<td>int type</td>
<td></td>
</tr>
<tr>
<td>4 u</td>
<td>u conversion</td>
<td>int type data is converted to an unsigned decimal string.</td>
<td>int type</td>
<td></td>
</tr>
<tr>
<td>5 x</td>
<td>x conversion</td>
<td>int type data is converted to unsigned hexadecimal. <code>a</code>, <code>b</code>, <code>c</code>, <code>d</code>, <code>e</code>, and <code>f</code> are used as hexadecimal characters.</td>
<td>int type</td>
<td></td>
</tr>
<tr>
<td>6 X</td>
<td>X conversion</td>
<td>int type data is converted to unsigned hexadecimal. <code>A</code>, <code>B</code>, <code>C</code>, <code>D</code>, <code>E</code>, and <code>F</code> are used as hexadecimal characters.</td>
<td>int type</td>
<td></td>
</tr>
<tr>
<td>Conversion Specifier</td>
<td>Conversion Type</td>
<td>Conversion Method</td>
<td>Type Subject to Conversion</td>
<td>Notes Related to Precision</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
<td>-------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>7</td>
<td>f</td>
<td>f conversion</td>
<td>double type</td>
<td>The precision specification indicates the number of digits after the decimal point. When there are characters after the decimal point, at least one digit is output before the decimal point. When the precision is omitted, 6 is assumed. When 0 is specified as the precision, the decimal point and subsequent characters are not output. The output data is rounded.</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>F conversion</td>
<td>double type</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>e</td>
<td>e conversion</td>
<td>double type</td>
<td>The precision specification indicates the number of digits after the decimal point. The format is such that one digit is output before the decimal point in the converted characters, and a number of digits equal to the precision are output after the decimal point. When the precision is omitted, 6 is assumed. When 0 is specified as the precision, characters after the decimal point are not output. The output data is rounded.</td>
</tr>
<tr>
<td>10</td>
<td>E</td>
<td>E conversion</td>
<td>double type</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>g</td>
<td>g conversion (or G conversion)</td>
<td>double type</td>
<td>The precision specification indicates the maximum number of significant digits in the converted data.</td>
</tr>
<tr>
<td>12</td>
<td>G</td>
<td>double type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversion Specification</td>
<td>Conversion Type</td>
<td>Conversion Method</td>
<td>Type Subject to Conversion</td>
<td>Notes Related to Precision</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------</td>
<td>------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>13 a</td>
<td>a conversion</td>
<td>double type data is converted to a hexadecimal string with the [-0]Xh.hhhhp ± d format. At least one digit is output as the exponent.</td>
<td>double type</td>
<td>The precision specification indicates the number of digits after the decimal point. The format is such that one digit is output before the decimal point in the converted characters, and a number of digits equal to the precision are output after the decimal point. When the precision is omitted, a precision sufficient for representing an accurate value is assumed. When 0 is specified as the precision, characters after the decimal point are not output. The output data is rounded.</td>
</tr>
<tr>
<td>14 A</td>
<td>A conversion</td>
<td>double type data is converted to a hexadecimal string with the [-0]Xh.hhhP ± d format. At least one digit is output as the exponent.</td>
<td>double type</td>
<td></td>
</tr>
<tr>
<td>15 c</td>
<td>c conversion</td>
<td>int type data is converted to unsigned char data, with conversion to the character corresponding to that data.</td>
<td>int type</td>
<td>The precision specification is invalid.</td>
</tr>
<tr>
<td>16 s</td>
<td>s conversion</td>
<td>The string pointed to by pointer to char type are output up to the null character indicating the end of the string or up to the number of characters specified by the precision. (Null characters are not output. Space, horizontal tab, and new-line characters are not included in the converted string.)</td>
<td>Pointer to char type</td>
<td>The precision specification indicates the number of characters to be output. If the precision is omitted, characters are output up to, but not including, the null character in the string pointed to by the data. (Null characters are not output. Space, horizontal tab, and new-line characters are not included in the converted string.)</td>
</tr>
<tr>
<td>17 p</td>
<td>p conversion</td>
<td>Assuming data as a pointer, conversion is performed to a string of compiler-defined printable characters.</td>
<td>Pointer to void type</td>
<td>The precision specification is invalid.</td>
</tr>
<tr>
<td>18 n</td>
<td>No conversion</td>
<td>Data is regarded as a pointer to int type, and the number of characters output so far is set in the storage area pointed to by that data.</td>
<td>Pointer to int type</td>
<td></td>
</tr>
<tr>
<td>19 %</td>
<td>No conversion</td>
<td>% is output.</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

\( f \)  * specification for field width or precision

* can be specified as the field width or precision specification value. In this case, the value of the parameter corresponding to the conversion specification is used as the field width or precision specification value. When this parameter has a negative field width, it is interpreted as flag ‘-’ and a positive field width. When the parameter has a negative precision, the precision is interpreted as being omitted.
vfprintf

Outputs a variable parameter list to the specified stream input/output file according to a format.

[Format]

```c
#include <stdarg.h>
#include <stdio.h>
long vfprintf (FILE *fp, const char *control, va_list arg);
```

[Parameters]

- `fp`  File pointer
- `control` Pointer to string indicating format
- `arg` Parameter list

[Return values]

- Normal: Number of characters converted and output
- Abnormal: Negative value

[Remarks]

The `vfprintf` function sequentially converts and edits a variable parameter list according to the string that represents the format pointed to by `control`, and outputs the result to the stream input/output file indicated by `fp`. The `vfprintf` function returns the number of data items converted and output, or a negative value when an error occurs. Within the `vfprintf` function, the `va_end` macro is not invoked.

For details of the format specifications, see the description of the `fprintf` function.

Parameter `arg`, indicating the parameter list, must be initialized beforehand by the `va_start` macro (and the succeeding `va_arg` macro).
printf

Converts data according to a format and outputs it to the standard output file (stdout).

[Format]

```
#include <stdio.h>
long printf (const char *control[, arg]...);
```

[Parameters]

control  Pointer to string indicating format
arg,...  Data to be output according to format

[Return values]

Normal: Number of characters converted and output
Abnormal: Negative value

[Remarks]

The `printf` function converts and edits parameter arg according to the string that represents the format pointed to by control, and outputs the result to the standard output file (stdout).

For details of the format specifications, see the description of the `fprintf` function.
vprintf

Outputs a variable parameter list to the standard output file (stdout) according to a format.

[Format]

```
#include <stdarg.h>
#include <stdio.h>
long vprintf (const char *control, va_list arg);
```

[Parameters]

- control  Pointer to string indicating format
- arg  Parameter list

[Return values]

- Normal: Number of characters converted and output
- Abnormal: Negative value

[Remarks]

The `vprintf` function sequentially converts and edits a variable parameter list according to the string that represents the format pointed to by `control`, and outputs the result to the standard output file. The `vprintf` function returns the number of data items converted and output, or a negative value when an error occurs. Within the `vprintf` function, the `va_end` macro is not invoked. For details of the format specifications, see the description of the `fprintf` function. Parameter `arg`, indicating the parameter list, must be initialized beforehand by the `va_start` macro (and the succeeding `va_arg` macro).
sprintf

Converts data according to a format and outputs it to the specified area.

[Format]

```c
#include <stdio.h>
long sprintf (char *s, const char *control[, arg...]);
```

[Parameters]

- `s`  Pointer to storage area to which data is to be output
- `control`  Pointer to string indicating format
- `arg,...`  Data to be output according to format

[Return values]

Number of characters converted

[Remarks]

The `sprintf` function converts and edits parameter `arg` according to the string that represents the format pointed to by `control`, and outputs the result to the storage area pointed to by `s`.

A null character is appended at the end of the converted and output string. This null character is not included in the return value (number of characters output).

For details of the format specifications, see the description of the `fprintf` function.
**sscanf**

Inputs data from the specified storage area and converts it according to a format.

**[Format]**

```c
#include <stdio.h>
long sscanf (const char *s, const char *control[, ptr...]);
```

**[Parameters]**

- `s`  Storage area containing data to be input
- `control`  Pointer to string indicating format
- `ptr`,...  Pointer to storage area that stores input and converted data

**[Return values]**

- Normal: Number of data items successfully input and converted
- Abnormal: `EOF`

**[Remarks]**

The `sscanf` function inputs data from the storage area pointed to by `s`, converts and edits it according to the string that represents the format pointed to by `control`, and stores the result in the storage area pointed to by `ptr`. The `sscanf` function returns the number of data items successfully input and converted. `EOF` is returned when the input data ends before the first conversion.

For details of the format specifications, see the description of the `fscanf` function.
snprintf

Converts data according to a format and outputs it to the specified area.

[Format]

```c
#include <stdio.h>
long snprintf(char *restrict s, size_t n, const char *restrict control [, arg]...);
```

[Parameters]

- `s` Pointer to storage area to which data is to be output
- `n` Number of characters to be output
- `control` Pointer to string indicating format
- `arg,...` Data to be output according to format

[Return values]

- Number of characters converted

[Remarks]

The `snprintf` function converts and edits parameter `arg` according to the format-representing string pointed to by `control`, and outputs the result to the storage area pointed to by `s`. A null character is appended at the end of the converted and output string. This null character is not included in the return value (number of characters output). For details of the format specifications, see the description of the `fprintf` function.
vsnprintf

Converts data according to a format and outputs it to the specified area.

[Format]
#include <stdarg.h>
#include <stdio.h>
long vsnprintf(char *restrict s, size_t n, const char *restrict control, va_list arg);

[Parameters]
  s  Pointer to storage area to which data is to be output
  n  Number of characters to be output
  control  Pointer to string indicating format
  arg  Parameter list

[Return values]
  Number of characters converted

[Remarks]
The vsnprintf function is equivalent to snprintf with arg specified instead of the variable parameters.
Initialize arg through the va_start macro before calling the vsnprintf function.
The vsnprintf function does not call the va_end macro.
vfscanf

Inputs data from a stream input/output file and converts it according to a format.

[Format]
```
#include <stdarg.h>
#include <stdio.h>
long vfscanf(FILE *restrict fp, const char *restrict control, va_list arg);
```

[Parameters]

- fp  File pointer
- control  Pointer to wide string indicating format
- arg  Parameter list

[Return values]

- Normal: Number of data items successfully input and converted
- Abnormal: Input data ends before input data conversion is performed: **EOF**

[Remarks]

The **vfscanf** function is equivalent to **fscanf** with **arg** specified instead of the variable parameter list. Initialize **arg** through the **va_start** macro before calling the **vfscanf** function. The **vfscanf** function does not call the **va_end** macro.
vscanf

Inputs data from the specified storage area and converts it according to a format.

[Format]

```c
#include <stdarg.h>
#include <stdio.h>
long vscanf(const char *restrict control, va_list arg);
```

[Parameters]

- `control`  Pointer to string indicating format
- `arg`  Parameter list

[Return values]

- Normal: Number of data items successfully input and converted
- Abnormal: Input data ends before input data conversion is performed: **EOF**

[Remarks]

The `vscanf` function is equivalent to `scanf` with `arg` specified instead of the variable parameters.
Initialize `arg` through the `va_start` macro before calling the `vscanf` function.
The `vscanf` function does not call the `va_end` macro.
vsscanf

Inputs data from the specified storage area and converts it according to a format.

[Format]
#include <stdarg.h>
#include <stdio.h>
long vsscanf(const char *restrict s, const char *restrict control, va_list arg);

[Parameters]
- s  Storage area containing data to be input
- control  Pointer to string indicating format
- arg  Parameter list

[Return values]
Normal: Number of data items successfully input and converted
Abnormal: Input data ends before input data conversion is performed: EOF

[Remarks]
The vsscanf function is equivalent to scanf with arg specified instead of the variable parameters. Initialize arg through the va_start macro before calling the vsscanf function. The vsscanf function does not call the va_end macro.
fscanf

Inputs data from a stream input/output file and converts it according to a format.

[Format]

```c
#include <stdio.h>
lng fscanf (FILE *fp, const char *control[, ptr]...);
```

[Parameters]

- `fp`  File pointer
- `control`  Pointer to string indicating format
- `ptr`, ...  Pointer to storage area that stores input data

[Return values]

Normal: Number of data items successfully input and converted
Abnormal: Input data ends before input data conversion is performed: EOF

[Remarks]

The `fscanf` function inputs data from the stream input/output file indicated by file pointer `fp`, converts and edits it according to the string that represents the format pointed to by `control`, and stores the result in the storage area pointed to by `ptr`.

The format specifications for inputting data are shown below.

**Overview of Formats**
The string that represents the format is made up of the following three kinds of string.

- **Space characters**
  If a space (" "), horizontal tab (\t), or new-line character (\n) is specified, processing is performed to skip to the next non-white-space character in the input data.

- **Ordinary characters**
  If a character that is neither one of the space characters listed above nor % is specified, one input data character is input. The input character must match a character specified in the string that represents the format.

- **Conversion specification**
  A conversion specification is a string beginning with % that specifies the method of converting the input data and storing it in the area pointed to by the following parameter. The conversion specification format conforms to the following rules:
  % [*] [Field width] [Converted data size] Conversion specifier
  If there is no pointer to the storage area that stores input data corresponding to the conversion specification in the format, the behavior is not guaranteed. In addition, when a pointer to a storage area that stores input data remains though the format is exhausted, that pointer is ignored.

**Description of Conversion Specifications**

- *** specification**
  Suppresses storage of the input data in the storage area pointed to by the parameter.

- **Field width**
  The maximum number of characters in the data to be input is specified as a decimal number.

- **Converted data size**
  For d, i, o, u, x, X, e, E, and f conversions (see Table 7.13), the size (short type, long type, long long type, or long double type) of the converted data is specified. In other conversions, this specification is ignored. Table 7.12 shows the types of size specification and their meanings.
### Table 7.12 Converted Data Size Specification Types and Meanings

<table>
<thead>
<tr>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For <code>d</code>, <code>i</code>, <code>o</code>, <code>u</code>, <code>x</code>, and <code>X</code> conversions, specifies that the converted data is of <strong>short</strong> type.</td>
</tr>
<tr>
<td>2</td>
<td>For <code>d</code>, <code>i</code>, <code>o</code>, <code>u</code>, <code>x</code>, and <code>X</code> conversions, specifies that the converted data is of <strong>long</strong> type. For <code>e</code>, <code>E</code>, and <code>f</code> conversions, specifies that the converted data is of <strong>double</strong> type.</td>
</tr>
<tr>
<td>3</td>
<td>For <code>e</code>, <code>E</code>, and <code>f</code> conversions, specifies that the converted data is of <strong>long double</strong> type.</td>
</tr>
<tr>
<td>4</td>
<td>For <code>d</code>, <code>i</code>, <code>o</code>, <code>u</code>, <code>x</code>, and <code>X</code> conversions, specifies that the converted data is of <strong>long long</strong> type.</td>
</tr>
</tbody>
</table>

**- Conversion specifier**

The input data is converted according to the type of conversion specified by the conversion specifier. However, processing is terminated when a white-space character is read, when a character for which conversion is not permitted is read, or when the specified field width has been exceeded.

### Table 7.13 Conversion Specifiers and Conversion Methods

<table>
<thead>
<tr>
<th>Conversion Specifier</th>
<th>Conversion Type</th>
<th>Conversion Method</th>
<th>Data Type Subject to Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 <code>d</code></td>
<td>d conversion</td>
<td>A decimal string is converted to integer type data.</td>
<td>Integer type</td>
</tr>
<tr>
<td>2 <code>i</code></td>
<td>i conversion</td>
<td>A decimal string with a sign prefixed, or a decimal string with u (U) or l (L) suffixed is converted to integer type data. A string beginning with 0x (or 0X) is interpreted as hexadecimal, and the string is converted to <strong>int</strong> type data.</td>
<td>Integer type</td>
</tr>
<tr>
<td>3 <code>o</code></td>
<td>o conversion</td>
<td>An octal string is converted to integer type data.</td>
<td>Integer type</td>
</tr>
<tr>
<td>4 <code>u</code></td>
<td>u conversion</td>
<td>An unsigned decimal string is converted to integer type data.</td>
<td>Integer type</td>
</tr>
<tr>
<td>5 <code>x</code></td>
<td>x conversion</td>
<td>A hexadecimal string is converted to integer type data. There is no difference in meaning between <code>x</code> conversion and <code>X</code> conversion.</td>
<td>Integer type</td>
</tr>
<tr>
<td>6 <code>X</code></td>
<td>X conversion</td>
<td>Characters are converted as a single string until a space, horizontal tab, or new-line character is read. A null character is appended at the end of the string. (The string in which the converted data is set must be large enough to include the null character.)</td>
<td>Character type</td>
</tr>
<tr>
<td>7 <code>s</code></td>
<td>s conversion</td>
<td>Characters are converted as a single string until a space, horizontal tab, or new-line character is read. A null character is appended at the end of the string. (The string in which the converted data is set must be large enough to include the null character.)</td>
<td>Character type</td>
</tr>
<tr>
<td>8 <code>c</code></td>
<td>c conversion</td>
<td>One character is input. The input character is not skipped even if it is a white-space character. To read only non-white-space characters, specify <code>%1s</code>. If the field width is specified, the number of characters equivalent to that specification are read. In this case, therefore, the storage area that stores the converted data needs the specified size.</td>
<td>char type</td>
</tr>
</tbody>
</table>
If the conversion specifier is a letter not shown in Table 7.13, the behavior is not guaranteed. For the other characters, the behavior is implementation-defined.
**scanf**

Inputs data from the standard input file (stdin) and converts it according to a format.

**[Format]**

```c
#include <stdio.h>
long scanf (const char *control[, ptr...]);
```

**[Parameters]**

- `control` Pointer to string indicating format
- `ptr...` Pointer to storage area that stores input and converted data

**[Return values]**

- Normal: Number of data items successfully input and converted
- Abnormal: `EOF`

**[Remarks]**

The `scanf` function inputs data from the standard input file (stdin), converts and edits it according to the string that represents the format pointed to by `control`, and stores the result in the storage area pointed to by `ptr`.

The `scanf` function returns the number of data items successfully input and converted as the return value. `EOF` is returned if the standard input file ends before the first conversion.

For details of the format specifications, see the description of the `fscanf` function.

For `%e` conversion, specify `l` for `double` type, and specify `L` for `long double` type. The default type is `float`. 
vsprintf

Outputs a variable parameter list to the specified storage area according to a format.

[Format]

```c
#include <stdarg.h>
#include <stdio.h>
long vsprintf (char *s, const char *control, va_list arg);
```

[Parameters]

- `s` Pointer to storage area to which data is to be output
- `control` Pointer to string indicating format
- `arg` Parameter list

[Return values]

Normal: Number of characters converted
Abnormal: Negative value

[Remarks]

The `vsprintf` function sequentially converts and edits a variable parameter list according to the string that represents the format pointed to by `control`, and outputs the result to the storage area pointed to by `s`. A null character is appended at the end of the converted and output string. This null character is not included in the return value (number of characters output).

For details of the format specifications, see the description of the `fprintf` function.

Parameter `arg`, indicating the parameter list, must be initialized beforehand by the `va_start` macro (and the succeeding `va_arg` macro).
fgetc

Inputs one character from a stream input/output file.

[Format]

#include <stdio.h>
long fgetc (FILE *fp);

[Parameters]

fp  File pointer

[Return values]

Normal: End-of-file: EOF
Otherwise: Input character
Abnormal: EOF

[Remarks]

When a read error occurs, the error indicator for that file is set.
The fgetc function inputs one character from the stream input/output file indicated by file pointer fp.
The fgetc function normally returns the input character, but returns EOF at end-of-file or when an error occurs. At end-of-file, the end-of-file indicator for that file is set.
 fgets

Inputs a string from a stream input/output file.

[Format]
#include <stdio.h>
char *fgets (char *s, long n, FILE *fp);

[Parameters]
 s  Pointer to storage area to which string is input
 n  Number of bytes of storage area to which string is input
 fp  File pointer

[Return values]
Normal: End-of-file: **NULL**
Otherwise: **s**
Abnormal: **NULL**

[Remarks]
The `fgets` function inputs a string from the stream input/output file indicated by file pointer `fp` to the storage area pointed to by `s`.
The `fgets` function performs input up to the (n–1)th character or a new-line character, or until end-of-file, and appends a null character at the end of the input string.
The `fgets` function normally returns `s`, the pointer to the storage area to which the string is input, but returns **NULL** at end-of-file or if an error occurs.
The contents of the storage area pointed to by `s` do not change at end-of-file, but are not guaranteed when an error occurs.
fputc

Outputs one character to a stream input/output file.

[Format]
#include <stdio.h>
long fputc (long c, FILE *fp);

[Parameters]
   c  Character to be output
   fp  File pointer

[Return values]
   Normal: Output character
   Abnormal: EOF

[Remarks]
When a write error occurs, the error indicator for that file is set.
The fputc function outputs character c to the stream input/output file indicated by file pointer fp.
The fputc function normally returns c, the output character, but returns EOF when an error occurs.
fputs

Outputs a string to a stream input/output file.

[Format]
#include <stdio.h>
long fputs (const char *s, FILE *fp);

[Parameters]
  s  Pointer to string to be output
  fp  File pointer

[Return values]
  Normal: 0
  Abnormal: Nonzero

[Remarks]
The fputs function outputs the string pointed to by s up to the character preceding the null character to
the stream input/output file indicated by file pointer fp. The null character indicating the end of the string
is not output. The fputs function normally returns zero, but returns nonzero when an error occurs.
getc

Inputs one character from a stream input/output file.

[Format]

```c
#include <stdio.h>
long getc (FILE *fp);
```

[Parameters]

- fp  File pointer

[Return values]

- Normal: End-of-file: **EOF**
- Otherwise: Input character
- Abnormal: **EOF**

[Remarks]

When a read error occurs, the error indicator for that file is set. The `getc` function inputs one character from the stream input/output file indicated by file pointer `fp`. The `getc` function normally returns the input character, but returns **EOF** at end-of-file or when an error occurs. At end-of-file, the end-of-file indicator for that file is set.
getchar

Inputs one character from the standard input file (stdin).

[Format]

```
#include <stdio.h>
long getchar (void);
```

[Return values]

Normal: End-of-file: **EOF**
Otherwise: Input character
Abnormal: **EOF**

[Remarks]

When a read error occurs, the error indicator for that file is set.
The `getchar` function inputs one character from the standard input file (**stdin**).
The `getchar` function normally returns the input character, but returns **EOF** at end-of-file or when an error occurs. At end-of-file, the end-of-file indicator for that file is set.
**gets**

Inputs a string from the standard input file (stdin).

**[Format]**

```c
#include <stdio.h>
char *gets (char *s);
```

**[Parameters]**

- `s` Pointer to storage area to which string is input

**[Return values]**

- Normal: End-of-file: **NULL**
- Otherwise: `s`
- Abnormal: **NULL**

**[Remarks]**

The `gets` function inputs a string from the standard input file (**stdin**) to the storage area starting at `s`. The `gets` function inputs characters up to end-of-file or until a new-line character is input, and appends a null character instead of a new-line character.

The `gets` function normally returns `s`, the pointer to the storage area to which the string is input, but returns **NULL** at the end of the standard input file or when an error occurs.

The contents of the storage area pointed to by `s` do not change at the end of the standard input file, but are not guaranteed when an error occurs.
putc

Outputs one character to a stream input/output file.

[Format]

#include <stdio.h>
long putc (long c, FILE *fp);

[Parameters]

c  Character to be output
fp  File pointer

[Return values]

Normal: Output character
Abnormal: EOF

[Remarks]

When a write error occurs, the error indicator for that file is set.
The putc function outputs character c to the stream input/output file indicated by file pointer fp.
The putc function normally returns c, the output character, but returns EOF when an error occurs.
## putchar

Outputs one character to the standard output file (stdout).

### [Format]

```
#include <stdio.h>
long putchar (long c);
```

### [Parameters]

- `c` Character to be output

### [Return values]

- Normal: Output character
- Abnormal: `EOF`

### [Remarks]

When a write error occurs, the error indicator for that file is set. The `putchar` function outputs character `c` to the standard output file (`stdout`). The `putchar` function normally returns `c`, the output character, but returns `EOF` when an error occurs.
puts

Outputs a string to the standard output file (stdout).

[Format]
#include <stdio.h>
long puts (const char *s);

[Parameters]
  s  Pointer to string to be output

[Return values]
  Normal: 0
  Abnormal: Nonzero

[Remarks]
The puts function outputs the string pointed to by s to the standard output file (stdout). The null character indicating the end of the string is not output, but a new-line character is output instead.
The puts function normally returns zero, but returns nonzero when an error occurs.
ungetc

Returns one character to a stream input/output file.

[Format]

```c
#include <stdio.h>
long ungetc (long c, FILE *fp);
```

[Parameters]

- c  Character to be returned
- fp  File pointer

[Return values]

- Normal: Returned character
- Abnormal: EOF

[Remarks]

The `ungetc` function returns character `c` to the stream input/output file indicated by file pointer `fp`. Unless the `fflush`, `fseek`, or `rewind` function is called, this returned character will be the next input data.

The `ungetc` function normally returns `c`, which is the returned character, but returns EOF when an error occurs.

The behavior is not guaranteed when the `ungetc` function is called more than once without intervening `fflush`, `fseek`, or `rewind` function execution. When the `ungetc` function is executed, the current file position indicator for that file is moved back one position; however, when this file position indicator has already been positioned at the beginning of the file, its value is not guaranteed.
fread

Inputs data from a stream input/output file to the specified storage area.

[Format]

```c
#include <stdio.h>
size_t fread (void *ptr, size_t size, size_t n, FILE *fp);
```

[Parameters]

- `ptr`  Pointer to storage area to which data is input
- `size`  Number of bytes in one member
- `n`  Number of members to be input
- `fp`  File pointer

[Return values]

- When `size` or `n` is 0: 0
- When `size` and `n` are both nonzero: Number of successfully input members

[Remarks]

The `fread` function inputs `n` members whose size is specified by `size`, from the stream input/output file indicated by file pointer `fp`, into the storage area pointed to by `ptr`. The file position indicator for the file is advanced by the number of bytes input.

The `fread` function returns the number of members successfully input, which is normally the same as the value of `n`. However, at end-of-file or when an error occurs, the number of members successfully input so far is returned, and then the return value will be less than `n`. The `ferror` and `feof` functions should be used to distinguish between end-of-file and error occurrence.

When the value of `size` or `n` is zero, zero is returned as the return value and the contents of the storage area pointed to by `ptr` do not change. When an error occurs or when only a part of the members can be input, the file position indicator is not guaranteed.
The `fwrite` function outputs \( n \) members whose size is specified by \( \text{size} \), from the storage area pointed to by \( \text{ptr} \), to the stream input/output file indicated by file pointer \( \text{fp} \). The file position indicator for the file is advanced by the number of bytes output.

The `fwrite` function returns the number of members successfully output, which is normally the same as the value of \( n \). However, when an error occurs, the number of members successfully output so far is returned, and then the return value will be less than \( n \).

When an error occurs, the file position indicator is not guaranteed.
**fseek**

Shifts the current read/write position in a stream input/output file.

**[Format]**

```c
#include <stdio.h>
long fseek (FILE *fp, long offset, long type);
```

**[Parameters]**

- **fp**: File pointer
- **offset**: Offset from position specified by type of offset
- **type**: Type of offset

**[Return values]**

- Normal: 0
- Abnormal: Nonzero

**[Remarks]**

The `fseek` function shifts the current read/write position in the stream input/output file indicated by file pointer `fp` by `offset` bytes from the position specified by `type` (the type of offset). The types of offset are shown in Table 7.14. The `fseek` function normally returns zero, but returns nonzero in response to an invalid request.

<table>
<thead>
<tr>
<th>Offset Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEEK_SET</td>
<td>Shifts to a position which is located <code>offset</code> bytes away from the beginning of the file. The value specified by <code>offset</code> must be zero or positive.</td>
</tr>
<tr>
<td>SEEK_CUR</td>
<td>Shifts to a position which is located <code>offset</code> bytes away from the current position in the file. The shift is toward the end of the file if the value specified by <code>offset</code> is positive, and toward the beginning of the file if negative.</td>
</tr>
<tr>
<td>SEEK_END</td>
<td>Shifts to a position which is located <code>offset</code> bytes forward from end-of-file. The value specified by <code>offset</code> must be zero or negative.</td>
</tr>
</tbody>
</table>

For a text file, the type of offset must be `SEEK_SET` and `offset` must be zero or the value returned by the `ftell` function for that file. Note also that calling the `fseek` function cancels the effect of the `ungetc` function.
Obtains the current read/write position in a stream input/output file.

[Format]

```c
#include <stdio.h>
long ftell (FILE *fp);
```

[Parameters]

- `fp` File pointer

[Return values]

- Current file position indicator position (text file)
- Number of bytes from beginning of file to current position (binary file)

[Remarks]

The `ftell` function obtains the current read/write position in the stream input/output file indicated by file pointer `fp`. For a binary file, the `ftell` function returns the number of bytes from the beginning of the file to the current position. For a text file, it returns, as the position of the file position indicator, an implementation-defined value that can be used by the `fseek` function.

When the `ftell` function is used twice for a text file, the difference in the return values will not necessarily represent the actual distance in the file.
**rewind**

Shifts the current read/write position in a stream input/output file to the beginning of the file.

**[Format]**

```c
#include <stdio.h>
void rewind (FILE *fp);
```

**[Parameters]**

- **fp** File pointer

**[Remarks]**

The `rewind` function shifts the current read/write position in the stream input/output file indicated by file pointer `fp`, to the beginning of the file.

The `rewind` function clears the end-of-file indicator and error indicator for the file.

Note that calling the `rewind` function cancels the effect of the `ungetc` function.
clearerr

Clears the error state of a stream input/output file.

[Format]

```c
#include <stdio.h>
void clearerr (FILE *fp);
```

[Parameters]

fp  File pointer

[Remarks]

The `clearerr` function clears the error indicator and end-of-file indicator for the stream input/output file indicated by file pointer `fp`. 
feof

Tests for the end of a stream input/output file.

[Format]
#include <stdio.h>
long feof (FILE *fp);

[Parameters]
fp File pointer

[Return values]
End-of-file: Nonzero
Otherwise: 0

[Remarks]
The feof function tests for the end of the stream input/output file indicated by file pointer fp.
The feof function tests the end-of-file indicator for the specified stream input/output file, and if the indicator is set, returns nonzero to indicate that the file is at its end. If the end-of-file indicator is not set, the feof function returns zero to show that the file is not yet at its end.
Tests for stream input/output file error state.

[Format]

```c
#include <stdio.h>
long ferror (FILE *fp);
```

[Parameters]

- fp  File pointer

[Return values]

- If file is in error state: Nonzero
- Otherwise: 0

[Remarks]

The `ferror` function tests whether the stream input/output file indicated by file pointer `fp` is in the error state. The `ferror` function tests the error indicator for the specified stream input/output file, and if the indicator is set, returns nonzero to show that the file is in the error state. If the error indicator is not set, the `ferror` function returns zero to show that the file is not in the error state.
perror

Outputs an error message corresponding to the error number to the standard error file (stderr).

[Format]

#include <stdio.h>
void perror (const char *s)

[Parameters]

s  Pointer to error message

[Remarks]

The perror function maps errno to the error message indicated by s, and outputs the message to the standard error file (stderr).
If s is not NULL and the string pointed to by s is not a null character, the output format is as follows: the string pointed to by s followed by a colon and space, then the implementation-defined error message, and finally a new-line character.
### 7.4.12 `<stdlib.h>`

Defines standard functions for standard processing of C programs.
The following macros are implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (macro)</td>
<td>onexit_t</td>
<td>Indicates the type returned by the function registered by the <code>onexit</code> function and the type of the value returned by the <code>onexit</code> function.</td>
</tr>
<tr>
<td></td>
<td>div_t</td>
<td>Indicates the type of structure of the value returned by the <code>div</code> function.</td>
</tr>
<tr>
<td></td>
<td>ldiv_t</td>
<td>Indicates the type of structure of the value returned by the <code>ldiv</code> function.</td>
</tr>
<tr>
<td>Constant (macro)</td>
<td>RAND_MAX</td>
<td>Indicates the maximum value of pseudo-random integers generated by the <code>rand</code> function.</td>
</tr>
<tr>
<td></td>
<td>EXIT_SUCCESS</td>
<td>Indicates the successfully completed state.</td>
</tr>
<tr>
<td>Function</td>
<td>atof</td>
<td>Converts a number-representing string to a <code>double</code> type floating-point number.</td>
</tr>
<tr>
<td></td>
<td>atoi</td>
<td>Converts a decimal-representing string to an <code>int</code> type integer.</td>
</tr>
<tr>
<td></td>
<td>atol</td>
<td>Converts a decimal-representing string to a <code>long</code> type integer.</td>
</tr>
<tr>
<td></td>
<td>atoll</td>
<td>Converts a decimal-representing string to a <code>long long</code> type integer.</td>
</tr>
<tr>
<td></td>
<td>strtod</td>
<td>Converts a number-representing string to a <code>double</code> type floating-point number.</td>
</tr>
<tr>
<td></td>
<td>strtof</td>
<td>Converts a number-representing string to a <code>float</code> type floating-point number.</td>
</tr>
<tr>
<td></td>
<td>strtol</td>
<td>Converts a number-representing string to a <code>long double</code> type floating-point number.</td>
</tr>
<tr>
<td></td>
<td>strtoul</td>
<td>Converts a number-representing string to an <code>unsigned long</code> type integer.</td>
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Converts a number-representing string to a double type floating-point number.

[Format]

```c
#include <stdlib.h>

double atof (const char *nptr);
```

[Parameters]

- `nptr` Pointer to a number-representing string to be converted

[Return values]

Converted data as a **double** type floating-point number

[Remarks]

If the converted result overflows or underflows, **errno** is set.
Data is converted up to the first character that does not fit the floating-point data type.
The `atof` function does not guarantee the return value if an error such as an overflow occurs. When you want to acquire the guaranteed return value, use the `strtod` function.
Converts a decimal-representing string to an int type integer.

[Format]

```c
#include <stdlib.h>
long atoi (const char *nptr);
```

[Parameters]

- `nptr` Pointer to a number-representing string to be converted

[Return values]

Converted data as an int type integer

[Remarks]

If the converted result overflows, `errno` is set. Data is converted up to the first character that does not fit the decimal data type. The `atoi` function does not guarantee the return value if an error such as an overflow occurs. When you want to acquire the guaranteed return value, use the `strtol` function.
Converts a decimal-representing string to a long type integer.

[Format]

```c
#include <stdlib.h>
long atol (const char *nptr);
```

[Parameters]

- `nptr` Pointer to a number-representing string to be converted

[Return values]

Converted data as a long type integer

[Remarks]

If the converted result overflows, `errno` is set.
Data is converted up to the first character that does not fit the decimal data type.

The `atol` function does not guarantee the return value if an error such as an overflow occurs. When you want to acquire the guaranteed return value, use the `strtol` function.
Converts a decimal-representing string to a `long long` type integer.

**Format**

```c
#include <stdlib.h>
long long atoll (const char *nptr);
```

**Parameters**

- `nptr` Pointer to a number-representing string to be converted

**Return values**

Converted data as a `long long` type integer

**Remarks**

If the converted result overflows, `errno` is set. Data is converted up to the first character that does not fit the decimal data type. The `atoll` function does not guarantee the return value if an error such as an overflow occurs. When you want to acquire the guaranteed return value, use the `strtoll` function.
Converts a number-representing string to a double type floating-point number.

[Format]
```c
#include <stdlib.h>
double strtod (const char *nptr, char **endptr);
```

[Parameters]
- `nptr`  Pointer to a number-representing string to be converted
- `endptr`  Pointer to the storage area containing a pointer to the first character that does not represent a floating-point number

[Return values]
- Normal: If the string pointed by `nptr` begins with a character that does not represent a floating-point number: 0
- If the string pointed by `nptr` begins with a character that represents a floating-point number: Converted data as a double type floating-point number
- Abnormal: If the converted data overflows: `HUGE_VAL` with the same sign as that of the string before conversion
- If the converted data underflows: 0

[Remarks]
The `strtod` function converts data, from the first digit or the decimal point up to the character immediately before the character that does not represent a floating-point number, into a double type floating-point number. However, if neither an exponent nor a decimal point is found in the data to be converted, the compiler assumes that the decimal point comes next to the last digit in the string. In the area pointed by `endptr`, the function sets up a pointer to the first character that does not represent a floating-point number. If some characters that do not represent a floating-point number come before digits, the value of `nptr` is set. If `endptr` is `NULL`, nothing is set in this area.
**strtof**

Converts a number-representing string to a **float** type floating-point number.

**[Format]**

```c
#include <stdlib.h>
float strtof (const char *nptr, char **endptr);
```

**[Parameters]**

- **nptr**: Pointer to a number-representing string to be converted
- **endptr**: Pointer to the storage area containing a pointer to the first character that does not represent a floating-point number

**[Return values]**

- **Normal**: If the string pointed by **nptr** begins with a character that does not represent a floating-point number: 0
  - If the string pointed by **nptr** begins with a character that represents a floating-point number: Converted data as a **float** type floating-point number
- **Abnormal**: If the converted data overflows: **HUGE_VALF** with the same sign as that of the string before conversion
  - If the converted data underflows: 0

**[Remarks]**

If the converted result overflows or underflows, **errno** is set.

The **strtof** function converts data, from the first digit or the decimal point up to the character immediately before the character that does not represent a floating-point number, into a **float** type floating-point number. However, if neither an exponent nor a decimal point is found in the data to be converted, the compiler assumes that the decimal point comes next to the last digit in the string. In the area pointed by **endptr**, the function sets up a pointer to the first character that does not represent a floating-point number. If some characters that do not represent a floating-point number come before digits, the value of **nptr** is set. If **endptr** is **NULL**, nothing is set in this area.
**strtold**

Converts a number-representing string to a long double type floating-point number.

**Format**

```c
#include <stdlib.h>
long double strtold (const char *nptr, char **endptr);
```

**Parameters**

- `nptr`  Pointer to a number-representing string to be converted
- `endptr` Pointer to the storage area containing a pointer to the first character that does not represent a floating-point number

**Return values**

- **Normal:** If the string pointed by `nptr` begins with a character that does not represent a floating-point number: 0
  - If the string pointed by `nptr` begins with a character that represents a floating-point number: Converted data as a long double type floating-point number
- **Abnormal:** If the converted data overflows: `HUGE_VALL` with the same sign as that of the string before conversion
  - If the converted data underflows: 0

**Remarks**

If the converted result overflows or underflows, `errno` is set.

The `strtold` function converts data, from the first digit or the decimal point up to the character immediately before the character that does not represent a floating-point number, into a long double type floating-point number. However, if neither an exponent nor a decimal point is found in the data to be converted, the compiler assumes that the decimal point comes next to the last digit in the string. In the area pointed by `endptr`, the function sets up a pointer to the first character that does not represent a floating-point number. If some characters that do not represent a floating-point number come before digits, the value of `nptr` is set. If `endptr` is `NULL`, nothing is set in this area.
`strtol`

Converts a number-representing string to a `long` type integer.

**[Format]**

```c
#include <stdlib.h>
long strtol (const char *nptr, char **endptr, long base);
```

**[Parameters]**

- `nptr` Pointer to a number-representing string to be converted
- `endptr` Pointer to the storage area containing a pointer to the first character that does not represent an integer
- `base` Radix of conversion (0 or 2 to 36)

**[Return values]**

Normal: If the string pointed by `nptr` begins with a character that does not represent an integer: 0
  - If the string pointed by `nptr` begins with a character that represents an integer: Converted data as a `long` type integer
Abnormal: If the converted data overflows: `LONG_MAX` or `LONG_MIN` depending on the sign of the string before conversion

**[Remarks]**

If the converted result overflows, `errno` is set.
- The `strtol` function converts data, from the first digit up to the character before the first character that does not represent an integer, into a `long` type integer.
- In the storage area pointed by `endptr`, the function sets up a pointer to the first character that does not represent an integer. If some characters that do not represent an integer come before the first digit, the value of `nptr` is set in this area.
- If `endptr` is `NULL`, nothing is set in this area.
- If the value of `base` is 0, the rules described in section 3.1.3 (4), Integers, are observed at conversion. If the value of `base` is 2 to 36, it indicates the radix of conversion, where a (or A) to z (or Z) in the string to be converted correspond to numbers 10 to 35. If a character that is not smaller than the `base` value is found in the string to be converted, conversion stops immediately. A 0 after a sign is ignored at conversion. Similarly, 0x (or 0X) is ignored when `base` is 16.
**strtoul**

Converts a number-representing string to an unsigned long type integer.

**[Format]**

```
#include <stdlib.h>
unsigned long strtoul (const char *nptr, char **endptr, long base);
```

**[Parameters]**

- `nptr`  Pointer to a number-representing string to be converted
- `endptr`  Pointer to the storage area containing a pointer to the first character that does not represent an integer
- `base`  Radix of conversion (0 or 2 to 36)

**[Return values]**

- Normal: If the string pointed by `nptr` begins with a character that does not represent an integer: 0
  - If the string pointed by `nptr` begins with a character that represents an integer: Converted data as an **unsigned** long type integer
- Abnormal: If the converted data overflows: **ULONG_MAX**

**[Remarks]**

If the converted result overflows, **errno** is set.

The **strtoul** function converts data, from the first digit up to the character before the first character that does not represent an integer, into an **unsigned long** type integer.

In the storage area pointed by `endptr`, the function sets up a pointer to the first character that does not represent an integer. If some characters that do not represent an integer come before the first digit, the value of `nptr` is set in this area.

If `endptr` is **NULL**, nothing is set in this area.

If the value of `base` is 0, the rules described in section 3.1.3 (4), Integers, are observed at conversion. If the value of `base` is 2 to 36, it indicates the radix of conversion, where a (or A) to z (or Z) in the string to be converted correspond to numbers 10 to 35. If a character that is not smaller than the `base` value is found in the string to be converted, conversion stops immediately. A 0 after a sign is ignored at conversion. Similarly, 0x (or 0X) is ignored when `base` is 16.
Converts a number-representing string to a \texttt{long long} type integer.

\textbf{[Format]}

\begin{verbatim}
#include <stdlib.h>
long long strtoll (const char *nptr, char **endptr, long base);
\end{verbatim}

\textbf{[Parameters]}

\begin{itemize}
  \item \texttt{nptr}  Pointer to a number-representing string to be converted
  \item \texttt{endptr}  Pointer to the storage area containing a pointer to the first character that does not represent an integer
  \item \texttt{base}  Radix of conversion (0 or 2 to 36)
\end{itemize}

\textbf{[Return values]}

\begin{itemize}
  \item \texttt{Normal}: If the string pointed by \texttt{nptr} begins with a character that does not represent an integer: 0
  \item If the string pointed by \texttt{nptr} begins with a character that represents an integer: Converted data as a \texttt{long long} type integer
  \item \texttt{Abnormal}: If the converted data overflows: \texttt{LLONG_MAX} or \texttt{LLONG_MIN} depending on the sign of the string before conversion
\end{itemize}

\textbf{[Remarks]}

If the converted result overflows, \texttt{errno} is set.

The \texttt{strtoll} function converts data, from the first digit up to the character before the first character that does not represent an integer, into a \texttt{long long} type integer.

In the storage area pointed by \texttt{endptr}, the function sets up a pointer to the first character that does not represent an integer. If some characters that do not represent an integer come before the first digit, the value of \texttt{nptr} is set in this area. If \texttt{endptr} is \texttt{NULL}, nothing is set in this area.

If the value of \texttt{base} is 0, the rules described in section 3.1.3 (4), Integers, are observed at conversion. If the value of \texttt{base} is 2 to 36, it indicates the radix of conversion, where a (or A) to z (or Z) in the string to be converted correspond to numbers 10 to 35. If a character that is not smaller than the \texttt{base} value is found in the string to be converted, conversion stops immediately. A 0 after a sign is ignored at conversion. Similarly, 0x (or 0X) is ignored when \texttt{base} is 16.
Converts a number-representing string to an unsigned long long type integer.

[Format]

```c
#include <stdlib.h>
unsigned long long strtoull (const char *nptr, char **endptr, long base);
```

[Parameters]

- `nptr`  Pointer to a number-representing string to be converted
- `endptr`  Pointer to the storage area containing a pointer to the first character that does not represent an integer
- `base`  Radix of conversion (0 or 2 to 36)

[Return values]

- **Normal**: If the string pointed by `nptr` begins with a character that does not represent an integer: 0
  - If the string pointed by `nptr` begins with a character that represents an integer: Converted data as an unsigned long long type integer
- **Abnormal**: If the converted data overflows: ULLONG_MAX

[Remarks]

If the converted result overflows, `errno` is set.

The `strtoull` function converts data, from the first digit up to the character before the first character that does not represent an integer, into an unsigned long long type integer.

In the storage area pointed by `endptr`, the function sets up a pointer to the first character that does not represent an integer. If some characters that do not represent an integer come before the first digit, the value of `nptr` is set in this area. If `endptr` is NULL, nothing is set in this area.

If the value of `base` is 0, the rules described in section 3.1.3 (4), Integers, are observed at conversion. If the value of `base` is 2 to 36, it indicates the radix of conversion, where a (or A) to z (or Z) in the string to be converted correspond to numbers 10 to 35. If a character that is not smaller than the `base` value is found in the string to be converted, conversion stops immediately. A 0 after a sign is ignored at conversion. Similarly, 0x (or 0X) is ignored when `base` is 16.
Generates a pseudo-random integer from 0 to **RAND_MAX**.

**[Format]**

```c
#include <stdlib.h>
long rand (void);
```

**[Return values]**

Pseudo-random integer
srand

Sets an initial value of the pseudo-random number sequence generated by the rand function.

[Format]
#include <stdlib.h>
void srand (unsigned long seed);

[Parameters]
seed  Initial value for pseudo-random number sequence generation

[Remarks]
The srand function sets up an initial value for pseudo-random number sequence generation of the rand function. If pseudo-random number sequence generation by the rand function is repeated and if the same initial value is set up again by the srand function, the same pseudo-random number sequence is repeated.

If the rand function is called before the srand function, 1 is set as the initial value for the pseudo-random number generation.
Allocates a storage area and clears all bits in the allocated storage area to 0.

[Format]

```c
#include <stdlib.h>
void *calloc (size_t nelem, size_t elsize);
```

[Parameters]

- `nelem` Number of elements
- `elsize` Number of bytes occupied by a single element

[Return values]

- Normal: Starting address of an allocated storage area
- Abnormal: Storage allocation failed, or either of the parameter is 0: `NULL`

[Remarks]

The `calloc` function allocates as many storage units of size `elsize` (bytes) as the number specified by `nelem`. The function also clears all the bits in the allocated storage area to 0.

The CC-RX has a security facility for detecting illegal operations to storage areas. For details, refer to the `-secure_malloc` option in "2.5.4 Library Generator Options".
**free**

Releases the specified storage area.

**[Format]**

```c
#include <stdlib.h>
void free (void *ptr);
```

**[Parameters]**

- `ptr` Address of storage area to release

**[Remarks]**

The `free` function releases the storage area pointed by `ptr`, to enable reallocation for use. If `ptr` is `NULL`, the function carries out nothing.

If the storage area attempted to release was not allocated by the `calloc`, `malloc`, or `realloc` function, or when the area has already been released by the `free` or `realloc` function, correct operation is not guaranteed. Operation result of reference to a released storage area is also not guaranteed.

The CC-RX has a security facility for detecting illegal operations to storage areas. For details, refer to the `-secure_malloc` option in "2.5.4 Library Generator Options".
malloc

Allocates a storage area.

[Format]
#include <stdlib.h>
void *malloc (size_t size);

[Parameters]
size  Size in number of bytes of storage area to allocate

[Return values]
Normal: Starting address of allocated storage area
Abnormal: Storage allocation failed, or \texttt{size} is 0: \texttt{NULL}

[Remarks]
The \texttt{malloc} function allocates a storage area of a specified number of bytes by \texttt{size}.
The CC-RX has a security facility for detecting illegal operations to storage areas. For details, refer to the
\texttt{-secure_malloc} option in \textquote{2.5.4 Library Generator Options}".
realloc

Changes the size of a storage area to a specified value.

[Format]

```c
#include <stdlib.h>
void *realloc (void *ptr, size_t size);
```

[Parameters]

- `ptr` Starting address of storage area to be changed
- `size` Size of storage area in number of bytes after the change

[Return values]

- Normal: Starting address of storage area whose size has been changed
- Abnormal: Storage area allocation has failed, or size is 0: NULL

[Remarks]

The `realloc` function changes the size of the storage area specified by `ptr` to the number of bytes specified by `size`. If the newly allocated storage area is smaller than the old one, the contents are left unchanged up to the size of the newly allocated area.

- When `ptr` is not a pointer to the storage area allocated by the `calloc`, `malloc`, or `realloc` function or when `ptr` is a pointer to the storage area released by the `free` or `realloc` function, operation is not guaranteed.

The CC-RX has a security facility for detecting illegal operations to storage areas. For details, refer to the `-secure_malloc` option in "2.5.4 Library Generator Options".
**bsearch**

Performs binary search.

**[Format]**

```c
#include <stdlib.h>
void *bsearch (const void *key, const void *base, size_t nmemb, size_t size, long (*compar)(const void *, const void *));
```

```cpp
void *bsearch(const void *key, const void *base, size_t nmemb, size_t size, int (*compar)(const void *, const void *));
```

**[Parameters]**

- **key**: Pointer to data to find
- **base**: Pointer to a table to be searched
- **nmemb**: Number of members to be searched
- **size**: Number of bytes of a member to be searched
- **compar**: Pointer to a function that performs comparison

**[Return values]**

If a matching member is found: Pointer to the matching member
If no matching member is found: **NULL**

**[Remarks]**

The **bsearch** function searches the table specified by **base** for a member that matches the data specified by **key**, by binary search method. The function that performs comparison should receive pointers **p1** (first parameter) and **p2** (second parameter) to two data items to compare, and return the result complying with the specification below.

- *p1 < *p2: Returns a negative value.
- *p1 == *p2: Returns 0.
- *p1 > *p2: Returns a positive value.

Members to be searched must be placed in the ascending order.
Performs sorting.

[Format]

// C
#include <stdlib.h>
void qsort (const void *base, size_t nmemb, size_t size, long (*compar)(const void *, const void *));

// C++/EC++
#include <stdlib.h>
void qsort(const void *base, size_t nmemb, size_t size, int (*compar)(const void *, const void *));

[Parameters]

base  Pointer to the table to be sorted
nmemb Number of members to sort
size  Number of bytes of a member to be sorted
compar Pointer to a function to perform comparison

[Remarks]

The qsort function sorts out data on the table pointed to by base. The data arrangement order is specified by the pointer to a function to perform comparison. This comparison function should receive pointers p1 (first parameter) and p2 (second parameter) as two data items to be compared, and return the result complying with the specification below.

*p1 < *p2: Returns a negative value.
*p1 == *p2: Returns 0.
*p1 > *p2: Returns a positive value.
abs

Calculates the absolute value of an int type integer.

[Format]
#include <stdlib.h>
long abs (long i);

[Parameters]
i  Integer to calculate the absolute value

[Return values]
Absolute value of i

[Remarks]
If the resultant absolute value cannot be expressed as an int type integer, correct operation is not guaranteed.
Carries out division of int type integers and obtains the quotient and remainder.

**[Format]**

```c
#include <stdlib.h>
div_t div (long numer, long denom);
```

**[Parameters]**

- `numer` Dividend
- `denom` Divisor

**[Return values]**

Quotient and remainder of division of `numer` by `denom`.

**[Remarks]**

Type `div_t` is defined as follows:

```c
typedef struct {
    long quot;
    long rem;
} div_t;
```
labs

Calculates the absolute value of a long type integer.

[Format]
#include <stdlib.h>
long labs (long j);

[Parameters]
  j  Integer to calculate the absolute value

[Return values]
  Absolute value of j

[Remarks]
  If the resultant absolute value cannot be expressed as a long type integer, correct operation is not guaranteed.
Carries out division of long type integers and obtains the quotient and remainder.

[Format]

```c
#include <stdlib.h>
ldiv_t ldiv (long numer, long denom);
```

[Parameters]
- numer Dividend
- denom Divisor

[Return values]
Quotient and remainder of division of numer by denom.

[Remarks]
Type ldiv_t is defined as follows:

```c
typedef struct {
    long quot;
    long rem;
} ldiv_t;
```
llabs

Calculates the absolute value of a long long type integer.

[Format]
#include <stdlib.h>
long long llabs (long long j);

[Parameters]
j Integer to calculate the absolute value

[Return values]
Absolute value of j

[Remarks]
If the resultant absolute value cannot be expressed as a long long type integer, correct operation is not guaranteed.
Carries out division of `long long` type integers and obtains the quotient and remainder.

[Format]

```c
#include <stdlib.h>
lldiv_t lldiv (long long numer, long long denom);
```

[Parameters]

- `numer` Dividend
- `denom` Divisor

[Return values]

Quotient and remainder of division of `numer` by `denom`.

[Remarks]

Type `lldiv_t` is defined as follows:

```c
typedef struct {
    long long quot;
    long long rem;
} lldiv_t;
```
### 7.4.13 `<string.h>`

Defines functions for handling character arrays.

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<th>Description</th>
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</tr>
<tr>
<td></td>
<td>strcpy</td>
<td>Copies contents of a source string including the null character to a destination storage area.</td>
</tr>
<tr>
<td></td>
<td>strncpy</td>
<td>Copies a source string of a specified length to a destination storage area.</td>
</tr>
<tr>
<td></td>
<td>strcat</td>
<td>Concatenates a string after another string.</td>
</tr>
<tr>
<td></td>
<td>strncat</td>
<td>Concatenates a string of a specified length after another string.</td>
</tr>
<tr>
<td></td>
<td>memcmp</td>
<td>Compares two storage areas specified.</td>
</tr>
<tr>
<td></td>
<td>strcmp</td>
<td>Compares two strings specified.</td>
</tr>
<tr>
<td></td>
<td>strncmp</td>
<td>Compares two strings specified for a specified length.</td>
</tr>
<tr>
<td></td>
<td>memchr</td>
<td>Searches a specified storage area for the first occurrence of a specified character.</td>
</tr>
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<td></td>
<td>strchr</td>
<td>Searches a specified string for the first occurrence of a specified character.</td>
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<tr>
<td></td>
<td>strcspn</td>
<td>Checks a specified string from the beginning and counts the number of consecutive characters at the beginning that are not included in another string specified.</td>
</tr>
<tr>
<td></td>
<td>strchrn</td>
<td>Searches a specified string for the first occurrence of any character that is included in another string specified.</td>
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<tr>
<td></td>
<td>memmove</td>
<td>Copies contents of a source storage area of a specified length to a destination storage area. Even if a part of the source storage area and a part of the destination storage area overlap, correct copy is performed.</td>
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### Implementation-Defined Specifications

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When using functions defined in this standard include file, note the following.

(1) On copying a string, if the destination area is smaller than the source area, correct operation is not guaranteed.

Example
```c
char a[]="abc";
char b[3];
.
.
strcpy (b, a);
```

In the above example, the size of array `a` (including the null character) is 4 bytes. Copying by `strcpy` overwrites data beyond the boundary of array `b`.

(2) On copying a string, if the source area overlaps the destination area, correct operation is not guaranteed.

Example
```c
int a[ ]="a";
.
.
strcpy(&a[1], a);
```

In the above example, before the null character of the source is read, ‘a’ is written over the null character. Then the subsequent data after the source string is overwritten in succession.

Subsequent data is copied in succession.
memcpy

Copies the contents of a source storage area of a specified length to a destination storage area.

[Format]

```c
#include <string.h>
void *memcpy (void *s1, const void *s2, size_t n);
```

[Parameters]

- `s1`: Pointer to destination storage area
- `s2`: Pointer to source storage area
- `n`: Number of characters to be copied

[Return values]

- `s1` value
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<td><code>strcpy</code></td>
<td>Copies the contents of a source string including the null character to a destination storage area.</td>
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</table>

**[Format]**

```
#include <string.h>
char *strcpy (char *s1, const char *s2);
```

**[Parameters]**

- `s1` Pointer to destination storage area
- `s2` Pointer to source string

**[Return values]**

- `s1` value
strncpy

Copies a source string of a specified length to a destination storage area.

[Format]

```
#include <string.h>
char *strncpy (char *s1, const char *s2, size_t n);
```

[Parameters]

- s1  Pointer to destination storage area
- s2  Pointer to source string
- n   Number of characters to be copied

[Return values]

- s1 value

[Remarks]

The **strncpy** function copies up to n characters from the beginning of the string pointed by s2 to a storage area pointed by s1. If the length of the string specified by s2 is shorter than n characters, the function elongates the string to the length by padding with null characters.

If the length of the string specified by s2 is longer than n characters, the copied string in s1 storage area ends with a character other than the null character.
**strcat**

Concatenates a string after another string.

**[Format]**

```c
#include <string.h>
char *strcat (char *s1, const char *s2);
```

**[Parameters]**

- `s1` Pointer to the string after which another string is appended
- `s2` Pointer to the string to be appended after the other string

**[Return values]**

- `s1` value

**[Remarks]**

The `strcat` function concatenates the string specified by `s2` at the end of another string specified by `s1`. The null character indicating the end of the `s2` string is also copied. The null character at the end of the `s1` string is deleted.
strncat

Concatenates a string of a specified length after another string.

[Format]

```c
#include <string.h>
char *strncat (char *s1, const char *s2, size_t n);
```

[Parameters]

- `s1`: Pointer to the string after which another string is appended
- `s2`: Pointer to the string to be appended after the other string
- `n`: Number of characters to concatenate

[Return values]

- `s1` value

[Remarks]

The `strncat` function concatenates up to `n` characters from the beginning of the string specified by `s2` at the end of another string specified by `s1`. The null character at the end of the `s1` string is replaced by the first character of the `s2` string. A null character is appended to the end of the concatenated string.
memcmp

Compares the contents of two storage areas specified.

[Format]

```c
#include <string.h>
long memcmp (const void *s1, const void *s2, size_t n);
```

[Parameters]

- s1  Pointer to the reference storage area to be compared
- s2  Pointer to the storage area to compare to the reference
- n  Number of characters to compare

[Return values]

- If storage area pointed by s1 > storage area pointed by s2: Positive value
- If storage area pointed by s1 == storage area pointed by s2: 0
- If storage area pointed by s1 < storage area pointed by s2: Negative value

[Remarks]

The `memcmp` function compares the contents of the first n characters in the storage areas pointed by s1 and s2. The rules of comparison are implementation-defined.
**strcmp**

Compares the contents of two strings specified.

**[Format]**

```c
#include <string.h>
long strcmp (const char *s1, const char *s2);
```

**[Return values]**

If string pointed by `s1` > string pointed by `s2`: Positive value
If string pointed by `s1` == string pointed by `s2`: 0
If string pointed by `s1` < string pointed by `s2`: Negative value

**[Parameters]**

- `s1` Pointer to the reference string to be compared
- `s2` Pointer to the string to compare to the reference

**[Remarks]**

The `strcmp` function compares the contents of the strings pointed by `s1` and `s2`, and sets up the comparison result as a return value. The rules of comparison are implementation-defined.
**strncmp**

Compares two strings specified up to a specified length.

**[Format]**

```c
#include <string.h>
long strncmp (const char *s1, const char *s2, size_t n);
```

**[Parameters]**

- `s1` Pointer to the reference string to be compared
- `s2` Pointer to the string to compare to the reference
- `n` Maximum number of characters to compare

**[Return values]**

- If string pointed by `s1` > string pointed by `s2`: Positive value
- If string pointed by `s1` == string pointed by `s2`: 0
- If string pointed by `s1` < string pointed by `s2`: Negative value

**[Remarks]**

The `strncmp` function compares the contents of the strings pointed by `s1` and `s2`, up to `n` characters. The rules of comparison are implementation-defined.
memchr

Searches a specified storage area for the first occurrence of a specified character.

[Format]

```c
#include <string.h>
void *memchr (const void *s, long c, size_t n);
```

[Parameters]

- `s`  Pointer to the storage area to be searched
- `c`  Character to search for
- `n`  Number of characters to search

[Return values]

- If the character is found: Pointer to the found character
- If the character is not found: `NULL`

[Remarks]

The `memchr` function searches the storage area specified by `s` from the beginning up to `n` characters, looking for the first occurrence of the character specified as `c`. If the `c` character is found, the function returns the pointer to the found character.
Strchr

Searches a specified string for the first occurrence of a specified character.

[Format]

    char *strchr (const char *s, long c);

[Parameters]

    s  Pointer to the string to be searched
    c  Character to search for

[Return values]

    If the character is found: Pointer to the found character
    If the character is not found: NULL

[Remarks]

    The strchr function searches the string specified by s looking for the first occurrence of the character specified as c. If the c character is found, the function returns the pointer to the found character. The null character at the end of the s string is included in the search object.
Checks a specified string from the beginning and counts the number of consecutive characters at the beginning that are not included in another string specified.

[Format]

```c
#include <string.h>
size_t strcspn (const char *s1, const char *s2);
```

[Parameters]
- `s1`  Pointer to the string to be checked
- `s2`  Pointer to the string used to check `s1`

[Return values]
Number of characters at the beginning of the `s1` string that are not included in the `s2` string

[Remarks]
The `strcspn` function checks from the beginning of the string specified by `s1`, counts the number of consecutive characters that are not included in another string specified by `s2`, and returns that length. The null character at the end of the `s2` string is not taken as a part of the `s2` string.
**strpbrk**

Searches a specified string for the first occurrence of the character that is included in another string specified.

**[Format]**

```c
#include <string.h>
char *strpbrk (const char *s1, const char *s2);
```

**[Parameters]**

- `s1`  Pointer to the string to be searched
- `s2`  Pointer to the string that indicates the characters to search `s1` for

**[Return values]**

- If the character is found: Pointer to the found character
- If the character is not found: **NULL**

**[Remarks]**

The **strpbrk** function searches the string specified by `s1` looking for the first occurrence of any character included in the string specified by `s2`. If any searched character is found, the function returns the pointer to the first occurrence.
strrchr

Searches a specified string for the last occurrence of a specified character.

[Format]

```c
#include <string.h>
char *strrchr (const char *s, long c);
```

[Parameters]
- s  Pointer to the string to be searched
- c  Character to search for

[Return values]
- If the character is found: Pointer to the found character
- If the character is not found: `NULL`

[Remarks]
The `strrchr` function searches the string specified by `s` looking for the last occurrence of the character specified by `c`. If the `c` character is found, the function returns the pointer to the last occurrence of that character. The null character at the end of the `s` string is included in the search objective.
Checks a specified string from the beginning and counts the number of consecutive characters at the beginning that are included in another string specified.

[Format]
```c
#include <string.h>
size_t strspn (const char *s1, const char *s2);
```

[Parameters]
- `s1` Pointer to the string to be checked
- `s2` Pointer to the string used to check `s1`

[Return values]
Number of characters at the beginning of the `s1` string that are included in the `s2` string

[Remarks]
The `strspn` function checks from the beginning of the string specified by `s1`, counts the number of consecutive characters that are included in another string specified by `s2`, and returns that length.
`strstr` searches a specified string for the first occurrence of another string specified.

**[Format]**

```c
#include <string.h>
char *strstr (const char *s1, const char *s2);
```

**[Parameters]**

- `s1` Pointer to the string to be searched
- `s2` Pointer to the string to search for

**[Return values]**

- If the string is found: Pointer to the found string
- If the string is not found: `NULL`

**[Remarks]**

The `strstr` function searches the string specified by `s1` looking for the first occurrence of another string specified by `s2`, and returns the pointer to the first occurrence.
Divides a specified string into some tokens.

[Format]

```c
#include <string.h>
char *strtok (char *s1, const char *s2);
```

[Return values]

If division into tokens is successful: Pointer to the first token divided
If division into tokens is unsuccessful: NULL

[Parameters]

- s1 Pointer to the string to be divided into some tokens
- s2 Pointer to the string representing string-dividing characters

[Remarks]

The **strtok** function should be repeatedly called to divide a string.

(a) First call

The string pointed by `s1` is divided at a character included in the string pointed by `s2`. If a token has been separated, the function returns a pointer to the beginning of that token. Otherwise, the function returns NULL.

(b) Second and subsequent calls

Starting from the next character separated before as the token, the function repeats division at a character included in the string pointed by `s2`. If a token has been separated, the function returns a pointer to the beginning of that token. Otherwise, the function returns NULL.

At the second and subsequent calls, specify NULL as the first parameter. The string pointed by `s2` can be changed at each call. The null character is appended at the end of a separated token.

An example of use of the **strtok** function is shown below.

**Example**

```c
1  #include <string.h>
2  static char s1[ ]="a@b, @c/@d";
3  char *ret;
4
5  ret = strtok(s1, "@");  
6  ret = strtok(NULL, ",@");
7  ret = strtok(NULL, "/@");
8  ret = strtok(NULL, "@");  
```

**Explanation:**

The above example program uses the **strtok** function to divide string "a@b, @c/@d" into tokens a, b, c, and d.

The second line specifies string "a@b, @c/@d" as an initial value for string `s1`.

The fifth line calls the **strtok** function to divide tokens using '@' as the delimiter. As a result, a pointer to character 'a' is returned, and the null character is embedded at '@,' the first delimiter after character 'a.' Thus string 'a' has been separated.

Specify NULL for the first parameter to consecutively separate tokens from the same string, and repeat calling the **strtok** function.

Consequently, the function separates strings 'b,' 'c,' and 'd.'
Sets a specified character a specified number of times at the beginning of a specified storage area.

[Format]
```
#include <string.h>
void *memset (void *s, long c, size_t n);
```

[Parameters]
- s  Pointer to storage area to set characters in
- c  Character to be set
- n  Number of characters to be set

[Return values]
Value of s

[Remarks]
The `memset` function sets the character specified by c a number of times specified by n in the storage area specified by s.
Returns an error message corresponding to a specified error number.

[Format]

```c
#include <string.h>
char *strerror (long s);
```

[Parameters]

- `s` Error number

[Return values]

Pointer to the error message (string) corresponding to the specified error number

[Remarks]

The `strerror` function receives an error number specified by `s` and returns an error message corresponding to the number. Contents of error messages are implementation-defined.

If the returned error message is modified, correct operation is not guaranteed.
strlen

Calculates the length of a string.

[Format]

#include <string.h>
size_t strlen (const char *s);

[Parameters]

- **s**: Pointer to the string to check the length of

[Return values]

- Number of characters in the string

[Remarks]

The null character at the end of the s string is excluded from the string length.
Copies the specified size of the contents of a source area to a destination storage area. If part of the source storage area and the destination storage area overlap, data is copied to the destination storage area before the overlapped source storage area is overwritten. Therefore, correct copy is enabled.

[Format]

```
#include <string.h>
void *memmove (void *s1, const void *s2, size_t n);
```

[Parameters]

- `s1` Pointer to the destination storage area
- `s2` Pointer to the source storage area
- `n` Number of characters to be copied

[Return values]

Value of `s1`
7.4.14 <complex.h>

Performs various complex number operations. For **double**-type complex number functions, the definition names are used as function names without change. For **float**-type and **long double**-type function names, "f" and "l" are added to the end of definition names, respectively.
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<tr>
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<td>casinf / casin / casinl &lt;-lang=c99&gt;</td>
<td>Calculates the arc sine of a complex number.</td>
</tr>
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<td></td>
<td>catanf / catan / catanl &lt;-lang=c99&gt;</td>
<td>Calculates the arc tangent of a complex number.</td>
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<td>ccosf / ccos / ccosl &lt;-lang=c99&gt;</td>
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<td>Calculates the sine of a complex number.</td>
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<td>Calculates the tangent of a complex number.</td>
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<td>cacoshf / cacosh / cacoshl &lt;-lang=c99&gt;</td>
<td>Calculates the arc hyperbolic cosine of a complex number.</td>
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<td>casinhf / casinh / casinhl &lt;-lang=c99&gt;</td>
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</tr>
<tr>
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<td>catanhf / catanh / catanhl &lt;-lang=c99&gt;</td>
<td>Calculates the arc hyperbolic tangent of a complex number.</td>
</tr>
<tr>
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<td>ccoshf / ccosh / ccoshl &lt;-lang=c99&gt;</td>
<td>Calculates the hyperbolic cosine of a complex number.</td>
</tr>
<tr>
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<td>csinhf / csinh / csinhl &lt;-lang=c99&gt;</td>
<td>Calculates the hyperbolic sine of a complex number.</td>
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<td>ctanhf / ctanh / ctanhl &lt;-lang=c99&gt;</td>
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<td>Calculates the imaginary part of a complex number.</td>
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<td>Calculates the projection of a complex number on Riemann sphere.</td>
</tr>
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<td>crealf / creal / creall &lt;-lang=c99&gt;</td>
<td>Calculates the real part of a complex number.</td>
</tr>
</tbody>
</table>
cacosf / cacos / cacosl

Calculates the arc cosine of a complex number.

[Format]

#include <complex.h>
float complex cacosf(float complex z);
double complex cacos(double complex z);
long double complex cacosl(long double complex z);

[Parameters]

z Complex number for which arc cosine is to be computed

[Return values]

Complex arc cosine of z

[Remarks]

The cacos function returns the arc cosine in the range \([0, \pi]\) on the real axis and in the infinite range on the imaginary axis.
Calculates the arc sine of a complex number.

[Format]

#include <complex.h>
float complex casinf(float complex z);
double complex casin(double complex z);
long double complex casinl(long double complex z);

[Parameters]

z Complex number for which arc sine is to be computed

[Return values]

Complex arc sine of z

[Remarks]

The \texttt{casin} function returns the arc sine in the range \([-\pi/2, \pi/2]\) on the real axis and in the infinite range on the imaginary axis.
Calculates the arc tangent of a complex number.

**[Format]**

```c
#include <complex.h>
float complex catanf(float complex z);
double complex catan(double complex z);
long double complex catanl(long double complex z);
```

**[Parameters]**

- `z` Complex number for which arc tangent is to be computed

**[Return values]**

- Complex arc tangent of `z`

**[Remarks]**

The `catan` function returns the arc tangent in the range \([-\pi/2, \pi/2]\) on the real axis and in the infinite range on the imaginary axis.
ccosf / ccos / ccosl

Calculates the cosine of a complex number.

[Format]

```c
#include <complex.h>
float complex ccosf(float complex z);
double complex ccos(double complex z);
long double complex ccosl(long double complex z);
```

[Parameters]

- z Complex number for which cosine is to be computed

[Return values]

Complex cosine of z
csinf / csin / csinl

Calculates the sine of a complex number.

[Format]

```c
#include <complex.h>
float complex csinf(float complex z);
double complex csin(double complex z);
long double complex csinl(long double complex z);
```

[Parameters]

- `z` Complex number for which sine is to be computed

[Return values]

- Complex sine of `z`
Calculates the tangent of a complex number.

**[Format]**

```c
#include <complex.h>
float complex ctanf(float complex z);
double complex ctan(double complex z);
long double complex ctanl(long double complex z);
```

**[Parameters]**

- `z` Complex number for which tangent is to be computed

**[Return values]**

- Complex tangent of `z`
### cacoshf / cacosh / cacoshl

Calculates the arc hyperbolic cosine of a complex number.

#### [Format]

```c
#include <complex.h>
float complex cacoshf(float complex z);
double complex cacosh(double complex z);
long double complex cacoshl(long double complex z);
```

#### [Parameters]

- `z` Complex number for which arc hyperbolic cosine is to be computed

#### [Return values]

Complex arc hyperbolic cosine of `z`

#### [Remarks]

The `cacoshf` function returns the arc hyperbolic cosine in the range `[0, π]`. 
Calculates the arc hyperbolic sine of a complex number.

[Format]

```
#include <complex.h>
float complex casinhf(float complex z);
double complex casinh(double complex z);
long double complex casinhl(long double complex z);
```

[Parameters]

- \( z \) Complex number for which arc hyperbolic sine is to be computed

[Return values]

Complex arc hyperbolic sine of \( z \)
Calculates the arc hyperbolic tangent of a complex number.

[Format]
#include <complex.h>
float complex catanhf(float complex z);
double complex catanh(double complex z);
long double complex catanhl(long double complex z);

[Parameters]
- z  Complex number for which arc hyperbolic tangent is to be computed

[Return values]
- Complex arc hyperbolic tangent of z
Calculates the hyperbolic cosine of a complex number.

**Format**

```
#include <complex.h>
float complex ccoshf(float complex z);
double complex ccosh(double complex z);
long double complex ccoshl(long double complex z);
```

**Parameters**

- `z` Complex number for which hyperbolic cosine is to be computed

**Return values**

- Complex hyperbolic cosine of `z`
Calculates the hyperbolic sine of a complex number.

