FUJITSU SEMICONDUCTOR
CONTROLLER MANUAL

CM81-00204-1E

FR FAMILY
F²MC FAMILY
32/16/8-BIT MICROCONTROLLER
SOFTUNE C COMPILER MANUAL

FUJITSU

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SOFTUNE C COMPILER MANUAL

FUJITSU LIMITED

PREFACE

■ Objective of This Manual and Target Readers

This manual describes the F²MC-16 family C compiler (hereinafter referred to as the compiler) usage procedures and libraries.

This manual is prepared for persons who use the above-mentioned compiler and create and development application programs in C language.

This manual is to be read by persons who have a basic knowledge of each MCU (Micro Controller Unit).

The compiler described in this manual conforms to the ***American National Standard for Information Systems — Programming Language C, X3.159-1989***, which is abbreviated "ANSI standard" in this manual.

■ Notes on Trademarks

Microsoft and Windows are registered trademarks of Microsoft Corp.

UNIX is a registered trademark that X/Open Co., Ltd. has licensed in the United States and other countries.

Other trademarks or registered trademarks are the property of their respective owners. The ™ or ® mark is not used within this manual.

■ Composition of Manual

This manual consists of the following chapters.

Chapter 1 GENERAL

This chapter outlines the C compiler.

Chapter 2 SETUP OF SYSTEM EMVIRONMENT BEFORE USING C COMPILER

This chapter describes the C compiler operating environment variables.

Chapter 3 OPERATION

This chapter describes the command function specifications.

Chapter 4 OBJECT PROGRAM STRUCTURE

This chapter describes the information necessary for program execution.

Chapter 5 EXTENDED LANGUAGE SPECIFICATIONS

This chapter describes the extended language specifications supported by the compiler and the limitations on compiler translation.

Chapter 6 EXECUTION ENVIRONMENT

This chapter describes the user program execution procedure to be performed in an environment where no operating system exists.

Chapter 7 LIBRARY OVERVIEW

This chapter outlines the C libraries by describing the organization of files provided by the libraries and the relationship to the system into which the libraries are incorporated.

Chapter 8 LIBRARY INCORPORATION

This chapter describes the processes and functions to be prepared for library use.

Chapter 9 COMPILER-DEPENDENT SPECIFICATIONS

This chapter describes the specifications that vary with the compiler.

Chapter 10 SIMULATOR DEBUGGER LOW-LEVEL FUNCTION LIBRARY

This chapter describes how to use the simulator debugger low-level function library.

APPENDIX

The Appendix gives a list of types, macros, and functions provided by the library and the operations specific to the libraries(A,B). Notes when FFMC-16LX CPU is used are described(C).

■ Syntax Books

For C language syntax and standard library functions, refer to commercially available ANSI standard compliant reference books.

■ Reference Books

- *The C Programming Language*

  (Brian W. Kernighan & Dennis M. Ritchie)
- *Japanese edition entitled Programming Language C UNIX Type Programming Method and Procedure*

  (Translated by Haruhisa Ishida; Kyoritsu Shuppan)
- *American National Standard for Information Systems æ Programming Language C, X3.159-1989*

  (Western Electric Company, Incorporated)
- *UNIX System User's Manual System V*

  (Western Electric Company, Incorporated)
- *UNIX System V Programmer Reference Manual*

  (AT&T Bell Laboratories)
- *User Reference Manual UTS/5 Release 0.1*

  (Western Electric Company, Incorporated and Amdahl Corporation)
- *UTS Command Reference Manual UTS/5 Release 0.1*

  (Western Electric Company, Incorporated and Amdahl Corporation)
- *Japanese Industrial Standards Programming Language C*

  (Japan Standards Association)

USING THIS MANUAL

■ Manual Configuration

Reading two facing pages enables you to understand the contents without turning the page.
The summary below the title will help you understand the outline of each chapter and section.

■ How To Find Your Information

You can find information via the table of contents or the index at the end of the manual.

■ Conventions

The following notational conventions are used in this manual.

`[item]`	:	The items enclosed within square brackets are omissible.
`{item 1|item 2}`	:	Either item 1 or item 2 must be specified. This rule also takes effect when there are three or more items.
`item ...`	:	The specifying of this item can be repeated any number of times.

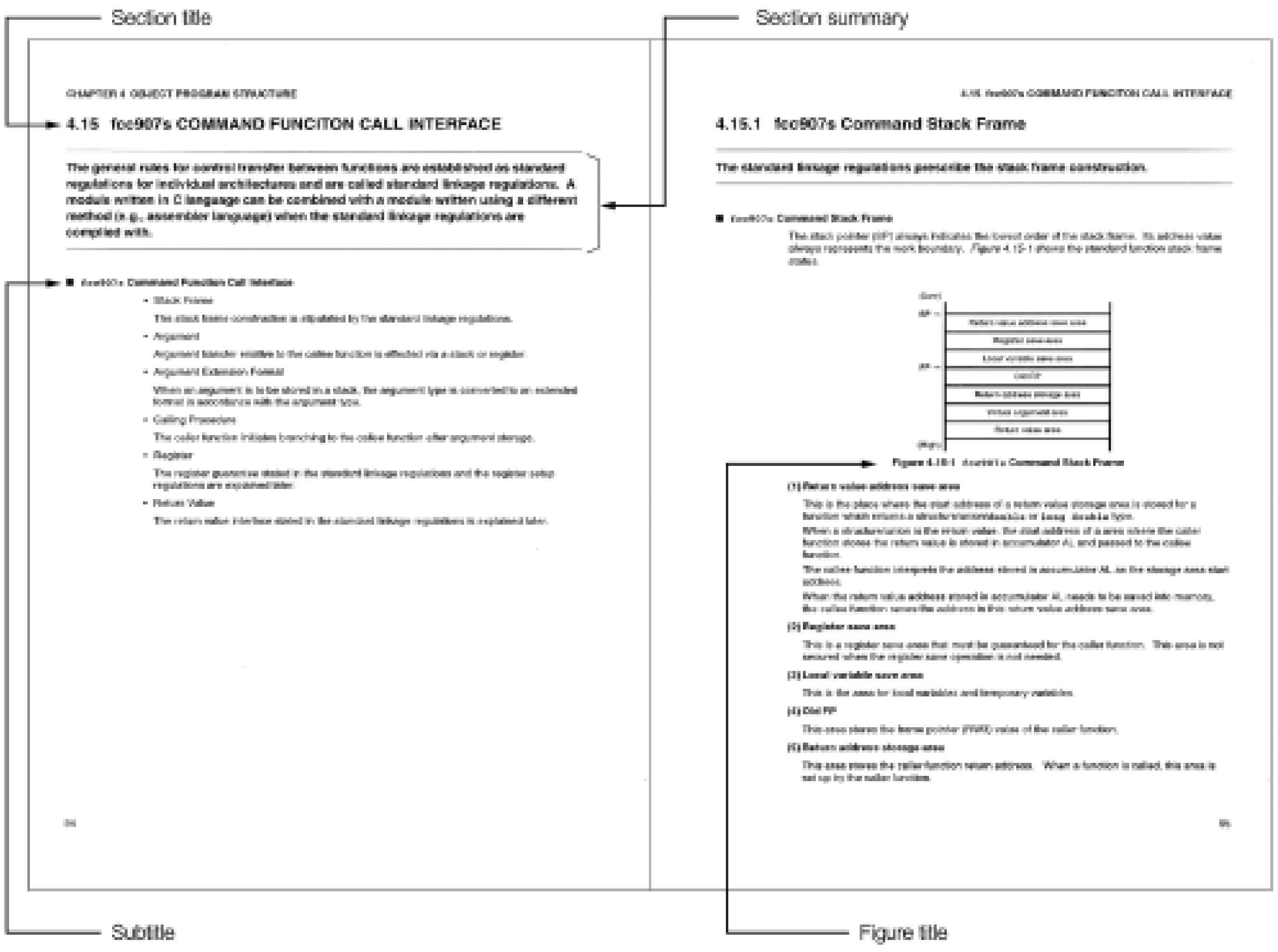
Examples set forth in this manual are based on the UNIX OS convention.

■ Product Naming

Products in this manual are named as follows:

- Windows95 means Microsoft® Windows95® operating system.
- WindowsNT means Microsoft® WindowsNT® Server network operating system Versions 3.51 and 4.0 and Microsoft® WindowsNT® Workstation operating system Versions 3.51 and 4.0.
- Windows means Microsoft® Windows® operating system Version 6.2.

■ Layout of Facing Pages



CHAPTER 4 OBJECT PROGRAM STRUCTURE

4.15 fcc907s COMMAND FUNCITON CALL INTERFACE

The general rules for control transfer between functions are established as standard regulations for individual architectures and are called standard linkage regulations. A module written in C language can be combined with a module written using a different method (e.g., assembler language) when the standard linkage regulations are complied with.

■ fcc907s Command Function Call Interface

- Stack Frame

  The stack frame construction is stipulated by the standard linkage regulations.

- Argument

  Argument transfer to the callee function is effected via a stack or register.

- Argument Extension Format

  When an argument is to be stored in a stack, the argument type is converted to an extended format in accordance with the argument type.

- Calling Procedure

  The caller function initiates branching to the callee function after argument storage.

- Register

  The register guarantee stated in the standard linkage regulations and the register setup regulations are explained later.

- Return Value

  The return value interface stated in the standard linkage regulations is explained later.

4.15 fcc907s COMMAND FUNCITON CALL INTERFACE

4.15.1 fcc907s Command Stack Frame

The standard linkage regulations prescribe the stack frame construction.

■ fcc907s Command Stack Frame

The stack pointer (SP) always indicates the lowest order of the stack frame. Its address value always represents the word boundary. *Figure 4.15-1* shows the standard function stack frame states.

Figure 4.15-1 fcc907s Command Stack Frame

(1) Return value address save area

This is the place where the start address of a return value storage area is stored for a function which returns a structure/union/double or long double type.

When a structure/union is the return value, the start address of a area where the caller function stores the return value is stored in accumulator AL and passed to the callee function.

The callee function interprets the address stored in accumulator AL as the storage area start address.

When the return value address stored in accumulator AL needs to be saved into memory, the callee function saves the address in this return value address save area.

(2) Register save area

This is a register save area that must be guaranteed for the caller function. This area is not secured when the register save operation is not needed.

(3) Local variable save area

This is the area for local variables and temporary variables.

(4) Old FP

This area stores the frame pointer (RW3) value of the caller function.

(5) Return address storage area

This area stores the caller function return address. When a function is called, this area is set up by the caller function.

CONTENTS

FIGURES

TABLES

CHAPTER 1 GENERAL

This chapter outlines the C compiler. The C compiler is a language processor program which translates source programs written in C language into the assembly language for Fujitsu-provided various microcontroller units.

1.1 C COMPILER FUNCTIONS

When a C source file is described, the C compiler generates an assembler source file which is expressed in assembly language.

■ C Compiler Functions

The processing steps for assembler source file generation are indicated below.

- Preprocessing

  Preprocessing is conducted by the preprocessor (**`cpp`**) which is a subcomponent of the compiler. Preprocessing instructions (**`#if`**, **`#define`**, **`#include`**, etc.) in a C source are interpreted and converted to a preprocessed C source.

- Compilation

  Compilation is conducted by the compiler (**`ccom`**). The preprocessed C source is converted to an assembler source.

For the use of the C compiler, the **`fcc907s`**, **`fcc911s`**, or **`fcc896s`** command is to be used. These commands automatically call up the tools composing the C compiler (preprocessor and compiler), and provides control over C source file compiling. The C compiler structure is shown in *Figure 1.1-1*.

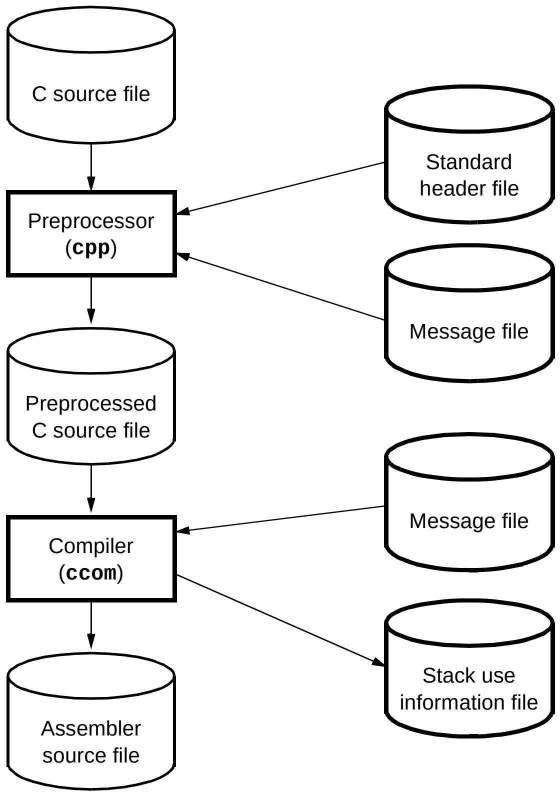


Figure 1.1-1 C Compiler Structure

In the subsequent sections, the C compiler translation process is explained using commands. For the details of the command function specifications, see ***Chapter 3, Operation***.

1.2 BASIC PROCESS OF COMMANDS

The basic process of commands is described below.
Each MCU has the following commands.

- **`fcc911s`: For FR family**
- **`fcc907s`: For F²MC-16L/16LX/16/16H/16F family**
- **`fcc896s`: For F²MC-8L family**

■ `fcc907s` Command Basic Process

The **`fcc907s`** command basically generates an object file from an described C source file. The command regards any file with a **`.c`** extension as a C source file.

An example of using the **`fcc907s`** command is given below, where **`%`** is the command prompt.

[Example 1]

```
% fcc907s -cpu MB90F553A file.c
```

At the input given above, the command regards **`file.c`** as a C source file and, if no error is detected, generates an object file (**`file.obj`**) in the current directory.

[Example 2]

```
% fcc907s -o outfile -cpu MB90F553A file.c
```

At the input given above, the command generates an object file (**`outfile`**). The command operation process can be controlled by specifying options, such as **`-o`**.

■ `fcc911s` Command Basic Process

The **`fcc911s`** command basically generates an absolute file from an described C source file. The command regards any file with a **`.c`** extension as a C source file.

An example of using the **`fcc911s`** command is given below, where **`%`** is the command prompt.

[Example 1]

```
% fcc911s -cpu MB91F154 file.c
```

At the input given above, the command regards **`file.c`** as a C source file and, if no error is detected, generates an absolute file (**`file.abs`**) in the current directory.

[Example 2]

```
% fcc911s -o outfile -cpu MB91F154 file.c
```

At the input given above, the command generates an absolute file (**`outfile`**). The command operation process can be controlled by specifying options, such as **`-o`**.

■ **fcc896s Command Basic Process**

The **fcc896s** command basically generates an absolute file from an described C source file. The command regards any file with a **.c** extension as a C source file.

An example of using the **fcc896s** command is given below, where **%** is the command prompt.

[Example 1]

```
% fcc896s -cpu MB89P935B file.c
```

At the input given above, the command regards **file.c** as a C source file and, if no error is detected, generates an absolute file (**file.abs**) in the current directory.

[Example 2]

```
% fcc896s -o outfile -cpu MB89P935B file.c
```

At the input given above, the command generates an absolute file (**outfile**). The command operation process can be controlled by specifying options, such as **-o**.

■ **Options for Compiling Process Control**

- **-P** option

  When the **-P** option is specified, the command calls up the preprocessor only and performs preprocessing to generate a preprocessed C source file in the current directory. The extension of the generated file is changed to **.i**.

- **-S** option

  When the **-S** option is specified, the command calls up the preprocessor and compiler and performs preprocessing and compiling to generate an assembler source file in the current directory. The extension of the generated file is changed to **.asm**.

- **-c** option (only for **fcc911s** and **fcc896s** commands)

  When the **-c** option is specified, the command calls up the preprocessor, compiler, and assembler and performs preprocessing, compiling, and assembling to generate an object file in the current directory. The extension of the generated file is changed to **.obj**. Note that this option cannot be specified for the **fcc907s** command.

- **-o** option

  When the **-o** option is specified, the command generates the file specified in the command line as a result of processing.

Output files generated according to the above options specifying can be used as the input files for the **fcc907s** command. The input files and output files generated by options are shown in *Figures 1.2-1 and 1.2-2*.

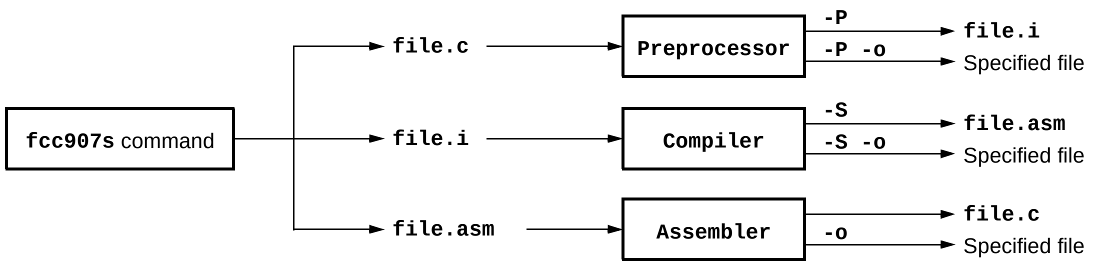


Figure 1.2-1 Relationship between Input Files and Output Files Generated by Options (`fcc907s` Command)

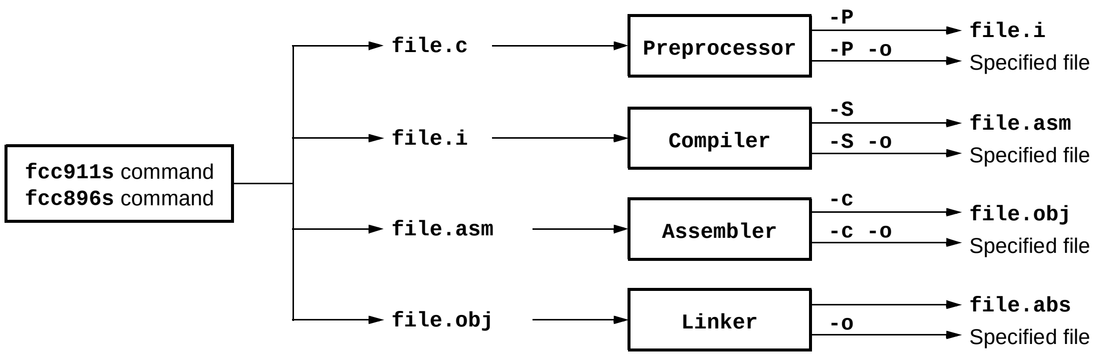


Figure 1.2-2 Relationship between Input Files and Output Files Generated by Options (`fcc911s` and `fcc896s` Commands)

1.3 C COMPILER BASIC FUNCTIONS

The C compiler functions are described below.

- **Header file search**
- **Coordination with symbolic debugger**
- **Optimization**

The symbolic debugger is a support tool for analyzing a program created in C language.

■ Header File Search

The header file can be acquired using the C program **`#include`** instruction. When the absolute pathname is specified, the header file enclosed within angular brackets (<>) is searched for in the directory specified by absolute pathname. When the absolute pathname is not specified, the standard directory is searched.

The standard header file is supplied by the C compiler.

The header file enclosed by double quotation marks (") is searched for in a directory specified by the absolute pathname. If the absolute pathname is not specified, such a header file is searched for in a directory having a file containing a **`#include`** line. If the header file is not found in a directory having a file containing a **`#include`** line, the standard directory is searched next.

The **`-I`** option makes it possible to add a directory for header file search.

[Example]

```
%  fcc907s  -cpu  MB90F553A -I  ../include  file.c
%  fcc911s  -cpu  MB91F154 -I  ../include  file.c
%  fcc896s  -cpu  MB89P935B -I  ../include  file.c
```

At the input given above, the command searches for the header file enclosed within angular brackets in the order shown below.

1. **`../include`**
2. Standard directory

The header file enclosed by double quotation marks is searched for in the order shown below.

1. Current directory having a file containing a **`#include`** line
2. **`../include`**
3. Standard directory

The **`-I`** option can be specified a desired number of times. When it is specified two or more times, search operations are conducted in the specified order.

■ Coordination with Symbolic Debugger

When the **`-g`** option is specified, the compiler generates the debug information to be used by the symbolic debugger. When such information is generated, C language level debugging can be accomplished within the symbolic debugger. Two types of symbol debuggers are available; simulator debugger and emulator debugger.

When the optimization option is specified, the compiler attempts to ensure good code generation by changing the computation target position and eliminating computations that are judged to be unnecessary. To minimize the amount of data exchange with memory, the compiler tries to retain data within a register. It is therefore conceivable that a break point positioned in a certain line may fail to cause a break or that currently monitored certain address data may fail to vary with the expected timing. It also well to remember that the debug data will not be generated for an unused local variable or a local variable whose area need not be positioned in a stack as a result of optimization.

Debugging must be conducted with the above considerations taken into account.

■ Optimization

When the **`-O`** option is specified, the compiler generates an object subjected to general-purpose optimization.

CHAPTER 2 SETUP OF SYSTEM EMVIRONMENT BEFORE USING C COMPILER

This chapter describes the C compiler operating environment variables (for the setting of environment variables, refer to the manual for each operating system). All the environment variables can be omitted.
For the supply style, refer to the *C Compiler Installation Manual*.
The Windows95/WindowsNT version permits the use of long file names for the directories to be set up as environment variables. For the characters applicable to long file names, see *3.3, File Names and Directory Names*.
[Setup Example]

```
  set  TMP=c:Fujitsu MCU tool
```

For environment variable setup, do not use double quotation marks (").

2.1 FETOOL

Specify the installation directory for the development environment.

■ FETOOL

[General Format 1] For UNIX OS

```
setenv FETOOL  Installation directory
```

[General Format 2] For Windows

```
set FETOOL=Installation directory
```

The driver accesses the compiler, message file, include file, and other items via the path specified by **FETOOL**.

When **FETOOL** setup is not completed, the parent directory for the directory where the activated command exists (the /.. position of the directory where the command exists) is regarded as the installation directory.

No more than one directory can be specified.

[Example] For UNIX OS

```
setenv FETOOL /usr/local/softune
```

[Example] For Windows

```
set FETOOL=c:\softune
```

2.2 LIB911/LIB896

Specify the directory that contains the library to which the `fcc911s` or `fcc896s` command is linked by default.

■ LIB911/LIB896

[General Format 1] For UNIX OS

```
setenv LIB911  Library directory [: Directory 2 ...]
setenv LIB896  Library directory [: Directory 2 ...]
```

[General Format 2] For Windows

```
set LIB911=Library directory [; Directory 2 ...]
set LIB896=Library directory [; Directory 2 ...]
```

Specify the directory to which linking is effected by default.

If **`LIB911`** setup is not completed, the directory placed at an offset from the directory specified by **`FETOOL`** (**`${FETOOL}/lib/911 or ${FETOOL}/lib/896`**) is regarded as the default library directory.

When two or more directories are specified, ":" (UNIX) or ";" (Windows) is interpreted as the directory name delimiter.

[Example] For UNIX OS

```
setenv LIB911 /usr/local/softune/lib/911
setenv LIB896 /usr/local/softune/lib/896
```

[Example] For Windows

```
set LIB911=d:\softune\lib\911
set LIB896=d:\softune\lib\896
```

2.3 OPT907/OPT911/OPT896

Specify the directory for the default option file to be used by the command. For the `fcc907s` command, set `OPT907`. For the `fcc911s` command, set `OPT911`. For the `fcc896s` command, set `OPT896`.

■ OPT907/OPT911/OPT896

[General Format 1] For UNIX OS

```
setenv OPT907  Default option file directory
setenv OPT911  Default option file directory
setenv OPT896  Default option file directory
```

[General Format 2] For Windows

```
set OPT907=Default option file directory
set OPT911=Default option file directory
set OPT896=Default option file directory
```

Specify the directory for the default option file to be used by the driver.

If **`OPT907/OPT911/OPT896`** setup is not completed, the directory placed at an offset from the directory specified by **`FETOOL`** (**`${FETOOL}/lib/907`**, **`${FETOOL}/lib/911`**, or **`${FETOOL}/lib/896`**) is regarded as the default option file directory.

No more than one directory can be specified.

[Example] For UNIX OS

```
setenv OPT907 /usr/local/softune/lib/907
setenv OPT911 /usr/local/softune/lib/911
setenv OPT896 /usr/local/softune/lib/896
```

[Example] For Windows

```
set OPT907=c:\softune\lib\907
set OPT911=c:\softune\lib\911
set OPT896=c:\softune\lib\896
```

2.4 INC907/INC911/INC896

Specify the directory where a standard header file search is to be conducted by the command. For the `fcc907s` command, set `INC907`. For the `fcc911s` command, set `INC911`. For the `fcc896s` command, set `INC896`.

■ INC907/INC911/INC896

[General Format 1] For UNIX OS

```
setenv INC907  Standard include directory
setenv INC911  Standard include directory
setenv INC896  Standard include directory
```

[General Format 2] For Windows

```
set INC907=Standard include directory
set INC911=Standard include directory
set INC896=Standard include directory
```

Specify the directory where the standard header file is to be searched for. The directory specified by **`INC907/INC911/INC896`** is regarded as the standard include directory.

If **`INC907C/INC911`** setup is not completed, the directory placed at an offset from the directory specified by **`FETOOL`** (**`${FETOOL}/lib/907/include`**, **`${FETOOL}/lib/911/include`**, or **`${FETOOL}/lib/896/include`**) is regarded as the standard header file directory.

No more than one directory can be specified.

[Example] For UNIX OS

```
setenv INC907 /usr/local/softune/lib/907/include
setenv INC911 /usr/local/softune/lib/911/include
setenv INC896 /usr/local/softune/lib/896/include
```

[Example] For Windows

```
set INC907=c:\softune\lib\907\include
set INC911=c:\softune\lib\911\include
set INC896=c:\softune\lib\896\include
```

2.5 TMP

Specify the directory for the temporary file to be used by the C compiler.

■ TMP

[General Format 1] For UNIX OS

```
setenv TMP  Temporary directory
```

[General Format 2] For Windows

```
set TMP=Temporary directory
```

Specify the working directory for creating the temporary file to be used by the C compiler.

If **`TMP`** setup is not completed, the temporary file is created in the **`/tmp`** directory for UNIX OS or in the current directory for Windows.

No more than one directory can be specified.

[Example] For UNIX OS

```
setenv TMP /usr/tmp
```

[Example] For Windows

```
set TMP=c:\tmp
```

2.6 FELANG

Specify the code for messages.

■ FELANG

[General Format 1] For UNIX OS

```
setemv FELANG  Message code
```

[General Format 2] For Windows

```
set FELANG=Message code
```

Specify the message code. The following codes can be specified.

- ASCII: Outputs messages in ASCII code
  The generated messages are in English.
  Select this code for a system without a Japanese language environment.
- EUC: Outputs messages in EUC code
  The generated messages are in Japanese.
- SJIS: Outputs messages in SHIFT JIS code
  The generated messages are in Japanese.

If **FELANG** setup is not completed, the ASCII code is considered to be selected.

[Example] For UNIX OS

```
setenv FELANG EUC
```

[Example] For Windows

```
set FELANG=SJIS
```

CHAPTER 3 OPERATION

This chapter describes the command function specifications.

3.1 COMMAND LINE

The command line format is shown below.

- **`fcc907s  [options]  operands`**
- **`fcc911s  [options]  operands`**
- **`fcc896s  [options]  operands`**

■ Command Line

Options and operands can be specified in the command line. They can be specified at any position within the command line. Two or more options and operands can be specified. Options can be omitted.

Option and operand entries are to be delimited by a blank character string. The command recognizes the options and operands in the order shown below.

1. An entry beginning with a hyphen (**-**) is first recognized as an option. The subsequent character string is interpreted to determine the option type.
2. As regards an option having an argument, the subsequent character string is regarded as the argument.
3. The remaining entries in the command line are recognized as operands.

[Example]

```
%fcc907s file1.c -S -I /home/myincs file2.c

%fcc911s file1.c -S -I /home/myincs file2.c

%fcc896s file1.c -S -I /home/myincs file2.c
```

At first, **`-S`** and **`-I`** are regarded as options. Since the **`-I`** option has an argument, the subsequent character string **`/home/myincs`** is regarded as the argument. The remaining entries (**`file1.c`** and **`file2.c`**) are regarded as operands.

Options	: **`-S`**, **`-I /home/myincs`**
Operands	: **`file1.c`**, **`file2.c`**

■ Command Process

The command calls up the preprocessor, compiler, assembler, and linker for all input files in the order of their specifying, and performs preprocessing, compiling, assembling, and linking. The results are output into files which are named by replacing the input file extensions with **`.obj`**.

[Example]

```
%fcc907s file1.c file2.c file3.c -cpu MB90F553A
```

Files named **`file1.c`**, **`file2.c`**, and **`file3.c`** are subjected to preprocessing, compiling, and assembling so that files named **`file1.obj`**, **`file2.obj`**, and **`file3.obj`** are generated.

```
%fcc911s file1.c file2.c file3.c -cpu MB91F154

%fcc896s file1.c file2.c file3.c -cpu MB89P935B
```

Files named **`file1.c`**, **`file2.c`**, and **`file3.c`** are subjected to preprocessing, compiling, assembling, and linking so that files named **`file1.abs`** are generated.

3.2 COMMAND OPERANDS

One or more input files can be specified as operands.

■ Command Operands

The command determines the file type according to the input file extension and performs an appropriate process to suit the file type.

The extension cannot be omitted.

- File Specifying

  C source files, preprocessed C source files, assembler source files, and object files can be specified as operands.

- File Extension

  The relationship between input file extensions and **`fcc907s`** command processes is shown in *Table 3-2-1*. Note, however, that the associated process may be inhibited depending on the option specifying.

Table 3.2-1 Relationship between Extensions and Command Processes

Extension	Command Process
`.c`	The file having this extension is regarded as a C source file and subjected to preprocessing and subsequent processes.
`.i`	The file having this extension is regarded as a preprocessed C source file and subjected to compiling and subsequent processes.
`.asm`	The file having this extension is regarded as a compiled assembler source file and subjected to assembling and subsequent processes.
`.obj`	The file having this extension is regarded as an assembled object file and subjected to linking and subsequent processes. For this type of file, the **`fcc907s`** command does nothing.
`.abs`	The file having this extension is regarded as a linked absolute file, and an error output is generated. No absolute file can be specified.

[Example]

```
%fcc907s file1.c file2.i -cpu MB90F553A
```

A file named **`file1.c`** is subjected to preprocessing, compiling, and assembling. A file named **`file2.i`** is then subjected to compiling and assembling to generate files named **`file1.obj`** and **`file2.obj`**.

```
%fcc911s file1.c file2.i -cpu MB91F154
%fcc896s file1.c file2.i -cpu MB89P935B
```

A file named **`file1.c`** is subjected to preprocessing, compiling, and assembling. A file named **`file2.i`** is then subjected to compiling, assembling, and linking, in order named, to generate a file named **`file1.abs`**.

3.3 FILE NAMES AND DIRECTORY NAMES

The following characters are applicable to file names and directory names.

■ File Names and Directory Names

- Windows95/WindowsNT version

  Alphanumeric characters, symbols except \, **/**, **:**, *****, **?**, **"**, **<**, **>**, and **|**, Shift-JIS kanji codes, and Shift-JIS 1-byte kana codes.

  When long file name is specified as option and operand, it should be enclosed by double quotation marks ("). However, do not use double quotation marks at setup environment variable with this file name.

- Other Versions

  Underbar (_) and alphanumeric characters (however, the first character must be the underbar or alphabetical character).

- Module Name

  The module name is based on a file name. It is formed by an underbar (_) and alphanumeric characters (The first character must be alphabetic with an underbar). If other characters are used for the file name, the characters that cannot be used for the module name are converted to underbars. File names allowing identical module names should not be used.

3.4 COMMAND OPTIONS

This section describes the command options.

■ Option Syntax

The option consists of a hyphen (-) and one or more characters following the hyphen. Some options have an argument. A blank character string must be positioned between an option and an argument. The command options cannot be grouped for purposes of specifying. Grouping is a technique of specifying which, for instance, uses a **`-Sg`** form to specify both the **`-S`** option and **`-g`** option.

■ Multiple Specifying of Same Option

If the same option is specified more than one time, only the last-specified option in the command line is assumed to be valid.

[Example]

```
%fcc907s -o outfile file.c -o outobj -cpu MB90F553A
%fcc911s -o outfile file.c -o outobj -cpu MB91F154
%fcc896s -o outfile file.c -o outobj -cpu MB89P935B
```

The resultant output file name will be **`outobj`**.

- Options that are significant when specified more than one time

```
-D  -f  -I  -INF  -K  -L  -l  -ra  -ro  -sc  -T  -U  -x  -Y
```

When the above options are specified more than one time, see details of options.

■ Position within Command Line

The option's position within the command line does not have a special meaning. Options are interpreted in the same manner no matter where in the command line they are specified.

[Example]

```
1) %fcc907s -C -E file1.c file2.c -cpu MB90F553A
2) %fcc907s file1.c -E file2.c -C -cpu MB90F553A
1) %fcc911s -C -E file1.c file2.c -cpu MB91F154
2) %fcc911s file1.c -E file2.c -C -cpu MB91F154
1) %fcc896s -C -E file1.c file2.c -cpu MB89P935B
2) %fcc896s file1.c -E file2.c -C -cpu MB89P935B
```

The same processing operations are performed for cases 1) and 2).

■ Exclusiveness and Dependency

Some options are mutually exclusive or dependent on each other. For option exclusiveness and dependency, see details of options.

■ Case Sensitiveness

As regards the options, their upper-case and lower-case characters are different from each other. For example, the **`-O`** option is different from the **`-o`** option. However, the upper- and lower-case characters of suboptions are not differentiated from each other. For example, the **`-K eopt`** option is considered in the same as the **`-K EOPT`** option. The suboptions are the character strings that follow the **`-K`** option or **`-INF`** option.

3.4.1 List of Command Options

When executed without argument specifying, the command outputs an option list to the standard output. The options for the command are listed in Tables 3.4-1 to 3.4-4. The options listed in the tables can be recognized by the command.

■ List of Command Options

Table 3.4-1 List of Command Options

Specifying Format	Function
`-B`	Allows the C++ type comments(//)
`-C`	Leaves a comment in the preprocessing result
`-cmsg`	Outputs the compiling process end message to the standard output
`-cpu  MB number`	Specifies the MB number of the CPU to be used
`-cwno`	Sets end code to 1 when warning given
`-D name[=[tokens]]`	Defines the macro **name**
`-E`	Performs preprocessing only and outputs the result to the standard output
`-f filename`	Specifies the option file
`-g`	Adds to the object the information necessary for debugging
`-H`	Outputs the acquired header file pathname to the standard output
`-help`	Outputs the option list to the standard output
`-I dir`	Specifies the directory for head file search
`-INF LIST`	Generates the assemble list
`-INF {SRCIN|LINENO}`	Inserts the associated C source information as a comment into the assembler source
`-INF STACK[=filename]`	Generates the stack use amount data
`-J {a|c}`	Specifies the specification level of the language to be interpreted by the compiler
`-K {DCONST|FCONST}`	Specifies the type of a real constant without a suffix
`-K EOPT`	Effects optimization for changing the arithmetic operation evaluation procedure
`-K LIB`	Recognizes the standard function operation and implements in-line expansion/substitution for other functions
`-K NOALIAS`	Effects optimization on the presumption that differing pointers do not indicate the same area
`-K NOINTLIB`	Effects no in-line expansion for interrupt related functions
`-K NOUNROLL`	Inhibits loop unrolling
`-K NOVOLATILE`	Does not consider **__io** qualifier variables to be volatile
`-K REALOS`	Effects in-line expansion for the ITRON system call function
`-K {SIZE|SPEED}`	Selects optimization with emphasis placed on the size and execution speed
`-K {UCHAR|SCHAR}`	Specifies the mere **char** sign handling
`-K {UBIT|SBIT}`	Specifies the mere **int** bit field sign handling
`-kanji {SJIS|EUC}`	Specifies kanji code used in program
`-O level`	Gives instructions for general-purpose optimization

Table 3.4-1 List of Command Options *(Continued)*

Specifying Format	Function
`-o pathname`	Outputs the result to the **`pathname`**
`-P`	Performs preprocessing only and outputs the result to **`.i`**
`-S`	Performs processes up to compiling and outputs the result to **`.asm`**
`-s defname=newname [, attr [, address]]`	Changes the section name
`-T item, arg1 [, arg2 ...]`	Passes arguments to the tool
`-U name`	Cancels the macro name definition
`-V`	Outputs the executed compiler tool version information to the standard output
`-w level`	Specifies the warning message output level
`-Xdof`	Inhibits the default option file read operation
`-x func [, func2 ...]`	Specifies the in-line expansion of functions
`-xauto [size]`	Specifies the in-line expansion of the functions whose logical line count is not less than **`size`**
`-Y item, dir`	Changes the **`item`** position to **`dir`**

Table 3.4-2 List of `fcc907s` Command Options

Specifying Format	Function
`-div905`	Specifies the DIV/DIVW instruction is generated
`-K ADDSP`	Releases actual argument areas altogether
`-K ARRAY`	Optimization of array element access code.
`-pack`	Packing of struct and union menbers.
`-model {SMALL|MEDIUM|COMPACT|LARGE}`	Specifies the memory model
`-ramconst`	Specifies that the mirror function will not be used
`-varorder {SORT|NORMAL}`	Specifies the rule of arrangement of external variables and static variables in section

Table 3.4-3 List of `fcc911s` Command Options

Specifying Format	Function
`-c`	Performs processes up to assembling and outputs the result to `.obj`
`-e name`	Specifies the entry of a program
`-K {A1|A4}`	Specifies the minimum boundary alignment value for static data
`-K {SCHEDULE|NOSCHEDULE}`	Specifies the recall of the scheduler
`-K {SARG|DARG}`	Specifies the argument area acquisition type
`-K {SHORTADDRESS[= {CODE|DATA}]` `|LONGADDRESS[= {CODE|DATA}]}`	Specifies the external symbol handling type
`-L path1 [, path2 ...]`	Specifies the library path
`-l lib1 [, lib2 ...]`	Specifies the library file name
`-m`	Outputs a map file at the time of linking
`-ra name = start/end`	Specifies the RAM area
`-ro name = start/end`	Specifies the ROM area
`-sc param`	Specifies the section arrangement
`-startup file`	Specifies the startup file name
`-varorder {SORT|NORMAL}`	Specifies the rule of arrangement of external variables and static variables in section

Table 3.4-4 List of `fcc896s` Command Options

Specifying Format	Function
`-c`	Performs processes up to assembling and outputs the result to `.obj`
`-e name`	Specifies the entry of a program
`-L path1 [, path2 ...]`	Specifies the library path
`-l lib1 [, lib2 ...]`	Specifies the library file name
`-K ADDSP`	Releases actual argument areas altogether
`-K ARRAY`	Optimization of array element access code.
`-m`	Outputs a map file at the time of linking
`-ra name = start/end`	Specifies the RAM area
`-ro name = start/end`	Specifies the ROM area
`-sc param`	Specifies the section arrangement
`-startup file`	Specifies the startup file name

3.4.2 List of Command Cancel Options

The cancel options for the command are listed in Tables 3.4-5 to 3.4-8. The listed options are used to cancel command options on an individual basis.

■ List of Command Cancel Options

Table 3.4-5 List of Command Cancel Options

Specifying Format	Function
-XB	Cancels the **-B** option
-XC	Cancels the **-C** option
-Xcmsg	Cancels the **-cmsg** option
-Xcwno	Cancels the **-cwno** option
-Xf	Cancels the **-f** option
-Xg	Cancels the **-g** option
-XH	Cancels the **-H** option
-Xhelp	Cancels the **-help** option
-XI	Cancels the **-I** option
-INF NOLINENO	Cancels the **LINENO** suboption
-INF NOLIST	Cancels the **LIST** suboption
-INF NOSRCIN	Cancels the **SRCIN** suboption
-INF NOSTACK	Cancels the **STACK** suboption
-K ALIAS	Cancels the **NOALIAS** suboption
-K INTLIB	Cancels the **NOINTLIB** suboption
-K NOEOPT	Cancels the **EOPT** suboption
-K NOLIB	Cancels the **LIB** suboption
-K NOREALOS	Cancels the **REALOS** suboption
-K UNROLL	Cancels the **NOUNROLL** suboption
-K VOLATILE	Cancels the **NOVOLATILE** suboption
-Xo	Cancels the **-o** option
-Xs	Cancels the **-s** option
-XT item	Cancels the **-T item** specifying
-XV	Cancels the **-V** option
-Xx	Cancels the **-x** option
-Xxauto	Cancels the **-xauto** option
-XY item	Cancels the **-Y item** specifying

Table 3.4-6 List of `fcc907s` Command Cancel Options

Specifying Format	Function
`-K NOADDSP`	Cancels the **`ADDSP`** suboption
`-K NOARRAY`	Cancels the **`ARRAY`** suboption
`-Xpack`	Cancels the **`-pack`** option
`-Xdiv905`	Cancels the **`-div905`** option
`-Xramconst`	Cancels the **`-ramconst`** option

Table 3.4-7 List of `fcc911s` Command Cancel Options

Specifying Format	Function
`-Xe`	Cancels the **`-e`** option
`-XL`	Cancels the **`-L`** option
`-Xl`	Cancels the **`-l`** option
`-Xm`	Cancels the **`-m`** option
`-Xra`	Cancels the **`-ra`** option
`-Xro`	Cancels the **`-ro`** option
`-Xsc`	Cancels the **`-sc`** option
`-Xstartup`	Cancels the **`-startup`** option

Table 3.4-8 List of `fcc896s` Command Cancel Options

Specifying Format	Function
`-Xe`	Cancels the **`-e`** option
`-K NOADDSP`	Cancels the **`ADDSP`** suboption
`-K NOARRAY`	Cancels the **`ARRAY`** suboption
`-XL`	Cancels the **`-L`** option
`-Xl`	Cancels the **`-l`** option
`-Xm`	Cancels the **`-m`** option
`-Xra`	Cancels the **`-ra`** option
`-Xro`	Cancels the **`-ro`** option
`-Xsc`	Cancels the **`-sc`** option
`-Xstartup`	Cancels the **`-startup`** option

3.5 DETAILS OF OPTIONS

This section details the options.

■ Translation Control Related Options

The translation control related options are related to preprocessor, compiler, assembler, and linker call control.

■ Preprocessor Related Options

The preprocessor related options are related to preprocessor operations.

■ Data Output Related Options

The data output related options are related to the command, preprocessor, and compiler data outputs.

■ Language Specification Related Options

The language specification related options are related to the specification of the language to be recognized by the compiler.

■ Optimization Related Options

The optimization related options are related to the optimization to be effected by the compiler.

■ Output Object Related Options

The output object related options are related to the output object format.

■ Debug Information Related Options

The debug information related options are related to the debug information to be referenced by the symbolic debugger.

■ Command Related Options

The command related options are related to the other tools recalled by commands.

■ Linkage Related Options

The linkage related options are related to linkage.

■ Option File Related Options

The option file related options are related to option files.

3.5.1 Translation Control Related Options

This section describes the options related to preprocessor, compiler, assembler, and linker call control.

■ Translation Control Related Options

The priorities of the translation control related options are defined as follows. They are not related to the order of specifying.

```
-E > -P > -S > -c
```

The translation control related option exclusiveness is shown in *Table 3.5-1*.

Table 3.5-1 Translation Control Related Option Exclusiveness

Specified Option	Option Invalidated
`-E`	`-S` and `-c`
`-P`	`-S` and `-c`
`-S`	`-c`
`-c`	None

If the **`-E`** and **`-P`** options are specified simultaneously, see the explanation below. The **`-c`** option cannot be used with the **`fcc907s`** command.

The translation control related options are detailed below.

❍ -E

This option subjects all files to preprocessing only and outputs the result to the standard output. The output result contains the preprocessing instruction generated by the preprocessor, which is necessary for the compiler. The information targets for the preprocessing instruction generated by the preprocessor are the **`#line`** and **`#pragma`** instructions. If the **`-P`** option is specified together with the **`-E`** option, the preprocessing instruction generated by the preprocessor is inhibited. If the input file is not a C source file, the **`-E`** option does not do anything.

[Example]

```
%fcc907s -E -cpu MB90F553A sample.c
%fcc911s -E -cpu MB91F154 sample.c
%fcc896s -E -cpu MB89P935B sample.c
```

The **`sample.c`** preprocessing result is output to the standard output.

❍ -P

This option subjects a C source file to preprocessing only and outputs the result to the file whose extension is changed to **`.i`**. Unlike the cases where the **`-E`** option is specified, the output result does not contain the preprocessing instruction generated by the preprocessor. If the input file is not a C source file, the **`-P`** option does not do anything.

[Example]

```
%fcc907s -P -cpu MB90F553A sample.c
%fcc911s -P -cpu MB91F154 sample.c
%fcc896s -P -cpu MB89P935B sample.c
```

The **sample.c** preprocessing result is output to the **sample.i**.

❍ **-S**

This option performs processes up to compiling and outputs the resultant assembler source to file extension changed to **.asm**. If the input is neither a C source file nor a preprocessed C source file, the **-S** option does not do anything.