[Format]

```
#include <complex.h>
float complex csinhf(float complex z);
double complex csinh(double complex z);
long double complex csinhl(long double complex z);
```

[Parameters]

- `z` Complex number for which hyperbolic sine is to be computed

[Return values]

Complex hyperbolic sine of `z`
Calculates the hyperbolic tangent of a complex number.

**[Format]**

```
#include <complex.h>
float complex ctanhf(float complex z);
double complex ctanh(double complex z);
long double complex ctanhl(long double complex z);
```

**[Parameters]**

- `z` Complex number for which hyperbolic tangent is to be computed

**[Return values]**

Complex hyperbolic tangent of `z`
Calculates the exponential function value of a complex number.

[Format]

```
#include <complex.h>
floating complex cexpf(floating complex z);
double complex cexp(double complex z);
long double complex cexpl(long double complex z);
```

[Parameters]

- `z`: Complex number for which exponential function is to be computed

[Return values]

- Exponential function value of `z`
Calculates the natural logarithm of a complex number.

[Format]

```c
#include <complex.h>
float complex clogf(float complex z);
double complex clog(double complex z);
long double complex clogl(long double complex z);
```

[Parameters]
- `z` Complex number for which natural logarithm is to be computed

[Return values]
- Normal: Natural logarithm of `z`
- Abnormal: Domain error: Returns not-a-number.

[Remarks]
- A domain error occurs if `z` is negative.
- A range error occurs if `z` is 0.0.
- The `clog` function returns the natural logarithm in the infinite range on the real axis and in the range \([-i\pi, +i\pi]\) on the imaginary axis.
cabsf / cabs / cabsl

Calculates the absolute value of a complex number.

[Format]
```
#include <complex.h>
float cabsf(float complex z);
double cabs(double complex z);
long double cabsl(long double complex z);
```

[Parameters]
- `z` Complex number for which absolute value is to be computed

[Return values]
- Absolute value of `z`
Calculates a power of a complex number.

[Format]

```c
#include <complex.h>
float complex cpowf(float complex x, float complex y);
double complex cpow(double complex x, double complex y);
long double complex cpowl(long double complex x, long double complex y);
```

[Parameters]

- x  Value to be raised to a power
- y  Power value

[Return values]

- Normal: Value of x raised to the power y
- Abnormal: Domain error: Returns not-a-number.

[Remarks]

A domain error occurs if x is 0.0 and y is 0.0 or smaller, or if x is negative and y is not an integer. The branch cut for the first parameter of the `cpow` function group is along the negative real axis.
ccqrtf / csqrt / csqrtl

Calculates the square root of a complex number.

[Format]

```c
#include <complex.h>
float complex csqrtf(float complex z);
double complex csqrt(double complex z);
long double complex csqrtl(long double complex z);
```

[Parameters]

- `z`  Complex number for which the square root is to be computed

[Return values]

- Normal: Complex square root of `z`
- Abnormal: Domain error: Returns not-a-number.

[Remarks]

- A domain error occurs if `z` is negative.
- The branch cut for the `csqrt` function group is along the negative real axis.
- The range of the return value from the `csqrt` function group is the right halfplane including the imaginary axis.
Calculates the argument.

[Format]

```c
#include <complex.h>
float cargf(float complex z);
double carg(double complex z);
long double cargl(long double complex z);
```

[Parameters]

- `z` Complex number for which the argument is to be computed

[Return values]

- Argument value of `z`

[Remarks]

The branch cut for the `carg` function group is along the negative real axis. The `carg` function group returns the argument in the range \([-\pi, +\pi]\).
ccimagf / cimag / cimagl

Calculates the imaginary part.

[Format]

#include <complex.h>
float cimagf(float complex z);
double cimag(double complex z);
long double cimagl(long double complex z);

[Parameters]

z  Complex number for which the imaginary part is to be computed

[Return values]

Imaginary part value of z as a real number
Reverses the sign of the imaginary part of a complex number and calculates the complex conjugate.

**[Format]**

```
#include <complex.h>
float complex conjf(float complex z);
double complex conj(double complex z);
long double complex conjl(long double complex z);
```

**[Parameters]**

- `z` Complex number for which the complex conjugate is to be computed

**[Return values]**

Complex conjugate of `z`
cprojf / cproj / cprojl

Calculates the projection of a complex number on the Riemann sphere.

[Format]

#include <complex.h>
float complex cprojf(float complex z);
double complex cproj(double complex z);
long double complex cprojl(long double complex z);

[Parameters]

z  Complex number for which the projection on the Riemann sphere is to be computed

[Return values]

Projection of z on the Riemann sphere
crealf / creal / creall

Calculates the real part of a complex number.

[Format]

```c
#include <complex.h>
float crealf(float complex z);
double creal(double complex z);
long double creall(long double complex z);
```

[Parameters]

- `z` Complex number for which the real part value is to be computed

[Return values]

- Real part value of `z`
### 7.4.15 <fenv.h>

Provides access to the floating-point environment. The following macros and functions are all implementation-defined.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (macro)</td>
<td>fenv_t</td>
<td>Indicates the type of the entire floating-point environment.</td>
</tr>
<tr>
<td></td>
<td>fexcept_t</td>
<td>Indicates the type of the floating-point status flags.</td>
</tr>
<tr>
<td>Constant (macro)</td>
<td>FE_DIVBYZERO</td>
<td>Indicates the values (macros) defined when the floating-point exception is</td>
</tr>
<tr>
<td></td>
<td>FE_INEXACT</td>
<td>supported.</td>
</tr>
<tr>
<td></td>
<td>FE_INVALID</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td>FE_ALL_EXCEPT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FE_DOWNWARD</td>
<td>Indicates the values (macros) of the floating-point rounding direction.</td>
</tr>
<tr>
<td></td>
<td>FE_TONEAREST</td>
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</tr>
<tr>
<td></td>
<td>FE_TOWARDZERO</td>
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<td></td>
<td>FE_UPWARD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FE_DFL_ENV</td>
<td>Indicates the default floating-point environment of the program.</td>
</tr>
<tr>
<td>Function</td>
<td>feclearexcept</td>
<td>Attempts to clear a floating-point exception.</td>
</tr>
<tr>
<td></td>
<td>fegetexceptflag</td>
<td>Attempts to store the state of a floating-point flag in an object.</td>
</tr>
<tr>
<td></td>
<td>feraiseexcept</td>
<td>Attempts to generate a floating-point exception.</td>
</tr>
<tr>
<td></td>
<td>fetestexcept</td>
<td>Attempts to set a floating-point flag.</td>
</tr>
<tr>
<td></td>
<td>fetestexceptflag</td>
<td>Checks if floating-point flags are set.</td>
</tr>
<tr>
<td></td>
<td>fegetround</td>
<td>Gets the rounding direction.</td>
</tr>
<tr>
<td></td>
<td>fetestround</td>
<td>Sets the rounding direction.</td>
</tr>
<tr>
<td></td>
<td>fegetenv</td>
<td>Attempts to get the floating-point environment.</td>
</tr>
<tr>
<td></td>
<td>feholdexcept</td>
<td>Saves the floating-point environment, clears the floating-point status flags, and sets the non-stop mode for the floating-point exceptions.</td>
</tr>
<tr>
<td></td>
<td>fesetenv</td>
<td>Attempts to set the floating-point environment.</td>
</tr>
<tr>
<td></td>
<td>feupdateenv</td>
<td>Attempts to save the floating-point exceptions in the automatic storage, set the floating-point environment, and generate the saved floating-point exceptions.</td>
</tr>
</tbody>
</table>
Attempts to clear a floating-point exception.

[Format]

```c
#include <fenv.h>
long feclearexcept(long e);
```

[Parameters]

- `e` Floating-point exception

[Return values]

- Normal: 0
- Abnormal: Nonzero

[Remarks]

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
fegetexceptflag

Gets the state of a floating-point flag.

[Format]

```
#include <fenv.h>
long fegetexceptflag(fexcept_t *f, long e);
```

[Parameters]

- f Pointer to area to store the exception flag state
- e Value indicating the exception flag whose state is to be acquired

[Return values]

Normal: 0
Abnormal: Nonzero

[Remarks]

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
Attempts to generate a floating-point exception.

[Format]
```
#include <fenv.h>
long feraiseexcept(long e);
```

[Parameters]
- `e` Value indicating the exception to be generated

[Return values]
- Normal: 0
- Abnormal: Nonzero

[Remarks]
When generating an "overflow" or "underflow" floating-point exception, whether the `feraiseexcept` function also generates an "inexact" floating-point exception is implementation-defined.

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
Sets the state of an exception flag.

[Format]

```c
#include <fenv.h>
long fesetexceptflag(const fexcept_t *f, long e);
```

[Parameters]

- `f` Pointer to the source location from which the exception flag state is to be acquired
- `e` Value indicating the exception flag whose state is to be set

[Return values]

- Normal: 0
- Abnormal: Nonzero

[Remarks]

Before calling the `fesetexceptflag` function, specify a flag state in the source location through the `fegetexceptflag` function.

The `fesetexceptflag` function only sets the flag state without generating the corresponding floating-point exception. Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
fetestexcept

Checks the exception flag states.

[Format]

#include <fenv.h>
long fetestexcept(long e);

[Parameters]

e Value indicating flags whose states are to be checked (multiple flags can be specified)

[Return values]

Bitwise OR of e and floating-point exception macros

[Remarks]

A single fetestexcept function call can check multiple floating-point exceptions. Do not use this function when compiler option nophu is selected. If used, the function returns a nonzero value, which indicates an abnormality.
fegetround

Get the current rounding direction.

[Format]

```c
#include <fenv.h>
long fegetround(void);
```

[Return values]

- **Normal**: 0
- **Abnormal**: Negative value when there is no rounding direction macro value or the rounding direction cannot be determined

[Remarks]

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
fesetround

Sets the current rounding direction.

[Format]

#include <fenv.h>
#include <assert.h>
long fesetround(long rd);

[Return values]

0 only when the rounding direction has been set successfully

[Remarks]

The rounding direction is not changed if the rounding direction requests through the fesetround function differs from the rounding macro value.

Do not use this function when compiler option nofpu is selected. If used, the function returns a nonzero value, which indicates an abnormality.
**fegetenv**

Gets the floating-point environment.

**[Format]**

```c
#include <fenv.h>
long fegetenv( fenv_t *f);
```

**[Parameters]**

- `f` Pointer to area to store the floating-point environment

**[Return values]**

- Normal: 0
- Abnormal: Nonzero

**[Remarks]**

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
**feholdexcept**

Saves the floating-point environment.

**[Format]**

```c
#include <fenv.h>
long feholdexcept(fenv_t *f);
```

**[Parameters]**

- `f` Pointer to the floating-point environment

**[Return values]**

- `0` only when the environment has been saved successfully

**[Remarks]**

When saving the floating-point function environment, the `feholdexcept` function clears the floating-point status flags and sets the non-stop mode for all floating-point exceptions. In non-stop mode, execution continues even after a floating-point exception occurs.

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
fesetenv

Sets the floating-point environment.

[Format]

#include <fenv.h>
long fesetenv(const fenv_t *f);

[Parameters]

f  Pointer to the floating-point environment

[Return values]

Normal: 0
Abnormal: Nonzero

[Remarks]

For the argument of this function, specify the environment stored or saved by the fegetenv or feholdexcept function, or the environment equal to the floating-point environment macro.

Do not use this function when compiler option nofpu is selected. If used, the function returns a nonzero value, which indicates an abnormality.
Sets the floating-point environment with the previously generated exceptions retained.

**Format**

```c
#include <fenv.h>
long feupdateenv(const fenv_t *f);
```

**Parameters**

- `f` Pointer to the floating-point environment to be set

**Return values**

- Normal: 0
- Abnormal: Nonzero

**Remarks**

For the argument of this function, specify the object stored or saved by the `fegetenv` or `feholdexcept` function call, or the floating-point environment equal to the floating-point environment macro.

Do not use this function when compiler option `nofpu` is selected. If used, the function returns a nonzero value, which indicates an abnormality.
### 7.4.16 `<inttypes.h>`

Extends the integer types.
The following macros and functions are all implementation-defined.

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<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>imaxdiv_t</td>
<td>Indicates the type of the value returned by the <code>imaxdiv</code> function.</td>
</tr>
<tr>
<td>Variable (macro)</td>
<td>Definition Name</td>
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<td>PRIdN</td>
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</tbody>
</table>
### Function

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>imaxabs</td>
<td>Calculates the absolute value.</td>
</tr>
<tr>
<td></td>
<td>imaxdiv</td>
<td>Calculates the quotient and remainder.</td>
</tr>
<tr>
<td>strtoimax</td>
<td>/ strtoumax</td>
<td>Equivalent to the <code>strtol</code>, <code>strtoll</code>, <code>strtoul</code>, and <code>strtoull</code> functions, except that the initial part of the string is converted to <code>intmax_t</code> and <code>uintmax_t</code> representation.</td>
</tr>
<tr>
<td>wcstoimax</td>
<td>/ wcstoumax</td>
<td>Equivalent to the <code>wcstol</code>, <code>wcstoll</code>, <code>wcstoul</code>, and <code>wcstoull</code> functions except that the initial part of the wide string is converted to <code>intmax_t</code> and <code>uintmax_t</code> representation.</td>
</tr>
</tbody>
</table>
Calculates the absolute value.

**[Format]**

```c
#include <inttypes.h>
intmax_t imaxabs(intmax_t a);
```

**[Parameters]**

- `a` Value for which the absolute value is to be computed

**[Return values]**

Absolute value of `a`
Performs "/" and "\%" operations for the same operands simultaneously.

[Format]

```c
#include <inttypes.h>
imaxdiv_t imaxdiv(intmax_t n, intmax_t d);
```

[Parameters]

- `n` The left hand side operand of "/" or "\%" operator
- `d` The right hand side operand of "/" or "\%" operator

[Return values]

An object typed as struct `imaxdiv_t`, which has members `quot` (the quotient) and `rem` (the remainder).

[Remarks]

Type `imaxdiv_t` is defined as follows:

```c
typedef struct {
    long long quot;
    long long rem;
} imaxdiv_t;
```
Converts a number-representing string to an `intmax_t` type integer.

**[Format]**

```c
#include <inttypes.h>
intmax_t strtoimax(const char *nptr, char **endptr, long base);
uintmax_t strtoumax(const char *nptr, char **endptr, long base);
```

**[Parameters]**

- `nptr`: Pointer to a number-representing string to be converted
- `endptr`: Pointer to the storage area containing a pointer to the first character that does not represent an integer
- `base`: Radix of conversion (0 or 2 to 36)

**[Return Values]**

- Normal: If the string pointed by `nptr` begins with a character that does not represent an integer: 0
- Normal: If the string pointed by `nptr` begins with a character that represents an integer: Converted data as an `intmax_t` type integer
- Abnormal: If the converted data overflows: `INTMAX_MAX`, `INTMAX_MIN`, or `UINTMAX_MAX`

**[Remarks]**

If the converted result overflows, `ERANGE` is set in `errno`.

The `strtoimax` and `strtoumax` functions are equivalent to the `strtol`, `strtoll`, `strtoul`, and `strtoull` functions except that the initial part of the string is respectively converted to `intmax_t` and `uintmax_t` integers.
Converts a number-representing string to an intmax_t or uintmax_t type integer.

[Format]

```c
#include <stddef.h>
#include <inttypes.h>
intmax_t wcstoimax(const wchar_t * restrict nptr, wchar_t ** restrict endptr, long base);
uintmax_t wcstoumax(const wchar_t * restrict nptr, wchar_t ** restrict endptr, long base);
```

[Parameters]

- nptr  Pointer to a number-representing string to be converted
- endptr  Pointer to the storage area containing a pointer to the first character that does not represent an integer
- base  Radix of conversion (0 or 2 to 36)

[Return Values]

- Normal: If the string pointed by nptr begins with a character that does not represent an integer: 0
  - If the string pointed by nptr begins with a character that represents an integer: Converted data as an intmax_t type integer
- Abnormal: If the converted data overflows: INTMAX_MAX, INTMAX_MIN, or UINTMAX_MAX

[Remarks]

- If the converted result overflows, ERANGE is set in errno.
- The wcstoiomax and wcstoumax functions are equivalent to the wcstol, wcstoll, wcstoul, and wcstoull functions, except that the initial part of the string is respectively converted to intmax_t and uintmax_t integers.
7.4.17  <iso646.h>

This header file defines macros only.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>and</td>
<td>&amp;&amp;</td>
</tr>
<tr>
<td></td>
<td>and_eq</td>
<td>&amp;=</td>
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<td></td>
<td>bitand</td>
<td>&amp;</td>
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<td>bitor</td>
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<td></td>
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<td>not_eq</td>
<td>!=</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or_eq</td>
<td></td>
</tr>
<tr>
<td></td>
<td>xor</td>
<td>^</td>
</tr>
<tr>
<td></td>
<td>xor_eq</td>
<td>^=</td>
</tr>
</tbody>
</table>
7.4.18 `<stdbool.h>`

This header file defines macros only.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro (variable)</td>
<td>bool</td>
<td>Expanded to <code>_Bool</code>.</td>
</tr>
<tr>
<td>Macro (constant)</td>
<td>true</td>
<td>Expanded to 1.</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>Expanded to 0.</td>
</tr>
<tr>
<td></td>
<td>__bool_true_false_are_defined</td>
<td>Expanded to 1.</td>
</tr>
</tbody>
</table>
7.4.19 `<stdint.h>`

This header file defines macros only.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>int_least8_t</td>
<td>Indicates the types whose size is large enough to store signed and unsigned integer types of 8, 16, 32, and 64 bits.</td>
</tr>
<tr>
<td></td>
<td>uint_least8_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_least16_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uint_least16_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_least32_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uint_least32_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_least64_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uint_least64_t</td>
<td></td>
</tr>
<tr>
<td>int_fast8_t</td>
<td></td>
<td>Indicates the types which can operate signed and unsigned integer types of 8, 16, 32, and 64 bits at the fastest speed.</td>
</tr>
<tr>
<td></td>
<td>uint_fast8_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_fast16_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uint_fast16_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_fast32_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uint_fast32_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_fast64_t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uint_fast64_t</td>
<td></td>
</tr>
<tr>
<td>intptr_t</td>
<td>uintptr_t</td>
<td>These indicate signed and unsigned integer types that can be converted to or from pointers to <code>void</code>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>intmax_t</td>
<td>uintmax_t</td>
<td>These indicate signed and unsigned integer types that can represent all signed and unsigned integer types.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>intN_t</td>
<td>uintN_t</td>
<td>These indicate N-bit signed and unsigned integer types.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_MIN</td>
<td>INT_MAX</td>
<td>Indicates the minimum value of exact-width signed integer type.</td>
</tr>
<tr>
<td>INT_MAX</td>
<td>UINT_MAX</td>
<td>Indicates the maximum value of exact-width signed integer type.</td>
</tr>
<tr>
<td>UINT_MIN</td>
<td>UINT_MAX</td>
<td>Indicates the maximum value of exact-width unsigned integer type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_LEASTN_MIN</td>
<td>INT_LEASTN_MAX</td>
<td>Indicates the minimum value of minimum-width signed integer type.</td>
</tr>
<tr>
<td>INT_LEASTN_MAX</td>
<td>UINT_LEASTN_MAX</td>
<td>Indicates the maximum value of minimum-width signed integer type.</td>
</tr>
<tr>
<td>UINT_LEASTN_MIN</td>
<td>UINT_LEASTN_MAX</td>
<td>Indicates the maximum value of minimum-width unsigned integer type.</td>
</tr>
<tr>
<td>INT_FASTN_MIN</td>
<td>INT_FASTN_MAX</td>
<td>Indicates the minimum value of fastest minimum-width signed integer type.</td>
</tr>
<tr>
<td>INT_FASTN_MAX</td>
<td>UINT_FASTN_MAX</td>
<td>Indicates the maximum value of fastest minimum-width signed integer type.</td>
</tr>
<tr>
<td>UINT_FASTN_MIN</td>
<td>UINT_FASTN_MAX</td>
<td>Indicates the maximum value of fastest minimum-width unsigned integer type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTPTR_MIN</td>
<td>INTPTR_MAX</td>
<td>Indicates the minimum value of pointer-holding signed integer type.</td>
</tr>
<tr>
<td>INTPTR_MAX</td>
<td>UINTPTR_MAX</td>
<td>Indicates the maximum value of pointer-holding signed integer type.</td>
</tr>
<tr>
<td>UINTPTR_MIN</td>
<td>UINTPTR_MAX</td>
<td>Indicates the maximum value of pointer-holding unsigned integer type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTMAX_MIN</td>
<td>INTMAX_MAX</td>
<td>Indicates the minimum value of greatest-width signed integer type.</td>
</tr>
<tr>
<td>INTMAX_MAX</td>
<td>UINTMAX_MAX</td>
<td>Indicates the maximum value of greatest-width signed integer type.</td>
</tr>
<tr>
<td>UINTMAX_MIN</td>
<td>UINTMAX_MAX</td>
<td>Indicates the maximum value of greatest-width unsigned integer type.</td>
</tr>
<tr>
<td>PTRDIFF_MIN</td>
<td>PTRDIFF_MAX</td>
<td>-2147483648</td>
</tr>
<tr>
<td>PTRDIFF_MAX</td>
<td></td>
<td>+2147483647</td>
</tr>
<tr>
<td>SIG_ATOMIC_MIN</td>
<td>SIG_ATOMIC_MAX</td>
<td>-2147483648</td>
</tr>
<tr>
<td>SIG_ATOMIC_MAX</td>
<td></td>
<td>+2147483647</td>
</tr>
<tr>
<td>SIZE_MAX</td>
<td></td>
<td>4294967295</td>
</tr>
</tbody>
</table>
### CC-RX 7. LIBRARY FUNCTIONAL SPECIFICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>WCHAR_MIN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>WCHAR_MAX</td>
<td>65535U</td>
</tr>
<tr>
<td></td>
<td>WINT_MIN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>WINT_MAX</td>
<td>65535U</td>
</tr>
<tr>
<td>Function</td>
<td>INTN_C</td>
<td>Expanded to an integer constant expression corresponding to Int_leastN_t.</td>
</tr>
<tr>
<td>(macro)</td>
<td>UINTN_C</td>
<td>Expanded to an integer constant expression corresponding to Uint_leastN_t.</td>
</tr>
<tr>
<td></td>
<td>INT_MAX_C</td>
<td>Expanded to an integer constant expression with type intmax_t.</td>
</tr>
<tr>
<td></td>
<td>UINT_MAX_C</td>
<td>Expanded to an integer constant expression with type uintmax_t.</td>
</tr>
</tbody>
</table>
7.4.20  `<tgmath.h>`

This header file defines macros only.

<table>
<thead>
<tr>
<th>Type-Generic Macro</th>
<th><code>&lt;math.h&gt;</code> Functions</th>
<th><code>&lt;complex.h&gt;</code> Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>acos</td>
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<td>cacos</td>
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<tr>
<td>asin</td>
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<td>casin</td>
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<tr>
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<tr>
<td>acosh</td>
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<td>sin</td>
<td>csin</td>
</tr>
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<tr>
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<tr>
<td>Type-Generic Macro</td>
<td>&lt;math.h&gt; Functions</td>
<td>&lt;complex.h&gt; Functions</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
<td>---------------------</td>
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<td>llround</td>
<td>llround</td>
<td>-</td>
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<td>log10</td>
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<td>log1p</td>
<td>log1p</td>
<td>-</td>
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<td>log2</td>
<td>log2</td>
<td>-</td>
</tr>
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<td>logb</td>
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</tr>
<tr>
<td>lrint</td>
<td>lrint</td>
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<td>lround</td>
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<td>nearbyint</td>
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</tr>
<tr>
<td>nextafter</td>
<td>nextafter</td>
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</tr>
<tr>
<td>nexttoward</td>
<td>nexttoward</td>
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<td>remainder</td>
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<td>rint</td>
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<td>tgamma</td>
<td>tgamma</td>
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<tr>
<td>trunc</td>
<td>trunc</td>
<td>-</td>
</tr>
<tr>
<td>carg</td>
<td>-</td>
<td>carg</td>
</tr>
<tr>
<td>cimag</td>
<td>-</td>
<td>cimag</td>
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<td>conj</td>
<td>-</td>
<td>conj</td>
</tr>
<tr>
<td>cproj</td>
<td>-</td>
<td>cproj</td>
</tr>
<tr>
<td>creal</td>
<td>-</td>
<td>creal</td>
</tr>
</tbody>
</table>
7.4.21 `<wchar.h>`

The following shows macros.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>mbstate_t</td>
<td>Indicates the type for holding the necessary state of conversion between sequences of multibyte characters and wide characters.</td>
</tr>
<tr>
<td></td>
<td>wint_t</td>
<td>Indicates the type for holding extended characters.</td>
</tr>
<tr>
<td>Constant</td>
<td>WEOF</td>
<td>Indicates the end-of-file.</td>
</tr>
<tr>
<td>Function</td>
<td>fwprintf</td>
<td>Converts the output format and outputs data to a stream.</td>
</tr>
<tr>
<td></td>
<td>vfwprintf</td>
<td>Equivalent to <code>fwprintf</code> with the variable argument list replaced by <code>va_list</code>.</td>
</tr>
<tr>
<td></td>
<td>swprintf</td>
<td>Converts the output format and writes data to an array of wide characters.</td>
</tr>
<tr>
<td></td>
<td>vswprintf</td>
<td>Equivalent to <code>swprintf</code> with the variable argument list replaced by <code>va_list</code>.</td>
</tr>
<tr>
<td></td>
<td>wprintf</td>
<td>Equivalent to <code>fwprintf</code> with <code>stdout</code> added as an argument before the specified arguments.</td>
</tr>
<tr>
<td></td>
<td>vwprintf</td>
<td>Equivalent to <code>wprintf</code> with the variable argument list replaced by <code>va_list</code>.</td>
</tr>
<tr>
<td></td>
<td>fwscanf</td>
<td>Inputs and converts data from the stream under control of the wide string and assigns it to an object.</td>
</tr>
<tr>
<td></td>
<td>vfwscanf <code>&lt;lang=c99&gt;</code></td>
<td>Equivalent to <code>fwscanf</code> with the variable argument list replaced by <code>va_list</code>.</td>
</tr>
<tr>
<td></td>
<td>swscanf</td>
<td>Converts data under control of the wide string and assigns it to an object.</td>
</tr>
<tr>
<td></td>
<td>vswscanf <code>&lt;lang=c99&gt;</code></td>
<td>Equivalent to <code>swscanf</code> with the variable argument list replaced by <code>va_list</code>.</td>
</tr>
<tr>
<td></td>
<td>wscanf</td>
<td>Equivalent to <code>fwscanf</code> with <code>stdin</code> added as an argument before the specified arguments.</td>
</tr>
<tr>
<td></td>
<td>vwscanf <code>&lt;lang=c99&gt;</code></td>
<td>Equivalent to <code>wscanf</code> with the variable argument list replaced by <code>va_list</code>.</td>
</tr>
<tr>
<td></td>
<td>fgetwc</td>
<td>Inputs a wide character as the <code>wchar_t</code> type and converts it to the <code>wint_t</code> type.</td>
</tr>
<tr>
<td></td>
<td>fgetws</td>
<td>Stores a sequence of wide characters in an array.</td>
</tr>
<tr>
<td></td>
<td>fputwc</td>
<td>Writes a wide character.</td>
</tr>
<tr>
<td></td>
<td>fputws</td>
<td>Writes a wide string.</td>
</tr>
<tr>
<td></td>
<td>fwide</td>
<td>Specifies the input/output unit.</td>
</tr>
<tr>
<td></td>
<td>getwc</td>
<td>Equivalent to <code>fgetwc</code>.</td>
</tr>
<tr>
<td></td>
<td>getwchar</td>
<td>Equivalent to <code>getwc</code> with <code>stdin</code> specified as an argument.</td>
</tr>
<tr>
<td></td>
<td>putwc</td>
<td>Equivalent to <code>fputwc</code>.</td>
</tr>
<tr>
<td></td>
<td>putwchar</td>
<td>Equivalent to <code>putwc</code> with <code>stdout</code> specified as the second argument.</td>
</tr>
<tr>
<td></td>
<td>ungetwc</td>
<td>Returns a wide character to a stream.</td>
</tr>
<tr>
<td></td>
<td>wcstod / wcstof / wcstold</td>
<td>These convert the initial part of a wide string to <code>double</code>, <code>float</code>, or <code>long double</code> representation.</td>
</tr>
<tr>
<td></td>
<td>wcstol / wcstoll / wcstoul</td>
<td>These convert the initial part of a wide string to <code>long int</code>, <code>long long int</code>, <code>unsigned long int</code>, or <code>unsigned long long int</code> representation.</td>
</tr>
</tbody>
</table>
### Type Definition Name Description

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>wcscpy</td>
<td>Copies a wide string.</td>
</tr>
<tr>
<td></td>
<td>wcsncpy</td>
<td>Copies n or fewer wide characters.</td>
</tr>
<tr>
<td></td>
<td>wmemcpy</td>
<td>Copies n wide characters.</td>
</tr>
<tr>
<td></td>
<td>wmemmove</td>
<td>Copies n wide characters.</td>
</tr>
<tr>
<td></td>
<td>wcscat</td>
<td>Copies a wide string and appends it to the end of another wide string.</td>
</tr>
<tr>
<td></td>
<td>wcsncat</td>
<td>Copies a wide string with n or fewer wide characters and appends it to the end of another wide character string.</td>
</tr>
<tr>
<td></td>
<td>wcscmp</td>
<td>Compares two wide strings.</td>
</tr>
<tr>
<td></td>
<td>wcsncmp</td>
<td>Compares two arrays with n or fewer wide characters.</td>
</tr>
<tr>
<td></td>
<td>wmemcmp</td>
<td>Compares n wide characters.</td>
</tr>
<tr>
<td></td>
<td>wcschr</td>
<td>Searches for a specified wide string in another wide string.</td>
</tr>
<tr>
<td></td>
<td>wcsstr</td>
<td>Searches for the first occurrence of a specified sequence of wide characters in a wide string.</td>
</tr>
<tr>
<td></td>
<td>wcstok</td>
<td>Divides a wide string into a sequence of tokens delimited by a specified wide character.</td>
</tr>
<tr>
<td></td>
<td>wmemchr</td>
<td>Searches for the first occurrence of a specified wide character within the first n wide characters in an object.</td>
</tr>
<tr>
<td></td>
<td>wcslen</td>
<td>Calculates the length of a wide string.</td>
</tr>
<tr>
<td></td>
<td>wmemset</td>
<td>Copies n wide characters.</td>
</tr>
<tr>
<td></td>
<td>mbsinit</td>
<td>Checks if a specified object indicates the initial conversion state.</td>
</tr>
<tr>
<td></td>
<td>mbrlen</td>
<td>Calculates the number of bytes in a multibyte character.</td>
</tr>
</tbody>
</table>
fwprintf

Outputs data to a stream input/output file according to the format.

[Format]
```
#include <stdio.h>
#include <wchar.h>
long fwprintf(FILE *restrict fp, const wchar_t *restrict control [, arg]...);
```

[Parameters]
- fp  File pointer
- control Pointer to wide string indicating format
- arg,... List of data to be output according to format

[Return values]
- Normal: Number of wide strings converted and output
- Abnormal: Negative value

[Remarks]
The fwprintf function is the wide-character version of the fprintf function.
vfwpprintf

Outputs a variable parameter list to the specified stream input/output file according to a format.

[Format]
```
#include <stdarg.h>
#include <stdio.h>
#include <wchar.h>
long vfwpprintf(FILE *restrict fp, const char *restrict control, va_list arg);
```

[Parameters]
- fp  File pointer
- control Pointer to wide string indicating format
- arg  Parameter list

[Return values]
- Normal: Number of characters converted and output
- Abnormal: Negative value

[Remarks]
The vfwpprintf function is the wide-character version of the vfprintf function.
swprintf

Converts data according to a format and outputs it to the specified area.

[Format]

```c
#include <stdio.h>
#include <wchar.h>
long swprintf(wchar_t *restrict s, size_t n, const wchar_t *restrict control [, arg]...);
```

[Parameters]

- `s`  Pointer to storage area to which data is to be output
- `n`  Number of wide characters to be output
- `control`  Pointer to wide string indicating format
- `arg`, ...  Data to be output according to format

[Return values]

- Normal: Number of characters converted
- Abnormal: When a representation format error occurs or writing n or more wide characters is requested: Negative value

[Remarks]

The `swprintf` function is the wide-character version of the `sprintf` function.
vswprintf

Outputs a variable parameter list to the specified storage area according to a format.

[Format]
#include <stdarg.h>
#include <wchar.h>
long vswprintf(wchar_t *restrict s, size_t n, const wchar_t *restrict control, va_list arg);

[Parameters]
  s  Pointer to storage area to which data is to be output
  n  Number of wide characters to be output
  control  Pointer to wide string indicating format
  arg  Parameter list

[Return values]
  Normal: Number of characters converted
  Abnormal: Negative value

[Remarks]
The vswprintf function is the wide-character version of the vsprintf function.
Converts data according to a format and outputs it to the standard output file (stdout).

[Format]
```c
#include <stdio.h>
#include <wchar.h>
long wprintf(const wchar_t *restrict control [, arg]...);
```

[Parameters]
- control  Pointer to string indicating format
- arg,...  Data to be output according to format

[Return values]
- Normal: Number of wide characters converted and output
- Abnormal: Negative value

[Remarks]
The `wprintf` function is the wide-character version of `printf` function.
Outputs a variable parameter list to the standard output file (stdout) according to a format.

[Format]

```c
#include <stdarg.h>
#include <wchar.h>
long vwprintf(const wchar_t *restrict control, va_list arg);
```

[Parameters]

- `control` Pointer to wide string indicating format
- `arg` Parameter list

[Return values]

- **Normal**: Number of characters converted and output
- **Abnormal**: Negative value

[Remarks]

The `vwprintf` function is the wide-character version of the `vprintf` function.
Inputs data from a stream input/output file and converts it according to a format.

[Format]

```
#include <stdio.h>
#include <wchar.h>
long fwscanf(FILE *restrict fp, const wchar_t *restrict control [, ptr]...);
```

[Parameters]

- `fp` File pointer
- `control` Pointer to wide string indicating format
- `ptr` Pointer to storage area that stores input data

[Return values]

Normal: Number of data items successfully input and converted
Abnormal: Input data ends before input data conversion is performed: `EOF`

[Remarks]

The `fwscanf` function is the wide-character version of the `fscanf` function.
vfscanf

Inputs data from a stream input/output file and converts it according to a format.

[Format]

```
#include <stdarg.h>
#include <stdio.h>
#include <wchar.h>
long vfwscanf(FILE *restrict fp, const wchar_t *restrict control, va_list arg);
```

[Parameters]

- fp  File pointer
- control  Pointer to wide string indicating format
- arg  Parameter list

[Return values]

Normal: Number of data items successfully input and converted
Abnormal: Input data ends before input data conversion is performed: EOF

[Remarks]

The `vfscanf` is the wide-character version of the `vscanf` function.
Inputs data from the specified storage area and converts it according to a format.

[Format]
```c
#include <stdio.h>
#include <wchar.h>
long swscanf(const wchar_t *restrict s, const wchar_t *restrict control[, ptr]...);
```

[Parameters]
- `s` Storage area containing data to be input
- `control` Pointer to wide string indicating format
- `ptr`,... Pointer to storage area that stores input and converted data

[Return values]
- Normal: Number of data items successfully input and converted
- Abnormal: `EOF`

[Remarks]
The `swscanf` is the wide-character version of the `sscanf` function.
vswscanf

Inputs data from the specified storage area and converts it according to a format.

[Format]

```
#include <stdarg.h>
#include <wchar.h>
long vswscanf(const wchar_t *restrict s, const wchar_t *restrict control, va_list arg);
```

[Parameters]

- `s` Storage area containing data to be input
- `control` Pointer to wide string indicating format
- `arg` Parameter list

[Return values]

- Normal: Number of data items successfully input and converted
- Abnormal: **EOF**
Inputs data from the standard input file (stdin) and converts it according to a format.

[Format]

```c
#include <wchar.h>
long wscanf(const wchar_t *control [, ptr]...);
```

[Parameters]

- control  Pointer to wide string indicating format
- ptr,...  Pointer to storage area that stores input and converted data

[Return values]

- Normal: Number of data items successfully input and converted
- Abnormal: EOF

[Remarks]

The `wscanf` function is the wide-character version of the `scanf` function.
vwscanf

Inputs data from the specified storage area and converts it according to a format.

[Format]

```c
#include <stdarg.h>
#include <wchar.h>
long vwscanf(const wchar_t *restrict control, va_list arg);
```

[Parameters]

control  Pointer to wide string indicating format  
arg  Parameter list

[Return values]

Normal: Number of data items successfully input and converted  
Abnormal: Input data ends before input data conversion is performed: EOF

[Remarks]

The `vwscanf` function is provided to support wide-character format with the `vscanf` function.
fgetwc

Inputs one wide character from a stream input/output file.

[Format]
#include <stdio.h>
#include <wchar.h>
wint_t fgetwc(FILE *fp);

[Parameters]
fp File pointer

[Return values]
Normal: End-of-file: EOF
Otherwise: Input wide character
Abnormal: EOF

[Remarks]
When a read error occurs, the error indicator for that file is set.
The fgetwc function is provided to support wide-character input to the fgetc function.
[Format]
#include <stdio.h>
#include <wchar.h>
wchar_t *fgetws(wchar_t *restrict s, long n, FILE *fp);

[Parameters]
 s  Pointer to storage area to which wide string is input
 n  Number of bytes of storage area to which wide string is input
 fp  File pointer

[Return values]
 Normal: End-of-file: NULL
 Otherwise: s
 Abnormal: NULL

[Remarks]
The fgetws function is provided to support wide-character input to the fgets function.
fputwc

Outputs one wide character to a stream input/output file.

[Format]

```c
#include <stdio.h>
#include <wchar.h>
wint_t fputwc(wchar_t c, FILE *fp);
```

[Parameters]

- `c` Character to be output
- `fp` File pointer

[Return values]

- Normal: Output wide character
- Abnormal: EOF

[Remarks]

When a write error occurs, the error indicator for that file is set.
The `fputwc` function is the wide-character version of the `fputc` function.
fputws

Outputs a wide string to a stream input/output file.

[Format]

```c
#include <stdio.h>
#include <wchar.h>
long fputws(const wchar_t *restrict s, FILE *restrict fp);
```

[Parameters]

- `s` Pointer to wide string to be output
- `fp` File pointer

[Return values]

- Normal: 0
- Abnormal: EOF

[Remarks]

The `fputws` function is the wide-character version of the `fputs` function.
fwide

Specifies the input unit of a file.

[Format]

```c
#include <stdio.h>
#include <wchar.h>
long fwide(FILE *fp, long mode);
```

[Parameters]

- `fp` File pointer
- `mode` Value indicating the input unit

[Return values]

- A wide character is specified as the unit: Value greater than 0
- A byte is specified as the unit: Value smaller than 0
- No input/output unit is specified: 0

[Remarks]

The `fwide` function does not change the stream input/output unit that has already been determined.
Inputs one wide character from a stream input/output file.

[Format]
```c
#include <stdio.h>
#include <wchar.h>
long getwc(FILE *fp);
```

[Parameters]
- fp  File pointer

[Return values]
- Normal: End-of-file: WEOF
- Otherwise: Input wide character
- Abnormal: EOF

[Remarks]
When a read error occurs, the error indicator for that file is set.

The `getwc` function is equivalent to `fgetwc`, but `getwc` may evaluate `fp` two or more times because it is implemented as a macro. Accordingly, specify an expression without side effects for `fp`. 
getwchar

Inputs one wide character from the standard input file (stdin).

[Format]

```c
#include <wchar.h>
long getwchar(void);
```

[Return values]

- Normal: End-of-file: WEOF
- Otherwise: Input wide character
- Abnormal: EOF

[Remarks]

When a read error occurs, the error indicator for that file is set.

The `getwchar` function is the wide-character version of the `getchar` function.
putwc

Outputs one wide character to a stream input/output file.

[Format]
#include <stdio.h>
#include <wchar.h>

wint_t putwc(wchar_t c, FILE *fp);

[Parameters]
c Wide character to be output
fp File pointer

[Return values]
Normal: Output wide character
Abnormal: WEOF

[Remarks]
When a write error occurs, the error indicator for that file is set.
The putwc function is equivalent to fputwc, but putwc may evaluate fp two or more times because it is implemented as a macro. Accordingly, specify an expression without side effects for fp.
putwchar

Outputs one wide character to the standard output file (stdout).

[Format]
#include <wchar.h>
wint_t putwchar(wchar_t c);

[Parameters]
c  Wide character to be output

[Return values]
Normal: Output wide character
Abnormal: WEOF

[Remarks]
When a write error occurs, the error indicator for that file is set.
The putwchar function is the wide-character version of the putchar function.
### ungetwc

Returns one wide character to a stream input/output file.

#### Format

```c
#include <stdio.h>
#include <wchar.h>
wint_t ungetwc(wint_t c, FILE *fp);
```

#### Parameters

- `c` Wide character to be returned
- `fp` File pointer

#### Return values

- Normal: Returned wide character
- Abnormal: `WEOF`

#### Remarks

The `ungetwc` function is the wide-character version of the `ungetc` function.
Converts the initial part of a wide string to a specified-type floating-point number.

[Format]

```c
#include <wchar.h>
double wcstod(const wchar_t *restrict nptr, wchar_t **restrict endptr);
float wcstof(const wchar_t *restrict nptr, wchar_t **restrict endptr);
long double wcstold(const wchar_t *restrict nptr, wchar_t **restrict endptr);
```

[Parameters]

- `nptr` Pointer to a number-representing string to be converted
- `endptr` Pointer to the storage area containing a pointer to the first character that does not represent a floating-point number

[Return Values]

Normal: If the string pointed by `nptr` begins with a character that does not represent a floating-point number: 0
- If the string pointed by `nptr` begins with a character that represents a floating-point number: Converted data as a specified-type floating-point number
Abnormal: If the converted data overflows: `HUGE_VAL`, `HUGE_VALF`, or `HUGE_VALL` with the same sign as that of the string before conversion
- If the converted data underflows: 0

[Remarks]

- If the converted result overflows or underflows, `errno` is set.
- The `wcstod` function group is the wide-character version of the `strtod` function group.
**CC-RX**

7. LIBRARY FUNCTIONAL SPECIFICATION

### wcstol / wcstoll / wcstoul / wcstoull

Converts the initial part of a wide string to a specified-type integer.

**[Format]**

```c
#include <wchar.h>
long int wcstol(const wchar_t * restrict nptr, wchar_t ** restrict endptr, long base);
long long int wcstoll(const wchar_t * restrict nptr, wchar_t ** restrict endptr, long base);
unsigned long int wcstoul(const wchar_t * restrict nptr, wchar_t ** restrict endptr, long base);
unsigned long long int wcstoull(const wchar_t * restrict nptr, wchar_t ** restrict endptr, long base);
```

**[Parameters]**

- `nptr`  Pointer to a number-representing string to be converted
- `endptr`  Pointer to the storage area containing a pointer to the first character that does not represent an integer
- `base`  Radix of conversion (0 or 2 to 36)

**[Return values]**

- Normal: If the string pointed by `nptr` begins with a character that does not represent an integer: 0
  
  If the string pointed by `nptr` begins with a character that represents an integer: Converted data as a specified-type integer

- Abnormal: If the converted data overflows: `LONG_MIN`, `LONG_MAX`, `LLONG_MIN`, `LLONG_MAX`, `ULONG_MAX`, or `ULLONG_MAX` depending on the sign of the string before conversion

**[Remarks]**

If the converted result overflows, `errno` is set.

The `wcstol` function group is the wide-character version of the `strtol` function group.
Copies the contents of a source wide string including the null character to a destination storage area.

[Format]
#include <wchar.h>
wchar_t *wcscpy(wchar_t * restrict s1, const wchar_t * restrict s2);

[Parameters]
- s1  Pointer to destination storage area
- s2  Pointer to source string

[Return values]
- s1 value

[Remarks]
The `wcscpy` function group is the wide-character version of the `strcpy` function group.
 wcsncpy

Copies a source wide string of a specified length to a destination storage area.

[Format]

```c
#include <wchar.h>
wchar_t *wcsncpy(wchar_t * restrict s1, const wchar_t * restrict s2, size_t n);
```

[Parameters]

- `s1`  Pointer to destination storage area
- `s2`  Pointer to source string
- `n`   Number of characters to be copied

[Return values]

- `s1` value

[Remarks]

The wcsncpy function is the wide-character version of the strncpy function.
`wmemcpy`

Copies the contents of a source storage area of a specified length to a destination storage area.

[Format]

```c
#include <wchar.h>
wchar_t *wmemcpy(wchar_t *restrict s1, const wchar_t *restrict s2, size_t n);
```

[Parameters]

- `s1` Pointer to destination storage area
- `s2` Pointer to source storage area
- `n` Number of characters to be copied

[Return values]

- `s1` value

[Remarks]

The `wmemcpy` function is the wide-character version of the `memcpy` function.
wmemmove

Copies the specified size of the contents of a source area to a destination storage area. If part of the source storage area and the destination storage area overlap, data is copied to the destination storage area before the overlapped source storage area is overwritten. Therefore, correct copy is enabled.

[Format]

#include <wchar.h>
wchar_t *wmemmove(wchar_t *s1, const wchar_t *s2, size_t n);

[Parameters]

s1  Pointer to destination storage area
s2  Pointer to source storage area
n  Number of characters to be copied

[Return values]

s1 value

[Remarks]

The wmemmove function is the wide-character version of the memmove function.
**wcscat**

Concatenates a string after another string.

**[Format]**

```c
#include <wchar.h>
wchar_t *wcscat(wchar_t *s1, const wchar_t *s2);
```

**[Parameters]**

- `s1` Pointer to the string after which another string is appended
- `s2` Pointer to the string to be appended after the other string

**[Return values]**

- `s1` value

**[Remarks]**

The `wcscat` function is the wide-character version of the `strcat` function.
wcsncat

Concatenates a string of a specified length after another string.

[Format]

```c
#include <wchar.h>
wchar_t *wcsncat(wchar_t * restrict s1, const wchar_t * restrict s2, size_t n);
```

[Parameters]

- `s1` Pointer to the string after which another string is appended
- `s2` Pointer to the string to be appended after the other string
- `n` Number of characters to concatenate

[Return values]

- `s1` value

[Remarks]

The `wcsncat` function is the wide-character version of the `strncat` function.
**wcscmp**

Compares the contents of two strings specified.

**[Format]**

```
#include <wchar.h>
long wcscmp(const wchar_t *s1, const wchar_t *s2);
```

**[Parameters]**

- `s1` Pointer to the reference string to be compared
- `s2` Pointer to the string to compare to the reference

**[Return values]**

- If string pointed by `s1` > string pointed by `s2`: Positive value
- If string pointed by `s1` == string pointed by `s2`: 0
- If string pointed by `s1` < string pointed by `s2`: Negative value

**[Remarks]**

The `wcscmp` function is the wide-character version of the `strcmpl` function.
### wcsncmp

Compares two strings specified up to a specified length.

**[Format]**

```c
#include <wchar.h>
long wcsncmp(const wchar_t *s1, const wchar_t *s2, size_t n);
```

**[Parameters]**

- `s1`  Pointer to the reference string to be compared
- `s2`  Pointer to the string to compare to the reference
- `n`   Maximum number of characters to compare

**[Return values]**

- If string pointed by `s1` > string pointed by `s2`: Positive value
- If string pointed by `s1` == string pointed by `s2`: 0
- If string pointed by `s1` < string pointed by `s2`: Negative value

**[Remarks]**

The `wcsncmp` function is the wide-character version of the `strncmp` function.
wmemcmp

Compares the contents of two storage areas specified.

[Format]

```c
#include <wchar.h>
long wmemcmp(const wchar_t * s1, const wchar_t * s2, size_t n);
```

[Parameters]

- s1  Pointer to the reference storage area to be compared
- s2  Pointer to the storage area to compare to the reference
- n   Number of characters to compare

[Return values]

- If storage area pointed by `s1` > storage area pointed by `s2`: Positive value
- If storage area pointed by `s1` == storage area pointed by `s2`: 0
- If storage area pointed by `s1` < storage area pointed by `s2`: Negative value

[Remarks]

The `wmemcmp` function is the wide-character version of the `memcmp` function.
Searches a specified string for the first occurrence of a specified character.

[Format]

```c
#include <wchar.h>
wchar_t *wcschr(const wchar_t *s, wchar_t c);
```

[Parameters]

- `s` Pointer to the string to be searched
- `c` Character to search for

[Return values]

- If the character is found: Pointer to the found character
- If the character is not found: `NULL`

[Remarks]

The `wcschr` function is the wide-character version of the `strchr` function.
wcscspn

Checks a specified string from the beginning and counts the number of consecutive characters at the beginning that are not included in another string specified.

[Format]

#include <wchar.h>
size_t wcscspn(const wchar_t *s1, const wchar_t *s2);

[Parameters]

s1  Pointer to the string to be checked
s2  Pointer to the string used to check s1

[Return values]

Number of characters at the beginning of the s1 string that are not included in the s2 string

[Remarks]

The wcscspn function is the wide-character version of the strcspn function.
wcspbrk

Searches a specified string for the first occurrence of the character that is included in another string specified.

[Format]

```c
#include <wchar.h>
wchar_t *wcspbrk(const wchar_t *s1, const wchar_t *s2);
```

[Parameters]

- `s1` Pointer to the string to be searched
- `s2` Pointer to the string that indicates the characters to search `s1` for

[Return values]

- If the character is found: Pointer to the found character
- If the character is not found: `NULL`

[Remarks]

The `wcspbrk` function is the wide-character version of the `strpbrk` function.
Searches a specified string for the last occurrence of a specified character.

[Format]

```c
#include <wchar.h>
wchar_t *wcsrchr(const wchar_t *s, wchar_t c);
```

[Parameters]

- `s` Pointer to the string to be searched
- `c` Character to search for

[Return values]

- If the character is found: Pointer to the found character
- If the character is not found: `NULL`
Checks a specified string from the beginning and counts the number of consecutive characters at the beginning that are included in another string specified.

[Format]

```c
#include <wchar.h>
size_t wcsspn(const wchar_t *s1, const wchar_t *s2);
```

[Parameters]

- `s1` Pointer to the string to be checked
- `s2` Pointer to the string used to check `s1`

[Return values]

Number of characters at the beginning of the `s1` string that are included in the `s2` string

[Remarks]

The `wcsspn` function is the wide-character version of the `strspn` function.
Searches a specified string for the first occurrence of another string specified.

[Format]

```
#include <wchar.h>
wchar_t *wcsstr(const wchar_t *s1, const wchar_t *s2);
```

[Parameters]

- `s1`  Pointer to the string to be searched
- `s2`  Pointer to the string to search for

[Return values]

- If the string is found:  Pointer to the found string
- If the string is not found: `NULL`
**wcstok**

Divides a specified string into some tokens.

**[Format]**

```c
#include <wchar.h>
wchar_t* wcstok(wchar_t * restrict s1, const wchar_t * restrict s2, wchar_t ** restrict ptr);
```

**[Parameters]**

- `s1`  Pointer to the string to be divided into some tokens
- `s2`  Pointer to the string representing string-dividing characters
- `ptr` Pointer to the string where search is to be started at the next function call

**[Return values]**

- If division into tokens is successful: Pointer to the first token divided
- If division into tokens is unsuccessful: **NULL**

**[Remarks]**

The `wcstok` function is the wide-character version of the `strtok` function.

To search the same string for the second or later time, set `s1` to **NULL** and `ptr` to the value returned by the previous function call to the same string.
wmemchr

Searches a specified storage area for the first occurrence of a specified character.

[Format]

```
#include <wchar.h>
wchar_t *wmemchr(const wchar_t *s, wchar_t c, size_t n);
```

[Parameters]

- s  Pointer to the storage area to be searched
- c  Character to search for
- n  Number of characters to search

[Return values]

- If the character is found: Pointer to the found character
- If the character is not found: NULL

[Remarks]

The wmemchr function is the wide-character version of the memchr function.
**wcslen**

Calculates the length of a wide string except the terminating null wide character.

**[Format]**

```c
#include <wchar.h>
size_t wcslen(const wchar_t *s);
```

**[Parameters]**

- `s` Pointer to the wide string to check the length of

**[Return values]**

- Number of characters in the wide string

**[Remarks]**

The `wcslen` function is the wide-character version of the `strlen` function.
wmemset

Sets a specified character a specified number of times at the beginning of a specified storage area.

[Format]

```c
#include <wchar.h>
wchar_t *wmemset(wchar_t *s, wchar_t c, size_t n);
```

[Parameters]

- `s`  Pointer to storage area to set characters in
- `c`  Character to be set
- `n`  Number of characters to be set

[Return values]

Value of `s`

[Remarks]

The `wmemset` function is the wide-character version of the `memset` function.
mbsinit

Checks if a specified mbstate_t object indicates the initial conversion state.

[Format]

```
#include <wchar.h>
long mbsinit(const mbstate_t *ps);
```

[Parameters]

- **ps**  Pointer to mbstate_t object

[Return values]

- Initial conversion state: Nonzero
- Otherwise: 0
Calculates the number of bytes in a specified multibyte character.

**[Format]**

```c
#include <wchar.h>
size_t mbrlen(const char * restrict s, size_t n, mbstate_t *restrict ps);
```

**[Parameters]**

- `s` Pointer to multibyte string
- `n` Maximum number of bytes to be checked for multibyte character
- `ps` Pointer to `mbstate_t` object

**[Return values]**

- 0: A null wide character is detected in `n` or fewer bytes.
- From 1 to `n` inclusive: A multibyte character is detected in `n` or fewer bytes.
- `(size_t)(-2)`: No complete multibyte character is detected in `n` bytes.
- `(size_t)(-1)`: An illegal multibyte sequence is detected.
7.5 EC++ Class Libraries

This section describes the specifications of the EC++ class libraries, which can be used as standard libraries in C++ programs. The class library types and corresponding standard include files are described. The specifications of each class library are given in accordance with the library configuration.

- Library types

Table 7.15 shows the class library types and the corresponding standard include files.

Table 7.15 Class Library Types and Corresponding Standard Include Files

<table>
<thead>
<tr>
<th>Library Type</th>
<th>Description</th>
<th>Standard Include Files</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream input/output class library</td>
<td>Performs input/output processing</td>
<td>&lt;ios&gt;, &lt;streambuf&gt;,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;istream&gt;, &lt;ostream&gt;,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;iomanip&gt;</td>
</tr>
<tr>
<td>Memory management library</td>
<td>Performs memory allocation and</td>
<td>&lt;new&gt;</td>
</tr>
<tr>
<td></td>
<td>deallocation</td>
<td></td>
</tr>
<tr>
<td>Complex number calculation class library</td>
<td>Performs calculation of complex</td>
<td>&lt;complex&gt;</td>
</tr>
<tr>
<td></td>
<td>number data</td>
<td></td>
</tr>
<tr>
<td>String manipulation class library</td>
<td>Performs string manipulation</td>
<td>&lt;string&gt;</td>
</tr>
</tbody>
</table>

7.5.1 Stream Input/Output Class Library

The header files for stream input/output class libraries are as follows:

- <ios>
  Defines data members and function members that specify input/output formats and manage the input/output states. The <ios> header file also defines the Init and ios_base classes in addition to the ios class.

- <streambuf>
  Defines functions for the stream buffer.

- <istream>
  Defines input functions from the input stream.

- <ostream>
  Defines output functions to the output stream.

- <iostream>
  Defines input/output functions.

- <iomanip>
  Defines manipulators with parameters.

The following shows the inheritance relation of the above classes. An arrow (->) indicates that a derived class references a base class. The streambuf class has no inheritance relation.
The following types are used by stream input/output class libraries.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>streamoff</td>
<td>Defined as long type.</td>
<td></td>
</tr>
<tr>
<td>streamsize</td>
<td>Defined as size_t type.</td>
<td></td>
</tr>
<tr>
<td>int_type</td>
<td>Defined as int type.</td>
<td></td>
</tr>
<tr>
<td>pos_type</td>
<td>Defined as long type.</td>
<td></td>
</tr>
<tr>
<td>off_type</td>
<td>Defined as long type.</td>
<td></td>
</tr>
</tbody>
</table>

(a) **ios_base::Init Class**

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>init_cnt</td>
<td>Static data member that counts the number of stream input/output objects. The data must be initialized to 0 by a low-level interface.</td>
</tr>
<tr>
<td>Function</td>
<td>Init()</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>~Init()</td>
<td>Destructor.</td>
</tr>
</tbody>
</table>

Constructor of class **Init**.
Increments **init_cnt**.

Destructor of class **Init**.
Decrements **init_cnt**.
### (b) ios_base Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>fmtflags</td>
<td>Type that indicates the format control information.</td>
</tr>
<tr>
<td>iostate</td>
<td></td>
<td>Type that indicates the stream buffer input/output state.</td>
</tr>
<tr>
<td>openmode</td>
<td></td>
<td>Type that indicates the open mode of the file.</td>
</tr>
<tr>
<td>seekdir</td>
<td></td>
<td>Type that indicates the seek state of the stream buffer.</td>
</tr>
<tr>
<td>Variable</td>
<td>fmtfl</td>
<td>Format flag.</td>
</tr>
<tr>
<td></td>
<td>wide</td>
<td>Field width.</td>
</tr>
<tr>
<td></td>
<td>prec</td>
<td>Precision (number of decimal point digits) at output.</td>
</tr>
<tr>
<td></td>
<td>fillch</td>
<td>Fill character.</td>
</tr>
<tr>
<td>Function</td>
<td>void _ec2p_init_base()</td>
<td>Initializes the base class.</td>
</tr>
</tbody>
</table>
|        | void _ec2p_copy_base(  
|        | ios_base()       | Constructor.                                              |
|        | ~ios_base()      | Destructor.                                               |
|        | fmtflags flags() const | References the format flag (fmtfl).                      |
|        | fmtflags flags(fmtflags fmtflg) | Sets fmtflg&format flag (fmtfl) to the format flag (fmtfl). |
|        | fmtflags setf(fmtflags fmtflg) | Sets fmtflg to format flag (fmtfl).                      |
|        | fmtflags setf(  
|        |     fmtflags fmtflg,  
|        |     fmtflags mask) | Sets mask&fmtflg to the format flag (fmtfl).              |
|        | void unsetf(fmtflags mask) | Sets ~mask&format flag (fmtfl) to the format flag (fmtfl). |
|        | char fill() const | References the fill character (fillch).                   |
|        | char fill(char ch) | Sets ch as the fill character (fillch).                   |
|        | int precision() const | References the precision (prec).                          |
|        | streamsize precision(  
|        |     streamsize preci) | Sets preci as precision (prec).                          |
|        | streamsize width() const | References the field width (wide).                      |
|        | streamsize width(streamsize wd) | Sets wd as field width (wide).                           |
### ios_base::fmtflags

Defines the format control information relating to input/output processing.

The definition for each bit mask of `fmtflags` is as follows:

<table>
<thead>
<tr>
<th>ios_base::fmtflags</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ios_base::boolalpha</td>
<td>0x0000</td>
</tr>
<tr>
<td>ios_base::skipws</td>
<td>0x0001</td>
</tr>
<tr>
<td>ios_base::unitbuf</td>
<td>0x0002</td>
</tr>
<tr>
<td>ios_base::uppercase</td>
<td>0x0004</td>
</tr>
<tr>
<td>ios_base::showbase</td>
<td>0x0008</td>
</tr>
<tr>
<td>ios_base::showpoint</td>
<td>0x0010</td>
</tr>
<tr>
<td>ios_base::showpos</td>
<td>0x0020</td>
</tr>
<tr>
<td>ios_base::left</td>
<td>0x0040</td>
</tr>
<tr>
<td>ios_base::right</td>
<td>0x0080</td>
</tr>
<tr>
<td>ios_base::internal</td>
<td>0x0100</td>
</tr>
<tr>
<td>ios_base::adjustfield</td>
<td>0x01c0</td>
</tr>
<tr>
<td>ios_base::dec</td>
<td>0x0200</td>
</tr>
<tr>
<td>ios_base::oct</td>
<td>0x0400</td>
</tr>
<tr>
<td>ios_base::hex</td>
<td>0x0800</td>
</tr>
<tr>
<td>ios_base::basefield</td>
<td>0x0e00</td>
</tr>
<tr>
<td>ios_base::scientific</td>
<td>0x1000</td>
</tr>
<tr>
<td>ios_base::fixed</td>
<td>0x2000</td>
</tr>
<tr>
<td>ios_base::floatfield</td>
<td>0x3000</td>
</tr>
<tr>
<td>ios_base::_fmtmask</td>
<td>0x3fff</td>
</tr>
</tbody>
</table>

### ios_base::iostate

Defines the input/output state of the stream buffer.

The definition for each bit mask of `iostate` is as follows:

<table>
<thead>
<tr>
<th>ios_base::iostate</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ios_base::goodbit</td>
<td>0x0000</td>
</tr>
<tr>
<td>ios_base::eofbit</td>
<td>0x0001</td>
</tr>
<tr>
<td>ios_base::failbit</td>
<td>0x0002</td>
</tr>
<tr>
<td>ios_base::badbit</td>
<td>0x0004</td>
</tr>
<tr>
<td>ios_base::_statemask</td>
<td>0x0007</td>
</tr>
</tbody>
</table>
**ios_base::openmode**

Defines open mode of the file.
The definition for each bit mask of **openmode** is as follows:

<table>
<thead>
<tr>
<th>Definition</th>
<th>Mask Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opens the input file.</td>
<td>0x01</td>
</tr>
<tr>
<td>Opens the output file.</td>
<td>0x02</td>
</tr>
<tr>
<td>Seeks for <code>eof</code> only once after the file has been opened.</td>
<td>0x04</td>
</tr>
<tr>
<td>Seeks for <code>eof</code> each time the file is written to.</td>
<td>0x08</td>
</tr>
<tr>
<td>Opens the file in overwrite mode.</td>
<td>0x10</td>
</tr>
<tr>
<td>Opens the file in binary mode.</td>
<td>0x20</td>
</tr>
</tbody>
</table>

**ios_base::seekdir**

Defines the seek state of the stream buffer.
Determines the position in a stream to continue the input/output of data.
The definition for each bit mask of **seekdir** is as follows:

<table>
<thead>
<tr>
<th>Definition</th>
<th>Mask Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of file.</td>
<td>0x0</td>
</tr>
<tr>
<td>Current position.</td>
<td>0x1</td>
</tr>
<tr>
<td>End of file.</td>
<td>0x2</td>
</tr>
</tbody>
</table>

**void ios_base::_ec2p_init_base()**

The initial settings are as follows:

- `fmtfl = skipws | dec;`
- `wide = 0;`
- `prec = 6;`
- `fillch = ' ';`

**void ios_base::_ec2p_copy_base(ios_base& ios_base_dt)**

Copies **ios_base_dt**.

**ios_base::ios_base()**

Constructor of class **ios_base**.
Calls **Init::Init()**.

**ios_base::~ios_base()**

Destructor of class **ios_base**.

**ios_base::fmtflags ios_base::flags() const**

References the format flag (**fmtfl**).
Return value: Format flag (**fmtfl**).
Sets `fmtflg` to the format flag (`fmtfl`).
Return value: Format flag (`fmtfl`) before setting.

```cpp
ios_base::fmtflags ios_base::flags(fmtflags fmtflg)
```

Sets `fmtflg` to the format flag (`fmtfl`).
Return value: Format flag (`fmtfl`) before setting.

```cpp
ios_base::fmtflags ios_base::setf(fmtflags fmtflg)
```

Sets the `mask` and `fmtflg` value to the format flag (`fmtfl`).
Return value: Format flag (`fmtfl`) before setting.

```cpp
ios_base::fmtflags ios_base::setf(fmtflags fmtflg, fmtflags mask)
```

Sets `~mask` and `fmtflg` to the format flag (`fmtfl`).

```cpp
void ios_base::unsetf(fmtflags mask)
```

References the fill character (`fillch`).
Return value: Fill character (`fillch`).

```cpp
char ios_base::fill() const
```

Sets `ch` as the fill character (`fillch`).
Return value: Fill character (`fillch`) before setting.

```cpp
char ios_base::fill(char ch)
```

References the precision (`prec`).
Return value: Precision (`prec`).

```cpp
int ios_base::precision() const
```

Sets `preci` as the precision (`prec`).
Return value: Precision (`prec`) before setting.

```cpp
streamsize ios_base::precision(streamsize preci)
```

References the field width (`wide`).
Return value: Field width (`wide`).

```cpp
streamsize ios_base::width() const
```

Sets `wd` as the field width (`wide`).
Return value: Field width (`wide`) before setting.

```cpp
streamsize ios_base::width(streamsize wd)
```
## ios Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>sb</td>
<td>Pointer to the streambuf object.</td>
</tr>
<tr>
<td></td>
<td>tiestr</td>
<td>Pointer to the ostream object.</td>
</tr>
<tr>
<td></td>
<td>state</td>
<td>State flag of streambuf.</td>
</tr>
</tbody>
</table>

**Function**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ios()</td>
<td>Constructor.</td>
</tr>
<tr>
<td>ios(streambuf* sbptr)</td>
<td>Performs initial setting.</td>
</tr>
<tr>
<td>virtual ~ios()</td>
<td>Destructor.</td>
</tr>
<tr>
<td>operator void*() const</td>
<td>Tests whether an error has been generated (state &amp; (badbit</td>
</tr>
<tr>
<td>bool operator!() const</td>
<td>Tests whether an error has been generated (state &amp; (badbit</td>
</tr>
<tr>
<td>iostate rdstate() const</td>
<td>References the state flag (state).</td>
</tr>
<tr>
<td>void clear(iostate st = goodbit)</td>
<td>Clears the state flag (state) except for the specified state (st).</td>
</tr>
<tr>
<td>void setstate(iostate st)</td>
<td>Specifies st as the state flag (state).</td>
</tr>
<tr>
<td>bool good() const</td>
<td>Tests whether an error has been generated (state == goodbit).</td>
</tr>
<tr>
<td>bool eof() const</td>
<td>Tests for the end of an input stream (state &amp; eofbit).</td>
</tr>
<tr>
<td>bool bad() const</td>
<td>Tests whether an error has been generated (state &amp; badbit).</td>
</tr>
<tr>
<td>bool fail() const</td>
<td>Tests whether the input text matches the requested pattern (state &amp; (badbit</td>
</tr>
<tr>
<td>ostream* tie() const</td>
<td>References the pointer to the ostream object (tiestr).</td>
</tr>
<tr>
<td>ostream* tie(ostream* tstrptr)</td>
<td>Sets tstrptr as the pointer to the ostream object (tiestr).</td>
</tr>
<tr>
<td>streambuf* rdbuf() const</td>
<td>References the pointer to the streambuf object (sb).</td>
</tr>
<tr>
<td>streambuf* rdbuf(streambuf* sbptr)</td>
<td>Sets sbptr as the pointer to the streambuf object (sb).</td>
</tr>
<tr>
<td>ios&amp; copyfmt(const ios&amp; rhs)</td>
<td>Copies the state flag (state) of rhs.</td>
</tr>
</tbody>
</table>

**ios::ios()**

Constructor of class *ios.*
Calls *init(0)* and sets the initial value to the member object.

**ios::ios(streambuf* sbptr)**

Constructor of class *ios.*
Calls *init(sbptr)* and sets the initial value to the member object.
void ios::init(streambuf* sbptr)

Sets `sbptr` to `sb`.
Sets `state` and `tiestr` to 0.

virtual ios::~ios()

Destructor of class `ios`.

ios::operator void*() const

Tests whether an error has been generated (!`state&(badbit | failbit)`).
Return value: An error has been generated: `false`
No error has been generated: `true`

bool ios::operator!() const

Tests whether an error has been generated (`state&(badbit | failbit)`).
Return value: An error has been generated: `true`
No error has been generated: `false`

iostate ios::rdstate() const

References the state flag (`state`).
Return value: State flag (`state`).

void ios::clear(iostate st = goodbit)

Clears the state flag (`state`) except for the specified state (`st`).
If the pointer to the `streambuf` object (`sb`) is 0, `badbit` is set to the state flag (`state`).

void ios::setstate(iostate st)

Sets `st` to the state flag (`state`).

bool ios::good() const

Tests whether an error has been generated (`state == goodbit`).
Return value: An error has been generated: `false`
No error has been generated: `true`

bool ios::eof() const

Tests for the end of the input stream (`state & eofbit`).
Return value: End of the input stream has been reached: `true`
End of the input stream has not been reached: `false`

bool ios::bad() const

Tests whether an error has been generated (`state & badbit`).
Return value: An error has been generated: `true`
No error has been generated: `false`
Tests whether the input text matches the requested pattern \((\text{state} \& (\text{badbit} | \text{failbit}))\).
Return value: Does not match the requested pattern: \text{true}  
Matches the requested pattern: \text{false}

References the pointer \(\text{tistr}\) to the \text{ostream} object.
Return value: Pointer to the \text{ostream} object \(\text{tistr}\).

Sets \text{tistr} as the pointer \(\text{tistr}\) to the \text{ostream} object.  
Return value: Pointer to the \text{ostream} object \(\text{tistr}\) before setting.

References the pointer to the \text{streambuf} object \(\text{sb}\).  
Return value: Pointer to the \text{streambuf} object \(\text{sb}\).

Sets \text{sbptr} as the pointer to the \text{streambuf} object \(\text{sb}\).  
Return value: Pointer to the \text{streambuf} object \(\text{sb}\) before setting.