[Example]

```
%fcc907s -S -cpu MB90F553A sample.c
%fcc911s -S -cpu MB91F154 sample.c
%fcc896s -S -cpu MB89P935B sample.c
```

The **sample.c** preprocessing and compiling process result are output to the **sample.asm**.

❍ **-c**

This option performs processes up to assembling and outputs the resultant object to file extension changed to **.obj**. If the input file is an object file, the -c option does not do anything. The option cannot be used with the **fcc907s** command.

[Example]

```
%fcc911s -c -cpu MB91F154 sample.c
%fcc896s -c -cpu MB89P935B sample.c
```

The **sample.c** preprocessing and compiling process result is output to the **sample.obj**.

The relationship among file types, translation control related options, and processes is shown in *Table 3.5-2*.

Table 3.5-2 Relationship Among File Types, Translation Control Related Options, and Processes

Option File Type (Extension)	-E	-P	-S	-c	Nothing Specified
C source file (**.c**)	P	P	P and C	P, C and A	P, C, A and L
Preprocessed C source file (**.i**)	—	—	C	C and A	C, A and L
Assembler source file (**.asm**)	—	—	—	A	A and L
Object file (**.obj**)	—	—	—	—	L

P: Preprocessing
C: Compiling
A: Assembling
L: Linking

The **fcc907s** command does not call linker.

[Example]

```
%fcc907s -E file1.c file2.i -cpu MB90F553A
%fcc911s -E file1.c file2.i -cpu MB91F154
%fcc896s -E file1.c file2.i -cpu MB89P935B
```

Subjects a file named **file1.c** to preprocessing only and outputs the result to the standard output. Performs nothing for a file named **file2.i**.

```
%fcc907s -E file1.c file2.i file3.asm -cpu MB90F553A
%fcc911s -E file1.c file2.i file3.asm -cpu MB91F154
%fcc896s -E file1.c file2.i file3.asm -cpu MB89P935B
```

Subjects a file named **file1.c** to preprocessing and compiling and a file named **file2.i** to compiling. Performs nothing for a file named **file3.asm**. As a result, files named **file1.asm** and **file2.asm** are generated in the current directory.

3.5.2 Preprocessor Related Options

This section describes the options related to preprocessor operations. If the preprocessor is not called, the preprocessor related options are invalid.

■ Preprocessor Related Options

The preprocessor related options are detailed below.

❍ -B

❍ -XB

The **-B** option allows C++ style comments. When specifying this option, // style in addition to /* */ style can be used.

The **-XB** option cancels the **-B** option.

❍ -C

❍ -XC

The **-C** option retains all comments except those which are in the preprocessing instruction line as the preprocessing result. If the option is not specified, the comments are replaced by one blank character.

The **-XC** option cancels the **-C** option.

[Output Example]

- Input:

```
/* Comment */
void func(void){}
```

- Operation:

```
fcc907s -C -E -cpu MB90F553A sample.c
fcc911s -C -E -cpu MB91F154 sample.c
fcc896s -C -E -cpu MB89P935B sample.c
```

- Output:

```
# 1 "test5.c"
/* Comment */
void func(void){}
```

❍ -D name [=[tokens]]

This option defines the macro **name** with the **tokens** used as the macro definition. The option is equivalent to the following **#define** instruction.

```
#define name  tokens
```

If =**tokens** entry is omitted, the value 1 is given as the **tokens** value. If the **tokens** entry is omitted, the specified lexeme is deleted from the source file. The error related to the **-D** option is the same as the error related to the **#define** instruction. This option can be specified more than one time.

[Example]

```
%fcc907s -D os=m -D sys file.c -cpu MB90F553A
%fcc911s -D os=m -D sys file.c -cpu MB91F154
%fcc896s -D os=m -D sys file.c -cpu MB89P935B
```

In a file named **`file.c`**, processing is conducted on the assumption that the macro definitions for **`os`** and **`sys`** are **`m`** and **`1`**, respectively.

❍ **`-H`**

❍ **`-XH`**

The **`-H`** option outputs to the standard output the header file pathnames acquired during preprocessing. The pathnames are sequentially output, one for each line, in the order of acquisition. If there are any two exactly the same pathnames, only the first one will be output. When this option is specified, the command internally sets up the **`-E`** option to subjects all files to preprocessing only. However, the preprocessing result will not be output.

The **`-XH`** option cancels the **`-H`** option.

[Output Example]

- Input:

```
#include <stdio.h>
#include "head.h"
```

- Operation:

```
fcc907s -H -cpu MB90F553A sample.c
```

- Output:

```
/usr/softune/lib/907/include/stdio.h
./head.h
```

- Operation:

```
fcc911s -H -cpu MB91F154 sample.c
```

- Output:

```
/usr/softune/lib/911/include/stdio.h
./head.h
```

- Operation:

```
fcc896s -H -cpu MB89P935B sample.c
```

- Output:

```
/usr/softune/lib/896/include/stdio.h
./head.h
```

❍ **`-I dir`**

❍ **`-XI`**

The **`-I`** option changes the manner of header file search so that the directory specified by **`dir`** will be searched prior to the standard directory. The standard directory is **`${INC907}`** (**`fcc907s`** command), **`${INC911}`** (**`fcc911s`** command), or **`${INC896}`** (**`fcc896s`** command).

This option can be specified more than one time. The search will be conducted in the order of specifying. When the option is specified, the header file search will be conducted in the following directories in the order shown below.

- Header file enclosed within angular brackets (< >)

    1.Directory specified by the **`-I`** option

    2.Standard directory

- Header file enclosed by double quotation marks (")

    1.Directory having a file containing the **`#include`** line

    2.Directory specified by the **`-I`** option

    3.Standard directory

If a header file is specified by specifying its absolute path name, only the directory specified by the specified absolute path name will be searched. If any nonexistent directory is specified, this option is invalid.

The **`-XI`** option cancels the **`-I`** option.

❍ **`-U name`**

This option cancels the macro **`name`** definition specified by **`-D`**. The option is equivalent to the following **`#undef`** instruction.

```
#undef name
```

If the same name is specified by the **`-D`** and **`-U`** options, the name definition will be canceled without regard to the order of option specifying.

This option can be specified more than one time.

The error related to the **`-U`** option is the same as the error related to the **`#undef`** instruction.

[Example]

```
%fcc907s -U m -D n -D m file.c -cpu MB90F553A
%fcc911s -U m -D n -D m file.c -cpu MB91F154
%fcc896s -U m -D n -D m file.c -cpu MB89P935B
```

This will cancel the macro m definition specified by the **`-D`** option.

3.5.3 Data Output Related Options

This section describes the options related to the command, preprocessor, and compiler data outputs.

■ Data Output Related Options

❍ `-cmsg`

This option outputs the compiling process completion message.

[Example]

- Operation:

```
fcc907s -cmsg -S -cpu MB90F553A sample.c
fcc911s -cmsg -S -cpu MB91F154 sample.c
fcc896s -cmsg -S -cpu MB89P935B sample.c
```

- Output:

```
COMPLETED C Compile, FOUND NO ERROR : sample.c
```

❍ `-cwno`

This option sets the end code to 1 when a warning-level error occurs. When the option is not specified, the end code is 0.

❍ `-help`

❍ `-Xhelp`

The **`-help`** option outputs the option list to the standard output. The **`-Xhelp`** option cancels the **`-help`** option.

[Example]

```
%fcc907s -help
%fcc911s -help
%fcc896s -help
```

Various command option lists are output to the standard output.

❍ `-INF LINENO`

❍ `-INF NOLINENO`

The **`-INF LINENO`** option inserts C source file line numbers into the assembler source file as comments. The **`LINENO`** suboption cannot be specified simultaneously with the **`SRCIN`** suboption.

The **`NOLINENO`** suboption cancels the **`LINENO`** suboption.

[Output Example]

- Input:

```
void func(void){}
```

- Operation:

```
fcc907s -INF lineno -S -cpu MB90F553A sample.c
```

- Output:

```
_func:
        LINK    #0
;;;;     a.c, line 1
        UNLINK
        RET
```

- Operation:

```
fcc911s -INF lineno -S -cpu MB91F154 sample.c
```

- Output:

```
_func:
        ST     RP, @-SP
        ENTER  #4
;;;;     a.c, line 1
L_func:
        LEAVE
        LD     @SP+, RP
        RET
```

- Operation:

```
fcc896s -INF lineno -S -cpu MB89P935B sample.c
```

- Output:

```
_func:
;;;;     e.c, line 1
L_func:
        RET
```

❍ **`-INF LIST`**

❍ **`-INF NOLIST`**

The **`-INF LIST`** option generates a file in the current directory and outputs the assemble list. The name of the generated file is determined by changing the source file name extension to **`.lst`**. Since the assemble list is generated at assembling, it is not generated when assembling is not conducted. For the details of the assemble list, refer to the ***Assembler Manual***.

The **`NOLIST`** suboption cancels the **`LIST`** suboption.

[Example]

```
%fcc907s -INF list -c -cpu MB90F553A sample.c
%fcc911s -INF list -c -cpu MB91F154 sample.c
%fcc896s -INF list -c -cpu MB89P935B sample.c
```

The **`sample.c`** preprocessing, compiling, and assembling process result are output to the **`sample.obj`**, and the resulting assemble list is output to the **`sample.lst`**.

❍ **-INF SRCIN**

❍ **-INF NOSRCIN**

The **`-INF SRCIN`** option inserts a C source file into the assembler source file as a comment. The **`SRCIN`** suboption cannot be specified simultaneously with the **`LINENO`** suboption.

The **`NOSRCIN`** suboption cancels the **`SRCIN`** suboption.

[Output Example]

- Input:

```
void func(void){}
```

- Operation:

```
fcc907s -INF srcin -S -cpu MB90F553A sample.c
```

- Output:

```
_func:
        LINK    #0
;;;;     void func(void){}
        UNLINK
        RET
```

- Operation:

```
fcc911s -INF srcin -S -cpu MB91F154 sample.c
```

- Output:

```
_func:
        ST      RP, @-SP
        ENTER   #4
;;;;     void func(void){}
L_func:
        LEAVE
        LD      @SP+, RP
        RET
```

- Operation:

```
fcc896s -INF srcin -S -cpu MB89P935B sample.c
```

- Output:

```
_func:
;;;;     void func(void){}
L_func:
        RET
```

❍ **-INF STACK [=file]**

❍ **-INF NOSTACK**

The **-INF STACK [=file]** option generates the specified file in the current directory and outputs the stack use amount data. If no file is specified, the information in all the simultaneously compiled files is output into files whose names are determined by changing the source file extensions to **.stk**.

If the **-K ADDSP** option is simultaneously specified, stacks will not successively be freed so that the generated stack use amount data is inaccurate. In such an instance, therefore, it is well to remember that the maximum stack use amount data calculated by the MUSC may be smaller than the actual maximum use amount. For stack use amount data utilization procedures and data file specifications, refer to the ***MUSC Operation Manual***.

The **NOSTACK** suboption cancels the **STACK** suboption.

[Output Example]

- Input:

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

- Operation:

```
fcc907s -INF stack -S -cpu MB90F553A sample.c
```

- Output:

```
@sample.c
#  E=Extern  S=Static  I=Interrupt
#   {Stack}    {E|S|I} {function name}
#       ->     {E_S}   {call function}
#                ...
#
         4      E       _func
        ->      E       _sub
```

- Operation:

```
fcc911s -INF stack -S -cpu MB91F154 sample.c
```

- Output:

```
@sample.c
#  E=Extern  S=Static  I=Interrupt
#   {Stack}    {E|S|I} {function name}
#       ->     {E|S}   {call function}
#               ...
#
        8      E       _func
       ->      E       _sub
```

- Operation:

```
fcc896s -INF stack -S -cpu MB89P935B sample.c
```

- Output:

```
@sample.c
#  E=Extern  S=Static  I=Interrupt
#   {Stack}    {E|S|I} {function name}
#       ->     {E|S}   {call function}
#               ...
#
        0      E       _func
       ->      E       _sub
```

❍ **`-o pathname`**

❍ **`-Xo`**

The **`-o`** option uses the **`pathname`** as the output file name. If this option is not specified, the default for the employed file format is complied with.

The **`-Xo`** option cancels the **`-o`** option.

[Example]

```
%fcc907s -o output.asm -S -cpu MB90F553A sample.c
%fcc911s -o output.asm -S -cpu MB91F154 sample.c
%fcc896s -o output.asm -S -cpu MB89P935B sample.c
```

The **`sample.c`** preprocessing and compiling process result are output to the **`output.asm`**.

❍ **`-V`**

❍ **`-XV`**

The **`-V`** option outputs the version information about each executed compiler tool to the standard output. The **`-XV`** option cancels the **`-V`** option.

[Output Example for **`fcc911s`** Command]

```
FR Family Softune C Compiler V30L05
ALL RIGHT RESERVED, COPYRIGHT (C) FUJITSU LIMITED 1986
LICENSED MATERIAL - PROGRAM PROPERTY OF FUJITSU LIMITED
```

[Output Example for **`fcc907s`** Command]

```
FFMC-16 Family Softune C Compiler V30L03
ALL RIGHT RESERVED, COPYRIGHT (C) FUJITSU LIMITED 1986
LICENSED MATERIAL - PROGRAM PROPERTY OF FUJITSU LIMITED
```

[Output Example for **`fcc896s`** Command]

```
FFMC-8L Family Softune C Compiler V30L03
ALL RIGHT RESERVED, COPYRIGHT (C) FUJITSU LIMITED 1986
LICENSED MATERIAL - PROGRAM PROPERTY OF FUJITSU LIMITED
```

❍ **`-w level`**

This option specifies the output level of warning-type diagnostic messages. Levels 0 through 8 can be specified. When level 0 is specified, no warning messages will be generated. The greater the **`level`** value, the more warning messages will be generated.

If the output level is not specified, **`-w 1`** applies.

For the details of diagnostic messages, see ***3.7, Messages Generated in Translation Process***.

[Output Example]

- Input:

```
const int a;
```

- Operation:

```
fcc907s -w 5 -S -cpu MB90F553A sample.c
fcc911s -w 5 -S -cpu MB91F154 sample.c
fcc896s -w 5 -S -cpu MB89P935B sample.c
```

- Output:

```
*** a.c(1) W1219C:  'const' a is not initialized.
```

[Warning item at each warning level]

- Level 0 : Warning-type diagnostic message is not generated.
- Level 1 : A basic warning-type diagnostic messages is generated.
- Level 2 : The following warning-type diagnostic messages in addition to level 1 is generated.

  Warning of the variable not used in the function is generated.

  Warning of the variable used before being initialized in the function is generated.

  Warning of the presence of the use of the Static function is generated.

- Level 3 : The following warning-type diagnostic messages in addition to level 2 is generated.

  When there is no return in the function which should return the value, warning is generated.

  When the value is not specified for return by the function which should return the

value, warning is generated.

Warning of pragma which cannot be recognized is generated.

When the variable and the constant are compared in the comparison operation, warning of the range of the value of the constant is generated.

- Level 4 : The following warning-type diagnostic messages in addition to level 3 is generated.

  When the extern function is declared in the block, warning is generated.

  When the struct/union is not defined in the external declaration of the struct/union array, warning is generated.

  When not the relational expression but the assignment expression, etc. are described in the place where the conditional expression is expected, warning is generated.

  When the address of the auto variable is used as a return value of the function, warning is generated.

- Level 5 : The following warning-type diagnostic messages in addition to level 4 is generated.

  When there is a implicit int type declaration, warning is generated.

  When there is no prototype declaration of the function, warning is generated.

  When the constant is described in the condition expression, warning is generated.

  When there is a implicit int type declaration of the parameter, warning is generated.

  When the declaration overload the declaration before, warning is generated.

  When the comma continues at enum member’s end, warning is generated.

  When there is no initial value in the declaration with const, warning is generated.

  When the address of the variable is compared with 0, warning is generated.

  When the type is defined in the cast expression, warning is generated.

  When register is specified for struct, union, and the array variable declaration, warning is generated.

- Level 6 : The following warning-type diagnostic messages in addition to level 5 is generated.

  When there is switch statement which is not default label, warning is generated.

- Level 7 : The following warning-type diagnostic messages in addition to level 6 is generated.

  When the int type is used, warning is generated.

  When the bitfield is neither int, signed int nor unsigned int type, warning is generated.

- Level 8 : The following warning-type diagnostic messages in addition to level 7 is generated.

  When the function is called with a pointer to the function, warning is generated.

3.5.4 Language Specification Related Options

This section describes the options related to the specifications of the language to be recognized by the compiler.

■ Language Specification Related Options

❍ `-J {a|c}`

This option specifies the language specification level to be interpreted by the compiler (preprocessor included).

When **`-Ja`** is specified, interpretation is conducted in compliance with the ANSI specifications including expansion specifications.

When **`-Jc`** is specified, interpretation is conducted in strict compliance with the ANSI specifications. In response to the expansion specifications, a warning message is output.

If the option is not specified, **`-Ja`** applies.

[Example]

```
%fcc907s -J a file1.c -J c file2.c -cpu MB90F553A
%fcc911s -J a file1.c -J c file2.c -cpu MB91F154
%fcc896s -J a file1.c -J c file2.c -cpu MB89P935B
```

The **`-Jc`** option becomes valid so that files named **`file1.c`** and **`file2.c`** are interpreted in strict compliance with the ANSI specifications.

■ `-K {DCONST|FCONST}`

When the **`FCONST`** suboption is specified, a floating-point constant whose suffix is not specified will be handled as a **`float`** type.

When the **`DCONST`** suboption is specified, a floating-point constant whose suffix is not specified will be handled as a **`double`** type.

If neither of the above two suboptions is specified, **`-K DCONST`** applies.

[Output Example]

- Input:

```
extern float    f1,f2;
void func(void){ f1 = f2+1.0;}
```

- Operation:

```
fcc907s -K fconst -cpu MB90F553A -S sample.c
```

- Output:

```
_func:
        LINK    #0
        MOVL    A, #1065353216
        MOVL    RL2, A
        MOVL    A, _f2
        CALLP   FADD
        MOVL    _F1, A
        UNLINK
        RET
```

- Operation:

```
fcc911s -K fconst -cpu MB91F154 -S sample.c
```

- Output:

```
_func:
        ST      RP, @-SP
        ENTER   #4
        LDI:32  #_f2, R12
        LD      @R12, R4
        LDI     #H'3F800000, R5
        CALL32  __addf, R12
        LDI:32  #_f1, R12
        ST      R4, @R12
L_func:
        LEAVE
        LD      @SP+, RP
        RET
```

- Operation:

```
fcc896s -K fconst -cpu MB89P935B -S sample.c
```

- Output:

```
_func:
        MOVW    A, _f2+2
        PUSHW   A
        MOVW    A, _f2
        PUSHW   A
        MOVW    A, #0
        PUSHW   A
        MOVW    A, #16256
        PUSHW   A
        CALL    LFADD
        PUPW    A
        MOVW    _f1, A
        PUPW    A
        MOVW    _f2+2, A
L_func:
        RET
```

❍ **-K NOINTLIB**

❍ **-K INTLIB**

The **NOINTLIB** suboption calls a normal function without effecting in-line expansion of an interrupt related function (**__DI()**, **__EI()**, and **__set_il()**).

The **INTLIB** suboption cancels the **NOINTLIB** suboption.

[Output Example]

- Input:

```
void func(void){ __DI();}
```

- Operation:

```
fcc907s -K nointlib -cpu MB90F553A -S sample.c
```

- Output:

```
_func:
        LINK    #0
        CALL    ___DI
        UNLINK
        RET
```

- Operation:

```
fcc911s -K nointlib -cpu MB91F154 -S sample.c
```

- Output:

```
_func:
        ST      RP, @-SP
        ENTER   #4
        CALL32  __DI, R12
L_func:
        LEAVE
        LD      @SP+, RP
        RET
```

- Operation:

```
fcc896s -K nointlib -cpu MB89P935B -S sample.c
```

- Output:

```
_func:
        CALL    __DI
L_func:
        RET
```

❍ **-K NOVOLATILE**

❍ **-K VOLATILE**

The **NOVOLATILE** suboption does not recognize a **__io** qualifier attached variable as a **volatile** type. Therefore, **__io** qualifier attached variables will be optimized.

The **VOLATILE** suboption cancels the **NOVOLATILE** suboption.

[Example]

```
%fcc907s -K novolatile -S -O -cpu MB90F553A sample.c
%fcc911s -K novolatile -S -O -cpu MB91F154 sample.c
%fcc896s -K novolatile -S -O -cpu MB89P935B sample.c
```

When an **__io** qualifier attached variable is processed in **sample.c**, it is not handled as a **__volatile** qualifier attached variable, but is treated as the optimization target.

❍ **-K {UCHAR|SCHAR}**

This option specifies whether or not to treat the **char** type most significant bit as a sign bit. When the **UCHAR** suboption is specified, the most significant bit will not be treated as a sign bit. When the **SCHAR** suboption is specified, the most significant bit will be treated as a sign bit.

If neither of the above two suboptions is specified, **-K UCHAR** applies.

[Output Example]

- Input:

```
extern int      data;
char            c = -1;
void func(void){ data = c;}
```

- Operation:

```
fcc907s -K schar -cpu MB90F553A -S sample.c
```

- Output:

```
        MOVX    A, _c; Code-extended
        MOVW    _data, A
```

- Operation:

```
fcc911s -K sbit -cpu MB91F154 -S sample.c
```

- Output:

```
        LDI:32  #_c, R12
        LDUB    @R12, R0
        EXTSB   R0; Code-extended
        LDI:32  #_data, R12
        ST      R0, @R12
```

- Operation:

```
fcc896s -K sbit -cpu MB89P935B -S sample.c
```

- Output:

```
        MOVW    A, #0
        MOV     A, _c; Code-extended
        MOVW    _data, A
```

❍ **-K REALOS**

❍ **-K NOREALOS**

The **REALOS** suboption effects in-line expansion of the ITRON system call function. It can be used in cases where a program running under REALOS is to be prepared. For the ITRON system call function, refer to the ***REALOS/907 Kernel Manual***.

When specifying the **REALOS** suboption, be sure to include the system call declaration header file provided by the REALOS. If the **REALOS** suboption is specified without including the system call declaration header file and system call in-line expansion is initiated, the operation is not guaranteed, because it is possible that an adequate argument-type check has not been completed.

The **NOREALOS** suboption cancels the **REALOS** suboption.

[Output Example]

- Input:

```
#include "scdef_w.h"
void func(void){ ext_tsk;}
```

- Operation:

```
fcc907s -K realos -cpu MB90F553A -S sample.c
```

- Output:

```
INTP    ext_tsk
BRA     *
```

- Input:

```
#include "itron.h"
#include "realos.h"
void func(void){ ext_tsk();}
```

- Operation:

```
fcc911s -K realos -cpu MB91F154 -S sample.c
```

- Output:

```
        LDI:8   #-21, R12
         EXTSB   R12
         INT     #64
```

- Input:

```
#include "scdef_w.h"
void func(void){ ext_tsk;}
```

- Operation:

```
fcc896s -K realos -cpu MB89P935B -S sample.c
```

- Output:

```
INTP    ext_tsk
BRA     *
```

❍ **-K {UBIT|SBIT}**

This option specifies whether or not to treat the most significant bit as a sign bit in situations where the **char**, **short int**, **int**, or **long int** type is selected as the bit field. When the **UBIT** suboption is specified, the most significant bit will not be treated as a sign bit. When the **SBIT** suboption is specified, the most significant bit will be treated as a sign bit.

If neither of the above two suboptions is specified, **-K UBIT** applies.

[Output Example]

- Input:

```
extern int      data;
struct tag { int bf:1;}st = {-1};
void func(void){ data = st.bf;}
```

- Operation:

```
fcc907s -K sbit -cpu MB90F553A -S sample.c
```

- Output:

```
        MOVB    A, _st:0
        EXT                    ; Code-extended
        MOVW    _data, A
```

- Operation:

```
fcc911s -K sbit -cpu MB91F154 -S sample.c
```

- Output:

```
        LDI:32  #_st, R12
        LDUB    @R12, R0
        EXTSB   R0             ; Code-extended
        ASR     #7, R0
        LDI:32  #_data, R12
        ST      R0, @R12
```

- Operation:

```
fcc896s -K sbit -cpu MB89P935B -S sample.c
```

- Output:

```
        MOV     A, _st+1
        MOVW    A, #15
        CALL    LSHLW
        MOVW    A, #15
        CALL    LSHLW          ; Code-extended
        MOVW    _data, A
```

3.5.5 Optimization Related Options

This section describes the options related to optimization by the compiler.

■ Optimization Related Options

❍ `-K SIZE`

This option selects an appropriate optimization combination with emphasis placed upon the object size. The available options are shown below.

`-O 3`

`-K EOPT`

`-K NOUNROLL`

`-K SHORTADDRESS`

If any option (e.g, **`-O0`**) contradictory to the **`SIZE`** suboption is specified after the **`SIZE`** suboption, such a contradictory option takes effect.

The **`-K SHORTADDRESS`** option can be specified for the **`fcc911s`** command only.

The **`-K SIZE`** option not only offers the optimization combination selection function, but also makes it possible to issue a generation instruction for object size minimization and effect object pattern switching.

❍ `-K SPEED`

This option selects an appropriate optimization combination with emphasis placed upon the generated object execution speed. The available options are shown below.

`-O 4`

`-K SHORTADDRESS`

If any option (e.g, **`-O0`**) contradictory to the **`SPEED`** suboption is specified after the **`SPEED`** suboption, such a contradictory option takes effect.

The **`-K SHORTADDRESS`** option can be specified for the **`fcc911s`** command only.

The **`-K SPEED`** option not only offers the optimization combination selection function, but also makes it possible to issue a generation instruction for execution speed maximization and effect object pattern switching.

❍ `-O [level]`

This option specifies the optimization level. Levels 0, 1, 2, 3, and 4 can be specified. The higher the optimization level, the shorter the generated object execution time but the longer the compilation time. Note that each optimization level contains lower optimization level functions.

One of the following levels is to be specified. When no level is specified, **`-02`** applies.

`-0`: Optimization Level 0

No optimization will be effected. This level is equivalent to cases where the **`-0`** is not specified.

`-1`: Optimization Level 1

Optimization will be effected in accordance with detailed analyses of a program flow.

-2: Optimization Level 2

The following optimization feature is exercised in addition to the feature provided by optimization level 1.

- Loop Unrolling

  Loop unrolling is performed to increase the execution speed by decreasing the loop count when loop-count detection is possible. However, it tends to increase object size. Therefore, this optimization should not be used in situations where object size is important.

  [Before Unrolling]

  ```
  for(i=0;i<3;i++){ a[i]=0;}
  ```

  [After Unrolling]

  ```
  a[0]=0;
  a[1]=0;
  a[2]=0;
  ```

-3: Optimization Level 3

The following optimization features are exercised in addition to the features provided by optimization level 2.

- Loop Unrolling (Extended)

  Loops, including branch instructions, that have not been the target of optimization level-2 loop unrolling, are the target of this extended loop unrolling.

- Optimization Function Repeated Execution

  In optimization function repeated execution, the optimization features except the loop unrolling feature will be repeatedly executed until no more optimization is needed. However, the translation time will increase.

-4: Optimization Level 4

The following optimization features are exercised in addition to the features provided by optimization level 3.

- Arithmetic Operation Evaluation Type Change (same as effected by **-K EOPT** specifying)

  Performs optimization to change arithmetic operation evaluation type at compilation stage. When this option is specified, there may be side effects on the execution results.

- Standard Function Expansion/Change (same as effected by **-K LIB** specifying)

Switches to a higher-speed standard function that recognizes standard function operations, performs standard function in-line expansion, and performs identical operations. When this option is specified, there may be side effects on the execution results. Since standard function in-line expansion is implemented, the code size may increase.

❍ **-K ADDSP**

❍ **-K NOADDSP**

The **-K** option releases actual argument areas placed in the stacks for function calling. Since the actual argument areas are released altogether for optimization purposes, the function calling overhead decreases so that a smaller, higher-speed object results.

When **-K ADDSP** is specified, the stacks will not successively be released. Therefore, the stack use amount data, which is generated upon **-INF STACK** option specifying, will be inaccurate. In such an instance, it is well to remember that the maximum stack use amount data calculated by the MUSC may be smaller than the actual maximum use amount.

The **NOADDSP** suboption cancels the **ADDSP** suboption.

The option can be specified only for the **fcc907s** and **fcc896s** commands.

[Output Example]

- Input:

```
extern int i;
extern void sub(int);
void func(void){
   sub(i);
   sub(i);
}
```

- Operation:

```
fcc907s -K addsp -cpu MB90F553A -S sample.c
```

- Output:

```
        MOVW    A, _i
        PUSHW   A
        CALL    _sub
        MOVW    A, _i
        PUSHW   A
        CALL    _sub
        ADDSP   #4; Releasing argument areas synthesized
```

❍ **-K EOPT**

❍ **-K NOEOPT**

The **EOPT** suboption effects optimization by changing the arithmetic operation evaluation type at the compilation stage. When this option is specified, there may be side effects on the execution results. This option takes effect only when it is specified simultaneously with the **-O** option.

The **NOEOPT** suboption cancels the **EOPT** suboption.

[Output Example]

- Input:

```
extern int i;
void func(int a, int b){
  i=a-100+b+100;
}
```

- Operation:

```
fcc907s -K eopt -O -cpu MB90F553A -S sample.c
```

- Output:

```
        MOVW    A, @RW3+4
        ADDW    A, @RW3+6 ; Order of arthmatic operation replaced
        MOVW    _i, A
```

- Operation:

```
fcc911s -K eopt -O -cpu MB91F154 -S sample.c
```

- Output:

```
        ADD     R5, R4    ; Order of arthmatic operation replaced
        LDI:32  #_i, R12
        ST      R4, @R12
```

- Operation:

```
fcc896s -K eopt -O -cpu MB89P935B -S sample.c
```

- Output:

```
   MOVW    A, @IX+4
   MOVW    A, @IX+6
   CLRC
   ADDCW   A              ; Order of arthmatic operation replaced
   MOVW    _i, A
```

❍ **-K LIB**

❍ **-K NOLIB**

The **LIB** suboption recognizes the standard function operation and replaces the standard function with a higher-speed standard function which effects standard function in-line expansion and performs the same operation as the original standard function. When this option is specified, there may be side effects on the execution results. Since standard function in-line expansion is implemented, the code size may increase. This option takes effect only when it is specified simultaneously with the **-O** option.

The **NOLIB** suboption cancels the **LIB** suboption.

[Output Example]

- Input:

```
extern int i;
void func(void){
  i=strlen("ABC");
}
```

- Operation:

```
fcc907s -K lib -O -cpu MB90F553A -S sample.c
```

- Output:

```
        MOVN    A, #3   ; Processing equivalent to strlen expanded
        MOVW    _i, A
```

- Operation:

```
fcc911s -K lib -O -cpu MB91F154 -S sample.c
```

- Output:

```
        LDI     #3, R0  ; Processing equivalent to strlen expanded
        LDI:32  #_i, R12
        ST      R0, @R12
```

- Operation:

```
fcc896s -K lib -O -cpu MB89P935B -S sample.c
```

- Output:

```
        MOVW    A, #3   ; Processing equivalent to strlen expanded
        MOVW    _i, A
```

❍ **-K {LONGADDRESS [= {CODE|DATA}] | SHORTADDRESS [= {CODE|DATA}]}**

The **SHORTADDRESS** suboption generates code on the presumption that the symbol (address) to be loaded within the program is within the 20-bit expression range. This option can be specified for the **fcc911s** command only. When **CODE** or **DATA** is specified, only the program code section (**CODE** or **CONST**) symbols or data section (**DATA** or **INIT**) symbols are to be processed. If the address is outside the 20-bit expression range, an error occurs at linking. A normal operation is performed even if symbols other than those loaded in the program are positioned at addresses in the 20-bit expression range.

The **LONGADDRESS** suboption handles a symbol address as a 32-bit address. This option can be specified for the **fcc911s** command only.

If neither of the above two suboptions is specified, **-K LONGADDRESS** applies.

[Output Example]

- Input:

```
extern int i;
extern void sub(void);
void func(void){
  i=10;
  sub();
}
```

- Operation:

```
fcc911s -K shortaddress -O -S -cpu MB91F154 sample.c
```

- Output:

```
        LDI:20  #_i, R12; 20-bit symbol used
        LDI     #10, R0
        ST      R0, @R12
        CALL20  _sub, R12; 20-bit symbol used
```

❍ **-K NOALIAS**

❍ **-K ALIAS**

The **NOALIAS** suboption optimizes the data specified by the pointer on the assumption that the pointer does not specify the same area as the other variables or pointers. This option takes effect only when it is specified simultaneously with the -O option. The language specification permits the pointer to point to the same area as any other variable or pointer. Therefore, when using this option, check the program carefully.

The **ALIAS** suboption cancels the **NOALIAS** suboption.

[Output Example]

- Input:

```
extern int i;
extern int j;
void func9(int *p){
  *p=i+1;
  j=i+1;
}
```

- Operation:

```
fcc907s -K noalias -O -cpu MB90F553A -S sample.c
```

- Output:

```
        MOVW    A, _i
        MOVN    A, #1
        ADDW    A
        MOVW    RW4, A
        MOVW    A, #RW3+4
        MOVW    @AL, AH
        MOVW    A, RW4
        MOVW    _j, A        ; Value of *p=i+1 reused
```

- Operation:

```
fcc911s -K noalias -O -cpu MB91F154 -S sample.c
```

- Output:

```
        LDI:32  #_i, R12
        LD      @R12, R0
        LDI:32  #_j, R12
        ADD     #1, R0
        ST      R0, @R4
        ST      R0, @R12     ; Value of *p=i+1 reused
```

- Operation:

```
fcc896s -K noalias -O -cpu MB89P935B -S sample.c
```

- Output:

```
                MOVW    A, _i
                INCW    A
                MOVW    @IX-2, A
                MOVW    A, @IX+4
                MOVW    @A, T
                MOVW    A, @IX-2
                MOVW    _j, A           ; Value of *p=i+1 reused
```

❍ **`-K {SCHEDULE|NOSCHEDULE}`**

This option specifies whether or not to implement instruction scheduling. When the **`SCHEDULE`** suboption is specified, instruction scheduling will be conducted. When the **`NOSCHEDULE`** suboption is specified, instruction scheduling will not be conducted. If the option specifying is omitted, the **`-O`** option specifying is complied with. When the **`-O`** option argument is 1 or greater, the **`-K SCHEDULE`** is assumed to be specified. These option can be specified for the **`fcc911s`** command only.

❍ **`-K NOUNROLL`**

❍ **`-K UNROLL`**

The **`NOUNROLL`** suboption inhibits loop unrolling optimization. Use this option when loop unrolling optimization is to be inhibited with the **`-O2`** to **`-O4`** options specified.

The **`UNROLL`** suboption cancels the **`NOUNROLL`** suboption.

❍ **`-x function name 1 [, function name 2, ...]`**

❍ **`-Xx`**

The **`-x`** option effects in-line expansion, instead of function calling, of functions defined by a C source. However, recursively called functions will not be subjected to in-line expansion. It should also be noted that functions may not be subjected to in-line expansion depending on **`asm`** statement use, structure/union type argument presence, **`setjmp`** function calling, and other conditions. The option takes effect only when it is specified simultaneously with the -O option.

The **`-Xx`** option cancels the **`-x`** option.

[Output Example]

- Input:

```
extern int a;
static void sub(void){ a=1; }
void func(void){ sub(); }
```

- Operation:

```
fcc907s -cpu MB90F553A -O -x sub -S sample.c
```

- Output:

```
_func:
        MOVN    A, #1
        MOVW    _a, A
        RET
```

- Operation:

```
fcc911s -cpu MB91F154 -O -x sub -S sample.c
```

- Output:

```
_func:
        LDI     #1, R0
        LDI:32  #_a, R12
        RET:D
        ST      R0, @R12
```

- Operation:

```
fcc896s -cpu MB89P935B -O -x sub -S sample.c
```

- Output:

```
_func:
        MOVN    A, #1
        MOVW    _a, A
L_func:
        RET
```

❍ **-xauto [size]**

❍ **-Xxauto**

The **-xauto** option effects in-line expansion, instead of function calling, of functions whose logical line count is not less than **size**. However, recursively called functions will not be subjected to in-line expansion. It should also be noted that functions may not be subjected to in-line expansion depending on **asm** statement use, structure/union type argument presence, **setjmp** function calling, and other conditions.

If the **size** entry is omitted, the value 30 is assumed to be specified. The option takes effect only when it is specified simultaneously with the **-O** option.

The **-Xxauto** option cancels the **-xauto** option.

❍ **-K ARRAY**

❍ **-K NOARRAY**

The ARRAY suboption optimizes the array element access code(e.g. a[i]++;). The ARRAY suboption takes effect only when it is specified simultaneously with the -O option. However, a part of optimization might be not effective when the ARRAY suboption is specified and the code worsen according to the source program.

This option can be specified for the fcc907s and fcc896s commnad only.

The NOARRAY suboption cancels the ARRAY suboption.

3.5.6 Output Object Related Options

This section describes the options related to output object formats.

■ Output Object Related Options

❍ `-cpu MB number`

In this option, the MB number of the CPU actually used is specified in the CPU information file. If the MB number not described in the CPU information file is specified, the compiler becomes an error because series information on the CPU is taken from the CPU information file.

This option cannot be omitted.

[Example]

```
%fcc911s -S -cpu MB91F154 sample.c
%fcc907s -S -cpu MB90F553A sample.c
%fcc896s -S -cpu MB89P935B sample.c
```

❍ `-div905`

❍ `-Xdiv905`

The **-div905** option and the **-Xdiv905** option are the options concerning the CPU bug of "DIV A,Ri" and "DIVW A,RWi" instructions of **MB90500 series**. This CPU bug is discribed to Appendix C "Notes of Signed Division Instruction of FFMC-16LX CPU".

The **-div905** option and the **-Xdiv905** option can be specified only for the **fcc907s** command. And, only when the MB number of **MB90500 series** is specified by the -cpu option, these become effective.

The **-div905** option generates signed division instruction(DIV and DIVW). Please specify this option only when there is no problem even if the signed division instruction(DIV and DIVW) is used.

The **-Xdiv905** option cancels the **-div905** option.

When the **-div905** option and the **-Xdiv905** option are omitted to the specification of the MB number of **MB90500 series** for the -cpu option, the **-Xdiv905** option is applied.

When the **-Xdiv905** option is specified, not the signed division instruction(DIV and DIVW) but Library Callis generated. Therefore, the amount of the stack use increases occasionally. Moreover, __mul(), __div(), and __mod() which is a built-in function are generated as not machine instructions but Library Callis.

❍ `-model {SMALL|MEDIUM|COMPACT|LARGE}`

This option specifies memory model. For the details of memory models, see ***4.4, Memory Models***. The option can be specified for the fcc907s command only.

❍ `-ramconst`

❍ `-Xramconst`

Specify this option (**`-ramconst`**) when the mirror function is not to be used. When specified, the option will position **`const`**-qualified static variables in the RAM.

When this option is specified, the compiler generates the **CINIT** section corresponding to the **CONST** section, so that ROM data can be accessed with 16-bit symbols. The startup routine must copy the **CONST** internal data to the **CINIT**.

This option does not work on **CONST_module name** sections that are generated relative to large models, compact models, or **__far**-qualified variables.

The **-Xramconst** option cancels the **-ramconst** option.

These options can be specified for the **fcc907s** command only.

[Output Example]

- Input:

```
const int a=0x10;
```

- Operation:

```
fcc907s -ramconst -S -cpu MB90F553A sample.c
```

- Output:

```
        .SECTION      CONST, CONST, ALIGN=2
        .ALIGN  2
        .DATA.H 16
        .SECTION      CINIT, DATA, ALIGN=2
        .ALIGN  2
        .GLOBAL _2
_a:
        .RES.H  1
```

❍ **-s defname=newname [, attr [, address]]**

❍ **-Xs**

The **-s** option changes the compiler output section name from **defname** to **newname**, and changes section type to **attr**.

In the **fcc907s** command, large models, compact models, medium models, and **__far**-qualified variable or function section names can be specified by attaching **FAR_** to the start.

The arrangement address can also be specified in the **address** position.

For compiler output section names, see ***4.1, fcc907s Command Section Structure***, ***4.2, fcc911s Command Section Structure***, and ***4.3, fcc896s Command Section Structure***. For selectable section types, refer to the ***Assembler Manual***.

If the arrangement address is specified, the arrangement address cannot be specified relative to the associated section at linking.

The **-Xs** option cancels the **-s** option.

[Output Example]

- Input:

```
void func(void){}
```

- Operation:

```
fcc907s -s CODE=PROGRAM, CODE, 0x1000 -S -cpu MB90F553A sample.c
```

- Output:

```
        .SECTION        PROGRAM, CODE, LOCATE=H’0:H’1000
;-------begin_of_function
        .GLOBAL _func
_func:
        LINK    #0
        UNLINK
        RET
```

- Operation:

```
fcc911s -s CODE=PROGRAM, CODE, 0x1000 -S -cpu MB91F154 sample.c
```

- Output:

```
        .SECTION        PROGRAM, CODE, LOCATE=H'00001000
;-------begin_of_function
        .GLOBAL _func
_func:
        ST      RP, @-SP
        ENTER   #4
L_main:
        LEAVE
        LD      @SP+, RP
        RET
```

- Operation:

```
fcc896s -s CODE=PROGRAM, CODE, 0x1000 -S -cpu MB89P935B sample.c
```

- Output:

```
        .SECTION        PROGRAM, CODE, LOCATE=H’1000
        .GLOBAL _func
_func:
L_func:
        RET
```

❍ **`-K {A1|A4}`**

This option specifies the minimum assignment boundary for external and static variables.

The **`A4`** suboption selects a 4-byte boundary as the minimum assignment boundary. When the 4-byte minimum assignment boundary is used, increased code generation efficiency is provided for in-line expansion of character string operations when **`-K lib`** is specified. Erroneous code operations occur if boundary alignment is incorrect. Therefore, if an object for which the **`A4`** suboption is specified is linked to an object for which the **`A4`** suboption is not specified, erratic operations may result. Also, generation of useless areas may be invoked by boundary alignment causing the object increase.

The **`A1`** suboption selects a 1-byte boundary as the minimum assignment boundary.

This option can be specified for the **fcc911s** command only. If neither of the above two suboptions is specified, **-K A1** applies.

[Output Example]

- Input:

```
char c;
```

- Operation:

```
fcc911s -K A4 -S -cpu MB91F154 sample.c
```

- Output:

```
.SECTION        DATA, DATA, ALIGN=4
        .GLOBAL _c
_c:; Positioned at 4-byte boundary
        .RES.B  4
```

❍ **-K {SARG|DARG}**

This option specifies type of acquisition of area required for argument delivery to function.

When the **DARG** suboption is specified, dynamic allocation is achieved at function calling. This effectively decreases the stack consumption.

On the other hand, when the **SARG** suboption is specified, allocation is performed at the beginning of the caller function. In this case, the code size generally decreases with an increase in execution speed. However, stack use tends to increase.

This option can be specified for the **fcc911s** command only. If neither of the above two suboptions is specified, **-K SARG** applies.

[Output Example]

- Input:

```
extern void sub(int,int,int,int,int);
void func(void){ sub(1,2,3,4,5);}
```

- Operation:

```
fcc911s -K darg -S -cpu MB91F154 sample.c
```

- Output:

```
        LDI     #1, R4
        LDI     #2, R5
        LDI     #3, R6
        LDI     #4, R7
        LDI     #5, R0
        ST       R0, @-SP; The argument area is allocated dynamically.
        CALL32  _sub, R12
        ADDSP    #4    ; The argument area is deallocated dynamically.
```

❍ `-varorder {SORT|NORMAL}`

This option specifies how external variables and static variables in a section are aligned. When **SORT** suboption is specified, to except the gap, external variables and static variables are aligned by the size of alignment. When **NORMAL** suboption is specified, external variables and static variables are aligned by the order of description. Variables specified __io qualifier are always aligned by the order of description.

This option can be specified for the **fcc911s** and **fcc907s** command only. If neither of the above two suboptions is specified, **-varorder SORT** applies.

- Input:

```
int  i1;
char c;
int  i2;
```

- Operation:

```
fcc911s -varorder NORMAL -S -cpu MB91F154 sample.c
```

- Output:

```
        .SECTION        DATA, DATA, ALIGN=4
        .ALIGN  4
_i1:    .RES.B  4
        .ALIGN  1
_c:     .RES.B  1
        .ALIGN  4
_i2:    .RES.B  4
```

- Operation:

```
fcc907s -varorder NORMAL -S -cpu MB90F553A sample.c
```

- Output:

```
        .SECTION        DATA, DATA, ALIGN=2
        .ALIGN  2
_i1:    .RES.B  2
_c:     .RES.B  1
        .ALIGN  2
_i2:    .RES.B  2
```

❍ -pack

❍ -Xpack

The -pack option packing the struct and union menbers.

This option can be specified for the fcc907s commnad only.

The -Xpack option cancels the -pack option.Input:

- Input:

```
struct tag {
  char a;
  int  b;
  char c;
} s;
f() {s.b=0;}
```

- Operation:

```
fcc907s -cpu MB90F553A -S -pack sample.c
```

- Output:

```
        MOVN    A, #0
        MOVW    _s+1, A
```

3.5.7 Debug Information Related Options

This section describes the options related to the debug information to be referenced by the symbolic debugger.