Copies the state flag \(\text{state}\) of \text{rhs}.  
Return value: \text{*this}
(d) ios Class Manipulators

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>ios_base&amp; showbase(ios_base&amp; str)</td>
<td>Specifies the radix display prefix mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; noshowbase(ios_base&amp; str)</td>
<td>Clears the radix display prefix mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; showpoint(ios_base&amp; str)</td>
<td>Specifies the decimal-point generation mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; noshowpoint(ios_base&amp; str)</td>
<td>Clears the decimal-point generation mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; showpos(ios_base&amp; str)</td>
<td>Specifies the + sign generation mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; noshowpos(ios_base&amp; str)</td>
<td>Clears the + sign generation mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; skipws(ios_base&amp; str)</td>
<td>Specifies the space skipping mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; nospwss (ios_base&amp; str)</td>
<td>Clears the space skipping mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; uppercase(ios_base&amp; str)</td>
<td>Specifies the uppercase letter conversion mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; nouppercase(ios_base&amp; str)</td>
<td>Clears the uppercase letter conversion mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; internal(ios_base&amp; str)</td>
<td>Specifies the internal fill mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; left(ios_base&amp; str)</td>
<td>Specifies the left side fill mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; right(ios_base&amp; str)</td>
<td>Specifies the right side fill mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; dec(ios_base&amp; str)</td>
<td>Specifies the decimal mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; hex(ios_base&amp; str)</td>
<td>Specifies the hexadecimal mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; oct(ios_base&amp; str)</td>
<td>Specifies the octal mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; fixed(ios_base&amp; str)</td>
<td>Specifies the fixed-point mode.</td>
</tr>
<tr>
<td></td>
<td>ios_base&amp; scientific(ios_base&amp; str)</td>
<td>Specifies the scientific description mode.</td>
</tr>
</tbody>
</table>

ios_base& showbase(ios_base& str)

Specifies an output mode of prefixing a radix at the beginning of data.
For a hexadecimal, 0x is prefixed. For a decimal, nothing is prefixed. For an octal, 0 is prefixed.
Return value: str

ios_base& noshowbase(ios_base& str)

Clears the output mode of prefixing a radix at the beginning of data.
Return value: str

ios_base& showpoint(ios_base& str)

Specifies the output mode of showing the decimal point.
If no precision is specified, six decimal-point (fraction) digits are displayed.
Return value: str

ios_base& noshowpoint(ios_base& str)

Clears the output mode of showing the decimal point.
Return value: str
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Return Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ios_base&amp; showpos(ios_base&amp; str)</td>
<td>Specifies the output mode of generating the + sign (adds a + sign to a positive number).</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; noshowpos(ios_base&amp; str)</td>
<td>Clears the output mode of generating the + sign.</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; skipws(ios_base&amp; str)</td>
<td>Specifies the input mode of skipping spaces (skips consecutive spaces).</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; noskipws(ios_base&amp; str)</td>
<td>Clears the input mode of skipping spaces.</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; uppercase(ios_base&amp; str)</td>
<td>Specifies the output mode of converting letters to uppers.</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; nouppercase(ios_base&amp; str)</td>
<td>Clears the output mode of converting letters to uppers.</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; internal(ios_base&amp; str)</td>
<td>When data is output in the field width (wide) range, it is output in the order of</td>
<td>str</td>
</tr>
<tr>
<td></td>
<td>Sign and radix</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fill character (fill)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Numeric value</td>
<td></td>
</tr>
<tr>
<td>ios_base&amp; left(ios_base&amp; str)</td>
<td>When data is output in the field width (wide) range, it is aligned to the left.</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; right(ios_base&amp; str)</td>
<td>When data is output in the field width (wide) range, it is aligned to the right.</td>
<td>str</td>
</tr>
<tr>
<td>ios_base&amp; dec(ios_base&amp; str)</td>
<td>Specifies the conversion radix to the decimal mode.</td>
<td>str</td>
</tr>
</tbody>
</table>
Specifies the conversion radix to the hexadecimal mode.
Return value: `str`

```cpp
ios_base& hex(ios_base& str)
```

Specifies the conversion radix to the octal mode.
Return value: `str`

```cpp
ios_base& oct(ios_base& str)
```

Specifies the fixed-point output mode.
Return value: `str`

```cpp
ios_base& fixed(ios_base& str)
```

Specifies the scientific description output mode (exponential description).
Return value: `str`

```cpp
ios_base& scientific(ios_base& str)
```

(e) **streambuf Class**

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td><code>eof</code></td>
<td>Indicates the end of the file.</td>
</tr>
<tr>
<td>Variable</td>
<td><code>_B_cnt_ptr</code></td>
<td>Pointer to the length of valid data in the buffer.</td>
</tr>
<tr>
<td></td>
<td><code>B_beg_ptr</code></td>
<td>Pointer to the base pointer of the buffer.</td>
</tr>
<tr>
<td></td>
<td><code>_B_len_ptr</code></td>
<td>Pointer to the length of the buffer.</td>
</tr>
<tr>
<td></td>
<td><code>B_next_ptr</code></td>
<td>Pointer to the next position of the buffer from which data is to be read.</td>
</tr>
<tr>
<td></td>
<td><code>B_end_ptr</code></td>
<td>Pointer to the end position of the buffer.</td>
</tr>
<tr>
<td></td>
<td><code>B_beg_pptr</code></td>
<td>Pointer to the start position of the control buffer.</td>
</tr>
<tr>
<td></td>
<td><code>B_next_pptr</code></td>
<td>Pointer to the next position of the buffer from which data is to be read.</td>
</tr>
<tr>
<td></td>
<td><code>C_flg_ptr</code></td>
<td>Pointer to the input/output control flag of the file.</td>
</tr>
</tbody>
</table>
### CC-RX LIBRARY FUNCTIONAL SPECIFICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>char* _ec2p_getflag() const</td>
<td>References the pointer for the file input/output control flag.</td>
</tr>
<tr>
<td></td>
<td>char*&amp; _ec2p_gnptr()</td>
<td>References the pointer to the next position of the buffer from which data is to be read.</td>
</tr>
<tr>
<td></td>
<td>char*&amp; _ec2p_pnptr()</td>
<td>References the pointer to the next position of the buffer where data is to be written.</td>
</tr>
<tr>
<td></td>
<td>void _ec2p_bcntplus()</td>
<td>Increments the valid data length of the buffer.</td>
</tr>
<tr>
<td></td>
<td>void _ec2p_bcntminus()</td>
<td>Decrements the valid data length of the buffer.</td>
</tr>
<tr>
<td></td>
<td>void _ec2p_setbPtr(char** begptr, char** curptr, long* cntptr, long* lenptr, char* flgptr)</td>
<td>Sets the pointers of <code>streambuf</code>.</td>
</tr>
<tr>
<td></td>
<td>streambuf()</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>virtual ~streambuf()</td>
<td>Destructor.</td>
</tr>
<tr>
<td></td>
<td>streambuf* pubsetbuf(char* s, streamsize n)</td>
<td>Allocates the buffer for stream input/output. This function calls <code>setbuf(s,n)</code>(^1).</td>
</tr>
<tr>
<td></td>
<td>pos_type pubseekoff(off_type off, ios_base::seekdir way, ios_base::openmode which = ios_base::in</td>
<td>Moves the position to read or write data in the input/output stream by using the method specified by <code>way</code>. This function calls <code>seekoff(off,way,which)</code>(^1).</td>
</tr>
<tr>
<td></td>
<td>pos_type pubseekpos(pos_type sp, ios_base::openmode which = ios_base::in</td>
<td>Calculates the offset from the beginning of the stream to the current position. This function calls <code>seekpos(sp,which)</code>(^1).</td>
</tr>
<tr>
<td></td>
<td>int pubsync()</td>
<td>Flushes the output stream. This function calls <code>sync()</code>(^1).</td>
</tr>
<tr>
<td></td>
<td>streamsize in_avail()</td>
<td>Calculates the offset from the end of the input stream to the current position.</td>
</tr>
<tr>
<td></td>
<td>int_type snextc()</td>
<td>Reads the next character.</td>
</tr>
<tr>
<td></td>
<td>int_type sbumpc()</td>
<td>Reads one character and sets the pointer to the next character.</td>
</tr>
<tr>
<td></td>
<td>int_type sgetc()</td>
<td>Reads one character.</td>
</tr>
<tr>
<td></td>
<td>int sgetn(char* s, streamsize n)</td>
<td>Reads n characters and sets them in the memory area specified by s.</td>
</tr>
<tr>
<td></td>
<td>int_type sputbackc(char c)</td>
<td>Puts back the read position.</td>
</tr>
<tr>
<td></td>
<td>int sungetc()</td>
<td>Puts back the read position.</td>
</tr>
<tr>
<td></td>
<td>int sputc(char c)</td>
<td>Inserts character c.</td>
</tr>
<tr>
<td></td>
<td>int_type sputn(const char* s, streamsize n)</td>
<td>Inserts n characters at the position pointed to by the amount specified by s.</td>
</tr>
<tr>
<td></td>
<td>char* eback() const</td>
<td>Reads the start pointer of the input stream.</td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Function</td>
<td>char* gptr() const</td>
<td>Reads the next pointer of the input stream.</td>
</tr>
<tr>
<td></td>
<td>char* egptr() const</td>
<td>Reads the end pointer of the input stream.</td>
</tr>
<tr>
<td></td>
<td>void gbump(int n)</td>
<td>Moves the next pointer of the input stream by the amount specified by n.</td>
</tr>
<tr>
<td></td>
<td>void setg( char* gbeg, char* gnext, char* gend)</td>
<td>Assigns each pointer of the input stream.</td>
</tr>
<tr>
<td></td>
<td>char* pbase() const</td>
<td>Calculates the start pointer of the output stream.</td>
</tr>
<tr>
<td></td>
<td>char* pptr() const</td>
<td>Calculates the next pointer of the output stream.</td>
</tr>
<tr>
<td></td>
<td>char* epptr() const</td>
<td>Calculates the end pointer of the output stream.</td>
</tr>
<tr>
<td></td>
<td>void pbump(int n)</td>
<td>Moves the next pointer of the output stream by the amount specified by n.</td>
</tr>
<tr>
<td></td>
<td>void setp(char* pbeg, char* pend)</td>
<td>Assigns each pointer of the output stream.</td>
</tr>
<tr>
<td></td>
<td>virtual streambuf* setbuf(char* s, streamsize n)</td>
<td>For each derived class, a defined operation is executed.</td>
</tr>
<tr>
<td></td>
<td>virtual pos_type seekoff( off_type off, ios_base::seekdir way, ios_base::openmode = (ios_base::openmode) (ios_base::in</td>
<td>ios_base::out))</td>
</tr>
<tr>
<td></td>
<td>virtual pos_type seekpos( pos_type sp, ios_base::openmode = (ios_base::openmode) (ios_base::in</td>
<td>ios_base::out))</td>
</tr>
<tr>
<td></td>
<td>virtual int sync()</td>
<td>Flushes the output stream.</td>
</tr>
<tr>
<td></td>
<td>virtual int showmanyc()</td>
<td>Calculates the number of valid characters in the input stream.</td>
</tr>
<tr>
<td></td>
<td>virtual streamsize xsgetn(char* s, streamsize n)</td>
<td>Sets n characters in the memory area specified by s.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type underflow()</td>
<td>Reads one character without moving the stream position.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type uflow()</td>
<td>Reads one character of the next pointer.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type pbackfail(int c = eof)</td>
<td>Puts back the character specified by c.</td>
</tr>
<tr>
<td></td>
<td>virtual streamsize xsputn(const char* s, streamsize n)</td>
<td>Inserts n characters in the position specified by s.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type overflow(int c = eof)</td>
<td>Inserts character c in the output stream.</td>
</tr>
</tbody>
</table>

Notes 1. This class does not define the processing.
References the pointer for the file input/output control flag.

References the pointer to the next position of the buffer from which data is to be read.

References the pointer to the next position of the buffer where data is to be written.

Increments the valid data length of the buffer.

Decrements the valid data length of the buffer.

Sets the pointers of streambuf.

Constructor.
The initial settings are as follows:
\[ B\_cnt\_ptr = B\_beg\_ptr = B\_next\_ptr = B\_end\_ptr = C\_flg\_ptr = _B\_len\_ptr = 0 \]
\[ B\_beg\_pptr = &B\_beg\_ptr \]
\[ B\_next\_pptr = &B\_next\_ptr \]

Destructor.

Allocates the buffer for stream input/output.
This function calls setbuf(s,n).
Return value: *this

Moves the read or write position for the input/output stream by using the method specified by way.
This function calls seekoff(off,way,which).
Return value: The stream position newly specified.
pos_type streambuf::pubseekpos(pos_type sp, ios_base::openmode which = (ios_base::openmode)(ios_base::in | ios_base::out))

Calculates the offset from the beginning of the stream to the current position.
Moves the current stream pointer by the amount specified by sp.
This function calls seekpos(sp,which).
Return value: The offset from the beginning of the stream.

int streambuf::pubsync()

Flushes the output stream.
This function calls sync().
Return value: 0

streamsize streambuf::in_avail()

Calculates the offset from the end of the input stream to the current position.
Return value:
If the position where data is read is valid: The offset from the end of the stream to the current position.
If the position where data is read is invalid: 0 (showmanyc() is called).

int_type streambuf::snextc()

Reads one character. If the character read is not eof, the next character is read.
Return value: If the character read is not eof: The character read
If the character read is eof: eof

int_type streambuf::sbumpc()

Reads one character and moves forward the pointer to the next.
Return value: If the position where data is read is valid: The character read
If the position where data is read is invalid: eof

int_type streambuf::sgetc()

Reads one character.
Return value: If the position where data is read is valid: The character read
If the position where data is read is invalid: eof

int streambuf::sgetn(char* s, streamsize n)

Sets n characters in the memory area specified by s. If an eof is found in the string read, setting is stopped.
Return value: The specified number of characters.

int_type streambuf::sputbackc(char c)

If the data read position is correct and the put back data of the position is the same as c, the read position is put back.
Return value: If the read position was put back: The value of c
If the read position was not put back: eof
If the data read position is correct, the read position is put back.
Return value: If the read position was put back: The value that was put back
If the read position was not put back: eof

int streambuf::sputc(char c)

Inserts character c.
Return value: If the write position is correct: The value of c
If the write position is incorrect: eof

int_type streambuf::sputn(const char* s, streamsize n)

Inserts n characters at the position specified by s.
If the buffer is smaller than n, the number of characters for the buffer is inserted.
Return value: The number of characters inserted.

char* streambuf::eback() const

Calculates the start pointer of the input stream.
Return value: Start pointer.

char* streambuf::gptr() const

Calculates the next pointer of the input stream.
Return value: Next pointer.

char* streambuf::egptr() const

Calculates the end pointer of the input stream.
Return value: End pointer.

void streambuf::gbump(int n)

Moves forward the next pointer of the input stream by the amount specified by n.

void streambuf::setg(char* gbeg, char* gnext, char* gend)

Sets each pointer of the input stream as follows:
* _B_beg_pptr = gbeg;
* _B_next_pptr = gnext;
  B_end_ptr = gend;
* _B_cnt_ptr = gend-gnext;
* _B_len_ptr = gend-gbeg;

char* streambuf::pbase() const

Calculates the start pointer of the output stream.
Return value: Start pointer.
Calculates the next pointer of the output stream.
Return value: Next pointer.

Calculates the end pointer of the output stream.
Return value: End pointer.

Moves forward the next pointer of the output stream by the amount specified by \( n \).

The settings for each pointer of the output stream are as follows:
* \( \text{B\_beg\_pptr} = \text{pbeg} \);
* \( \text{B\_next\_pptr} = \text{pbeg} \);
* \( \text{B\_end\_ptr} = \text{pend} \);
* \( \text{B\_cnt\_ptr} = \text{pend}\text{-}\text{pbeg} \);
* \( \text{B\_len\_ptr} = \text{pend}\text{-}\text{pbeg} \);

For each derived class from \text{streambuf}, a defined operation is executed.
Return value: *this (This class does not define the processing.)

Changes the stream position.
Return value: -1 (This class does not define the processing.)

Changes the stream position.
Return value: -1 (This class does not define the processing.)

Flushes the output stream.
Return value: 0 (This class does not define the processing.)

Calculates the number of valid characters in the input stream.
Return value: 0 (This class does not define the processing.)
virtual streamsize streambuf::xsgetn(char* s, streamsize n)

Sets n characters in the memory area specified by s.
If the buffer is smaller than n, the number of characters for the buffer is inserted.
Return value: The number of characters input.

virtual int_type streambuf::underflow()

Reads one character without moving the stream position.
Return value: eof (This class does not define the processing.)

virtual int_type streambuf::uflow()

Reads one character of the next pointer.
Return value: eof (This class does not define the processing.)

virtual int_type streambuf::pbackfail(int_type c = eof)

Puts back the character specified by c.
Return value: eof (This class does not define the processing.)

virtual streamsize streambuf::xsputn(const char* s, streamsize n)

Inserts n characters specified by s in to the stream position.
If the buffer is smaller than n, the number of characters for the buffer is inserted.
Return value: The number of characters inserted.

virtual int_type streambuf::overflow(int_type c = eof)

Inserts character c in the output stream.
Return value: eof (This class does not define the processing.)

(f) istream::sentry Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>ok_</td>
<td>Whether the current state is input-enabled.</td>
</tr>
<tr>
<td>Function</td>
<td>sentry(istream&amp; is, bool noskipws = false)</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>~sentry()</td>
<td>Destructor.</td>
</tr>
<tr>
<td></td>
<td>operator bool()</td>
<td>References ok_.</td>
</tr>
</tbody>
</table>

istream::sentry::sentry(istream& is, bool noskipws = _false)

Constructor of internal class sentry.
If good() is non-zero, enables input with or without a format.
If tie() is non-zero, flushes the related output stream.

istream::sentry::~sentry()

Destructor of internal class sentry.
References ****ok****.
Return value: ****ok****.

### (g) istringstream Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>chcount</td>
<td>The number of characters extracted by the input function called last.</td>
</tr>
<tr>
<td>Function</td>
<td>int _ec2p_getistr(char* str, unsigned int dig, int mode)</td>
<td>Converts <em>str</em> with the radix specified by <em>dig</em>.</td>
</tr>
<tr>
<td></td>
<td>istream(streambuf* sb)</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>virtual ~istream()</td>
<td>Destructor.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(bool&amp; n)</td>
<td>Stores the extracted characters in <em>n</em>.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(short&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(unsigned short&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(int&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(unsigned int&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(long&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(unsigned long&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(long long&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(unsigned long long&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(float&amp; n)</td>
<td></td>
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<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(double&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(long double&amp; n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(void*&amp; p)</td>
<td>Converts the extracted characters to a pointer to <em>void</em> and stores them in <em>p</em>.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator &gt;&gt; (streambuf* sb)</td>
<td>Extracts characters and stores them in the memory area specified by <em>sb</em>.</td>
</tr>
<tr>
<td></td>
<td>streamsize gcount() const</td>
<td>Calculates <em>chcount</em> (number of characters extracted).</td>
</tr>
<tr>
<td></td>
<td>int_type get()</td>
<td>Extracts a character</td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(char&amp; c)</td>
<td>Extracts characters and stores them in <em>c</em>.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(signed char&amp; c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(unsigned char&amp; c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(char* s, streamsize n)</td>
<td>Extracts strings with size <em>n-1</em> and stores them in the memory area specified by <em>s</em>.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(signed char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(unsigned char* s, streamsize n)</td>
<td></td>
</tr>
</tbody>
</table>
### 7. LIBRARY FUNCTIONAL SPECIFICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>istream&amp; get(char* s, streamsize n, char delim)</td>
<td>Extracts strings with size $n-1$ and stores them in the memory area specified by $s$. If $\text{delim}$ is found in the string, input is stopped.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>signed char* s, streamsize n, char delim)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>unsigned char* s, streamsize n, char delim)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(streambuf&amp; sb)</td>
<td>Extracts strings and stores them in the memory area specified by $\text{sb}$.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; get(streambuf&amp; sb, char delim)</td>
<td>Extracts strings and stores them in the memory area specified by $\text{sb}$. If $\text{delim}$ is found in the string, input is stopped.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(char* s, streamsize n)</td>
<td>Extracts strings with size $n-1$ and stores them in the memory area specified by $s$.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(signed char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(unsigned char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(char* s, streamsize n, char delim)</td>
<td>Extracts strings with size $n-1$ and stores them in the memory area specified by $s$. If $\text{delim}$ is found in the string, input is stopped.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>signed char* s, streamsize n, char delim)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>unsigned char* s, streamsize n, char delim)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; ignore(</td>
<td>Skips reading the number of characters specified by $n$. If $\text{delim}$ is found in the string, skipping is stopped.</td>
</tr>
<tr>
<td></td>
<td>streamsize n = 1, int_type delim = streambuf::eof</td>
<td></td>
</tr>
<tr>
<td></td>
<td>int_type peek()</td>
<td>Seeks for input characters that can be acquired next.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; read(char* s, streamsize n)</td>
<td>Extracts strings with size $n$ and stores them in the memory area specified by $s$.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; read(signed char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; read(unsigned char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>streamsize readsome(char* s, streamsize n)</td>
<td>Extracts strings with size $n$ and stores them in the memory area specified by $s$.</td>
</tr>
<tr>
<td></td>
<td>streamsize readsome(signed char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>streamsize readsome(unsigned char* s, streamsize n)</td>
<td></td>
</tr>
</tbody>
</table>
### Type Definition Name Description

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td><code>istream&amp; putback(char c)</code></td>
<td>Puts back a character to the input stream.</td>
</tr>
<tr>
<td></td>
<td><code>istream&amp; unget()</code></td>
<td>Puts back the position of the input stream.</td>
</tr>
<tr>
<td></td>
<td><code>int sync()</code></td>
<td>Checks the existence of the input stream. This function calls <code>streambuf::pubsync()</code>.</td>
</tr>
<tr>
<td></td>
<td><code>pos_type tellg()</code></td>
<td>Finds the input stream position. This function calls <code>streambuf::pubseekoff(0,cur,in)</code>.</td>
</tr>
<tr>
<td></td>
<td><code>istream&amp; seekg(pos_type pos)</code></td>
<td>Moves the current stream pointer by the amount specified by <code>pos</code>. This function calls <code>streambuf::pubseekpos(pos)</code>.</td>
</tr>
<tr>
<td></td>
<td><code>istream&amp; seekg(off_type off, ios_base::seekdir dir)</code></td>
<td>Moves the position to read the input stream by using the method specified by <code>dir</code>. This function calls <code>streambuf::pubseekoff(off,dir)</code>.</td>
</tr>
<tr>
<td></td>
<td><code>int istream::_ec2p_getistr(char* str, unsigned int dig, int mode)</code></td>
<td>Converts <code>str</code> to the radix specified by <code>dig</code>. Return value: The converted radix.</td>
</tr>
</tbody>
</table>

Constructor of class `istream`. Calls `ios::init(sb)`. Specifies `chcount=0`. Destructor of class `istream`. `istream& istream::operator>>(bool& n)` Stores the extracted characters in `n`. Return value: `*this` `istream& istream::operator>>(short& n)` Stores the extracted characters in `n`. Return value: `*this` `istream& istream::operator>>(unsigned short& n)` Stores the extracted characters in `n`. Return value: `*this` `istream& istream::operator>>(int& n)` Stores the extracted characters in `n`. Return value: `*this`
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```cpp
istream& istream::operator>>(unsigned int& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(long& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(unsigned long& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(long long& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(unsigned long long& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(float& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(double& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(long double& n)
Stores the extracted characters in n.
Return value: *this
```

```cpp
istream& istream::operator>>(void*& p)
Converts the extracted characters to a void* type and stores them in the memory specified by p.
Return value: *this
```

```cpp
istream& istream::operator>>(streambuf* sb)
Extracts characters and stores them in the memory area specified by sb.
If there are no extracted characters, setstate(failbit) is called.
Return value: *this
```
References **chcount** (number of extracted characters).

Return value: **chcount**

```c
int_type istream::get()
```

Extracts characters.

Return value: If characters are extracted: Extracted characters.

If no characters are extracted: Calls `setstate(failbit)` and becomes `streambuf::eof`.

```c
istream& istream::get(char& c)
```

Extracts characters and stores them in `c`. If the extracted character is `streambuf::eof`, `failbit` is set.

Return value: `*this`

```c
istream& istream::get(signed char& c)
```

Extracts characters and stores them in `c`. If the extracted character is `streambuf::eof`, `failbit` is set.

Return value: `*this`

```c
istream& istream::get(unsigned char& c)
```

Extracts characters and stores them in `c`. If the extracted character is `streambuf::eof`, `failbit` is set.

Return value: `*this`

```c
istream& istream::get(char* s, streamsize n)
```

Extracts a string with size `n-1` and stores it in the memory area specified by `s`. If `ok_==false` or no character has been extracted, `failbit` is set.

Return value: `*this`

```c
istream& istream::get(signed char* s, streamsize n)
```

Extracts a string with size `n-1` and stores it in the memory area specified by `s`. If `ok_==false` or no character has been extracted, `failbit` is set.

Return value: `*this`

```c
istream& istream::get(unsigned char* s, streamsize n)
```

Extracts a string with size `n-1` and stores it in the memory area specified by `s`. If `ok_==false` or no character has been extracted, `failbit` is set.

Return value: `*this`

```c
istream& istream::get(char* s, streamsize n, char delim)
```

Extracts a string with size `n-1` and stores it in the memory area specified by `s`.

If `delim` is found in the string, input is stopped.

If `ok_==false` or no character has been extracted, `failbit` is set.

Return value: `*this`
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7. LIBRARY FUNCTIONAL SPECIFICATION

**istream& istream::get(signed char* s, streamsize n, char delim)**

Extracts a string with size \( n-1 \) and stores it in the memory area specified by \( s \).
If \( \text{delim} \) is found in the string, input is stopped.
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::get(unsigned char* s, streamsize n, char delim)**

Extracts a string with size \( n-1 \) and stores it in the memory area specified by \( s \).
If \( \text{delim} \) is found in the string, input is stopped.
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::get(streambuf& sb)**

Extracts a string and stores it in the memory area specified by \( \text{sb} \).
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::get(streambuf& sb, char delim)**

Extracts a string and stores it in the memory area specified by \( \text{sb} \).
If \( \text{delim} \) is found in the string, input is stopped.
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::getline(char* s, streamsize n)**

Extracts a string with size \( n-1 \) and stores it in the memory area specified by \( s \).
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::getline(signed char* s, streamsize n)**

Extracts a string with size \( n-1 \) and stores it in the memory area specified by \( s \).
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::getline(unsigned char* s, streamsize n)**

Extracts a string with size \( n-1 \) and stores it in the memory area specified by \( s \).
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this

**istream& istream::getline(char* s, streamsize n, char delim)**

Extracts a string with size \( n-1 \) and stores it in the memory area specified by \( s \).
If character \( \text{delim} \) is found, input is stopped.
If \( \text{ok} == \text{false} \) or no character has been extracted, \( \text{failbit} \) is set.
Return value: \*this
istream& istream::getline(signed char* s, streamsize n, char delim)

Extracts a string with size n-1 and stores it in the memory area specified by s.
If character delim is found, input is stopped.
If ok_==false or no character has been extracted, failbit is set.
Return value: *this

istream& istream::getline(unsigned char* s, streamsize n, char delim)

Extracts a string with size n-1 and stores it in the memory area specified by s.
If character delim is found, input is stopped.
If ok_==false or no character has been extracted, failbit is set.
Return value: *this

istream& istream::ignore(streamsize n = 1, int_type delim = streambuf::eof)

Skips reading the number of characters specified by n.
If character delim is found, skipping is stopped.
Return value: *this

int_type istream::peek()

Seeks input characters that will be available next.
Return value: If ok_==false: streambuf::eof
If ok_!=false: rdbuf()->sgetc()

istream& istream::read(char* s, streamsize n)

If ok_!=false, extracts a string with size n and stores it in the memory area specified by s. If the number of extracted characters does not match with the number of n, eofbit is set.
Return value: *this

istream& istream::read(signed char* s, streamsize n)

If ok_!=false, extracts a string with size n and stores it in the memory area specified by s. If the number of extracted characters does not match with the number of n, eofbit is set.
Return value: *this

istream& istream::read(unsigned char* s, streamsize n)

If ok_!=false, extracts a string with size n and stores it in the memory area specified by s. If the number of extracted characters does not match with the number of n, eofbit is set.
Return value: *this

streamsize istream::readsome(char* s, streamsize n)

Extracts a string with size n and stores it in the memory area specified by s.
If the number of characters exceeds the stream size, only the number of characters equal to the stream size is stored.
Return value: The number of extracted characters.
streamsize istream::readsome(signed char* s, streamsize n)

Extracts a string with size $n$ and stores it in the memory area specified by $s$. If the number of characters exceeds the stream size, only the number of characters equal to the stream size is stored. Return value: The number of extracted characters.

streamsize istream::readsome(unsigned char* s, streamsize n)

Extracts a string with size $n$ and stores it in the memory area specified by $s$. If the number of characters exceeds the stream size, only the number of characters equal to the stream size is stored. Return value: The number of extracted characters.

istream& istream::putback(char c)

Puts back character $c$ to the input stream. If the characters put back are streambuf::eof, badbit is set. Return value: *this

istream& istream::unget()

Puts back the pointer of the input stream by one. If the extracted characters are streambuf::eof, badbit is set. Return value: *this

int istream::sync()

Checks for an input stream. This function calls streambuf::pubsync(). Return value: If there is no input stream: streambuf::eof If there is an input stream: 0

pos_type istream::tellg()

Checks for the position of the input stream. This function calls streambuf::pubseekoff(0,cur,in). Return value: Offset from the beginning of the stream If an error occurs during the input processing, -1 is returned.

istream& istream::seekg(pos_type pos)

Moves the current stream pointer by the amount specified by $pos$. This function calls streambuf::pubseekpos(pos). Return value: *this

istream& istream::seekg(off_type off, ios_base::seekdir dir)

Moves the position to read the input stream using the method specified by $dir$. This function calls streambuf::pubseekoff(off,dir). If an error occurs during the input processing, this processing is not performed. Return value: *this
### (h) istream Class Manipulator

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>istream&amp; ws(istream&amp; is)</td>
<td>Skips reading the spaces.</td>
</tr>
</tbody>
</table>

**istream& ws(istream& is)**

Skips reading white spaces.
Return value: **is**

### (i) istream Non-Member Function

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>istream&amp; operator&gt;&gt;(istream&amp; in, char* s)</td>
<td>Extracts a string and stores it in the memory area specified by <strong>s</strong>.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(istream&amp; in, signed char* s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(istream&amp; in, unsigned char* s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(istream&amp; in, char&amp; c)</td>
<td>Extracts a character and stores it in <strong>c</strong>.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(istream&amp; in, signed char&amp; c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(istream&amp; in, unsigned char&amp; c)</td>
<td></td>
</tr>
</tbody>
</table>

**istream& operator>>(istream& in, char* s)**

Extracts a string and stores it in the memory area specified by **s**.
Processing is stopped if
the number of characters stored is equal to field width – 1
**streambuf::eof** is found in the input stream
the next available character **c** satisfies **isspace(c)==1**
If no characters are stored, **failbit** is set.
Return value: **in**

**istream& operator>>(istream& in, signed char* s)**

Extracts a string and stores it in the memory area specified by **s**.
Processing is stopped if
the number of characters stored is equal to field width – 1
**streambuf::eof** is found in the input stream
the next available character **c** satisfies **isspace(c)==1**
If no characters are stored, **failbit** is set.
Return value: **in**

**istream& operator>>(istream& in, unsigned char* s)**

Extracts a string and stores it in the memory area specified by **s**.
Processing is stopped if
the number of characters stored is equal to field width – 1
**streambuf::eof** is found in the input stream
the next available character **c** satisfies **isspace(c)==1**
If no characters are stored, **failbit** is set.
Return value: **in**


```c
istream& operator>>(istream& in, char& c)
```

Extracts a character and stores it in `c`. If no character is stored, `failbit` is set.
Return value: `in`

```c
istream& operator>>(istream& in, signed char& c)
```

Extracts a character and stores it in `c`. If no character is stored, `failbit` is set.
Return value: `in`

```c
istream& operator>>(istream& in, unsigned char& c)
```

Extracts a character and stores it in `c`. If no character is stored, `failbit` is set.
Return value: `in`

### (j) ostream::sentry Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>ok_</td>
<td>Whether or not the current state allows output.</td>
</tr>
<tr>
<td></td>
<td>_ec2p_os</td>
<td>Pointer to the <code>ostream</code> object.</td>
</tr>
<tr>
<td>Function</td>
<td>sentry(ostream&amp; os)</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>~sentry()</td>
<td>Destructor.</td>
</tr>
<tr>
<td></td>
<td>operator bool()</td>
<td>References <code>ok_</code>.</td>
</tr>
</tbody>
</table>

```cpp
ostream::sentry::sentry(ostream& os)
```

Constructor of the internal class `sentry`. If `good()` is non-zero and `tie()` is non-zero, `flush()` is called. Specifies `os` to `_ec2p_os`.

```cpp
ostream::sentry::~sentry()
```

Destructor of internal class `sentry`. If `_ec2p_os->flags() & ios_base::unitbuf` is true, `flush()` is called.

```cpp
ostream::sentry::operator bool()
```

References `ok_`. Return value: `ok_`
### ostream Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>ostream(streambuf* sbptr)</td>
<td>Constructor.</td>
</tr>
<tr>
<td>Virtual</td>
<td>~ostream()</td>
<td>Destructor.</td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(bool n)</td>
<td>Inserts n in the output stream.</td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(short n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(unsigned short n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(int n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(unsigned int n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(long n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(unsigned long n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(long long n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(unsigned long long n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(float n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(double n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(long double n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>operator&lt;&lt;(void* n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>put(char c)</td>
<td>Inserts character c into the output stream.</td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>write(const char* s, streamsize n)</td>
<td>Inserts n characters from s into the output stream.</td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>write(const signed char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>write(const unsigned char* s, streamsize n)</td>
<td></td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>flush()</td>
<td>Flushes the output stream. This function calls streambuf::pubsync().</td>
</tr>
<tr>
<td>pos_type</td>
<td>tellp()</td>
<td>Calculates the current write position. This function calls streambuf::pub-</td>
</tr>
<tr>
<td>seekp(pos_type pos)</td>
<td></td>
<td>seekoff(0,cur,out).</td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>seekp(pos_type pos)</td>
<td>Calculates the offset from the beginning of the stream to the current position. Moves the current stream pointer by the amount specified by pos. This function calls streambuf::pubseekpos(pos).</td>
</tr>
<tr>
<td>ostream&amp;</td>
<td>seekp(off_type off, seekdir dir)</td>
<td>Moves the stream write position by the amount specified by off, from dir. This function calls streambuf::pubseekoff(off,dir).</td>
</tr>
</tbody>
</table>
Constructor.
Calls ios(sbptr).

virtual ostream::~ostream()

Destructor.

ostream& ostream::operator<<(bool n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(short n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(unsigned short n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(int n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(unsigned int n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(long n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(unsigned long n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this

ostream& ostream::operator<<(unsigned long n)

If sentry::ok_==true, n is inserted into the output stream.
If sentry::ok_==false, failbit is set.
Return value: *this
If `sentry::ok_`==true, `n` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::operator<<(long long n)
```

If `sentry::ok_`==true, `n` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::operator<<(unsigned long long n)
```

If `sentry::ok_`==true, `n` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::operator<<(float n)
```

If `sentry::ok_`==true, `n` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::operator<<(double n)
```

If `sentry::ok_`==true, `n` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::operator<<(long double n)
```

If `sentry::ok_`==true, `n` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::operator<<(void* n)
```

If `sentry::ok_`==true, the output string of `sbptr` is inserted into the output stream.
If `sentry::ok_`==false, `failbit` is set.
Return value: *this

```cpp
ostream& ostream::put(char c)
```

If (`sentry::ok_`) and (`rdbuf()->sputc(c)`!=`streambuf::eof`), `c` is inserted into the output stream.
Otherwise `badbit` is set.
Return value: *this

```cpp
ostream& ostream::write(const char* s, streamsize n)
```

If (`sentry::ok_`) and (`rdbuf()->sputn(s, n)`==n), `n` characters specified by `s` are inserted into the output stream.
Otherwise `badbit` is set.
Return value: *this
If (sentry::ok_ == true) and (rdbuf()->sputn(s, n) == n), \(n\) characters specified by \(s\) are inserted into the output stream. Otherwise \texttt{badbit} is set. Return value: \texttt{*this}

\begin{verbatim}
ostream& ostream::write(const signed char* s, streamsize n)
\end{verbatim}

Flushes the output stream. This function calls \texttt{streambuf::pubsync()}. Return value: \texttt{*this}

\begin{verbatim}
flush()
\end{verbatim}

Calculates the current write position. This function calls \texttt{streambuf::pubseekoff(0,cur,out)}. Return value: The current stream position. If an error occurs during processing, -1 is returned.

\begin{verbatim}
seekp(pos_type pos)
\end{verbatim}

If no error occurs, the offset from the beginning of the stream to the current position is calculated. Moves the current stream pointer by the amount specified by \texttt{pos}. This function calls \texttt{streambuf::pubseekpos(pos)}. Return value: \texttt{*this}

\begin{verbatim}
seekp(off_type off, seekdir dir)
\end{verbatim}

If no error occurs, the stream write position is moved by the amount specified by \texttt{off}, from \texttt{dir}. This function calls \texttt{streambuf::pubseekoff(off,dir)}. Return value: \texttt{*this}

\begin{verbatim}
endl(ostream& os)
\end{verbatim}

Inserts a new line code and flushes the output stream. This function calls \texttt{flush()}. Return value: \texttt{os}
Inserts a **NULL** code into the output line.
Return value: **os**

Flushes the output stream.
This function calls **streambuf::sync()**.
Return value: **os**

### ostream Non-Member Function

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, char s)</td>
<td>Inserts s into the output stream.</td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, signed char s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, unsigned char s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, const char* s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, const signed char* s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, const unsigned char* s)</td>
<td></td>
</tr>
</tbody>
</table>

If (sentry::ok_ == true) and an error does not occur, s is inserted into the output stream. Otherwise **failbit** is set. Return value: **os**

If (sentry::ok_ == true) and an error does not occur, s is inserted into the output stream. Otherwise **failbit** is set. Return value: **os**

If (sentry::ok_ == true) and an error does not occur, s is inserted into the output stream. Otherwise **failbit** is set. Return value: **os**

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If (sentry::ok_ == true) and an error does not occur, s is inserted into the output stream. Otherwise **failbit** is set. Return value: **os**
### smanip Class Manipulator

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>smanip resetiosflags(ios_base::fmtflags mask)</td>
<td>Clears the flag specified by the <code>mask</code> value.</td>
</tr>
<tr>
<td></td>
<td>smanip setiosflags(ios_base::fmtflags mask)</td>
<td>Specifies the format flag (<code>fmtfl</code>).</td>
</tr>
<tr>
<td></td>
<td>smanip setbase(int base)</td>
<td>Specifies the radix used at output.</td>
</tr>
<tr>
<td></td>
<td>smanip setfill(char c)</td>
<td>Specifies the fill character (<code>fillch</code>).</td>
</tr>
<tr>
<td></td>
<td>smanip setprecision(int n)</td>
<td>Specifies the precision (<code>prec</code>).</td>
</tr>
<tr>
<td></td>
<td>smanip setw(int n)</td>
<td>Specifies the field width (<code>wide</code>).</td>
</tr>
</tbody>
</table>

- **smanip resetiosflags(ios_base::fmtflags mask)**

  Clears the flag specified by the `mask` value.
  Return value: Target object of input/output.

- **smanip setiosflags(ios_base::fmtflags mask)**

  Specifies the format flag (`fmtfl`).
  Return value: Target object of input/output.

- **smanip setbase(int base)**

  Specifies the radix used at output.
  Return value: Target object of input/output.

- **smanip setfill(char c)**

  Specifies the fill character (`fillch`).
  Return value: Target object of input/output.

- **smanip setprecision(int n)**

  Specifies the precision (`prec`).
  Return value: Target object of input/output.

- **smanip setw(int n)**

  Specifies the field width (`wide`).
  Return value: Target object of input/output.
(o) Example of Using EC++ Input/Output Libraries

The input/output stream can be used if a pointer to an object of the `mystrbuf` class is used instead of `streambuf` at the initialization of the `istream` and `ostream` objects.

The following shows the inheritance relationship of the above classes. An arrow (->) indicates that a derived class references a base class.

```
streambuf
  -> mystrbuf
```

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>_file_Ptr</td>
<td>File pointer.</td>
</tr>
<tr>
<td>Function</td>
<td>mystrbuf()</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>mystrbuf(void* ptr)</td>
<td>Initializes the <code>streambuf</code> buffer.</td>
</tr>
<tr>
<td></td>
<td>virtual ~mystrbuf()</td>
<td>Destructor.</td>
</tr>
<tr>
<td></td>
<td>void* myfptr() const</td>
<td>Returns a pointer to the <code>FILE</code> type structure.</td>
</tr>
<tr>
<td></td>
<td>mystrbuf* open(const char* filename, int mode)</td>
<td>Specifies the file name and mode, and opens the file.</td>
</tr>
<tr>
<td></td>
<td>mystrbuf* close()</td>
<td>Closes the file.</td>
</tr>
<tr>
<td></td>
<td>virtual streambuf* setbuf(char* s, streamsize n)</td>
<td>Allocates the stream input/output buffer.</td>
</tr>
<tr>
<td></td>
<td>virtual pos_type seekoff( off_type off, ios_base::seekdir way, ios_base::openmode = (ios_base::openmode) (ios_base::in</td>
<td>ios_base::out))</td>
</tr>
<tr>
<td></td>
<td>virtual pos_type seekpos( pos_type sp, ios_base::openmode = (ios_base::openmode) (ios_base::in</td>
<td>ios_base::out))</td>
</tr>
<tr>
<td></td>
<td>virtual int sync()</td>
<td>Flushes the stream.</td>
</tr>
<tr>
<td></td>
<td>virtual int showmanyc()</td>
<td>Returns the number of valid characters in the input stream.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type underflow()</td>
<td>Reads one character without moving the stream position.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type pbackfail(int type c = streambuf::eof)</td>
<td>Puts back the character specified by <code>c</code>.</td>
</tr>
<tr>
<td></td>
<td>virtual int_type overflow(int type c = streambuf::eof)</td>
<td>Inserts the character specified by <code>c</code>.</td>
</tr>
<tr>
<td></td>
<td>void _Init(_f_type* fp)</td>
<td>Initialization.</td>
</tr>
</tbody>
</table>
7.5.2 Memory Management Library

The header file for the memory management library is as follows:

- `<new>`
  Defines the memory allocation/deallocation function.

By setting an exception handling function address to the `_ec2p_new_handler` variable, exception handling can be executed if memory allocation fails. The `_ec2p_new_handler` is a static variable and the initial value is NULL. If this handler is used, reentrance will be lost.

Operations required for the exception handling function:
- Creates an allocatable area and returns the area.
- Operations are not prescribed for cases where an area cannot be created.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>new_handler</td>
<td>Pointer type to the function that returns a void type.</td>
</tr>
<tr>
<td>Variable</td>
<td>_ec2p_new_handler</td>
<td>Pointer to an exception handling function.</td>
</tr>
</tbody>
</table>
Allocates a memory area with the size specified by `size`.
If memory allocation fails and when `new_handler` is set, `new_handler` is called.
Return value: If memory allocation succeeds: Pointer to `void` type
If memory allocation fails: `NULL`

Allocates an array area with the size specified by `size`.
If memory allocation fails and when `new_handler` is set, `new_handler` is called.
Return value: If memory allocation succeeds: Pointer to `void` type
If memory allocation fails: `NULL`

Allocates the area specified by `ptr` as the storage area.
Return value: `ptr`

Allocates the area specified by `ptr` as the array area.
Return value: `ptr`

Deallocates the storage area specified by `ptr`.
If `ptr` is `NULL`, no operation will be performed.

Deallocates the array area specified by `ptr`.
If `ptr` is `NULL`, no operation will be performed.

Sets `new_P` to `_ec2p_new_handler`.
Return value: `_ec2p_new_handler`
7.5.3 Complex Number Calculation Class Library

The header file for the complex number calculation class library is as follows:

- `<complex>`
  Defines the `float_complex` and `double_complex` classes.
These classes have no derivation.

(a) `float_complex` Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>value_type</td>
<td><code>float</code> type</td>
</tr>
<tr>
<td>Variable</td>
<td>_re</td>
<td>Defines the real part of <code>float</code> precision.</td>
</tr>
<tr>
<td></td>
<td>_im</td>
<td>Defines the imaginary part of <code>float</code> precision.</td>
</tr>
<tr>
<td>Function</td>
<td>float_complex(float re = 0.0f, float im = 0.0f)</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>float_complex(const double_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float real() const</td>
<td>Acquires the real part (_re).</td>
</tr>
<tr>
<td></td>
<td>float imag() const</td>
<td>Acquires the imaginary part (_im).</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator=(float rhs)</td>
<td>Copies rhs to the real part. 0.0f is assigned to the imaginary part.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator+=(float rhs)</td>
<td>Adds rhs to the real part and stores the sum in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator-=(float rhs)</td>
<td>Subtracts rhs from the real part and stores the difference in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator*=(float rhs)</td>
<td>Multiplies *this by rhs and stores the product in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator/=(float rhs)</td>
<td>Divides *this by rhs and stores the quotient in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator=(const float_complex&amp; rhs)</td>
<td>Copies rhs.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator+=(const float_complex&amp; rhs)</td>
<td>Adds rhs to *this and stores the sum in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator-=(const float_complex&amp; rhs)</td>
<td>Subtracts rhs from *this and stores the difference in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator*=(const float_complex&amp; rhs)</td>
<td>Multiplies *this by rhs and stores the product in *this.</td>
</tr>
<tr>
<td></td>
<td>float_complex&amp; operator/=(const float_complex&amp; rhs)</td>
<td>Divides *this by rhs and stores the quotient in *this.</td>
</tr>
</tbody>
</table>

Constructor of class `float_complex`.
The initial settings are as follows:

```cpp
_re = re;
_im = im;
```
Constructor of class `float_complex`.
The initial settings are as follows:
_\_re = (float)rhs.real();
_\_im = (float)rhs.imag();

```
float float_complex::real() const
```

Acquires the real part.
Return value: `this->\_re`

```
float float_complex::imag() const
```

Acquires the imaginary part.
Return value: `this->\_im`

```
float_complex& float_complex::operator=(float rhs)
```

Copies `rhs` to the real part (`_re`).
0.0f is assigned to the imaginary part (`_im`).
Return value: `*this`

```
float_complex& float_complex::operator+=(float rhs)
```

Adds `rhs` to the real part (`_re`) and stores the result in the real part (`_re`).
The value of the imaginary part (`_im`) does not change.
Return value: `*this`

```
float_complex& float_complex::operator-=(float rhs)
```

Subtracts `rhs` from the real part (`_re`) and stores the result in the real part (`_re`).
The value of the imaginary part (`_im`) does not change.
Return value: `*this`

```
float_complex& float_complex::operator*=(float rhs)
```

Multiplies `*this` by `rhs` and stores the result in `*this`.
(_\_re= _re*rhs, _\_im= _im*rhs)
Return value: `*this`

```
float_complex& float_complex::operator/=(float rhs)
```

Divides `*this` by `rhs` and stores the result in `*this`.
(_\_re= _re/rhs, _\_im= _im/rhs)
Return value: `*this`

```
float_complex& float_complex::operator=(const float_complex& rhs)
```

Copies `rhs` to `*this`.
Return value: `*this`
(b) float_complex Non-Member Function

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>float_complex operator+ (const float_complex&amp; lhs)</td>
<td>Performs unary + operation of lhs.</td>
</tr>
<tr>
<td></td>
<td>float_complex operator+ (const float_complex&amp; lhs,</td>
<td>Returns the result of adding lhs to rhs.</td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator+ (const float&amp; lhs,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator- (const float_complex&amp; lhs)</td>
<td>Performs unary - operation of lhs.</td>
</tr>
<tr>
<td></td>
<td>float_complex operator- (const float_complex&amp; lhs,</td>
<td>Returns the result of subtracting rhs from lhs.</td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator- (const float&amp; lhs,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator- (const float_complex&amp; lhs,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator- (const float&amp; lhs,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator- (const float&amp; lhs,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Function</td>
<td>float_complex operator*(const float_complex&amp; lhs, const float_complex&amp; rhs)</td>
<td>Returns the result of multiplying \texttt{lhs} by \texttt{rhs}.</td>
</tr>
<tr>
<td></td>
<td>float_complex operator*(const float_complex&amp; lhs, const float&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator*(const float&amp; lhs, const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator/(const float_complex&amp; lhs, const float_complex&amp; rhs)</td>
<td>Returns the result of dividing \texttt{lhs} by \texttt{rhs}.</td>
</tr>
<tr>
<td></td>
<td>float_complex operator/(const float&amp; lhs, const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator/(const float_complex&amp; lhs, const float&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex operator/(const float&amp; lhs, const float_complex&amp; rhs)</td>
<td>Divides \texttt{lhs} by \texttt{rhs} and stores the quotient in \texttt{lhs}.</td>
</tr>
<tr>
<td></td>
<td>bool operator=='(const float_complex&amp; lhs, const float_complex&amp; rhs)</td>
<td>Compares the real parts of \texttt{lhs} and \texttt{rhs}, and the imaginary parts of \texttt{lhs} and \texttt{rhs}.</td>
</tr>
<tr>
<td></td>
<td>bool operator=='(const float_complex&amp; lhs, const float&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator=='(const float&amp; lhs, const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator!='(const float_complex&amp; lhs, const float_complex&amp; rhs)</td>
<td>Compares the real parts of \texttt{lhs} and \texttt{rhs}, and the imaginary parts of \texttt{lhs} and \texttt{rhs}.</td>
</tr>
<tr>
<td></td>
<td>bool operator!='(const float_complex&amp; lhs, const float&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator!='(const float&amp; lhs, const float_complex&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator!='(const float_complex&amp; lhs, const float&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator'&gt;&gt;=(istream&amp; is, float_complex&amp; x)</td>
<td>Inputs \texttt{x} in a format of \texttt{u}, (\texttt{u,v}) (\texttt{u}: real part, \texttt{v}: imaginary part).</td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator'&lt;&lt;=(ostream&amp; os, const float_complex&amp; x)</td>
<td>Outputs \texttt{x} in a format of \texttt{u}, (\texttt{u,v}) (\texttt{u}: real part, \texttt{v}: imaginary part).</td>
</tr>
<tr>
<td></td>
<td>float real(const float_complex&amp; x)</td>
<td>Acquires the real part.</td>
</tr>
<tr>
<td></td>
<td>float imag(const float_complex&amp; x)</td>
<td>Acquires the imaginary part.</td>
</tr>
<tr>
<td></td>
<td>float abs(const float_complex&amp; x)</td>
<td>Calculates the absolute value.</td>
</tr>
<tr>
<td></td>
<td>float arg(const float_complex&amp; x)</td>
<td>Calculates the phase angle.</td>
</tr>
<tr>
<td></td>
<td>float norm(const float_complex&amp; x)</td>
<td>Calculates the absolute value of the square.</td>
</tr>
</tbody>
</table>
### Function Table

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>float_complex (\text{conj}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the conjugate complex number.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{polar}(\text{const float}&amp; \ rh, \text{const float}&amp; \ theta))</td>
<td>Calculates the float_complex value for a complex number with size (\text{rho}) and phase angle (\text{theta}).</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{cos}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the complex cosine.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{cosh}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the complex hyperbolic cosine.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{exp}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the exponent function.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{log}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the natural logarithm.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{log10}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the common logarithm.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{pow}(\text{const float_complex}&amp; \ x, \text{int} \ y))</td>
<td>Calculates (x) to the (y)th power.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{pow}(\text{const float_complex}&amp; \ x, \text{const float}&amp; \ y))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{pow}(\text{const float}&amp; \ x, \text{const float_complex}&amp; \ y))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{sin}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the complex sine.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{sinh}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the complex hyperbolic sine.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{sqrt}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the square root within the right half space.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{tan}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the complex tangent.</td>
</tr>
<tr>
<td></td>
<td>float_complex (\text{tanh}(\text{const float_complex}&amp; \ x))</td>
<td>Calculates the complex hyperbolic tangent.</td>
</tr>
</tbody>
</table>

#### Unary + operation of \text{lhs}

**Return value:** \text{lhs}

**float\_complex operator+(\text{const float\_complex}& \ \text{lhs})**

Performs unary + operation of \text{lhs}.

#### Adding \text{lhs} to \text{rhs}

**Return value:** float\_complex\(\text{lhs}\)+\text{rhs}

**float\_complex operator+(\text{const float\_complex}& \ \text{lhs}, \text{const float\_complex}& \ \text{rhs})**

Returns the result of adding \text{lhs} to \text{rhs}.

**Return value:** float\_complex\(\text{lhs}\)+\text{rhs}

**float\_complex operator+(\text{const float\_complex}& \ \text{lhs}, \text{const float}& \ \text{rhs})**

Returns the result of adding \text{lhs} to \text{rhs}.

**Return value:** float\_complex\(\text{lhs}\)+\text{rhs}
<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Return Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>operator+(const float&amp; lhs, const float_complex&amp; rhs)</code></td>
<td>Returns the result of adding <code>lhs</code> to <code>rhs</code>.</td>
<td><code>float_complex(lhs)+=rhs</code></td>
</tr>
<tr>
<td><code>operator-(const float_complex&amp; lhs)</code></td>
<td>Performs unary - operation of <code>lhs</code>.</td>
<td><code>float_complex(-lhs.real(), -lhs.imag())</code></td>
</tr>
<tr>
<td><code>operator-(const float_complex&amp; lhs, const float_complex&amp; rhs)</code></td>
<td>Returns the result of subtracting <code>rhs</code> from <code>lhs</code>.</td>
<td><code>float_complex(lhs)-=rhs</code></td>
</tr>
<tr>
<td><code>operator-(const float&amp; lhs, const float_complex&amp; rhs)</code></td>
<td>Returns the result of subtracting <code>rhs</code> from <code>lhs</code>.</td>
<td><code>float_complex(lhs)-=rhs</code></td>
</tr>
<tr>
<td><code>operator*(const float_complex&amp; lhs, const float_complex&amp; rhs)</code></td>
<td>Returns the result of multiplying <code>lhs</code> by <code>rhs</code>.</td>
<td><code>float_complex(lhs)*=rhs</code></td>
</tr>
<tr>
<td><code>operator*(const float_complex&amp; lhs, const float&amp; rhs)</code></td>
<td>Returns the result of multiplying <code>lhs</code> by <code>rhs</code>.</td>
<td><code>float_complex(lhs)*=rhs</code></td>
</tr>
<tr>
<td><code>operator/(const float_complex&amp; lhs, const float_complex&amp; rhs)</code></td>
<td>Returns the result of dividing <code>lhs</code> by <code>rhs</code>.</td>
<td><code>float_complex(lhs)/=rhs</code></td>
</tr>
<tr>
<td><code>operator/(const float_complex&amp; lhs, const float&amp; rhs)</code></td>
<td>Returns the result of dividing <code>lhs</code> by <code>rhs</code>.</td>
<td><code>float_complex(lhs)/=rhs</code></td>
</tr>
</tbody>
</table>
float_complex operator/(const float& lhs, const float_complex& rhs)

Returns the result of dividing lhs by rhs.
Return value: float_complex(lhs)/=rhs

bool operator==(const float_complex& lhs, const float_complex& rhs)

Compares the real parts of lhs and rhs, and the imaginary parts of lhs and rhs.
For a float type parameter, the imaginary part is assumed to be 0.0f.
Return value: lhs.real()==rhs.real() & lhs.imag()==rhs.imag()

bool operator==(const float_complex& lhs, const float& rhs)

Compares the real parts of lhs and rhs, and the imaginary parts of lhs and rhs.
For a float type parameter, the imaginary part is assumed to be 0.0f.
Return value: lhs.real()==rhs.real() & lhs.imag()==rhs.imag()

bool operator==(const float& lhs, const float_complex& rhs)

Compares the real parts of lhs and rhs, and the imaginary parts of lhs and rhs.
For a float type parameter, the imaginary part is assumed to be 0.0f.
Return value: lhs.real()==rhs.real() || lhs.imag()==rhs.imag()

bool operator!=(const float_complex& lhs, const float_complex& rhs)

Compares the real parts of lhs and rhs, and the imaginary parts of lhs and rhs.
For a float type parameter, the imaginary part is assumed to be 0.0f.
Return value: lhs.real()!=rhs.real() || lhs.imag()!=rhs.imag()

bool operator!=(const float_complex& lhs, const float& rhs)

Compares the real parts of lhs and rhs, and the imaginary parts of lhs and rhs.
For a float type parameter, the imaginary part is assumed to be 0.0f.
Return value: lhs.real()!=rhs.real() || lhs.imag()!=rhs.imag()

bool operator!=(const float& lhs, const float_complex& rhs)

Comparator for output:

istream& operator>>(istream& is, float_complex& x)

Inputs x in a format of u, (u), or (u,v) (u: real part, v: imaginary part).
The input value is converted to float_complex.
If x is input in a format other than the u, (u), or (u,v) format, is.setstate(ios_base::failbit) is called.
Return value: is

ostream& operator<<(ostream& os, const float_complex& x)

Outputs x to os.
The output format is u, (u), or (u,v) (u: real part, v: imaginary part).
Return value: os
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Return Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>float real(const float_complex&amp; x)</code></td>
<td>Acquires the real part.</td>
<td><code>x.real()</code></td>
</tr>
<tr>
<td><code>float imag(const float_complex&amp; x)</code></td>
<td>Acquires the imaginary part.</td>
<td><code>x.imag()</code></td>
</tr>
<tr>
<td><code>float abs(const float_complex&amp; x)</code></td>
<td>Calculates the absolute value.</td>
<td>`(</td>
</tr>
<tr>
<td><code>float arg(const float_complex&amp; x)</code></td>
<td>Calculates the phase angle.</td>
<td><code>atan2f(x.imag(), x.real())</code></td>
</tr>
<tr>
<td><code>float norm(const float_complex&amp; x)</code></td>
<td>Calculates the absolute value of the square.</td>
<td>`</td>
</tr>
<tr>
<td><code>float_complex conj(const float_complex&amp; x)</code></td>
<td>Calculates the conjugate complex number.</td>
<td><code>float_complex(x.real(), (-1)*x.imag())</code></td>
</tr>
<tr>
<td><code>float_complex polar(const float&amp; rho, const float&amp; theta)</code></td>
<td>Calculates the <code>float_complex</code> value for a complex number with size <code>rho</code> and phase angle (argument) <code>theta</code>.</td>
<td><code>float_complex(rho*cosf(theta), rho*sinf(theta))</code></td>
</tr>
<tr>
<td><code>float_complex cos(const float_complex&amp; x)</code></td>
<td>Calculates the complex cosine.</td>
<td><code>float_complex(cosf(x.real())*coshf(x.imag()), (-1)*sinf(x.real())*sinhf(x.imag()))</code></td>
</tr>
<tr>
<td><code>float_complex sinh(const float_complex&amp; x)</code></td>
<td>Calculates the complex hyperbolic cosine.</td>
<td><code>cos(float_complex((-1)*x.imag(), x.real()))</code></td>
</tr>
<tr>
<td><code>float_complex&amp; float_complex::operator-=(const float_complex&amp; rhs)</code></td>
<td>Calculates the exponent function.</td>
<td><code>expf(x.real())*cosf(x.imag()), expf(x.real())*sinf(x.imag())</code></td>
</tr>
</tbody>
</table>
Calculates the natural logarithm (base e).
Return value: \( \text{float\_complex}(\logf(\abs{x}), \arg(x)) \)

```cpp
float\_complex log(const float\_complex& x)
```

Calculates the common logarithm (base 10).
Return value: \( \text{float\_complex}(\log10f(\abs{x}), \arg(x)/\logf(10)) \)

```cpp
float\_complex log10(const float\_complex& x)
```

Calculates \( x \) to the \( y \)th power.
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: If \( \text{float\_complex pow(const float\_complex& x, const float\_complex& y)} \): \( \exp(y*\logf(x)) \)
Otherwise: \( \exp(y*\logf(x)) \)

```cpp
float\_complex pow(const float\_complex& x, const float\_complex& y)
```

Calculates \( x \) to the \( y \)th power.
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: If \( \text{float\_complex pow(const float\_complex& x, const float\_complex& y)} \): \( \exp(y*\logf(x)) \)
Otherwise: \( \exp(y*\logf(x)) \)

```cpp
float\_complex pow(const float\_complex& x, const float\_complex& y)
```

Calculates \( x \) to the \( y \)th power.
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: If \( \text{float\_complex pow(const float\_complex& x, const float\_complex& y)} \): \( \exp(y*\logf(x)) \)
Otherwise: \( \exp(y*\logf(x)) \)

```cpp
float\_complex pow(const float\_complex& x, const float\_complex& y)
```

Calculates \( x \) to the \( y \)th power.
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: If \( \text{float\_complex pow(const float\_complex& x, const float\_complex& y)} \): \( \exp(y*\logf(x)) \)
Otherwise: \( \exp(y*\logf(x)) \)

```cpp
float\_complex pow(const float\_complex& x, const float\_complex& y)
```

Calculates \( x \) to the \( y \)th power.
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: If \( \text{float\_complex pow(const float\_complex& x, const float\_complex& y)} \): \( \exp(y*\logf(x)) \)
Otherwise: \( \exp(y*\logf(x)) \)

```cpp
float\_complex pow(const float\_complex& x, const float\_complex& y)
```

Calculates \( x \) to the \( y \)th power.
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: If \( \text{float\_complex pow(const float\_complex& x, const float\_complex& y)} \): \( \exp(y*\logf(x)) \)
Otherwise: \( \exp(y*\logf(x)) \)

```cpp
float\_complex pow(const float\_complex& x, const float\_complex& y)
```

Calculates the complex sine.
Return value: \( \text{float\_complex}(\sinf(x.\real())*\coshf(x.\imag()), \cosf(x.\real())*\sinhf(x.\imag())) \)

```cpp
float\_complex sin(const float\_complex& x)
```

Calculates the complex hyperbolic sine.
Return value: \( \text{float\_complex}(0,-1)*\sin(\text{float\_complex}((-1)*x.\imag(),x.\real())) \)

```cpp
float\_complex sinh(const float\_complex& x)
```

Calculates the square root within the right half space.
Return value: \( \text{float\_complex}(\sqrtf(\abs{x})*\cosf(\arg(x)/2), \sqrtftf(\abs{x})*\sinf(\arg(x)/2)) \)

```cpp
float\_complex sqrt(const float\_complex& x)
```
Calculates the complex tangent.
Return value: \( \sin(x)/\cos(x) \)

Calculates the complex hyperbolic tangent.
Return value: \( \sinh(x)/\cosh(x) \)

### (c) double_complex Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>value_type</td>
<td>double type.</td>
</tr>
<tr>
<td>Variable</td>
<td>_re</td>
<td>Defines the real part of double precision.</td>
</tr>
<tr>
<td></td>
<td>_im</td>
<td>Defines the imaginary part of double precision.</td>
</tr>
<tr>
<td>Function</td>
<td>double_complex( double re = 0.0, double im = 0.0)</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>double_complex(const float_complex&amp;)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double real() const</td>
<td>Acquires the real part.</td>
</tr>
<tr>
<td></td>
<td>double imag() const</td>
<td>Acquires the imaginary part.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator=(double rhs)</td>
<td>Copies rhs to the real part. 0.0 is assigned to the imaginary part.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator+=(double rhs)</td>
<td>Adds rhs to the real part of *this and stores the sum in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator-=(double rhs)</td>
<td>Subtracts rhs from the real part of *this and stores the difference in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator*==(double rhs)</td>
<td>Multiplies *this by rhs and stores the product in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator/=(double rhs)</td>
<td>Divides *this by rhs and stores the quotient in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator=( const double_complex&amp; rhs)</td>
<td>Copies rhs.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator+=( const double_complex&amp; rhs)</td>
<td>Adds rhs to *this and stores the sum in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator-=( const double_complex&amp; rhs)</td>
<td>Subtracts rhs from *this and stores the difference in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator*==( const double_complex&amp; rhs)</td>
<td>Multiplies *this by rhs and stores the product in *this.</td>
</tr>
<tr>
<td></td>
<td>double_complex&amp; operator/=( const double_complex&amp; rhs)</td>
<td>Divides *this by rhs and stores the quotient in *this.</td>
</tr>
</tbody>
</table>
Constructor of class `double_complex`.
The initial settings are as follows:
_\_re = re;
_\_im = im;

Constructor of class `double_complex`.
The initial settings are as follows:
_\_re = (double)rhs.real();
_\_im = (double)rhs.imag();

Acquires the real part.
Return value: `this->_re`

Acquires the imaginary part.
Return value: `this->_im`

Copies `rhs` to the real part (_\_re).
0.0 is assigned to the imaginary part (_\_im).
Return value: `*this`

Adds `rhs` to the real part (_\_re) and stores the result in the real part (_\_re).
The value of the imaginary part (_\_im) does not change.
Return value: `*this`

Subtracts `rhs` from the real part (_\_re) and stores the result in the real part (_\_re).
The value of the imaginary part (_\_im) does not change.
Return value: `*this`

Multiplies `*this` by `rhs` and stores the result in `*this`.
(_\_re=_\_re*rhs, _\_im=_\_im*rhs)
Return value: `*this`

Divides `*this` by `rhs` and stores the result in `*this`.
(_\_re=_\_re/rhs, _\_im=_\_im/rhs)
Return value: `*this`
double_complex& double_complex::operator=(const double_complex& rhs)

Copies rhs to *this.
Return value: *this

double_complex& double_complex::operator+=(const double_complex& rhs)

Adds rhs to *this and stores the result in *this.
Return value: *this

double_complex& double_complex::operator-=(const double_complex& rhs)

Subtracts rhs from *this and stores the result in *this.
Return value: *this

double_complex& double_complex::operator*=(const double_complex& rhs)

Multiplies *this by rhs and stores the result in *this.
Return value: *this

double_complex& double_complex::operator/=(const double_complex& rhs)

Divides *this by rhs and stores the result in *this.
Return value: *this

(d) double_complex Non-Member Function

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>double_complex operator+</td>
<td>Performs unary + operation of lhs.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; lhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex operator+</td>
<td>Returns the result of adding rhs to lhs.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; lhs, const double_complex&amp; rhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex operator+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; lhs, const double&amp; rhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex operator+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const double&amp; lhs, const double_complex&amp; rhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex operator-</td>
<td>Performs unary - operation of lhs.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; lhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex operator-</td>
<td>Returns the result of subtracting rhs from lhs.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; lhs, const double_complex&amp; rhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex operator-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const double&amp; lhs, const double_complex&amp; rhs</td>
<td></td>
</tr>
</tbody>
</table>
## Function double_complex operator*(
const double_complex& lhs,
const double_complex& rhs)

Returns the result of multiplying lhs by rhs.

## Function double_complex operator*(
const double_complex& lhs,
const double& rhs)

double_complex operator*(
const double& lhs,
const double_complex& rhs)

## Function double_complex operator/(const double_complex& lhs,
const double_complex& rhs)

double_complex operator/(const double_complex& lhs,
const double& rhs)

double_complex operator/(const double& lhs,
const double_complex& rhs)

Returns the result of dividing lhs by rhs.

## Function bool operator==(const double_complex& lhs,
const double_complex& rhs)

bool operator==(const double_complex& lhs,
const double& rhs)

bool operator==(const double& lhs,
const double_complex& rhs)

bool operator!=(const double_complex& lhs,
const double_complex& rhs)

bool operator!=(const double_complex& lhs,
const double& rhs)

bool operator!=(const double& lhs,
const double_complex& rhs)

## Function istream& operator>>(
istream& is,
double_complex& x)

double real(const double_complex& x) Acquires the real part.

double imag(const double_complex& x) Acquires the imaginary part.

double abs(const double_complex& x) Calculates the absolute value.

double arg(const double_complex& x) Calculates the phase angle.

double norm(const double_complex& x) Calculates the absolute value of the square.

## Table

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| Function | double_complex operator*(
const double_complex& lhs,
const double_complex& rhs) | Returns the result of multiplying lhs by rhs. |
| Function | double_complex operator*(
const double_complex& lhs,
const double& rhs) | |
| Function | double_complex operator*(
const double& lhs,
const double_complex& rhs) | |
| Function | double_complex operator/(const double_complex& lhs,
const double_complex& rhs) | Returns the result of dividing lhs by rhs. |
| Function | double_complex operator/(const double_complex& lhs,
const double& rhs) | |
| Function | double_complex operator/(const double& lhs,
const double_complex& rhs) | |
| Function | bool operator==(const double_complex& lhs,
const double_complex& rhs) | |
| Function | bool operator==(const double_complex& lhs,
const double& rhs) | |
| Function | bool operator==(const double& lhs,
const double_complex& rhs) | |
| Function | bool operator!=(const double_complex& lhs,
const double_complex& rhs) | |
| Function | bool operator!=(const double_complex& lhs,
const double& rhs) | |
| Function | bool operator!=(const double& lhs,
const double_complex& rhs) | |
| Function | istream& operator>>(
istream& is,
double_complex& x) | Inputs x in a format of u, (u), or (u,v) (u: real part, v: imaginary part). |
| Function | ostream& operator<<(ostream& os,
const double_complex& x) | Outputs x in a format of u, (u), or (u,v) (u: real part, v: imaginary part). |
### Function Definitions

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>double_complex conj(</td>
<td>Calculates the conjugate complex number.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex polar(</td>
<td>Calculates the double_complex value for a complex number with size rho and</td>
</tr>
<tr>
<td></td>
<td>const double&amp; rho,</td>
<td>phase angle theta.</td>
</tr>
<tr>
<td></td>
<td>const double&amp; theta)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex cos(</td>
<td>Calculates the complex cosine.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex cosh(</td>
<td>Calculates the complex hyperbolic cosine.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex exp(</td>
<td>Calculates the exponent function.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex log(</td>
<td>Calculates the natural logarithm.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex log10(</td>
<td>Calculates the common logarithm.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex pow(</td>
<td>Calculates x to the yth power.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x, int y)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex pow(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x, const double&amp; y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex pow(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x, const double_complex&amp; y)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex pow(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const double&amp; x, const double_complex&amp; y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex sin(</td>
<td>Calculates the complex sine.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex sinh(</td>
<td>Calculates the complex hyperbolic sine.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex sqrt(</td>
<td>Calculates the square root within the right half space.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex tan(</td>
<td>Calculates the complex tangent.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>double_complex tanh(</td>
<td>Calculates the complex hyperbolic tangent.</td>
</tr>
<tr>
<td></td>
<td>const double_complex&amp; x)</td>
<td></td>
</tr>
</tbody>
</table>

**double_complex operator+(const double_complex& lhs)**

Performs unary + operation of lhs.
Return value: lhs

**double_complex operator+(const double_complex& lhs, const double_complex& rhs)**

Returns the result of adding lhs to rhs.
Return value: double_complex(lhs)==rhs
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Return Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>double_complex operator+(const double_complex&amp; lhs, const double&amp; rhs)</code></td>
<td>Adds <code>lhs</code> to <code>rhs</code>.</td>
<td><code>double_complex(lhs) += rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator+(const double&amp; lhs, const double_complex&amp; rhs)</code></td>
<td>Adds <code>lhs</code> to <code>rhs</code>.</td>
<td><code>double_complex(lhs) += rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator-(const double_complex&amp; lhs)</code></td>
<td>Performs unary <code>-</code> operation on <code>lhs</code>.</td>
<td><code>double_complex(-lhs.real(), -lhs.imag())</code></td>
</tr>
<tr>
<td><code>double_complex operator-(const double_complex&amp; lhs, const double_complex&amp; rhs)</code></td>
<td>Subtracts <code>rhs</code> from <code>lhs</code>.</td>
<td><code>double_complex(lhs) -= rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator-(const double_complex&amp; lhs, const double&amp; rhs)</code></td>
<td>Subtracts <code>rhs</code> from <code>lhs</code>.</td>
<td><code>double_complex(lhs) -= rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator-(const double&amp; lhs, const double_complex&amp; rhs)</code></td>
<td>Subtracts <code>rhs</code> from <code>lhs</code>.</td>
<td><code>double_complex(lhs) -= rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator*(const double_complex&amp; lhs, const double_complex&amp; rhs)</code></td>
<td>Multiplies <code>lhs</code> by <code>rhs</code>.</td>
<td><code>double_complex(lhs) *= rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator*(const double&amp; lhs, const double_complex&amp; rhs)</code></td>
<td>Multiplies <code>lhs</code> by <code>rhs</code>.</td>
<td><code>double_complex(lhs) *= rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator*(const double_complex&amp; lhs, const double&amp; rhs)</code></td>
<td>Multiplies <code>lhs</code> by <code>rhs</code>.</td>
<td><code>double_complex(lhs) *= rhs</code></td>
</tr>
<tr>
<td><code>double_complex operator/(const double_complex&amp; lhs, const double_complex&amp; rhs)</code></td>
<td>Divides <code>lhs</code> by <code>rhs</code>.</td>
<td><code>double_complex(lhs) /= rhs</code></td>
</tr>
</tbody>
</table>
double_complex operator/(const double_complex& lhs, const double& rhs)

Returns the result of dividing \textit{lhs} by \textit{rhs}.
Return value: \textit{double_complex(lhs)} /= \textit{rhs}

double_complex operator/(const double& lhs, const double_complex& rhs)

Returns the result of dividing \textit{lhs} by \textit{rhs}.
Return value: \textit{double_complex(lhs)} /= \textit{rhs}

bool operator==(const double_complex& lhs, const double_complex& rhs)

Compares the real parts of \textit{lhs} and \textit{rhs}, and the imaginary parts of \textit{lhs} and \textit{rhs}.
For a \texttt{double} type parameter, the imaginary part is assumed to be 0.0.
Return value: \textit{lhs}.real() == \textit{rhs}.real() && \textit{lhs}.imag() == \textit{rhs}.imag()

bool operator==(const double_complex& lhs, const double& rhs)

Compares the real parts of \textit{lhs} and \textit{rhs}, and the imaginary parts of \textit{lhs} and \textit{rhs}.
For a \texttt{double} type parameter, the imaginary part is assumed to be 0.0.
Return value: \textit{lhs}.real() == \textit{rhs}.real() && \textit{lhs}.imag() == \textit{rhs}.imag()

bool operator==(const double& lhs, const double_complex& rhs)

Compares the real parts of \textit{lhs} and \textit{rhs}, and the imaginary parts of \textit{lhs} and \textit{rhs}.
For a \texttt{double} type parameter, the imaginary part is assumed to be 0.0.
Return value: \textit{lhs}.real() == \textit{rhs}.real() && \textit{lhs}.imag() == \textit{rhs}.imag()

bool operator!=(const double_complex& lhs, const double_complex& rhs)

Compares the real parts of \textit{lhs} and \textit{rhs}, and the imaginary parts of \textit{lhs} and \textit{rhs}.
For a \texttt{double} type parameter, the imaginary part is assumed to be 0.0.
Return value: \textit{lhs}.real() != \textit{rhs}.real() || \textit{lhs}.imag() != \textit{rhs}.imag()

bool operator!=(const double_complex& lhs, const double& rhs)

Compares the real parts of \textit{lhs} and \textit{rhs}, and the imaginary parts of \textit{lhs} and \textit{rhs}.
For a \texttt{double} type parameter, the imaginary part is assumed to be 0.0.
Return value: \textit{lhs}.real() != \textit{rhs}.real() || \textit{lhs}.imag() != \textit{rhs}.imag()

bool operator!=(const double& lhs, const double_complex& rhs)

Compares the real parts of \textit{lhs} and \textit{rhs}, and the imaginary parts of \textit{lhs} and \textit{rhs}.
For a \texttt{double} type parameter, the imaginary part is assumed to be 0.0.
Return value: \textit{lhs}.real() != \textit{rhs}.real() || \textit{lhs}.imag() != \textit{rhs}.imag()

istream& operator>>(istream& is, double_complex& x)

Inputs complex number \texttt{x} in a format of \texttt{u}, (\texttt{u}), or (\texttt{u,v}) \texttt{(u}: real part, \texttt{v}: imaginary part).
The input value is converted to \texttt{double_complex}.
If \texttt{x} is input in a format other than the \texttt{u}, (\texttt{u}), or (\texttt{u,v}) format, \texttt{is.setstate(ios_base::failbit)} is called.
Return value: \texttt{is}
Inputs x to os.
The output format is u, (u), or (u,v) (u: real part, v: imaginary part).
Return value: os

double real(const double_complex& x)

Acquires the real part.
Return value: x.real()

double imag(const double_complex& x)

Acquires the imaginary part.
Return value: x.imag()

double abs(const double_complex& x)

Calculates the absolute value.
Return value: (|x.real()|^2 + |x.imag()|^2)^(1/2)

double arg(const double_complex& x)

Calculates the phase angle.
Return value: atan2(x.imag(), x.real())

double norm(const double_complex& x)

Calculates the absolute value of the square.
Return value: |x.real()|^2 + |x.imag()|^2

double_complex conj(const double_complex& x)

Calculates the conjugate complex number.
Return value: double_complex(x.real(), (-1)*x.imag())

double_complex polar(const double& rho, const double& theta)

Calculates the double_complex value for a complex number with size rho and phase angle (argument) theta.
Return value: double_complex(rho*cos(theta), rho*sin(theta))

double_complex cos(const double_complex& x)

Calculates the complex cosine.
Return value: double_complex(cos(x.real())*cosh(x.imag()),
(-1)*sin(x.real())*sinh(x.imag()))

double_complex cosh(const double_complex& x)

Calculates the complex hyperbolic cosine.
Return value: cos(double_complex((-1)*x.imag(), x.real()))
### Library Functional Specification

**Calculates the exponent function.**
Return value: \( \exp(x.\text{real}()) \cdot \cos(x.\text{imag}()) \cdot \exp(x.\text{real}()) \cdot \sin(x.\text{imag}()) \)

**Calculates the natural logarithm (base e).**
Return value: \( \text{double\_complex} (\log(\text{abs}(x)), \text{arg}(x)) \)

**Calculates the common logarithm (base 10).**
Return value: \( \text{double\_complex} (\log_{10}(\text{abs}(x)), \text{arg}(x)/\log(10)) \)

**Calculates \( x \) to the \( y \)th power.**
If \( \text{pow}(0,0) \), a domain error will occur.
Return value: \( \exp(y \cdot \log(x)) \)

**Calculates the complex sine**
Return value: \( \text{double\_complex} (\sin(x.\text{real}()) \cdot \cosh(x.\text{imag}()), \cos(x.\text{real}()) \cdot \sinh(x.\text{imag}())) \)

**Calculates the complex hyperbolic sine**
Return value: \( \text{double\_complex} (0, -1) \cdot \sin(\text{double\_complex}((-1) \cdot x.\text{imag}(), x.\text{real}())) \)

**Calculates the square root within the right half space**
Return value: \( \text{double\_complex} (\sqrt{\text{abs}(x)} \cdot \cos(\text{arg}(x)/2), \sqrt{\text{abs}(x)} \cdot \sin(\text{arg}(x)/2)) \)
Calculates the complex tangent.
Return value: $\frac{\sin(x)}{\cos(x)}$