■ Debug Information Related Options

❍ **`-g`**

❍ **`-Xg`**

The **`-g`** option adds debug data to the object file. To assure debugging accuracy, you should refrain from specifying the optimization option (**`-O[1-4]`**). If the optimization option is specified, the compiler tries to assure better code output by changing the arithmetic operation target position and omitting any arithmetic operations that are judged to be unnecessary. To minimize the amount of data exchange with memory, the compiler tries to retain data within a register. It is therefore conceivable that a break point positioned in a certain line may fail to cause a break or that currently monitored certain address data may fail to vary with the expected timing. It also well to remember that the debug data will not be generated for an unused local variable or a local variable whose area need not be positioned in a stack as a result of optimization. Debugging must be conducted with the above considerations taken into account.

The **`-Xg`** option cancels the **`-g`** option.

3.5.8 Command Related Options

This section describes the options related to the other tools called by the `fcc907s`.

■ Command Related Options

❍ **`-Y item, dir`**

❍ **`-XY`**

The **`-Y`** option changes the **`item`** position to the **`dir`** directory. The **`-XY`** option cancels the **`-Y`** option. The **`item`** is one of the following.

`p`: Changes the preprocessor pathname to dir

`c`: Changes the compiler pathname to **`dir`**

`a`: Changes the assembler pathname to **`dir`**

`l`: Changes the linker pathname to **`dir`**

[Example]

```
%fcc907s file.c -Y p, /home/newlib -cpu MB90F553A
%fcc911s file.c -Y p, /home/newlib -cpu MB91F154
```

Calls the preprocessor using **`/home/newlib/cpp`** as the path name.

❍ **`-T item, arg1 [, arg2 ...]`**

❍ **`-XT`**

The **`-T`** option passes **`arg`** to **`item`** as an individual compiler tool argument. The **`-XT`** option cancels the

`-T` option.

Use a comma to separate arguments. To describe a comma as an argument, position a backslash (\) immediately before the comma. The comma positioned after the backslash will not be interpreted as a delimiter. To write a blank as an argument, describe a comma in place of a blank.

For the options for various commands, refer to the associated manuals. The following can be specified as the **`item`**.

`a`: Assembler

`l`: Linker

[Example]

```
%fcc907s -T a, -l, asmlist file.c -cpu MB90F553A
%fcc911s -T a, -l, asmlist file.c -cpu MB91F154
%fcc896s -T a, -l, asmlist file.c -cpu MB89P935B
```

Sequentially passes arguments **`-l`** and **`asmlist`** to the assembler. Therefore, the assemble list **`asmlist`** will be generated as a result of command execution.

3.5.9 Linkage Related Options

This section describes the options related to linkage.

■ Linkage Related Options

❍ `-e name`

❍ `-Xe`

The **`-e`** option sets the entry symbol to **`name`** at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands. The **`-Xe`** option cancels the **`-e`** option. Since the option definition is usually provided in the startup routine, this option does not have to be specified.

For details of the option, refer to the ***Linkage Kit Manual***.

❍ `-L path1 [, path2 ...]`

❍ `-XL`

The **`-L`** option adds **`path`** to the library path used at linking to search for a library to be linked. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands. If the option is not specified, **`${LIB911}`** or **`${LIB896}`** is selected automatically.

The **`-XL`** option cancels the **`-L`** option.

For details of the option, refer to the ***Linkage Kit Manual***.

❍ `-l lib1 [, lib2 ...]`

❍ `-Xl`

The **`-l`** option specifies the name (**`lib`**) of the library to be linked at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands. If the extension entry is omitted, the **`.lib`** extension is added automatically.

The **`-Xl`** option cancels the **`-l`** option.

For the objects output by the compiler, by default, "**`lib911.lib`**" or "**`lib896.lib`**" are set as the names of the libraries to be linked.

For the details of the option, refer to the ***Linkage Kit Manual***.

❍ `-m`

❍ `-Xm`

The **`-m`** option generates a map file at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands.

A map file output with a file name with the **`.map`** extension is generated in the current directory.

The **`-Xm`** option cancels the **`-m`** option.

❍ **`-ra name = start/end`**

❍ **`-Xra`**

The **`-ra`** option specifies the RAM area at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands.

The **`-Xra`** option cancels the **`-ra`** option.

For details of the option, refer to the ***Linkage Kit Manual***.

❍ **`-ro name = start/end`**

❍ **`-Xro`**

The **`-ro`** option specifies the ROM area at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands.

The **`-Xro`** option cancels the **`-ro`** option.

For details of the option, refer to the ***Linkage Kit Manual***.

❍ **`-sc param`**

❍ **`-Xsc`**

The **`-sc`** option specifies the section arrangement at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands. If the option is not specified, **`-sc IOPORT=0,*=0x1000`** is selected automatically.

The **`-Xsc`** option cancels the **`-sc`** option.

For details of the option, refer to the ***Linkage Kit Manual***.

❍ **`-startup filename`**

❍ **`-Xstartup`**

The **`-startup`** option selects **`filename`** as the object file name of the startup routine to be linked at linking. This option can be specified only for the **`fcc911s`** and **`fcc896s`** commands.

If the option is not specified, "**`${FETOOL}/lib/911/startup.obj`**" or "**`${FETOOL}/lib/896/startup.obj`**" is selected automatically.

The **`-Xstartup`** option cancels the **`-startup`** option.

For details of the startup routine, see ***Chapter 6, Execution Environment***.

3.5.10 Option File Related Options

This section describes the option file related options.

■ Option File Related Options

❍ **`-f filename`**

❍ **`-Xf`**

The **`-f`** option is used to read the specified option file (**`filename`**). If the option file name does not have an extension, an **`.opt`** extension will be added. The command options can be written in an option file. For the details of an option file, see ***3.6, Option Files***.

The **`-Xf`** option cancels the **`-f`** option.

❍ **`-Xdof`**

This option specifies that the default option file will not be read. For the default option file, see ***3.6, Option Files***.

3.6 OPTION FILES

This section describes fcc907s command option files. With the option file feature, it is possible to specify a bunch of options written in a file. This feature also permits you to put startup options to be specified in a file.

■ Option File

Option file reading takes place when an associated option is specified. This assures that the same result is obtained as when an option is specified at the **-f** specifying position in the command line.

If the option file name is without an extension, an **.opt** extension will be added.

■ Option File General Format

All entries that can be made in a command line can be written in an option file.

A line feed in an option file is replaced by a blank.

A comment in an option file is replaced by a blank.

[Example]

```
-I /usr/include  #  Include specifying
-D F2MC16        #  Macro specifying
-g               #  Debug data generation specifying
-S               #  Execution of processes up to compiling
```

■ Option File Limitations

The length of a line that can be written in an option file is limited to 4095 characters.

The **-f** option can be written in an option file. However, nesting is limited to 8 levels.

The Kanji character code in the option file should be the same as using the host's Kanji character code. The operation is not guaranteed when the Kanji character code on the command line and the Kanji character code in the option file are different.

OS	Kanji character code which can be used
Windows	ShiftJIS
Solaris2.x	EUC
HP-UX10.x	ShiftJIS

■ Acceptable Comment Entry in Option File

A comment can be started from any column.

A comment is to begin with a sharp (#). The entire remaining portion of the line serves as the comment.

In addition, the following comments can also be used.

```
/* Comment */

// Comment

; Comment
```

[Example]

```
-I /usr/include  #  Include specifying

-D F2MC16        /* Macro specifying */

-g               // Debug data generation specifying

-S               ;  Execution of processes up to compiling
```

■ Default Option File

A preselected option file can be read to initiate command execution. The obtained result will be the same as when an option is specified prior to another option specified in the command line.

The default option file name is predetermined as follows.

[For UNIX OS]

```
${OPT907}/fcc907.opt

${OPT911}/fcc911.opt

${OPT896}/fcc896.opt
```

[For Windows]

```
%OPT907%\fcc907.opt

%OPT911%\fcc911.opt

%OPT896%\fcc896.opt
```

The default option file name of the **fcc907s** command is "**fcc907.opt**". The default option file name of the **fcc911s** command is "**fcc911.opt**". The default option file name of the **fcc896s** command is "**fcc896.opt**".

If the default option file does not exist in the specified directory, such a specifying is ignored.

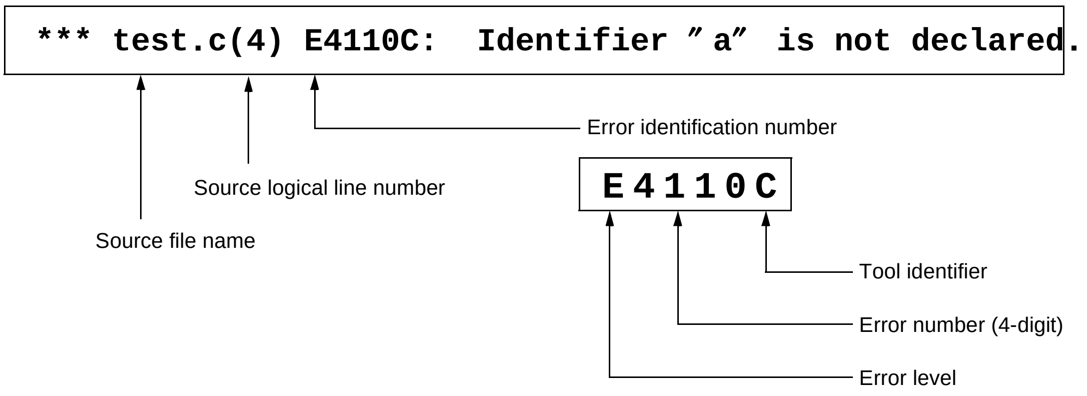
To inhibit the default option file feature, specify the **-Xdof** option in the command line.

3.7 MESSAGES GENERATED IN TRANSLATION PROCESS

When an error is found in a source program or a condition which does not constitute a substantial error but requires attention is encountered, diagnostic messages may be generated at the time of translation.
For message outputs generated by tools other than the compiler, refer to the respective manuals for the tool.

■ Messages Generated in Translation Process

A diagnostic message output example is shown in *Figure 3.7-1*.



```
*** test.c(4) E4110C:  Identifier ″a″ is not declared.
```

Figure 3.7-1 Diagnostic Message Example

■ Tool Identifier

The tool identifier indicates the tool that has detected the error.

D: Driver

P: Preprocessor

C: Compiler

S: Scheduler

A: Assembler

L: Linker

■ Error Level

The error level represents the diagnostic check result type.

Table 3.7-1 shows the relationship between various error levels and return codes and their meanings..

Table 3.7-1 Relationship between Error Levels and Return Codes

Error Level	Return Code	Meaning
I	0	Indicates a condition which does not constitute an error but requires attention
W	0	Indicates a minor error Process execution continues without being interrupted. The return code can be changed by the **-cwno** option.
E	2	Indicates a serious error Process execution stops.
F	3	Indicates a fatal error which is related to quantitative limitations or system failure Process execution stops.

CHAPTER 4 OBJECT PROGRAM STRUCTURE

This chapter describes the information necessary for program execution.

4.1 fcc907s COMMAND SECTION STRUCTURE

Table 4.1-1 shows the sections to be generated by the compiler and their meanings. When a section name is accessed using a 24-bit symbol, its name used is the section name plus the "`_module name`" attached to the end of the section name. The section name specified by -s option becomes "`FAR_SectionName`". The source file name is used as the module name. If the section name is changed by the `-s` option, the changed section name is used.

■ `fcc907s` Command Section Structure

Table 4.1-1 `fcc907s` Command Section List

No.	Section Type	Section Name	Type	Boundary Alignment [Byte]	Write	Initial Value
1	`Code section`	**CODE**	**CODE**	2	Disabled	Provided
2	`Initialized section`	**INIT**	**DATA**	2	Enabled	Not provided
3	`Initial value of INIT`	**DCONST**	**CONST**	2	Enabled	Not provided
4	`Constant section`	**CONST**	**CONST**	2	Disabled	Provided
5	`RAM area of CONST`	**CINIT**	**DATA**	2	Disabled	Not provided
6	`Data section`	**DATA**	**DATA**	2	Enabled	Not provided
7	`Initialized direct section`	**DIRINIT**	**DIR**	2	Enabled	Not provided
8	`Initial value of DIRINIT`	**DIRCONST**	**DIRCONST**	2	Enabled	Provided
9	`Direct section`	**DIRDATA**	**DIR**	2	Enabled	Not provided
10	`I/O section`	**IO**	**IO**	2	Enabled	Not provided
11	`Vector section`	**INTVECT**	**DATA**	2	Enabled	Provided

The purpose of each section use and the relationship to the C language are explained below.

(1) `Code section`

Stores machine codes. This section corresponds to the procedure section for the C language.

The default section name is **`CODE`**.

(2) `Initialized section`

Stores the initial value attached variable area. For the C language, this section corresponds to the area for external variables without the const qualifier, static external variables, and static internal variables.

The default section name is **`INIT`**.

(3) Initial value of DINIT

Stores the initial values for initial value attached variables. This section is located in the ROM. It is necessary to copy the **DCONST** data to the **INIT** using the startup routine. If the order of section output by the compiler is changed to the detriment of **DCONST**-to-**INIT** correspondence, no subsequent operations will be guaranteed.

The default section name is **DCONST**.

(4) Constant section

Stores the write-protected initial value attached variable area. For the C language, this section corresponds to the area for **const** qualifier attached external variables, static external variables, and static internal variables.

The default section name is **CONST**.

(5) RAM area of CCONST

When the employed CPU type does not permit the use of the mirror function, this section can be generated by specifying the **-ramconst** option. It is necessary to copy the **CONST** data to the **CINIT** using the startup routine. If the order of section output by the compiler is changed to the detriment of **CONST**-to-**CINIT** correspondence, no subsequent operations will be guaranteed.

The default section name is **CINIT**.

(6) Data section

Stores the area for variables without the initial value. For the C language, this section corresponds to the area for external variables (including those which are with the **const** qualifier), static external variables, and static internal variables.

The default section name is **DATA**.

(7) Initialized direct section

Stores the area for **__direct**-qualified initial value attached variables. For the C language, this section corresponds to the area for external variables, static external variables, and static internal variables that are **__direct**-qualified and without the **const** qualifier.

The default section name is **DIRINIT**.

(8) Initial value of DIRINIT

Stores the initial values for the **__direct**-qualified initial value attached variables. This section is located in the ROM. It is necessary to copy the **DIRCONST** data to the **DIRINIT** using the startup routine. If the order of section output by the compiler is changed to the detriment of **DIRCONST**-to-**DIRINIT** correspondence, no subsequent operations will be guaranteed.

The default section name is **DIRCONST**.

(9) Direct section

Stores the area for the **__direct**-qualified variables without the initial value. For the C language, this section corresponds to the area for **__direct**-qualified external variables (including those which are provided with the **const** qualifier), static external variables, and static internal variables.

The default section name is **DIRDATA**.

(10) `I/O section`

Stores the area for the __**`io`**-qualified variables. For the C language, this section corresponds to the area for __**`io`**-qualified external variables (including those which are provided with the **`const`** qualifier), static external variables, and static internal variables.

The default section name is **`IO`**.

(11) `Vector section`

Stores interrupt vector tables. For the C language, this section is generated only when the generation of a vector table is specified by **`#pragma intvect`**.

The default section name is **`INTVECT`**.

4.2 fcc911s COMMAND SECTION STRUCTURE

The `fcc911s` command has the following six sections:

- **`Code section`**
- **`Initialized section`**
- **`Constant section`**
- **`Data section`**
- **`I/O section`**
- **`Vector section`**

■ `fcc911s` Command Section Structure

Table 4.2-1 shows the sections to be generated by the compiler and their meanings.

Table 4.2-1 `fcc911s` Command Section List

No.	Section Type	Section Name	Type	Boundary Alignment [Byte]	Write	Initial Value
1	`Code section`	`CODE`	`CODE`	2	Disabled	Provided
2	`Initialized section`	`INIT`	`DATA`	4	Enabled	Provided
3	`Constant section`	`CONST`	`CONST`	4	Disabled	Provided
4	`Data section`	`DATA`	`DATA`	4	Enabled	Not provided
5	`I/O section`	`IO`	`IO`	4	Enabled	Not provided
6	`Vector section`	`INTVECT`	`DATA`	4	Enabled	Provided

The purpose of each section use and the relationship to the C language are explained below.

(1) `Code section`

Stores machine codes. This section corresponds to the procedure section for the C language.

(2) `Initialized section`

Stores the initial value attached variable area. For the C language, this section corresponds to the area for external variables without the **`const`** qualifier, static external variables, and static internal variables.

(3) `Constant section`

Stores the write-protected initial value attached variable area. For the C language, this section corresponds to the area for **`const`** qualifier attached external variables, static external variables, and static internal variables.

(4) `Data section`

Stores the area for variables without the initial value. For the C language, this section corresponds to the area for external variables (including those which are with the **`const`** qualifier), static external variables, and static internal variables.

(5) `I/O section`

Stores the area for the __**`io`**-qualified variables. For the C language, this section corresponds to the area for __**`io`**-qualified external variables (including those which are provided with the **`const`** qualifier), static external variables, and static internal variables.

The default section name is IO.

(6) `Vector section`

Stores interrupt vector tables. For the C language, this section is generated only when generation of a vector table is specified by **`#pragma intvect`**.

The default section name is **`INTVECT`**.

4.3 fcc896s COMMAND SECTION STRUCTURE

The `fcc896s` command has the following eight sections:

- **`Code section`**
- **`Initialized section`**
- **`Constant section`**
- **`Data section`**
- **`Initialized direct section`**
- **`Direct section`**
- **`I/O section`**
- **`Vector section`**

■ `fcc896s` Command Section Structure

Table 4.3-1 shows the sections to be generated by the compiler and their meanings.

Table 4.3-1 `fcc896s` Command Section List

No.	Section Type	Section Name	Type	Boundary Alignment [Byte]	Write	Initial Value
1	`Code section`	`CODE`	`CODE`	1	Disabled	Provided
2	`Initialized section`	`INIT`	`DATA`	1	Enabled	Provided
3	`Constant section`	`CONST`	`CONST`	1	Disabled	Provided
4	`Data section`	`DATA`	`DATA`	1	Enabled	Not provided
5	`Initialized direct section`	`DIRINIT`	`DIR`	1	Enabled	Provided
6	`Direct section`	`DIRDATA`	`DIR`	1	Enabled	Not provided
7	`I/O section`	`IO`	`IO`	1	Enabled	Not provided
8	`Vector section`	`INTVECT`	`DATA`	1	Enabled	Provided

The purpose of each section use and the relationship to the C language are explained below.

(1) `Code section`

Stores machine codes. This section corresponds to the procedure section for the C language.

(2) `Initialized section`

Stores the initial value attached variable area. For the C language, this section corresponds to the area for external variables without the **`const`** qualifier, static external variables, and static internal variables.

(3) `Constant section`

Stores the write-protected initial value attached variable area. For the C language, this section corresponds to the area for **`const`** qualifier attached external variables, static external variables, and static internal variables.

(4) `Data section`

Stores the area for variables without the initial value. For the C language, this section corresponds to the area for external variables (including those which are with the **`const`** qualifier), static external variables, and static internal variables.

(5) `Initialized direct section`

Stores the area for __**`direct`**-qualified initial value attached variables. For the C language, this section corresponds to the area for external variables, static external variables, and static internal variables that are __**`direct`**-qualified and without the const qualifier.

The default section name is **`DIRINIT`**.

(6) `Direct section`

Stores the area for the __**`direct`**-qualified variables without the initial value. For the C language, this section corresponds to the area for __**`direct`**-qualified external variables (including those which are provided with the **`const`** qualifier), static external variables, and static internal variables.

The default section name is **`DIRVAR`**.

(7) `I/O section`

Stores the area for the __**`io`**-qualified variables. For the C language, this section corresponds to the area for __**`io`**-qualified external variables (including those which are provided with the **`const`** qualifier), static external variables, and static internal variables.

The default section name is **`IO`**.

(8) `Vector section`

Stores interrupt vector tables. For the C language, this section is generated only when generation of a vector table is specified by **`#pragma intvect`**.

The default section name is **`INTVECT`**.

4.4 MEMORY MODELS

This section describes the memory models. The memory models exist in the F^{2}MC-16L/16LX/16/16H/16F family architecture only.

■ Memory Models

Table 4.4-1 shows the memory models selectable for compilation and their meanings. The compiler treats the code address and data address default set as a preselected memory model. In cases where a `__far/ __near` type qualifier is attached to a variable or function, the type qualifier specifying is complied with.

Table 4.4-1 List of Memory Models

Memory Model	Code Address Space	Data Address Space	Compile Option
Small model	16 bit	16 bit	`-model small`
Medium model	24 bit	16 bit	`-model medium`
Compact model	16 bit	24 bit	`-model compact`
Large model	24 bit	24 bit	`-model large`

❍ Small Model

The small model is to be specified in situations where all codes and data can be positioned within a 16-bit address space. Since all addresses are expressed using 16 bits, a compact, high-speed program can be realized.

When using a product without the mirror function, it is necessary to specify the **`-ramconst`** option for the purpose of securing a ROM data accessing area in RAM.

If the address size is specified by a type qualifier, such a specified address size is complied with.

When calling a **`__near`** type qualified function from a **`__far`** type qualified function, both functions must be positioned in the same section. The reason is that the PCB set up for **`__far`** type qualified function calling is used as is for **`__near`** type qualified function calling.

❍ Medium Model

The medium model is to be specified in situations where codes can be positioned in a 24-bit address space and data can be positioned in a 16-bit address space.

When using a product without the mirror function, it is necessary to specify the **`-ramconst`** option for the purpose of securing a ROM data accessing area in RAM.

If the address size is specified by a type qualifier, such a specified address size is complied with.

❍ Compact Model

The compact model is to be specified in situations where codes can be positioned in a 16-bit address space and data can be positioned in a 24-bit address space.

If the address size is specified by a type qualifier, such a specified address size is complied with.

Variables have to be adjusted to the bank boundary. If not, the generated code cannot access such variable correctly.

❍ Large Model

The large model is to be specified in situations where all codes and data can be positioned in a 24-bit address space. Since all addresses are expressed using 24 bits, the codes used are redundant as compared to those for the small model.

If the address size is specified by a type qualifier, such a specified address size is complied with.

Variables have to be adjusted to the bank boundary. If not, the generated code cannot access such variable correctly.

4.5 GENERATION RULES FOR NAMES USED BY COMPILER

This section describes the rules for the names used by the compiler.

■ Generation Rules for Names Used by Compiler

Table 4.5-1 shows the relationship between the names generated by the compiler and the C language.