```c
double_complex tan(const double_complex& x)
```

Calculates the complex hyperbolic tangent.
Return value: $\frac{\sinh(x)}{\cosh(x)}$

```c
double_complex tanh(const double_complex& x)
```
7.5.4 String Handling Class Library

The header file for the string handling class library is as follows:

- `<string>`
  Defines class `string`.

This class has no derivation.

(a) string Class

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>iterator</td>
<td>char* type.</td>
</tr>
<tr>
<td></td>
<td>const_iterator</td>
<td>const char* type.</td>
</tr>
<tr>
<td>Constant</td>
<td>npos</td>
<td>Maximum string length (UNIT_MAX characters).</td>
</tr>
<tr>
<td>Variable</td>
<td>s_ptr</td>
<td>Pointer to the memory area where the string is</td>
</tr>
<tr>
<td></td>
<td>s_len</td>
<td>The length of the string stored by the object.</td>
</tr>
<tr>
<td></td>
<td>s_res</td>
<td>Size of the allocated memory area to store string</td>
</tr>
<tr>
<td>Function</td>
<td>string(void)</td>
<td>Constructor.</td>
</tr>
<tr>
<td></td>
<td>string(const char* str, size_t n = npos)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string(const char* str)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string(size_t n, char c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>~string()</td>
<td>Destructor.</td>
</tr>
<tr>
<td></td>
<td>string&amp; operator=(const string&amp; str)</td>
<td>Assigns str.</td>
</tr>
<tr>
<td></td>
<td>string&amp; operator=(const char* str)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t &amp; operator=(const char c)</td>
<td>Assigns c.</td>
</tr>
<tr>
<td></td>
<td>iterator begin()</td>
<td>Calculates the start pointer of the string.</td>
</tr>
<tr>
<td></td>
<td>const_iterator begin() const</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iterator end()</td>
<td>Calculates the end pointer of the string.</td>
</tr>
<tr>
<td></td>
<td>const_iterator end() const</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t size() const</td>
<td>Calculates the length of the stored string.</td>
</tr>
<tr>
<td></td>
<td>size_t length() const</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t max_size() const</td>
<td>Calculates the size of the allocated memory area.</td>
</tr>
<tr>
<td></td>
<td>void resize(size_t n, char c)</td>
<td>Changes the storable string length to n.</td>
</tr>
<tr>
<td></td>
<td>void resize(size_t n)</td>
<td>Changes the storable string length to n.</td>
</tr>
<tr>
<td></td>
<td>size_t capacity() const</td>
<td>Calculates the size of the allocated memory area.</td>
</tr>
<tr>
<td></td>
<td>void reserve(size_t res_arg = 0)</td>
<td>Performs re-allocation of the memory area.</td>
</tr>
<tr>
<td></td>
<td>void clear()</td>
<td>Clears the stored string.</td>
</tr>
<tr>
<td></td>
<td>bool empty() const</td>
<td>Checks whether the stored string length is 0.</td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Function</td>
<td>const char&amp; operator[](size_t pos) const</td>
<td>References s_ptr[pos].</td>
</tr>
<tr>
<td></td>
<td>char&amp; operator[](size_t pos)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const char&amp; at(size_t pos) const</td>
<td></td>
</tr>
<tr>
<td></td>
<td>char&amp; at(size_t pos)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; operator+=(const string&amp; str)</td>
<td>Adds string str.</td>
</tr>
<tr>
<td></td>
<td>string&amp; operator+=(char c)</td>
<td>Adds character c.</td>
</tr>
<tr>
<td></td>
<td>string&amp; append(const string&amp; str)</td>
<td>Adds string str.</td>
</tr>
<tr>
<td></td>
<td>string&amp; append(const char* str)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; append(const char* str, size_t pos, size_t n)</td>
<td>Adds n characters of string str at object position pos.</td>
</tr>
<tr>
<td></td>
<td>string&amp; append(const char* str, size_t n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; append(size_t n, char c)</td>
<td>Adds n characters, each of which is c.</td>
</tr>
<tr>
<td></td>
<td>string&amp; assign(const string&amp; str)</td>
<td>Assigns string str.</td>
</tr>
<tr>
<td></td>
<td>string&amp; assign(const char* str)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; assign(const char* str, size_t pos, size_t n)</td>
<td>Add n characters to string str at position pos.</td>
</tr>
<tr>
<td></td>
<td>string&amp; assign(const char* str, size_t n)</td>
<td>Assigns n characters of string str.</td>
</tr>
<tr>
<td></td>
<td>string&amp; assign(size_t n, char c)</td>
<td>Assigns n characters, each of which is c.</td>
</tr>
<tr>
<td></td>
<td>string&amp; insert(size_t pos1, const string&amp; str)</td>
<td>Inserts string str to position pos1.</td>
</tr>
<tr>
<td></td>
<td>string&amp; insert(size_t pos1, const string&amp; str, size_t pos2, size_t n)</td>
<td>Inserts n characters starting from position pos2 of string str to position pos1.</td>
</tr>
<tr>
<td></td>
<td>string&amp; insert(size_t pos, size_t n, const char* str, size_t n)</td>
<td>Inserts n characters of string str to position pos.</td>
</tr>
<tr>
<td></td>
<td>string&amp; insert(size_t pos, const char* str, size_t n)</td>
<td>Inserts string str to position pos.</td>
</tr>
<tr>
<td></td>
<td>string&amp; insert(size_t pos, size_t n, char c)</td>
<td>Inserts a string of n characters, each of which is c, to position pos.</td>
</tr>
<tr>
<td></td>
<td>iterator insert(iterator p, char c = char())</td>
<td>Inserts character c before the string specified by p.</td>
</tr>
<tr>
<td></td>
<td>void insert(iterator p, size_t n, char c)</td>
<td>Inserts n characters, each of which is c, before the character specified by p.</td>
</tr>
<tr>
<td></td>
<td>string&amp; erase(size_t pos = 0, size_t n = npos)</td>
<td>Deletes n characters from position pos.</td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Function</td>
<td>iterator erase(iterator position)</td>
<td>Deletes the character referenced by <strong>position</strong>.</td>
</tr>
<tr>
<td></td>
<td>iterator erase(iterator first, iterator last)</td>
<td>Deletes the characters in range <strong>[first, last]</strong>.</td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string of <strong>n1</strong> characters starting from <strong>pos1</strong> with string <strong>str</strong>.</td>
</tr>
<tr>
<td></td>
<td>size_t pos1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const string&amp; str)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string of <strong>n1</strong> characters starting from <strong>pos1</strong> with string of <strong>n2</strong> characters from <strong>pos2</strong> of <strong>str</strong>.</td>
</tr>
<tr>
<td></td>
<td>size_t pos1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const string&amp; str,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t pos2,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string of <strong>n1</strong> characters starting from <strong>pos</strong> with string <strong>str</strong> of <strong>n2</strong> characters.</td>
</tr>
<tr>
<td></td>
<td>size_t pos,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const char* str,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string of <strong>n1</strong> characters starting from <strong>pos</strong> with <strong>n2</strong> characters, each of which is <strong>c</strong>.</td>
</tr>
<tr>
<td></td>
<td>size_t pos,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n2,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>char <strong>c</strong>)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string from position <strong>i1</strong> to <strong>i2</strong> with string <strong>str</strong>.</td>
</tr>
<tr>
<td></td>
<td>iterator i1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iterator i2,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const string&amp; str)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string from position <strong>i1</strong> to <strong>i2</strong> with <strong>n</strong> characters of string <strong>str</strong>.</td>
</tr>
<tr>
<td></td>
<td>iterator i1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iterator i2,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const char* str,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>string&amp; replace(</td>
<td>Replaces the string from position <strong>i1</strong> to <strong>i2</strong> with <strong>n</strong> characters, each of which is <strong>c</strong>.</td>
</tr>
<tr>
<td></td>
<td>iterator i1,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iterator i2,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>char <strong>c</strong>)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t copy(</td>
<td>Copies the first <strong>n</strong> characters of string <strong>str</strong> to position <strong>pos</strong>.</td>
</tr>
<tr>
<td></td>
<td>char* str,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t n,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>size_t pos = 0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>const)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>void swap(string&amp; str)</td>
<td>Swaps <code>*this</code> with string <strong>str</strong>.</td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
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<tr>
<td>Function</td>
<td>const char* c_str() const</td>
<td>References the pointer to the memory area where the string is stored.</td>
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<td>const char* data() const</td>
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<td></td>
<td>size_t find(</td>
<td>Finds the position where the string same as string str first appears after</td>
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<td>const string&amp; str,</td>
<td>position pos.</td>
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<td>size_t pos = 0) const</td>
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<td>char c, size_t pos = 0) const</td>
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<td>size_t rfind(</td>
<td>Finds the position where a string same as string str appears most recently</td>
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<td>const string&amp; str,</td>
<td>before position pos.</td>
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<td>const char* str,</td>
<td>most recently before position pos.</td>
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<td>size_t pos, size_t n) const</td>
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</tbody>
</table>
Function

- `size_t find_last_of(char c, size_t pos = npos) const` finds the position where character `c` appears most recently before position `pos`.

- `size_t find_last_not_of(const string& str, size_t pos = npos) const` finds the position where a character different from any character included in string `str` appears most recently before position `pos`.

- `size_t find_first_not_of(const string& str, size_t pos = 0) const` finds the position where a character different from any character included in string `str` first appears after position `pos`.

- `size_t find_first_not_of(const char* str, size_t pos = 0) const` finds the position where a character different from any character in the first `n` characters of string `str` first appears after position `pos`.

- `size_t find_first_not_of(const char* str, size_t pos, size_t n) const` finds the position where a character different from any character included in string `str` appears after position `pos`.

- `size_t find_first_not_of(char c, size_t pos = 0) const` finds the position where a character different from `c` first appears after position `pos`.

- `size_t find_first_not_of(const char* str, size_t pos = npos) const` finds the position where a character different from any character in the first `n` characters of string `str` appears after position `pos`.

- `size_t find_first_not_of(const char* str, size_t pos, size_t n) const` finds the position where a character different from any character in the first `n` characters of string `str` appears after position `pos`.

- `size_t find_last_not_of(const string& str, size_t pos = npos) const` finds the position where a character different from any character included in string `str` appears most recently before position `pos`.

- `size_t find_last_not_of(const char* str, size_t pos = npos) const` finds the position where a character different from any character in the first `n` characters of string `str` appears most recently before position `pos`.

- `size_t find_last_not_of(const char* str, size_t pos, size_t n) const` finds the position where a character different from any character in the first `n` characters of string `str` appears most recently before position `pos`.

- `string substr(size_t pos = 0, size_t n = npos) const` creates an object from a string in the range `[pos, n]` of the stored string.

- `int compare(const string& str) const` compares the string with string `str`.

- `int compare(size_t pos1, size_t n1, const string& str) const` compares `n1` characters from position `pos1` of `*this` with `str`.

- `int compare(size_t pos1, size_t n1, const string& str, size_t pos2, size_t n2) const` compares the string of `n1` characters from position `pos1` with the string of `n2` characters from position `pos2` of string `str`.

- `int compare(const char* str) const` compares `*this` with string `str`.

- `int compare(size_t pos1, size_t n1, const char* str, size_t n2 = npos) const` compares the string of `n1` characters from position `pos1` with `n2` characters of string `str`.
string::string(void)

Sets as follows:
  s_ptr = 0;
  s_len = 0;
  s_res = 1;

string::string(const string& str, size_t pos = 0, size_t n =npos)

Copies str. Note that s_len will be the smaller value of n and s_len.

string::string(const char* str, size_t n)

Sets as follows:
  s_ptr = str;
  s_len = n;
  s_res = n + 1;

string::string(const char* str)

Sets as follows:
  s_ptr = str;
  s_len = length of string str;
  s_res = length of string str + 1;

string::string(size_t n, char c)

Sets as follows:
  s_ptr = string of n characters, each of which is c
  s_len = n;
  s_res = n + 1;

string::~string()

Destructor of class string.
Deallocates the memory area where the string is stored.

string& string::operator(const string& str)

Assigns the data of str.
Return value: *this

string& string::operator=(const char* str)

Creates a string object from str and assigns its data to the string object.
Return value: *this

string& string::operator=(char c)

Creates a string object from c and assigns its data to the string object.
Return value: *this
Calculates the start pointer of the string.
Return value: Start pointer of the string.

string::iterator string::begin()

Calculates the end pointer of the string.
Return value: End pointer of the string.

string::const_iterator string::end() const

Calculates the length of the stored string.
Return value: Length of the stored string.

size_t string::size() const

Calculates the size of the allocated memory area.
Return value: Size of the allocated memory area.

size_t string::max_size() const

Changes the number of characters in the string that can be stored by the object to n.
If \( n \leq \text{size()} \), replaces the string with the original string with length n.
If \( n > \text{size()} \), replaces the string with a string that has c appended to the end so that the length will be equal to n.
The length must be \( n \leq \text{max\_size()} \).
If \( n > \text{max\_size()} \), the string length is \( n = \text{max\_size()} \).

void string::resize(size_t n, char c)

Changes the number of characters in the string that can be stored by the object to n.
If \( n \leq \text{size()} \), replaces the string with the original string with length n.
The length must be \( n \leq \text{max\_size()} \).

void string::resize(size_t n)

Calculates the size of the allocated memory area.
Return value: Size of the allocated memory area.

size_t string::capacity() const
void string::reserve(size_t res_arg = 0)

Re-allocates the memory area.
After reserve(), capacity() will be equal to or larger than the reserve() parameter.
When the memory area is re-allocated, all references, pointers, and iterator that references the elements of the numeric sequence become invalid.

void string::clear()

Clears the stored string.

bool string::empty() const

Checks whether the number of characters in the stored string is 0.
Return value: If the length of the stored string is 0: true
If the length of the stored string is not zero: false

const char& string::operator[](size_t pos) const

References s_ptr[pos].
Return value: If n< s_len: s_ptr [pos]
If n>= s_len: \0'

char& string::operator[](size_t pos)

References s_ptr[pos].
Return value: If n< s_len: s_ptr [pos]
If n>= s_len: \0'

const char& string::at(size_t pos) const

References s_ptr[pos].
Return value: If n< s_len: s_ptr [pos]
If n>= s_len: \0'

char& string::at(size_t pos)

References s_ptr[pos].
Return value: If n< s_len: s_ptr [pos]
If n>= s_len: \0'

string& string::operator+=(const string& str)

Appends the string stored in str to the object.
Return value: *this

string& string::operator+=(const char* str)

Creates a string object from str and adds the string to the object.
Return value: *this
string& string::operator+=(char c)

Creates a string object from c and adds the string to the object.
Return value: *this

string& string::append(const string& str)

Appends string str to the object.
Return value: *this

string& string::append(const char* str)

Appends string str to the object.
Return value: *this

string& string::append(const string& str, size_t pos, size_t n);

Appends n characters of string str to the object position pos.
Return value: *this

string& string::append(const char* str, size_t n)

Appends n characters of string str to the object.
Return value: *this

string& string::append(size_t n, char c)

Appends n characters, each of which is c, to the object.
Return value: *this

string& string::assign(const string& str)

Assigns string str.
Return value: *this

string& string::assign(const char* str)

Assigns string str.
Return value: *this

string& string::assign(const string& str, size_t pos, size_t n)

Assigns n characters of string str to position pos.
Return value: *this

string& string::assign(const char* str, size_t n)

Assigns n characters of string str.
Return value: *this
string& string::assign(size_t n, char c)

Assigns n characters, each of which is c.
Return value: *this

string& string::insert(size_t pos1, const string& str)

Inserts string str to position pos1.
Return value: *this

string& string::insert(size_t pos1, const string& str, size_t pos2, size_t n)

Inserts n characters starting from position pos2 of string str to position pos1.
Return value: *this

string& string::insert(size_t pos, const char* str, size_t n)

Inserts n characters of string str to position pos.
Return value: *this

string& string::insert(size_t pos, const char* str)

Inserts string str to position pos.
Return value: *this

string& string::insert(size_t pos, size_t n, char c)

Inserts a string of n characters, each of which is c, to position pos.
Return value: *this

string::iterator string::insert(iterator p, char c = char())

Inserts character c before the string specified by p.
Return value: The inserted character

void string::insert(iterator p, size_t n, char c)

Inserts n characters, each of which is c, before the character specified by p.

string& string::erase(size_t pos = 0, size_t n = npos)

Deletes n characters starting from position pos.
Return value: *this

iterator string::erase(iterator position)

Deletes the character referenced by position.
Return value: If the next iterator of the element to be deleted exists: The next iterator of the deleted element
If the next iterator of the element to be deleted does not exist: end()
iterator string::erase(iterator first, iterator last)

Deletes the characters in range [first, last).
Return value: If the next iterator of last exists: The next iterator of last
              If the next iterator of last does not exist: end()

string& string::replace(size_t pos1, size_t n1, const string& str)

Replaces the string of n1 characters starting from position pos1 with string str.
Return value: *this

string& string::replace(size_t pos1, size_t n1, const char* str)

Replaces the string of n1 characters starting from position pos1 with string str.
Return value: *this

string& string::replace(size_t pos1, size_t n1, const string& str, size_t pos2, size_t n2)

Replaces the string of n1 characters starting from position pos1 with the string of n2 characters starting from position pos2 in string str.
Return value: *this

string& string::replace(size_t pos, size_t n1, const char* str, size_t n2)

Replaces the string of n1 characters starting from position pos with n2 characters of string str.
Return value: *this

string& string::replace(size_t pos, size_t n1, const string& str, size_t pos2, size_t n2, char c)

Replaces the string of n1 characters starting from position pos with n2 characters, each of which is c.
Return value: *this

string& string::replace(iterator i1, iterator i2, const string& str)

Replaces the string from position i1 to i2 with string str.
Return value: *this

string& string::replace(iterator i1, iterator i2, const char* str)

Replaces the string from position i1 to i2 with string str.
Return value: *this

string& string::replace(iterator i1, iterator i2, const char* str, size_t n)

Replaces the string from position i1 to i2 with n characters of string str
Return value: *this

string& string::replace(iterator i1, iterator i2, size_t n, char c)

Replaces the string from position i1 to i2 with n characters, each of which is c.
Return value: *this
size_t string::copy(char* str, size_t n, size_t pos = 0) const

Copies n characters of string str to position pos. Return value: rlen

void string::swap(string& str)

Swaps *this with string str.

const char* string::c_str() const

References the pointer to the memory area where the string is stored. Return value: s_ptr

const char* string::data() const

References the pointer to the memory area where the string is stored. Return value: s_ptr

size_t string::find(const string& str, size_t pos = 0) const

Finds the position where the string same as string str first appears after position pos. Return value: Offset of string.

size_t string::find (const char* str, size_t pos = 0) const

Finds the position where the string same as string str first appears after position pos. Return value: Offset of string.

size_t string::find(const char* str, size_t pos, size_t n) const

Finds the position where the string same as n characters of string str first appears after position pos. Return value: Offset of string.

size_t string::find(char c, size_t pos = 0) const

Finds the position where character c first appears after position pos. Return value: Offset of string.

size_t string::rfind(const string& str, size_t pos = npos) const

Finds the position where a string same as string str appears most recently before position pos. Return value: Offset of string.

size_t string::rfind(const char* str, size_t pos = npos) const

Finds the position where a string same as string str appears most recently before position pos. Return value: Offset of string.
Finds the position where the string same as \( n \) characters of string \( \text{str} \) appears most recently before position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{rfind} (\text{const char}_* \text{ str}, \text{size}_t \text{ pos}, \text{size}_t \text{ n}) \text{ const}
\]

Finds the position where character \( c \) appears most recently before position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{rfind} (\text{char} \ c, \text{size}_t \text{ pos} = \text{npos}) \text{ const}
\]

Finds the position where any character included in string \( \text{str} \) first appears after position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{first}_\text{of} (\text{const string}_& \text{ str}, \text{size}_t \text{ pos} = 0) \text{ const}
\]

Finds the position where any character included in string \( \text{str} \) first appears after position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{first}_\text{of} (\text{const char}_* \text{ str}, \text{size}_t \text{ pos} = 0) \text{ const}
\]

Finds the position where any character included in \( n \) characters of string \( \text{str} \) first appears after position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{first}_\text{of} (\text{char} \ c, \text{size}_t \text{ pos} = 0) \text{ const}
\]

Finds the position where character \( c \) first appears after position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{last}_\text{of} (\text{const string}_& \text{ str}, \text{size}_t \text{ pos} = \text{npos}) \text{ const}
\]

Finds the position where any character included in string \( \text{str} \) appears most recently before position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{last}_\text{of} (\text{const char}_* \text{ str}, \text{size}_t \text{ pos} = \text{npos}) \text{ const}
\]

Finds the position where any character included in string \( \text{str} \) appears most recently before position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{last}_\text{of} (\text{const char}_* \text{ str}, \text{size}_t \text{ pos}, \text{size}_t \text{ n}) \text{ const}
\]

Finds the position where any character included in \( n \) characters of string \( \text{str} \) appears most recently before position \( \text{pos} \).  
Return value: Offset of string.

\[
\text{size}_t \text{_string}::\text{find}_\text{last}_\text{of} (\text{char} \ c, \text{size}_t \text{ pos} = \text{npos}) \text{ const}
\]

Finds the position where character \( c \) appears most recently before position \( \text{pos} \).  
Return value: Offset of string.
Finds the position where a character different from any character included in string `str` first appears after position `pos`.
Return value: Offset of string.

size_t string::find_first_not_of(const string& str, size_t pos = 0) const

Finds the position where a character different from any character included in string `str` first appears after position `pos`.
Return value: Offset of string.

size_t string::find_first_not_of(const char* str, size_t pos, size_t n) const

Finds the position where a character different from any character included in string `str` first appears after position `pos`.
Return value: Offset of string.

size_t string::find_first_not_of(char c, size_t pos = 0) const

Finds the position where a character different from character `c` first appears after position `pos`.
Return value: Offset of string.

size_t string::find_last_not_of(const string& str, size_t pos = npos) const

Finds the position where a character different from any character included in string `str` appears most recently before position `pos`.
Return value: Offset of string.

size_t string::find_last_not_of(const char* str, size_t pos = npos) const

Finds the position where a character different from any character included in string `str` appears most recently before position `pos`.
Return value: Offset of string.

size_t string::find_last_not_of(const char* str, size_t pos, size_t n) const

Finds the position where a character different from any character included in string `str` appears most recently before position `pos`.
Return value: Offset of string.

size_t string::find_last_not_of(char c, size_t pos = npos) const

Finds the position where a character different from character `c` appears most recently before position `pos`.
Return value: Offset of string.

string string::substr(size_t pos = 0, size_t n = npos) const

Creates an object from a string in the range `[pos,n]` of the stored string.
Return value: Object with a string in the range `[pos,n]`. 
int string::compare(const string& str) const

Compares the string with string str.
Return value: If the strings are the same: 0
   If the strings are different: 1 when this->s_len > str.s_len,
   -1 when this->s_len < str.s_len

int string::compare(size_t pos1, size_t n1, const string& str) const

Compares a string of n1 characters starting from position pos1 of *this with string str.
Return value: If the strings are the same: 0
   If the strings are different: 1 when this->s_len > str.s_len,
   -1 when this->s_len < str.s_len

int string::compare(size_t pos1, size_t n1, const string& str, size_t pos2, size_t n2) const

Compares a string of n1 characters starting from position pos1 with the string of n2 characters from position pos2 of string str.
Return value: If the strings are the same: 0
   If the strings are different: 1 when this->s_len > str.s_len,
   -1 when this->s_len < str.s_len

int string::compare(const char* str) const

Compares *this with string str.
Return value: If the strings are the same: 0
   If the strings are different: 1 when this->s_len > str.s_len,
   -1 when this->s_len < str.s_len

int string::compare(size_t pos1, size_t n1, const char* str, size_t n2 = npos) const

Compares the string of n1 characters from position pos1 with n2 characters of string str.
Return value: If the strings are the same: 0
   If the strings are different: 1 when this->s_len > str.s_len,
   -1 when this->s_len < str.s_len

(b) string Class Manipulators

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>string operator +( const string&amp; lhs, const string&amp; rhs)</td>
<td>Appends the string (or characters) of rhs to the string (or characters) of lhs, creates an object and stores the string in the object.</td>
</tr>
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<td></td>
<td>string operator+(const char* lhs, const string&amp; rhs)</td>
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<tr>
<td></td>
<td>string operator+(char lhs, const string&amp; rhs)</td>
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<td></td>
<td>string operator+(const string&amp; lhs, const char* rhs)</td>
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<td></td>
<td>string operator+(const string&amp; lhs, char rhs)</td>
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<tr>
<td></td>
<td>bool operator==( const string&amp; lhs, const string&amp; rhs)</td>
<td>Compares the string of lhs with the string of rhs.</td>
</tr>
<tr>
<td></td>
<td>bool operator==(const char* lhs, const string&amp; rhs)</td>
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<tr>
<td></td>
<td>bool operator==(const string&amp; lhs, const char* rhs)</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Definition Name</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Function</td>
<td>bool operator!=(const string&amp; lhs, const string&amp; rhs)</td>
<td>Compares the string of lhs with the string of rhs.</td>
</tr>
<tr>
<td></td>
<td>bool operator!=(const char* lhs, const string&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator!=(const string&amp; lhs, const char* rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&lt;(const string&amp; lhs, const string&amp; rhs)</td>
<td>Compares the string length of lhs with the string length of rhs.</td>
</tr>
<tr>
<td></td>
<td>bool operator&lt;(const char* lhs, const string&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&lt;(const string&amp; lhs, const char* rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&gt;(const string&amp; lhs, const string&amp; rhs)</td>
<td>Compares the string length of lhs with the string length of rhs.</td>
</tr>
<tr>
<td></td>
<td>bool operator&gt;(const char* lhs, const string&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&gt;(const string&amp; lhs, const char* rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&lt;=(const string&amp; lhs, const string&amp; rhs)</td>
<td>Compares the string length of lhs with the string length of rhs.</td>
</tr>
<tr>
<td></td>
<td>bool operator&lt;=(const char* lhs, const string&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&lt;=(const string&amp; lhs, const char* rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&gt;=(const string&amp; lhs, const string&amp; rhs)</td>
<td>Compares the string length of lhs with the string length of rhs.</td>
</tr>
<tr>
<td></td>
<td>bool operator&gt;=(const char* lhs, const string&amp; rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bool operator&gt;=(const string&amp; lhs, const char* rhs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>void swap(string&amp; lhs, string&amp; rhs)</td>
<td>Swaps the string of lhs with the string of rhs.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; operator&gt;&gt;(istream&amp; is, string&amp; str)</td>
<td>Extracts the string to str.</td>
</tr>
<tr>
<td></td>
<td>ostream&amp; operator&lt;&lt;(ostream&amp; os, const string&amp; str)</td>
<td>Inserts string str.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(istream&amp; is, string&amp; str, char delim)</td>
<td>Extracts a string from is and appends it to str. If delim is found in the string, input is stopped.</td>
</tr>
<tr>
<td></td>
<td>istream&amp; getline(istream&amp; is, string&amp; str)</td>
<td>Extracts a string from is and appends it to str. If a new-line character is detected, input is stopped.</td>
</tr>
</tbody>
</table>

```plaintext
string operator+(const string& lhs, const string& rhs)
```

Appends the string (characters) of lhs with the strings (characters) of rhs, creates an object and stores the string in the object.
Return value: Object where the linked strings are stored.

```plaintext
string operator+(const char* lhs, const string& rhs)
```

Appends the string (characters) of lhs with the strings (characters) of rhs, creates an object and stores the string in the object.
Return value: Object where the linked strings are stored.
string operator+(char lhs, const string& rhs)

Appends the string (characters) of lhs with the strings (characters) of rhs, creates an object and stores the string in the object.
Return value: Object where the linked strings are stored.

string operator+(const string& lhs, const char* rhs)

Appends the string (characters) of lhs with the strings (characters) of rhs, creates an object and stores the string in the object.
Return value: Object where the linked strings are stored.

string operator+(const string& lhs, char rhs)

Appends the string (characters) of lhs with the strings (characters) of rhs, creates an object and stores the string in the object.
Return value: Object where the linked strings are stored.

bool operator==(const string& lhs, const string& rhs)

Compares the string of lhs with the string of rhs.
Return value: If the strings are the same: true
            If the strings are different: false

bool operator==(const char* lhs, const string& rhs)

Compares the string of lhs with the string of rhs.
Return value: If the strings are the same: true
            If the strings are different: false

bool operator==(const string& lhs, const char* rhs)

Compares the string of lhs with the string of rhs.
Return value: If the strings are the same: true
            If the strings are different: false

bool operator!=(const string& lhs, const string& rhs)

Compares the string of lhs with the string of rhs.
Return value: If the strings are the same: false
            If the strings are different: true

bool operator!=(const char* lhs, const string& rhs)

Compares the string of lhs with the string of rhs.
Return value: If the strings are the same: false
            If the strings are different: true

bool operator!=(const string& lhs, const char* rhs)

Compares the string of lhs with the string of rhs.
Return value: If the strings are the same: false
            If the strings are different: true
compareTo(const string& lhs, const string& rhs)

Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} < \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} >= \text{rhs} \cdot \text{s_len} \): false

compareTo(const char* lhs, const string& rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} < \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} >= \text{rhs} \cdot \text{s_len} \): false

compareTo(const string& lhs, const char* rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} < \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} >= \text{rhs} \cdot \text{s_len} \): false

compareTo(const string& lhs, const string& rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} > \text{rhs} \cdot \text{s_len} \): true

compareTo(const char* lhs, const string& rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} > \text{rhs} \cdot \text{s_len} \): true

compareTo(const string& lhs, const char* rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} > \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} <= \text{rhs} \cdot \text{s_len} \): false

compareTo(const string& lhs, const string& rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} <= \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} > \text{rhs} \cdot \text{s_len} \): false

compareTo(const char* lhs, const string& rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} <= \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} > \text{rhs} \cdot \text{s_len} \): false

compareTo(const string& lhs, const char* rhs)

 Compares the string length of \( \text{lhs} \) with the string length of \( \text{rhs} \).

Return value: If \( \text{lhs} \cdot \text{s_len} <= \text{rhs} \cdot \text{s_len} \): true

If \( \text{lhs} \cdot \text{s_len} > \text{rhs} \cdot \text{s_len} \): false
### bool operator\((\text{const string& } \text{lhs}, \text{const string& } \text{rhs})\)

Compares the string length of \text{lhs} with the string length of \text{rhs}.

Return value:
- If \text{lhs.s_len} \geq \text{rhs.s_len}: \text{true}
- If \text{lhs.s_len} < \text{rhs.s_len}: \text{false}

### bool operator\((\text{const char* } \text{lhs}, \text{const string& } \text{rhs})\)

Compares the string length of \text{lhs} with the string length of \text{rhs}.

Return value:
- If \text{lhs.s_len} \geq \text{rhs.s_len}: \text{true}
- If \text{lhs.s_len} < \text{rhs.s_len}: \text{false}

### bool operator\((\text{const string& } \text{lhs}, \text{const char* } \text{rhs})\)

Compares the string length of \text{lhs} with the string length of \text{rhs}.

Return value:
- If \text{lhs.s_len} \geq \text{rhs.s_len}: \text{true}
- If \text{lhs.s_len} < \text{rhs.s_len}: \text{false}

### void swap(string& \text{lhs}, string& \text{rhs})

Swaps the string of \text{lhs} with the string of \text{rhs}.

### istream& operator\((\text{istream& } \text{is}, \text{string& } \text{str})\)

Extracts a string to \text{str}.

Return value: \text{is}

### ostream& operator\((\text{ostream& } \text{os}, \text{const string& } \text{str})\)

Inserts string \text{str}.

Return value: \text{os}

### istream& getline(istream& is, string& str, char delim)

Extracts a string from \text{is} and appends it to \text{str}.

If \text{delim} is found in the string, the input is stopped.

Return value: \text{is}

### istream& getline(istream& is, string& str)

Extracts a string from \text{is} and appends it to \text{str}.

If a new-line character is found, the input is stopped.

Return value: \text{is}
7.6 Unsupported Libraries

Table 7.16 lists the libraries which are specified in the C language specifications but not supported by this compiler.

Table 7.16 Unsupported Libraries

<table>
<thead>
<tr>
<th>No.</th>
<th>Header File</th>
<th>Library Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>locale.h(^1)</td>
<td>setlocale, localeconv</td>
</tr>
<tr>
<td>2</td>
<td>signal.h(^1)</td>
<td>signal, raise</td>
</tr>
<tr>
<td>3</td>
<td>stdio.h</td>
<td>remove, rename, tmpfile, tmpnam, fgetpos, fsetpos</td>
</tr>
<tr>
<td>4</td>
<td>stdlib.h</td>
<td>abort, atexit, exit, __Exit, getenv, system, mblen, mbtowc, wctomb, mbstowcs, wcstombs</td>
</tr>
<tr>
<td>5</td>
<td>string.h</td>
<td>strcoll, strxfrm</td>
</tr>
<tr>
<td>6</td>
<td>time.h</td>
<td>clock, difftime, mktime, time, asctime, ctime, gmtime, localtime, strftime</td>
</tr>
<tr>
<td>7</td>
<td>wctype.h</td>
<td>iswalnum, iswalpha, iswblank, iswcntrl, iswdigit, iswgraph, iswlower, iswprint, iswpunct, iswspace, iswupper, iswxdigit, wctype, towlower, towupper, towctrans, wctrans</td>
</tr>
<tr>
<td>8</td>
<td>wchar.h</td>
<td>wcsftime, wcscoll, wcsxfrm, wctob, mbtowc, wcrtomb, mbsrtowcs, wcsrtombs</td>
</tr>
</tbody>
</table>

Note The header file is not supported.
8. STARTUP

This chapter describes the startup routine.

8.1 Overview

Running a user program that was written in C/C++ requires a separate program to handle copying of initialized data for inclusion in the target system and to start the user program (main function). This program is called the startup routine. The user must create the startup routines for user programs. Renesas provides the source code for a startup routine with its integrated development environment (IDE) for the RX Family so that the user has a startup routine that can be adjusted to suit the target system.

8.2 File Contents

Startup routine that The Renesas integrated development environment (IDE) for RX Family supplies is as follows:

<table>
<thead>
<tr>
<th>Table 8.1 List of Programs Created in Integrated Development Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Name</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>(a)</td>
</tr>
<tr>
<td>(b)</td>
</tr>
<tr>
<td>(c)</td>
</tr>
<tr>
<td>(d)</td>
</tr>
<tr>
<td>(e)</td>
</tr>
<tr>
<td>(f)</td>
</tr>
<tr>
<td>(g)</td>
</tr>
<tr>
<td>(h)</td>
</tr>
<tr>
<td>(i)</td>
</tr>
<tr>
<td>(j)</td>
</tr>
<tr>
<td>(k)</td>
</tr>
<tr>
<td>(l)</td>
</tr>
</tbody>
</table>

Notes 1. This is for the RXv1 instruction-set architecture. For an RX instruction-set architecture other than the RXv1 instruction-set architecture, this becomes the "exception vector table".

8.3 Startup Program Creation

Here, processing to prepare the environment for program execution is described. However, the environment for program execution will differ among user systems, and so a program to set the execution environment must be created according to the specifications of the user system.

This section describes the standard startup program. The startup program for an application that uses the PIC/PID function needs special processing; refer also to section 8.5.7 Application Startup.

A summary of the necessary procedures is given below.

- Fixed vector table setting
  Sets the fixed vector table to initiate the initial setting routine (PowerOn_Reset_PC) at a power-on reset. In addition to the reset vector, processing routines, such as, privileged instruction exception, access exception, undefined instruction exception, floating-point exception, and nonmaskable interrupt, can be registered to the fixed vector table.

- Initial setting
  Performs the procedures required to reach the main function. Registers and sections are initialized and various initial setting routines are called.
- Low-level interface routine creation
  Routines providing an interface between the user system and library functions which are necessary when standard I/O (stdio.h, ios, streambuf, istream, and ostream) and memory management libraries (stdlib.h and new) are used.

- Termination processing routine (exit, atexit, and abort)* creation
  Processing for terminating the program is performed.

Note * When using the C library function exit, atexit, or abort to terminate a program, these functions must be created as appropriate to the user system. When using the C++ program or C library macro assert, the abort function must always be created.

8.3.1 Fixed Vector Table Setting

To call the initial setting routine (PowerOn_Reset_PC) at a power-on reset, set the address of PowerOn_Reset_PC to the reset vector of the fixed vector table. A coding example is shown below.

In addition to the reset vector, processing routines, such as, privileged instruction exception, access exception, undefined instruction exception, floating-point exception, and nonmaskable interrupt, can be registered to the fixed vector table. For details on the fixed vector table, refer to the hardware manual.

Example:

extern void PowerOn_Reset_PC(void);

#pragma section C FIXEDVECT /* Outputs RESET_Vectors to the FIXEDVECT */
/* section by #pragma section declaration. */
/* Allocates the FIXEDVECT section to reset */
/* vector by the start option at linkage. */

void (*const RESET_Vectors[])(void)=
    PowerOn_Reset_PC,
};

8.3.2 Initial Setting

The initial setting routine (PowerOn_Reset_PC) is a function that contains the procedures required before and after executing the main function. Processings required in the initial setting routine are described below in order.

(1) Initialization of PSW for Initial Setting Processing
   The PSW register necessary for performing the initial setting processing is initialized. For example, disabling interrupts is set in PSW during the initial setting processing to prevent from accepting interrupts. All bits in PSW are initialized to 0 at a reset, and the interrupt enable bit (I bit) is also initialized to 0 (interrupt disabled state).

(2) Initialization of Stack Pointer
   The stack pointer (USP register and ISP register) is initialized. The #pragma entry declaration for the PowerOn_Reset_PC function makes the compiler automatically create the ISP/USP initialization code at the beginning of the function.
   This procedure does not have to be written because the PowerOn_Reset_PC function is declared by #pragma entry.

(3) Initialization of General Registers Used as Base Registers
   When the base option is used in the compiler, general registers used as base addresses in the entire program need to be initialized. The #pragma entry declaration for the PowerOn_Reset_PC function makes the compiler automatically create the initialization code for each register at the beginning of the function.
   This procedure does not have to be written because the PowerOn_Reset_PC function is declared by #pragma entry.

(4) Initialization of Control Registers
   The address of the variable vector table is written to INTB. FINTV, FPSW, BPC, BPSW, EXTB, and DPSW are also initialized as required. These registers can be initialized using the intrinsic functions of the compiler. Note however that only PSW is not initialized because it holds the interrupt mask setting.

(5) Initializing the Trigonometric Function Unit
   When the -tfu option is specified, also call the __init_tfu() intrinsic function to initialize the trigonometric function unit.
(6) Initialization Processing of Sections
The initialization routine for RAM area sections (_INITSCT) is called. Uninitialized data sections are initialized to zero. For initialized data sections, the initial values of the ROM area are copied to the RAM area. _INITSCT is provided as a standard library.

The user needs to write the sections to be initialized to the tables for section initialization (DTBL and BTBL). The section address operator is used to set the start and end addresses of the sections used by the _INITSCT function.

Section names in the section initialization tables are declared, using C$BSEC for uninitialized data areas, and C$DSEC for initialized data areas.

A coding example is shown below.

Example:

```c
#pragma section C C$DSEC  //Section name must be C$DSEC
extern const struct {
    void *rom_s;             //Start address member of the initialized data
    //section in ROM
    void *rom_e;             //End address member of the initialized data
    //section in ROM
    void *ram_s;             //Start address member of the initialized data
    //section in RAM
} DTBL[] = {__sectop("D"), __secend("D"), __sectop("R")};
```

```c
#pragma section C C$BSEC  //Section name must be C$BSEC
extern const struct {
    void *b_s;            //Start address member of the uninitialized data section
    void *b_e;              //End address member of the uninitialized data section
} BTBL[] = {__sectop("B"), __secend("B")};
```

(7) Initialization Processing of Libraries
The routine for performing necessary initialization processing (_INITLIB) is called when the C/C++ library functions are used.

In order to set only those values which are necessary for the functions that are actually to be used, please refer to the following guidelines.

- When an initial setting is required in the prepared low-level interface routines, the initial setting (_INIT_LOWLEVEL) in accordance with the specifications of the low-level interface routines is necessary.

- When using the `rand` function or `strtok` function, initial settings other than those for standard I/O (_INIT_OTHERLIB) are necessary.

An example of a program to perform initial library settings is shown below.
including `<stdio.h>`
#include `<stdlib.h>`
define IOSTREAM 3
const size_t _sbrk_size = 520; // Specifies the minimum unit of the size to
// define for the heap area (default: 1024)
extern char * _s1ptr;
#endif
void _INITLIB (void)
{
  _INIT_LOWLEVEL(); // Set initial setting for low-level
  _INIT_OTHERLIB(); // Set initial setting for rand function and
                      // strtok function
}
void _INIT_LOWLEVEL (void)
{
  // Set necessary initial setting for low-level
  // library
}
void _INIT_OTHERLIB(void)
{
  srand(1); // Set initial setting if using rand function
  _s1ptr=NULL; // Set initial setting if using strtok function
}
#endif

Notes 1. Specify the filename for the standard I/O file. This name is used in the low-level interface routine
"open".

Notes 2. In the case of a console or other interactive device, a flag is set to prevent the use of buffering.

(8) Initialization of Global Class Objects
When developing a C++ program, the routine (_CALL_INIT) for calling the constructor of a class object that is
declared as global is called. _CALL_INIT is provided as a standard library.

(9) Initialization of PSW for main Function Execution
The PSW register is initialized. The interrupt mask setting is canceled here.

(10) Changing of PM Bit in PSW
After a reset, operation is in privileged mode (PM bit in PSW is 0). To switch to user mode, intrinsic function
chg_pmusr is executed.
When using the chg_pmusr function, some care should be taken. Refer to the description of chg_pmusr in 4.2.6
Intrinsic Functions.

(11) User Program Execution
The main function is executed.

(12) Global Class Object Postprocessing
When developing a C++ program, the routine (_CALL_END) for calling the destructor of a class object that is
declared as global is called. _CALL_END is provided as a standard library.
8.3.3 Coding Example of Initial Setting Routine

A coding example of the `PowerOn_Reset_PC` function is shown here. For the actual initial setting routine created in the integrated development environment, refer to 8.4 Coding Example.

```c
#include     <machine.h>
#include     <h_c_lib.h>
#include     "typedefine.h"
#include     "stacksct.h"
#ifdef __cplusplus
extern "C" {
#endif
void PowerOn_Reset_PC(void);
void main(void);
#ifdef __cplusplus
}
#endif
#ifdef __cplusplus                      // Use SIM I/O
extern "C" {
#endif
extern void _INITLIB(void);
#ifdef __cplusplus
}
#endif
#define PSW_init  0x00010000
#define FPSW_DPSW_init 0x00000100
#pragma section ResetPRG
#pragma entry PowerOn_Reset_PC
void PowerOn_Reset_PC(void)
{
#if (__RX_ISA_VERSION__ >= 2) || defined(__RXV2)
    set_extb(__sectop("EXCEPTVECT"));
#endif
    set_intb(__sectop("CSVECT"));
#ifdef __FPU
    set_fpsw(FPSW_DPSW_init);
#endif
#ifdef __DPFPU
    __set_dpsw(FPSW_DPSW_init);
#endif
#if __TFU == 1
    __init_tfu();
#endif
_INITSCT();
_INITLIB();
set_psw(PSW_init);
main();
brk();
}
```
8.3.4 Low-Level Interface Routines

Low-level interface routines are user-defined functions which are called from library functions in order to implement library functions in accordance with the specifications of the user system. They need to be created in any of the following cases.

(1) When using library functions related to standard I/O or memory management
(2) When a library function has to be a reentrant library

Table 8.2 lists the low-level interface routines used by C library functions.

Table 8.2 List of Low-Level Interface Routines

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>open</td>
<td>Opens file.</td>
</tr>
<tr>
<td>close</td>
<td>Closes file.</td>
</tr>
<tr>
<td>read</td>
<td>Reads from file.</td>
</tr>
<tr>
<td>write</td>
<td>Writes to file.</td>
</tr>
<tr>
<td>lseek</td>
<td>Sets the read/write position in a file.</td>
</tr>
<tr>
<td>sbrk</td>
<td>Allocates area in memory.</td>
</tr>
<tr>
<td>errno_addr</td>
<td>Acquires errno address.</td>
</tr>
<tr>
<td>wait_sem</td>
<td>Defines semaphore.</td>
</tr>
<tr>
<td>signal_sem</td>
<td>Releases semaphore.</td>
</tr>
</tbody>
</table>

Notes 1. The function names open, close, read, write, lseek, sbrk, errno_addr, wait_sem, and signal_sem are reserved for low-level interface routines. They should not be used in user programs.

Notes 2. These routines are necessary when the reentrant library is used.

Initialization necessary for low-level interface routines must be performed on program startup. This initialization should be performed using the _INIT_LOWLEVEL function in library initial setting processing (_INITLIB).

Below, after explaining the basic approach to low-level I/O, the specifications for each interface routine are described.

(1) Approach to I/O

In the standard I/O library, files are managed by means of FILE-type data; but in low-level interface routines, positive integers are assigned in a one-to-one correspondence with actual files for management. These integers are called file numbers.

In the open routine, a file number is provided for a specified filename. The open routine must set the following information such that this number can be used for file input and output.

- The device type of the file (console, printer, disk file, etc.) (In the cases of special devices such as consoles or printers, special filenames must be set by the system and identified in the open routine.)
- When using file buffering, information such as the buffer position and size
- In the case of a disk file, the byte offset from the start of the file to the position for reading or writing

Based on the information set using the open routine, all subsequent I/O (read and write routines) and read/write positioning (lseek routine) is performed.

When output buffering is being used, the close routine should be executed to write the contents of the buffer to the actual file, so that the data area set by the open routine can be reused.

(2) Specifications of Low-Level Interface Routines

In this section, specifications for low-level interface routines are described. For each routine, the interface for calling the routine, its operation, and information for using the routine are described.

The interface for the routines is indicated using the following format. Low-level interface routines should always be given a prototype declaration. Add "extern C" to declare in the C++ program.
(Routine name)

[Description]
- (A summary of the routine operations is given)

[Return value]
- Normal: (The return value on normal termination is explained)
- Error: (The return value when an error occurs is given)

[Parameters]
- (Name) (Meaning)
- (The name of the parameter appearing in the interface) (The value passed as a parameter)
long open (const char *name, long mode, long flg)

[Description]

- Prepares for operations on the file corresponding to the filename of the first parameter. In the open routine, the file type (console, printer, disk file, etc.) must be determined in order to enable writing or reading at a later time. The file type must be referenced using the file number returned by the open routine each time reading or writing is to be performed.

- The second parameter mode specifies processing to be performed when the file is opened. The meanings of each of the bits of this parameter are as follows.

![mode diagram]

**Table 8.3** Explanation of Bits in Parameter "mode" of open Routine

<table>
<thead>
<tr>
<th>mode Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O_RDONLY (bit 0)</td>
<td>When this bit is 1, the file is opened in read-only mode</td>
</tr>
<tr>
<td>O_WRONLY (bit 1)</td>
<td>When this bit is 1, the file is opened in write-only mode</td>
</tr>
<tr>
<td>O_RDWR (bit 2)</td>
<td>When this bit is 1, the file is opened for both reading and writing</td>
</tr>
<tr>
<td>O_CREAT (bit 3)</td>
<td>When this bit is 1, if a file with the filename given does not exist, it is created</td>
</tr>
<tr>
<td>O_TRUNC (bit 4)</td>
<td>When this bit is 1, if a file with the filename given exists, the file contents are deleted and the file size is set to 0</td>
</tr>
<tr>
<td>O_APPEND (bit 5)</td>
<td>Sets the position within the file for the next read/write operation</td>
</tr>
<tr>
<td>When 0: Set to read/write from the beginning of file</td>
<td></td>
</tr>
<tr>
<td>When 1: Set to read/write from file end</td>
<td></td>
</tr>
</tbody>
</table>

- When there is a contradiction between the file processing specified by mode and the properties of the actual file, error processing should be performed. When the file is opened normally, the file number (a positive integer) should be returned which should be used in subsequent read, write, lseek, and close routines. The correspondence between file numbers and the actual files must be managed by low-level interface routines. If the open operation fails, -1 should be returned.

[Return value]

| Normal: | The file number for the successfully opened file |
| Error: | -1 |

[Parameters]

| name | Name of the file |
| mode | Specifies the type of processing when the file is opened |
| flg | Specifies processing when the file is opened (always 0777) |
long close (long fileno)

[Description]
- The file number obtained using the open routine is passed as a parameter.
- The file management information area set using the open routine should be released to enable reuse. Also, when output file buffering is performed in low-level interface routines, the buffer contents should be written to the actual file.
- When the file is closed successfully, 0 is returned; if the close operation fails, -1 is returned.

[Return value]

<table>
<thead>
<tr>
<th>Normal:</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error:</td>
<td>-1</td>
</tr>
</tbody>
</table>

[Parameters]

| fileno | Number of the file to be closed |
long read (long fileno, unsigned char *buf, long count)

[Description]
- Data is read from the file specified by the first parameter (fileno) to the area in memory specified by the second parameter (buf). The number of bytes of data to be read is specified by the third parameter (count).
- When the end of the file is reached, only a number of bytes fewer than or equal to count bytes can be read.
- The position for file reading/writing advances by the number of bytes read.
- When reading is performed successfully, the actual number of bytes read is returned; if the read operation fails, -1 is returned.

[Return value]
- Normal: Actual number of bytes read
- Error: -1

[Parameters]
- fileno: Number of the file to be read
- buf: Memory area to store read data
- count: Number of bytes to read
long write (long fileno, const unsigned char *buf, long count)

[Description]
- Writes data to the file indicated by the first parameter (fileno) from the memory area indicated by the second parameter (buf). The number of bytes to be written is indicated by the third parameter (count).
- If the device (disk, etc.) of the file to be written is full, only a number of bytes fewer than or equal to count bytes can be written. It is recommended that, if the number of bytes actually written is zero a certain number of times in succession, the disk should be judged to be full and an error (-1) should be returned.
- The position for file reading/writing advances by the number of bytes written. If writing is successful, the actual number of bytes written should be returned; if the write operation fails, -1 should be returned.

[Return value]
Normal: Actual number of bytes written
Error: -1

[Parameters]
fileno Number of the file to which data is to be written
buf Memory area containing data for writing
count Number of bytes to write
long lseek (long fileno, long offset, long base)

[Description]
- Sets the position within the file, in byte units, for reading from and writing to the file.
- The position within a new file should be calculated and set using the following methods, depending on the third parameter (base).
  (1) When base is 0: Set the position at offset bytes from the file beginning
  (2) When base is 1: Set the position at the current position plus offset bytes
  (3) When base is 2: Set the position at the file size plus offset bytes
- When the file is a console, printer, or other interactive device, when the new offset is negative, or when in cases (1) and (2) the file size is exceeded, an error occurs.
- When the file position is set correctly, the new position for reading/writing should be returned as an offset from the file beginning; when the operation is not successful, -1 should be returned.

[Return value]
Normal: The new position for file reading/writing, as an offset in bytes from the file beginning
Error: -1

[Parameters]
fileno File number
offset Position for reading/writing, as an offset (in bytes)
base Starting-point of the offset
char *sbrk (size_t size)

[Description]
- The size of the memory area to be allocated is passed as a parameter.
- When calling the sbrk routine several times, memory areas should be allocated in succession starting from lower addresses. If the memory area for allocation is insufficient, an error should occur. When allocation is successful, the address of the beginning of the allocated memory area should be returned; if unsuccessful, "(char *) -1" should be returned.
- If you wish to use the standard library function malloc, calloc, or realloc, or the C++ function new, allocate at least 16 bytes of memory.

[Return value]
Normal: Start address of allocated memory
Error: (char *) -1

[Parameters]
size Size of data to be allocated
long *errno_addr (void)

[Description]
- Returns the address of the error number of the current task.
- This routine is necessary when using a standard library, which was created by the standard library generator with the reent option specified.

[Return value]
Address of the error number of the current task
long wait_sem (long semnum)

[Description]
- Defines the semaphore specified by semnum.
- When the semaphore has been defined normally, 1 must be returned. Otherwise, 0 must be returned.
- This routine is necessary when using a standard library, which was created by the standard library generator with the reent option specified.

[Return value]
Normal: 1
Error: 0

[Parameters]
semnum Semaphore ID
long signal_sem (long semnum)

[Description]
- Releases the semaphore specified by semnum.
- When the semaphore has been released normally, 1 must be returned. Otherwise, 0 must be returned.
- This routine is necessary when using a standard library, which was created by the standard library generator with the reent option specified.

[Return value]
- Normal: 1
- Error: 0

[Parameters]
- semnum
  Semaphore ID
(3) Example of Coding Low-Level Interface Routines

#include <string.h>

/* File Numbers */
#define STDIN  0 /* Standard Input (Console) */
#define STDOUT 1 /* Standard Output (Console) */
#define STDERR 2 /* Standard Error Output (Console) */

#define FLMIN 0 /* Minimum value of the File Number */
#define FLMAX 3 /* Maximum value of the Number of Files */

/* File Flags */
#define O_RDONLY 0x0001 /* Read Only */
#define O_WRONLY 0x0002 /* Write Only */
#define O_RDWR 0x0004 /* Read and Write */

/* Special Character Codes */
#define CR 0x0d /* Carriage Return */
#define LF 0x0a /* Line Feed */

/* Heap Size of the sbrk */
#define HEAPSIZE 1024

extern void charput(char); /* Inputs a Byte */
extern char charget(void); /* Outputs a Byte */

union HEAP_TYPE{
    long dummy; /* (Dummy: for 4-bytes alignment) */
    char heap[HEAPSIZE]; /* Heap Area of the sbrk */
};

static union HEAP_TYPE heap_area;

static char *brk=(char*)&heap_area; /* Latest Address of sbrk Assigned */
long open(const char *name, /* File Name */
long mode, /* File Open Mode */
long flg) /* Open Flag (Not Used) */
{
/* Checks mode of the file, and Returns file number */

if (strcmp(name,"stdin")==0) { /* Standard Input File */
  if ((mode&O_RDONLY)==0) {
    return (-1);
  }
  flmod[STDIN]=mode;
  return (STDIN);
}

else if (strcmp(name,"stdout")==0) { /* Standard Output File */
  if ((mode&O_WRONLY)==0) {
    return (-1);
  }
  flmod[STDOUT]=mode;
  return (STDOUT);
}

else if (strcmp(name,"stderr")==0) { /* Standard Error Output File */
  if ((mode&O_WRONLY)==0) {
    return (-1);
  }
  flmod[STDERR]=mode;
  return (STDERR);
}

else {
  return (-1); /* Error */
}

}/******************************************************************************/
/*                             close --- Close A File                             */
/*                           Return Value: 0    (Success)                      */
/*                                        -1    (Fail)                        */
/******************************************************************************/
long close(long fileno) /* File Number */
{
  if (fileno<FLMIN || FLMAX<fileno) { /* Checks the File Number */
    return -1;
  }
  flmod[fileno]=0; /* Resets the File Mode */
  return 0;
}
```c
 /******************************************************************************/
/*                             read --- Input Data                            */
/*                    Return Value: Bytes Number of Read  (Success)           */
/*                                  -1                    (Fail)              */
/******************************************************************************/
long read(long fileno,                      /* File Number */
          unsigned char *buf,                /* Write Buffer Address */
          long  count)                       /* Bytes Number of Read */
{
    unsigned long i;
    /* Checks mode of the file, and Sets the Write Buffer each bytes */
    if (flmod[fileno]&O_RDONLY || flmod[fileno]&O_RDWR) {
        for (i=0; i<count; i++) {
            *buf=charget();
            if (*buf=='') {                 /* Replaces CR into LF */
                *buf='\n';
            }
            buf++;
        }
        return count;
    } else {
        return -1;
    }
}
/******************************************************************************/
/*                            write --- Output Data                           */
/*                    Return Value: Bytes Number of Write (Success)           */
/*                                  -1                    (Fail)              */
/******************************************************************************/
long write(long fileno,                     /* File Number */
           const unsigned char *buf,        /* Read Buffer Address */
           long count)                       /* Bytes Number of Write */
{
    unsigned long i;
    unsigned char c;
    /* Checks mode of the file, and Output from the Write Buffer each bytes */
    if (flmod[fileno]&O_WRONLY || flmod[fileno]&O_RDWR) {
        for (i=0; i<count; i++) {
            c=*buf++;
            charput(c);
        }
        return count;
    } else {
        return -1;
    }
}
long lseek(long fileno, /* File Number */
           long offset, /* Position of Reading and Writing */
           long  base) /* Start of Offset */
{
    return -1;
}

char *sbrk(size_t size) /* Allcation Memory Size */
{
    char *p;

    /* Checks Free Area */
    if (brk+size>heap_area.heap+HEAPSIZE) {
        return (char *)-1;
    }

    p=brk; /* Allocate an Area */
    brk+=size; /* Updates the Latest Address */
    return p;
}
RX Family Simulator/Debugger Interface Routine
- Inputs and outputs one character -

.GLBI_charput
.GLBI_charget

SIM_IO .EQU 0h

;-------------------------------
;_charput:
;-------------------------------
_charput:
  MOV.L  #IO_BUF,R2
  MOV.B  R1,[R2]
  MOV.L  #1220000h,R1
  MOV.L  #PARM,R3
  MOV.L  R2,[R3]
  MOV.L  R3,R2
  MOV.L  #SIM_IO,R3
  JSR    R3
  RTS

;-------------------------------
;_charget:
;-------------------------------
_charget:
  MOV.L  #1210000h,R1
  MOV.L  #IO_BUF,R2
  MOV.L  #PARM,R3
  MOV.L  R2,[R3]
  MOV.L  R3,R2
  MOV.L  #SIM_IO,R3
  JSR    R3
  MOV.L  #IO_BUF,R2
  MOVU.B [R2],R1
  RTS

;-------------------------------
; I/O Buffer
;-------------------------------
.PARM: .BLKL 1

.IO_BUF: .BLKB 1

.END
(4) Example of Low-Level Interface Routine for Reentrant Library

The following shows an example of low-level interface routines for a reentrant library. These routines are necessary when using a library, which was created by the library generator with the `reent` option specified. When failing to allocate semaphores with the `wait_sem` function or `signal_sem` function, set `errno` as follows to return from the library function.

Table 8.4 Error number list of the reentrant library sets to `errno` variable

<table>
<thead>
<tr>
<th>Function Name</th>
<th><code>errno</code></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>wait_sem</code></td>
<td>EMALRESM</td>
<td>Failed to allocate semaphore resources for malloc.</td>
</tr>
<tr>
<td></td>
<td>ETOKRESM</td>
<td>Failed to allocate semaphore resources for strtok.</td>
</tr>
<tr>
<td></td>
<td>EFLSRESM</td>
<td>Failed to allocate semaphore resources for <code>_Files</code>.</td>
</tr>
<tr>
<td></td>
<td>EMBLNRESM</td>
<td>Failed to allocate semaphore resources for <code>mbrlen</code>.</td>
</tr>
<tr>
<td><code>signal_sem</code></td>
<td>EMALFRSM</td>
<td>Failed to release semaphore resources for malloc.</td>
</tr>
<tr>
<td></td>
<td>ETOKFRSM</td>
<td>Failed to release semaphore resources for strtok.</td>
</tr>
<tr>
<td></td>
<td>EFLSFRSM</td>
<td>Failed to release semaphore resources for <code>_Files</code>.</td>
</tr>
<tr>
<td></td>
<td>EMBLNFRSM</td>
<td>Failed to release semaphore resources for <code>mbrlen</code>.</td>
</tr>
</tbody>
</table>

When an interrupt with a priority level higher than the current level is generated after semaphores have been defined, deadlocks will occur if semaphores are defined again. Therefore, be careful for processes that share resources because they might be nested by interrupts.
#define MALLOC_SEM 1 /* Semaphore No. for malloc */
#define STRTOK_SEM 2 /* Semaphore No. for strtok */
#define FILE_TBL_SEM 3 /* Semaphore No. for fopen */
#define MBRLEN_SEM 4 /* Semaphore No. for mbrlen */
#define FPSWREG_SEM 5 /* Semaphore No. for FPSW register */
#define FILES_SEM 6 /* Semaphore No. for _Files */
#define SEMSIZE 26 /* FILES_SEM + _nfiles (assumed _nfiles=20) */

#define TRUE 1
#define FALSE 0
#define OK 1
#define NG 0
extern long *errno_addr(void);
extern long wait_sem(long);
extern long signal_sem(long);
static long sem_errno;
static int force_fail_signal_sem = FALSE;
static int semaphore[SEMSIZE];

/******************************************************************************/
/*                  errno_addr: Acquisition of errno address                  */
/*                        Return value: errno address                         */
/******************************************************************************/
long *errno_addr(void)
{
    /* Return the errno address of the current task */
    return (&sem_errno);
}

/******************************************************************************/
/*           wait_sem: Defines the specified numbers of semaphores            */
/*                       Return value: OK(=1) (Normal)                        */
/*                                     NG(=0) (Error)                         */
/******************************************************************************/
long wait_sem(long semnum) /* Semaphore ID */
{
    if((0 < semnum) && (semnum < SEMSIZE)) {
        if(semaphore[semnum] == FALSE) {
            semaphore[semnum] = TRUE;
            return(OK);
        }
    }
    return(NG);
}

/******************************************************************************/
/*          signal_sem: Releases the specified numbers of semaphores          */
/*                       Return value: OK(=1) (Normal)                        */
/*                                     NG(=0) (Error)                         */
/******************************************************************************/
long signal_sem(long semnum) /* Semaphore ID */
{
    if(!force_fail_signal_sem) {
        if((0 <= semnum) && (semnum < SEMSIZE)) {
            if( semaphore[semnum] == TRUE ) {
                semaphore[semnum] = FALSE;
                return(OK);
            }
        }
    }
    return(NG);
}
### 8.3.5 Termination Processing Routine

1. **Example of Preparation of a Routine for Termination Processing Registration and Execution (atexit)**

The method for preparation of the library function *atexit* to register termination processing is described. The *atexit* function registers, in a table for termination processing, a function address passed as a parameter. If the number of functions registered exceeds the limit (in this case, the number that can be registered is assumed to be 32), or if an attempt is made to register the same function twice, **NULL** is returned. Otherwise, a value other than **NULL** (in this case, the address of the registered function) is returned.

A program example is shown below.

**Example:**

```c
#include <stdlib.h>

long _atexit_count=0;

void (*_atexit_buf[32])(void);

#ifdef __cplusplus
extern "C"
#endif

long atexit(void (*f)(void))
{
    int i;
    for(i=0; i<_atexit_count; i++)  // Check whether it is already registered
        if(_atexit_buf[i]==f)
            return 1;
    if(_atexit_count==32)  // Check the limit value of number of registration
        return 1;
    else {
        _atexit_count++;
        _atexit_buf[_atexit_count]=f;  // Register the function address
        return 0;
    }
}
```

2. **Example of Preparation of a Routine for Program Termination (exit)**

The method for preparation of an *exit* library function for program termination is described. Program termination processing will differ among user systems; refer to the program example below when preparing a termination procedure according to the specifications of the user system.

The *exit* function performs termination processing for a program according to the termination code for the program passed as a parameter, and returns to the environment in which the program was started. Here, the termination code is set to an external variable, and execution returned to the environment saved by the *setjmp* function immediately before the *main* function was called. In order to return to the environment prior to program execution, the following *callmain* function should be created, and instead of calling the function *main* from the *PowerOn_Reset_PC* initial setting function, the *callmain* function should be called.

A program example is shown below.
Example of Creation of an Abnormal Termination (abort) Routine

On abnormal termination, processing for abnormal termination must be executed in accordance with the specifications of the user system.

In a C++ program, the `abort` function will also be called in the following cases:

- When exception processing was unable to operate correctly.
- When a pure virtual function is called.
- When `dynamic_cast` has failed.
- When `typeid` has failed.
- When information could not be acquired when a class array was deleted.
- When the definition of the destructor call for objects of a given class causes a contradiction.

Below is shown an example of a program which outputs a message to the standard output device, then closes all files and begins an infinite loop to wait for reset.

```c
#include <setjmp.h>
#include <stddef.h>

extern long _atexit_count;
extern void_t (*_atexit_buf[32])(void);
#ifdef __cplusplus
extern "C"
#endif
void _CLOSEALL(void);
int main(void);
extern jmp_buf _init_env;
int _exit_code;

#ifdef __cplusplus
extern "C"
#endif
void exit(int code)
{
    _exit_code=code; // Set the return code in _exit_code
    for(i=_atexit_count-1; i>=0; i--)/
    (*_atexit_buf[i])(); // Execute in sequence the functions
    _CLOSEALL(); // Close all open functions
    longjmp(_init_env, 1); // Return to the environment saved by
                           // setjmp
}

#ifdef __cplusplus
extern "C"
#endif
void callmain(void)
{
    // Save the current environment using setjmp and call the main function
    if(!setjmp(_init_env))
    {
        _exit_code=main(); // On returning from the exit function,
                          // terminate processing
    }
}
8.4 Coding Example

This section shows an example of an actual startup program created for the simulator in the integrated development environment when the RX610 is selected as the CPU type.

(1) Source Files

The startup program consists of the files shown in table 7.4.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) resetprg.c</td>
<td>Initial setting routine (reset vector function)</td>
</tr>
<tr>
<td>(b) intprg.c</td>
<td>Vector function definitions</td>
</tr>
<tr>
<td>(c) vecttbl.c</td>
<td>Fixed vector table '1'</td>
</tr>
<tr>
<td>(d) dbsct.c</td>
<td>Section initialization processing (table)</td>
</tr>
<tr>
<td>(e) lowsrc.c</td>
<td>Low-level interface routine (C language part)</td>
</tr>
<tr>
<td>(f) lowlvl.src</td>
<td>Low-level interface routine (assembly language part)</td>
</tr>
<tr>
<td>(g) sbrk.c</td>
<td>Low-level interface routine (sbrk function)</td>
</tr>
<tr>
<td>(h) typedefine.h</td>
<td>Type definition header</td>
</tr>
<tr>
<td>(i) vect.h</td>
<td>Vector function header</td>
</tr>
<tr>
<td>(j) stacksct.h</td>
<td>Stack size settings</td>
</tr>
<tr>
<td>(k) lowsrc.h</td>
<td>Low-level interface routine (C language header)</td>
</tr>
<tr>
<td>(l) sbrk.h</td>
<td>Low-level interface routine (sbrk function header)</td>
</tr>
</tbody>
</table>

Notes 1. This is for the RXv1 instruction-set architecture.
For an RX instruction-set architecture other than the RXv1 instruction-set architecture, this becomes the "exception vector table".

The following shows the contents of files (a) to (l).
(a) resetprg.c: Initial Setting Routine (Reset Vector Function)

```c
#include <machine.h>
#include <h_c_lib.h>
#include <stdio.h>     // Remove the comment when you use errno
#include <stdlib.h>     // Remove the comment when you use rand()
#include "typedefine.h"   // Define Types
#include "stacksct.h"     // Stack Sizes (Interrupt and User)

#ifdef __cplusplus
extern "C" {
#endif

void PowerOn_Reset_PC(void);
void main(void);
#ifdef __cplusplus
}
#endif

#ifdef __cplusplus        // For Use SIM I/O
extern "C" {
#endif
extern void _INIT_IOLIB(void);
extern void _CLOSEALL(void);
#ifdef __cplusplus
}
#endif

#define PSW_init       0x00010000  // PSW bit pattern
#define FPSW_DPSW_init  0x00000000  // FPSW/DPSW bit base pattern

//extern void srand(_UINT);   // Remove the comment when you use rand()
//extern _SBYTE *_s1ptr;      // Remove the comment when you use strtok()

#ifdef __cplusplus          // Use Hardware Setup
//extern "C" {               // Sections C$INIT and C$END will be generated
#endif
extern void HardwareSetup(void);
#ifdef __cplusplus
}
#endif

#ifdef __cplusplus         // Remove the comment when you use global class
object
//extern "C" {               // Sections C$INIT and C$END will be generated
#endif
extern void _CALL_INIT(void);
extern void _CALL_END(void);
#ifdef __cplusplus
}
#endif

#pragma section ResetPRG     // output PowerOn_Reset_PC to PResetPRG section

#pragma entry PowerOn_Reset_PC

void PowerOn_Reset_PC(void)
{
    #if (__RX_ISA_VERSION__ >= 2) || defined(__RXV2)
        set_extb(__sectop("EXCEPTVECT")); // Remove the comment when you want to set
                                            // an address
        // into the Exception Vector Table Register
    #endif
    // of RXv2 or later
```
```c
#define __sectop("C$VECT")

#if defined __FPU
#ifdef __ROZ                // Initialize FPSW/DPSW
#define _ROUND 0x00000001   // Let FPSW/DPSW RM/DRM bits=01 (round to zero)
#else
#define _ROUND 0x00000000   // Let FPSW/DPSW RM/DRM bits=00 (round to nearest)
#endif
#endif
#ifdef __DOFF
#define _DENOM 0x00000100   // Let FPSW/DPSW DN/DDN bit=1 (denormal as zero)
#else
#define _DENOM 0x00000000   // Let FPSW/DPSW DN/DDN bit=0 (denormal as is)
#endif

set_fpsw(FPSW_DPSW_init | _ROUND | _DENOM);
#if defined __DPFPU
__set_dpsw(FPSW_DPSW_init | _ROUND | _DENOM);
#endif
#endif

_INITSCT();                    // Initialize Sections
_INIT_IOLIB();                 // Use SIM I/O

//errno=0; // Remove the comment when you use errno
//srand((_UINT)1); // Remove the comment when you use rand()
//_s1ptr=NULL; // Remove the comment when you use strtok()

//HardwareSetup(); // Use Hardware Setup

//_CALL_INIT(); // Remove the comment when you use global class object

set_psw(PSW_init); // Set Ubit & Ibit for PSW
//chg_pmusr(); // Remove the comment when you need to change PSW
// PMbit (SuperVisor->User)

main();

_CLOSEALL();                  // Use SIM I/O

//_CALL_END(); // Remove the comment when you use global class
// object

brk();
```

(b) intprg.c: Vector Function Definitions

```c
#include <machine.h>
#include "vect.h"
#pragma section IntPRG

// Exception (Supervisor Instruction)
void Excep_SuperVisorInst(void){/* brk(); */}

// Exception (Undefined Instruction)
void Excep_UndefinedInst(void){/* brk(); */}

// Exception (Floating Point)
void Excep_FloatingPoint(void){/* brk(); */}

// NMI
void NonMaskableInterrupt(void){/* brk(); */}

// Dummy
void Dummy(void){/* brk(); */}

// BRK
void Excep_BRK(void){ wait(); }
```

(c) vecttbl.c: Fixed Vector Table

```c
#include "vect.h"
#pragma section C FIXEDVECT

void (*const Fixed_Vectors[])(void) = {
    // Exception (Supervisor Instruction)
    Excep_SuperVisorInst,
    // Reserved Dummy,
    // Reserved Dummy,
    // Exception (Undefined Instruction)
    Excep_UndefinedInst,
    // Reserved Dummy,
    // Exception (Floating Point)
    Excep_FloatingPoint,
    // Reserved Dummy,
    // Reserved Dummy,
    // Reserved Dummy,
    // Reserved Dummy,
    // NMI
    NonMaskableInterrupt,
    // RESET
    // <<VECTOR DATA START (POWER ON RESET)>>
    // Power On Reset PC
    PowerOn_Reset_PC
    // <<VECTOR DATA END (POWER ON RESET)>>
};
```

[Reference]
Case when an RX instruction-set architecture other than the RXv1 instruction-set architecture is selected (exception vector table)
#include "vect.h"

#pragma section C EXCEPTVECT

void (*const Excep_Vectors[])(void) = {
    //;0xffffff80  Reserved
    Dummy,
    //;0xffffff84  Reserved
    Dummy,
    //;0xffffff88  Reserved
    Dummy,
    //;0xffffff8c  Reserved
    Dummy,
    //;0xffffff90  Reserved
    Dummy,
    //;0xffffff94  Reserved
    Dummy,
    //;0xffffff98  Reserved
    Dummy,
    //;0xffffff9c  Reserved
    Dummy,
    //;0xffffffa0  Reserved
    Dummy,
    //;0xffffffa4  Reserved
    Dummy,
    //;0xffffffa8  Reserved
    Dummy,
    //;0xffffffac  Reserved
    Dummy,
    //;0xffffffb0  Reserved
    Dummy,
    //;0xffffffb4  Reserved
    Dummy,
    //;0xffffffb8  Reserved
    Dummy,
    //;0xffffffbc  Reserved
    Dummy,
    //;0xffffffc0  Reserved
    Dummy,
    //;0xffffffc4  Reserved
    Dummy,
    //;0xffffffc8  Reserved
    Dummy,
    //;0xffffffcc  Reserved
    Dummy,
    //;0xffffffd0  Exception(Supervisor Instruction)
    Excep_SuperVisorInst,
    //;0xffffffd4  Exception(Access Instruction)
    Excep_AccessInst,
    //;0xffffffd8  Reserved
    Dummy,
    //;0xffffffdc  Exception(Undefined Instruction)
    Excep_UndefInst,
    //;0xffffffee0  Reserved
    Dummy,
    //;0xfffffffe4  Exception(Floating Point)
    Excep_FloatingPoint,
(d)  dbsct.c: Section Initialization Processing (table)

```c
#include "typedefine.h"

#pragma unpack

#pragma section C C$DSEC
extern const struct {
    _UBYTE *rom_s;    /* Start address of the initialized data section in ROM */
    _UBYTE *rom_e;    /* End address of the initialized data section in ROM */
    _UBYTE *ram_s;    /* Start address of the initialized data section in RAM */
}   _DTBL[] = {
    { __sectop("D"), __secend("D"), __sectop("R") },
    { __sectop("D_2"), __secend("D_2"), __sectop("R_2") },
    { __sectop("D_1"), __secend("D_1"), __sectop("R_1") }
};

#pragma section C C$BSEC
extern const struct {
    _UBYTE *b_s;         /* Start address of non-initialized data section */
    _UBYTE *b_e;         /* End address of non-initialized data section */
}   _BTBL[] = {
    { __sectop("B"), __secend("B") },
    { __sectop("B_2"), __secend("B_2") },
    { __sectop("B_1"), __secend("B_1") }
};

#pragma section

/*
** CTBL prevents excessive output of W0561100 messages when linking.
** Even if CTBL is deleted, the operation of the program does not change.
*/
_UBYTE * const _CTBL[] = {
    __sectop("C_1"), __sectop("C_2"), __sectop("C"),
    __sectop("W_1"), __sectop("W_2"), __sectop("W")
};

#pragma packoption
```
(e) ** lowscc.c : Low-Level Interface Routine (C Language Part)**

```c
#include <string.h>
#include <stdio.h>
#include <stddef.h>
#include "lowsrc.h"

#define STDIN  0
#define STDOUT 1
#define STDERR 2
#define FLMIN  0
#define _MOPENR0x1
#define _MOPENW0x2
#define _MOPENA0x4
#define _MTRUNC0x8
#define _MCREAT0x10
#define _MBINOx20
#define _MEXCL0x40
#define _MALBUF0x80
#define _MACEROx100
#define _MERROx200
#define _MLBF0x400
#define _MNBF0x800
#define _MREAD0x1000
#define _MWRITE0x2000
#define _MBYTE0x4000
#define _MWIDE0x8000
#define O_RDONLY0x0001
#define O_WRONLY0x0002
#define O_RDWR0x0004
#define O_CREAT0x0008
#define O_TRUNC0x0010
#define O_APPEND0x0020
#define CR 0x0d
#define LF 0x0a

extern const long _nfiles;
char flmod[IOSTREAM];

unsigned char sml_buf[IOSTREAM];

#define FPATH_STDIN     "C:\stdin"
#define FPATH_STDOUT    "C:\stdout"
#define FPATH_STDERR    "C:\stderr"
extern void charput(unsigned char);
extern unsigned char charget( void);

#include <stdio.h>
FILE *Files[IOSTREAM];
char *env_list[] = {
    "ENV1=temp01",
    "ENV2=temp02",
    "ENV9=end",
    "\0"
};
```
char **environ = env_list;

void _INIT_IOLIB( void )
{
    _Files[0] = stdin;
    _Files[1] = stdout;
    _Files[2] = stderr;

    if( freopen( FPATH_STDIN, "r", stdin ) == NULL )
        stdin->_Mode = 0xffff;
    stdin->_Mode |= _MOPENR;
    stdin->_Bend = stdin->_Buf + 1;

    if( freopen( FPATH_STDOUT, "w", stdout ) == NULL )
        stdout->_Mode = 0xffff;
    stdout->_Mode |= _MNBF;
    stdout->_Bend = stdout->_Buf + 1;

    if( freopen( FPATH_STDERR, "w", stderr ) == NULL )
        stderr->_Mode = 0xffff;
    stderr->_Mode |= _MNBF;
    stderr->_Bend = stderr->_Buf + 1;
}

void _CLOSEALL( void )
{
    long i;
    for( i=0; i < _nfiles; i++ )
    {
        if( _Files[i]->_Mode & (_MOPENR | _MOPENW | _MOPENA ) )
            fclose( _Files[i] );
    }
}

long open(const char *name,
          long  mode,
          long flg)
{
    if( strcmp( name, FPATH_STDIN ) == 0 )
    {
        if( ( mode & O_RDONLY ) == 0 ) return -1;
        flmod[STDIN] = mode;
        return STDIN;
    }
    else if( strcmp( name, FPATH_STDOUT ) == 0 )
    {
        if( ( mode & O_WRONLY ) == 0 ) return -1;
        flmod[STDOUT] = mode;
        return STDOUT;
    }
    else if(strcmp(name, FPATH_STDERR ) == 0 )
    {
        if( ( mode & O_WRONLY ) == 0 ) return -1;
        flmod[STDERR] = mode;
        return STDERR;
    }
    else return -1;
}
long close( long fileno )
{
    return 1;
}

long write(long  fileno,
    const unsigned char *buf,
    long  count)
{
    long  i;
    unsigned char  c;

    if((fileno & O_WRONLY || flmod[fileno] & O_RDWR)
    {
        if( fileno == STDIN ) return -1;
        else if( (fileno == STDOUT) || (fileno == STDERR) )
        {
            for( i = count; i > 0; --i )
            {
                c = *buf++;
                charput(c);
            }
            return count;
        }
        else return -1;
    }
    else return -1;
}

long read( long fileno, unsigned char *buf, long count )
{
    long i;
    if((fileno & _MOPENR) || (flmod[fileno] & O_RDWR)){
        for(i = count; i > 0; i--){
            *buf = charget();
            if(*buf==CR){
                *buf = LF;
            }
            buf++;
        }
        return count;
    } else {
        return -1;
    }
}

long lseek( long fileno, long offset, long base )
{
    return -1L;
}
(f)  lowlv.src: Low-Level Interface Routine (Assembly Language Part)

    .GLB  _charput
    .GLB  _charget

    SIM_IO  .EQU 0h

    .SECTION  P,CODE
    ;-----------------------------------------------------------------------
    ;  _charput:
    ;-----------------------------------------------------------------------
    _charput:
    MOV.L  #IO_BUF,R2
    MOV.B  R1,[R2]
    MOV.L  #1220000h,R1
    MOV.L  #PARM,R3
    MOV.L  R2,[R3]
    MOV.L  R3,R2
    MOV.L  #SIM_IO,R3
    JSR    R3
    RTS

    ;-----------------------------------------------------------------------
    ;  _charget:
    ;-----------------------------------------------------------------------
    _charget:
    MOV.L  #1210000h,R1
    MOV.L  #IO_BUF,R2
    MOV.L  #PARM,R3
    MOV.L  R2,[R3]
    MOV.L  R3,R2
    MOV.L  #SIM_IO,R3
    JSR    R3
    MOV.L  #IO_BUF,R2
    MOVU.B  [R2],R1
    RTS

    ;-----------------------------------------------------------------------
    ;  I/O Buffer
    ;-----------------------------------------------------------------------
    .SECTION  B,DATA,ALIGN=4
    PARM:  .BLKL  1
    .SECTION  B_1,DATA
    IO_BUF:  .BLKB  1
    .END
(g) sbrk.c: Low-Level Interface Routine (sbrk Function)

```c
#include <stddef.h>
#include <stdio.h>
#include "typedefine.h"
#include "sbrk.h"

_SBYTE *sbrk(size_t size);

//const size_t _sbrk_size=    /* Specifies the minimum unit of */
                         /* the defined heap area*/
extern _SBYTE *_s1ptr;

union HEAP_TYPE {
    _SDWORD dummy;     /* Dummy for 4-byte boundary */
    _SBYTE heap[HEAPSIZE]; /* Declaration of the area managed by sbrk */
};

static union HEAP_TYPE heap_area;

/* End address allocated by sbrk */
static _SBYTE *brk=(_SBYTE *)&heap_area;

/**************************************************************************/
/*     sbrk:Memory area allocation                                       */
/*          Return value:Start address of allocated area (Pass)           */
/*                       -1                              (Failure)        */
/**************************************************************************/
_SBYTE  *sbrk(size_t size)                      /* Assigned area size   */
{
    _SBYTE  *p;
    if(brk+size > heap_area.heap+HEAPSIZE){     /* Empty area size      */
        p = (_SBYTE *)-1;
    }
    else {
        p = brk;
        brk += size;                            /* Area assignment      */
        return p;                             /* End address update   */
    }
}
```

(h) typedefine.h: Type Definition Header

```c
typedef signed char _SBYTE;
typedef unsigned char _UBYTE;
typedef signed short _SWORD;
typedef unsigned short _UWORD;
typedef signed int _SINT;
typedef unsigned int _UINT;
typedef signed long _SDWORD;
typedef unsigned long _UDWORD;
typedef signed long long _SQWORD;
typedef unsigned long long _UQWORD;
```
(i) **vect.h: Vector Function Header**

```c
// Exception (Supervisor Instruction)
#pragma interrupt (Excep_SupervisorInst)
void Excep_SupervisorInst(void);

// Exception (Undefined Instruction)
#pragma interrupt (Excep_UndefinedInst)
void Excep_UndefinedInst(void);

// Exception (Floating Point)
#pragma interrupt (Excep_FloatingPoint)
void Excep_FloatingPoint(void);

// NMI
#pragma interrupt (NonMaskableInterrupt)
void NonMaskableInterrupt(void);

// Dummy
#pragma interrupt (Dummy)
void Dummy(void);

// BRK
#pragma interrupt (Excep_BRK(vect=0))
void Excep_BRK(void);

//;<<VECTOR DATA START (POWER ON RESET)>>
//;Power On Reset PC
extern void PowerOn_Reset_PC(void);
//;<<VECTOR DATA END (POWER ON RESET)>>
```

(j) **stacksct.h: Stack Size Settings**

```c
// #pragma stacksize su=0x100 // Remove the comment when you use user stack
#pragma stacksize si=0x300
```

(k) **lowsrc.h: Low-Level Interface Routine (C Language Header)**

```c
/* Number of I/O Streams*/
#define IOSTREAM 20
```

(l) **sbrk.h: Low-Level Interface Routine (sbrk Function Header)**

```c
/* Size of area managed by sbrk */
#define HEAPSIZE 0x400
```

(2) **Execution Commands**

The following shows an example of commands for building these files.

In this example, the name of the user program file (containing the `main` function) is `UserProgram.c`, and the body of the file names (names excluding extensions) for the load module or library to be created is `LoadModule`.
8.5 Usage of PIC/PID Function

This section gives an overview of the PIC/PID function and describes how to create startup programs when using the PIC/PID function.

The PIC/PID function enables the code and data in the ROM to be reallocated to desired addresses without re-linkage even when the allocation addresses have been determined through previously completed linkage.

PIC stands for position independent code, and PID stands for position independent data. The PIC function generates PIC and the PID function generates PID; here, these functions are collectively called the PIC/PID function.

8.5.1 Terms Used in this Section

(1) Master and Application
In the PIC/PID function, a program whose code or data in the ROM has been converted into PIC or PID is called an application, and the program necessary to execute an application is called the master.

The master executes the application initiation processing, and also provides the shared libraries called from applications and RAM areas for applications. PIC and PID are included only in applications; the master does not have them.

(2) Shared Library
A group of functions in the master, which can be called from multiple applications.

(3) Jump Table
A program through which applications can call shared libraries.
8.5.2 Function of Each Option

The following describes the options related to the PIC/PID function.
For details of each option function, refer to the respective option description of the COMMAND REFERENCE chapter.

(1) Application Code Generation (pic and pid Options)
When the **pic** option is specified for compilation, the PIC function is enabled and the code in the code area (**P** section) becomes PIC. The PIC always uses PC relative mode to acquire branch destination addresses or function addresses, so it can be reallocated to any desired addresses even after linkage.

When the **pid** option is specified for compilation, the PID function is enabled and the data in ROM data areas (**C_8**, **C_2**, **C_1**, **W**, **W_2**, **W_1**, and **L** sections) becomes PID. A program executes relative access to the PID by using the register (PID register) that indicates the start address of the PID. The user can move the PID to any desired addresses by modifying the PID register value even after linkage.

Note that the PIC function (**pic** option) and PID function (**pid** option) are designed to operate independently. However, it is recommended to enable both functions and allocate the PIC and PID to adjacent areas. Support for independently using either the PIC or PID function and for debugging of applications where the distance between the PIC and PID is variable may or may not be available, depending on the version of the debugger. The examples described later assume that both PIC and PID functions are enabled together.

(2) Shared Library Support (jump_entries_for_pic and nouse_pid_register Options)
These options provide a function for calling the libraries of the master from an application.

The **nouse_pid_register** option should be used for master compilation to generate a code that does not use the PID register.

When the **jump_entries_for_pic** option is specified in the optimizing linkage editor at master linkage, a jump table is created to be used to call library functions at fixed addresses from an application.

(3) Sharing of RAM Area (Fsymbol Option)
This option enables variables in the master to be read or written from an application whose linkage unit differs from that of the master.

When the **Fsymbol** option is specified in the optimizing linkage editor at master linkage, a symbol table is created to be used to refer to variables at fixed addresses from an application.

8.5.3 Restrictions on Applications

(1) RAM Areas
The PID function cannot be applied to the RAM area.

(2) Simultaneous Execution of Applications
When the PIC/PID function is used, multiple copies of a single application can be stored in the ROM and each copy can be executed. However, copies of a single application cannot be executed at the same time because the RAM areas for them overlap each other.

(3) Startup
The standard startup program (created by the integrated development environment as described in section 8.3 Startup Program Creation) cannot be used to start up an application without change. Create a startup program as described in 8.5.7 Application Startup.

8.5.4 System Dependent Processing Necessary for PIC/PID Function

The following processing should be prepared by the user depending on the system specifications.

(1) Initialization of Master
Execute the same processing as that for a usual program which does not use the PIC/PID function.

(2) Initiation of Application from the Master
Set the PID register to the start address of the application PID and branch to the PIC start address to initiate the application.

(3) Initialization of Application
Initialize the section and execute the **main** function of the application.

(4) Termination of Application
After execution of the **main** function, return execution to the master.
8.5.5 Combinations of Code Generating Options

When the master and application are built, the option settings related to the PIC/PID function should be matched between the objects that compose the master and application.

The following shows the rules for specifying options for each object compilation and the conditions of option settings in other objects that can be linked.

(1) Master
When building the master, specify the PIC/PID function options as shown in Table 8.6.

Table 8.6 Rules for Specifying PIC/PID Function Options in Master

<table>
<thead>
<tr>
<th>Option Name</th>
<th>For Compilation</th>
<th>Conditions on Setting the Option for Linkable Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>pic</td>
<td>× Not allowed</td>
<td>pic is not specified</td>
</tr>
<tr>
<td>pid</td>
<td>× Not allowed</td>
<td>pid is not specified</td>
</tr>
<tr>
<td>nousepid_register</td>
<td>O Can be specified except the standard library and setting PID register of the startup program</td>
<td>No conditions</td>
</tr>
<tr>
<td>fint_register</td>
<td>O Can be specified</td>
<td>fint_register with the same parameters must be specified</td>
</tr>
<tr>
<td>base</td>
<td>O Can be specified</td>
<td>base with the same parameters must be specified</td>
</tr>
</tbody>
</table>

(2) Application
When building an application, specify the PIC/PID function options as shown in Table 8.7.

Table 8.7 Rules for Specifying PIC/PID Function Options in Application

<table>
<thead>
<tr>
<th>Option Name</th>
<th>For Compilation</th>
<th>Conditions on Setting the Option for Linkable Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>pic</td>
<td>O Can be specified</td>
<td>pic is necessary</td>
</tr>
<tr>
<td>pid</td>
<td>O Can be specified</td>
<td>pid is necessary</td>
</tr>
<tr>
<td>nousepid_register</td>
<td>× Not allowed</td>
<td>nousepid_register is not specified</td>
</tr>
<tr>
<td>fint_register</td>
<td>O Can be specified</td>
<td>fint_register with the same parameters must be specified</td>
</tr>
<tr>
<td>base</td>
<td>O Can be specified</td>
<td>base with the same parameters must be specified</td>
</tr>
</tbody>
</table>

Note * When pid is specified, base=rom=<register> is not allowed.

(3) Between Master and Application
In the master and application, the PIC/PID function options should be specified as shown in Table 8.8.

Table 8.8 Rules for Combinations of PIC/PID Function Options between Master and Application

<table>
<thead>
<tr>
<th>Options in Application</th>
<th>Options in Master</th>
</tr>
</thead>
<tbody>
<tr>
<td>pic</td>
<td>No conditions</td>
</tr>
<tr>
<td>pid</td>
<td>nousepid_register is necessary if application calls functions of master</td>
</tr>
<tr>
<td>fint_register</td>
<td>fint_register with the same parameters is necessary</td>
</tr>
<tr>
<td>base</td>
<td>base* with the same parameters is necessary</td>
</tr>
</tbody>
</table>

Note * When pid is specified, base=rom=<register> is not allowed.
8.5.6 Master Startup

The processing necessary to start up the master is the same as that for a usual program that does not use the PIC/PID function except for the two processes described below. Add these two processes to the startup processing created according to section 7.3, Startup Program Creation.

1) Initiation of and Return from Application

Set up the PID register in the main function and branch to the PIC entry address to initiate the application. In addition, a means for returning from the application to the master should be provided.

2) Reference to Shared Library Functions to be Used

The shared libraries to be used by the application should be referred to also by the master in advance.

The following shows an example for calling a PIC/PID application from the main function. This example assumes the following conditions:

- After application execution, control can be returned to the master through the RTS instruction.
- The application does not pass a return value.
- The PID initiation address (PIC_entry) and PID start address (PID_address) for the application are known and fixed when the master is built.
- R13 is used as the PID register.
- Initialization of the section areas on the application side is not done on the master side.
- The application uses only the printf function as the shared library.

Example:

```c
#include <stdio.h>
#pragma inline_asm Launch_PICPID_Application

void Launch_PICPID_Application(void *pic_entry, void *pid_address)
{
    MOV.L R2, __PID_R13
    JSR R1
}

int main()
{
    void *PIC_entry = (void*)0x500000;  /* PIC initiation address */
    void *PID_address = (void*)0x120000;  /* PID start address */

    /* (1) Initiation of and Return from Application */
    Launch_PICPID_Application(PIC_entry, PID_address);

    return 0;
}

/* (2) Reference to Shared Library Functions to be Used */
void *__dummy_ptr = (void*)printf;  /* printf function */
```

8.5.7 Application Startup

Specify the following in the application.

The items marked with [Optional] may be unnecessary in some cases.

1) Preparation of Entry Point (PIC Initiation Address)

This is the address from which the application is initiated.

2) Initialization of Stack Pointer [Optional]

This processing is not necessary when the application shares the stack with the master.

When necessary, add appropriate settings by referring to section 7.3.2 (2).
(3) Initialization of General Registers Used as Base Registers [Optional]
This processing is not necessary when no base register is used.
When necessary, add appropriate settings by referring to section 7.3.2 (3).

(4) Initialization Processing of Sections [Optional]
This processing is not necessary when the master initializes them.
When necessary, add appropriate settings by referring to the example shown later.
Note that the processing described in section 7.3.2 (5) cannot be used without change.

(5) Initialization Processing of Libraries [Optional]
This processing is not necessary when no standard library is used.
When necessary, add appropriate settings by referring to section 7.3.2 (6).
Initialization of PSW for main Function Execution [Optional]
Specify interrupt masks or move to the user mode as necessary.
Add appropriate settings by referring to sections 7.3.2 (8) and 7.3.2 (9).

(6) User Program Execution
Execute the main function.
Specify the processing by referring to section 7.3.2 (10).

The following shows an example of application startup.
The processing is divided into three files.

- startup_picpid.c: Body of the startup processing.
- initsct_pid.src: Section initialization for PID; _INITSCT_PID.
  This is created by modifying the _INITSCT function described in section 7.3.2 (5) to support the PID function.
  "_PID_REG" in the program will be converted into PID register when the assembling.
- initiolib.c: Contains _INITLIB, which initializes the standard libraries.
  This is created by modifying the code described in section 7.3.2 (6) to be used for the application.

[startup_picpid.c]

```c
// Initialization Processing Described in Section 7.3.2(5)
#pragma section C C$DSEC //Section name is set to C$DSEC
const struct {
    void *rom_s; //Start address member of the initialized data section in ROM
    void *rom_e; //End address member of the initialized data section in ROM
    void *ram_s; //Start address member of the initialized data section in RAM
} DTBL[] = {
    __sectop("D"), __secend("D"), __sectop("R")};
#pragma section C C$BSEC //Section name is set to C$BSEC
const struct {
    void *b_s; //Start address member of the uninitialized data section
    void *b_e; //End address member of the uninitialized data section
} BTBL[] = {
    __sectop("B"), __secend("B")};

extern void main(void);
extern void _INITLIB(void); // Library initialization processing described
    //in section 7.3.2 (6)
#pragma entry application_pic_entry
void application_pic_entry(void)
{
    _INITSCT_PICPID();
    _INITLIB();
    main();
}
```
The code snippet is for initializing a PID (Proportional-Integral-Derivative) routine, specifically the Section Initialization Routine for PID Support in a microcontroller. Here's the code snippet with comments for clarity:

```assembly
/* Section Initialization Routine for PID Support */
/* ** Note ** Check the PID register. */
/* This code assumes that R13 is used as the PID register. If another */
/* register is used as the PID register, modify the description related to R13 */
/* in the following code to the register assigned as the PID register */
/* in your system. */

.glob __INITSCT_PICPID
.glob __PID_TOP
.section C$BSEC,ROMDATA,ALIGN=4
.section C$DSEC,ROMDATA,ALIGN=4
.section P,CODE

__INITSCT_PICPID:           ; function: __INITSCT
  .STACK __INITSCT_PICPID=28
  PUSHM R1-R6
  ADD ~__PID_TOP, __PID_REG, R6 ; How long distance PID moves
  ;
  ; clear BBS(B)
  ;
  ADD $TOPOF C$BSEC, R6, R4
  ADD $SIZEOF C$BSEC, R4, R5
  MOV.L #0, R2
  BRA next_loop1

loop1:
  MOV.L [R4+], R1
  MOV.L [R4+], R3
  CMP R1, R3
  BLEU next_loop1
  SUB R1, R3
  SSTR.B

next_loop1:
  CMP R4, R5
  BGTU loop1

  ;
  ; copy DATA from ROM(D) to RAM(R)
  ;
  ADD $TOPOF C$DSEC, R6, R4
  ADD $SIZEOF C$DSEC, R4, R5
  BRA next_loop3

loop3:
  MOV.L [R4+], R2
  MOV.L [R4+], R3
  MOV.L [R4+], R1
  CMP R2, R3
  BLEU next_loop3
  SUB R2, R3
  ADD R6, R2 ; Adjust for real address of PID
  SMOVFP

next_loop3:
  CMP R4, R5
  BGTU loop3
  POPM R1-R6
  RTS

.end
```
#include <stdio.h>
#include <stdlib.h>
#define IOSTREAM 3
const size_t _sbrk_size = 520; // Specifies the minimum unit of the heap area
  // allocation size. (Default: 1024)

void _INIT_LOWLEVEL(void);
void _INIT_OTHERLIB(void);

void _INITLIB (void)
{
  _INIT_LOWLEVEL(); // Initial settings for low-level interface routines
  _INIT_IOLIB();    // Initial settings for I/O library
  _INIT_OTHERLIB(); // Initial settings for rand and strtok functions
}

void _INIT_LOWLEVEL(void)
{
  // Make necessary settings for low-level library
}

void _INIT_OTHERLIB(void)
{
  srand(1); // Initial settings necessary when the rand function is used
}
9. FUNCTION CALL INTERFACE SPECIFICATIONS

9.1 Function Calling Interface

This chapter describes how to handle, for example, arguments when calling functions written in the C or C++ language from a program when using the CC-RX compiler.

The compiler generates code in accord with the following descriptions.

Follow the rules described in this chapter when creating functions which interface the C/C++ language with assembler code.

With regard to interrupt functions, also refer to section 4.2.4 Using Extended Specifications (3) Interrupt Function Creation.

9.1.1 Rules Concerning the Stack

(1) Stack Pointer
Valid data must not be stored in a stack area with an address lower than the stack pointer (in the direction of address H’0), since the data may be destroyed by an interrupt process.

(2) Allocating and Deallocation of Stack Frames
In a function call (immediately after the JSR or the BSR instruction has been executed), the stack pointer indicates the lowest address of the stack used by the calling function. Allocating and setting data at addresses greater than this address must be done by the caller.

After the callee deallocates the area it has set with data, control returns to the caller usually with the RTS instruction. The caller then deallocates the area having a higher address (the return value address and the parameter area).

Figure 9.1 illustrates the stack frame status immediately after a function call.

Figure 9.1 Allocation and Deallocation of a Stack Frame

At a function call and immediately after control returns from a function

9.1.2 Rules Concerning Registers

Registers having the same value before and after a function call is not guaranteed for some registers; some registers may change during a function call. Some registers are used for specific purposes according to the option settings. Table 9.1 shows the rules for using registers.

Table 9.1 Rules to Use Registers

<table>
<thead>
<tr>
<th>Register</th>
<th>Register Value Does Not Change During Function Call</th>
<th>Function Entry</th>
<th>Function Exit</th>
<th>High-Speed Interrupt Register+1</th>
<th>Base Register+2</th>
<th>PID Register+3</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>Guaranteed</td>
<td>Stack pointer</td>
<td>Stack pointer</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R1</td>
<td>Not guaranteed</td>
<td>Parameter 1</td>
<td>Return value 1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R2</td>
<td>Not guaranteed</td>
<td>Parameter 2</td>
<td>Return value 2</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R3</td>
<td>Not guaranteed</td>
<td>Parameter 3</td>
<td>Return value 3</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R4</td>
<td>Not guaranteed</td>
<td>Parameter 4</td>
<td>Return value 4</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Register</td>
<td>Register Value Does Not Change During Function Call</td>
<td>Function Entry</td>
<td>Function Exit</td>
<td>High-Speed Interrupt Register*1</td>
<td>Base Register*2</td>
<td>PID Register*3</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>----------------------------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>R5</td>
<td>Not guaranteed</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R7</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R8</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R9</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R10</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>R11</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>R12</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>R13</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>R14</td>
<td>Not guaranteed</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15</td>
<td>Not guaranteed</td>
<td>Pointer to return value of structure</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DR0 to DR15 [V3.01.00 or later]</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCMR [V3.01.00 or later]</td>
<td>Guaranteed</td>
<td>(Value at function entry is held)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPSW DECNT DEPC [V3.01.00 or later]</td>
<td>Not guaranteed</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISP</td>
<td>Same as R0 when used as the stack pointer. In other cases, the values do not change. *4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USP</td>
<td>Same as R0 when used as the stack pointer. In other cases, the values do not change. *4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>Program counter*5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSW</td>
<td>Not guaranteed</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FPSW</td>
<td>Not guaranteed</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACC</td>
<td>Not guaranteed</td>
<td>(Undefined)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTB</td>
<td>No change*4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPSW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FINTV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Notes 1. The high-speed interrupt function may use some or all four registers among R10 to R13, depending on the `fint_register` option. Registers assigned to the high-speed interrupt function cannot be used for other purposes. For details on the function, refer to the description on the option.

Notes 2. The base register function may use some or all six registers among R8 to R13, depending on the `base` option. Registers assigned to the base register function cannot be used for other purposes. For details on the function, refer to the description on the option.

Notes 3. The PID function may use one of R9 to R13, depending on the `pid` option. The register assigned to the PID function cannot be used for other purposes. For details on the function, refer to the description on the option.

Notes 4. This does not apply in the case when the registers are set or modified through an intrinsic function or `#pragma inline_asm`.

Notes 5. This depends on the specifications of the instruction used for function calls. To call a function, use BSR, JSR, BRA, or JMP.

Notes 6. For the instructions that modify the ACC (accumulator), refer to the software manual for the target RX series product.

9.1.3 Rules Concerning Setting and Referencing Parameters

General rules concerning parameters and the method for allocating parameters are described. Refer to section 8.2.5, Examples of Parameter Allocation, for details on how to actually allocate parameters.

(1) Passing Parameters
A function is called after parameters have been copied to a parameter area in registers or on the stack. Since the caller does not reference the parameter area after control returns to it, the caller is not affected even if the callee modifies the parameters.

(2) Rules on Type Conversion
(a) Parameters whose types are declared by a prototype declaration are converted to the declared types.
(b) Parameters whose types are not declared by a prototype declaration are converted according to the following rules.
   - `int` type of 2 bytes or less is converted to a 4-byte `int` type.
   - `float` type parameters are converted to `double` type parameters.
   - Types other than the above are not converted.

Example
```c
void p(int,... );
void f( )
{
  char c;
  p(1.0, c);
}
```
c is converted to a 4-byte `int` type because a type is not declared for the parameter.
1.0 is converted to a 4-byte `int` type because the type of the parameter is `int`.

(3) Parameter Area Allocation
Parameters are allocated to registers or to a parameter area on the stack. Figure 9.2 shows the parameter-allocated areas.

Following the order of their declaration in the source program, parameters are normally allocated to the registers starting with the smallest numbered register. After parameters have been allocated to all registers, parameters are allocated to the stack. However, in some cases, such as a function with variable-number parameters, parameters are allocated to the stack even though there are empty registers left. The `this` pointer to a nonstatic function member in a C++ program is always assigned to R1.

Table 9.2 lists general rules on parameter area allocation.
CC-RX 9. FUNCTION CALL INTERFACE SPECIFICATIONS

Figure 9.2 Parameter Area Allocation

![Parameter Area Allocation Diagram]

Table 9.2 General Rules on Parameter Area Allocation

<table>
<thead>
<tr>
<th>Target Type</th>
<th>Parameter Storage Registers</th>
<th>Allocation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>signed char, (unsigned) char, bool, _Bool, (signed) short, unsigned short, (signed) int, unsigned int, (signed) long, unsigned long, float, double<em>1, long double</em>1, pointer to a data member, and reference</td>
<td>One register among R1 to R4</td>
<td>Sign extension is performed for <strong>signed char</strong> or (signed) <strong>short</strong> type, and zero extension is performed for (unsigned) <strong>char</strong> type, and the results are allocated. All other types are allocated without any extension performed.</td>
</tr>
<tr>
<td>(signed) long long, unsigned long long, double<em>2, and long double</em>2</td>
<td>Two registers among R1 to R4</td>
<td>The lower four bytes are allocated to the smaller numbered register and the upper four bytes are allocated to the larger numbered register.</td>
</tr>
<tr>
<td>Structure, union, or class whose size is a multiple of 4 not greater than 16 bytes</td>
<td>Among R1 to R4, a number of registers obtained by dividing the size by 4</td>
<td>From the beginning of the memory image, parameters are allocated in 4-byte units to the registers starting with the smallest numbered register.</td>
</tr>
</tbody>
</table>

Notes 1. When **dbl_size=8** is not specified.

Notes 2. When **dbl_size=8** is specified.

Notes 3. If a function has been declared to have variable parameters by a prototype declaration, parameters which do not have a corresponding type in the declaration and the immediately preceding parameter are allocated to the stack. For parameters which do not have a corresponding type, an integer of 2 bytes or less is converted to **long** type and **float** type is converted to **double** type so that all parameters will be handled with a boundary alignment number of 4.

Example

```c
int f2(int,int,int,...);
:
f2(a,b,c,x,y,z);  ? x, y, and z are allocated to the stack.
```

(4) Allocation Method for Parameters Allocated to the Stack
The address and allocation method to the stack for the parameters that are shown in table 3.28 as parameters allocated to the stack are as follows:
- Each parameter is placed at an address matching its boundary alignment number.
- Parameters are stored in the parameter area on the stack in a manner so that the leftmost parameter in the parameter sequence will be located at the deep end of the stack. To be more specific, when parameter A and its right-hand parameter B are both allocated to the stack, the address of parameter B is calculated by adding the occupation size of parameter A to the address of parameter A and then aligning the address to the boundary alignment number of parameter B.

9.1.4 Rules Concerning Setting and Referencing Return Values

General rules concerning return values and the areas for setting return values are described.

(1) Type Conversion of a Return Value
A return value is converted to the data type returned by the function.

Example

```c
long f( );
l long f() {
    float x;
    return x;  // The return value is converted to long type by a prototype declaration
}
```

(2) Return Value Setting Area
The return value of a function is written to either a register or memory depending on its type. Refer to table 3.29 for the relationship between the type and the setting area of the return value.

<table>
<thead>
<tr>
<th>Return Value Type</th>
<th>Return Value Setting Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>signed char, (unsigned) char, (signed) short, unsigned short, (signed) int, unsigned int, (signed) long, unsigned long, float, double±2, long double±2, pointer, bool, _Bool, reference, and pointer to a data member</td>
<td>R1 Note however that the result of sign extension is set for signed char or (signed) short type, and the result of zero extension is set for (unsigned) char or unsigned short type.</td>
</tr>
<tr>
<td>double±3, long double±3, (signed) long long, and unsigned long long</td>
<td>R1, R2 The lower four bytes are set to R1 and the upper four bytes are set to R2.</td>
</tr>
<tr>
<td>Structure, union, or class whose size is 16 bytes or less and is also a multiple of 4</td>
<td>They are set from the beginning of the memory image in 4-byte units in the order of R1, R2, R3, and R4.</td>
</tr>
<tr>
<td>Structure, union, or class other than those above</td>
<td>Return value setting area (memory)*1</td>
</tr>
</tbody>
</table>

Notes 1. When a function return value is to be written to memory, the return value is written to the area indicated by the return value address. The caller must allocate the return value setting area in addition to the parameter area, and must set the address of the return value setting area in R15 before calling the function.

Notes 2. When `dbl_size=8` is not specified.

Notes 3. When `dbl_size=8` is specified.

9.1.5 Examples of Parameter Allocation

Examples of parameter allocation are shown in the following. Note that addresses increase from the right side to the left side in all figures (upper address is on the left side).

Examples 1. Parameters matching the type to be passed to registers are allocated, in the order in which they are declared, to registers R1 to R4. If there is a parameter that will not be allocated to registers midway, parameters after that will be allocated to registers. The parameter will be placed on the stack at an address corrected to match the boundary alignment number of that parameter.
Examples 2. Parameters of a structure or union whose size is 16 bytes or less and is also a multiple of 4 are allocated to registers. Parameters of all other structures and unions are allocated to the stack.

```
union U { int a[2]; int b; } u;
struct S { short & char c[4]; } s;
struct T { char & char f[2]; char e; } t;
int f(union U, struct S, struct T);
```

Examples 3. When declared in a prototype declaration as a function with a variable-number of parameters, the parameters without corresponding types and the immediately preceding parameter are allocated to the stack in the order in which they are declared.

```
int f(int, float, int, int, ...)
```

Examples 4. When the type returned by a function is more than 16 bytes, or for a structure or union that is not the size of a multiple of 4, the return value address is set to R15.
Examples 5. When setting the return value to memory, normally a stack is allocated, as shown in example 4. In the case of setting the return value to a variable, however, no stack is allocated and it is directly set to the memory area for that variable. In this case, the address for the variable is set to R15.

```
struct S { char a[7]; };
struct S f {
    int a1,
    int a2,
    int a3,
    int a4,
    int a5;
};
f(1,2,3,4,5);
```

```
struct S { char a[7]; } t;
struct S f {
    int a1,
    int a2,
    int a3,
    int a4,
    int a5;
};
t = f(1,2,3,4,5);
```

9.2 Method for Mutual Referencing of External Names between Compiler and Assembler

This section describes mutual referencing between the compiler and assembler. External names which have been declared in a C/C++ program can be referenced and updated in both directions between the C/C++ program and an assembly-language program. The compiler treats the following items as external names.

- Global variables which are not declared as static storage classes (C/C++ programs)
- Variable names declared as extern storage classes (C/C++ programs)
- Function names not specified as static storage classes (C programs)
- Non-member, non-inline function names not specified as static storage classes (C++ programs)
- Non-inline member function names (C++ programs)
- Static data member names (C++ programs)
9.2.1 Referencing Assembly-Language Program External Names in C/C++ Programs

In assembly-language programs, `.GLB` is used to declare external symbol names (preceded by an underscore `_`). In C/C++ programs, symbol names (not preceded by an underscore) are declared using the `extern` keyword.

[Example of assembly-language source]
```
.glb _a, _b
.SECTION D,ROMDATA,ALIGN=4
_a: .LWORD 1
_b: .LWORD 1
.END
```

[Example of C source]
```
extern int a,b;
void f()
{
    a+=b;
}
```

9.2.2 Referencing C/C++ Program External Names (Variables and C Functions) from Assembly-Language Programs

A C/C++ program can define external variable names (without an underscore `_`). In an assembly-language program, `.GLB` is used to declare an external name (preceded by an underscore).

[Example of C source]
```
int a;
```

[Example of assembly-language source]
```
.GLB _a
.SECTION P,CODE
MOV.L #A_a,R1
MOV.L [R1],R2
ADD #1,R2
MOV.L R2,[R1]
RTS
.SECTION D,ROMDATA,ALIGN=4
A_a: .LWORD _a
.END
```
9.2.3 Referencing C++ Program External Names (Functions) from Assembly-Language Programs

By declaring functions to be referenced from an assembly-language program using the `extern "C"` keyword, the function can be referenced using the same rules as in (2) above. However, functions declared using `extern "C"` cannot be overloaded.

[Example of C++ source]

```cpp
extern "C"
void sub()
{

}
```

[Example of assembly-language source]

```asm
.globl _sub
.section P, CODE
:     push.l r13
    mov.l 4([r0]), r1
    mov.l r3, r12
    mov.l #_sub, r14
    jsr r14
    pop r13
    rts
:     .end
```

10. MESSAGES

10.1 GENERAL

This document describes internal error message, error message, fatal error message, information message, warning message and MISRA-C detection message that Renesas Tool outputs.

10.2 MESSAGE FORMATS

(1) When the file name and line number are included

```
file-name (line-number) : message-type component-number message-number : message
```

(2) When the file name and line number aren't included