Table 4.5-1 Label Generation Rules

C Language Counterpart	Label Generated by Compiler
Function name	**`_function name`**
External variable name	**`_external variable name`**
Static variable name	**`LI_no`**
Local variable name	—
Virtual argument name	—
Character string, derived type	**`LS_no`**
Automatic variable initial value	**`LS_no`**
Target location label	**`L_no`**

Note: The compiler internal generation number is placed at the **no** position.

4.6 fcc907s COMMAND BOUNDARY ALIGNMENT

This section describes the standard data type and boundary alignment. Table 4.6-1 shows the assignment rules.

■ `fcc907s` Command Boundary Alignment

Table 4.6-1 `fcc907s` Command Variable Assignment Rules

Variable Type	Assignment Size [Byte]	Boundary Alignment [Byte]
`char`	1	1
`signed char`	1	1
`unsigned char`	1	1
`short`	2	2
`unsigned short`	2	2
`int`	2	2
`unsigned int`	2	2
`long`	4	2
`unsigned long`	4	2
`float`	4	2
`double`	8	2
`long double`	8	2
`near` pointer/address	2	2
`far` pointer/address	4	2
Structure/union	Explained later	Explained later

4.7 fcc911s COMMAND BOUNDARY ALIGNMENT

This section describes the standard data type and boundary alignment. Table 4.7-1 shows the assignment rules.

■ `fcc911s` Command Boundary Alignment

Table 4.7-1 `fcc911s` Command Variable Assignment Rules

Variable Type	Assignment Size [Byte]	Boundary Alignment [Byte]
`char`	1	1
`signed char`	1	1
`unsigned char`	1	1
`short`	2	2
`unsigned short`	2	2
`int`	4	4
`unsigned int`	4	4
`long`	4	4
`unsigned long`	4	4
`float`	4	4
`double`	8	4
`long double`	8	4
Pointer/address	4	4
Structure/union	Explained later	Explained later

Note: When the **`-K A4`** option is specified, 4-byte boundary alignment may be effected in some cases. The **`-K A4`** option does not affect structure/union member boundary alignment.

4.8 fcc896s COMMAND BOUNDARY ALIGNMENT

This section describes the standard data type and boundary alignment. Table 4.8-1 shows the assignment rules.

■ fcc896s Command Boundary Alignment

Table 4.8-1 `fcc896s` Command Variable Assignment Rules

Variable Type	Assignment Size [Byte]	Boundary Alignment [Byte]
`char`	1	1
`signed char`	1	1
`unsigned char`	1	1
`short`	2	1
`unsigned short`	2	1
`int`	2	1
`unsigned int`	2	1
`long`	4	1
`unsigned long`	4	1
`float`	4	1
`double`	8	1
`long double`	8	1
Pointer/address	2	1
Structure/union	Explained later	Explained later

4.9 fcc907s COMMAND BIT FIELD

This section describes the bit field data size and boundary alignment for the `fcc907s` command.
The bit field data is assigned to a storage unit that has an adequate size for bit field data retention and is located at the smallest address.

■ `fcc907s` Command Bit Field

Consecutive bit field data are packed at consecutive bits having the same storage unit, without regard to the type, beginning with the LSB and continuing toward the MSB. An example is shown in *Figure 4.9-1*.

```
struct tag1 {
      int   A:10;
      short B:3;
      char  C:2;
};
```

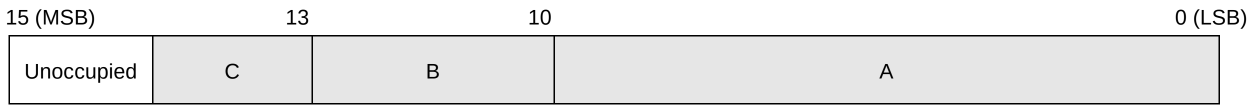


Figure 4.9-1 Example 1 of Bit Field Data Size and Boundary Alignment for fcc907s Command

If a field to be assigned lies over a bit field type boundary, its assignment is completed by aligning it with a boundary suitable for the type. An example is shown in *Figure 4.9-2*..

```
struct tag2 {
      long int   A:12;   /* 4-byte boundary data */
      short      B:5;    /* 2-byte boundary data */
      char       C:5;    /* 2-byte boundary data */
};
```

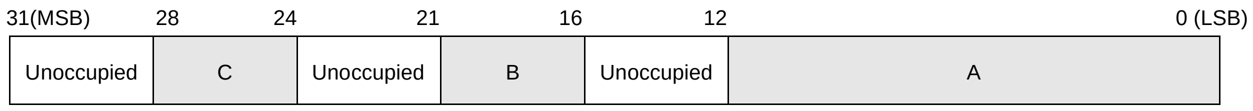


Figure 4.9-2 Example 2 of Bit Field Data Size and Boundary Alignment for fcc907s Command

When a bit field having a bit length of 0 is declared, it is forcibly assigned to the next storage unit. An example is shown in *Figure 4.9-3*.

```
struct tag3 {
      int   A:5;
      int   B:5;
      int    :0;
      int   C:6;
};
```

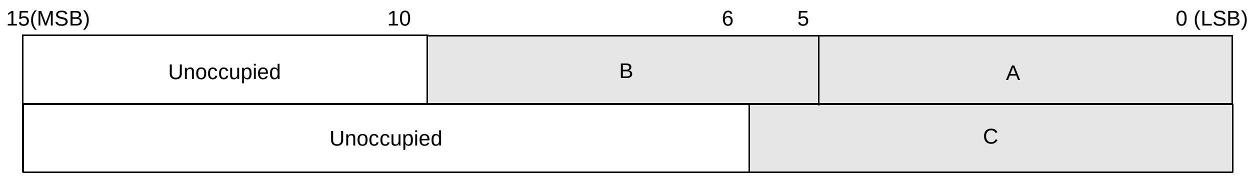


Figure 4.9-3 Example 3 of Bit Field Data Size and Boundary Alignment for fcc907s Command

4.10 fcc911s COMMAND BIT FIELD

This section describes the bit field data size and boundary alignment for the `fcc911s` command.
The bit field data is assigned to a storage unit that has an adequate size for bit field data retention and is located at the smallest address.

■ `fcc911s` Command Bit Field

Consecutive bit field data are packed at consecutive bits having the same storage unit, without regard to the type, beginning with the MSB and continuing toward the LSB. An example is shown in *Figure 4.10-1*.

```
struct tag1 {
      int   A:10;
      short B:3;
      char  C:2;
};
```

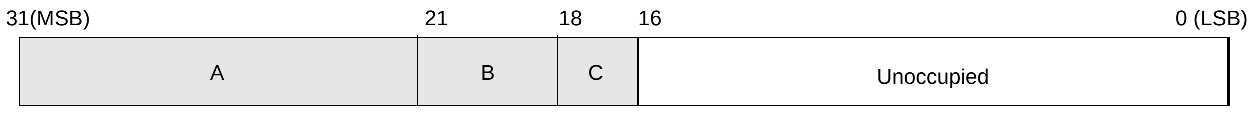


Figure 4.10-1 Example 1 of Bit Field Data Size and Boundary Alignment for `fcc911s` Command

If a field to be assigned lies over a bit field type boundary, its assignment is completed by aligning it with a boundary suitable for the type. An example is shown in *Figure 4.10-2*.

```
struct tag2 {
      int   A:12;   /* 4-byte boundary data */
      short B:5;    /* 2-byte boundary data */
      char  C:5;    /* 1-byte boundary data */
};
```

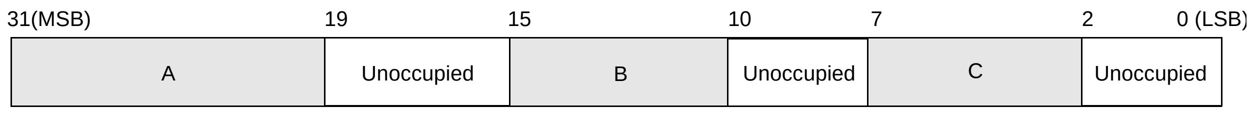


Figure 4.10-2 Example 2 of Bit Field Data Size and Boundary Alignment for `fcc911s` Command

When a bit field having a bit length of 0 is declared, it is forcibly assigned to the next storage unit. An example is shown in *Figure 4.10-3*.

```
struct tag3 {
      int   A:10;
      int   B:5;
      int    :0;
      int   C:6;
};
```

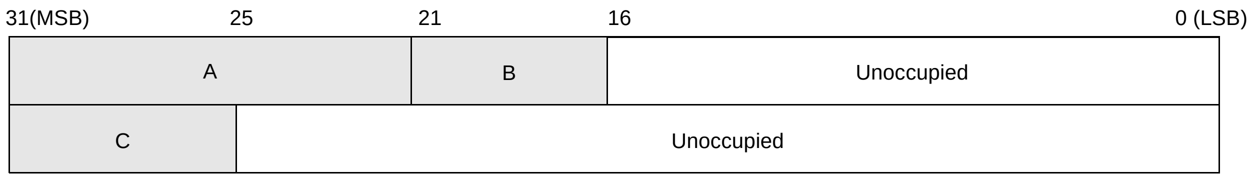


Figure 4.10-3 Example 3 of Bit Field Data Size and Boundary Alignment for `fcc911s` Command

4.11 fcc896s COMMAND BIT FIELD

This section describes the bit field data size and boundary alignment for the `fcc896s` command.
The bit field data is assigned to a storage unit that has an adequate size for bit field data retention and is located at the smallest address.

■ fcc896s Command Bit Field

Consecutive bit field data are packed at consecutive bits having the same storage unit, without regard to the type, beginning with the LSB and continuing toward the MSB. An example is shown in *Figure 4.11-1*.

```
struct tag1 {
      int   A:10;
      short B:3;
      char  C:2;
};
```

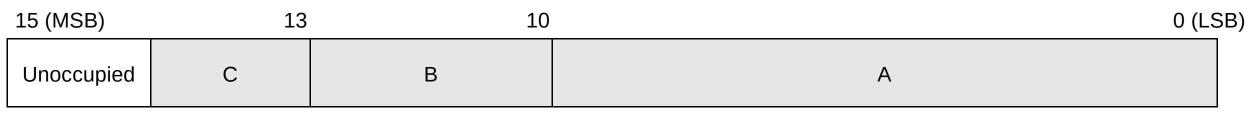


Figure 4.11-1 Example 1 of Bit Field Data Size and Boundary Alignment for `fcc896s` Command

If a field to be assigned lies over a bit field type boundary, its assignment is completed by aligning it with a boundary suitable for the type. An example is shown in *Figure 4.11-2*.

```
struct tag2 {
      int   A:12;
      int   B:5;
};
```

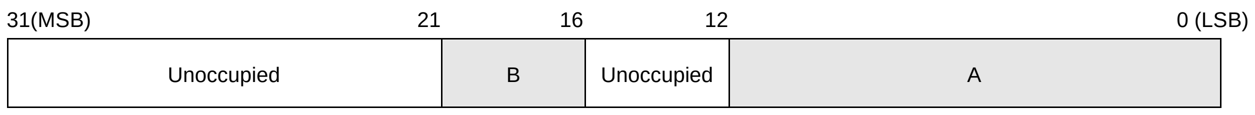


Figure 4.11-2 Example 2 of Bit Field Data Size and Boundary Alignment for `fcc896s` Command

When a bit field having a bit length of 0 is declared, it is forcibly assigned to the next storage unit. An example is shown in *Figure 4.11-3*.

```
struct tag3 {
      int   A:5;
      int   B:5;
      int    :5;
      int   C:6;
};
```

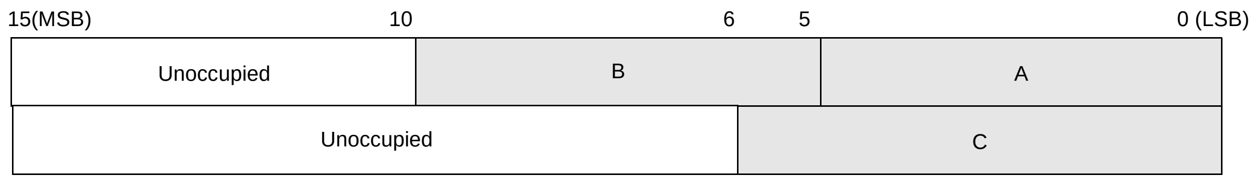


Figure 4.11-3 Example 3 of Bit Field Data Size and Boundary Alignment for *fcc896s* Command

4.12 fcc907s COMMAND STRUCTURE/UNION

This section describes the structure/union data size and boundary alignment for the `fcc907s` command. The structure/union data size is a multiple of the maximum boundary alignment size of the members. Boundary alignment for the area itself is accomplished by means of member maximum boundary alignment. The individual members are subjected to boundary alignment in accordance with the member type.

■ `fcc907s` Command Structure/Union

Figures 4.12-1 to 4.12-3 show examples concerning structure/union data size and boundary alignment.

```
struct st1  {  char  A;  }                    →    sizeof(st1)  = 1 BYTE
struct st2  {  short A;  }                    →    sizeof(st2)  = 2 BYTES
struct st3  {  char  A;  short B;  }          →    sizeof(st3)  = 4 BYTES
struct st4  {  char  A;  int   B;  }          →    sizeof(st4)  = 4 BYTES

struct tag3 {
              char   A;
              short  B;
};
```

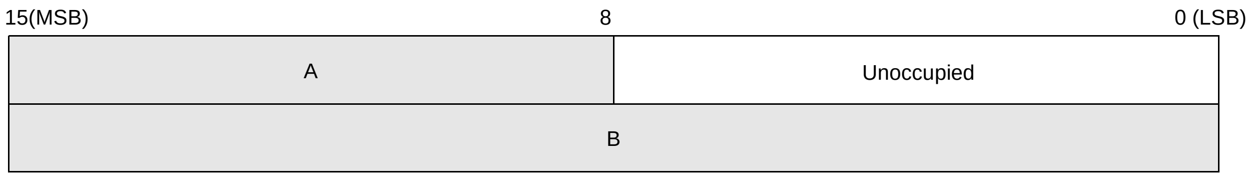


Figure 4.12-1 Example 1 of Structure/Union Data Size and Boundary Alignment for `fcc907s` Command

```
struct tag4 {
              char   A;
              int    B;
};
```

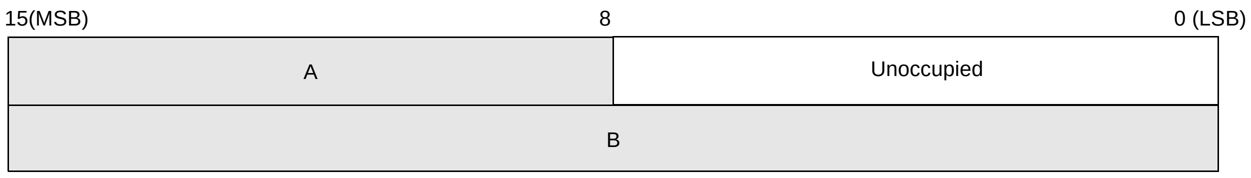


Figure 4.12-2 Example 2 of Structure/Union Data Size and Boundary Alignment for `fcc907s` Command

```
struct tag5 {
              char   A;
              struct tag6 {
                            short  A;
                            char   B;
              } S6;
};
                                       sizeof(tag5) = 6 BYTES
                                       sizeof(tag6) = 4 BYTES
```

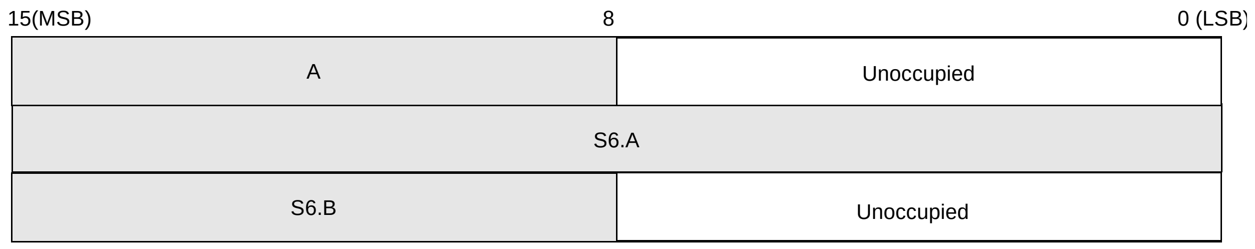


Figure 4.12-3 Example 3 of Structure/Union Data Size and Boundary Alignment for `fcc907s` Command

4.13 fcc911s COMMAND STRUCTURE/UNION

This section describes the structure/union data size and boundary alignment for the `fcc911s` command. The structure/union data size is a multiple of the maximum boundary alignment size of the members. Boundary alignment for the area itself is accomplished by means of member maximum boundary alignment. The individual members are subjected to boundary alignment in accordance with the member type.

■ `fcc911s` Command Structure/Union

Figures 4.13-1 to 4.13-3 show examples concerning structure/union data size and boundary alignment.

```
struct st1  {  char  A;  }                   →    sizeof(st1)  = 1 BYTE
struct st2  {  short A;  }                   →    sizeof(st2)  = 2 BYTES
struct st3  {  char  A;  short B;  }         →    sizeof(st3)  = 4 BYTES
struct st4  {  char  A;  int   B;  }         →    sizeof(st4)  = 8 BYTES

struct tag3 {
              char   A;
              short  B;
};
```

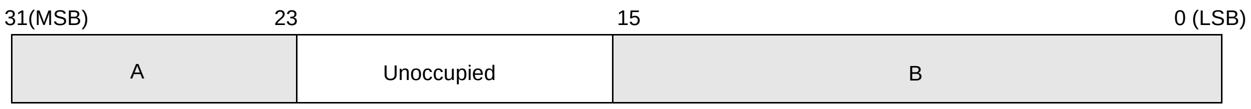


Figure 4.13-1 Example 1 of Structure/Union Data Size and Boundary Alignment for `fcc911s` Command

```
struct tag4 {
              char   A;
              int    B;
};
```

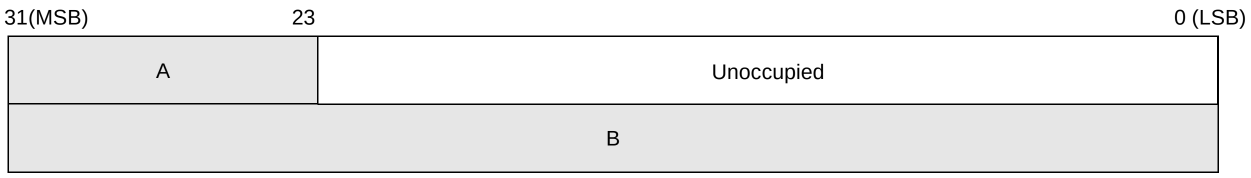


Figure 4.13-2 Example 2 of Structure/Union Data Size and Boundary Alignment for `fcc911s` Command

```
struct tag5 {
              char   A;
              struct tag6 {
                            short  A;
                            char   B;
              } S6;
};
                                      sizeof(tag5) = 6 BYTES
                                      sizeof(tag6) = 4 BYTES
```

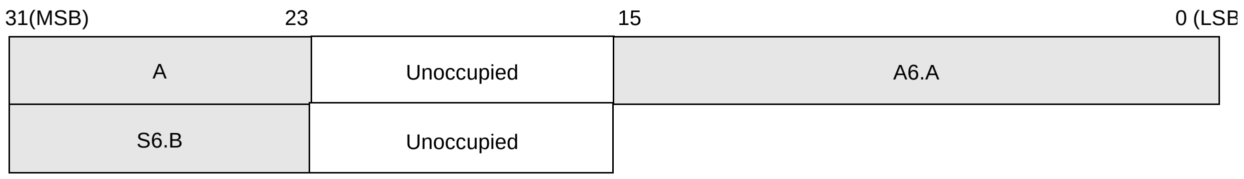


Figure 4.13-3 Example 3 of Structure/Union Data Size and Boundary Alignment for `fcc911s` Command

4.14 fcc896s COMMAND STRUCTURE/UNION

This section describes the structure/union data size and boundary alignment for the `fcc896s` command. The structure data size is equal to total of the member size. The union data size is equal to the size of the maximum member.

■ `fcc896s` Command Structure/Union

```
struct st1  {  char  A;  }          →sizeof(st1)  = 1 BYTE
struct st2  {  short A;  }          →sizeof(st2)  = 2 BYTES
struct st3  {  char  A;  short B;  } →sizeof(st3)  = 3 BYTES
struct st4  {  char  A;  char  B;  } →sizeof(st4)  = 3 BYTES
```

4.15 fcc907s COMMAND FUNCITON CALL INTERFACE

The general rules for control transfer between functions are established as standard regulations for individual architectures and are called standard linkage regulations. A module written in C language can be combined with a module written using a different method (e.g., assembler language) when the standard linkage regulations are complied with.

■ `fcc907s` Command Function Call Interface

- Stack Frame

  The stack frame construction is stipulated by the standard linkage regulations.

- Argument

  Argument transfer relative to the callee function is effected via a stack or register.

- Argument Extension Format

  When an argument is to be stored in a stack, the argument type is converted to an extended format in accordance with the argument type.

- Calling Procedure

  The caller function initiates branching to the callee function after argument storage.

- Register

  The register guarantee stated in the standard linkage regulations and the register setup regulations are explained later.

- Return Value

  The return value interface stated in the standard linkage regulations is explained later.

4.15.1 fcc907s Command Stack Frame

The standard linkage regulations prescribe the stack frame construction.

■ `fcc907s` Command Stack Frame

The stack pointer (SP) always indicates the lowest order of the stack frame. Its address value always represents the work boundary. *Figure 4.15-1* shows the standard function stack frame status.

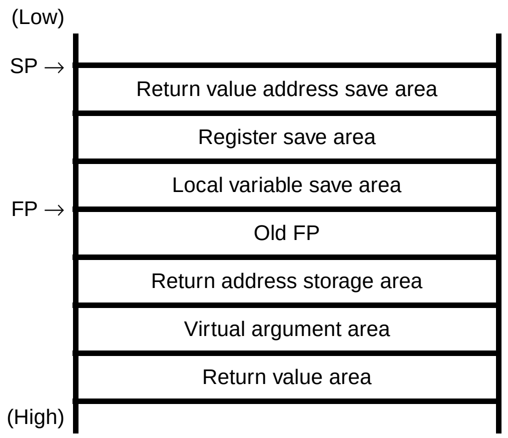


Figure 4.15-1 `fcc907s` Command Stack Frame

(1) Return value address save area

This is the place where the start address of a return value storage area is stored for a function which returns a structure/union/**`double`** or **`long double`** type.

When a structure/union is the return value, the start address of a area where the caller function stores the return value is stored in accumulator AL and passed to the callee function.

The callee function interprets the address stored in accumulator AL as the storage area start address.

When the return value address stored in accumulator AL needs to be saved into memory, the callee function saves the address in this return value address save area.