```
message-type component-number message-number : message
```

Remark  Following contents are output as the continued character string.

<table>
<thead>
<tr>
<th>MESSAGE TYPES</th>
<th>1 alphabetic character</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPONENT NUMBERS</td>
<td>05</td>
</tr>
<tr>
<td>MESSAGE NUMBERS</td>
<td>5 digits</td>
</tr>
</tbody>
</table>

10.3 MESSAGE TYPES

Table 10.1 Message Type (CC-RX (V2.00.00 or higher))

<table>
<thead>
<tr>
<th>Message Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Internal error : Processing is aborted. No output objects are generated.</td>
</tr>
<tr>
<td>E</td>
<td>Error : Processing is aborted if a set number of errors occur. No output objects are generated.</td>
</tr>
<tr>
<td>F</td>
<td>Fatal error : Processing is aborted. No output objects are generated.</td>
</tr>
<tr>
<td>M</td>
<td>Information : Informational message. Check the message and continue the process.</td>
</tr>
<tr>
<td>W</td>
<td>Warning : Processing continues. Output objects are generated (They might not be what the user intended).</td>
</tr>
</tbody>
</table>

10.4 MESSAGE NUMBERS

The message numbers of the CC-RX (V2.00.00 or higher) are 5 digits number output following component number (05).

10.5 MESSAGES

This chapter describes the messages displayed by Renesas Tool.
### 10.5.1 Internal Errors

#### Table 10.2 Internal Errors

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Action by User</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0510000</td>
<td>[Message] Internal error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0511200</td>
<td>[Message] Internal error(error-information).</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] The amount of data input (source file name, specified options) to ccrx.exe is too large.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Divide the data input to ccrx.exe and perform startup in several times.</td>
<td></td>
</tr>
<tr>
<td>C0519997</td>
<td>[Message] Internal error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0530001</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0530002</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0530003</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0530004</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0530005</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0530006</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
<tr>
<td>C0554098</td>
<td>[Message] Internal Error.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] An internal error occurred during processing by the assembler.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Make a note of the internal error number, file name, line number, and comment in the message, and contact the support department of the vendor.</td>
<td></td>
</tr>
<tr>
<td>C0564000</td>
<td>[Message] Internal error : (&quot;internal error number&quot;) &quot;file line number&quot; / &quot;comment&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] An internal error occurred during processing by the linker.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Make a note of the internal error number, file name, line number, and comment in the message, and contact the support department of the vendor.</td>
<td></td>
</tr>
<tr>
<td>C0564001</td>
<td>[Message] Internal Error.</td>
<td>Please contact your vendor or your Renesas Electronics overseas representative.</td>
</tr>
</tbody>
</table>
### 10.5.2 Errors

Table 10.3  Errors

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0511101</td>
<td>&quot;path&quot; specified by the &quot;character string&quot; option is a folder. Specify an input file.</td>
</tr>
<tr>
<td>E0511102</td>
<td>The file &quot;file&quot; specified by the &quot;character string&quot; option is not found.</td>
</tr>
<tr>
<td>E0511103</td>
<td>&quot;path&quot; specified by the &quot;character string&quot; option is a folder. Specify an output file.</td>
</tr>
<tr>
<td>E0511104</td>
<td>The output folder &quot;folder&quot; specified by the &quot;character string&quot; option is not found.</td>
</tr>
<tr>
<td>E0511107</td>
<td>&quot;path&quot; specified by the &quot;character string&quot; option is not found.</td>
</tr>
<tr>
<td>E0511108</td>
<td>The &quot;character string&quot; option is not recognized.</td>
</tr>
<tr>
<td>E0511109</td>
<td>The &quot;character string&quot; option can not have an argument.</td>
</tr>
<tr>
<td>E0511110</td>
<td>The &quot;character string&quot; option requires an argument.</td>
</tr>
<tr>
<td>E0511111</td>
<td>The &quot;character string&quot; option can not have a parameter.</td>
</tr>
<tr>
<td>E0511112</td>
<td>The &quot;character string&quot; option requires a parameter.</td>
</tr>
<tr>
<td>E0511113</td>
<td>Invalid argument for the &quot;character string&quot; option.</td>
</tr>
<tr>
<td>E0511117</td>
<td>Invalid parameter for the &quot;character string&quot; option.</td>
</tr>
<tr>
<td>E0511118</td>
<td>Symbol is required for the &quot;character string&quot; option.</td>
</tr>
<tr>
<td>E0511120</td>
<td>Specify a value (value1 - value2) for the &quot;character string&quot; option.</td>
</tr>
<tr>
<td>E0511122</td>
<td>The argument for the &quot;character string&quot; option must be an object file.</td>
</tr>
<tr>
<td>E0511127</td>
<td>The specified device is not supported.</td>
</tr>
<tr>
<td>E0511129</td>
<td>Command file &quot;file&quot; is read more than once.</td>
</tr>
<tr>
<td>E0511130</td>
<td>Command file &quot;file&quot; cannot be read.</td>
</tr>
<tr>
<td>E0511131</td>
<td>Syntax error in command file &quot;file&quot;.</td>
</tr>
<tr>
<td>E0511132</td>
<td>Failed to create temporary folder.</td>
</tr>
<tr>
<td>E0511133</td>
<td>The parameter for the &quot;character string&quot; option must be a folder when multiple source files are specified.</td>
</tr>
<tr>
<td>E0511134</td>
<td>Input file &quot;file&quot; is not found.</td>
</tr>
<tr>
<td>E0511135</td>
<td>&quot;path&quot; specified as an input file is a folder.</td>
</tr>
<tr>
<td>E0511136</td>
<td>Failed to delete a temporary file &quot;file&quot;.</td>
</tr>
<tr>
<td>E0511137</td>
<td>Failed to delete a temporary folder &quot;folder&quot;.</td>
</tr>
<tr>
<td>E0511138</td>
<td>Failed to open an input file &quot;file&quot;.</td>
</tr>
<tr>
<td>E0511139</td>
<td>Failed to open an output file &quot;file&quot;.</td>
</tr>
<tr>
<td>E0511140</td>
<td>Failed to close an input file &quot;file&quot;.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E051141</td>
<td>[Message] Failed to write an output file &quot;file&quot;.</td>
</tr>
<tr>
<td>E051142</td>
<td>[Message] Multiple source files are not allowed when the &quot;character string&quot; option is specified.</td>
</tr>
<tr>
<td>E051145</td>
<td>[Message] &quot;character string2&quot; specified in the &quot;character string1&quot; option is not available.</td>
</tr>
<tr>
<td>E051148</td>
<td>[Message] &quot;file name&quot; is specified as an output file for the different options.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] &quot;file name&quot; is specified as an output file for the different options. Specify a different file name.</td>
</tr>
<tr>
<td>E051150</td>
<td>[Message] The &quot;character string1&quot; option and the &quot;character string2&quot; option are inconsistent.</td>
</tr>
<tr>
<td>E051152</td>
<td>[Message] The &quot;character string1&quot; option needs the &quot;character string2&quot; option.</td>
</tr>
<tr>
<td>E051154</td>
<td>[Message] Component file &quot;file name&quot; for the CC-RX is not found. Reinstall the CC-RX.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] The component file &quot;file name&quot; for the CC-RX is not found. Reinstall the CC-RX.</td>
</tr>
<tr>
<td>E051155</td>
<td>[Message] The &quot;character string&quot; option needs other option(s).</td>
</tr>
<tr>
<td>E051157</td>
<td>[Message] The &quot;character string1&quot; option or the &quot;character string2&quot; option must be specified for this device.</td>
</tr>
<tr>
<td>E051158</td>
<td>[Message] The &quot;character string&quot; option is not supported for this device.</td>
</tr>
<tr>
<td>E051159</td>
<td>[Message] When the &quot;character string&quot; option is specified, source files cannot be input.</td>
</tr>
<tr>
<td>E051160</td>
<td>[Message] The &quot;character string&quot; option must be specified for this device.</td>
</tr>
<tr>
<td>E051161</td>
<td>[Message] Failed to delete a file &quot;file&quot;.</td>
</tr>
<tr>
<td>E051165</td>
<td>[Message] Lacking cpu specification.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Use the cpu option or environment variable CPU_RX to specify the CPU.</td>
</tr>
<tr>
<td>E051167</td>
<td>[Message] Illegal section naming.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] There is an error in section naming. The same section name is specified for different use of the section.</td>
</tr>
<tr>
<td>E051173</td>
<td>[Message] Failed to access a temporary file</td>
</tr>
<tr>
<td>E051175</td>
<td>[Message] Neither isa nor cpu is specified.</td>
</tr>
<tr>
<td>E051176</td>
<td>[Message] Both &quot;-isa&quot; option and &quot;-cpu&quot; option are specified.</td>
</tr>
<tr>
<td>E051178</td>
<td>[Message] &quot;character string&quot; option is unavailable because the license of version Professional edition is not found. Please consider purchasing the product of Professional edition.</td>
</tr>
<tr>
<td>E0511200</td>
<td>[Message] Internal error(error-information).</td>
</tr>
<tr>
<td>E0512001</td>
<td>[Message] Failed to delete a temporary file &quot;file&quot;.</td>
</tr>
<tr>
<td>E0520001</td>
<td>[Message] Last line of file ends without a newline.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] The last line in the file does not end with a line break. Add a line break.</td>
</tr>
<tr>
<td>E0520002</td>
<td>[Message] Last line of file ends with a backslash.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] There is a backslash at the end of the last line of the file. Delete it.</td>
</tr>
<tr>
<td>E0520005</td>
<td>[Message] Could not open source file &quot;file name&quot;.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] There is an unclosed comment at the end of the file. Make sure that there are no unclosed comments.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Unknown token. Check the indicated location.</td>
</tr>
<tr>
<td>E0520008</td>
<td>[Message] Missing closing quote.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] The string is missing a closing quotation mark. Make sure that there are no unclosed quotation mark.</td>
</tr>
<tr>
<td>E0520010</td>
<td>[Message] &quot;#&quot; not expected here.</td>
</tr>
<tr>
<td>E0520012</td>
<td>[Message] Parsing restarts here after previous syntax error.</td>
</tr>
<tr>
<td>E0520013</td>
<td>[Message] Expected a file name.</td>
</tr>
<tr>
<td>E0520017</td>
<td>[Message] Expected a &quot;[&quot;.</td>
</tr>
<tr>
<td>E0520018</td>
<td>[Message] Expected a &quot;]&quot;.</td>
</tr>
<tr>
<td>E0520019</td>
<td>[Message] Extra text after expected end of number.</td>
</tr>
<tr>
<td>E0520020</td>
<td>[Message] Identifier &quot;character string&quot; is undefined.</td>
</tr>
<tr>
<td>E0520022</td>
<td>[Message] Invalid hexadecimal number.</td>
</tr>
<tr>
<td>E0520023</td>
<td>[Message] Integer constant is too large.</td>
</tr>
<tr>
<td>E0520024</td>
<td>[Message] Invalid octal digit.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] Invalid hexadecimal number. Hexadecimal numbers cannot contain '8' or '9'.</td>
</tr>
<tr>
<td>E0520025</td>
<td>[Message] Quoted string should contain at least one character.</td>
</tr>
<tr>
<td>E0520027</td>
<td>[Message] Character value is out of range.</td>
</tr>
<tr>
<td>E0520028</td>
<td>[Message] Expression must have a constant value.</td>
</tr>
<tr>
<td>E0520030</td>
<td>[Message] Floating constant is out of range.</td>
</tr>
<tr>
<td>E0520031</td>
<td>[Message] Expression must have integral type.</td>
</tr>
<tr>
<td>E0520032</td>
<td>[Message] Expression must have arithmetic type.</td>
</tr>
<tr>
<td>E0520033</td>
<td>[Message] Expected a line number</td>
</tr>
<tr>
<td></td>
<td>[Explanation] The line number after the &quot;#line&quot; statement does not exist.</td>
</tr>
<tr>
<td>E0520034</td>
<td>[Message] Invalid line number</td>
</tr>
<tr>
<td></td>
<td>[Explanation] The line number after the &quot;#line&quot; statement is invalid.</td>
</tr>
<tr>
<td>E0520036</td>
<td>[Message] The #if for this directive is missing.</td>
</tr>
<tr>
<td>E0520037</td>
<td>[Message] The #endif for this directive is missing.</td>
</tr>
<tr>
<td>E0520038</td>
<td>[Message] Directive is not allowed -- an #else has already appeared.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] This directive is invalid because there is already an &quot;#else&quot; statement.</td>
</tr>
<tr>
<td>E0520039</td>
<td>[Message] Division by zero.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0520041</td>
<td>Expression must have arithmetic or pointer type.</td>
</tr>
<tr>
<td>E0520042</td>
<td>Operand types are incompatible (&quot;type1&quot; and &quot;type2&quot;).</td>
</tr>
<tr>
<td>E0520044</td>
<td>Expression must have pointer type.</td>
</tr>
<tr>
<td>E0520045</td>
<td>#undef may not be used on this predefined name.</td>
</tr>
<tr>
<td>E0520046</td>
<td>&quot;macro&quot; is predefined; attempted redefinition ignored.</td>
</tr>
<tr>
<td>E0520047</td>
<td>Incompatible redefinition of macro &quot;macro&quot; (declared at line number).</td>
</tr>
<tr>
<td>E0520049</td>
<td>Duplicate macro parameter name.</td>
</tr>
<tr>
<td>E0520050</td>
<td>&quot;##&quot; may not be first in a macro definition.</td>
</tr>
<tr>
<td>E0520051</td>
<td>&quot;##&quot; may not be last in a macro definition.</td>
</tr>
<tr>
<td>E0520052</td>
<td>Expected a macro parameter name.</td>
</tr>
<tr>
<td>E0520053</td>
<td>Expected a &quot;.&quot;.</td>
</tr>
<tr>
<td>E0520054</td>
<td>Too few arguments in macro invocation.</td>
</tr>
<tr>
<td>E0520055</td>
<td>Too many arguments in macro invocation.</td>
</tr>
<tr>
<td>E0520056</td>
<td>Operand of sizeof may not be a function.</td>
</tr>
<tr>
<td>E0520057</td>
<td>This operator is not allowed in a constant expression.</td>
</tr>
<tr>
<td>E0520058</td>
<td>This operator is not allowed in a preprocessing expression.</td>
</tr>
<tr>
<td>E0520059</td>
<td>Function call is not allowed in a constant expression.</td>
</tr>
<tr>
<td>E0520060</td>
<td>This operator is not allowed in an integral constant expression.</td>
</tr>
<tr>
<td>E0520061</td>
<td>Integer operation result is out of range.</td>
</tr>
<tr>
<td>E0520062</td>
<td>Shift count is negative.</td>
</tr>
<tr>
<td>E0520063</td>
<td>Shift count is too large.</td>
</tr>
<tr>
<td>E0520064</td>
<td>Declaration does not declare anything.</td>
</tr>
<tr>
<td>E0520065</td>
<td>Expected a &quot;&quot;.</td>
</tr>
<tr>
<td>E0520066</td>
<td>Enumeration value is out of &quot;int&quot; range.</td>
</tr>
<tr>
<td>E0520067</td>
<td>Expected a &quot;)&quot;.</td>
</tr>
<tr>
<td>E0520069</td>
<td>Integer conversion resulted in truncation</td>
</tr>
<tr>
<td>E0520070</td>
<td>Incomplete type is not allowed.</td>
</tr>
<tr>
<td>E0520071</td>
<td>Operand of sizeof may not be a bit field.</td>
</tr>
<tr>
<td>E0520075</td>
<td>Operand of &quot;***&quot; must be a pointer.</td>
</tr>
<tr>
<td>E0520077</td>
<td>This declaration has no storage class or type specifier.</td>
</tr>
<tr>
<td>E0520078</td>
<td>A parameter declaration may not have an initializer.</td>
</tr>
<tr>
<td>E0520079</td>
<td>Expected a type specifier.</td>
</tr>
<tr>
<td>E0520080</td>
<td>A storage class may not be specified here.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0520081</td>
<td>More than one storage class may not be specified.</td>
</tr>
<tr>
<td>E0520083</td>
<td>Type qualifier specified more than once.</td>
</tr>
<tr>
<td>E0520084</td>
<td>Invalid combination of type specifiers.</td>
</tr>
<tr>
<td>E0520085</td>
<td>Invalid storage class for a parameter.</td>
</tr>
<tr>
<td>E0520086</td>
<td>Invalid storage class for a function.</td>
</tr>
<tr>
<td>E0520087</td>
<td>A type specifier may not be used here.</td>
</tr>
<tr>
<td>E0520088</td>
<td>Array of functions is not allowed.</td>
</tr>
<tr>
<td>E0520089</td>
<td>Array of void is not allowed.</td>
</tr>
<tr>
<td>E0520090</td>
<td>Function returning function is not allowed.</td>
</tr>
<tr>
<td>E0520091</td>
<td>Function returning array is not allowed.</td>
</tr>
<tr>
<td>E0520092</td>
<td>Identifier-list parameters may only be used in a function definition.</td>
</tr>
<tr>
<td>E0520093</td>
<td>Function type may not come from a typedef.</td>
</tr>
<tr>
<td>E0520094</td>
<td>The size of an array must be greater than zero.</td>
</tr>
<tr>
<td>E0520095</td>
<td>Array is too large.</td>
</tr>
<tr>
<td>E0520096</td>
<td>A translation unit must contain at least one declaration.</td>
</tr>
<tr>
<td>E0520097</td>
<td>A function may not return a value of this type.</td>
</tr>
<tr>
<td>E0520098</td>
<td>An array may not have elements of this type.</td>
</tr>
<tr>
<td>E0520099</td>
<td>A declaration here must declare a parameter.</td>
</tr>
<tr>
<td>E0520100</td>
<td>Duplicate parameter name.</td>
</tr>
<tr>
<td>E0520101</td>
<td>&quot;symbol&quot; has already been declared in the current scope.</td>
</tr>
<tr>
<td>E0520102</td>
<td>Forward declaration of enum type is nonstandard.</td>
</tr>
<tr>
<td>E0520103</td>
<td>Class is too large.</td>
</tr>
<tr>
<td>E0520104</td>
<td>Struct or union is too large.</td>
</tr>
<tr>
<td>E0520105</td>
<td>Invalid size for bit field.</td>
</tr>
<tr>
<td>E0520106</td>
<td>Invalid type for a bit field.</td>
</tr>
<tr>
<td>E0520107</td>
<td>Zero-length bit field must be unnamed.</td>
</tr>
<tr>
<td>E0520109</td>
<td>Expression must have (pointer-to-) function type.</td>
</tr>
<tr>
<td>E0520110</td>
<td>Expected either a definition or a tag name.</td>
</tr>
<tr>
<td>E0520112</td>
<td>Expected &quot;while&quot;.</td>
</tr>
<tr>
<td>E0520114</td>
<td>Type &quot;symbol&quot; was referenced but not defined.</td>
</tr>
<tr>
<td>E0520115</td>
<td>A continue statement may only be used within a loop.</td>
</tr>
<tr>
<td>E0520116</td>
<td>A break statement may only be used within a loop or switch.</td>
</tr>
<tr>
<td>E0520118</td>
<td>A void function may not return a value.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0520119</td>
<td>[Message] Cast to type &quot;type&quot; is not allowed.</td>
</tr>
<tr>
<td>E0520120</td>
<td>[Message] Return value type does not match the function type.</td>
</tr>
<tr>
<td>E0520121</td>
<td>[Message] A case label may only be used within a switch.</td>
</tr>
<tr>
<td>E0520122</td>
<td>[Message] A default label may only be used within a switch.</td>
</tr>
<tr>
<td>E0520123</td>
<td>[Message] case label value has already appeared in this switch.</td>
</tr>
<tr>
<td>E0520124</td>
<td>[Message] default label has already appeared in this switch.</td>
</tr>
<tr>
<td>E0520125</td>
<td>[Message] Expected a &quot;.&quot;.</td>
</tr>
<tr>
<td>E0520126</td>
<td>[Message] Expression must be an lvalue.</td>
</tr>
<tr>
<td>E0520129</td>
<td>[Message] A block-scope function may only have extern storage class.</td>
</tr>
<tr>
<td>E0520130</td>
<td>[Message] Expected a &quot;.&quot;.</td>
</tr>
<tr>
<td>E0520131</td>
<td>[Message] Expression must have pointer-to-class type.</td>
</tr>
<tr>
<td>E0520132</td>
<td>[Message] Expression must have pointer-to-struct-or-union type.</td>
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<tr>
<td>E0520133</td>
<td>[Message] Expected a member name.</td>
</tr>
<tr>
<td>E0520134</td>
<td>[Message] Expected a field name.</td>
</tr>
<tr>
<td>E0520135</td>
<td>[Message] symbol has no member member.</td>
</tr>
<tr>
<td>E0520136</td>
<td>[Message] Type &quot;symbol&quot; has no field &quot;field&quot;.</td>
</tr>
<tr>
<td>E0520137</td>
<td>[Message] Expression must be a modifiable lvalue.</td>
</tr>
<tr>
<td>E0520138</td>
<td>[Message] Taking the address of a register variable is not allowed.</td>
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<tr>
<td>E0520139</td>
<td>[Message] Taking the address of a bit field is not allowed.</td>
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<tr>
<td>E0520141</td>
<td>[Message] Unnamed prototyped parameters not allowed when body is present.</td>
</tr>
<tr>
<td>E0520142</td>
<td>[Message] Expression must have pointer-to-object type.</td>
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<tr>
<td>E0520144</td>
<td>[Message] A value of type &quot;type1&quot; cannot be used to initialize an entity of type &quot;type2&quot;.</td>
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<tr>
<td>E0520145</td>
<td>[Message] Type &quot;symbol&quot; may not be initialized.</td>
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<tr>
<td>E0520146</td>
<td>[Message] Too many initializer values.</td>
</tr>
<tr>
<td>E0520147</td>
<td>[Message] Declaration is incompatible with &quot;declaration&quot; (declared at line number).</td>
</tr>
<tr>
<td>E0520148</td>
<td>[Message] Type &quot;symbol&quot; has already been initialized.</td>
</tr>
<tr>
<td>E0520149</td>
<td>[Message] A global-scope declaration may not have this storage class.</td>
</tr>
<tr>
<td>E0520150</td>
<td>[Message] A type name may not be redeclared as a parameter.</td>
</tr>
<tr>
<td>E0520151</td>
<td>[Message] A typedef name may not be redeclared as a parameter.</td>
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<tr>
<td>E0520153</td>
<td>[Message] Expression must have class type.</td>
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<tr>
<td>E0520154</td>
<td>[Message] Expression must have struct or union type.</td>
</tr>
<tr>
<td>E0520157</td>
<td>[Message] Expression must be an integral constant expression.</td>
</tr>
<tr>
<td>E0520158</td>
<td>[Message] Expression must be an lvalue or a function designator.</td>
</tr>
<tr>
<td>E0520159</td>
<td>[Message] Declaration is incompatible with previous &quot;declaration&quot; (declared at line number).</td>
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<tr>
<td>E0520160</td>
<td>[Message] External name conflicts with external name of &quot;symbol&quot;.</td>
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<tr>
<td>E0520166</td>
<td>[Message] Invalid floating constant.</td>
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<tr>
<td>E0520167</td>
<td>[Message] Argument of type &quot;type1&quot; is incompatible with parameter of type &quot;type2&quot;.</td>
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<td>E0520168</td>
<td>[Message] A function type is not allowed here.</td>
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<td>E0520169</td>
<td>[Message] Expected a declaration.</td>
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<tr>
<td>E0520170</td>
<td>[Message] Pointer points outside of underlying object.</td>
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<td>E0520171</td>
<td>[Message] Invalid type conversion.</td>
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<td>E0520172</td>
<td>[Message] External/internal linkage conflict with previous declaration.</td>
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<td>E0520173</td>
<td>[Message] Floating-point value does not fit in required integral type.</td>
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<td>E0520179</td>
<td>[Message] Right operand of &quot;%&quot; is zero.</td>
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<tr>
<td>E0520183</td>
<td>[Message] Type of cast must be integral.</td>
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<tr>
<td>E0520184</td>
<td>[Message] Type of cast must be arithmetic or pointer.</td>
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<tr>
<td>E0520195</td>
<td>[Message] An asm function must be prototyped.</td>
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<td>E0520196</td>
<td>[Message] An asm function may not have an ellipsis.</td>
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<td>E0520220</td>
<td>[Message] Integral value does not fit in required floating-point type.</td>
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<td>E0520221</td>
<td>[Message] Floating-point value does not fit in required floating-point type.</td>
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<td>E0520222</td>
<td>[Message] Floating-point operation result is out of range.</td>
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<td>E0520228</td>
<td>[Message] Trailing comma is nonstandard.</td>
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<td>E0520230</td>
<td>[Message] Nonstandard type for a bit field.</td>
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<td>E0520235</td>
<td>[Message] Variable any-string was declared with a never-completed type.</td>
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<td>E0520238</td>
<td>[Message] Invalid specifier on a parameter.</td>
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<td>E0520239</td>
<td>[Message] Invalid specifier outside a class declaration.</td>
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<td>E0520241</td>
<td>[Message] A union is not allowed to have a base class.</td>
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<td>E0520242</td>
<td>[Message] Multiple access control specifiers are not allowed.</td>
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<tr>
<td>E0520243</td>
<td>[Message] class or struct definition is missing.</td>
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<tr>
<td>E0520244</td>
<td>[Message] Qualified name is not a member of class type or its base classes.</td>
</tr>
<tr>
<td>E0520245</td>
<td>[Message] A nonstatic member reference must be relative to a specific object.</td>
</tr>
<tr>
<td>E0520246</td>
<td>[Message] A nonstatic data member may not be defined outside its class.</td>
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<tr>
<td>E0520247</td>
<td>[Message] Type &quot;symbol&quot; has already been defined.</td>
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<tr>
<td>E0520248</td>
<td>[Message] Pointer to reference is not allowed.</td>
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<td>E0520249</td>
<td>Reference to reference is not allowed.</td>
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<td>E0520250</td>
<td>Reference to void is not allowed.</td>
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<td>E0520251</td>
<td>Array of reference is not allowed.</td>
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<tr>
<td>E0520252</td>
<td>Reference &quot;name&quot; requires an initializer.</td>
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<tr>
<td>E0520253</td>
<td>Expected a &quot;,&quot;.</td>
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<tr>
<td>E0520254</td>
<td>Type name is not allowed.</td>
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<td>E0520255</td>
<td>Type definition is not allowed.</td>
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<tr>
<td>E0520256</td>
<td>Invalid redeclaration of type name &quot;type&quot;.</td>
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<tr>
<td>E0520257</td>
<td>const type &quot;symbol&quot; requires an initializer.</td>
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<tr>
<td>E0520258</td>
<td>&quot;this&quot; may only be used inside a nonstatic member function</td>
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<td>E0520259</td>
<td>Constant value is not known.</td>
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<td>E0520260</td>
<td>Explicit type is missing (&quot;int&quot; assumed).</td>
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<tr>
<td>E0520262</td>
<td>Not a class or struct name.</td>
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<tr>
<td>E0520263</td>
<td>Duplicate base class name.</td>
</tr>
<tr>
<td>E0520264</td>
<td>Invalid base class.</td>
</tr>
<tr>
<td>E0520265</td>
<td>&quot;name&quot; is inaccessible.</td>
</tr>
<tr>
<td>E0520266</td>
<td>&quot;name&quot; is ambiguous.</td>
</tr>
<tr>
<td>E0520267</td>
<td>Old-style parameter list (anachronism).</td>
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<tr>
<td>E0520268</td>
<td>Declaration may not appear after executable statement in block.</td>
</tr>
<tr>
<td>E0520269</td>
<td>Conversion to inaccessible base class &quot;type&quot; is not allowed.</td>
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<td>E0520274</td>
<td>Improperly terminated macro invocation.</td>
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<tr>
<td>E0520276</td>
<td>Name followed by &quot;:=&quot; must be a class or namespace name.</td>
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<tr>
<td>E0520277</td>
<td>Invalid friend declaration.</td>
</tr>
<tr>
<td>E0520278</td>
<td>A constructor or destructor may not return a value.</td>
</tr>
<tr>
<td>E0520279</td>
<td>Invalid destructor declaration.</td>
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<tr>
<td>E0520280</td>
<td>Declaration of a member with the same name as its class.</td>
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<tr>
<td>E0520281</td>
<td>Global-scope qualifier (leading &quot;:&quot;) is not allowed.</td>
</tr>
<tr>
<td>E0520282</td>
<td>The global scope has no xxx.</td>
</tr>
<tr>
<td>E0520283</td>
<td>Qualified name is not allowed.</td>
</tr>
<tr>
<td>E0520284</td>
<td>NULL reference is not allowed.</td>
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<tr>
<td>E0520285</td>
<td>Initialization with &quot;:...&quot; is not allowed for object of type &quot;type&quot;.</td>
</tr>
<tr>
<td>E0520286</td>
<td>Base class &quot;type&quot; is ambiguous.</td>
</tr>
<tr>
<td>E0520287</td>
<td>Derived class type1 contains more than one instance of class type2.</td>
</tr>
<tr>
<td>E0520288</td>
<td>Cannot convert pointer to base class type2 to pointer to derived class type1 -- base class is virtual.</td>
</tr>
<tr>
<td>E0520289</td>
<td>No instance of constructor name matches the argument list.</td>
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<tr>
<td>E0520290</td>
<td>Copy constructor for class type is ambiguous.</td>
</tr>
<tr>
<td>E0520291</td>
<td>No default constructor exists for class type.</td>
</tr>
<tr>
<td>E0520292</td>
<td>name is not a nonstatic data member or base class of class type.</td>
</tr>
<tr>
<td>E0520293</td>
<td>Indirect nonvirtual base class is not allowed.</td>
</tr>
<tr>
<td>E0520294</td>
<td>Invalid union member -- class type has a disallowed member function.</td>
</tr>
<tr>
<td>E0520296</td>
<td>Invalid use of non-Value array.</td>
</tr>
<tr>
<td>E0520297</td>
<td>Expected an operator.</td>
</tr>
<tr>
<td>E0520298</td>
<td>Inherited member is not allowed.</td>
</tr>
<tr>
<td>E0520299</td>
<td>Cannot determine which instance of name is intended.</td>
</tr>
<tr>
<td>E0520300</td>
<td>A pointer to a bound function may only be used to call the function.</td>
</tr>
<tr>
<td>E0520301</td>
<td>typedef name has already been declared (with same type).</td>
</tr>
<tr>
<td>E0520302</td>
<td>Symbol has already been defined.</td>
</tr>
<tr>
<td>E0520304</td>
<td>No instance of name matches the argument list.</td>
</tr>
<tr>
<td>E0520305</td>
<td>Type definition is not allowed in function return type declaration.</td>
</tr>
<tr>
<td>E0520306</td>
<td>Default argument not at end of parameter list.</td>
</tr>
<tr>
<td>E0520307</td>
<td>Redefinition of default argument.</td>
</tr>
<tr>
<td>E0520308</td>
<td>More than one instance of name matches the argument list:</td>
</tr>
<tr>
<td>E0520309</td>
<td>More than one instance of constructor name matches the argument list:</td>
</tr>
<tr>
<td>E0520310</td>
<td>Default argument of type type1 is incompatible with parameter of type type2.</td>
</tr>
<tr>
<td>E0520311</td>
<td>Cannot overload functions distinguished by return type alone.</td>
</tr>
<tr>
<td>E0520312</td>
<td>No suitable user-defined conversion from type1 to type2 exists.</td>
</tr>
<tr>
<td>E0520313</td>
<td>Type qualifier is not allowed on this function.</td>
</tr>
<tr>
<td>E0520314</td>
<td>Only nonstatic member functions may be virtual.</td>
</tr>
<tr>
<td>E0520315</td>
<td>The object has cv-qualifiers that are not compatible with the member function.</td>
</tr>
<tr>
<td>E0520316</td>
<td>Program too large to compile (too many virtual functions).</td>
</tr>
<tr>
<td>E0520317</td>
<td>Return type is not identical to nor covariant with return type type of overridden virtual function name.</td>
</tr>
<tr>
<td>E0520318</td>
<td>Override of virtual name is ambiguous.</td>
</tr>
<tr>
<td>E0520319</td>
<td>Pure specifier (&quot;= 0&quot;) allowed only on virtual functions.</td>
</tr>
<tr>
<td>E0520320</td>
<td>Badly-formed pure specifier (only &quot;*&quot; is allowed).</td>
</tr>
<tr>
<td>E0520321</td>
<td>Data member initializer is not allowed.</td>
</tr>
<tr>
<td>E0520322</td>
<td>Object of abstract class type is not allowed:</td>
</tr>
<tr>
<td>E0520323</td>
<td>function returning abstract class type is not allowed:</td>
</tr>
<tr>
<td>E0520325</td>
<td>inline specifier allowed on function declarations only.</td>
</tr>
<tr>
<td>E0520326</td>
<td>inline is not allowed.</td>
</tr>
<tr>
<td>E0520327</td>
<td>Invalid storage class for an inline function.</td>
</tr>
<tr>
<td>E0520328</td>
<td>Invalid storage class for a class member.</td>
</tr>
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<tr>
<td>E0520329</td>
<td>Local class member <em>name</em> requires a definition.</td>
</tr>
<tr>
<td>E0520330</td>
<td><em>name</em> is inaccessible.</td>
</tr>
<tr>
<td>E0520332</td>
<td>class <em>type</em> has no copy constructor to copy a const object.</td>
</tr>
<tr>
<td>E0520333</td>
<td>Defining an implicitly declared member function is not allowed.</td>
</tr>
<tr>
<td>E0520334</td>
<td>class <em>type</em> has no suitable copy constructor.</td>
</tr>
<tr>
<td>E0520335</td>
<td>Linkage specification is not allowed.</td>
</tr>
<tr>
<td>E0520336</td>
<td>Unknown external linkage specification.</td>
</tr>
<tr>
<td>E0520337</td>
<td>Linkage specification is incompatible with previous &quot;symbol&quot;.</td>
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<tr>
<td>E0520338</td>
<td>More than one instance of overloaded function <em>name</em> has &quot;C&quot; linkage.</td>
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<tr>
<td>E0520339</td>
<td>class <em>type</em> has more than one default constructor.</td>
</tr>
<tr>
<td>E0520340</td>
<td>Value copied to temporary, reference to temporary used.</td>
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<tr>
<td>E0520341</td>
<td>&quot;operator operator&quot; must be a member function.</td>
</tr>
<tr>
<td>E0520342</td>
<td>Operator may not be a static member function.</td>
</tr>
<tr>
<td>E0520343</td>
<td>No arguments allowed on user-defined conversion.</td>
</tr>
<tr>
<td>E0520344</td>
<td>Too many parameters for this operator function.</td>
</tr>
<tr>
<td>E0520345</td>
<td>Too few parameters for this operator function.</td>
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<tr>
<td>E0520346</td>
<td>Nonmember operator requires a parameter with class type.</td>
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<tr>
<td>E0520347</td>
<td>Default argument is not allowed.</td>
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<tr>
<td>E0520348</td>
<td>More than one user-defined conversion from <em>type1</em> to <em>type2</em> applies:</td>
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<tr>
<td>E0520349</td>
<td>No operator <em>operator</em> matches these operands.</td>
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<tr>
<td>E0520350</td>
<td>More than one operator <em>operator</em> matches these operands:</td>
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<tr>
<td>E0520351</td>
<td>First parameter of allocation function must be of type &quot;size_t&quot;.</td>
</tr>
<tr>
<td>E0520352</td>
<td>Allocation function requires &quot;void **&quot; return type.</td>
</tr>
<tr>
<td>E0520353</td>
<td>Deallocation function requires &quot;void&quot; return type.</td>
</tr>
<tr>
<td>E0520354</td>
<td>First parameter of deallocation function must be of type &quot;void **&quot;.</td>
</tr>
<tr>
<td>E0520356</td>
<td>Type must be an object type.</td>
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<tr>
<td>E0520357</td>
<td>Base class <em>xxx</em> has already been initialized.</td>
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<tr>
<td>E0520358</td>
<td>Base class name required -- <em>xxx</em> assumed (anachronism).</td>
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<tr>
<td>E0520359</td>
<td>Symbol has already been initialized.</td>
</tr>
<tr>
<td>E0520360</td>
<td>Name of member or base class is missing.</td>
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<tr>
<td>E0520363</td>
<td>Invalid anonymous union -- nonpublic member is not allowed.</td>
</tr>
<tr>
<td>E0520364</td>
<td>Invalid anonymous union -- member function is not allowed.</td>
</tr>
<tr>
<td>E0520365</td>
<td>Anonymous union at global or namespace scope must be declared static.</td>
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<tr>
<td>E0520366</td>
<td>Symbol provides no initializer for:</td>
</tr>
<tr>
<td>E0520367</td>
<td>Implicitly generated constructor for class <em>type</em> cannot initialize:</td>
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<tr>
<td>E0520369</td>
<td><em>name</em> has an uninitialized const or reference member.</td>
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<tr>
<td>E0520371</td>
<td>class type has no assignment operator to copy a const object.</td>
</tr>
<tr>
<td>E0520372</td>
<td>class type has no suitable assignment operator.</td>
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<tr>
<td>E0520373</td>
<td>Ambiguous assignment operator for class type.</td>
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<tr>
<td>E0520375</td>
<td>Declaration requires a typedef name.</td>
</tr>
<tr>
<td>E0520378</td>
<td>static is not allowed.</td>
</tr>
<tr>
<td>E0520380</td>
<td>Expression must have pointer-to-member type.</td>
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<tr>
<td>E0520384</td>
<td>No instance of overloaded name matches the argument list.</td>
</tr>
<tr>
<td>E0520386</td>
<td>No instance of name matches the required type.</td>
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<tr>
<td>E0520389</td>
<td>A cast to abstract class type is not allowed:</td>
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<tr>
<td>E0520390</td>
<td>Function &quot;main&quot; may not be called or have its address taken.</td>
</tr>
<tr>
<td>E0520391</td>
<td>A new-initializer may not be specified for an array.</td>
</tr>
<tr>
<td>E0520392</td>
<td>Member function name may not be redeclared outside its class.</td>
</tr>
<tr>
<td>E0520393</td>
<td>Pointer to incomplete class type is not allowed.</td>
</tr>
<tr>
<td>E0520394</td>
<td>Reference to local variable of enclosing function is not allowed.</td>
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<tr>
<td>E0520397</td>
<td>Implicitly generated assignment operator cannot copy:</td>
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<tr>
<td>E0520401</td>
<td>Destructor for base class type is not virtual.</td>
</tr>
<tr>
<td>E0520403</td>
<td>Invalid redeclaration of member &quot;symbol&quot;.</td>
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<tr>
<td>E0520404</td>
<td>Function &quot;main&quot; may not be declared inline.</td>
</tr>
<tr>
<td>E0520405</td>
<td>Member function with the same name as its class must be a constructor.</td>
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<tr>
<td>E0520407</td>
<td>A destructor may not have parameters.</td>
</tr>
<tr>
<td>E0520408</td>
<td>Copy constructor for class type1 may not have a parameter of type type2.</td>
</tr>
<tr>
<td>E0520409</td>
<td>Type &quot;symbol&quot; returns incomplete type &quot;type&quot;.</td>
</tr>
<tr>
<td>E0520410</td>
<td>Protected name is not accessible through a type pointer or object.</td>
</tr>
<tr>
<td>E0520411</td>
<td>A parameter is not allowed.</td>
</tr>
<tr>
<td>E0520413</td>
<td>No suitable conversion function from type1 to type2 exists.</td>
</tr>
<tr>
<td>E0520415</td>
<td>No suitable constructor exists to convert from type1 to type2.</td>
</tr>
<tr>
<td>E0520416</td>
<td>More than one constructor applies to convert from type1 to type2:</td>
</tr>
<tr>
<td>E0520417</td>
<td>More than one conversion function from type1 to type2 applies:</td>
</tr>
<tr>
<td>E0520418</td>
<td>More than one conversion function from type to a built-in type applies:</td>
</tr>
<tr>
<td>E0520424</td>
<td>A constructor or destructor may not have its address taken.</td>
</tr>
<tr>
<td>E0520427</td>
<td>Qualified name is not allowed in member declaration.</td>
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<tr>
<td>E0520429</td>
<td>The size of an array in &quot;new&quot; must be non-negative.</td>
</tr>
<tr>
<td>E0520432</td>
<td>Enum declaration is not allowed.</td>
</tr>
<tr>
<td>E0520433</td>
<td>Qualifiers dropped in binding reference of type type1 to initializer of type type2.</td>
</tr>
<tr>
<td>E0520434</td>
<td>A reference of type type1 (not const-qualified) cannot be initialized with a value of type type2.</td>
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<tr>
<td>E0520435</td>
<td>A pointer to function may not be deleted.</td>
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<td>E0520436</td>
<td>Conversion function must be a nonstatic member function.</td>
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<td>E0520437</td>
<td>Template declaration is not allowed here.</td>
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<td>E0520438</td>
<td>Expected a &quot;&lt;&quot;.</td>
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<td>E0520439</td>
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<tr>
<td>E0520440</td>
<td>Template parameter declaration is missing.</td>
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<td>E0520441</td>
<td>Argument list for &quot;name&quot; is missing.</td>
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<tr>
<td>E0520442</td>
<td>Too few arguments for &quot;name&quot;.</td>
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<tr>
<td>E0520443</td>
<td>Too many arguments for &quot;symbol&quot;.</td>
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<tr>
<td>E0520445</td>
<td>name1 is not used in declaring the parameter types of &quot;name2&quot;.</td>
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<tr>
<td>E0520449</td>
<td>More than one instance of name matches the required type.</td>
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<td>E0520450</td>
<td>The type &quot;long long&quot; is nonstandard.</td>
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<td>E0520451</td>
<td>Omission of &quot;class&quot; is nonstandard.</td>
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<td>E0520452</td>
<td>Return type may not be specified on a conversion function.</td>
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<td>E0520456</td>
<td>Excessive recursion at instantiation of name.</td>
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<td>E0520457</td>
<td>name is not a function or static data member.</td>
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<td>E0520458</td>
<td>Argument of type type1 is incompatible with template parameter of type type2.</td>
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<td>E0520459</td>
<td>Initialization requiring a temporary or conversion is not allowed.</td>
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<td>E0520460</td>
<td>declaration of xxx hides function parameter.</td>
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<td>E0520461</td>
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<td>E0520463</td>
<td>&quot;template&quot; is not allowed.</td>
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<td>E0520464</td>
<td>type is not a class template.</td>
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<td>E0520466</td>
<td>&quot;main&quot; is not a valid name for a function template.</td>
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<td>E0520467</td>
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<td>E0520468</td>
<td>A template argument may not reference a local type.</td>
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<td>E0520469</td>
<td>Tag kind of xxx is incompatible with declaration of &quot;symbol&quot;.</td>
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<td>E0520470</td>
<td>The global scope has no tag named xxx.</td>
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<td>E0520471</td>
<td>symbol has no tag member named xxx.</td>
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<td>E0520473</td>
<td>name may be used only in pointer-to-member declaration.</td>
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<td>E0520475</td>
<td>A template argument may not reference a non-external entity.</td>
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<td>E0520477</td>
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<td>E0520478</td>
<td>Type used as destructor name does not match type type.</td>
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<td>E0520481</td>
<td>Invalid storage class for a template declaration.</td>
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<td>E0520484</td>
<td>Invalid explicit instantiation declaration.</td>
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<td>E0520485</td>
<td>name is not an entity that can be instantiated.</td>
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<td>E0520489</td>
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<td>E0520490</td>
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<td>No instance of name matches the specified type.</td>
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<td>E0520494</td>
<td>Declaring a void parameter list with a typedef is nonstandard.</td>
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<td>E0520496</td>
<td>Template parameter name may not be redeclared in this scope.</td>
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<td>E0520498</td>
<td>Template argument list must match the parameter list.</td>
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<td>E0520501</td>
<td>An operator name must be declared as a function.</td>
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<td>E0520502</td>
<td>Operator name is not allowed.</td>
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<td>E0520506</td>
<td>Too many template parameters -- does not match previous declaration.</td>
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<td>E0520507</td>
<td>Function template for operator delete(void *) is not allowed.</td>
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<td>E0520508</td>
<td>class template and template parameter may not have the same name.</td>
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<td>E0520510</td>
<td>A template argument may not reference an unnamed type.</td>
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<td>E0520511</td>
<td>Enumerated type is not allowed.</td>
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<td>E0520513</td>
<td>A value of type &quot;type1&quot; cannot be assigned to an entity of type &quot;type2&quot;.</td>
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<td>Cannot convert to incomplete class type.</td>
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<td>E0520517</td>
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<td>Nonstandard preprocessing directive.</td>
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<td>E0520520</td>
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<td>A dependent statement may not be a declaration.</td>
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<td>A parameter may not have void type.</td>
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<td>E0520529</td>
<td>This operator is not allowed in a template argument expression.</td>
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<td>E0520530</td>
<td>Try block requires at least one handler/</td>
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<td>E0520531</td>
<td>Handler requires an exception declaration.</td>
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<td>E0520532</td>
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<td>E0520536</td>
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<td>E0520540</td>
<td>Support for exception handling is disabled.</td>
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<td>E0520543</td>
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<td>E0520545</td>
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<td>E0520546</td>
<td>Transfer of control bypasses initialization of:</td>
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<td>E0520548</td>
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<td>E0520551</td>
<td>Symbol cannot be defined in the current scope.</td>
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<td>E0520555</td>
<td>Tag kind of name is incompatible with template parameter of type type.</td>
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<tr>
<td>E0520556</td>
<td>Function template for operator new(size_t) is not allowed.</td>
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<tr>
<td>E0520558</td>
<td>Pointer to member of type &quot;type&quot; is not allowed.</td>
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<tr>
<td>E0520559</td>
<td>Pointer to member of type type is not allowed.</td>
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<tr>
<td>E0520560</td>
<td>Symbol is reserved for future use as a keyword.</td>
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<td>E0520561</td>
<td>Invalid macro definition:</td>
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<td>E0520562</td>
<td>Invalid macro undefined:</td>
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<td>E0520598</td>
<td>A template parameter may not have void type.</td>
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<td>E0520599</td>
<td>Excessive recursive instantiation of name due to instantiate-all mode.</td>
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<td>E0520601</td>
<td>A throw expression may not have void type.</td>
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<td>E0520603</td>
<td>Parameter of abstract class type type is not allowed:</td>
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<tr>
<td>E0520604</td>
<td>Array of abstract class type is not allowed:</td>
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<tr>
<td>E0520605</td>
<td>Floating-point template parameter is nonstandard.</td>
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<tr>
<td>E0520606</td>
<td>This pragma must immediately precede a declaration.</td>
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<tr>
<td>E0520607</td>
<td>This pragma must immediately precede a statement.</td>
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<tr>
<td>E0520608</td>
<td>This pragma must immediately precede a declaration or statement.</td>
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<td>E0520609</td>
<td>This kind of pragma may not be used here.</td>
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<tr>
<td>E0520612</td>
<td>Specific definition of inline template function must precede its first use.</td>
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<td>E0520615</td>
<td>Parameter type involves pointer to array of unknown bound.</td>
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<tr>
<td>E0520618</td>
<td>Struct or union declares no named members.</td>
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<tr>
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<td>Nonstandard unnamed field.</td>
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<td>E0520620</td>
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<td>E0520643</td>
<td>Restrict is not allowed.</td>
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<tr>
<td>E0520644</td>
<td>A pointer or reference to function type may not be qualified by &quot;restrict&quot;.</td>
</tr>
<tr>
<td>E0520647</td>
<td>Conflicting calling convention modifiers.</td>
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<td>E0520651</td>
<td>A calling convention may not be followed by a nested declarator.</td>
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<tr>
<td>E0520654</td>
<td>Declaration modifiers are incompatible with previous declaration.</td>
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<td>E0520656</td>
<td>Transfer of control into a try block.</td>
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<tr>
<td>E0520658</td>
<td>Closing brace of template definition not found.</td>
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<td>E0520660</td>
<td>Invalid packing alignment value.</td>
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<td>E0520661</td>
<td>[Message] Expected an integer constant.</td>
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<td>E0520663</td>
<td>[Message] Invalid source file identifier string.</td>
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<td>E0520664</td>
<td>[Message] A class template cannot be defined in a friend declaration.</td>
</tr>
<tr>
<td>E0520665</td>
<td>[Message] asm is not allowed.</td>
</tr>
<tr>
<td>E0520666</td>
<td>[Message] asm must be used with a function definition.</td>
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<tr>
<td>E0520667</td>
<td>[Message] asm function is nonstandard.</td>
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<tr>
<td>E0520668</td>
<td>[Message] Ellipsis with no explicit parameters is nonstandard.</td>
</tr>
<tr>
<td>E0520669</td>
<td>[Message] &amp;... is nonstandard.</td>
</tr>
<tr>
<td>E0520670</td>
<td>[Message] invalid use of &quot;&amp;...&quot;.</td>
</tr>
<tr>
<td>E0520672</td>
<td>[Message] Initial value of reference to const volatile must be an lvalue.</td>
</tr>
<tr>
<td>E0520673</td>
<td>[Message] Using out-of-scope declaration of type &quot;symbol&quot; (declared at line number).</td>
</tr>
<tr>
<td>E0520674</td>
<td>[Message] xxx, required for copy that was eliminated, is inaccessible.</td>
</tr>
<tr>
<td>E0520675</td>
<td>[Message] xxx required for copy that was eliminated, is not callable because reference parameter cannot be bound to rvalue.</td>
</tr>
<tr>
<td>E0520676</td>
<td>[Message] &lt;typeinfo&gt; must be included before typeid is used.</td>
</tr>
<tr>
<td>E0520677</td>
<td>[Message] xxx cannot cast away const or other type qualifiers.</td>
</tr>
<tr>
<td>E0520678</td>
<td>[Message] The type in a dynamic_cast must be a pointer or reference to a complete class type, or void *.</td>
</tr>
<tr>
<td>E0520679</td>
<td>[Message] The operand of a pointer dynamic_cast must be a pointer to a complete class type.</td>
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<td>E0520680</td>
<td>[Message] The operand of a reference dynamic_cast must be an lvalue of a complete class type.</td>
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<td>E0520681</td>
<td>[Message] The operand of a runtime dynamic_cast must have a polymorphic class type.</td>
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<tr>
<td>E0520682</td>
<td>[Message] An array type is not allowed here.</td>
</tr>
<tr>
<td>E0520683</td>
<td>[Message] Expected an &quot;.=&quot;.</td>
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<tr>
<td>E0520684</td>
<td>[Message] Expected a declarator in condition declaration.</td>
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<tr>
<td>E0520685</td>
<td>[Message] xxx, declared in condition, may not be redeclared in this scope.</td>
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<td>E0520686</td>
<td>[Message] Default template arguments are not allowed for function templates.</td>
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<td>E0520687</td>
<td>[Message] Expected a &quot;,&quot; or &quot;&gt;&quot;.</td>
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<td>[Message] Expected a template parameter list.</td>
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<td>E0520689</td>
<td>[Message] bool type is not allowed.</td>
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<td>E0520690</td>
<td>[Message] Offset of base class <code>name1</code> within class <code>name2</code> is too large.</td>
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<td>E0520691</td>
<td>[Message] Expression must have bool type (or be convertible to bool).</td>
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<tr>
<td>E0520692</td>
<td>[Message] The type in a const_cast must be a pointer, reference, or pointer to member to an object type.</td>
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<td>E0520693</td>
<td>[Message] A const_cast can only adjust type qualifiers; it cannot change the underlying type.</td>
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<td>E0520694</td>
<td>[Message] mutable is not allowed.</td>
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<td>E0520695</td>
<td>[Message] namespace definition is not allowed.</td>
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<td>[Message] name must be a namespace name.</td>
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<td>E0520727</td>
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<td>E0520731</td>
<td>[Message] Array with incomplete element type is nonstandard.</td>
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<td>E0520732</td>
<td>[Message] Allocation operator may not be declared in a namespace.</td>
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<td>E0520733</td>
<td>[Message] Deallocation operator may not be declared in a namespace.</td>
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<td>E0520734</td>
<td>[Message] name1 conflicts with using-declaration of name2.</td>
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<td>E0520742</td>
<td>[Message] symbol has no actual member xxx.</td>
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<td>E0520750</td>
<td>[Message] name was used before its template was declared.</td>
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<td>E0520751</td>
<td>[Message] Static and nonstatic member functions with same parameter types cannot be overloaded.</td>
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<td>E0520752</td>
<td>[Message] No prior declaration of &quot;symbol&quot;.</td>
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<td>E0520753</td>
<td>[Message] A template-id is not allowed.</td>
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<td>E0520754</td>
<td>[Message] A class-qualified name is not allowed.</td>
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<td>E0520755</td>
<td>[Message] symbol may not be redeclared in the current scope.</td>
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<td>E0520756</td>
<td>[Message] Qualified name is not allowed in namespace member declaration.</td>
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<td>E0520757</td>
<td>[Message] symbol is not a type name.</td>
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<td>E0520758</td>
<td>[Message] Explicit instantiation is not allowed in the current scope.</td>
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<td>E0520759</td>
<td>[Message] symbol cannot be explicitly instantiated in the current scope.</td>
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<td>E0520761</td>
<td>[Message] typename may only be used within a template.</td>
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<td>[Message] Nonstandard character at start of object-like macro definition.</td>
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<td>[Message] Exception specification for virtual name1 is incompatible with that of overridden name2.</td>
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<td>[Message] Conversion from pointer to smaller integer.</td>
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<td>[Message] Exception specification for implicitly declared virtual name1 is incompatible with that of overridden name2.</td>
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<td>E0520769</td>
<td>[Message] name1, implicitly called from name2, is ambiguous.</td>
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<td>[Message] Declaration conflicts with xxx (reserved class name).</td>
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<td>[Message] Invalid anonymous union -- class member template is not allowed.</td>
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<td>E0520776</td>
<td>Template nesting depth does not match the previous declaration of %n.</td>
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<td>E0520779</td>
<td>xxx, declared in for-loop initialization, may not be redeclared in this scope.</td>
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<td>E0520782</td>
<td>Definition of virtual name is required here.</td>
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<td>A storage class is not allowed in a friend declaration.</td>
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<td>E0520785</td>
<td>Template parameter list for name is not allowed in this declaration.</td>
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<td>E0520786</td>
<td>name is not a valid member class or function template.</td>
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<td>E0520787</td>
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<tr>
<td>E0520788</td>
<td>A template declaration containing a template parameter list may not be followed by an explicit specialization declaration.</td>
</tr>
<tr>
<td>E0520789</td>
<td>Explicit specialization of name1 must precede the first use of name2.</td>
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<tr>
<td>E0520790</td>
<td>Explicit specialization is not allowed in the current scope.</td>
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<tr>
<td>E0520791</td>
<td>Partial specialization of &quot;symbol&quot; is not allowed.</td>
</tr>
<tr>
<td>E0520792</td>
<td>name is not an entity that can be explicitly specialized.</td>
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<tr>
<td>E0520793</td>
<td>Explicit specialization of %n must precede its first use.</td>
</tr>
<tr>
<td>E0520795</td>
<td>Specializing name requires &quot;template&lt;&quot;&quot;&quot; syntax.</td>
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<tr>
<td>E0520799</td>
<td>Specializing symbol without &quot;template&lt;&quot;&quot;&quot; syntax is nonstandard.</td>
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<tr>
<td>E0520800</td>
<td>This declaration may not have extern &quot;C&quot; linkage.</td>
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<tr>
<td>E0520801</td>
<td>name is not a class or function template name in the current scope.</td>
</tr>
<tr>
<td>E0520803</td>
<td>Specifying a default argument when redeclaring an already referenced function template is not allowed.</td>
</tr>
<tr>
<td>E0520804</td>
<td>Cannot convert pointer to member of base class type2 to pointer to member of derived class type1 -- base class is virtual.</td>
</tr>
<tr>
<td>E0520805</td>
<td>Exception specification is incompatible with that of name.</td>
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<tr>
<td>E0520807</td>
<td>Unexpected end of default argument expression.</td>
</tr>
<tr>
<td>E0520808</td>
<td>Default-initialization of reference is not allowed.</td>
</tr>
<tr>
<td>E0520809</td>
<td>Uninitialized &quot;symbol&quot; has a const member.</td>
</tr>
<tr>
<td>E0520810</td>
<td>Uninitialized base class type has a const member.</td>
</tr>
<tr>
<td>E0520811</td>
<td>const name requires an initializer -- class type has an explicitly declared default constructor.</td>
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<tr>
<td>E0520812</td>
<td>Const object requires an initializer -- class type has an explicitly declared default constructor.</td>
</tr>
<tr>
<td>E0520816</td>
<td>In a function definition a type qualifier on a &quot;void&quot; return type is not allowed.</td>
</tr>
<tr>
<td>E0520817</td>
<td>Static data member declaration is not allowed in this class.</td>
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<tr>
<td>E0520818</td>
<td>Template instantiation resulted in an invalid function declaration.</td>
</tr>
<tr>
<td>E0520819</td>
<td>... is not allowed.</td>
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<td>E0520822</td>
<td>Invalid destructor name for type type.</td>
</tr>
<tr>
<td>E0520824</td>
<td>Destructor reference is ambiguous -- both name1 and name2 could be used.</td>
</tr>
<tr>
<td>E0520827</td>
<td>Only one member of a union may be specified in a constructor initializer list.</td>
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<tr>
<td>Code</td>
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<td>-------------------------------------------------------------------------</td>
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<tr>
<td>E0520828</td>
<td>[Message] Support for &quot;new[]&quot; and &quot;delete[]&quot; is disabled.</td>
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<tr>
<td>E0520832</td>
<td>[Message] No appropriate operator delete is visible.</td>
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<tr>
<td>E0520833</td>
<td>[Message] Pointer or reference to incomplete type is not allowed.</td>
</tr>
<tr>
<td>E0520834</td>
<td>[Message] Invalid partial specialization -- name is already fully specialized.</td>
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<tr>
<td>E0520835</td>
<td>[Message] Incompatible exception specifications.</td>
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<tr>
<td>E0520840</td>
<td>[Message] A template argument list is not allowed in a declaration of a primary template.</td>
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<tr>
<td>E0520841</td>
<td>[Message] Partial specializations may not have default template arguments.</td>
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<tr>
<td>E0520842</td>
<td>[Message] name1 is not used in or cannot be deduced from the template argument list of name2.</td>
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<tr>
<td>E0520844</td>
<td>[Message] The template argument list of the partial specialization includes a nontype argument whose type depends on a template parameter.</td>
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<tr>
<td>E0520845</td>
<td>[Message] This partial specialization would have been used to instantiate name.</td>
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<tr>
<td>E0520846</td>
<td>[Message] This partial specialization would have made the instantiation of name ambiguous.</td>
</tr>
<tr>
<td>E0520847</td>
<td>[Message] Expression must have integral or enum type.</td>
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<tr>
<td>E0520848</td>
<td>[Message] Expression must have arithmetic or enum type.</td>
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<tr>
<td>E0520849</td>
<td>[Message] Expression must have arithmetic, enum, or pointer type.</td>
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<tr>
<td>E0520850</td>
<td>[Message] Type of cast must be integral or enum.</td>
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<tr>
<td>E0520851</td>
<td>[Message] Type of cast must be arithmetic, enum, or pointer.</td>
</tr>
<tr>
<td>E0520852</td>
<td>[Message] Expression must be a pointer to a complete object type.</td>
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<tr>
<td>E0520854</td>
<td>[Message] A partial specialization nontype argument must be the name of a nontype parameter or a constant.</td>
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<td>E0520855</td>
<td>[Message] Return type is not identical to return type type of overridden virtual function name.</td>
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<td>E0520857</td>
<td>[Message] A partial specialization of a class template must be declared in the namespace of which it is a member.</td>
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<tr>
<td>E0520858</td>
<td>[Message] name is a pure virtual function.</td>
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<tr>
<td>E0520859</td>
<td>[Message] Pure virtual name has no overrider.</td>
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<td>E0520861</td>
<td>[Message] Invalid character in input line.</td>
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<td>E0520862</td>
<td>[Message] Function returns incomplete type &quot;type&quot;.</td>
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<tr>
<td>E0520864</td>
<td>[Message] name is not a template.</td>
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<td>E0520865</td>
<td>[Message] A friend declaration may not declare a partial specialization.</td>
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<td>[Message] Space required between adjacent &quot;-&gt;&quot; delimiters of nested template argument lists (&quot;&gt;&gt;&quot; is the right shift operator).</td>
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<td>E0520870</td>
<td>[Message] Invalid multibyte character sequence.</td>
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<td>[Message] Template instantiation resulted in unexpected function type of type1 (the meaning of a name may have changed since the template declaration -- the type of the template is type2).</td>
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<td>E0520872</td>
<td>[Message] Ambiguous guiding declaration -- more than one function template name matches type type.</td>
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<td>[Message] Non-integral operation not allowed in nontype template argument.</td>
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<td>E0520875</td>
<td>[Message] Embedded C++ does not support templates.</td>
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<td>E0520954</td>
<td>[Message] A return statement is not allowed in a handler of a function try block of a constructor.</td>
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<td>E0520955</td>
<td>[Message] Ordinary and extended designators cannot be combined in an initializer designation.</td>
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<td>E0520956</td>
<td>[Message] The second subscript must not be smaller than the first.</td>
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<td>E0520960</td>
<td>[Message] Type used as constructor name does not match type type.</td>
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<td>E0520961</td>
<td>[Message] Use of a type with no linkage to declare a variable with linkage.</td>
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<tr>
<td>E0520962</td>
<td>[Message] Use of a type with no linkage to declare a function.</td>
</tr>
<tr>
<td>E0520963</td>
<td>[Message] Return type may not be specified on a constructor.</td>
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<tr>
<td>E0520964</td>
<td>[Message] Return type may not be specified on a destructor.</td>
</tr>
<tr>
<td>E0520965</td>
<td>[Message] Incorrectly formed universal character name.</td>
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<td>E0520966</td>
<td>[Message] Universal character name specifies an invalid character.</td>
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<tr>
<td>E0520967</td>
<td>[Message] A universal character name cannot designate a character in the basic character set.</td>
</tr>
<tr>
<td>E0520968</td>
<td>[Message] This universal character is not allowed in an identifier.</td>
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<td>E0520969</td>
<td>[Message] The identifier <strong>VA_ARGS</strong> can only appear in the replacement lists of variadic macros.</td>
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<tr>
<td>E0520971</td>
<td>[Message] Array range designators cannot be applied to dynamic initializers.</td>
</tr>
<tr>
<td>E0520975</td>
<td>[Message] A variable-length array type is not allowed.</td>
</tr>
<tr>
<td>E0520976</td>
<td>[Message] A compound literal is not allowed in an integral constant expression.</td>
</tr>
<tr>
<td>E0520977</td>
<td>[Message] A compound literal of type &quot;type&quot; is not allowed.</td>
</tr>
<tr>
<td>E0520978</td>
<td>[Message] A template friend declaration cannot be declared in a local class.</td>
</tr>
<tr>
<td>E0520979</td>
<td>[Message] Ambiguous &quot;?&quot; operation: second operand of type type1 can be converted to third operand type type2, and vice versa.</td>
</tr>
<tr>
<td>E0520980</td>
<td>[Message] Call of an object of a class type without appropriate operator() or conversion functions to pointer-to-function type.</td>
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<td>E0520982</td>
<td>[Message] There is more than one way an object of type &quot;type&quot; can be called for the argument list:</td>
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<tr>
<td>E0520983</td>
<td>[Message] typedef name has already been declared (with similar type).</td>
</tr>
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<td>E0520985</td>
<td>[Message] Storage class &quot;mutable&quot; is not allowed for anonymous unions.</td>
</tr>
<tr>
<td>E0520987</td>
<td>[Message] Abstract class type type is not allowed as catch type:</td>
</tr>
<tr>
<td>E0520988</td>
<td>[Message] A qualified function type cannot be used to declare a nonmember function or a static member function.</td>
</tr>
<tr>
<td>E0520989</td>
<td>[Message] A qualified function type cannot be used to declare a parameter.</td>
</tr>
<tr>
<td>E0520990</td>
<td>[Message] Cannot create a pointer or reference to qualified function type.</td>
</tr>
<tr>
<td>E0520992</td>
<td>[Message] Invalid macro definition:</td>
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<tr>
<td>E0520993</td>
<td>[Message] Subtraction of pointer types &quot;type1&quot; and &quot;type2&quot; is nonstandard.</td>
</tr>
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<td>E0520994</td>
<td>[Message] An empty template parameter list is not allowed in a template template parameter declaration.</td>
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<td>E0520995</td>
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<tr>
<td>E0521042</td>
<td>Incorrect use of va_copy.</td>
</tr>
<tr>
<td>E0521043</td>
<td>xxx can only be used with floating-point types.</td>
</tr>
<tr>
<td>E0521044</td>
<td>Complex type is not allowed.</td>
</tr>
<tr>
<td>E0521045</td>
<td>Invalid designator kind.</td>
</tr>
<tr>
<td>E0521047</td>
<td>Complex floating-point operation result is out of range.</td>
</tr>
<tr>
<td>E0521048</td>
<td>Conversion between real and imaginary yields zero.</td>
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<tr>
<td>E0521049</td>
<td>An initializer cannot be specified for a flexible array member.</td>
</tr>
<tr>
<td>E0521051</td>
<td>Standard requires that &quot;symbol&quot; be given a type by a subsequent declaration (&quot;int&quot; assumed).</td>
</tr>
<tr>
<td>E0521052</td>
<td>A definition is required for inline &quot;symbol&quot;.</td>
</tr>
<tr>
<td>E0521054</td>
<td>A floating-point type must be included in the type specifier for a _Complex or _Imaginary type.</td>
</tr>
<tr>
<td>E0521055</td>
<td>Types cannot be declared in anonymous unions.</td>
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<tr>
<td>E0521056</td>
<td>Returning pointer to local variable.</td>
</tr>
<tr>
<td>E0521057</td>
<td>Returning pointer to local temporary.</td>
</tr>
<tr>
<td>E0521061</td>
<td>Declaration of &quot;symbol&quot; is incompatible with a declaration in another translation unit.</td>
</tr>
<tr>
<td>E0521062</td>
<td>The other declaration is %p.</td>
</tr>
<tr>
<td>E0521065</td>
<td>A field declaration cannot have a type involving a variable length array.</td>
</tr>
<tr>
<td>E0521066</td>
<td>Declaration of &quot;symbol&quot; had a different meaning during compilation of file.</td>
</tr>
<tr>
<td>E0521067</td>
<td>Expected &quot;template&quot;.</td>
</tr>
<tr>
<td>E0521072</td>
<td>A declaration cannot have a label.</td>
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<td>E0521075</td>
<td>&quot;symbol&quot; already defined during compilation of any-string.s</td>
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<tr>
<td>E0521076</td>
<td>&quot;symbol&quot; already defined in another translation unit.</td>
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<td>E0521081</td>
<td>A field with the same name as its class cannot be declared in a class with a user-declared constructor.</td>
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<td>E0521086</td>
<td>The object has cv-qualifiers that are not compatible with the member &quot;symbol&quot;.</td>
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<tr>
<td>E0521087</td>
<td>No instance of xxx matches the argument list and object (the object has cv-qualifiers that prevent a match).</td>
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<tr>
<td>E0521088</td>
<td>An attribute specifies a mode incompatible with xxx.</td>
</tr>
<tr>
<td>E0521089</td>
<td>There is no type with the width specified.</td>
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<tr>
<td>E0521139</td>
<td>The &quot;template&quot; keyword used for syntactic disambiguation may only be used within a template.</td>
</tr>
<tr>
<td>E0521144</td>
<td>Storage class must be auto or register.</td>
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<td>E0521146</td>
<td>xxx is not a base class member.</td>
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<td>E0521158</td>
<td>void return type cannot be qualified.</td>
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<tr>
<td>E0521161</td>
<td>A member template corresponding to xxx is declared as a template of a different kind in another translation unit.</td>
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<td>va_start should only appear in a function with an ellipsis parameter.</td>
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<td>[Message]</td>
</tr>
<tr>
<td>E0521317</td>
<td>[Message]</td>
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<tr>
<td>E0521318</td>
<td>[Message]</td>
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<td>E0521321</td>
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<td>E0521323</td>
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<td>E0521326</td>
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<tr>
<td>E0521327</td>
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<tr>
<td>E0521344</td>
<td>[Message]</td>
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<tr>
<td>E0521345</td>
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<tr>
<td>E0521348</td>
<td>[Message]</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
</tr>
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<td>-------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0521349</td>
<td>A parameter cannot be allocated in a named address space.</td>
</tr>
<tr>
<td>E0521350</td>
<td>Invalid suffix on fixed-point or floating-point constant.</td>
</tr>
<tr>
<td>E0521351</td>
<td>A register variable cannot be allocated in a named address space.</td>
</tr>
<tr>
<td>E0521352</td>
<td>Expected &quot;SAT&quot; or &quot;DEFAULT&quot;.</td>
</tr>
<tr>
<td>E0521355</td>
<td>A function return type cannot be qualified with a named address space.</td>
</tr>
<tr>
<td>E0521365</td>
<td>Named-register variables cannot have void type.</td>
</tr>
<tr>
<td>E0521372</td>
<td>Nonstandard qualified name in global scope declaration.</td>
</tr>
<tr>
<td>E0521380</td>
<td>Virtual xxx was not defined (and cannot be defined elsewhere because it is a member of an unnamed namespace).</td>
</tr>
<tr>
<td>E0521381</td>
<td>Carriage return character in source line outside of comment or character/string literal.</td>
</tr>
<tr>
<td>E0521382</td>
<td>Expression must have fixed-point type.</td>
</tr>
<tr>
<td>E0521398</td>
<td>Invalid member for anonymous member class -- class xxx has a disallowed member function.</td>
</tr>
<tr>
<td>E0521403</td>
<td>A variable-length array is not allowed in a function return type.</td>
</tr>
<tr>
<td>E0521404</td>
<td>Variable-length array type is not allowed in pointer to member of type &quot;type&quot;.</td>
</tr>
<tr>
<td>E0521405</td>
<td>The result of a statement expression cannot have a type involving a variable-length array.</td>
</tr>
<tr>
<td>E0521420</td>
<td>Some enumerator values cannot be represented by the integral type underlying the enum type.</td>
</tr>
<tr>
<td>E0521424</td>
<td>Second operand of offsetof must be a field.</td>
</tr>
<tr>
<td>E0521425</td>
<td>Second operand of offsetof may not be a bit field.</td>
</tr>
<tr>
<td>E0521436</td>
<td>xxx is only allowed in C.</td>
</tr>
<tr>
<td>E0521437</td>
<td>__ptr32 and __ptr64 must follow a &quot;***&quot;.</td>
</tr>
<tr>
<td>E0521441</td>
<td>Complex integral types are not supported.</td>
</tr>
<tr>
<td>E0521442</td>
<td>__real and __imag can only be applied to complex values.</td>
</tr>
<tr>
<td>E0521445</td>
<td>Invalid redefinition of &quot;symbol&quot;.</td>
</tr>
<tr>
<td>E0521534</td>
<td>Duplicate function modifier.</td>
</tr>
<tr>
<td>E0521535</td>
<td>Invalid character for char16_t literal.</td>
</tr>
<tr>
<td>E0521536</td>
<td>__LPREFIX cannot be applied to char16_t or char32_t literals.</td>
</tr>
<tr>
<td>E0521537</td>
<td>Unrecognized calling convention xxx must be one of:</td>
</tr>
<tr>
<td>E0521539</td>
<td>Option &quot;--uliterals&quot; can be used only when compiling C.</td>
</tr>
<tr>
<td>E0521542</td>
<td>Some enumerator constants cannot be represented by &quot;type&quot;.</td>
</tr>
<tr>
<td>E0521543</td>
<td>xxx not allowed in current mode.</td>
</tr>
<tr>
<td>E0521557</td>
<td>Alias creates cycle of aliased entities.</td>
</tr>
<tr>
<td>E0521558</td>
<td>Subscript must be constant.</td>
</tr>
<tr>
<td>E0521574</td>
<td>Static assertion failed with xxx.</td>
</tr>
<tr>
<td>E0521576</td>
<td>[Message]</td>
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<td>E0521577</td>
<td>[Message]</td>
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<td>[Message]</td>
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<td>E0521598</td>
<td>[Message]</td>
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<tr>
<td>E0521602</td>
<td>[Message]</td>
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<tr>
<td>E0521603</td>
<td>[Message]</td>
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<td>E0521604</td>
<td>[Message]</td>
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<tr>
<td>E0521605</td>
<td>[Message]</td>
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<tr>
<td>E0521606</td>
<td>[Message]</td>
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<tr>
<td></td>
<td>[Explanation]</td>
</tr>
<tr>
<td>E0521608</td>
<td>[Message]</td>
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<tr>
<td>E0521609</td>
<td>[Message]</td>
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<td>E0521610</td>
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<td>[Message]</td>
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<td>E0521615</td>
<td>[Message]</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
</tr>
<tr>
<td>E0521616</td>
<td>[Message]</td>
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<tr>
<td>E0521617</td>
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<tr>
<td>E0521618</td>
<td>[Message]</td>
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<tr>
<td>E0521619</td>
<td>[Message]</td>
</tr>
<tr>
<td>E0521620</td>
<td>[Message]</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0521621</td>
<td>[Message] Cannot write I/O register &quot;register name&quot;.</td>
</tr>
<tr>
<td>E0521622</td>
<td>[Message] Cannot read I/O register &quot;register name&quot;.</td>
</tr>
<tr>
<td>E0521624</td>
<td>[Message] Second argument for __set_il() must be string literal.</td>
</tr>
<tr>
<td>E0521625</td>
<td>[Message] Cannot set interrupt level for &quot;request&quot;.</td>
</tr>
<tr>
<td>E0521626</td>
<td>[Message] Specification character string is specified for function &quot;function name&quot;, previously specified #pragma inline is ignored.</td>
</tr>
<tr>
<td>E0521627</td>
<td>[Message] Function for #pragma smart_correct is same.</td>
</tr>
<tr>
<td>E0521628</td>
<td>[Message] Function for #pragma smart_correct &quot;function&quot; is undefined.</td>
</tr>
<tr>
<td>E0521629</td>
<td>[Message] Could not open symbol file &quot;file name&quot;.</td>
</tr>
<tr>
<td>E0521630</td>
<td>[Message] Could not close symbol file &quot;file name&quot;.</td>
</tr>
<tr>
<td>E0521632</td>
<td>[Message] Unrecognized symbol information &quot;character string&quot; is ignored.</td>
</tr>
<tr>
<td>E0521633</td>
<td>[Message] Section name is not specified.</td>
</tr>
<tr>
<td>E0521634</td>
<td>[Message] Unrecognized section name &quot;section&quot;.</td>
</tr>
<tr>
<td>E0521635</td>
<td>[Message] &quot;variable name&quot; has already been placed into &quot;section name&quot; section in symbol file. The latter is ignored.</td>
</tr>
<tr>
<td>E0521636</td>
<td>[Message] &quot;variable name&quot; has already been placed into &quot;section name&quot; section in symbol file. #pragma is ignored.</td>
</tr>
<tr>
<td>E0521637</td>
<td>[Message] Illegal binary digit.</td>
</tr>
<tr>
<td>E0521638</td>
<td>[Message] First argument for special function name() must be integer constant.</td>
</tr>
<tr>
<td>E0521639</td>
<td>[Message] Function &quot;function name&quot; specified as &quot;direct&quot; can not be allocated in text.</td>
</tr>
<tr>
<td>E0521640</td>
<td>[Message] Function allocated in text can not be specified #pragma interrupt with &quot;direct&quot;.</td>
</tr>
<tr>
<td>E0521641</td>
<td>[Message] FE level interrupt not supported.</td>
</tr>
<tr>
<td>E0521642</td>
<td>[Message] Cannot give a name for &quot;attribute&quot; section.</td>
</tr>
<tr>
<td>E0521643</td>
<td>[Message] &quot;direct&quot; cannot be specified for plural interrupt.</td>
</tr>
<tr>
<td>E0521644</td>
<td>[Message] Reduced exception handler option of device is available. Address of the handler-maybe overlaps.</td>
</tr>
<tr>
<td>E0521645</td>
<td>[Message] Function &quot;function name&quot; has illegal type for interrupt function, must be void(void).</td>
</tr>
<tr>
<td>E0521646</td>
<td>[Message] Cannot use direct with NO VECT.</td>
</tr>
<tr>
<td>E0521647</td>
<td>[Message] character string is not allowed here.</td>
</tr>
<tr>
<td>E0521648</td>
<td>[Message] Cannot call type function &quot;function name&quot;.</td>
</tr>
<tr>
<td>E0521649</td>
<td>[Message] Cannot use character string1 with character string2.</td>
</tr>
</tbody>
</table>

[Explanation] The functions of string 1 and string 2 cannot be used at the same time.

[Message] [CC-RX] White space is required between the macro name xxx and its replacement text.

[Action by User] [CC-RX] Insert white space between the macro name and its replacement text.
<table>
<thead>
<tr>
<th>Code</th>
<th>[Message]</th>
<th>[Explanation]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0521650</td>
<td><strong>type</strong> &quot;symbol name&quot; has already been declared with other #pragma pic/nopic.</td>
<td>There is a &quot;#pragma pic/nopic&quot; specification in conflict with <strong>type</strong> &quot;symbol name&quot;.</td>
</tr>
<tr>
<td>E0523005</td>
<td>Invalid pragma declaration</td>
<td>Write the #pragma syntax in accord with the correct format.</td>
</tr>
<tr>
<td>E0523006</td>
<td>&quot;symbol name&quot; has already been specified by other pragma</td>
<td>Two or more #pragma directives have been specified for one symbol, and such specification is not allowed.</td>
</tr>
<tr>
<td>E0523007</td>
<td>Pragma may not be specified after definition</td>
<td>The #pragma directive precedes definition of the target symbol.</td>
</tr>
<tr>
<td>E0523008</td>
<td>Invalid kind of pragma is specified to this symbol</td>
<td>The given type of #pragma directive is not specifiable for the symbol.</td>
</tr>
<tr>
<td>E0523042</td>
<td>Using &quot;function item&quot; function at influence the code generation of &quot;SuperH&quot; compiler</td>
<td>The use of &quot;function item&quot; may affect compatibility with the SuperH compiler. Confirm details of differences from the specification.</td>
</tr>
<tr>
<td>E0523047</td>
<td>Illegal #pragma interrupt declaration</td>
<td>The interrupt function declaration by #pragma interrupt is incorrect.</td>
</tr>
<tr>
<td>E0523049</td>
<td>Multiple #pragma for one function</td>
<td>Two or more #pragma directives have been specified for one symbol, and such specification is not allowed.</td>
</tr>
<tr>
<td>E0523057</td>
<td>Illegal section specified</td>
<td>Strings that are not usable for the purpose were used to specify the attributes of sections.</td>
</tr>
<tr>
<td>E0523058</td>
<td>Illegal #pragma section syntax</td>
<td>The #pragma section syntax is illegal.</td>
</tr>
<tr>
<td>E0523059</td>
<td>Cannot change text section</td>
<td>The #pragma section syntax is incorrect.</td>
</tr>
<tr>
<td>E0523061</td>
<td>Argument is incompatible with formal parameter of intrinsic function.</td>
<td></td>
</tr>
<tr>
<td>E0523062</td>
<td>Return value type does not match the intrinsic function type.</td>
<td></td>
</tr>
<tr>
<td>E0523065</td>
<td>Cannot assign address constant to initializer for bitfield</td>
<td>An address constant cannot be written as the initial value of a bit field.</td>
</tr>
<tr>
<td>E0523066</td>
<td>The combination of the option and section specification is inaccurate</td>
<td></td>
</tr>
<tr>
<td>E0523129</td>
<td>The &quot;option name&quot; option is necessary for use of &quot;function&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0523002</td>
<td>Exception exception has occurred at compile time.</td>
<td></td>
</tr>
<tr>
<td>E0544003</td>
<td>The size of &quot;section name&quot; section exceeds the limit.</td>
<td></td>
</tr>
<tr>
<td>E0544240</td>
<td>Illegal naming of section &quot;section name&quot;.</td>
<td>There is an error in section naming. The same section name is specified for different use of the section.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0544854</td>
<td>Illegal address was specified with #pragma address.</td>
<td>&quot;#pragma address&quot; specification satisfies either of the following conditions. (1) The same address was specified for different variables. (2) Overlapping address ranges were specified for different variables.</td>
</tr>
<tr>
<td>E0552000</td>
<td>No space after mnemonic or directive.</td>
<td>The mnemonic or assemble directive is not followed by a space character.</td>
</tr>
<tr>
<td>E0552001</td>
<td>',' is missing.</td>
<td>' , ' is not entered.</td>
</tr>
<tr>
<td>E0552002</td>
<td>Characters exist in expression.</td>
<td>Extra characters are written in an instruction or expression.</td>
</tr>
<tr>
<td>E0552003</td>
<td>Size specifier is missing.</td>
<td>No size specifier is entered.</td>
</tr>
<tr>
<td>E0552004</td>
<td>Invalid operand(s) exist in instruction.</td>
<td>The instruction contains an invalid operand.</td>
</tr>
<tr>
<td>E0552005</td>
<td>Operand type is not appropriate.</td>
<td>The operand type is incorrect.</td>
</tr>
<tr>
<td>E0552006</td>
<td>Size specifier is not appropriate.</td>
<td>The size specifier is written incorrectly.</td>
</tr>
<tr>
<td>E0552007</td>
<td>Operand label is not in the same section.</td>
<td>The branch destination is not in the same section.</td>
</tr>
<tr>
<td>E0552008</td>
<td>Illegal displacement value.</td>
<td>An illegal displacement value is specified.</td>
</tr>
<tr>
<td>E0552009</td>
<td>FPU instruction or FPSW is used.</td>
<td>A floating-point operation (FPU) instruction or FPSW is used.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
<td>Action by User</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0552010</td>
<td>ISAV2 instruction or EXTB is used</td>
<td>Check the RX instruction-set architecture selected by the -isa option or environment variable ISA_RX.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E0552011</td>
<td>Type instruction is used.</td>
<td>Instructions of the indicated type are not usable with the current settings of options or environment variables. Change the settings as required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E0552020</td>
<td>Invalid operand(s) exist in debug information</td>
<td>The operand of the .line directive is invalid.</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>E0552022</td>
<td>Symbol name is missing.</td>
<td>Symbol is not entered.</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>E0552023</td>
<td>Illegal directive command is used</td>
<td>An illegal instruction is entered.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E0552024</td>
<td>No ';' at the top of comment.</td>
<td>Enter a semicolon at the beginning of each comment. Check whether the mnemonic or operand is written correctly.</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>E0552026</td>
<td>'CODE' section in big endian is not appropriate.</td>
<td>Specify a multiple of 4 for the start address.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E0552027</td>
<td>Illegal character code.</td>
<td></td>
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<tr>
<td>E0552028</td>
<td>Unrecognized character escape sequence.</td>
<td></td>
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<tr>
<td>E0552029</td>
<td>Invalid description in #pragma inline_asm function.</td>
<td></td>
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<tr>
<td>E0552040</td>
<td>Include nesting over.</td>
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<tr>
<td>E0552041</td>
<td>Can't open include file 'XXXX'.</td>
<td></td>
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<tr>
<td>E0552042</td>
<td>Including the include file in itself.</td>
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<tr>
<td>E0552049</td>
<td>[Message]</td>
<td>Invalid reserved word exist in operand.</td>
</tr>
<tr>
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<td>---------------------------------------</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The operand contains a reserved word.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Reserved words cannot be written in an operand. Rewrite the operand correctly.</td>
</tr>
<tr>
<td>E0552050</td>
<td>[Message]</td>
<td>Operand value is not defined.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>An undefined operand value is entered.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Write a valid value for operands.</td>
</tr>
<tr>
<td>E0552051</td>
<td>[Message]</td>
<td>'{' is missing.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>'{' is not specified.</td>
</tr>
<tr>
<td>E0552052</td>
<td>[Message]</td>
<td>Addressing mode specifier is not appropriate.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The addressing mode specifier is written incorrectly.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Make sure that the addressing mode is written correctly.</td>
</tr>
<tr>
<td>E0552053</td>
<td>[Message]</td>
<td>Reserved word is missing.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>No reserved word is entered.</td>
</tr>
<tr>
<td>E0552054</td>
<td>[Message]</td>
<td>']' is missing.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>']' is not entered.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Write the right bracket ']' corresponding to the '['.</td>
</tr>
<tr>
<td>E0552055</td>
<td>[Message]</td>
<td>Right quote is missing.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>A right quote is not entered.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Enter the right quote.</td>
</tr>
<tr>
<td>E0552056</td>
<td>[Message]</td>
<td>The value is not constant.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The value is indeterminate when assembled.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Write an expression, symbol name, or label name that will have a determinate value when assembled.</td>
</tr>
<tr>
<td>E0552057</td>
<td>[Message]</td>
<td>Quote is missing.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>Quotes for a character string are not entered.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Enclose a character string with quotes as you write it.</td>
</tr>
<tr>
<td>E0552058</td>
<td>[Message]</td>
<td>Illegal operand is used.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The operand is incorrect.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Check the syntax for this operand and rewrite it correctly.</td>
</tr>
<tr>
<td>E0552059</td>
<td>[Message]</td>
<td>Operand number is not enough.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The number of operands is insufficient.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Check the syntax for these operands and rewrite them correctly.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The macro is nested too many levels.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Make sure that the macro is nested no more than 65,535 levels. Check the syntax for this source statement and rewrite it correctly.</td>
</tr>
<tr>
<td>ID</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>E0552061</td>
<td>[Message] Too many macro local label definition.</td>
<td>[Explanation] Too many macro local labels are defined.</td>
</tr>
<tr>
<td>E0552062</td>
<td>[Message] '.MACRO' is missing for '.ENDM'.</td>
<td>[Explanation] .MACRO for .ENDM is not found.</td>
</tr>
<tr>
<td>E0552063</td>
<td>[Message] '.MREPEAT' is missing for '.ENDR'.</td>
<td>[Explanation] .MREPEAT for .ENDR is not found.</td>
</tr>
<tr>
<td>E0552064</td>
<td>[Message] '.MACRO' or '.MREPEAT' is missing for '.EXITM'.</td>
<td>[Explanation] .MACRO or .MREPEAT for .EXITM is not found.</td>
</tr>
<tr>
<td>E0552065</td>
<td>[Message] No macro name.</td>
<td>[Explanation] No macro name is entered.</td>
</tr>
<tr>
<td>E0552066</td>
<td>[Message] Too many formal parameter.</td>
<td>[Explanation] There are too many formal parameters defined for the macro.</td>
</tr>
<tr>
<td>E0552068</td>
<td>[Message] Source line is too long.</td>
<td>[Explanation] The source line is excessively long.</td>
</tr>
<tr>
<td>E0552069</td>
<td>[Message] '.MACRO' is missing for '.LOCAL'.</td>
<td>[Explanation] .MACRO for .LOCAL is not found.</td>
</tr>
<tr>
<td>E0552070</td>
<td>[Message] No '.ENDM' statement.</td>
<td>[Explanation] .ENDM is not entered.</td>
</tr>
<tr>
<td>E0552071</td>
<td>[Message] No '.ENDR' statement.</td>
<td>[Explanation] .ENDR is not entered.</td>
</tr>
<tr>
<td>Message ID</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>E0552072</td>
<td>')' is missing.</td>
<td>')' is not entered.</td>
</tr>
<tr>
<td>E0552073</td>
<td>Operand expression is not completed.</td>
<td>The operand description is not complete.</td>
</tr>
<tr>
<td>E0552074</td>
<td>Syntax error in expression.</td>
<td>The expression is written incorrectly.</td>
</tr>
<tr>
<td>E0552075</td>
<td>String value exist in expression.</td>
<td>A character string is entered in the expression.</td>
</tr>
<tr>
<td>E0552076</td>
<td>Division by zero.</td>
<td>A divide by 0 operation is attempted.</td>
</tr>
<tr>
<td>E0552077</td>
<td>No '.END' statement.</td>
<td>.END is not entered.</td>
</tr>
<tr>
<td>E0552078</td>
<td>The specified address overlaps at 'address'.</td>
<td>Something has already been allocated to 'address'.</td>
</tr>
<tr>
<td>E0552080</td>
<td>'.IF' is missing for '.ELSE'.</td>
<td>.IF for .ELSE is not found.</td>
</tr>
<tr>
<td>E0552081</td>
<td>'.IF' is missing for '.ELIF'.</td>
<td>.IF for .ELIF is not found.</td>
</tr>
<tr>
<td>E0552082</td>
<td>'.IF' is missing for '.ENDIF'.</td>
<td>.IF for .ENDIF is not found.</td>
</tr>
<tr>
<td>E0552083</td>
<td>Too many nesting level of condition assemble.</td>
<td>Condition assembling is nested too many levels.</td>
</tr>
<tr>
<td>E0552084</td>
<td>No '.ENDIF' statement.</td>
<td>No corresponding .ENDIF is found for the .IF statement in the source file.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>E0552088</td>
<td>Can't open <code>.ASSERT</code> message file 'XXXX'.</td>
<td>The <code>.ASSERT</code> output file cannot be opened.</td>
</tr>
<tr>
<td>E0552089</td>
<td>Can't write <code>.ASSERT</code> message file 'XXXX'.</td>
<td>Data cannot be written to the <code>.ASSERT</code> output file.</td>
</tr>
<tr>
<td>E0552090</td>
<td>Too many temporary label.</td>
<td>There are too many temporary labels.</td>
</tr>
<tr>
<td>E0552091</td>
<td>Temporary label is undefined.</td>
<td>The temporary label is not defined yet.</td>
</tr>
<tr>
<td>E0552100</td>
<td>Value is out of range.</td>
<td>The value is out of range.</td>
</tr>
<tr>
<td>E0552112</td>
<td>Symbol is missing.</td>
<td>Symbol is not entered.</td>
</tr>
<tr>
<td>E0552113</td>
<td>Symbol definition is not appropriate.</td>
<td>The symbol is defined incorrectly.</td>
</tr>
<tr>
<td>E0552114</td>
<td>Symbol has already defined as another type.</td>
<td>The symbol has already been defined in a different directive with the same name.</td>
</tr>
<tr>
<td>E0552115</td>
<td>Symbol has already defined as the same type.</td>
<td>The symbol has already been defined.</td>
</tr>
<tr>
<td>E0552116</td>
<td>Symbol is multiple defined.</td>
<td>The symbol is defined twice or more.</td>
</tr>
<tr>
<td>E0552117</td>
<td>Invalid label definition.</td>
<td>An invalid label is entered.</td>
</tr>
<tr>
<td>E0552118</td>
<td>Invalid symbol definition.</td>
<td>An invalid symbol is entered.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0552119</td>
<td>[Message] Reserved word is used as label or symbol.</td>
<td>[Explanation] Reserved word is used as a label or symbol.</td>
</tr>
<tr>
<td>E0552120</td>
<td>[Message] Created symbol is too long</td>
<td>[Explanation] The label for a reserved word created by the <code>-create_unfilled_area</code> option is too long.</td>
</tr>
<tr>
<td>E0552130</td>
<td>[Message] No <code>.SECTION</code> statement.</td>
<td>[Explanation] .SECTION is not entered.</td>
</tr>
<tr>
<td>E0552131</td>
<td>[Message] Section type is not appropriate.</td>
<td>[Explanation] An instruction or a directive used in a section does not match the section type.</td>
</tr>
<tr>
<td>E0552132</td>
<td>[Message] Section has already determined as attribute.</td>
<td>[Explanation] The attribute of this section has already been defined as relative. Directive command <code>.ORG</code> cannot be written here.</td>
</tr>
<tr>
<td>E0552133</td>
<td>[Message] Section attribute is not defined.</td>
<td>[Explanation] Section attribute is not defined. Directive command <code>.ALIGN</code> cannot be written in this section.</td>
</tr>
<tr>
<td>E0552134</td>
<td>[Message] Section name is missing.</td>
<td>[Explanation] No section name is entered.</td>
</tr>
<tr>
<td>E0552135</td>
<td>[Message] 'ALIGN' is multiple specified in <code>.SECTION</code>.</td>
<td>[Explanation] Two or more ALIGN's are specified in the .SECTION definition line.</td>
</tr>
<tr>
<td>E0552136</td>
<td>[Message] Section type is multiple specified.</td>
<td>[Explanation] Section type is specified two or more times in the section definition line.</td>
</tr>
<tr>
<td>E0552137</td>
<td>[Message] Too many operand.</td>
<td>[Explanation] There are extra operands.</td>
</tr>
<tr>
<td>E0562000</td>
<td>[Message] Invalid option : &quot;option&quot;</td>
<td>[Explanation] <code>option</code> is not supported.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0562001</td>
<td>Option &quot;option&quot; cannot be specified on command line</td>
<td>option cannot be specified on the command line.</td>
</tr>
<tr>
<td>E0562002</td>
<td>Input option cannot be specified on command line</td>
<td>The input option was specified on the command line.</td>
</tr>
<tr>
<td>E0562003</td>
<td>Subcommand option cannot be specified in subcommand file</td>
<td>The -subcommand option was specified in a subcommand file. The -subcommand option cannot be nested.</td>
</tr>
<tr>
<td>E0562004</td>
<td>Option &quot;option1&quot; cannot be combined with option &quot;option2&quot;</td>
<td>option 1 and option 2 cannot be specified simultaneously.</td>
</tr>
<tr>
<td>E0562005</td>
<td>Option &quot;option&quot; cannot be specified while processing &quot;process&quot;</td>
<td>option cannot be specified for process.</td>
</tr>
<tr>
<td>E0562006</td>
<td>Option &quot;option1&quot; is ineffective without option &quot;option2&quot;</td>
<td>option 1 requires option 2 be specified.</td>
</tr>
<tr>
<td>E0562010</td>
<td>Option &quot;option&quot; requires parameter</td>
<td>option requires a parameter to be specified.</td>
</tr>
<tr>
<td>E0562011</td>
<td>Invalid parameter specified in option &quot;option&quot; : &quot;parameter&quot;</td>
<td>An invalid parameter was specified for option.</td>
</tr>
<tr>
<td>E0562012</td>
<td>Invalid number specified in option &quot;option&quot; : &quot;value&quot;</td>
<td>An invalid value was specified for option.</td>
</tr>
<tr>
<td>E0562013</td>
<td>Invalid address value specified in option &quot;option&quot; : &quot;address&quot;</td>
<td>The address address specified in option is invalid.</td>
</tr>
<tr>
<td>E0562014</td>
<td>Illegal symbol/section name specified in &quot;option&quot; : &quot;name&quot;</td>
<td>The section or symbol name specified in option uses an illegal character.</td>
</tr>
<tr>
<td>E0562016</td>
<td>Invalid alignment value specified in option &quot;option&quot; : &quot;alignment value&quot;</td>
<td>The alignment value specified in option is invalid.</td>
</tr>
<tr>
<td>E0562017</td>
<td>Cannot output &quot;section&quot; specified in option &quot;option&quot;</td>
<td>Could not output a portion of the code in &quot;section&quot; specified by &quot;option.&quot; Part of the instruction code in &quot;section&quot; has been swapped with instruction code in another section due to endian conversion.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0562020</td>
<td>Duplicate file specified in option &quot;option&quot;: &quot;file&quot;</td>
<td>The same file was specified twice in option.</td>
</tr>
<tr>
<td>E0562022</td>
<td>Address ranges overlap in option &quot;option&quot;: &quot;address range&quot;</td>
<td>Address ranges address range specified in option overlap.</td>
</tr>
<tr>
<td>E0562100</td>
<td>Invalid address specified in cpu option : &quot;address&quot;</td>
<td>An address was specified with the -cpu option that cannot be specified for a cpu.</td>
</tr>
<tr>
<td>E0562101</td>
<td>Invalid address specified in option &quot;option&quot;: &quot;address&quot;</td>
<td>The address specified in option exceeds the address range that can be specified by the cpu or the range specified by the cpu option.</td>
</tr>
<tr>
<td>E0562110</td>
<td>Section size of second parameter in rom option is not 0 : &quot;section&quot;</td>
<td>The second parameter in the -rom option specifies &quot;section&quot; with non-zero size.</td>
</tr>
<tr>
<td>E0562111</td>
<td>Absolute section cannot be specified in &quot;option&quot; option : &quot;section&quot;</td>
<td>An absolute address section was specified in option.</td>
</tr>
<tr>
<td>E0562120</td>
<td>Library &quot;file&quot; without module name specified as input file</td>
<td>A library file without a module name was specified as the input file.</td>
</tr>
<tr>
<td>E0562121</td>
<td>Input file is not library file : &quot;file(module)&quot;</td>
<td>The file specified by file (module) as the input file is not a library file.</td>
</tr>
<tr>
<td>E0562130</td>
<td>Cannot find file specified in option &quot;option&quot;: &quot;file&quot;</td>
<td>The file specified in option could not be found.</td>
</tr>
<tr>
<td>E0562131</td>
<td>Cannot find module specified in option &quot;option&quot;: &quot;module&quot;</td>
<td>The module specified in option could not be found.</td>
</tr>
<tr>
<td>E0562132</td>
<td>Cannot find &quot;name&quot; specified in option &quot;option&quot;</td>
<td>The symbol or section specified in option does not exist.</td>
</tr>
<tr>
<td>E0562133</td>
<td>Cannot find defined symbol &quot;name&quot; in option &quot;option&quot;</td>
<td>The externally defined symbol specified in option does not exist.</td>
</tr>
<tr>
<td>E0562140</td>
<td>Symbol/section &quot;name&quot; redefined in option &quot;option&quot;</td>
<td>The symbol or section specified in option has already been defined.</td>
</tr>
<tr>
<td>E0562141</td>
<td>Module &quot;module&quot; redefined in option &quot;option&quot;</td>
<td>The module specified in option has already been defined.</td>
</tr>
<tr>
<td>E0562142</td>
<td>Interrupt number &quot;vector number&quot; of &quot;section&quot; has multiple definition</td>
<td>Vector number definition was made multiple times in vector table section. Only one address can be specified for a vector number.</td>
</tr>
<tr>
<td>E0562200</td>
<td>Illegal object file : &quot;file&quot;</td>
<td>A format other than ELF format was input.</td>
</tr>
<tr>
<td>E0562201</td>
<td>Illegal library file : &quot;file&quot;</td>
<td>file is not a library file.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E0562210</td>
<td>[Message] Invalid input file type specified for option &quot;option&quot; : &quot;file(type)&quot;</td>
<td>When specifying option, a file (type) that cannot be processed was input.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562211</td>
<td>[Message] Invalid input file type specified while processing &quot;process&quot; : &quot;file(type)&quot;</td>
<td>A file (type) that cannot be processed was input during processing process.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562212</td>
<td>[Message] &quot;option&quot; cannot be specified for inter-module optimization information in &quot;file&quot;</td>
<td>The option option cannot be used because file includes inter-module optimization information.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562220</td>
<td>[Message] Illegal mode type &quot;mode type&quot; in &quot;file&quot;</td>
<td>A file with a different mode type was input.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562221</td>
<td>[Message] Section type mismatch : &quot;section&quot;</td>
<td>Sections with the same name but different attributes (whether initial values present or not) were input.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562300</td>
<td>[Message] Duplicate symbol &quot;symbol&quot; in &quot;file&quot;</td>
<td>There are duplicate occurrences of symbol.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562301</td>
<td>[Message] Duplicate module &quot;module&quot; in &quot;file&quot;</td>
<td>There are duplicate occurrences of module.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562310</td>
<td>[Message] Undefined external symbol &quot;symbol&quot; referenced in &quot;file&quot;</td>
<td>An undefined symbol symbol was referenced in file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562311</td>
<td>[Message] Section &quot;section1&quot; cannot refer to overlaid section : &quot;section2-symbol&quot;</td>
<td>A symbol defined in section 1 was referenced in section 2 that is allocated to the same address as section 1 overlaid.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562320</td>
<td>[Message] Section address overflowed out of range : &quot;section&quot;</td>
<td>The address of section exceeds the usable address range.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562321</td>
<td>[Message] Section &quot;section1&quot; overlaps section &quot;section2&quot;</td>
<td>The addresses of section 1 and section 2 overlap.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562330</td>
<td>[Message] Relocation size overflow : &quot;file&quot;-&quot;section&quot;-&quot;offset&quot;</td>
<td>The result of the relocation operation exceeded the relocation size. Possible causes include inaccessibility of a branch destination, and referencing of a symbol which must be located at a specific address.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>E0562331</td>
<td>[Message] Division by zero in relocation value calculation : &quot;file&quot;-&quot;section&quot;-&quot;offset&quot;</td>
<td>Division by zero occurred during a relocation operation.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>------------</td>
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<td>-------------</td>
</tr>
</tbody>
</table>
| E0562332   | [Message] Relocation value is odd number : "file"."section"."offset"  
[Explanation] The result of the relocation operation is an odd number. 
[Action by User] Check for problems in calculation of the position at offset in section in the source list. |
| E0562340   | [Message] Symbol name "file"."section"."symbol" is too long  
[Explanation] The length of "symbol" in "section" exceeds the assembler translation limit. 
[Action by User] To output a symbol address file, use a symbol name that is no longer than the assembler translation limit. |
| E0562366   | [Message] "section" specified in option "option" was moved other area. |
| E0562403   | [Message] Fast interrupt register in "file" conflicts with that in another file  
[Explanation] The register number specified for the fast interrupt general register in file does not match the settings in other files. 
[Action by User] Correct the register number to match the other settings and recompile the code. |
| E0562404   | [Message] Base register "base register type" in "file" conflicts with that in another file  
[Explanation] The register number specified for base register type in file does not match the settings in other files. 
[Action by User] Correct the register number to match the other settings and recompile the code. |
| E0562405   | [Message] Option "compile option" in "file" conflicts with that in another files  
[Explanation] Specification of compile option is inconsistent between the input files. 
[Action by User] Review the compile option. |
| E0562410   | [Message] Address value specified by map file differs from one after linkage as to "symbol"  
[Explanation] The address of symbol differs between the address within the external symbol allocation information file used at compilation and the address after linkage. 
[Action by User] Check (1) to (2) below.  
(1) Do not change the program before or after the map option specification at compilation.  
(2) rlink optimization may cause the sequence of the symbols after the map option specification at compilation to differ from that before the map option. Disable the map option at compilation or disable the rlink option for optimization. |
| E0562411   | [Message] Map file in "file" conflicts with that in another file  
[Explanation] Different external symbol allocation information files were used by the input files at compilation. |
| E0562412   | [Message] Cannot open file : "file"  
[Explanation] file (external symbol allocation information file) cannot be opened. 
[Action by User] Check whether the file name and access rights are correct. |
| E0562413   | [Message] Cannot close file : "file"  
[Explanation] file (external symbol allocation information file) cannot be closed. There may be insufficient disk space. |
| E0562414   | [Message] Cannot read file : "file"  
[Explanation] file (external symbol allocation information file) cannot be read. There may be insufficient disk space. |
### MESSAGES

<table>
<thead>
<tr>
<th>Message ID</th>
<th>Message Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0562415</td>
<td>[Message]</td>
<td>Illegal map file : &quot;file&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td><em>file</em> (external symbol allocation information file) has an illegal format.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Check whether the file name is correct.</td>
</tr>
<tr>
<td>E0562416</td>
<td>[Message]</td>
<td>Order of functions specified by map file differs from one after linkage as to &quot;function name&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The sequences of a function <em>function name</em> and those of other functions are different between the information within the external symbol allocation information file used at compilation and the location after linkage. The address of static within the function may be different between the external symbol allocation information file and the result after linkage.</td>
</tr>
<tr>
<td>E0562417</td>
<td>[Message]</td>
<td>Map file is not the newest version : &quot;file name&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The external symbol allocation information file is not the latest version.</td>
</tr>
<tr>
<td>E0562420</td>
<td>[Message]</td>
<td>&quot;file1&quot; overlap address &quot;file2&quot; : &quot;address&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The address specified for <em>file 1</em> is the same as that specified for <em>file 2</em>.</td>
</tr>
<tr>
<td>E0562600</td>
<td>[Message]</td>
<td>Library &quot;library&quot; requires &quot;licence edition&quot;</td>
</tr>
<tr>
<td>E0572000</td>
<td>[Message]</td>
<td>Invalid option : &quot;option&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>&quot;option&quot; is not supported.</td>
</tr>
<tr>
<td>E0572200</td>
<td>[Message]</td>
<td>Illegal object file : &quot;file&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The input file is not in the ELF format.</td>
</tr>
<tr>
<td>E0572500</td>
<td>[Message]</td>
<td>Cannot find library file : &quot;file&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>&quot;file&quot; specified as the library file was not found.</td>
</tr>
<tr>
<td>E0572501</td>
<td>[Message]</td>
<td>&quot;instance&quot; has been referenced as both an explicit specialization and a generated instantiation</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>For the file using &quot;instance&quot;, confirm that form=relocate has not been used to generate a relocatable object file.</td>
</tr>
<tr>
<td>E0572502</td>
<td>[Message]</td>
<td>&quot;instance&quot; assigned to &quot;file1&quot; and &quot;file2&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The definition of &quot;instance&quot; is duplicated in &quot;file1&quot; and &quot;file2&quot;</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>For the file using &quot;instance&quot;, confirm that form=relocate has not been used to generate a relocatable object file.</td>
</tr>
<tr>
<td>E0573005</td>
<td>[Message]</td>
<td>Instantiation loop</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>An input file name may coincide with another file.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Change the filenames so that they do not coincide without the extension.</td>
</tr>
<tr>
<td>E0573007</td>
<td>[Message]</td>
<td>Cannot create instantiation request file &quot;file&quot;</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The intermediate file for instantiation was not created.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Check whether access rights for the object creation directory are correct.</td>
</tr>
<tr>
<td>E0573008</td>
<td>[Message]</td>
<td>Cannot change to directory &quot;folder&quot;</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Check if &quot;folder&quot; exists.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>E0573009</td>
<td>[Message] File &quot;file&quot; is read-only</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Change the access rights.</td>
<td></td>
</tr>
<tr>
<td>E057300</td>
<td>[Message] Cannot open file : &quot;file&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the filename and access rights.</td>
<td></td>
</tr>
<tr>
<td>E057303</td>
<td>[Message] Cannot read file : &quot;file&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] The input file was blank or there was not enough disk space.</td>
<td></td>
</tr>
<tr>
<td>E057310</td>
<td>[Message] Cannot open temporary file</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] An intermediate file cannot be opened. The HLNK_TMP specification was incorrect or there was not enough disk space.</td>
<td></td>
</tr>
<tr>
<td>E057320</td>
<td>[Message] Memory overflow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] There is no more space in the usable memory within the linkage editor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Increase the amount of memory available.</td>
<td></td>
</tr>
<tr>
<td>E0592001</td>
<td>[Message] Multiple input files are not allowed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Use a list file to convert more than one file.</td>
<td></td>
</tr>
<tr>
<td>E0592002</td>
<td>[Message] Multiple output files are not allowed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Use a list file to convert more than one file.</td>
<td></td>
</tr>
<tr>
<td>E0592003</td>
<td>[Message] List file is specified more than once.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Combine them into a single list file.</td>
<td></td>
</tr>
<tr>
<td>E0592004</td>
<td>[Message] Invalid argument for the &quot;option&quot; option.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the argument.</td>
<td></td>
</tr>
<tr>
<td>E0592005</td>
<td>[Message] The &quot;option&quot; option can not have an argument.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] An invalid argument was specified for the &quot;option&quot; option.</td>
<td></td>
</tr>
<tr>
<td>E0592006</td>
<td>[Message] The &quot;option&quot; option requires an argument.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] A required argument is missing from the &quot;option&quot; option specification.</td>
<td></td>
</tr>
<tr>
<td>E0592007</td>
<td>[Message] The &quot;option&quot; option is specified more than once.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] Option &quot;option&quot; can only be specified once at a time.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] No output file has been specified for the specified input file.</td>
<td></td>
</tr>
<tr>
<td>E0592010</td>
<td>[Message] Failed to open an output file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0592013</td>
<td>[Message] Failed to delete a temporary file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0592015</td>
<td>[Message] Failed to close an input file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0592016</td>
<td>[Message] Failed to write an output file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0592018</td>
<td>[Message] Failed to open an list file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Action by User] Make sure that the list file exists and has been specified correctly.</td>
<td></td>
</tr>
<tr>
<td>E0592019</td>
<td>[Message] Syntax error in list file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation] There is a syntax error in list file &quot;file&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0592020</td>
<td>[Message] Failed to read a list file &quot;file&quot;.</td>
<td></td>
</tr>
</tbody>
</table>
### 10. MESSAGES

<table>
<thead>
<tr>
<th>Message ID</th>
<th>Message</th>
<th>Explanation</th>
<th>Action by User</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0592101</td>
<td>Unknown character ‘C’.</td>
<td>The pre-conversion C-language source file could not be converted, because it contains a character that is not permitted by the C language.</td>
<td>Edit the C-language source file and correct any syntax errors.</td>
</tr>
<tr>
<td>E0592102</td>
<td>Illegal syntax in string.</td>
<td>The pre-conversion C-language source file could not be converted, because it contains a syntax error.</td>
<td>Edit the C-language source file and correct any syntax errors.</td>
</tr>
<tr>
<td>E0592201</td>
<td>Illegal syntax.</td>
<td>The pre-conversion assembly-language source file could not be converted, because it contains a syntax error.</td>
<td>Edit the assembly-language source file and correct any syntax errors.</td>
</tr>
<tr>
<td>E0593002</td>
<td>&quot;-Xsfg_size_tidata_byte&quot; size larger than &quot;-Xsfg_size_tidata&quot; size.</td>
<td>Set size &quot;-Xsfg_size_tidata_byte&quot; to equal to or less than size &quot;-Xsfg_size_tidata&quot;, or size &quot;-Xsfg_size_tidata&quot; to greater than or equal to size &quot;-Xsfg_size_tidata_byte&quot;.</td>
<td></td>
</tr>
<tr>
<td>E0593003</td>
<td>Can not Read Symbol Information.</td>
<td>The symbol could not be loaded because there is no symbol-analysis information in memory, or it is corrupt.</td>
<td>Check the CX options and rebuild.</td>
</tr>
<tr>
<td>E0593004</td>
<td>Can not Write the SFG file.</td>
<td>There could be a problem with disk space or user privileges.</td>
<td>Make sure that there is enough space to write the data, and check the user privileges.</td>
</tr>
<tr>
<td>E0594000</td>
<td>Cannot find project file(file name).</td>
<td>There is no project file.</td>
<td>Make sure that the file exists.</td>
</tr>
<tr>
<td>E0594001</td>
<td>Project file read error(file name).</td>
<td>An error occurred while loading the project file. Reading the project file may be blocked.</td>
<td></td>
</tr>
<tr>
<td>E0594002</td>
<td>Illegal format in project file(file name).</td>
<td>The project file format is invalid.</td>
<td>This error occurs when invalid format is found in the project file. Either correct the error, or create the project again.</td>
</tr>
</tbody>
</table>
### 10.5.3 Fatal Errors

#### Table 10.4 Fatal Errors

<table>
<thead>
<tr>
<th>Message Code</th>
<th>Message</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0511128</td>
<td>[Message]</td>
<td>Library file &quot;file-name&quot; is not found.</td>
</tr>
<tr>
<td>F0520003</td>
<td>[Message]</td>
<td>#include file &quot;file&quot; includes itself.</td>
</tr>
<tr>
<td>F0520004</td>
<td>[Message]</td>
<td>Out of memory.</td>
</tr>
<tr>
<td>F0520005</td>
<td>[Message]</td>
<td>Out of memory. Close other applications, and perform the compile again.</td>
</tr>
<tr>
<td>F0520013</td>
<td>[Message]</td>
<td>Expected a file name.</td>
</tr>
<tr>
<td>F0520016</td>
<td>[Message]</td>
<td>&quot;file&quot; is not a valid source file name.</td>
</tr>
<tr>
<td>F0520035</td>
<td>[Message]</td>
<td>#error directive: character string</td>
</tr>
<tr>
<td>F0520143</td>
<td>[Message]</td>
<td>Program too large or complicated to compile.</td>
</tr>
<tr>
<td>F0520164</td>
<td>[Message]</td>
<td>Name of directory for temporary files is too long (xxx).</td>
</tr>
<tr>
<td>F0520182</td>
<td>[Message]</td>
<td>Could not open source file xxx (no directories in search list).</td>
</tr>
<tr>
<td>F0520219</td>
<td>[Message]</td>
<td>Error while deleting file &quot;file&quot;.</td>
</tr>
<tr>
<td>F0520542</td>
<td>[Message]</td>
<td>Could not create instantiation request file name.</td>
</tr>
<tr>
<td>F0520563</td>
<td>[Message]</td>
<td>Invalid preprocessor output file.</td>
</tr>
<tr>
<td>F0520571</td>
<td>[Message]</td>
<td>Invalid option: option</td>
</tr>
<tr>
<td>F0520641</td>
<td>[Message]</td>
<td>xxx is not a valid directory.</td>
</tr>
<tr>
<td>F0520869</td>
<td>[Message]</td>
<td>Could not set locale xxx to allow processing of multibyte characters.</td>
</tr>
<tr>
<td>F0520919</td>
<td>[Message]</td>
<td>Invalid output file: xxx</td>
</tr>
<tr>
<td>F0520920</td>
<td>[Message]</td>
<td>Cannot open output file: xxx</td>
</tr>
<tr>
<td>F0520926</td>
<td>[Message]</td>
<td>Cannot open definition list file: xxx</td>
</tr>
<tr>
<td>F0521083</td>
<td>[Message]</td>
<td>Exported template file xxx is corrupted.</td>
</tr>
<tr>
<td>F0521151</td>
<td>[Message]</td>
<td>Mangled name is too long.</td>
</tr>
<tr>
<td>F0521335</td>
<td>[Message]</td>
<td>Cannot open predefined macro file: xxx</td>
</tr>
<tr>
<td>F0521336</td>
<td>[Message]</td>
<td>Invalid predefined macro entry at line line: line2</td>
</tr>
<tr>
<td>F0521337</td>
<td>[Message]</td>
<td>Invalid macro mode name xxx.</td>
</tr>
<tr>
<td>F0521338</td>
<td>[Message]</td>
<td>Incompatible redefinition of predefined macro xxx.</td>
</tr>
<tr>
<td>F0523029</td>
<td>[Message]</td>
<td>Cannot open rule file</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The file specified in the -misra2004=&quot;file name&quot; or -misra2012=&quot;file name&quot; option cannot be opened.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F0523030</th>
<th>[Message]</th>
<th>Incorrect description &quot;file name&quot; in rule file</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The file specified in the -misra2004=&quot;file name&quot; or -misra2012=&quot;file name&quot; option includes illegal code.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F0523031</th>
<th>[Message]</th>
<th>Rule rule number is unsupported</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The number of a rule that is not supported was specified.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F0523073</th>
<th>[Message]</th>
<th><em>instruction-set architecture name</em> does not support this intrinsic function.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The specified intrinsic function is not supported. Check the <em>-isa</em> option setting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F0523088</th>
<th>[Message]</th>
<th>Bit position is out of range.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>F0523129</th>
<th>[Message]</th>
<th>The &quot;option name&quot; option is necessary for use of &quot;function&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>The option must be specified to use this function.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>An intermediate file internally generated by the compiler cannot be opened.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>An intermediate file internally generated by the compiler cannot be closed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>An error occurred while an intermediate file was being written to.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F0530320</th>
<th>[Message]</th>
<th>Duplicate symbol &quot;symbol name&quot;.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>F0530800</th>
<th>[Message]</th>
<th>Type of symbol &quot;symbol-name&quot; differs between files.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>F0530808</th>
<th>[Message]</th>
<th>Alignment of variable &quot;variable-name&quot; differs between files.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>F0530810</th>
<th>[Message]</th>
<th>#pragma directive for symbol &quot;symbol-name&quot; differs between files.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>Memory is insufficient.</td>
</tr>
<tr>
<td></td>
<td>[Action by User]</td>
<td>Close other applications and recompile the program.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>A temporary file that was internally generated by the compiler cannot be opened.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>A temporary file that was internally generated by the compiler cannot be closed.</td>
</tr>
</tbody>
</table>

|-----------|-----------|----------------------------------|

<table>
<thead>
<tr>
<th>F0533303</th>
<th>[Message]</th>
<th>Cannot write to an intermediate file.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>F0533306</th>
<th>[Message]</th>
<th>Compilation was interrupted.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>During compilation, an interrupt due to entry of the Cntl + C key combination was detected.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>F053330</td>
<td>Cannot open an intermediate file.</td>
<td>A temporary file that was internally generated by the compiler cannot be opened.</td>
</tr>
<tr>
<td>F0540027</td>
<td>Cannot read file &quot;file-name&quot;</td>
<td></td>
</tr>
<tr>
<td>F0540204</td>
<td>Illegal stack access.</td>
<td>Attempted usage of the stack by a function has exceeded 2 Gbytes.</td>
</tr>
<tr>
<td>F0540300</td>
<td>Cannot open an intermediate file.</td>
<td>A temporary file that was internally generated by the compiler cannot be opened.</td>
</tr>
<tr>
<td>F0540301</td>
<td>Cannot close an intermediate file.</td>
<td>A temporary file that was internally generated by the compiler cannot be closed.</td>
</tr>
<tr>
<td>F0540302</td>
<td>Cannot read an intermediate file.</td>
<td>An error occurred during reading of a temporary file.</td>
</tr>
<tr>
<td>F0540303</td>
<td>Cannot write to an intermediate file.</td>
<td>An error occurred during writing of a temporary file.</td>
</tr>
<tr>
<td>F0540400</td>
<td>Different parameters are set for the same #pragma &quot;identifier&quot;.</td>
<td></td>
</tr>
<tr>
<td>F0544302</td>
<td>Cannot read an intermediate file.</td>
<td>An error occurred while an intermediate file was being read.</td>
</tr>
<tr>
<td>F0544802</td>
<td>The value of the parameter for the in-line function is outside the defined range.</td>
<td>The value of the parameter for the inline function is outside the supported range.</td>
</tr>
<tr>
<td>F0553000</td>
<td>Can't create file 'filename'.</td>
<td>The filename file cannot be generated.</td>
</tr>
<tr>
<td>F0553001</td>
<td>Can't open file 'filename'.</td>
<td>The filename file cannot be opened.</td>
</tr>
<tr>
<td>F0553002</td>
<td>Can't write file 'filename'.</td>
<td>The filename file cannot be written to.</td>
</tr>
<tr>
<td>F0553003</td>
<td>Can't read file 'filename'.</td>
<td>The filename file cannot be read.</td>
</tr>
<tr>
<td>F0553004</td>
<td>Can't create Temporary file.</td>
<td>Temporary file cannot be generated.</td>
</tr>
<tr>
<td>F0553005</td>
<td>Can't open Temporary file.</td>
<td>The temporary file cannot be opened.</td>
</tr>
<tr>
<td>Message ID</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>F0553006</td>
<td>Can't read Temporary file.</td>
<td>The temporary file cannot be read.</td>
</tr>
<tr>
<td>F0553007</td>
<td>Can't write Temporary file.</td>
<td>The temporary file cannot be written to.</td>
</tr>
<tr>
<td>F0553008</td>
<td>Illegal file name <code>filename</code>.</td>
<td>The file name is illegal.</td>
</tr>
<tr>
<td>F0553016</td>
<td>Lacking cpu specification.</td>
<td>No CPU type is specified.</td>
</tr>
<tr>
<td>F0553100</td>
<td>Command line is too long.</td>
<td>The command line has too many characters.</td>
</tr>
<tr>
<td>F0553101</td>
<td>Invalid option 'xx' is used.</td>
<td>An invalid command option xx is used.</td>
</tr>
<tr>
<td>F0553102</td>
<td>Ignore option 'xx'.</td>
<td>An invalid option is specified.</td>
</tr>
<tr>
<td>F0553103</td>
<td>Option 'xx' is not appropriate.</td>
<td>Command option xx is written incorrectly.</td>
</tr>
<tr>
<td>F0553104</td>
<td>No input files specified.</td>
<td>No input file is specified.</td>
</tr>
<tr>
<td>F0553105</td>
<td>Source files number exceed 80.</td>
<td>The number of source files exceeds 80.</td>
</tr>
<tr>
<td>F0553106</td>
<td>Lacking cpu specification.</td>
<td>No CPU type is specified.</td>
</tr>
<tr>
<td>F0553110</td>
<td>Multiple register base/fint_register.</td>
<td>A single register is specified by the baseand fint_registeroptions.</td>
</tr>
<tr>
<td>F0553111</td>
<td>Multiple register base/pid.</td>
<td>A single register is specified by the baseand pidoptions.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0553113</td>
<td>[Message] Neither isa nor cpu is specified</td>
<td></td>
</tr>
<tr>
<td>F0553114</td>
<td>[Message] Both '-isa' option and '-cpu' option are specified</td>
<td></td>
</tr>
<tr>
<td>F0553115</td>
<td>[Message] The '-cpu' option and the '-fpu' option are inconsistent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0553201</td>
<td>[Message] Not enough memory.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0553202</td>
<td>[Message] Can't find work dir.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563000</td>
<td>[Message] No input file</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563001</td>
<td>[Message] No module in library</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563002</td>
<td>[Message] Option &quot;option1&quot; is ineffective without option &quot;option2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563003</td>
<td>[Message] Illegal file format &quot;file&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563004</td>
<td>[Message] Invalid inter-module optimization information type in &quot;file&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563020</td>
<td>[Message] No cpu information in input files</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563100</td>
<td>[Message] Section address overflow out of range : &quot;section&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563102</td>
<td>[Message] Section contents overlap in absolute section &quot;section&quot; in &quot;file&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0563103</td>
<td>[Message] Section size overflow : &quot;section&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>F0563110</td>
<td>Illegal cpu type &quot;cpu type&quot; in &quot;file&quot;</td>
<td>A file with a different cpu type was input.</td>
</tr>
<tr>
<td>F0563111</td>
<td>Illegal encode type &quot;endian type&quot; in &quot;file&quot;</td>
<td>A file with a different endian type was input.</td>
</tr>
<tr>
<td>F0563112</td>
<td>Invalid relocation type in &quot;file&quot;</td>
<td>There is an unsupported relocation type in file.</td>
</tr>
<tr>
<td>F0563115</td>
<td>Cpu type in &quot;file&quot; is not supported</td>
<td>The CPU type specified in &quot;file&quot; is not supported. Check if the input file is correct.</td>
</tr>
<tr>
<td>F0563120</td>
<td>Illegal size of the absolute code section : &quot;section&quot; in &quot;file&quot;</td>
<td>Absolute-addressing section section in file has an illegal size.</td>
</tr>
<tr>
<td>F0563120</td>
<td>Multiple files cannot be specified while processing &quot;process&quot;</td>
<td></td>
</tr>
<tr>
<td>F0563200</td>
<td>Too many sections</td>
<td>The number of sections exceeded the translation limit. It may be possible to eliminate this problem by specifying multiple file output.</td>
</tr>
<tr>
<td>F0563201</td>
<td>Too many symbols</td>
<td>The number of symbols exceeded the translation limit. It may be possible to eliminate this problem by specifying multiple file output.</td>
</tr>
<tr>
<td>F0563202</td>
<td>Too many modules</td>
<td>The number of modules exceeded the translation limit.</td>
</tr>
<tr>
<td>F0563203</td>
<td>Reserved module name &quot;rlink_generates&quot;</td>
<td>rlink_generates.* (** is a value from 01 to 99) is a reserved name used by the optimizing linkage editor. It is used as an .obj or .rel file name or a module name within a library.</td>
</tr>
<tr>
<td>F0563204</td>
<td>Reserved section name &quot;$sss_fetch&quot;</td>
<td>sss_fetch.* (sss is any string, and ** is a value from 01 to 99) is a reserved name used by the optimizing linkage editor.</td>
</tr>
<tr>
<td>F0563200</td>
<td>Cannot open file : &quot;file&quot;</td>
<td>file cannot be opened.</td>
</tr>
<tr>
<td>F0563201</td>
<td>Cannot close file : &quot;file&quot;</td>
<td>file cannot be closed. There may be insufficient disk space.</td>
</tr>
<tr>
<td>F0563302</td>
<td>Cannot write file : &quot;file&quot;</td>
<td>Writing to file is not possible. There may be insufficient disk space.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
<td>Explanation</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>F0563303</td>
<td>Cannot read file : &quot;file&quot;</td>
<td><em>file</em> cannot be read. An empty file may have been input, or there may be insufficient disk space.</td>
</tr>
<tr>
<td>F0563310</td>
<td>Cannot open temporary file</td>
<td>A temporary file cannot be opened.</td>
</tr>
<tr>
<td>F0563314</td>
<td>Cannot delete temporary file</td>
<td>A temporary file cannot be deleted. There may be insufficient disk space.</td>
</tr>
<tr>
<td>F0563320</td>
<td>Memory overflow</td>
<td>There is no more space in the usable memory within the linker.</td>
</tr>
<tr>
<td>F0563400</td>
<td>Cannot execute &quot;load module&quot;</td>
<td><em>load module</em> cannot be executed.</td>
</tr>
<tr>
<td>F0563410</td>
<td>Interrupt by user</td>
<td>An interrupt generated by (Ctrl) + C keys from a standard input terminal was detected.</td>
</tr>
<tr>
<td>F0563420</td>
<td>Error occurred in &quot;load module&quot;</td>
<td>An error occurred while executing <em>load module</em>.</td>
</tr>
<tr>
<td>F0563430</td>
<td>The total section size exceeded the limit of the evaluation version of <em>version</em>. Please consider purchasing the product.</td>
<td></td>
</tr>
<tr>
<td>F0563431</td>
<td>Incorrect device type, object file mismatch.</td>
<td></td>
</tr>
<tr>
<td>F0563600</td>
<td>Option &quot;option&quot; requires parameter</td>
<td></td>
</tr>
<tr>
<td>F0563601</td>
<td>Invalid parameter specified in option &quot;option&quot; : &quot;parameter&quot;</td>
<td></td>
</tr>
<tr>
<td>F0578200</td>
<td>memory allocation fault</td>
<td>Not enough memory.</td>
</tr>
<tr>
<td>F0578201</td>
<td>bad key character - use [dm(a</td>
<td>b)qr(a</td>
</tr>
<tr>
<td>F0578202</td>
<td>bad option character - use [cv]</td>
<td><em>character</em> cannot be specified as an option.</td>
</tr>
<tr>
<td>F0578203</td>
<td>bad option string</td>
<td><em>string</em> cannot be specified as an option.</td>
</tr>
<tr>
<td>F0578204</td>
<td>can not create file</td>
<td>Could not create file <em>file</em>.</td>
</tr>
<tr>
<td>F0578205</td>
<td>file name name... is too long - limit is number</td>
<td>File name <em>name</em> is too long. The maximum value is <em>number</em>.</td>
</tr>
<tr>
<td>Message ID</td>
<td>Description</td>
<td>Explanation</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578207</td>
<td>[Message] can not close file</td>
<td>Could not close file file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578208</td>
<td>[Message] can not read file</td>
<td>Cannot read from file file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578209</td>
<td>[Message] can not write file</td>
<td>Cannot write to file file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578210</td>
<td>[Message] can not seek file</td>
<td>Cannot seek in file file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578212</td>
<td>[Message] can not nest command file file</td>
<td>Command file file is nested. Nesting is not allowed.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578213</td>
<td>[Message] file is not library file</td>
<td>file is not a library file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578214</td>
<td>[Message] malformed library file file</td>
<td>Library file file could be corrupt.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578215</td>
<td>[Message] can not find member member</td>
<td>Member member not found in library file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578216</td>
<td>[Message] symbol table limit error file (number1) - limit is number2</td>
<td>The number of symbols number1 in library file file exceeds the maximum limit. The maximum value is number2.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578218</td>
<td>[Message] string table error file</td>
<td>The library string table for library file file could be corrupt.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578219</td>
<td>[Message] file has no member</td>
<td>There are no members in library file file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578220</td>
<td>[Message] version error file</td>
<td>The version of the format of the specified file file is not supported by this librarian.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0578221</td>
<td>[Message] can not read library header file</td>
<td>Cannot read header from library file file.</td>
</tr>
<tr>
<td></td>
<td>[Explanation]</td>
<td></td>
</tr>
<tr>
<td>F0593113</td>
<td>[Message] Neither isa nor cpu is specified</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F0593114</td>
<td>[Message] Both <code>-isa</code> option and <code>-cpu</code> option are specified</td>
<td></td>
</tr>
</tbody>
</table>
### 10.5.4 Informations

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0520009</td>
<td>Nested comment is not allowed.</td>
</tr>
<tr>
<td>M0520018</td>
<td>Expected a &quot;)&quot;.</td>
</tr>
<tr>
<td>M0520111</td>
<td>Statement is unreachable.</td>
</tr>
<tr>
<td>M0520128</td>
<td>Loop is not reachable from preceding code.</td>
</tr>
<tr>
<td>M0520174</td>
<td>Expression has no effect.</td>
</tr>
<tr>
<td>M0520177</td>
<td>Type &quot;symbol&quot; was declared but never referenced.</td>
</tr>
<tr>
<td>M0520193</td>
<td>Zero used for undefined preprocessing identifier xxx.</td>
</tr>
<tr>
<td>M0520237</td>
<td>Selector expression is constant.</td>
</tr>
<tr>
<td>M0520261</td>
<td>Access control not specified (&quot;name&quot; by default).</td>
</tr>
<tr>
<td>M0520324</td>
<td>Duplicate friend declaration.</td>
</tr>
<tr>
<td>M0520381</td>
<td>Extra &quot;;&quot; ignored.</td>
</tr>
<tr>
<td>M0520399</td>
<td>name has an operator new xxx() but no default operator delete xxx().</td>
</tr>
<tr>
<td>M0520400</td>
<td>name has a default operator delete xxx() but no operator new xxx().</td>
</tr>
<tr>
<td>M0520479</td>
<td>name redeclared &quot;inline&quot; after being called.</td>
</tr>
<tr>
<td>M0520487</td>
<td>Inline name cannot be explicitly instantiated.</td>
</tr>
<tr>
<td>M0520534</td>
<td>Use of a local type to specify an exception.</td>
</tr>
<tr>
<td>M0520535</td>
<td>Redundant type in exception specification.</td>
</tr>
<tr>
<td>M0520549</td>
<td>symbol is used before its value is set.</td>
</tr>
<tr>
<td>M0520550</td>
<td>Type &quot;symbol&quot; was set but never used.</td>
</tr>
<tr>
<td>M0520618</td>
<td>Struct or union declares no named members.</td>
</tr>
<tr>
<td>M0520652</td>
<td>Calling convention is ignored for this type.</td>
</tr>
<tr>
<td>M0520678</td>
<td>Call of &quot;symbol&quot; cannot be inlined.</td>
</tr>
<tr>
<td>M0520679</td>
<td>symbol cannot be inlined.</td>
</tr>
<tr>
<td>M0520815</td>
<td>Type qualifier on return type is meaningless.</td>
</tr>
<tr>
<td>M0520826</td>
<td>name was never referenced.</td>
</tr>
<tr>
<td>M0520831</td>
<td>Support for placement delete is disabled.</td>
</tr>
<tr>
<td>M0520863</td>
<td>Effect of this &quot;#pragma pack&quot; directive is local to xxx.</td>
</tr>
<tr>
<td>M0520866</td>
<td>Exception specification ignored.</td>
</tr>
<tr>
<td>M0520949</td>
<td>Specifying a default argument on this declaration is nonstandard.</td>
</tr>
<tr>
<td>M0521348</td>
<td>Declaration hides &quot;symbol&quot;.</td>
</tr>
<tr>
<td>M0521353</td>
<td>symbol has no corresponding member operator delete xxx (to be called if an exception is thrown during initialization of an allocated object).</td>
</tr>
<tr>
<td>M0521380</td>
<td>Virtual xxx was not defined (and cannot be defined elsewhere because it is a member of an unnamed namespace).</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>M0521381</td>
<td>Message: Carriage return character in source line outside of comment or character/string literal.</td>
</tr>
<tr>
<td>M0523009</td>
<td>This pragma has no effect.</td>
</tr>
<tr>
<td>M0523028</td>
<td>Rule: rule number : description</td>
</tr>
<tr>
<td>M0523033</td>
<td>Precision lost.</td>
</tr>
<tr>
<td>M0523086</td>
<td>Rule: rule number : description</td>
</tr>
<tr>
<td>M0560002</td>
<td>Symbol &quot;symbol&quot; created by optimization &quot;optimization&quot;</td>
</tr>
<tr>
<td>M0560004</td>
<td>Symbol &quot;symbol&quot; deleted by optimization</td>
</tr>
<tr>
<td>M0560005</td>
<td>The offset value from the symbol location has been changed by optimization &quot;file&quot;-&quot;section&quot;-&quot;symbol±offset&quot;</td>
</tr>
<tr>
<td>M0560100</td>
<td>No inter-module optimization information in &quot;file&quot;</td>
</tr>
<tr>
<td>M0560101</td>
<td>No stack information in &quot;file&quot;</td>
</tr>
<tr>
<td>M0560102</td>
<td>Stack size &quot;size&quot; specified to the undefined symbol &quot;symbol&quot; in &quot;file&quot;</td>
</tr>
<tr>
<td>M0560103</td>
<td>Multiple stack sizes specified to the symbol &quot;symbol&quot;</td>
</tr>
<tr>
<td>M0560300</td>
<td>Mode type &quot;mode type1&quot; in &quot;file&quot; differ from &quot;mode type2&quot;</td>
</tr>
<tr>
<td>M0560400</td>
<td>Unused symbol &quot;file&quot;-&quot;symbol&quot;</td>
</tr>
<tr>
<td>M0560500</td>
<td>Generated CRC code at &quot;address&quot;</td>
</tr>
<tr>
<td>M0560510</td>
<td>Section &quot;section&quot; was moved other area specified in option &quot;cpu=&lt;attribute&gt;&quot;</td>
</tr>
</tbody>
</table>

Rule rule number : description

Explanation: Violation of a MISRA-C:2004 rule (indicated by the rule number and description) was detected.

Explanation: Violation of a MISRA-C:2012 rule (indicated by the rule number and description) was detected.

Explanation: The symbol named symbol was created as a result of the optimization.

Explanation: As a result of symbol_delete optimization, the symbol named symbol in file was deleted.

Explanation: As a result of the size being changed by optimization within the range of symbol±offset, the offset value was changed. Check that this does not cause a problem. To disable changing of the offset value, cancel the specification of the gOptimize option on assembly of file.

Explanation: No inter-module optimization information was found in file. Inter-module optimization is not performed on file. To perform inter-module optimization, specify the gOptimize option on compiling and assembly.

Explanation: No stack information was found in file. file may be an assembler output file. The contents of the file will not be in the stack information file output by the linker.

Explanation: Stack size size is specified for the undefined symbol named symbol in file.

Explanation: Multiple stack sizes are specified for the symbol named symbol.

Explanation: Mode type mode type1 in file differ from mde type2.

Explanation: A file with a different mode type was input.

Explanation: The symbol named symbol in file is not used.

Explanation: CRC code was generated at address.

Explanation: section without dividing is allocated according to cpu=<attribute>.
<table>
<thead>
<tr>
<th>M0560511</th>
<th>[Message]</th>
<th>Sections &quot;section name&quot;,&quot;new section name&quot; are Non-contiguous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Explanation]</td>
<td>section was divided and the newly created section is new section name.</td>
</tr>
<tr>
<td>M0560700</td>
<td>[Message]</td>
<td>Section address overflow out of range : &quot;section&quot;</td>
</tr>
</tbody>
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### 10.5.5 Warnings

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<td>&quot;path&quot; specified by the &quot;character string&quot; option is a file. Specify a folder.</td>
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<td>W0511106</td>
<td>The folder &quot;folder&quot; specified by the &quot;character string&quot; option is not found.</td>
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<td>W0511123</td>
<td>The &quot;character string2&quot; option is ignored when the &quot;character string1&quot; option is specified at the same time.</td>
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<tr>
<td>W0511143</td>
<td>The &quot;-Xfloat&quot; option is ignored because specified device does not have FPU.</td>
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<tr>
<td>W0511144</td>
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<tr>
<td>W0511146</td>
<td>&quot;symbol name&quot; specified in the &quot;character string&quot; option is not allowed for a preprocessor macro. Recognized only as an assembler symbol.</td>
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<tr>
<td>W0511147</td>
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<tr>
<td>W0511149</td>
<td>The &quot;character string2&quot; option is ignored when the &quot;character string1&quot; option and the &quot;character string2&quot; option are inconsistent.</td>
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<td>W0511151</td>
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<tr>
<td>W0511153</td>
<td>Optimization item options were cleared when &quot;-Ocharacter string&quot; option is specified. Optimization item options need to specify after &quot;-Ocharacter string&quot; option.</td>
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<tr>
<td>W0511156</td>
<td>Device file is not found in the folder specified by the &quot;-Xdev_path&quot; option.</td>
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<td></td>
<td>[Explanation] Device file is not found in the folder specified by the &quot;-Xdev_path&quot; option. Will search standard device file folder.</td>
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<tr>
<td>W0511164</td>
<td>Duplicate file name. &quot;file-name&quot;.</td>
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<td></td>
<td>[Explanation] The same file name was specified more than once in a command line. CC-RH is not capable of handling multiple instances of the same file name. Only the last file name to have been specified is valid.</td>
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<tr>
<td>W0511166</td>
<td>&quot;macro name&quot; is not a valid predefined macro name.</td>
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<td></td>
<td>[Explanation] Specification of the undefine option is invalid.</td>
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<tr>
<td>W0511168</td>
<td>&quot;option-name&quot; option has no effect in this version.</td>
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<tr>
<td>W0511169</td>
<td>&quot;code&quot; is not valid in &quot;language specifications&quot;</td>
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<td>[Explanation] &quot;code&quot; is invalid in the &quot;language specifications (C or C++)&quot;.</td>
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<tr>
<td>W0511170</td>
<td>&quot;option-name&quot; option is ignored due to the specification of another option.</td>
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<tr>
<td>W0511171</td>
<td>&quot;code&quot; is ignored in &quot;language specifications&quot;.</td>
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<tr>
<td></td>
<td>[Explanation] &quot;code&quot; is ignored in the &quot;language specifications (C or C++)&quot;.</td>
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<tr>
<td>W0511172</td>
<td>Nothing to compile, assemble or link.(input and output combination)</td>
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<td></td>
<td>[Action by User] Check the combination of the input file and output option.</td>
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<tr>
<td>W0511179</td>
<td>The evaluation version is valid for the remaining number days.</td>
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<tr>
<td>W0511180</td>
<td>The evaluation period of version has expired.</td>
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<td>W0511185</td>
<td>The trial period for the features of the Professional edition expires in number days. Please consider purchasing the product of Professional edition.</td>
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<tr>
<td>W0519999</td>
<td>The &quot;option-name&quot; option is not implemented.</td>
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<td>Code</td>
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<td>W0520001</td>
<td>Last line of file ends without a newline.</td>
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<td>W0520009</td>
<td>Nested comment is not allowed.</td>
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<td>W0520011</td>
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<td>W0520012</td>
<td>Parsing restarts here after previous syntax error.</td>
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<td>W0520014</td>
<td>Extra text after expected end of preprocessing directive.</td>
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<td>W0520021</td>
<td>Type qualifiers are meaningless in this declaration.</td>
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<td>W0520026</td>
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<td>W0520027</td>
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<td>W0520038</td>
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<td>W0520039</td>
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<td>W0520042</td>
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<td>W0520045</td>
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<td>W0520054</td>
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<td>W0520055</td>
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<td>W0520326</td>
<td>Inline is not allowed.</td>
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<td>W0520335</td>
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<td>W0520368</td>
<td>\texttt{xxx defines no constructor to initialize the following:}</td>
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<td>W0520370</td>
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<td>W0520720</td>
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<td>W0520722</td>
<td>Use of alternative token &quot;&lt;=&quot; appears to be unintended.</td>
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<td>W0520723</td>
<td>Use of alternative token &quot;%:%.&quot; appears to be unintended.</td>
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<td>W0520737</td>
<td>Using-declaration ignored -- it refers to the current namespace.</td>
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<td>W0520780</td>
<td>Reference is to symbol1 -- under old for-init scoping rules it would have been symbol2.</td>
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<td>W0520783</td>
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<td>W0520794</td>
<td>Template parameter %sq may not be used in an elaborated type specifier.</td>
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<td>Specifying a default argument when redeclaring an unreferenced function template is nonstandard.</td>
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<td>Omission of exception specification is incompatible with name.</td>
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<td>[Message] xxx has no corresponding operator deleteyyy (to be called if an exception is thrown during initialization of an allocated object).</td>
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<td>W0520831</td>
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<td>W0520837</td>
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<td>W0520867</td>
<td>[Message] Declaration of &quot;size_t&quot; does not match the expected type &quot;type&quot;.</td>
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<td>W0520870</td>
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<td>[Message] Ambiguous class member reference -- symbol1 used in preference to symbol2.</td>
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<td>W0520925</td>
<td>[Message] Type qualifiers on function types are ignored.</td>
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<td>W0520936</td>
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<td>W0520940</td>
<td>[Message] Missing return statement at end of non-void &quot;symbol&quot;.</td>
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<td>W0520942</td>
<td>[Message] enum bit-fields are always unsigned, but enum %t includes negative enumerator.</td>
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<tr>
<td>W0520948</td>
<td>[Message] Nonstandard local-class friend declaration -- no prior declaration in the enclosing scope.</td>
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<td>W0520951</td>
<td>[Message] Return type of function &quot;main&quot; must be &quot;int&quot;.</td>
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<td>W0520959</td>
<td>[Message] Declared size for bit field is larger than the size of the bit field type; truncated to any-string bits.</td>
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<td>W0520961</td>
<td>[Message] Use of a type with no linkage to declare a variable with linkage.</td>
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<td>W0520962</td>
<td>[Message] Use of a type with no linkage to declare a function.</td>
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<td>W0520970</td>
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<td>W0520997</td>
<td>[Message] function2 is hidden by function1 -- virtual function override intended?</td>
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<td>[Message] A storage class may not be specified here.</td>
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<td>W0521028</td>
<td>[Message] Invalid redeclaration of nested class.</td>
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<td>W0521046</td>
<td>[Message] Floating-point value cannot be represented exactly.</td>
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<td>W0521050</td>
<td>[Message] Imaginary *= imaginary sets the left-hand operand to zero.</td>
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<td>W0521051</td>
<td>[Message] Standard requires that &quot;symbol&quot; be given a type by a subsequent declaration (&quot;int&quot; assumed).</td>
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<td>W0521053</td>
<td>[Message] Conversion from integer to smaller pointer.</td>
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<td>[Message] Types cannot be declared in anonymous unions.</td>
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<td>W0521056</td>
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<td>W0521057</td>
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</tr>
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<tr>
<td>W0521072</td>
<td>[Message] A declaration cannot have a label.</td>
</tr>
<tr>
<td>W0521105</td>
<td>[Message] #warning directive: character string.</td>
</tr>
<tr>
<td>W0521145</td>
<td>[Message] type1 would have been promoted to &quot;type2&quot; when passed through the ellipsis parameter; use the latter type instead.</td>
</tr>
<tr>
<td>W0521163</td>
<td>[Message] va_start should only appear in a function with an ellipsis parameter.</td>
</tr>
<tr>
<td>W0521192</td>
<td>[Message] Null (zero) character in input line ignored.</td>
</tr>
<tr>
<td>W0521193</td>
<td>[Message] Null (zero) character in string or character constant.</td>
</tr>
<tr>
<td>W0521194</td>
<td>[Message] Null (zero) character in header name.</td>
</tr>
<tr>
<td>W0521197</td>
<td>[Message] The prototype declaration of %nfd is ignored after this unprototyped redeclaration.</td>
</tr>
<tr>
<td>W0521211</td>
<td>[Message] Nonstandard cast to array type ignored.</td>
</tr>
<tr>
<td>W0521213</td>
<td>[Message] field uses tail padding of a base class.</td>
</tr>
<tr>
<td>W0521218</td>
<td>[Message] Base class xxx uses tail padding of base class yyy.</td>
</tr>
<tr>
<td>W0521222</td>
<td>[Message] Invalid error number.</td>
</tr>
<tr>
<td>W0521223</td>
<td>[Message] Invalid error tag.</td>
</tr>
<tr>
<td>W0521224</td>
<td>[Message] Expected an error number or error tag.</td>
</tr>
<tr>
<td>W0521235</td>
<td>[Message] Nonstandard conversion between pointer to function and pointer to data.</td>
</tr>
<tr>
<td>W0521273</td>
<td>[Message] Alignment-of operator applied to incomplete type.</td>
</tr>
<tr>
<td>W0521285</td>
<td>[Message] Nonstandard qualified name in namespace member declaration.</td>
</tr>
<tr>
<td>W0521290</td>
<td>[Message] Non-POD class type passed through ellipsis.</td>
</tr>
<tr>
<td>W0521294</td>
<td>[Message] Integer operand may cause fixed-point overflow.</td>
</tr>
<tr>
<td>W0521296</td>
<td>[Message] Fixed-point value cannot be represented exactly.</td>
</tr>
<tr>
<td>W0521297</td>
<td>[Message] Constant is too large for long long; given unsigned long long type (nonstandard).</td>
</tr>
<tr>
<td>W0521301</td>
<td>[Message] xxx declares a non-template function -- add &lt;&gt; to refer to a template instance.</td>
</tr>
<tr>
<td>W0521302</td>
<td>[Message] Operation may cause fixed-point overflow.</td>
</tr>
<tr>
<td>W0521307</td>
<td>[Message] Class member typedef may not be redeclared.</td>
</tr>
<tr>
<td>W0521308</td>
<td>[Message] Taking the address of a temporary.</td>
</tr>
<tr>
<td>W0521310</td>
<td>[Message] Fixed-point value implicitly converted to floating-point type.</td>
</tr>
<tr>
<td>W0521316</td>
<td>[Message] Value cannot be converted to fixed-point value exactly.</td>
</tr>
<tr>
<td>W0521319</td>
<td>[Message] Fixed-point operation result is out of range.</td>
</tr>
<tr>
<td>W0521342</td>
<td>[Message] const_cast to enum type is nonstandard.</td>
</tr>
<tr>
<td>W0521346</td>
<td>[Message] Function returns incomplete class type %t.</td>
</tr>
<tr>
<td>W0521361</td>
<td>[Message] Negation of an unsigned fixed-point value.</td>
</tr>
<tr>
<td>W0521373</td>
<td>[Message] Implicit conversion of a 64-bit integral type to a smaller integral type (potential portability problem).</td>
</tr>
<tr>
<td>W0521374</td>
<td>[Message] Explicit conversion of a 64-bit integral type to a smaller integral type (potential portability problem).</td>
</tr>
<tr>
<td>Message</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W0521375</td>
<td>Conversion from pointer to same-sized integral type (potential portability problem).</td>
</tr>
<tr>
<td>W0521386</td>
<td>Storage specifier ignored.</td>
</tr>
<tr>
<td>W0521396</td>
<td>White space between backslash and newline in line splice ignored.</td>
</tr>
<tr>
<td>W0521400</td>
<td>Positional format specifier cannot be zero.</td>
</tr>
<tr>
<td>W0521420</td>
<td>Some enumerator values cannot be represented by the integral type underlying the enum type.</td>
</tr>
<tr>
<td>W0521422</td>
<td>Multicharacter character literal (potential portability problem).</td>
</tr>
<tr>
<td>W0521427</td>
<td>Offsetof applied to non-POD types is nonstandard.</td>
</tr>
<tr>
<td>W0521433</td>
<td>No prior push_macro for xxx.</td>
</tr>
<tr>
<td>W0521443</td>
<td>__real/__imag applied to real value.</td>
</tr>
<tr>
<td>W0521444</td>
<td>Symbol was declared &quot;deprecated (xxx)&quot;.</td>
</tr>
<tr>
<td>W0521544</td>
<td>Argument must be a constant null pointer value.</td>
</tr>
<tr>
<td>W0521547</td>
<td>Insufficient number of arguments for sentinel value.</td>
</tr>
<tr>
<td>W0521548</td>
<td>Sentinel argument must correspond to an ellipsis parameter.</td>
</tr>
<tr>
<td>W0521551</td>
<td>No #pragma start_map_region is currently active: pragma ignored.</td>
</tr>
<tr>
<td>W0521553</td>
<td>Nonstandard empty wide character literal treated as L'0'.</td>
</tr>
<tr>
<td>W0521561</td>
<td>Predefined meaning of &quot;symbol&quot; discarded.</td>
</tr>
<tr>
<td>W0521564</td>
<td>Enum qualified name is nonstandard.</td>
</tr>
<tr>
<td>W0521565</td>
<td>Anonymous union qualifier is nonstandard.</td>
</tr>
<tr>
<td>W0521566</td>
<td>Anonymous union qualifier is ignored.</td>
</tr>
<tr>
<td>W0521570</td>
<td>Nonstandard specifier ignored.</td>
</tr>
<tr>
<td>W0521607</td>
<td>#pragma text must precede the definition of function &quot;function&quot;.</td>
</tr>
<tr>
<td>W0521644</td>
<td>Definition at end of file not followed by a semicolon or a declarator.</td>
</tr>
<tr>
<td>W0521649</td>
<td>Required between the macro name &quot;macro name&quot; and its replacement text</td>
</tr>
<tr>
<td>W0523042</td>
<td>Using &quot;function item&quot; function at influence the code generation of &quot;SuperH&quot; compiler</td>
</tr>
<tr>
<td>W0523060</td>
<td>Incompatible section specified</td>
</tr>
<tr>
<td>W0523063</td>
<td>&quot;character string&quot; has no effect in this version</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>W0523064</td>
<td>Address taken &quot;variable-name&quot;. It may cause an upset endian indirect reference.</td>
</tr>
<tr>
<td>W0530809</td>
<td>const qualifier for variable &quot;variable-name&quot; differs between files.</td>
</tr>
<tr>
<td>W0530811</td>
<td>Type of symbol &quot;symbol-name&quot; differs between files.</td>
</tr>
<tr>
<td>W0544001</td>
<td>Alignment of &quot;section-name&quot; sections is inconsistent. &quot;value&quot; is assumed.</td>
</tr>
<tr>
<td>W0544002</td>
<td>Endian of &quot;section-name&quot; sections is inconsistent. &quot;endian type&quot; is assumed.</td>
</tr>
<tr>
<td>W0550002</td>
<td>Cannot use option1 with option2, option2 ignored.</td>
</tr>
<tr>
<td>W0550003</td>
<td>&quot;option&quot; option needs argument, ignored.</td>
</tr>
<tr>
<td>W0550004</td>
<td>Illegal &quot;option&quot; option's value, ignored.</td>
</tr>
<tr>
<td>W0550005</td>
<td>Illegal &quot;option&quot; option's symbol &quot;symbol&quot;, ignored.</td>
</tr>
<tr>
<td>W0550006</td>
<td>Illegal &quot;option&quot; option's argument, ignored.</td>
</tr>
<tr>
<td>W0550007</td>
<td>option -C mismatch. ignore -C. output core common object.</td>
</tr>
<tr>
<td>W0550008</td>
<td>option option is not supported for core core.</td>
</tr>
<tr>
<td>W0550009</td>
<td>Cannot find programmable peripheral I/O registers, ignored -Xprogrammable_io option.</td>
</tr>
<tr>
<td>W0550010</td>
<td>Illegal displacement in inst instruction.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
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<td>------------------------------</td>
</tr>
<tr>
<td>W0550011</td>
<td>[Message] Illegal operand (range error in immediate).</td>
</tr>
<tr>
<td>W0550012</td>
<td>[Message] Operand overflow.</td>
</tr>
<tr>
<td>W0550014</td>
<td>[Message] Illegal list value, ignored.</td>
</tr>
<tr>
<td>W0550015</td>
<td>[Message] Illegal register number, ignored.</td>
</tr>
<tr>
<td>W0550016</td>
<td>[Message] Illegal operand (access width mismatch).</td>
</tr>
<tr>
<td>W0550017</td>
<td>[Message] Base register is ep(r30) only.</td>
</tr>
<tr>
<td>W0550018</td>
<td>[Message] Illegal regID for inst.</td>
</tr>
<tr>
<td>W0550019</td>
<td>[Message] Illegal operand (immediate must be multiple of 4).</td>
</tr>
<tr>
<td>W0550020</td>
<td>[Message] Duplicated cpu type, ignored $PROCESSOR.</td>
</tr>
<tr>
<td>W0550021</td>
<td>[Message] string already specified, ignored.</td>
</tr>
<tr>
<td>Message</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W0550022</td>
<td>[Message] Duplicated option <code>option</code>, ignored.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] Duplicated option <code>option</code>, ignored. The previously specified option will be used. This specification will be ignored.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the option specification.</td>
</tr>
<tr>
<td>W0550023</td>
<td>[Message] Start address of programmable io is out of range(0x0,value1-value2), ignored.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] Start address of programmable io is out of range(0x0,value1-value2), ignored. The specified value will be ignored, and the initial value of the device will be used.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the option values.</td>
</tr>
<tr>
<td>W0550024</td>
<td>[Message] Sorry, <code>-option option</code> not implemented, ignored.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the option specification.</td>
</tr>
<tr>
<td>W0550026</td>
<td>[Message] Illegal register number, aligned odd register(rXX) to be even register(rYY).</td>
</tr>
<tr>
<td></td>
<td>[Explanation] Odd-numbered registers (r1, r3, ... r31) have been specified. The only general-purpose register that can be specified are even-numbered (r0, r2, r4, ... r30). Assembly will continue, assuming that even-numbered registers (r0, r2, r4, ... r30) have been specified.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the register specification.</td>
</tr>
<tr>
<td>W0550027</td>
<td>[Message] Illegal <code>control</code> value, ignored.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] The <code>control</code> control instruction differs from a previous specification. The previous specification will take precedence, and register modes specified by subsequent <code>control</code> control instructions will be ignored.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the <code>control</code> control instruction specification.</td>
</tr>
<tr>
<td></td>
<td>[Explanation] Duplicated <code>reg_mode</code>, ignored <code>$REG_MODE</code>. The <code>-Xreg_mode</code> option takes precedence, and register modes specified via the <code>$REG_MODE</code> control instruction will be ignored.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the option specification.</td>
</tr>
<tr>
<td>W0550029</td>
<td>[Message] Can not use r0 as destination in mul/mulu in <code>device-name</code> core.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the operand.</td>
</tr>
<tr>
<td>W0550030</td>
<td>[Message] Can not use mul/mulu X,Y,Y format in <code>device-name</code> core.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the operand.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Check the identifier.</td>
</tr>
<tr>
<td>W0550032</td>
<td>[Message] Cache instruction is used as cll.</td>
</tr>
<tr>
<td></td>
<td>[Action by User] The use of the cache instruction as cll is not recommended. Use the cll instruction.</td>
</tr>
<tr>
<td>W0550065</td>
<td>[Message] &quot;path-name&quot; specified by the &quot;character string&quot; option is a file. Specify a folder.</td>
</tr>
<tr>
<td>W0550066</td>
<td>[Message] The folder &quot;folder-name&quot; specified by the &quot;character string&quot; option is not found.</td>
</tr>
<tr>
<td>W05500623</td>
<td>[Message] The &quot;character string2&quot; option is ignored when the &quot;character string1&quot; option is specified at the same time.</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W0550644</td>
<td>&quot;-C&quot; option and &quot;-Xcommon&quot; option is mismatch. Instruction set by &quot;character string1&quot; option is ignored. Create common object for &quot;character string2&quot; instruction set.</td>
</tr>
<tr>
<td>W0550646</td>
<td>&quot;character string1&quot; specified in the &quot;character string2&quot; option is not allowed for a preprocessor macro. Recognized only as an assembler symbol</td>
</tr>
<tr>
<td>W0550647</td>
<td>The &quot;character string&quot; option is specified more than once. The latter is valid.</td>
</tr>
<tr>
<td>W0550649</td>
<td>The &quot;character string2&quot; option is ignored when the &quot;character string1&quot; option and the &quot;character string2&quot; option are inconsistent.</td>
</tr>
<tr>
<td>W0550651</td>
<td>The &quot;character string2&quot; option is ignored when the &quot;character string1&quot; option is not specified.</td>
</tr>
<tr>
<td>W0551000</td>
<td>`.ALIGN' with not 'ALIGN' specified relocatable section.</td>
</tr>
<tr>
<td>W0551001</td>
<td>Destination address may be changed.</td>
</tr>
<tr>
<td>W0551002</td>
<td>Floating point value is out of range.</td>
</tr>
<tr>
<td>W0551003</td>
<td>Location counter exceed.</td>
</tr>
<tr>
<td>W0551004</td>
<td>`.ALIGN' size is different.</td>
</tr>
<tr>
<td>W0551006</td>
<td>Data in 'CODE' section align in 4byte.</td>
</tr>
<tr>
<td>W0551007</td>
<td>Data size in 'CODE' section align in 4byte.</td>
</tr>
<tr>
<td>W0551009</td>
<td>Multiple symbols.</td>
</tr>
<tr>
<td>W0551010</td>
<td>Section attribute mismatch.</td>
</tr>
<tr>
<td></td>
<td>Message</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W0551011</td>
<td>Use PM instruction.</td>
</tr>
<tr>
<td>W0551012</td>
<td>Use FPU instruction.</td>
</tr>
<tr>
<td>W0551013</td>
<td>Use DSP instruction.</td>
</tr>
<tr>
<td>W0551014</td>
<td>Too many actual macro parameters.</td>
</tr>
<tr>
<td>W0551015</td>
<td>Actual macro parameters are not enough.</td>
</tr>
<tr>
<td>W0551016</td>
<td>'.END' statement is in include file.</td>
</tr>
<tr>
<td>W0551017</td>
<td>Use of &lt;instruction type&gt; instruction found.</td>
</tr>
<tr>
<td>W0561000</td>
<td>Option &quot;option&quot; ignored</td>
</tr>
<tr>
<td>W0561001</td>
<td>Option &quot;option1&quot; is ineffective without option &quot;option2&quot;</td>
</tr>
<tr>
<td>W0561002</td>
<td>Option &quot;option1&quot; cannot be combined with option &quot;option2&quot;</td>
</tr>
<tr>
<td>W0561003</td>
<td>Divided output file cannot be combined with option &quot;option&quot;</td>
</tr>
<tr>
<td>W0561004</td>
<td>Fatal level message cannot be changed to other level : &quot;option&quot;</td>
</tr>
<tr>
<td>W0561005</td>
<td>Subcommand file terminated with end option instead of exit option</td>
</tr>
<tr>
<td>W0561006</td>
<td>Options following exit option ignored</td>
</tr>
<tr>
<td>W0561007</td>
<td>Duplicate option : &quot;option&quot;</td>
</tr>
<tr>
<td>Code</td>
<td>Message</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W0561010</td>
<td>Duplicate file specified in option &quot;option&quot; : &quot;file name&quot;</td>
</tr>
<tr>
<td>W0561011</td>
<td>Duplicate module specified in option &quot;option&quot; : &quot;module&quot;</td>
</tr>
<tr>
<td>W0561012</td>
<td>Duplicate symbol/section specified in option &quot;option&quot; : &quot;name&quot;</td>
</tr>
<tr>
<td>W0561013</td>
<td>Duplicate number specified in option &quot;option&quot; : &quot;number&quot;</td>
</tr>
<tr>
<td>W0561014</td>
<td>License manager is not installed</td>
</tr>
<tr>
<td>W0561016</td>
<td>The evaluation version of version is valid for the remaining number days.</td>
</tr>
<tr>
<td>W0561017</td>
<td>Paid license of &quot;version&quot; is not found, and the evaluation period has expired.</td>
</tr>
<tr>
<td>W0561100</td>
<td>Cannot find &quot;name&quot; specified in option &quot;option&quot;</td>
</tr>
<tr>
<td>W0561101</td>
<td>&quot;name&quot; in rename option conflicts between symbol and section</td>
</tr>
<tr>
<td>W0561102</td>
<td>Symbol &quot;symbol&quot; redefined in option &quot;option&quot;</td>
</tr>
<tr>
<td>W0561103</td>
<td>Invalid address value specified in option &quot;option&quot; : &quot;address&quot;</td>
</tr>
<tr>
<td>W0561104</td>
<td>Invalid section specified in option &quot;option&quot; : &quot;section&quot;</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Confirm the following:</td>
</tr>
<tr>
<td></td>
<td>(1) The &quot;-output&quot; option does not accept specification of a section that has no initial value.</td>
</tr>
<tr>
<td></td>
<td>(2) The &quot;-jump_entries_for_pic&quot; option accepts specification of only a code section and no other sections.</td>
</tr>
<tr>
<td>W0561110</td>
<td>Entry symbol &quot;symbol&quot; in entry option conflicts</td>
</tr>
<tr>
<td>W0561120</td>
<td>Section address is not assigned to &quot;section&quot;</td>
</tr>
<tr>
<td></td>
<td>[Action by User] Specify the address of the section using the rlink option &quot;-start&quot;.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Message</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>W0561121</td>
<td>[Message] Address cannot be assigned to absolute section &quot;section&quot; in start option</td>
</tr>
<tr>
<td>W0561122</td>
<td>[Message] Section address in start option is incompatible with alignment : &quot;section&quot;</td>
</tr>
<tr>
<td>W0561130</td>
<td>[Message] Section attribute mismatch in rom option : &quot;section1&quot;,&quot;section2&quot;</td>
</tr>
<tr>
<td>W0561140</td>
<td>[Message] Load address overflowed out of record-type in option &quot;option&quot;</td>
</tr>
<tr>
<td>W0561141</td>
<td>[Message] Cannot fill unused area from &quot;address&quot; with the specified value</td>
</tr>
<tr>
<td>W0561142</td>
<td>[Message] Cannot find symbol which is a pair of &quot;symbol&quot;</td>
</tr>
<tr>
<td>W0561143</td>
<td>[Message] Address range &quot;start address-end address&quot; cannot be placed in flash memory area.</td>
</tr>
<tr>
<td>W0561150</td>
<td>[Message] Sections in &quot;option&quot; option have no symbol</td>
</tr>
<tr>
<td>W0561160</td>
<td>[Message] Undefined external symbol &quot;symbol&quot;</td>
</tr>
<tr>
<td>W0561181</td>
<td>[Message] Fail to write &quot;type of output code&quot;</td>
</tr>
<tr>
<td>W0561182</td>
<td>[Message] Cannot generate vector table section &quot;section&quot;</td>
</tr>
<tr>
<td>W0561183</td>
<td>[Message] Interrupt number &quot;vector number&quot; of &quot;section&quot; is defined in input file</td>
</tr>
<tr>
<td>W0561184</td>
<td>[Message] Interrupt number &quot;vector number&quot; of &quot;section&quot; is defined</td>
</tr>
<tr>
<td>W0561190</td>
<td>[Message] Section &quot;section&quot; was moved other area specified in option &quot;cpu=&lt;attribute&gt;&quot;</td>
</tr>
<tr>
<td>Message Id</td>
<td>Message</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>W0561191</td>
<td>[Message] Area of &quot;FIX&quot; is within the range of the area specified by &quot;cpu=&lt;attribute&gt;:&lt;start&gt;-&lt;end&gt;&quot;</td>
</tr>
<tr>
<td>W0561192</td>
<td>[Message] Bss Section &quot;section name&quot; is not initialized</td>
</tr>
<tr>
<td>W0561193</td>
<td>[Message] Section &quot;section name&quot; specified in option &quot;option&quot; is ignored</td>
</tr>
<tr>
<td>W0561194</td>
<td>[Message] Section &quot;section&quot; in relocation &quot;file&quot;:&quot;section&quot;:&quot;offset&quot; is changed.</td>
</tr>
<tr>
<td>W0561200</td>
<td>[Message] Backed up file &quot;file1&quot; into &quot;file2&quot;</td>
</tr>
<tr>
<td>W0561300</td>
<td>[Message] Option &quot;option&quot; is ineffective without debug information</td>
</tr>
<tr>
<td>W0561301</td>
<td>[Message] No inter-module optimization information in input files</td>
</tr>
<tr>
<td>W0561302</td>
<td>[Message] No stack information in input files</td>
</tr>
<tr>
<td>W0561305</td>
<td>[Message] Entry address in &quot;file&quot; conflicts : &quot;address&quot;</td>
</tr>
<tr>
<td>W0561310</td>
<td>[Message] &quot;section&quot; in &quot;file&quot; is not supported in this tool</td>
</tr>
<tr>
<td>W0561311</td>
<td>[Message] Invalid debug information format in &quot;file&quot;</td>
</tr>
<tr>
<td>W0561320</td>
<td>[Message] Duplicate symbol &quot;symbol&quot; in &quot;file&quot;</td>
</tr>
<tr>
<td>Message Code</td>
<td>Message</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>W0561321</td>
<td>[Message] Entry symbol &quot;symbol&quot; in &quot;file&quot; conflicts</td>
</tr>
<tr>
<td>W0561322</td>
<td>[Message] Section alignment mismatch : &quot;section&quot;</td>
</tr>
<tr>
<td>W0561323</td>
<td>[Message] Section attribute mismatch : &quot;section&quot;</td>
</tr>
<tr>
<td>W0561324</td>
<td>[Message] Symbol size mismatch : &quot;symbol&quot; in &quot;file&quot;</td>
</tr>
<tr>
<td>W0561325</td>
<td>[Message] Symbol attribute mismatch : &quot;symbol&quot; : &quot;file&quot;</td>
</tr>
<tr>
<td>W0561326</td>
<td>[Message] Reserved symbol &quot;symbol&quot; is defined in &quot;file&quot;</td>
</tr>
<tr>
<td>W0561327</td>
<td>[Message] Section alignment in option &quot;aligned_section&quot; is small : &quot;section&quot;</td>
</tr>
<tr>
<td>W0561331</td>
<td>[Message] Section alignment is not adjusted : &quot;section&quot;</td>
</tr>
<tr>
<td>W0561402</td>
<td>[Message] Parentheses specified in option &quot;start&quot; with optimization</td>
</tr>
<tr>
<td>W0561410</td>
<td>[Message] Cannot optimize &quot;file&quot;.&quot;section&quot; due to multi label relocation operation</td>
</tr>
<tr>
<td>W0561430</td>
<td>[Message] Cannot generate effective bls file for compiler optimization</td>
</tr>
<tr>
<td></td>
<td>[Action by User] The optimization of access to external variables (map option) in the compiler has the following restriction. Check if this restriction is applicable and modify the section allocation. Access to external variables cannot be optimized in some cases if a data section is allocated immediately after a data section when the base option is specified for compilation. Note: The bls file indicates the external symbol allocation information file. It contains the information to be used for the map option of the compiler.</td>
</tr>
<tr>
<td>Message ID</td>
<td>Message</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>W0561510</td>
<td>Input file was compiled with option &quot;smap&quot; and option &quot;map&quot; is specified at linkage</td>
</tr>
<tr>
<td>W0571600</td>
<td>An error occurred during name decoding of &quot;instance&quot;</td>
</tr>
<tr>
<td>W0578306</td>
<td>can not open file file</td>
</tr>
<tr>
<td>W0578307</td>
<td>can not close file file</td>
</tr>
<tr>
<td>W0578308</td>
<td>can not read file file</td>
</tr>
<tr>
<td>W0578309</td>
<td>can not write file file</td>
</tr>
<tr>
<td>W0578310</td>
<td>can not seek file file</td>
</tr>
<tr>
<td>W0578311</td>
<td>can not find file file</td>
</tr>
<tr>
<td>W0578315</td>
<td>can not find member member</td>
</tr>
<tr>
<td>W0578322</td>
<td>this symbol offset not true</td>
</tr>
</tbody>
</table>
10.5.6 Standard Library Error Messages

For some library functions, if an error occurs during the library function execution, an error code is set in the macro `errno` defined in the header file `<errno.h>` contained in the standard library.

Error messages are defined in the error codes so that error messages can be output. The following shows an example of an error message output program.

Example

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <errno.h>

main()
{
    FILE *fp;

    fp=fopen("file", "w");
    fp=NULL;

    fclose(fp); /* error occurred */

    printf("%s\n", strerror(errno)); /* print error message */
}
```