(2) Register save area

This is a register save area that must be guaranteed for the caller function. This area is not secured when the register save operation is not needed.

(3) Local variable save area

This is the area for local variables and temporary variables.

(4) Old FP

This area stores the frame pointer (RW3) value of the caller function.

(5) Return address storage area

This area stores the caller function return address. When a function is called, this area is set up by the caller function.

(6) Actual argument area/virtual argument area

When a function is called, this area is used for argument transfer. When the argument is set up by the caller function, this area is referred to as the actual argument area. When the argument is referenced by the callee function, this area is referred to as the virtual argument area.

For details, see ***4.15.2***, **`fcc907s`** ***Command Argument***.

(7) Return value area

When a structure, union, **`double`**, or **`long double`** type return function is called, this area is secured by the caller function. This area does not always have to be secured at this location. However, the callee function performs processing on the assumption that this area is secured in the stack. Therefore, if this area is secured outside the stack, no subsequent operations will be guaranteed.

The compiler secures the **`double/long double`** type return function return value area which overlaps the actual argument area. This is so done as to enhance the object efficiency in some special cases. Therefore, when the **`double/long double`** type return function stores the return value in the return value area, it must start with the highest-order address and continue sequentially toward the lowest-order address. Further, a write operation must be conducted after all the virtual arguments are completely referenced.

4.15.2 fcc907s Command Argument

Argument transfer relative to the callee function is effected via the stack. For an argument less than 2 bytes long or an argument having a size which is not a multiple of 2, an area having a size which is determined by reckoning a less-than-2-byte portion as 2 bytes will be secured within the stack.
The actual argument area is allocated/deallocated by the caller function.

■ `fcc907s` Command Argument

Figure 4.15-2 shows an example of argument transfer relative to the callee function.

```
struct A{char a; }st;
extern void sub(char,struct A,int};
sub(1,st,2);
```

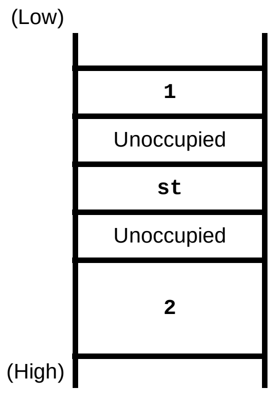


Figure 4.15-2 Example of Argument Transfer Relative to Callee Function

4.15.3 fcc907s Command Argument Extension Format

When an argument is to be stored in the stack, its type is converted to an extended type in accordance with the individual argument type. The argument is released by the caller function after the return from the callee function is made.

■ `fcc907s` Command Argument Extension Format

Table 4.15-1 shows the argument extension format.

Table 4.15-1 `fcc907s` Command Argument Extension Format

Actual Argument Type	Extended Type*1	Stack Storage Size [Byte]
`char`	`int`	2
`signed char`	`int`	2
`unsigned char`	`int`	2
`short`	No extension	2
`unsigned short`	No extension	2
`int`	No extension	2
`unsigned int`	No extension	2
`long`	No extension	4
`unsigned long`	No extension	4
`float`	`double`	8
`double`	No extension	8
`long double`	No extension	8
`near` pointer/address	No extension	2
`far` pointer/address	No extension	4
Structure/union	*2	*2

*1: The extended type represents an extended type that is provided when no argument type is given. When a prototype declaration is made, it is complied with. For an argument less than 2 bytes long or an argument having a size which is not a multiple of 2, an area having a size which is determined by reckoning a less-than-2-byte portion as 2 bytes will be secured within the stack even when extension is not effected.

*2: For an argument less than 2 bytes long or an argument having a size which is not a multiple of 2, an area having a size which is determined by reckoning a less-than-2-byte portion as 2 bytes will be secured within the stack.

4.15.4 fcc907s Command Calling Procedure

The caller function initiates branching to the callee function after argument storage.

■ `fcc907s` Command Calling Procedure

Figure 4.15-3 shows the stack frame prevailing at calling in compliance with the standard linkage regulations.

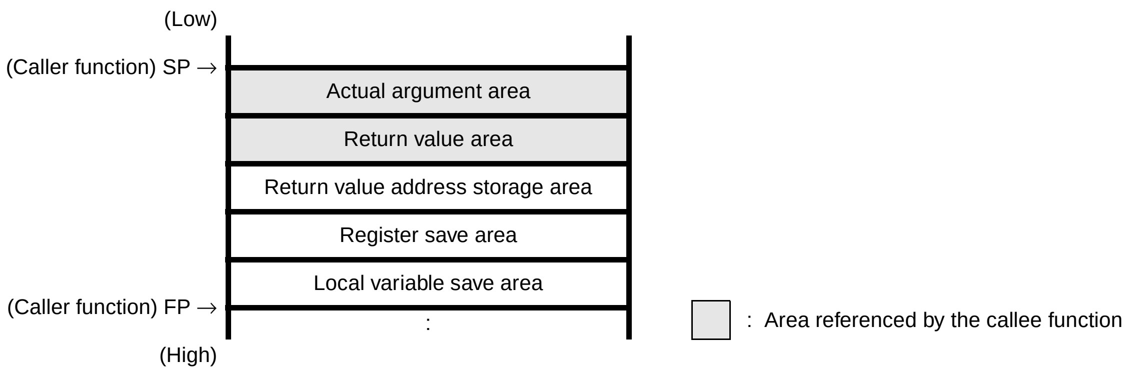


Figure 4.15-3 Stack Frame Prevailing at Calling in Compliance with `fcc907s` Command Standard Linkage Regulations

The callee function saves the caller function frame pointer (RW3) in the stack and then stores the prevailing stack pointer value in the stack as the new frame pointer value. Subsequently, the local variable area and caller function register save area are acquired from the stack to save the caller register.

Figure 4.15-4 shows the stack frame that is created by the callee function in compliance with the standard linkage regulations.

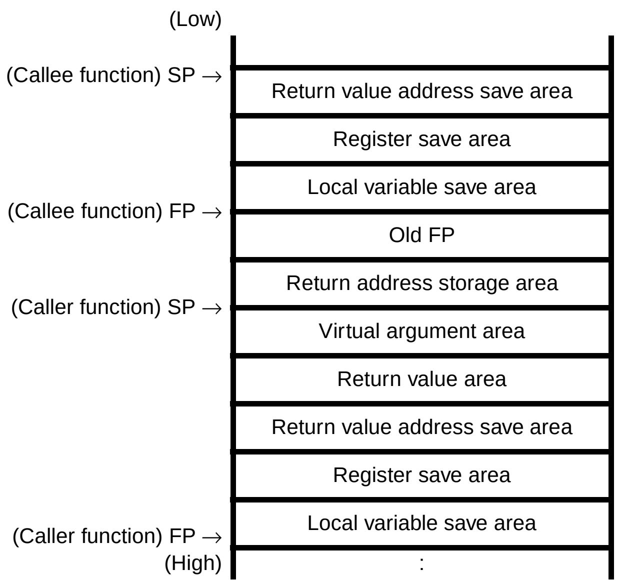


Figure 4.15-4 Stack Frame Created by Callee Function in Compliance with `fcc907s` Command Standard Linkage Regulations

4.15.5 fcc907s Command Register

This section describes the register guarantee and register setup regulations in the standard linkage regulations.

■ `fcc907s` Command Register Guarantee

The callee function guarantees the following registers of the caller function.

- General-purpose registers RW0 to RW3, RW6, RW7, and USP (SSP)

The register guarantee is provided when the callee function acquires a new area from the stack and saves the register value in that area. Note, however, that registers remaining unchanged within the function are not saved. If such registers are altered using the **`asm`** statement, etc., no subsequent operations will be guaranteed.

■ `fcc907s` Command Register Setup

Table 4.15-2 shows the register regulations for function call and return periods.

Table 4.15-2 Register Regulations for `fcc907s` Command Function Call and Return Periods

Register	Call Period	Return Period
A	Return value area address	Return value*
RW0 to RW2	Not stipulated	Call period value guaranteed
RW3	Frame pointer	Call period value guaranteed
RW4 and WR5	Not stipulated	Not stipulated
RW6 and RW7	Not stipulated	Call period value guaranteed
USP (SSP)	Stack pointer	Call period value guaranteed

Note: There are no stipulations for situations where a function without the return value is called or a function having a structure/union/**`double`**/**`long double`** type return value is called.

4.15.6 fcc907s Command Return Value

Table 4.15-3 shows the return value interface stated in the standard linkage regulations.

■ `fcc907s` Command Return Value

Table 4.15-3 `fcc907s` Command Return Value Interface Stated in Standard Linkage Regulations

Return Value Type	Return Value Interface
`void`	None
`char`	AL
`signed char`	AL
`unsigned char`	AL
`short`	AL
`unsigned short`	AL
`int`	AL
`unsigned int`	AL
`long`	A
`unsigned long`	A
`float`	A
`near` pointer/address	AL
`far` pointer/address	A
`double`	AL*
`long double`	AL*
Structure/union	AL*

Note: The caller function stores the start address of the return value storage area into AL and then passes it to the callee function. The callee function interprets AL as the start address of the return value storage area. When this address needs to be saved in memory, the callee function secures the return value address save area and saves the address in that area.

4.16 fcc911s COMMAND FUNCTION CALL INTERFACE

The general rules for control transfer between functions are established as standard regulations for individual architectures and are called standard linkage regulations. A module written in C language can be combined with a module written using a different method (e.g., assembler language) when the standard linkage regulations are complied with.

■ `fcc911s` Command Function Call Interface

- Stack Frame

  The stack frame construction is stipulated by the standard linkage regulations.
- Argument

  Argument transfer relative to the callee function is effected via a stack or register.
- Argument Extension Format

  When an argument is to be stored in a stack, the argument type is converted to an extended format in accordance with the argument type.
- Calling Procedure

  The caller function initiates branching to the callee function after argument storage.
- Register

  The register guarantee stated in the standard linkage regulations and the register setup regulations are explained later.
- Return Value

  The return value interface stated in the standard linkage regulations is explained later.

4.16.1 fcc911s Command Stack Frame

The standard linkage regulations prescribe the stack frame construction.

■ `fcc911s` Command Stack Frame

The stack pointer (SP) always indicates the lowest order of the stack frame. Its address value always represents the work boundary. *Figure 4.16-1* shows the standard function stack frame status.

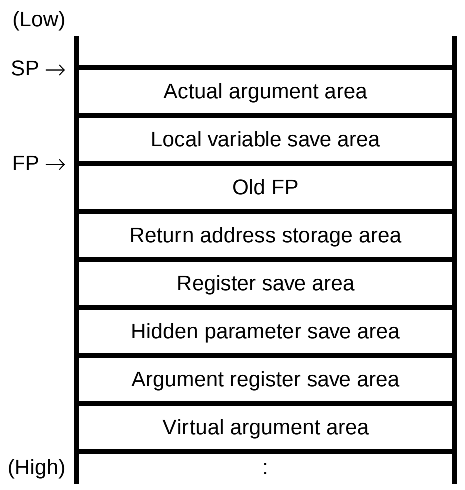


Figure 4.16-1 `fcc911s` Command Stack Frame

(1) Actual argument area/virtual argument area

When a function is called, this area is used for argument transfer. When the argument is set up by the caller function, this area is referred to as the actual argument area. When the argument is referenced by the callee function, this area is referred to as the virtual argument area. The area is allocated when all arguments cannot be placed on the argument register at the time of argument transfer.

For details, see ***4.16.2***, **`fcc911s`** ***Command Argument***.

(2) Local variable save area

This is the area for local variables and temporary variables.

(3) Old FP

This area stores the FP value of the caller function.

(4) Return address storage area

This area saves the RP. The RP stores the address of a return to the caller function for the purpose of function calling.

(5) Register save area

This is a register save area that must be guaranteed for the caller function. This area is not secured when the register save operation is not needed.

(6) Hidden parameter save area

This area stores the start address of the return value storage area for a structure/union return function.

When a structure/union is used as the return value, the caller function stores the return value storage area start address in register R4 and passes it to the caller function.

The callee function interprets the address stored in the R4 as the return value storage area start address.

When register R4 needs to be saved into memory, the callee function saves it in the hidden parameter save area. This area is not secured when the save operation is not needed.

(7) Argument register save area

This area saves the argument register. This area is not secured when the save operation is not needed.

For details, see ***4.16.2***, **`fcc911s`** ***Command Argument***.

4.16.2 fcc911s Command Argument

Arguments, the count of which equals the count of argument registers (4 words), are positioned in registers R4 to R7 and delivered to the callee function. When a structure/union return function is called, three argument registers (R5 to R7) are used because the return value area address is stored in register R4.
Arguments not placed in the argument registers will be stored in the stack actual argument area for transfer purposes.
When an 8-byte type argument is to be delivered using registers, it is divided into two and placed in two registers for transfer.

■ `fcc911s` Command Argument

When argument registers must be saved to memory, the callee function secures an argument register save area in the stack. In this case, a continuous argument register save area must be established in the virtual argument area. The argument register save area must be allocated as needed to cover the size of the argument register to be saved.

If the function has a variable count of arguments, it saves all argument registers in the argument register save area.

[Example 1]

```
double d;
sub(d);
```

The high-order words of **d** are delivered by R4, and the low-order words of **d** are delivered by R5.

[Example 2]

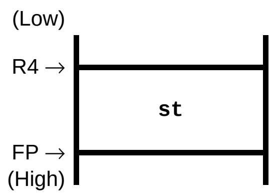
```
int a, b, c;
double d;
sub(a, b, c, d);
```

a is delivered by R4, **b** by R5, and c by R6. The high-order words of **d** are delivered by R7, and the low-order words of **d** are delivered by the stack.

When a structure/union is to be delivered as an argument, the caller copies the structure to the local variable area and passes the address of that area to the callee. In this case, if the structure/union size is less than 4 bytes or is not divisible by 4, the less-than-4-byte fraction is handled as one 4-byte unit.

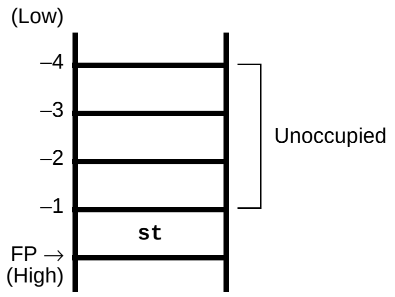
[Example 3]

```
struct A st;
sub(st);
```



[Example 4]

```
struct A {char a; } st;
```

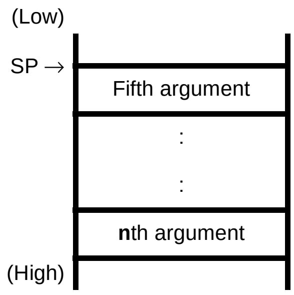


When a function receiving a variable count of arguments is to be called, the arguments are placed in registers in the same manner as for transfer. The called function stores all the register-delivered arguments in the argument register save area in the stack.

The actual argument area is allocated/deallocated by the caller function, whereas the argument register save area is allocated/deallocated by the callee function.

Figures 4.16-2 and *4.16-3* show the argument formats prescribed in the standard linkage regulations.

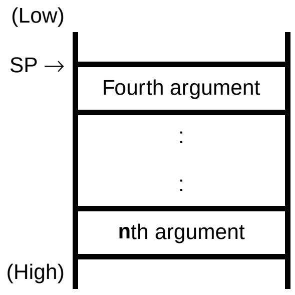
First argument	→	R4
Second argument	→	R5
Thid argument	→	R6
Fourth argument	→	R7



Note: Two argument registers are required for 8-byte type arguments.

Figure 4.16-2 `fcc911s` Command Argument Format Stated in Standard Linkage Regulations

Return value area address	→	R4
First argument	→	R5
Second argument	→	R6
Thid argument	→	R7



Note: Two argument registers are required for 8-byte type arguments.

Figure 4.16-3 Argument Format for `fcc911s` Command Structure/Union Return Function Calling

4.16.3 fcc911s Command Argument Extension Format

When an argument is to be stored in the stack, its type is converted to an extended type in accordance with the individual argument type. The argument is freed by the caller function after the return from the callee function is made.

■ `fcc911s` Command Argument Extension Format

Table 4.16-1 shows the argument extension format.

Table 4.16-1 `fcc911s` Command Argument Extension Format

Actual Argument Type	Extended Type*1	Stack Storage Size [Byte]
`char`	`int`	4
`signed char`	`int`	4
`unsigned char`	`int`	4
`short`	`int`	4
`unsigned short`	`int`	4
`int`	No extension	4
`unsigned int`	No extension	4
`long`	No extension	4
`unsigned long`	No extension	4
`float`	`double`	8
`double`	No extension	8
`long double`	No extension	8
Pointer/address	No extension	4
Structure/union	—	4*2

*1: The extended type represents an extended type that is provided when no argument type is given. When a prototype declaration is made, it is complied with.

*2: When a structure/union is to be delivered as an argument, the caller copies it to the local variable area and delivers the address of that area.

4.16.4 fcc911s Command Calling Procedure

The caller function initiates branching to the callee function after argument storage.

■ `fcc911s` Command Calling Procedure

Figure 4.16-4 shows the stack frame prevailing at calling in compliance with the standard linkage regulations.

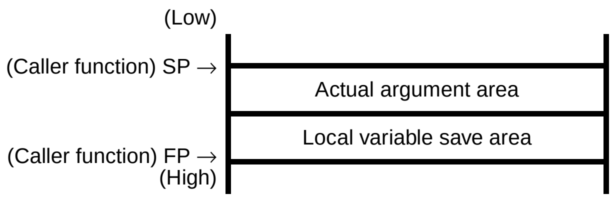


Figure 4.16-4 Stack Frame Prevailing at Calling in Compliance with `fcc911s` Command Standard Linkage Regulations

The callee function saves the caller function frame pointer (FP) in the stack and then stores the prevailing stack pointer value in the stack as the new frame pointer value. Subsequently, the local variable area and caller function register save area are acquired from the stack to save the caller register.

Figure 4.16-5 shows the stack frame that is created by the callee function in compliance with the standard linkage regulations.

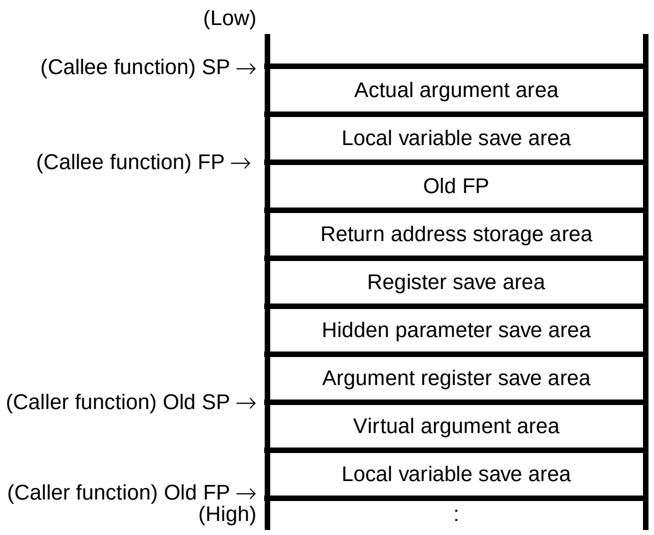


Figure 4.16-5 Stack Frame Created by Callee Function in Compliance with `fcc911s` Command Standard Linkage Regulations

4.16.5 fcc911s Command Register

This section describes the register guarantee and register setup regulations in the standard linkage regulations.

■ `fcc911s` Command Register Guarantee

The callee function guarantees the following registers of the caller function.

- General-purpose registers R8 to R11, R14, and R15

The register guarantee is provided when the callee function acquires a new area from the stack and saves the register value in that area. Note, however, that registers remaining unchanged within the function are not saved. If such registers are altered using the asm statement, etc., no subsequent operations will be guaranteed.

■ `fcc911s` Command Register Setup

Table 4.16-2 shows the register regulations for function call and return periods.

Table 4.16-2 Register Regulations for `fcc911s` Command Function Call and Return Periods

Register	Call Period	Return period
R4	Argument/return value area address*1	Return value*2
R5	Argument register*1	Return value*3
R6 and R7	Argument register*1	Not stipulated
R0 to R3	Not stipulated	Not stipulated
R12 and R13	Not stipulated	Not stipulated
R8 to R11	Not stipulated	Call period value guaranteed
R14	Frame pointer (FP)	Call period value guaranteed
R15	Stack pointer (SP)	Call period value guaranteed

*1: There are no stipulations for unused registers in situations where the argument is less than 4 words.

*2: There are no stipulations for situations where a function without the return value is called or a function with a structure/union type return value is called.

*3: There are no stipulations for situations where the function to be called has a return value other than a **`double`** or **`long double`** type.

4.16.6 fcc911s Command Return Value

Table 4.16-3 shows the return value interface stated in the standard linkage regulations.

■ fcc911s Command Return Value

Table 4.16-3 `fcc911s` Command Return Value Interface Stated in Standard Linkage Regulations

Return Value Type	Return Value Interface
`void`	None
`char`	R4
`signed char`	R4
`unsigned char`	R4
`short`	R4
`unsigned short`	R4
`int`	R4
`unsigned int`	R4
`long`	R4
`unsigned long`	R4
`float`	R4
`double`	R4 and R5*1
`long double`	R4 and R5*1
Pointer/address	R4
Structure/union	R4*2

*1: The 4 high-order bytes of a total of 8 bytes are stored in R4 and the remaining 4 low-order bytes are stored in R5.

*2: When a structure/union is used as the return value, the caller function stores the start address of the return value storage area into R4 and then passes it to the callee function. The callee function interprets R4 as the start address of the return value storage area. When this address needs to be saved in memory, the callee function secures the hidden parameter save area and saves the address in that area.

4.17 fcc896s COMMAND FUNCITON CALL INTERFACE

The general rules for control transfer between functions are established as standard regulations for individual architectures and are called standard linkage regulations. A module written in C language can be combined with a module written using a different method (e.g., assembler language) when the standard linkage regulations are complied with.

■ `fcc896s` Command Function Call Interface

- Stack Frame

  The stack frame construction is stipulated by the standard linkage regulations.
- Argument

  Argument transfer relative to the callee function is effected via a stack or register.
- Argument Extension Format

  When an argument is to be stored in a stack, the argument type is converted to an extended format in accordance with the argument type.
- Calling Procedure

  The caller function initiates branching to the callee function after argument storage.
- Register

  The register guarantee stated in the standard linkage regulations and the register setup regulations are explained later.
- Return Value

  The return value interface stated in the standard linkage regulations is explained later.

4.17.1 fcc896s Command Stack Frame

The standard linkage regulations prescribe the stack frame construction.

■ `fcc896s` Command Stack Frame

The stack pointer (SP) always indicates the lowest order of the stack frame. Its address value always represents the work boundary. *Figure 4.17-1* shows the standard function stack frame status.