Description:

1. Since the file pointer of `NULL` is passed to the `fclose` function as an argument, an error will occur. In this case, an error code corresponding to `errno` is set.

2. The `strerror` function returns a pointer of the string literal of the corresponding error message when the error code is passed as an argument. An error message is output by specifying the output of the string literal of the `printf` function.
<table>
<thead>
<tr>
<th>Error No.</th>
<th>Error Message/Explanation</th>
<th>Functions to Set Error Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x22</td>
<td>Data out of range</td>
<td>frexp, ldexp, modf, ceil, floor, fmod, atof, atoi, atoll, atol, atolfixed, atolaccum, strtod, strtoul, strtoull, strtol, frexp, ldexp, modf, ceil, floor, fmod, atof, atoi, atoll, atol, atolfixed, atolaccum, perror, fprintf, fscanf, printf, scanf, sprintf, ssprintf, vfprintf, vprintf, vscanf, acos, acosf, asin, asinf, atan, atan2, atan2f, atanf, cabs, cabsf, cos, cossf, exp, expf, exp, exp, floor, floor, fmod, modf, ldexp, ldexpf, log, log10, log10f, logf, modf, pow, powf, sin, sinf, sinh, sinh, sqrt, sqrtf, tan, tanf, tanh, tanhf, fabs, fabsf, frexp, ldexpf</td>
</tr>
<tr>
<td>0x21</td>
<td>Data out of domain</td>
<td>acos, acosf, asin, asinf, atan, atan2, atan2f, atan, ceil, ceilf, cos, cosf, cossf, exp, expf, floor, floor, fmod, modf, ldexp, ldexpf, log, log10, log10f, logf, modf, pow, powf, sin, sinf, sinh, sinh, sqrt, sqrtf, tan, tanf, tanh, tanhf, fabs, fabsf, frexp, ldexpf</td>
</tr>
<tr>
<td>0x450</td>
<td>Too long string</td>
<td>atof, atoll, atol, atolfixed, atolaccum, strtod, strtoul, strtoull, strtol, frexp, ldexp, modf, ceil, floor, fmod, atof, atoi, atoll, atol, atolfixed, atolaccum, perror, fprintf, fscanf, printf, scanf, sprintf, ssprintf, vfprintf, vprintf, vscanf, acos, acosf, asin, asinf, atan, atan2, atan2f, atanf, cabs, cabsf, cos, cossf, exp, expf, exp, exp, floor, floor, fmod, modf, ldexp, ldexpf, log, log10, log10f, logf, modf, pow, powf, sin, sinf, sinh, sinh, sqrt, sqrtf, tan, tanf, tanh, tanhf, fabs, fabsf, frexp</td>
</tr>
<tr>
<td>0x04B0</td>
<td>Invalid radix</td>
<td>atof, atol, atolfixed, atolaccum, strtod, strtoul, strtoull, strtol, frexp, ldexp, modf, ceil, floor, fmod, atof, atoi, atoll, atol, atolfixed, atolaccum, perror, fprintf, fscanf, printf, scanf, sprintf, ssprintf, vfprintf, vprintf, vscanf, acos, acosf, asin, asinf, atan, atan2, atan2f, atanf, cabs, cabsf, cos, cossf, exp, expf, exp, exp, floor, floor, fmod, modf, ldexp, ldexpf, log, log10, log10f, logf, modf, pow, powf, sin, sinf, sinh, sinh, sqrt, sqrtf, tan, tanf, tanh, tanhf, fabs, fabsf, frexp</td>
</tr>
<tr>
<td>0x04B2</td>
<td>Number too long</td>
<td>atof, atolfixed, atolaccum, strtod, strtoul, strtoull, strtol, frexp, ldexp, modf, ceil, floor, fmod, atof, atoi, atoll, atol, atolfixed, atolaccum, perror, fprintf, fscanf, printf, scanf, sprintf, ssprintf, vfprintf, vprintf, vscanf, acos, acosf, asin, asinf, atan, atan2, atan2f, atanf, cabs, cabsf, cos, cossf, exp, expf, exp, exp, floor, floor, fmod, modf, ldexp, ldexpf, log, log10, log10f, logf, modf, pow, powf, sin, sinf, sinh, sinh, sqrt, sqrtf, tan, tanf, tanh, tanhf, fabs, fabsf, frexp</td>
</tr>
<tr>
<td>0x04B4</td>
<td>Exponent too large</td>
<td>atof, strtold, fsscanf, ssscanf</td>
</tr>
<tr>
<td>0x04B6</td>
<td>Normalized exponent too large</td>
<td>atof, strtold, fsscanf, ssscanf</td>
</tr>
<tr>
<td>0x04BA</td>
<td>Overflow out of float</td>
<td>fsscanf, sscanf</td>
</tr>
<tr>
<td>0x04C4</td>
<td>Underflow out of float</td>
<td>fsscanf, ssscanf</td>
</tr>
<tr>
<td>0x04E2</td>
<td>Overflow out of double</td>
<td>fsscanf, sscanf</td>
</tr>
<tr>
<td>0x04EC</td>
<td>Underflow out of double</td>
<td>fsscanf, ssscanf</td>
</tr>
<tr>
<td>0x04F6</td>
<td>Overflow out of long double</td>
<td>fsscanf, ssscanf</td>
</tr>
<tr>
<td>0x0500</td>
<td>Underflow out of long double</td>
<td>fsscanf, ssscanf</td>
</tr>
</tbody>
</table>
11. Usage Notes

This chapter describes the points to be noted when using the CCRX.

11.1 Notes on Program Coding

(1) Functions with Prototype Declarations

When a function is called, the prototype of the called function must be declared. If a function is called without a prototype declaration, parameters may not be received and passed correctly.

Examples 1. The function has the float type parameter (when \texttt{dbl\_size=8} is specified).

```c
void g()
{
    float a;
    ...
    f(a);       //Converts \texttt{a} to \texttt{double} type
}
void f(float x)
{...}
```

Examples 2. The function has \texttt{signed char, (unsigned) char, (signed) short, and unsigned short} type parameters passed by stack.

```c
void h();
void g()
{
    char a,b;
    ...
    h(1,2,3,4,a,b);   // Converts \texttt{a} and \texttt{b} to \texttt{int} type
}
void h(int a1, int a2, int a3, int a4, char a5, char a6)
{...}
```

(2) Function Declaration Containing Parameters without Type Information

When more than one function declaration (including function definition) is made for the same function, do not use both a format in which parameters and types are not specified together and a format in which parameters and types are specified together.

If both formats are used, the generated code may not process types correctly because there is a difference in how the parameters are interpreted in the caller and callee.

When the error message \texttt{C5147} is displayed at compilation, this problem may have caused it. In such a case, either use only a format in which parameters and types are specified together or check the generated code to ensure that there is no problem in parameter passing.

Example Since \texttt{old\_style} is written in different formats, the meaning of the types of parameters \texttt{d} and \texttt{e} are different in the caller and callee. Thus, parameters are not passed correctly.
Expressions whose Evaluation Order is not Specified by the C/C++ Language

When using an expression whose evaluation order is not specified in the C/C++ language specifications, the operation is not guaranteed in a program code whose execution results differ depending on the evaluation order.

Example

```c
extern int old_style(int, int, int, short, short);
/* Function declaration: Format in which parameters and types are specified together */
int old_style(a, b, c, d, e)
    /* Function definition: Format in which parameters and types are not specified together */
    int a, b, c;
    short d, e;
    { return a + b + c + d + e; }
int result;
func()
    { result = old_style(1, 2, 3, 4, 5); }
```

Overflow Operation and Zero Division

Even if an overflow operation or floating-point zero division is performed, error messages will not be output. However, if an overflow operation is included in the operations of a single constant or between constants, error messages will be output at compilation.

Example

```c
void main()
    { int ia;
      int ib;
      float fa;
      float fb;
      ib=32767;
      fb=3.4e+38f;
      /* Compilation error messages are output when an overflow operation */
      /* is included in operations of a constant or between constants */
      ia=99999999999; /* (W) Detects overflow in constant operation */
      fa=3.5e+40f;    /* (E) Detects overflow in floating-point operation */
      /* No error message is output for overflow at execution */
      ib=ib+32767;    /* Ignores overflow in operation result */
      fb=fb+3.4e+38f; /* Ignores overflow in floating-point operation result */
    }
```

Writing to const Variables
Even if a variable is declared with `const` type, if assignment is done to a non-`const` type variable converted from `const` type or if a program compiled separately uses a parameter of a different type, the compiler cannot check the writing to a `const` type variable. Therefore, precautions must be taken.

**Example**

```c
<Example>
const char *p;  /* Because the first parameter in library */
:   /* function strcat is a pointer to char, the */
strcat(p, "abc");  /* area indicated by the parameter may change */

file 1
const int i;

file 2
extern int i;  /* In file 2, variable i is not declared as */
:   /* const, therefore writing to it in file 2 */
i=10;  /* is not an error */
</Example>
```

(6) **Precision of Mathematical Function Libraries**

For functions `acos(x)` and `asin(x)`, an error is large around x=1. Therefore, precautions must be taken. The error range is as follows:

- Absolute error for `acos(1.0 - ε)`
  - double precision: $2^{-39}$ ($ε = 2^{-33}$)
  - single precision: $2^{-21}$ ($ε = 2^{-19}$)

- Absolute error for `asin(1.0 - ε)`
  - double precision: $2^{-39}$ ($ε = 2^{-28}$)
  - single precision: $2^{-21}$ ($ε = 2^{-16}$)

(7) **Codes that May be Deleted by Optimization**

A code continuously referencing the same variable or a code containing an expression whose result is not used may be deleted as redundant codes at optimization by the compiler. Variables should be declared with `volatile` in order for accesses to always be guaranteed.

**Example**

```
[1] b=a;  /* The expression in the first line may be deleted */
      /* as redundant code */
b=a;

[2] while(1)a;  /* The reference to variable a and the loop */
      /* statement may be deleted as redundant code */
```

(8) **Differences between C89 Operation and C99 Operation**

In the C99, selection statements and repeat statements are enclosed in curly brackets `{ }`. This causes operations to differ in the C89 and C99.

**Example**

```
<Example>
enum {a,b};
int g(void)
{
    if(!sizeof(enum[b,a]))
        return a;
    return b;
}
</Example>
```

If the above code is compiled with `-lang=c99` specified, it is interpreted as follows:
g()=0 in -lang=c becomes g()=1 in -lang=c99.

(9) Operations and Type Conversions That Lead to Overflows
The result of any operation or type conversion must be within the allowed range of values for the given type (i.e. values must not overflow). If an overflow does occur, the result of the operation or type conversion may be affected by other conditions such as compiler options.
In the standard C language, the result of an operation that leads to an overflow is undefined and thus may differ according to the current conditions of compilation. Ensure that no operations in a program will lead to an overflow. The following example illustrates this problem.

Example

```
enum {a,b};
int g(void)
{
    {
        if(!sizeof(enum{b,a}))
            return a;
    }
    return b;
}
```

The value of `ui2`, which is acquired as the result of executing `ex1func`, depends on whether `–fpu` or `–nofpu` has been specified.
- `fpu` (with the FPU): `ui2 = 65535`
- `nofpu` (without the FPU): `ui2 = 0`
This is because the method of type conversion from `float` to `unsigned short` differs according to whether `–fpu` or `–nofpu` has been specified.

(10) Symbols That Contain Two or More Underscores (__)
Symbols must not contain sequences of two or more underscores. Even though the code generated in such cases seems normal, the symbol names may be mistaken as different C++ function names when they are output as linkage-map information.

Example
```
int sample__Fc(void) { return 0; }
```
This will be output to the linkage map as `sample(char)` rather than `_sample__Fc`. 
11.2 Notes on Compiling a C Program with the C++ Compiler

(1) Functions with Prototype Declarations
Before using a function, a prototype declaration is necessary. At this time, the types of the parameters should also be declared.

```c
extern void func1();
void g()
{
    func1(1); // Error
}
```

```c
extern void func1(int);
void g()
{
    func1(1); // OK
}
```

(2) Linkage of const Objects
Whereas in C programs `const` type objects are linked externally, in C++ programs they are linked internally. In addition, `const` type objects require initial values.

```c
const cvalue1; // Error
const cvalue2 = 1; // Links internally
const cvalue1 = 0; // Gives initial value
extern const cvalue2 = 1; // Links externally as a C program
```

(3) Assignment of void*
In C++ programs, if explicit casting is not used, assignment of pointers to other objects (excluding pointers to functions and to members) is not possible.

```c
void func(void *ptrv, int *ptri)
{
    ptri = ptrv; // Error
}
```

```c
void func(void *ptrv, int *ptri)
{
    ptri = (int *)ptrv; // OK
}
```

11.3 Notes on Options

(1) Options Requiring the Same Specifications
Options that should always be specified in the same way are shown in (a) and (b) below. If relocatable files and library files using different options are linked, the operation of the program at runtime is not guaranteed.

(a) The five options `isa`, `cpu`, `endian`, `base`, and `fint_register` should be specified in the same way in the compiler, assembler, and library generator.

(b) The options in the Microcontroller Options section of the COMMAND REFERENCE chapter, except for the options in (a), must be specified in the same way in the compiler and library generator.

(2) When Using -reent (an Option Which Generates a Reentrant Library) of lbgrx (a Library Generator)
To enable specification of the -reent option for the lbgrx library generator in a project generated in a Renesas integrated development environment, confirm if the low-level _INIT_IOLIB() function of the project contains the statements for execution in relation to alignment_Files listed below.
If the function does not include these statements, add them with reference to the contents of the _INIT_IOLIB() function in the listing of the lowsrc.c file in the of section 8.4 Coding Example.

```c
_FILES[0] = stdin;
_FILES[1] = stdout;
_FILES[2] = stderr;
```
11.4 Preventing E0562330 Errors in Cases Where Optimization by the Optimizing Linkage Editor is Enabled

The optimizing linkage editor is used for optimization, which involves replacing existing code with code that takes up less space in relation to the address where each symbol referred to by the original instruction is located. To reduce the size of the code as much as possible, the linkage editor will attempt to replace numerous instructions.

Replacing instructions may, however, change the addresses where individual symbols are located and thus prevent reference to symbols by the optimized code. In such cases, the optimizing linkage editor reports an E0562330 error and stops operations so that code having this problem will not be output.

Due to the characteristics of the RX architecture, this error may arise when any symbol (e.g. a variable, constant, or switch table) located at FFFF8000h or a higher address prior to optimization is allocated to an address below FFFF8000h after optimization.

(1) Outline
Examples of conditions leading to E0562330 errors are given below.

In a program where the reading of constants CONST1 and CONST2 is intended, section P is followed by section C, which is allocated to address FFFF8000h prior to optimization.

Examples 1. Section P

; 6-byte instruction MOV.L #_CONST1:32, R1
MOV.L #0FFFF8002H, R1

; 6-byte instruction MOV.L #_CONST2:32, R2
MOV.L #0FFFF8006H, R2

Section C

CONST0:                ; Allocated to address FFFF8000h
.byte 00H,01H
CONST1:                ; Allocated to address FFFF8002h
.byte "123"
.byte 00H
CONST2:                ; Allocated to address FFFF8006h
.byte "abc"
.byte 00H

Since optimization changes the address of section C from FFFF8000H (a 32-bit immediate value) to -8000H (a signed 16-bit immediate value), the 32-bit immediate-value transfer MOV.L instruction will be replaced by a 16-bit immediate-value transfer instruction. This reduces the size of section P and leads to its allocation to a lower address than section C.

Examples 2. Section P

; 4-byte instruction MOV.L #_CONST1:16, R1
MOV.L #-8002H, R1 ; Exceeds the range of signed 16-bit values

; 4-byte instruction MOV.L #_CONST2:16, R2
MOV.L #-7FFEH, R2

Section C

CONST0:                ; Allocated to address FFFF7FFCh
.byte 00H,01H
CONST1:                ; Allocated to address FFFF7FFEh
.byte "123"
.byte 00H
CONST2:                ; Allocated to address FFFF8002h
.byte "abc"
.byte 00H
Due to optimization of multiple MOV.L instructions, constant CONST1 is allocated to an address beyond the range of signed 16-bit values, leading to an E0562330 error as shown below.

Examples 3.
E0562330: Relocation size overflow : "fileA.obj"="P"="0000002"

(2) How to identify the cause
You can identify the cause of the error in the following way.
First, specify the optimizing linkage editor options nooptimize and list and build the user program to generate a link map file. Since the information on the allocation of sections begins from the line "*** Mapping List ***" in the link map file, check sections allocated to FFFF8000h and higher addresses.

Examples 4.

*** Mapping List ***
C ffff7ffc ffff8005 a 1

After that, specify the assembler option listfile and build the user program to generate a source listing file. Find the section (P in example 3) in the source listing file for the object file ("fileA.obj" in example 3) indicated by the error message.
The offset value indicated by the error message is the value after optimization.
In the source listing file, locate the instructions that are at or above the offset address (0000002 in example 3) and references to any symbols within sections allocated to the address FFFF8000h or a higher address.
In example 5, you can see that the MOV.L instruction that attempts access to constant CONST1 in section C at an address above FFFF8000h is the reason for the error.

Examples 5.

.section P, CODE
00000000 FB1Arrrr MOV.L #_CONST1:16, R1 <- Access to section C
00000004 FB2Arrrr MOV.L #_CONST2:16, R2

.section C, ROMDATA
00000000 _CONST0:
00000000 0001 .byte 00H,01H
00000002 _CONST1:
00000002 313233 .byte "123"
00000005 00 .byte 00H
00000006 _CONST2:
00000006 616263 .byte "abc"
00000009 00 .byte 00H

(3) Countermeasures
Select one of the following countermeasures.

- Countermeasure 1: Change the order of sections
  If the first address of a section allocated to address FFFF8000h or above before optimization is shifted to an address below FFFF8000h after optimization, use the start option to change the place of that section in the order of sections.

Example
Before:  
- start=P,C,L,D/FFFF7000
After (switching sections C and L):
- start=P,L,C,D/FFFF7000

If an E0562330 error is still output even after the order of sections is switched, change the order again until the error is no longer output.
- Countermeasure 2: Allocate the section to address $\text{FFFF8000h}$
If the first address of a section allocated to address $\text{FFFF8000h}$ or above before optimization is shifted to an address below $\text{FFFF8000h}$ after optimization, use the `start` option to allocate that section to address $\text{FFFF8000h}$.

Example
Before:

```
-start=P,C,L,D/FFFF7000
```

After:

```
-start=P/FFFF70000,C,L,D/FFFF8000
```

- Countermeasure 3: Disable optimization by the optimizing linkage editor
Use the `-nooptimize` option to completely disable optimization or select the desired sub-options for the `-optimize` option to prevent the output of the E0562330 error while watching the reduction of the size of code by optimization.

11.5 Compatibility with an Older Version or Older Revision
The effect of the compatibility regarding a version change or revision change is described here.

11.5.1 V.1.01 and Later Versions (Compatibility with V.1.00)
(1) Changing Specifications of Intrinsic Functions
For intrinsic functions having parameters or return values that indicate addresses, their type is changed from the conventional `unsigned long` to `void *`. The changed functions are shown in Table 11.1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Specification</th>
<th>Function</th>
<th>Changed Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User stack pointer (USP)</td>
<td>void set_usp(void *data)</td>
<td>USP setting</td>
<td>Parameter</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>void *get_usp(void)</td>
<td>USP reference</td>
<td>Return value</td>
</tr>
<tr>
<td>3</td>
<td>Interrupt stack pointer (ISP)</td>
<td>void set_isp(void *data)</td>
<td>ISP setting</td>
<td>Parameter</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>void *get_isp(void)</td>
<td>ISP reference</td>
<td>Return value</td>
</tr>
<tr>
<td>5</td>
<td>Interrupt table register (INTB)</td>
<td>void set_intb (void *data)</td>
<td>INTB setting</td>
<td>Parameter</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>void *get_intb(void)</td>
<td>INTB reference</td>
<td>Return value</td>
</tr>
<tr>
<td>7</td>
<td>Backup PC (BPC)</td>
<td>void set_bpc(void *data)</td>
<td>BPC setting</td>
<td>Parameter</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>void *get_bpc(void)</td>
<td>BPC reference</td>
<td>Return value</td>
</tr>
<tr>
<td>9</td>
<td>Fast interrupt vector register (FINTV)</td>
<td>void set_fintv(void *data)</td>
<td>FINTV setting</td>
<td>Parameter</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>void *get_fintv(void)</td>
<td>FINTV reference</td>
<td>Return value</td>
</tr>
</tbody>
</table>

Due to this change, a program using the above functions in V.1.00 may generate a warning or an error about invalid types. In this case, add or delete the cast to correct the types.

An example of a startup program normally used in V.1.00 is shown below. This example will output warning message W0520167 in V.1.01, but this warning can be avoided by deleting the cast to correct the type.

Example

[Usage example of `set_intb` function]
Usage Notes

(2) Adding Section L (section Option and Start Option)

V.1.01 is provided with section L which is used for storing literal areas, such as, string literal. Since the number of sections has increased and section L is located at the end at linkage, the optimizing linkage editor may output address error F0563100 in some cases.

To avoid such an error, adopt either one of the following methods.

(a) Add L to the section sequence specified with the Start option of the optimizing linkage editor at linkage.

Example

[Example of specification in V.1.00]

```c
#pragma entry Reset_Program
void PowerON_Reset_PC(void)
{
...
    set_intb((unsigned long)__sectop("C$VECT")); //Warning W0520167 is output
    ...
}
```

[Example of code changed to match V.1.01]

```c
#pragma entry Reset_Program
void PowerON_Reset_PC(void)
{
...
    set_intb(__sectop("C$VECT")); //Cast (unsigned long) is deleted
    ...
}
```

(b) Select -section=L=C at compilation.

By specifying -section=L=C at compilation, the output destination of the literal area is changed to section C, and a section configuration compatible with V.1.00 can be achieved.

Note that this method may affect code efficiency compared to the above method of changing the Start option at linkage.

11.5.2 V.2.00 and Later Versions (Compatibility with Versions between 1.00 and 1.02)

(1) Restriction That Applies to Operation of the Linkage Editor When the -merge_files Option of the Compiler Has been Used

When an object module file created by the compiler with the -merge_files option specified is to be linked, correct operation is not guaranteed if the -delete, -rename, or -replace option is specified.

(2) Note on Generation of Code That Corresponds to if Statements When optimize=0

In this version of this compiler, if statements where the conditional expression has a constant value and statements that will accordingly never be executed are not reflected in the output code whether or not optimize=0 is specified.

In the examples below, lines marked [Deleted] are not reflected at the time of code generation.

Examples 1. Expression that produces a constant value

```c
#include <machine.h>
#pragma entry Reset_Program
void PowerON_Reset_PC(void)
{
...
    set_intb((unsigned long)__sectop("C$VECT")); //Warning W0520167 is output
    ...
}
```
Examples 2. Constant expressions that include symbolic addresses are also treated as constant expressions.

```c
int a,b,c;
void func01(void)
{
    if (1+2) { /* [Deleted] */
        /* Executed */
        a = b;
    } else {
        /* Never executed */
        a++; /* [Deleted] */
        b = c; /* [Deleted] */
    }
}

void f1(void),f2(void);
void func02(void)
{
    if (f1==0) { /* [Deleted] */
        /* Never executed */
        f2(); /* [Deleted] */
    } else {
        /* Executed */
        f1();
    }
}
```

(3) Differences in Assembly Source Code Output by -show=source
There are the following differences in the assembly source code to be output by this version of this compiler when -show=source is specified.

- `.LINE` is not displayed unless -debug has been specified.
- `#include` statements are not expanded.
- The instruction that corresponds to source code that follows `#line` may be incorrect.

11.5.3 V.2.03 and Later Versions (Compatibility with Versions between 1.00 and 2.02)

(1) Const-type Static Variables without Initial Values
In versions before 2.02, const-type static variables with initial values were output first, but from this revision, const-type static variables are aligned in the data area in order of their definition regardless of the existence of initial values.

Example

```c
const int a=1;
const int b;
const int c=2;
```

[Result of compilation for versions before 2.02.00]

```assembly
.SECTION C,ROMDATA,ALIGN=4
_a:
    .lword 00000001H
_c:
    .lword 00000002H ; The variables with initial values are output first.
_b:
    .lword 00000000H
```
11.5.4 V2.06 and Later Versions (Compatibility with V2.05 and earlier)

(1) Introducing the Method for Controlling the Output of Bit Manipulation Instructions

In V2.05 and earlier versions of the compiler, there was no method for the user to always output bit manipulation instructions.
In V2.06, the compiler is modified to allow the user to control whether to output bit manipulation instructions instead of using intrinsic functions.

To output bit manipulation instructions without using intrinsic functions, create a source program so that all conditions shown below are satisfied.
(a) A constant value is assigned.
(b) The value is assigned to a single-bit bit field of a 1-byte type.
(c) The bit field where the value is assigned is qualified with `volatile`.

To stop the output of bit manipulation instructions, satisfy condition (c) above and either assign a value that is not a constant in condition (a) or use a type that is not a 1-byte type in condition (b).

Otherwise, the compiler automatically determines whether to output bit manipulation instructions according to the specified optimization level and the contents of the source program.

Note 1-byte types are `char`, `unsigned char`, `signed char`, `_Bool`, and `bool`. `_Bool` and `bool` are excluded when `-lang=c` is specified.

Example

```c
volatile struct {
    unsigned char bit0:1;
    unsigned int  bit1:1;
} data;

void func(void) {
    data.bit0 = 1;  /* A bit manipulation instruction is output. */
    data.bit1 = 1;  /* No bit manipulation instruction is output. */
}
```

To always output bit manipulation instructions in V2.05, use intrinsic functions `__bclr()`, `__bset()`, and `__bnot()`. When the intrinsic functions are not used, the compiler automatically determines whether to output bit manipulation instructions according to the specified optimization level and the contents of the source program. The V2.04 and earlier versions of the compiler do not support these intrinsic functions. To check whether bit manipulation instructions are output, refer to the assembly source code output by the compiler.

11.5.5 Version of Compiler Package

When using an optimizing linker, use one provided with the same compiler package used to generate all object files, relocatable files, and library files that are to be input. An optimizing linker provided with a newer compiler package can also be used.
When using standard library functions, use those provided with the same compiler package as the optimizing linker in use.
11.6 W0523041 message [C/C++ compiler]

When the -int_to_short option is specified and a file including a C standard header is compiled as C++ or EC++, the
compiler may show the W0523041 message. In this case, simply ignore the message because there are no problems.

[NOTE]
In compilation of C++ or EC++, the -int_to_short option will be invalid.
Data that are shared between C and C++ (EC++) program must be declared as the long or short type rather than as the
int type.

11.7 Using MVTC or POPC instructions [Assembler]

In the assembly language, the program counter (PC) cannot be specified for MVTC or POPC instructions.

11.8 Using the -delete option for linkage [Optimizing linkage editor]

When a function symbol is removed by the -delete option, its following function in the source program is not allowed to
have a breakpoint at its function name on the editor while debugging. If you intend to set a breakpoint via the [Label]
window at the function entrance, set the breakpoint via the [Label] window or at the program code of the function.

11.9 Path names

Absolute paths that include drive letters or relative paths can be used as the path names for specifying input/output files
or folders. Each path name should consist of no more than 259 characters.
A. QUICK GUIDE

This chapter describes programming methods and the usage of extended functions for effective use of the RX family.

A.1 Variables (C Language)

This section describes variables (C language).

A.1.1 Changing Mapped Areas

The defaults for the mapped sections of variables are as follows:

- Variables without initial values: Sections B, B_2, and B_1
- Variables with initial values: Sections D, D_2, and D_1 (ROM) and sections R, R_2, and R_1 (RAM)
- const variables: Sections C, C_2, and C_1

For changing the area (section) to map variables, specify the section type and section name through `#pragma section`.

```
#pragma section <section type> <section name>
```

Variable declaration/definition

```
#pragma section
```

When a section type is specified, only section names of the specified type can be changed.

Note that in the RX family C/C++ compiler, the section to map a variable depends on the alignment value of the variable.

Example

- B: Variables without initial values and an alignment value of four bytes are mapped
- B_2: Variables without initial values and an alignment value of two bytes are mapped
- B_1: Variables without initial values and an alignment value of one byte are mapped

For variables with initial values, the initial value is mapped to ROM and the variable itself is mapped to RAM (both ROM and RAM areas are necessary). When the `resetprg.c` file of the startup routine is used, the `INITSCT` function copies the initial values in ROM to the variables in RAM.

The relationship between the section type and the created section is shown in the following.

<table>
<thead>
<tr>
<th>Name</th>
<th>Section Name</th>
<th>Attribute</th>
<th>Format Type</th>
<th>Initial Value and Write Operation</th>
<th>Alignment Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant area</td>
<td>C^{1*2}</td>
<td>romdata</td>
<td>Relative</td>
<td>Has initial values and writing is not possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td></td>
<td>C_{2<em>1</em>2}</td>
<td>romdata</td>
<td>Relative</td>
<td>Has initial values and writing is not possible</td>
<td>2 bytes</td>
</tr>
<tr>
<td></td>
<td>C_{1<em>1</em>2}</td>
<td>romdata</td>
<td>Relative</td>
<td>Has initial values and writing is not possible</td>
<td>1 byte</td>
</tr>
<tr>
<td>Initialized data area</td>
<td>D^{1*2}</td>
<td>romdata</td>
<td>Relative</td>
<td>Has initial values and writing is possible</td>
<td>4 bytes</td>
</tr>
<tr>
<td></td>
<td>D_{2<em>1</em>2}</td>
<td>romdata</td>
<td>Relative</td>
<td>Has initial values and writing is possible</td>
<td>2 bytes</td>
</tr>
<tr>
<td></td>
<td>D_{1<em>1</em>2}</td>
<td>romdata</td>
<td>Relative</td>
<td>Has initial values and writing is possible</td>
<td>1 byte</td>
</tr>
</tbody>
</table>
Example 1. Section names can be switched by the section option or the #pragma section extension. However, partial data (e.g., string literal) is not affected by #pragma section. For details, see the detailed description of 4.2.3 #pragma Directive - #pragma section.

Example 2. Specifying a section with an alignment value of 4 when switching the section names also changes the section name of sections with an alignment value of 1 or 2. When #pragma endian is used to specify an endian that differs from the setting by the endian option, a dedicated section is created and the relevant data stored. For this section, after the section name, _B is added for #pragma endian big and _L is added for #pragma endian little. However, partial data (e.g., string literal) is not affected by #pragma endian. For details, see the detailed description of 4.2.3 #pragma Directive - #pragma endian.

Example 3. <section> is a C, D, or B section name, and <address> is an absolute address (hexadecimal).

Example 4. The initial value and write operation depend on the attribute of <section>.

A.1.2 Defining Variables Used at Normal Processing and Interrupt Processing

Variables used for both normal processing and interrupt processing must be volatile qualified.

When a variable is qualified with the volatile qualifier, that variable is not to be optimized and optimization, such as assigning it to a register, is not performed. When operating a variable that has been volatile qualified, a code that reads its value from memory and writes its value to memory after operation must be used. A variable not volatile qualified is assigned to a register by optimization, and the code that loads that variable from memory may be deleted. When the same value is to be assigned to a variable that is not volatile qualified, the processing may be interpreted as redundant and the code deleted by optimization.

A.1.3 Generating a Code that Accesses Variables in the Declared Size

When accessing a variable in its declared size, the __evenaccess extended function should be used.
The `__evenaccess` declaration guarantees access in the size of the variable type. The guaranteed size is a scalar type (`signed char`, `unsigned char`, `signed short`, `unsigned short`, `signed int`, `unsigned int`, `signed long`, or `unsigned long`) of four bytes or less.

The `__evenaccess` is invalid to the case of accessing of members by a lump of these structure and union frame. When a structure or union is specified, the `__evenaccess` declaration is effective for all members. In such a case, the access size of a scalar type member of four bytes or less is guaranteed but the access size for the whole structure or union is not guaranteed.

[Example]

C source code

```c
#pragma address A=0xff0178
unsigned long __evenaccess A;
void test(void)
{
    A &= ~0x20;
}
```

Output code (when `__evenaccess` is not specified)

```assembly
_test:
    MOV.L #16712056,R1
    BCLR #5,[R1] ; 1-byte memory access
    RTS
```

Output code (when `__evenaccess` is specified)

```assembly
_test:
    MOV.L #16712056,R1
    MOV.L [R1],R5 ; 4-byte memory access
    BCLR #5,R5
    MOV.L R5,[R1] ; 4-byte memory access
    RTS
```

### A.1.4 Performing `const` Declaration for Variables with Unchangeable Initialized Data

A variable with an initial value is normally transferred from a ROM area to a RAM area at startup, and processing is performed using the RAM area. Accordingly, if the value is initialized data which is unchangeable in the program, the allocated RAM area goes to waste. If the `const` operator is added to initialized data, transfer to the RAM area at startup is disabled and the amount of used memory can be saved.

In addition, writing a program based on the rule of not changing the initial values also makes usage of ROM easier.

[Example before improvement]

```c
char a[] = { 1, 2, 3, 4, 5 };
Initial values are transferred from ROM to RAM and then processing is performed.
```

[Example after improvement]

```c
const char a[] = { 1, 2, 3, 4, 5 };
Processing is performed using the initial values in ROM.
```

### A.1.5 Defining the `const` Constant Pointer

The pointer is interpreted differently according to where "`const`" is specified.

[Example 1]

```c
const char *p;
In this example, the object (`*p`) indicated by the pointer cannot be changed. The pointer itself (`p`) can be changed.
```

Therefore, the result becomes as shown below and the pointer itself is mapped to RAM (section B).

```
*p = 0; /* Error */
p = 0; /* Correct */
```

[Example 2]

```c
char *const p;
```
In this example, the pointer itself (p) cannot be changed. The object (*p) indicated by the pointer can be changed. Therefore, the result becomes as shown below and the pointer itself is mapped to ROM (section C).

*p = 0; /* Correct */
p = 0; /* Error */

[Example 3]
char *const p;
In this example, the pointer itself (p) and the object (*p) indicated by the pointer cannot be changed. Therefore, the result becomes as shown below and the pointer itself is mapped to ROM (section C).

*p = 0; /* Error */
p = 0; /* Error */

A.1.6 Referencing Addresses of a Section

The addresses and size of a section can be referenced by using section address operators.

__sectop ("<section name>"): References the start address of <section name>
__secend ("<section name>"): References the sum of the size of <section name> and the address where <section name> starts.
__secsize ("<section name>"): References the size of <section name>

[Example]

```c
#pragma section $DSEC
static const struct {
    void *rom_s; /* Acquires the start address value of the initialized data section in ROM */
    void *rom_e; /* Acquires the last address value of the initialized data section in ROM */
    void *ram_s; /* Acquires the start address value of the initialized data section in RAM */
} DTBL[]={__sectop("D"), __secend("D"), __sectop("R")};
```

The INITSC function in the resetprg.c file of the startup routine executes transfer from ROM to RAM and initialization of uninitialized areas. The addresses acquired by __sectop and __secend written in the dbsct.c file are referenced during execution.

A.2 Functions

This section describes functions.

A.2.1 Filling Assembler Instructions

In the RX family C/C++ compiler, assembler instructions can be written in a C-language source program using #pragma inline_asm.

[Example]

```c
#pragma inline_asm
static int func(int a, int b){
    ADD R2,R1 ; Assembly-language description
}
main(int *p){
    *p = func(10,20);
}
```

Inline expansion is performed for an assembly-language function specified by #pragma inline_asm. The general function calling rules are also applied to the calls of assembly-language inline functions.

A.2.2 Performing In-Line Expansion of Functions

#pragma inline declares a function for which inline expansion is performed.

The compiler options inline and noinline are also used to enable or disable inline expansion. However, even when the noinline option is specified, inline expansion is done for the function specified by #pragma inline.
A global function or a static function member can be specified as a function name. When inline expansion is performed for a function specified by \#pragma inline or a function with the inline function specifier (C++ and C (C99), the body of the function is expanded where the function is called.

[Example]

C source code

```c
#pragma inline(func)
static int func (int a, int b)
{
    return (a+b)/2;
}
int x;
main()
{
    x=func(10,20);
}
```

Expanded image

```c
int x;
main()
{
    int func_result;
    {
        int a_1=10, b_1=20;
        func_result=(a_1+b_1)/2;
    }
    x=func_result;
}
```

A.2.3 Performing (Inter-File) In-Line Expansion of Functions

Normally, inline expansion is performed for functions within a file. However, using the -file_inline option of the compiler allows inline expansion to be performed for even inter-file function calling.

[Example]

```c
<.a.c>
func()
    g();
}
<b.c>
g()
    h();
}
```

By compiling with the specification of ccrx-inline-file_inline=b.c a.c, calling of function g in a.c is expanded and becomes as follows:

```c
func()
    h();
}
```

A.3 Using Microcomputer Functions

This section describes usage of microcomputer functions.

A.3.1 Processing an Interrupt in C Language

Use \#pragma interrupt to declare an interrupt function.

[Example]
C source code

```c
#pragma interrupt func
void func(){ .... }
```

Generated code

```assembly
_func:
    PUSHM R1-R3 ; Saves registers used in the function
    ...
    (R1, R2, and R3 are used in the function)
    ...
    POPM R1-R3 ; Restores registers that were saved at the function entry
    RTE
```

A.3.2 Using CPU Instructions in C Language

The compiler provides the following intrinsic functions for cases of accessing control registers and special instructions that cannot be expressed in C language. Refer to "4.2.6 Intrinsic Functions".

A.4 Variables (Assembly Language)

This section describes variables (assembly language).

A.4.1 Defining Variables without Initial Values

Allocate a memory area in a DATA section.

To define a DATA section, use the .SECTION directive. To allocate a memory area, use the .BLKB directive for specification in 1-byte units, the .BLKW directive for 2-byte units, the .BLKL directive for 4-byte units, and the .BLKD directive for 8-byte units.

[Example]

```assembly
.SECTION area,DATA
work1: .BLKB 1; Allocates a RAM area in 1-byte units
work2: .BLKW 1; Allocates a RAM area in 2-byte units
work3: .BLKL 1; Allocates a RAM area in 4-byte units
work4: .BLKD 1; Allocates a RAM area in 8-byte units
```

A.4.2 Defining a cost Constant with an Initial Value

Initialize a memory area in a ROMDATA section.

To define a ROMDATA section, use the .SECTION directive. To initialize memory, use the .BYTE directive for 1 byte, the .WORD directive for 2 bytes, the .LWORD directive for 4 bytes, the .FLOAT directive for floating-point 4 bytes, and the .DOUBLE directive for floating-point 8 bytes.

[Example]

```assembly
.SECTION value,ROMDATA
work1: .BYTE "data"; Stores 1-byte fixed data in ROM
work2: .WORD "data"; Stores 2-byte fixed data in ROM
work3: .LWORD "data"; Stores 4-byte fixed data in ROM
work4: .FLOAT 5E2; Stores 4-byte floating-point data in ROM
work5: .DOUBLE 5E2; Stores 8-byte floating-point data in ROM
```

A.4.3 Referencing the Address of a Section

The size and start address of a section that were specified as operands using the SIZEOF and TOPOF operators are handled as values.

[Example]
A.5 Startup Routine

This section describes the startup routine.

A.5.1 Allocating Stack Areas

Since the `PowerON_Reset_PC` function in the `resetprg.c` file of the startup routine is declared by `#pragma entry`, the compiler and optimizing linkage editor automatically generate the initialization code for the user stack `USP` and interrupt stack `ISP` at the top of the function, based on the settings below.

1. Setting the User Stack
   Specify the size of the stack area by `#pragma stacksize su=0xXXX` in the `stacksct.h` file, and specify the location of the `SU` section by the `-start` option of the optimizing linkage editor.

2. Setting the Interrupt Stack
   Specify the size of the stack area by `#pragma stacksize si=0xXXX` in the `stacksct.h` file, and specify the location of the `SI` section by the `-start` option of the optimizing linkage editor.

[Example]

```
<resetprg.c>
...
#pragma section ResetPRG
#pragma entry PowerON_Reset_PC
void PowerON_Reset_PC(void)
{
...
<stacksct.h>
#pragma stacksize su=0x300
#pragma stacksize si=0x100
```

[Generated code example]

```
When // -start=SU,SI/01000 is specified
  _PowerON_Reset_PC        MVTC        #00001300H,USP
  MVTC        #00001400H,ISP
...
```

A.5.2 Initializing RAM

The `_INITSCT` function in the `resetprg.c` file of the startup routine is used to initialize uninitialized areas. To add a section to be initialized, add the following description to the `dbsct.c` file.

[Example]
A.5.3 Transferring Variables with Initial Values from ROM to RAM

The \_INITSCT function in the resetprg.c file of the startup routine is used to transfer variables with initial values from ROM to RAM. To add a section to be transferred, add the following description to the dbsct.c file.

[Example]

```c
#include <stdio.h>

int main() {
  return 0;
}
```

In the above example, the addresses used in the \_INITSCT function are stored in the table in order to transfer the contents of the D, D_2, and D_1 sections to the R, R_2, and R_1 sections. Note that the location addresses of the D, D_2, D_1, R, R_2, and R_1 sections should be specified by the `-start` option of the optimizing linkage editor. The relocation solution by transferring data from ROM to RAM should be specified by the `-rom` option of the optimizing linkage editor.

A.6 Reducing the Code Size

This section describes code size reduction.

A.6.1 Data Structure

In a case where related data is referenced many times in the same function, usage of a structure will facilitate generation of a code using relative access, and an improvement in efficiency can be expected. The efficiency will also be improved when data is passed as arguments. Because the access range of relative access is limited, it is effective to place the frequently accessed data at the top of the structure.

When data takes the form of a structure, it is easy to perform tuning that changes the data expressions.

[Example]

Numeric values are assigned to variables a, b, and c.

Source code before improvement
Variables that can be used as local variables must be declared as local variables and not as global variables. There is a possibility that the value of a global variable will be changed by function calling or pointer operations, thus the efficiency of optimization is degraded.

The following advantages are available when local variables are used.

- Access cost is low
- May be assigned to a register
- Efficiency of optimization is good

[Example]
Case in which global variables are used for temporary variables (before improvement) and case in which local variables are used (after improvement)
A.6.3 Offset for Structure Members

A structure member is accessed after adding the offset to the structure address. Since a small offset is advantageous for the size, members often used should be declared at the top.

The most effective combination is within 32 bytes from the top for the signed char or unsigned char type, within 64 bytes from the top for the short or unsigned short type, or within 128 bytes from the top for the int, unsigned int, long, or unsigned long type.

[Example]
An example in which the code is changed because of the offset of the structure is shown below.

Source code before improvement

```c
struct str {
    long L1[8];
    char C1;
};
struct str STR1;
char x;
void func()
{
    x = STR1.C1;
}
```

Assembly-language expansion code before improvement

```assembly
__func:
    MOV.L #_tmp,R4
    MOV.L [R1],[R4]
    MOV.L [R2],[R1]
    MOV.L [R4],[R2]
    RTS
```

Source code after improvement

```c
int tmp;
void func(int* a, int* b)
{
    tmp = *a;
    *a = *b;
    *b = tmp;
}
```

Assembly-language expansion code after improvement

```assembly
__func:
    MOV.L [R1],R5
    MOV.L [R2],[R1]
    MOV.L R5,[R2]
    RTS
```
Note When defining a structure, declare the members while considering the boundary alignment value. The boundary alignment value of a structure is the most largest boundary alignment value within the structure. The size of a structure becomes a multiple of the boundary alignment value. For this reason, when the end of a structure does not match the boundary alignment value of the structure itself, the size of the structure also includes the unused area that was created for guaranteeing the next boundary alignment.

Source code before improvement

```c
/* Boundary alignment value is 4 because the maximum member is the int type */
struct str {
    char C1; /* 1 byte + 3 bytes of boundary alignment */
    long L1; /* 4 bytes */
    char C2; /* 1 byte */
    char C3; /* 1 byte */
    char C4; /* 1 byte + 1 byte of boundary alignment */
}STR1;
```

`.SECTION B,DATA,ALIGN=4
.glb _STR1
_STR1: ; static: STR1
.blkl 3

Source code after improvement

```c
/* Boundary alignment value is 4 because the maximum member is the int type */
struct str {
    char C1; /* 1 byte + 3 bytes of boundary alignment */
    long L1; /* 4 bytes */
    char C2; /* 1 byte */
    char C3; /* 1 byte */
    char C4; /* 1 byte + 1 byte of boundary alignment */
}STR1;
```
A.6.4 Allocating Bit Fields

To set members of different bit fields, the data including the bit field needs to be accessed each time. These accesses can be kept down to one access by collectively allocating the related bit fields to the same structure.

[Example]
An example in which the size is improved by allocating bit fields related to the same structure is shown below.

Source code before improvement

```c
struct str {
    char C1; /* 1 byte */
    char C2; /* 1 byte */
    char C3; /* 1 byte */
    char C4; /* 1 byte */
    long L1; /* 4 bytes */
} STR1;
```

```
/* Boundary alignment value is 4 because the maximum member is the int type */
struct str {
    char C1; /* 1 byte */
    char C2; /* 1 byte */
    char C3; /* 1 byte */
    char C4; /* 1 byte */
    long L1; /* 4 bytes */
} STR1;
```

str size after improvement

```
.SECTION B,DATA,ALIGN=4
.glob _STR1
_STR1: ; static: STR1
.blkl 2
```

```c
struct str {
    Int flag1:1;
} b1,b2,b3;
void func()
{
    b1.flag1 = 1;
    b2.flag1 = 1;
    b3.flag1 = 1;
}
```

Assembly-language expansion code before improvement

```
_func:
    MOV.L #_b1,R5
    BSET #00H,[R5]
    MOV.L #_b2,R5
    BSET #00H,[R5]
    MOV.L #_b3,R5
    BSET #00H,[R5]
    RTS
```

Source code after improvement
A.6.5 Optimization of External Variable Accesses when the Base Register is Specified

When R13 is specified as the base register of the RAM section, accesses to the RAM section are performed relative to the R13 register. Furthermore, if optimization of inter-module external variable accesses is enabled, the value relative to the R13 register is optimized, and the instruction size becomes smaller if the value is 8 bits or less.

**Example**

Source code before improvement

```c
struct str
{
    int flag1:1;
    int flag2:1;
    int flag3:1;
}a1;
void func()
{
    a1.flag1 = 1;
    a1.flag2 = 1;
    a1.flag3 = 1;
}
```

Assembly-language expansion code before improvement

```assembly
_func:
    MOV.L #_a1,R4
    MOVU.B [R4],R5
    OR #07H,R5
    MOV.B R5,[R4]
    RTS
```

Source code after improvement

```c
struct str
{
    int flag1:1;
    int flag2:1;
    int flag3:1;
}a1;
void func()
{
    a1.flag1 = 1;
    a1.flag2 = 1;
    a1.flag3 = 1;
}
```

Assembly-language expansion code after improvement

```assembly
_func:
    MOV.L #_a1,R4
    MOVU.B [R4],R5
    OR #07H,R5
    MOV.B R5,[R4]
    RTS
```

Source code before improvement

```c
int a;
int b;
int c;
int d;
void fu{
    a=0;
    b=1;
    c=2;
    d=3;
}
```

Assembly-language expansion code before improvement

```assembly
_func:
    MOV.L #_a,R4
    MOV.L #00000000H,[R4]
    MOV.L #_b,R4
    MOV.L #00000001H,[R4]
    MOV.L #_c,R4
    MOV.L #00000002H,[R4]
    MOV.L #_d,[R4]
    MOV.L #00000003H,[R4]
    RTS
```

Source code after improvement

```c
struct str
{
    int flag1:1;
    int flag2:1;
    int flag3:1;
}a1;
void func()
{
    a1.flag1 = 1;
    a1.flag2 = 1;
    a1.flag3 = 1;
}
```

Assembly-language expansion code after improvement

```assembly
_func:
    MOV.L #_a1,R4
    MOVU.B [R4],R5
    OR #07H,R5
    MOV.B R5,[R4]
    RTS
```
A.6.6 Specified Order of Section Addresses by Optimizing Linkage Editor at Optimization of External Variable Accesses

In an instruction that accesses memory in the register relative-address format, the instruction size is small when the displacement value is small.

In some cases, the code size can be improved when the order of allocating the sections by the optimizing linkage editor is changed with reference to the following guidelines.

- Place at the beginning the sections of external variables that are frequently accessed in the function.
- Place at the beginning the sections of external variables with small type sizes.

Note however that the build time gets longer when external variable accesses are optimized because the compiler runs twice.

[Example]

Source code before improvement

```c
int a;
int b;
int c;
int d;
void fu{
    a=0;
    b=1;
    c=2;
    d=3;
}
```

Assembly-language expansion code before improvement

```asm
_func:
    MOV.L #0000000H, _a-__RAM_TOP:16[R13]
    MOV.L #0000001H, _b-__RAM_TOP:16[R13]
    MOV.L #0000002H, _c-__RAM_TOP:16[R13]
    MOV.L #0000003H, _d-__RAM_TOP:16[R13]
    RTS
```

Assembly-language expansion code after improvement

```asm
_func:
    MOV.L #0000000H, _a-__RAM_TOP:16[R13]
    MOV.L #0000001H, _b-__RAM_TOP:16[R13]
    MOV.L #0000002H, _c-__RAM_TOP:16[R13]
    MOV.L #0000003H, _d-__RAM_TOP:16[R13]
    RTS
```
<When the allocation order of sections is "D, D_2, D_1" or D*>  
_func:
    MOV.L #d41,R4
    MOV.B R1,0120H[R4]
    MOV.B R1,0121H[R4]
    MOV.B R1,0122H[R4]
    MOV.B R1,0123H[R4]
    MOV.W R1,0100H[R4]
    MOV.W R1,0102H[R4]
    MOV.W R1,0104H[R4]
    MOV.W R1,0106H[R4]
    MOV.L R1,[R4]
    MOV.L R1,04H[R4]
    MOV.L R1,08H[R4]
    MOV.L R1,0CH[R4]
    RTS

Source code after improvement

    /* Section D_1 */
    char d11=0, d12=0, d13=0, d14=0;
    /* Section D_2 */
    short d21=0, d22=0, d23=0, d24=0, dmy2[12]={0};
    /* Section D */
    int d41=0, d42=0, d43=0, d44=0, dmy4[60]={0}

    void func(int a){
        d11 = a;
        d12 = a;
        d13 = a;
        d14 = a;
        d21 = a;
        d22 = a;
        d23 = a;
        d24 = a;
        d41 = a;
        d42 = a;
        d43 = a;
        d44 = a;
    }

Assembly-language expansion code after improvement

<When the allocation order of sections is "D_1, D_2, D" or D*>  
_func:
    MOV.L #d11,R4
    MOV.B R1,[R4]
    MOV.B R1,01H[R4]
    MOV.B R1,02H[R4]
    MOV.B R1,03H[R4]
    MOV.W R1,04H[R4]
    MOV.W R1,06H[R4]
    MOV.W R1,08H[R4]
    MOV.W R1,0AH[R4]
    MOV.L R1,24H[R4]
    MOV.L R1,28H[R4]
    MOV.L R1,2CH[R4]
    MOV.L R1,30H[R4]
    RTS
A.6.7 Interrupt

Due to many registers being saved and restored before and after an interrupt processing, the expected interrupt response time may not be obtained. In such a case, the fast interrupt setting (\texttt{fint}) and \texttt{fint_register} option should be used to keep down the number of saving and restoring of registers so that the interrupt response time can be reduced.

Note however that usage of the \texttt{fint_register} option limits the usable registers in other functions so the efficiency of the entire program is degraded in some cases.

[Example]

Source code before improvement

```c
#pragma interrupt int_func
volatile int count;

void int_func()
{
    count++;
}
```

Assembly-language expansion code before improvement

```assembly
_int_func:
    PUSHM R4-R5
    MOV.L #_count,R4
    MOV.L [R4],R5
    ADD #01H,R5
    MOV.L R5,[R4]
    POPM R4-R5
    RTE
```

Source code after improvement

```c
#pragma interrupt int_func(fint)
volatile int count;

void int_func()
{
    count++;
}
```

Assembly-language expansion code after improvement

```assembly
<int_func>
    MOV.L #_count,R12
    MOV.L [R12],[R13]
    ADD #01H,R13
    MOV.L R13,[R12]
    RTFI
```

A.7 High-Speed Processing

This section describes high-speed processing.

A.7.1 Loop Control Variable

Loop expansion cannot be optimized if there is a possibility that the size difference prevents the loop control variable from expressing the data to be compared when determining whether the loop end condition is met. For example, if the loop control variable is \texttt{signed char} while the data to be compared is \texttt{signed long}, loop expansion is not optimized. Thus,
compared to signed char and signed short, it is easier to perform optimization of loop expansion for signed long. To optimize loop expansion, specify the loop control variable as a 4-byte integer type.

[Example]

Source code before improvement

```c
signed long array_size=16;
signed char array[16];

void func()
{
    signed char I;
    for(i=0;i<array_size;i++)
    {
        array[i]=0;
    }
}
```

Assembly-language expansion code before improvement

```assembly
<When loop=2 is specified>
_func:
    MOV.L #_array_size,R4
    MOV.L [R4],R2
    MOV.L #00000000H,R5
    BRA L11
L12:
    MOV.L #_array,R14
    MOV.L #00000000H,R3
    MOV.B R3,[R5,R4]
    ADD #01H,R5
L11:
    MOV.B R5,R5
    CMP R2,R5
    BLT L12
L13:
    RTS
```

Source code after improvement

```c
signed long array_size=16;
signed char array[16];

void func()
{
    signed long I;
    for(i=0;i<array_size;i++)
    {
        array[i]=0;
    }
}
```

Assembly-language expansion code after improvement

```assembly
```

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A.7.2  Function Interface

The number of arguments should be carefully selected so that all arguments can be set in registers (up to four). If there are too many arguments, turn them into a structure and pass the pointer. If the structure itself is passed through and forth, instead of the pointer of the structure, the structure may be too large to be set in a register. When arguments are set in registers, calling and processing at the entry and exit of the function can be simplified. In addition, space in the stack area can be saved. Note that registers R1 to R4 are to be used for arguments.

[Example]
Function f has four more arguments than the number of registers for arguments.
Source code before improvement

```c
void call_func()
{
    func(1,2,3,4,5,6,7,8);
}
```

Assembly-language expansion code before improvement

```assembly
<When loop=2 is specified>
_func:
    MOV.L #_array_size,R5
    MOV.L [R5],R2
    MOV.L #00000000H,R4
    ADD #FFFFFFFFH,R2,R3
    CMP R3,R2
    BLE L12
L11:
    MOV.L #_array,R1
    MOV.L R1,R5
    BRA L13
L14:
    MOV.W #0000H,[R5]
    ADD #02H,R5
    ADD #02H,R4
L13:
    CMP R3,R4
    BLT L14
L15:
    CMP R2,R4
    BGE L17 L16:
    MOV.L #00000000H,R5
    MOV.B R5,[R4,R1]
    RTS
L12:
    MOV.L #_array,R5
    MOV.L #00000000H,R3
L19:
    CMP.R2,R4
    BGE L17
L20:
    MOV.B R3,[R5+]
    ADD #01H,R4
    BRA L19
L17:
    RTS
```
A.7.3 Reducing the Number of Loops

Loop expansion is especially effective for inner loops. Since the program size is increased by loop expansion, loop expansion should be performed when a fast execution speed is preferred at the expense of the program size.

[Example]
Array a[] is initialized.

Source code before improvement

```c
extern int a[100];
void func()
{
    int I;
    for( i = 0 ; i < 100 ; i++ ){
        a[i] = 0;
    }
}
```

Assembly-language expansion code before improvement

```
_extern a[100];
void func()
{
    int I;
    _call_func:
        _call_func:
            SUB #04H,R0
            MOV.L #08070605H,[R0]
            MOV.L #00000004H,R4
            MOV.L #00000003H,R3
            MOV.L #00000002H,R2
            MOV.L #00000001H,R1
            _call_func:
            ADD #04H,R0
            RTS
```

Source code after improvement

```c
struct str{
    char a;
    char b;
    char c;
    char d;
    char e;
    char f;
    char g;
    char h;
};
struct str arg = {1,2,3,4,5,6,7,8};

void call_func()
{
    func(&arg);
}
```

Assembly-language expansion code after improvement

```
_call_func:
    MOV.L #arg,R1
    BRA _func
```
A.7.4 Usage of a Table

If the processing in each case label of a switch statement is almost the same, consider the usage of a table.

[Example]
The character constant to be assigned to variable ch is changed by the value of variable i.

Source code before improvement

```c
char func(int i)
{
    char ch;
    switch (i) {
    case 0:
        ch = 'a'; break;
    case 1:
        ch = 'x'; break;
    case 2:
        ch = 'b'; break;
    }
    return(ch);
}
```

Source code after improvement

```c
void func()
{
    int I;
    for( i = 0 ; i < 100 ; i+=2 )
    {
        a[i] = 0;
        a[i+1] = 0;
    }
}
```

Assembly-language expansion code after improvement

```assembly
_func:
    MOV.L #00000032H,R4
    MOV.L #_a,R5
L11:
    MOV.L #00000000H,[R5]
    MOV.L #00000000H,04H[R5]
    ADD #08H,R5
    SUB #01H,R4
    BNE L11
L12:
    RTS
```
Assembly-language expansion code before improvement

```assembly
_func:
  CMP #00H,R1
  BEQ L17
L16:
  CMP #01H,R1
  BEQ L19
  CMP #02H,R1
  BEQ L20
  BRA L21
L12:
L17:
  MOV.L #00000061H,R1
  BRA L21
L13:
L19:
  MOV.L #00000078H,R1
  BRA L21
L14:
L20:
  MOV.L #00000062H,R1
L11:
L21:
  MOVU.B R1,R1
  RTS
```

Source code after improvement

```c
char chbuf[] = {'a', 'x', 'b'};

char func(int i)
{
    return (chbuf[i]);
}
```

Assembly-language expansion code after improvement

```assembly
_func:
  MOV.L #chbuf,R4
  MOVU.B [R1,R4],R1
  RTS
```

A.7.5 Branch

When comparison is performed in order beginning at the top, such as in an `else if` statement, the execution speed in the cases at the end gets slow if there is many branching. Cases with frequent branching should be placed near the beginning.
[Example]
The return value changes depending on the value of the argument.
Source code before improvement

```c
int func(int a)
{
  if (a==1)
    a = 2;
  else if (a==2)
    a = 4;
  else if (a==3)
    a = 0;
  else
    a = 0;
  return(a);
}
```

Assembly-language expansion code before improvement

```assembly
_func:
    CMP #01H,R1
    BEQ L11
L12:
    CMP #02H,R1
    BNE L14
L13:
    MOV.L #00000004H,R1
    RTS
L14:
    CMP #03,R1
    BNE L17
L16:
    MOV.L #00000008H,R1
    RTS
L17:
    MOV.L #00000000H,R1
    RTS
L11:
    MOV.L #00000002H,R1
    RTS
```

Source code after improvement

```c
int func(int a)
{
  if (a==3)
    a = 8;
  else if (a==2)
    a = 4;
  else if (a==1)
    a = 2;
  else
    a = 0;
  return (a);
}
```

Assembly-language expansion code after improvement
A.7.6 Inline Expansion

The execution speed can be improved by performing inline expansion for functions that are frequently called. A significant effect may be obtained by expanding functions that are particularly called in the loop. However, since the program size is inclined to be increased by inline expansion, inline expansion should be performed when a fast execution speed is preferred at the expense of the program size.

[Example]

The elements of array \( a \) and array \( b \) are exchanged.

Source code before improvement

```c
int x[10], y[10];
static void sub(int *a, int *b, int I)
{
    int temp;
    temp = a[i];
    a[i] = b[i];
    b[i] = temp;
}

void func()
{
    int I;
    for(i=0;i<10;i++)
    {
        sub(x,y,i);
    }
}
```

Assembly-language expansion code before improvement

```assembly
_func:
    CMP #03H,R1
    BEQ L11
L12:
    CMP #02H,R1
    BNE L14
L13:
    MOV.L #00000004H,R1
    RTS
L14:
    CMP #01H,R1
    NE L17
L16:
    MOV.L #00000002H,R1
    RTS
L17:
    MOV.L #00000000H,R1
    RTS
L11:
    MOV.L #00000008H,R1
    RTS
```

_Example_

The elements of array \( a \) and array \( b \) are exchanged.
Source code after improvement

```c
int x[10], y[10];
#pragma inline(sub)
static void sub(int *a, int *b, int I)
{
    int temp;
    temp = a[I];
    a[I] = b[I];
    b[I] = temp;
}

void func()
{
    int I;
    for(i=0;i<10;i++)
    {
        sub(x,y,i);
    }
}
```

Assembly-language expansion code after improvement

```assembly
__$sub:
    SHLL #02H,R3
    ADD R3,R1
    MOV.L [R1],R5
    ADD R3,R2
    MOV.L [R2],[R1]
    MOV.L R5,[R2]
    RTS

_func:
    PUSHM R6-R8
    MOV.L #00000000H,R6
    MOV.L #_x,R7
    MOV.L #_y,R8

L12:
    MOV.L R6,R3
    MOV.L R7,R1
    MOV.L R8,R2
    ADD #01H,R6
    BSR __$sub
    CMP #0AH,R6
    BLT L12

L13:
    RTSD #0CH,R6-R8
```
A.8 Modification of C Source

By using expanded function object with high efficiency can be created.
Here, two methods are described for shifting to the CCRX from other C compiler and shifting to C compiler from the
CCRX.

<From other C compiler to the CCRX>
- #pragma
C source needs to be modified, when C compiler supports the #pragma. Modification methods are examined accord-
ing to the C compiler specifications.

- Expanded Specifications
It should be modified when other C compilers are expanding the specifications such as adding keywords etc. Modified
methods are examined according to the C compiler specifications.

Note #pragma is one of the pre-processing directives supported by ANSI. The character string next to
#pragma is made to be recognized as directives to C compiler. If that directive does not supported by the
compiler, #pragma directive is ignored and the compiler continues the process and ends normally.

<From the CCRX to other C compiler>
- The CCRX, either deletes key word or divides # fdef in order shift to other C compiler as key word has been added as
expanded function.

Example 1. Disable the keywords

```c
#ifndef __RX
#define __evenaccess       /*Change variable with __evenaccess specified to normal
variable*/
#endif
```

Example 2. Change to other keywords

```c
#ifndef __RX
#define _Pragma("inline func")
#else
inline
#endif
void func() { }
```
## Revision Record

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
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<tbody>
<tr>
<td>1.00</td>
<td>Nov 28, 2014</td>
<td>- First Edition issued</td>
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</table>
| 1.01 | Sep 14, 2015 | 14 The description of the license is added.  
21, and others  
The following compile options are added.  
-misra2012  
-stack_protector/-stack_protector_all  
21, and others  
The following compile options are made usable in the Professional Edition.  
-misra2004  
-ignore_filesMisra  
-check_language_extension  
150, 153 The following description is deleted.  
- The utf8 option is valid only when the lang=c99 option has been specified.  
156 and others The assembler option -utf8 is added.  
219 The function of the linker option -crc is expanded.  
324, 335 #pragma stack_protector and #pragma no_stack_protector are added.  
783, and others Unnecessary messages are deleted.  
785, and others The following message numbers are added.  
E0511178  
M0523086  
W0511179 |
| 1.02 | Jul 01, 2016 | 44 The following MISRA-C:2012 rules are added.  
2.6 2.7 9.2 9.3 12.1 12.3 12.4 14.4 15.1 15.2 15.3 15.4 15.5 15.6 15.7 16.1 16.2 16.3 16.4 16.5 16.6 16.7 17.1 17.7 18.4 18.5 19.2 20.1 20.2 20.3 20.4 20.5 20.6 20.7 20.8 20.9 20.10 20.11 20.12 20.13 20.14  
220 [Description] is changed.  
272, and others The library generator option -secure_malloc is added.  
340, and others Added an alias for each existing intrinsic function, which prefixes "__" to its name.  
344, and others The intrinsic functions are added.  
__bclr  
__bset  
__bnot  
344, and others The description of the intrinsic functions is changed. |
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<td>1.02</td>
<td>Jul 01, 2016</td>
<td>617, 618</td>
<td>The following library functions are changed. calloc, free, malloc, realloc</td>
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<td></td>
<td></td>
<td>832, 844</td>
<td>The following message numbers are added. F0523088 W0520171</td>
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<td>1.03</td>
<td>Dec 01, 2016</td>
<td>15</td>
<td>The description of &quot;License&quot; is changed. &quot;Standard and Professional Editions&quot; is added. &quot;Free Evaluation Editions&quot; is added.</td>
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<td>45</td>
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<td>63</td>
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<td>307-315</td>
<td>The descriptions of the following implementation-defined items are changed. 4.1.3 Table 4.1, Table 4.3, Table 4.4, Table 4.5, Table 4.7, Table 4.9, Table 4.10, Table 4.11, Table 4.12, Table 4.13, Table 4.14, Table 4.15, Table 4.16</td>
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<td>343</td>
<td>The description is changed.</td>
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<td>552, 554, 568</td>
<td>The tables are changed.</td>
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<td>574</td>
<td>[Return values] is changed.</td>
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<td>F0563020 is added.</td>
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<td>866, 867</td>
<td>&quot;Standard Library Error Messages&quot; is added.</td>
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<td>&quot;V2.06 and Later Versions (Compatibility with V2.05 and earlier)&quot; is added.</td>
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<td>Jun 01, 2017</td>
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<td>The following MISRA-C:2012 rules are added. 12.5 13.1 13.2 13.5 17.5 17.8 21.13 21.15 21.16</td>
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<td>24, 48, 66</td>
<td>The -avoid_cross_boundary_prefetch option is added.</td>
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<td>The -end_record option is added.</td>
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<td>209</td>
<td>-show=relocation_attribute and end_record is added to Specifiable Option.</td>
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<td>294</td>
<td>Table 3.2 is changed.</td>
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<td>&quot;Linkage Map Information&quot; is changed.</td>
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<td>The description of (7) is changed.</td>
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<td>The description of (4) is changed.</td>
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<td>The description of &quot;Scalar Type (C), Basic Type (C++)&quot; is changed.</td>
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<td>The description of &quot;Specification of Function for generating a code for detection of stack smashing&quot; is changed.</td>
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<td>The -cfi_ignore_module optimizing linkage editor (rlink) option is added.</td>
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<td>&quot;fix_record_length_and_align&quot; is added to No. 4 of &quot;Specifiable Option&quot;.</td>
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<td>The &quot;cﬁ&quot; suboption is added to table 2.17.</td>
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<td>Item No. 30 is added to table 2.19.</td>
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<td>Item No. 10 is added to table 3.2.</td>
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<td>The following macros are added to table 4.22. <strong>STDC_IEC_559</strong>, <strong>STDC_IEC_559_COMPLEX</strong>, and <strong>STDC_ISO_10646</strong>.</td>
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<td>Item No. 8 is added to table 5.35.</td>
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<td>The descriptions of definitions in &lt;float.h&gt; are reviewed.</td>
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<td>The following messages are added. E051117, E0562366, E0563602, F0563003, F0563150, F0563431, F0563600, F0563601, M0560700, W0561014, and W0561184</td>
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<td>The -split_vect optimizing linkage editor (rlink) option is added.</td>
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<td>__RXV3 and <strong>RX_ISA_VERSION</strong></td>
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<td>The description of &quot;Interrupt Function Creation&quot; is changed.</td>
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<td>The descriptions of [Remarks] of set_extb and get_extb are changed.</td>
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<td>RDCW, RSTR, SAVE, and UTOF</td>
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C - 5
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<td>Jun 01, 2018</td>
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<td>The following reentrants are added. fabs, fabsf, and fabsl</td>
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<td>Table 7.10 is changed.</td>
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<td>Table 7.11 is changed.</td>
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<td>23, 29, 42</td>
<td>The -truncated_address_initializer compile option is added.</td>
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<td>The -misra_intermodule compile option is added.</td>
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<td>The description of the -nouse_div_inst compile option is changed.</td>
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<td>The description of the -nofpu compile option is changed.</td>
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<td>The -dpfpu compile option is added.</td>
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<td>143</td>
<td>[Description] of the compile option -base is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>147</td>
<td>[Default] and [Description] of the compile option -pid are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 173</td>
<td>The description of the -chkpm assembler command option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 174</td>
<td>The description of the -chkfpu assembler command option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 175</td>
<td>The description of the -chkdsp assembler command option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 170, 176</td>
<td>The -chkdpfpu assembler command option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 182</td>
<td>The description of the -fpu assembler command option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 183</td>
<td>The description of the -nofpu assembler command option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 177, 184</td>
<td>The -dpfpu assembler command option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 177, 185</td>
<td>The -nodfpup assembler command option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 177, 186</td>
<td>The -bank assembler command option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168, 177, 187</td>
<td>The -nobank assembler command option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>195</td>
<td>[Remarks] of the assembler command option -cpu is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>215, 225, 275, 282</td>
<td>The -lib_rename optimizing linkage editor option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>311</td>
<td>The following options are added to table 2.19. create_unfilled_area, stack_protector, stack_protector_all, misra2004, misra2012, and misra_intermodule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>335</td>
<td>Table 4.7 is changed.</td>
</tr>
<tr>
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<td></td>
<td>356</td>
<td>The following macro is added to table 4.22. __DPFPUP</td>
</tr>
<tr>
<td>Rev.</td>
<td>Date</td>
<td>Page</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.07</td>
<td>Dec 01, 2018</td>
<td>362, 363, 365</td>
<td>The description of &quot;Interrupt Function Creation&quot; is changed.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>The following Intrinsic Functions are added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>377, 400-402</td>
<td>__set_dpsw, __get_dpsw, __set_decnt, __get_decnt, __set_depc, and __get_depc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The description of &quot;ASSEMBLY LANGUAGE SPECIFICATIONS&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The description of &quot;General Instruction Addressing&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The description of &quot;Specific Instruction Addressing&quot; is changed.</td>
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<td></td>
<td>The following macro is added to table 5.35.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>__DPFPFU</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>&quot;Instructions&quot; is deleted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The following sections are added to table 6.1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C_8, D_8, and B_8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The description of &quot;Initialization of Control Registers&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;Coding Example of Initial Setting Routine&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;resetprg.c: Initial Setting Routine (Reset Vector Function)&quot; is changed.</td>
</tr>
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<td></td>
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<td></td>
<td>The description of &quot;Application Code Generation (pic and pid Options)&quot; is changed.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>The following messages are added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E0520069, W0520070, and W0551017</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The following messages are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E0523065 and W0520069</td>
</tr>
<tr>
<td>1.08</td>
<td>Apr 01, 2019</td>
<td>26, 79, 114, 312</td>
<td>The -tfu compile option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The following macros are added to table 4.22.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>__TFU and __TFU_MATHLIB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Examples 7 is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The __set_depc intrinsic function is deleted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The following intrinsic functions are added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>__init_tfu, __sincosf, and __atan2hypotf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>379, 409, 410</td>
<td>The descriptions of [Remarks] of __set_dpsw, __get_dpsw, __set_decnt,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>__get_decnt, and __get_depc are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>406-408</td>
<td>The following &quot;Reentrant&quot; are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>atan2, cos, sin, fabs, atan2f, cosf, sinf, and fabsl</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Notes 2 is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>469, 470</td>
<td>The following &quot;Reentrant&quot; are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>atan2l, cosl, sinl, sqrtl, and fabsl</td>
</tr>
<tr>
<td>Rev.</td>
<td>Date</td>
<td>Page</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.08</td>
<td>Apr 01, 2019</td>
<td></td>
<td>475 Notes 1 and Notes 2 are added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>490,</td>
<td>The descriptions of the hypot, hypotf, and hypotl library function are changed.</td>
</tr>
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<td></td>
<td></td>
<td>503</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>557</td>
<td>The descriptions of [Format] of bsearch and qsort are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>680</td>
<td>&quot;Initializing the Trigonometric Function Unit&quot; is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>683</td>
<td>&quot;Coding Example of Initial Setting Routine&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>760,</td>
<td>The following messages are added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>772,</td>
<td>E0523129, E0562600, and F0523129</td>
</tr>
<tr>
<td></td>
<td></td>
<td>777</td>
<td></td>
</tr>
<tr>
<td>1.09</td>
<td>Nov 01, 2019</td>
<td></td>
<td>12 The description of &quot;Copyrights&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>47</td>
<td>For the -misra2012 compile option, [Remarks] is changed and [Example] is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>47</td>
<td>The following MISRA-C:2012 rules are added:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.13</td>
<td>14.2, 14.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23,</td>
<td>The -g_line compile option is added.</td>
</tr>
<tr>
<td></td>
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<td>51,</td>
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<td>56</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>114</td>
<td>[Description] of the tfu compile option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>214,</td>
<td>The ALLOW_DUPLICATE_MODULE_NAME optimizing linkage editor (rlink) option is added</td>
</tr>
<tr>
<td></td>
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<td>217,</td>
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<td>224,</td>
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<td>227,</td>
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<td>282</td>
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<td></td>
<td></td>
<td>313</td>
<td>Table 2.19 is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>334</td>
<td>&quot;Implementation Defined Items&quot; is deleted, and &quot;Implementation-defined behavior of C90&quot; is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>339</td>
<td>&quot;Implementation-defined behavior of C99&quot; is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>369,</td>
<td>The description of &quot;Section Switch&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>370</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>513</td>
<td>The descriptions of functions are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>569</td>
<td>HUGE_VAL and HUGE_VALL are added to &quot;HUGE_VALF&quot; in the &quot;Definition Name&quot; row of the table.</td>
</tr>
<tr>
<td></td>
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<td>702</td>
<td>In &quot;cacosf / cacos / cacosf&quot;, [Return values] and [Remarks] are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>703</td>
<td>In &quot;casinf / casin / casinl&quot;, [Return values] and [Remarks] are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>704</td>
<td>In &quot;catanf / catan / catanl&quot;, [Return values] is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>708</td>
<td>In &quot;cacosgf / cacosf / cacosgf&quot;, [Return values] and [Remarks] are changed.</td>
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<td></td>
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<td>740</td>
<td>The description of maxdiv is entirely changed.</td>
</tr>
<tr>
<td>Rev.</td>
<td>Date</td>
<td>Description</td>
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<tr>
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<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>1.10</td>
<td>Nov 01, 2020</td>
<td>The target CPU cores are added.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front cover</td>
<td></td>
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</tr>
<tr>
<td>18</td>
<td></td>
<td>The tool usage information file is added to Table 2.1.</td>
<td></td>
</tr>
<tr>
<td>25,</td>
<td></td>
<td>The -branch_chaining compile option is added.</td>
<td></td>
</tr>
<tr>
<td>79,</td>
<td></td>
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<tr>
<td>84,</td>
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<td>118</td>
<td></td>
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<tr>
<td>25,</td>
<td></td>
<td>The -nobranch_chaining compile option is added.</td>
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<tr>
<td>79,</td>
<td></td>
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<td>82,</td>
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<td>119</td>
<td></td>
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<tr>
<td>31</td>
<td></td>
<td>[Description] of the -preinclude compile option is changed.</td>
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<tr>
<td>131</td>
<td></td>
<td>[Description] of the -dbl_size compile option is changed.</td>
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<td>218,</td>
<td></td>
<td>A typographical error is corrected (stack information file).</td>
<td></td>
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<td>281</td>
<td></td>
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</tr>
<tr>
<td>218,</td>
<td></td>
<td>The -verbose optimizing linkage editor (rlink) option is added.</td>
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</tr>
<tr>
<td>279,</td>
<td></td>
<td></td>
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<td>295</td>
<td></td>
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<td></td>
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<tr>
<td>922</td>
<td></td>
<td>The following registers are added to Table 9.1: DCMR, DPSW, DECNT, and DEPC</td>
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<tr>
<td>960</td>
<td></td>
<td>The following message is added: E0552020</td>
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</tr>
<tr>
<td>1015</td>
<td></td>
<td>Notes are added.</td>
<td></td>
</tr>
<tr>
<td>Rev.</td>
<td>Date</td>
<td>Description</td>
<td></td>
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<td>------</td>
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<td>-----------------------------------------------------------------------------</td>
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<td>1.11</td>
<td>Nov 01, 2021</td>
<td>The description of &quot;GENERAL&quot; is changed.</td>
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<td></td>
<td>The description of &quot;Environment Variables&quot; is changed.</td>
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<td></td>
<td>The -type_size_access_to_volatile compile option is added.</td>
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<td></td>
<td></td>
<td>[Remarks] of the -speed compile option is changed.</td>
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<td></td>
<td>[Remarks] of the -size compile option is changed.</td>
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<td></td>
<td>[Remarks] of the -inline compile option is changed.</td>
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<td></td>
<td>[Remarks] of the -noinline compile option is changed.</td>
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<tr>
<td></td>
<td></td>
<td>[Description] of the -map compile option is changed.</td>
<td></td>
</tr>
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<td></td>
<td>The description of the -pack compile option is entirely changed.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>The description of the -unpack compile option is entirely changed.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>The following option name is changed to lowercase.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-allow_duplicate_module_name</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>[Remarks] of the -optimize optimizing linkage editor (rlink) option is changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The description in (47) in &quot;Implementation-defined behavior of C99&quot; is changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A description is added in &quot;#pragma Directive&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Descriptions are changed in &quot;Using Extended Specifications&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The description is changed in &quot;Using a Keyword&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The description is changed in &quot;List of Section Names&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The specification format of frexp is changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The descriptions of the following functions are changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>div, ldv, lldv, imaxdiv</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following messages are changed:</td>
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<td></td>
<td></td>
<td>E0511178, F0563430, W0511180, W0511185, W0561016, W0561017</td>
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<tr>
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<td></td>
<td>Errors in the following messages are corrected:</td>
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<td></td>
<td>E0520137, W0521053</td>
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</tr>
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<td></td>
<td>The following message is deleted:</td>
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<td></td>
<td></td>
<td>E0521212</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following messages are added:</td>
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<td></td>
<td></td>
<td>M0520177, M0520550, M0520826</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The descriptions of &quot;Performing In-Line Expansion of Functions&quot; is changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The descriptions of &quot;Using CPU Instructions in C Language&quot; is changed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The descriptions of &quot;Modification of C Source&quot; is changed.</td>
<td></td>
</tr>
<tr>
<td>Rev.</td>
<td>Date</td>
<td>Page</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
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<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.12</td>
<td>Dec 01, 2022</td>
<td>25, 79, 115</td>
<td>The -tfu_version compile option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25, 79, 116</td>
<td>The -nosave_tfu compile option is added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>66, 193, 258, 310, 370, 477, and others</td>
<td>Applicable revisions are added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>113, 114</td>
<td>[Description] and [Remarks] of the -tfu compile option are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>156</td>
<td>[Remarks] of the -save_acc compile option is changed. MACW instruction -&gt; MACLO instruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>226</td>
<td>[Remarks] of the -entry optimizing linkage editor (rlink) option is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>247, 248</td>
<td>[Description] and [Example] of the -crc optimizing linkage editor (rlink) option are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>318</td>
<td>The following options are added to the &quot;Options that Become Invalid&quot; column in Table 2.19. tfu_version, nosave_tfu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>339</td>
<td>The description of (23) in &quot;Undefined Behavior&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>341</td>
<td>The description of (25) in &quot;Implementation-defined behavior of C90&quot; is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>355</td>
<td>The information in the &quot;Signed/Unsigned&quot; column for the &quot;Pointer to a data member&quot; row in Table 4.1 is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>370</td>
<td>The &quot;Predefined Macro&quot; column in Table 4.6 is changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>377, 378</td>
<td>The following interrupt specifications are added to the description of &quot;Interrupt Function Creation&quot;. tfu, no_tfu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>395, 428-431</td>
<td>The following intrinsic functions are added. __sincosfx, __sinfx, __cosfx, __atan2hypotfx, __atan2fx, __hypotfx</td>
</tr>
<tr>
<td></td>
<td></td>
<td>425</td>
<td>[Description], [Example], and [Remarks] of the __init_tfu intrinsic function are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>426</td>
<td>[Example] and [Remarks] of the __sincosf intrinsic function are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>427</td>
<td>[Example] and [Remarks] of the __atan2hypotf intrinsic function are changed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>492, 496</td>
<td>Notes of Tables 7.4 and 7.5 are changed.</td>
</tr>
<tr>
<td>Rev.</td>
<td>Date</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
<td>------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1.12</td>
<td>Dec 01, 2022</td>
<td><em>Description column of the table for <code>&lt;stdint.h&gt;</code> is changed.</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Coding example in &quot;Coding Example of Initial Setting Routine&quot; is changed.</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Following messages are added.</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E0523049, E0562220, F0520571, F0563115</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Following message is changed.</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>W0561017</td>
<td></td>
</tr>
</tbody>
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