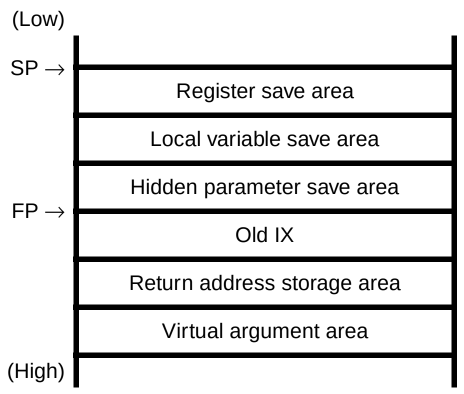


Figure 4.17-1 fcc896s Command Stack Frame

(1) Register save area

This is a register save area that must be guaranteed for the caller function. This area is not secured when the register save operation is not needed.

(2) Local variable area

This is the area for local variables and temporary variables.

(3) Hidden parameter save area

This area stores the start address of the return value storage area for a structure/union return function.

When a structure/union is used as the return value, the caller function stores the return value storage area start address in register EP and passes it to the caller function.

The callee function interprets the address stored in the EP as the return value storage area start address.

When register EP needs to be saved into memory, the callee function saves it in the hidden parameter save area. This area is not secured when the save operation is not needed.

(4) Old IX

This area stores the frame pointer (IX) value of the caller function.

(5) Return address storage area

This area stores the caller function return address. When a function is called, this area is set up by the caller function.

(6) Actual argument area/virtual argument area

When a function is called, this area is used for argument transfer. When the argument is set up by the caller function, this area is referred to as the actual argument area. When the argument is referenced by the callee function, this area is referred to as the virtual argument area.

For details, see ***4.15.2***, **`fcc907s`** ***Command Argument***.

4.17.2 fcc896s Command Argument

Argument transfer relative to the callee function is effected via the stack. For an argument less than 2 bytes long or an argument having a size which is not a multiple of 2, an area having a size which is determined by reckoning a less-than-2-byte portion as 2 bytes will be secured within the stack.
The actual argument area is allocated/deallocated by the caller function.

■ fcc896s Command Argument

Figure 4.17-2 shows an example of argument transfer relative to the callee function.

```
struct A{char A; }st;
extern void sub(char,struct A,int};
sub(1,st,2);
```

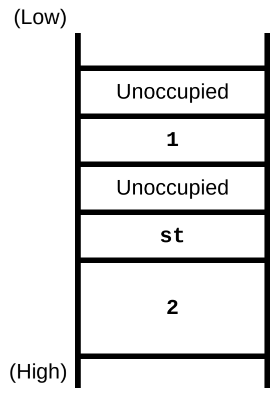


Figure 4.17-2 Example of Argument Transfer Relative to Callee Function

4.17.3 fcc896s Command Argument Extension Format

When an argument is to be stored in the stack, its type is converted to an extended type in accordance with the individual argument type. The argument is released by the caller function after the return from the callee function is made.

■ `fcc896s` Command Argument Extension Format

Table 4.17-1 shows the argument extension format.

Table 4.17-1 `fcc896s` Command Argument Extension Format

Actual Argument Type	Extended Type*1	Stack Storage Size [Byte]
`char`	`int`	2
`signed char`	`int`	2
`unsigned char`	`int`	2
`short`	No extension	2
`unsigned short`	No extension	2
`int`	No extension	2
`unsigned int`	No extension	2
`long`	No extension	4
`unsigned long`	No extension	4
`float`	`double`	8
`double`	No extension	8
`long double`	No extension	8
Pointer/address	No extension	2
Structure/union	*2	*2

*1: The extended type represents an extended type that is provided when no argument type is given. When a prototype declaration is made, it is complied with. For an argument less than 2 bytes long or an argument having a size which is not a multiple of 2, an area having a size which is determined by reckoning a less-than-2-byte portion as 2 bytes will be secured within the stack even when extension is not effected.

*2: For an argument less than 2 bytes long or an argument having a size which is not a multiple of 2, an area having a size which is determined by reckoning a less-than-2-byte portion as 2 bytes will be secured within the stack.

4.17.4 fcc896s Command Calling Procedure

The caller function initiates branching to the callee function after argument storage.

■ fcc896s Command Calling Procedure

Figure 4.17-3 shows the stack frame prevailing at calling in compliance with the standard linkage regulations.

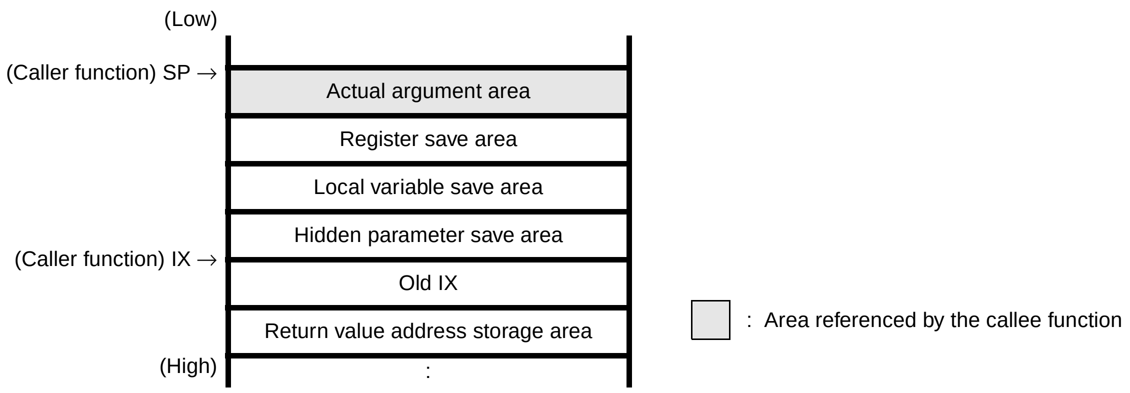


Figure 4.17-3 Stack Frame Prevailing at Calling in Compliance with `fcc896s` Command Standard Linkage Regulations

The callee function saves the caller function frame pointer (IX) in the stack and then stores the prevailing stack pointer value in the stack as the new frame pointer value. Subsequently, the local variable area and caller function register save area are acquired from the stack to save the caller register.

Figure 4.17-4 shows the stack frame that is created by the callee function in compliance with the standard linkage regulations.

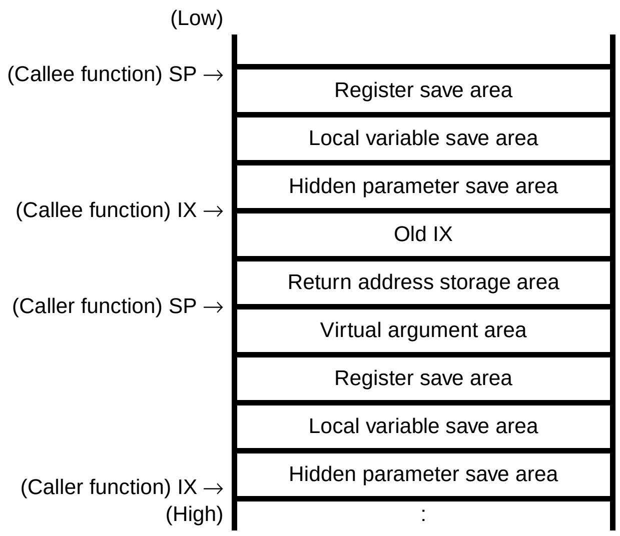


Figure 4.17-4 Stack Frame Created by Callee Function in Compliance with `fcc896s` Command Standard Linkage Regulations

4.17.5 fcc896s Command Register

This section describes the register guarantee and register setup regulations in the standard linkage regulations.

■ `fcc896s` Command Register Guarantee

The callee function guarantees the following registers of the caller function.

- General-purpose registers R2 to R7, IX and SP

The register guarantee is provided when the callee function acquires a new area from the stack and saves the register value in that area. Note, however, that registers remaining unchanged within the function are not saved. If such registers are altered using the **`asm`** statement, etc., no subsequent operations will be guaranteed.

■ fcc896s Command Register Setup

Table 4.17-2 shows the register regulations for function call and return periods.

Table 4.17-2 Register Regulations for `fcc896s` Command Function Call and Return Periods

Register	Call Period	Return Period
EP	Return value area address	Return value*
A and T	Not stipulated	Not stipulated
R0 and R1	Not stipulated	Not stipulated
R2 to R7	Not stipulated	Call period value guaranteed
IX	Frame pointer	Call period value guaranteed
SP	Stack pointer	Call period value guaranteed

Note: There are no stipulations for situations where a function without the return value is called or a function having a structure/union/**`long`**/**`double`**/**`long double`** type return value is called.

4.17.6 fcc896s Command Return Value

Table 4.17-3 shows the return value interface stated in the standard linkage regulations.

■ `fcc896s` Command Return Value

Table 4.17-3 `fcc896s` Command Return Value Interface Stated in Standard Linkage Regulations

Return Value Type	Return Value Interface
`void`	None
`char`	EP
`signed char`	EP
`unsigned char`	EP
`short`	EP
`unsigned short`	EP
`int`	EP
`unsigned int`	EP
`long`	EP*
`unsigned long`	EP*
`float`	EP*
`double`	EP*
`long double`	EP*
Pointer/address	EP
Structure/union	EP*

Note: The caller function stores the start address of the return value storage area into EP and then passes it to the callee function. The callee function interprets EP as the start address of the return value storage area. When this address needs to be saved in memory, the callee function secures the return value address save area and saves the address in that area.

4.18 fcc907s COMMAND INTERRUPT FUNCITON CALL INTERFACE

The interrupt function can be written using the `__interrupt` type qualifier. If the interrupt function is called by a method other than an interrupt, no subsequent operations will be guaranteed. The function call interface within the interrupt function is the same as stated in the standard linkage regulations.

■ `fcc907s` Command Interrupt Function Call Interface

- Interrupt Stack Frame

  When an interrupt occurs, the stack is changed to the interrupt stack.
- Argument

  No argument can be specified for the interrupt function. If any argument is specified for the interrupt function, no subsequent operations will be guaranteed.
- Interrupt Function Calling Procedure

  The interrupt function is called by an interrupt via the interrupt vector table. If the interrupt function is called by any other method, no subsequent operations will be guaranteed.
- Register

  As regards the interrupt function, all registers are guaranteed.
- Return Value

  The interrupt function does not usually have a return value.

4.18.1 fcc907s Command Interrupt Stack Frame

When an interrupt occurs, the stack is changed to the interrupt stack.

■ fcc907s Command Interrupt Stack Frame

When an interrupt occurs, the stack pointer (USP) is replaced by the interrupt stack pointer (SSP). Within the interrupt function, the interrupt stack pointer is used as the normal stack pointer.

Figure 4.18-1 shows the interrupt stack frame status prevailing immediately after interrupt generation.

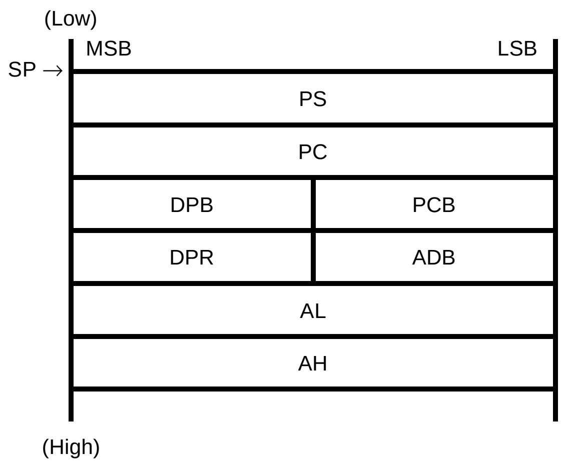


Figure 4.18-1 `fcc907s` Command Interrupt Stack Frame

4.18.2 fcc907s Command Interrupt Function Calling Procedure

The interrupt function is called by an interrupt via the interrupt vector table. If the interrupt function is called by any other method, no subsequent operations will be guaranteed.

■ `fcc907s` Command Interrupt Function Calling Procedure

Figure 4.18-2 shows an example interrupt vector table.

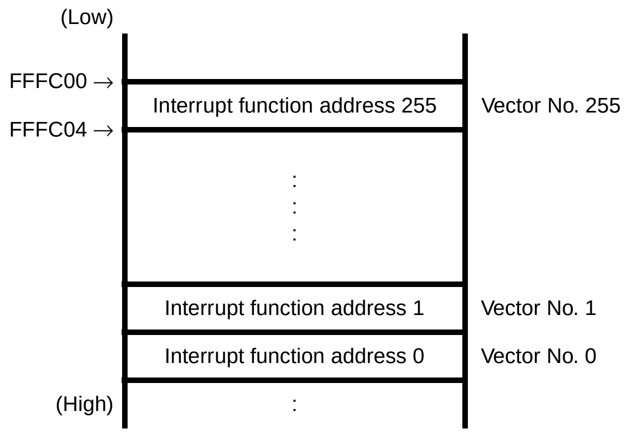

(Low)
FFFC00 →
FFFC04 →
Interrupt function address 255
Vector No. 255
Interrupt function address 1
Vector No. 1
Interrupt function address 0
Vector No. 0
(High)

Figure 4.18-2 `fcc907s` Command Interrupt Vector Table

4.19 fcc911s COMMAND INTERRUPT FUNCITON CALL INTERFACE

The interrupt function can be written using the `__interrupt` type qualifier. If the interrupt function is called by a method other than an interrupt, no subsequent operations will be guaranteed. The function call interface within the interrupt function is the same as stated in the standard linkage regulations.

■ `fcc911s` Command Interrupt Function Call Interface

- Interrupt Stack Frame

  When an interrupt occurs, the stack is changed to the interrupt stack.
- Argument

  No argument can be specified for the interrupt function. If any argument is specified for the interrupt function, no subsequent operations will be guaranteed.
- Interrupt Function Calling Procedure

  The interrupt function is called by an interrupt via the interrupt vector table. If the interrupt function is called by any other method, no subsequent operations will be guaranteed.
- Register

  As regards the interrupt function, all registers are guaranteed.
- Return Value

  The interrupt function does not usually have a return value.

4.19.1 fcc911s Command Interrupt Stack Frame

When an interrupt occurs, the stack is changed to the interrupt stack.

■ `fcc911s` Command Interrupt Stack Frame

When an interrupt occurs, the stack pointer (SP) is replaced by the interrupt stack pointer (SSP). Within the interrupt function, the interrupt stack pointer is used as the normal stack pointer.

Figure 4.19-1 shows the interrupt stack frame status prevailing immediately after interrupt generation.

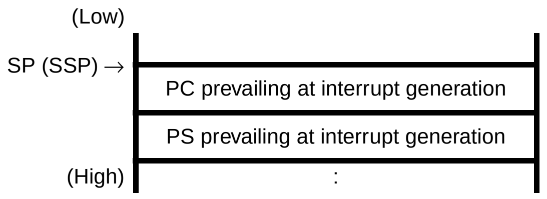

(Low)
SP (SSP) →
PC prevailing at interrupt generation
PS prevailing at interrupt generation
(High)
:

Figure 4.19-1 `fcc911s` Command Interrupt Stack Frame

4.19.2 fcc911s Command Interrupt Function Calling Procedure

The interrupt function is called by an interrupt via the interrupt vector table. If the interrupt function is called by any other method, no subsequent operations will be guaranteed.

■ `fcc911s` Command Interrupt Function Calling Procedure

Figure 4.19-2 shows an example interrupt vector table.

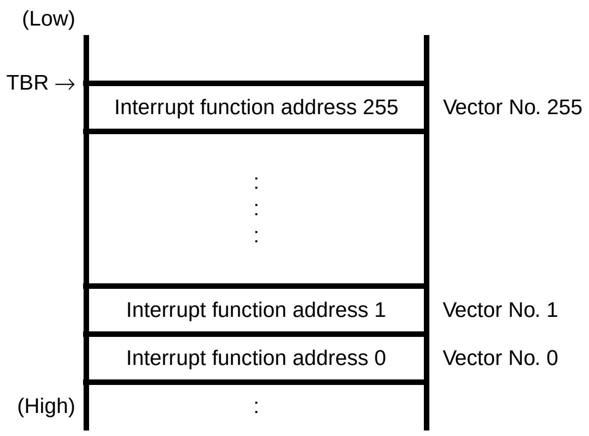

(Low)
TBR →
Interrupt function address 255
Vector No. 255
:
:
:
Interrupt function address 1
Vector No. 1
Interrupt function address 0
Vector No. 0
(High)
:

Figure 4.19-2 `fcc911s` Command Interrupt Vector Table

When an interrupt is generated, the vector table corresponding to the interrupt vector number is referenced according to the following calculation.

`TBR + 0 × 3FC - (4 × vector number)`

For the details of interrupts, refer to the ***FR20 Architecture Manual***.

4.20 fcc896s COMMAND INTERRUPT FUNCITON CALL INTERFACE

The interrupt function can be written using the `__interrupt` type qualifier. If the interrupt function is called by a method other than an interrupt, no subsequent operations will be guaranteed. The function call interface within the interrupt function is the same as stated in the standard linkage regulations.

■ `fcc896s` Command Interrupt Function Call Interface

- Argument

  No argument can be specified for the interrupt function. If any argument is specified for the interrupt function, no subsequent operations will be guaranteed.
- Interrupt Function Calling Procedure

  The interrupt function is called by an interrupt via the interrupt vector table. If the interrupt function is called by any other method, no subsequent operations will be guaranteed.
- Register

  As regards the interrupt function, all registers are guaranteed.
- Return Value

  The interrupt function does not usually have a return value.

4.20.1 fcc896s Command Interrupt Stack Frame

When an interrupt occurs, the stack is changed to the interrupt stack.

■ `fcc896s` Command Interrupt Stack Frame

Figure 4.20-1 shows the interrupt stack frame status prevailing immediately after interrupt generation.

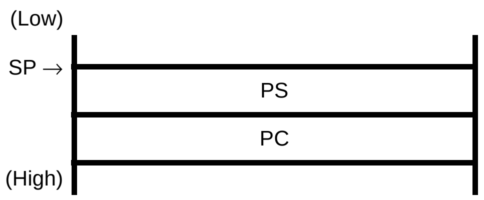


Figure 4.20-1 `fcc896s` Command Interrupt Stack Frame

4.20.2 fcc896s Command Interrupt Function Calling Procedure

The interrupt function is called by an interrupt via the interrupt vector table. If the interrupt function is called by any other method, no subsequent operations will be guaranteed.

■ `fcc896s` Command Interrupt Function Calling Procedure

Figure 4.20-2 shows an example interrupt vector table.

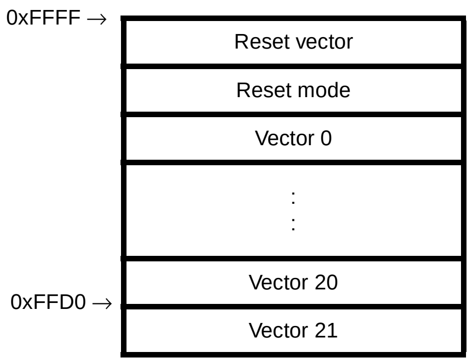


Figure 4.20-2 fcc896s Command Interrupt Vector Table

CHAPTER 5 EXTENDED LANGUAGE SPECIFICATIONS

This chapter describes the extended language specifications supported by the compiler and the limitations on compiler translation.

5.1 ASSEMBLER DESCRIPITON FUNCTIONS

There are the following two assembler description functions.

- **`asm` statement**
- **Pragma instruction**

■ Description by `asm` Statement

When the **`asm`** statement is written, the character string literal is expanded as the assembler instruction. This function makes it possible to write the **`asm`** statement inside and outside the function.

[General Format]

```
__asm (Character string literal);
```

[Explanation]

When the statement is written inside the function, the assembler is expanded at the written position.

When the statement is written outside the function, it is expanded as an independent section. Therefore, if the statement is to be written outside the function, be sure to write the section definition pseudo instruction to define the section. If the section is not defined, no subsequent operations will be guaranteed.

When using a general-purpose register within the **`asm`** statement in the function during **`fcc907s`** or **`fcc896s`** command execution, the user is responsible for register saving and restoration. The accumulator can be freely used.

When using a general-purpose register within the **`asm`** statement in the function during **`fcc911s`** command execution, the user is responsible for register saving and restoration. However, the user need not to be conscious of general-purpose registers R0 to R3, R12, and R13 because saving and restoring are performed by the compiler.

If the **`asm`** statement exists in a C source program, various optimization features are inhibited even when the -O optimization option is specified.

[Output Example for **`fcc907s`** Command]

- Input:

```
/* When written inside the function */
extern int temp;
sample(){
   __asm("    MOVN    A, #1");
   __asm("    MOVN    _temp, A");
}
/* When written outside the function */
__asm("       .SECTION        DATA, DATA, ALIGN=2");
__asm("       .ALIGN  2");
__asm("       .GLOBAL _a");
__asm("  _a:  .RES.B  2");
```

- Output:

```
        .SECTION        CODE, CODE, ALIGN=2
CSEG    CSEG
;-------begin_of_function
        .GLOBAL _sample
_sample:
        LINK   #0
        MOVN   A, #1
        MOVW   _temp, A
        UNLINK
        RET
        .SECTION        DATA, DATA, ALIGN=2
        .ALIGN  2
        .GLOBAL _a
_a:     .RES.B  2
```

[Output Example for **`fcc911s`** Command]

- Input:

```
/* When written inside the function */
extern int temp;
sample(){
   __asm("    LDI     #1, R0");
   __asm("    LDI:32  #_temp, R12");
   __asm("    ST      R0, @R12");
}
/* When written outside the function */
__asm("       .SECTION        DATA, DATA, ALIGN=4");
__asm("       .GLOBAL _a");
__asm("_a:");
__asm("       .RES.B  4");
```

- Output:

```
        .SECTION        CODE, CODE, ALIGN=2
;-------begin_of_function
        .GLOBAL _sample
_sample:
        ST      RP, @-SP
        ENTER   #4
        LDI     #1, R0
        LDI:32  #_temp, R12
        ST      R0, @R12
L_sample:
        LEAVE
        LD      @SP+, RP
        RET
        .SECTION        DATA, DATA, ALIGN=4
        .GLOBAL _a
_a:
        .RES.B  4
```

[Output Example for **fcc896s** Command]

- Input:

```
/* When written inside the function */
extern int temp;
sample(){
   __asm("    MOVW    A, #1");
   __asm("    MOVW    _temp, A");
}
/* When written outside the function */
__asm("       .SECTION        DATA, DATA, ALIGN=1");
__asm("       .GLOBAL _a");
__asm("  _a:  .RES.H  1");
```

- Output:

```
        .SECTION       CODE, CODE, ALIGN=1
        .GLOBAL _sample
_sample:
        MOVW   A, #1
        MOVW   _temp, A
L_sample:
        RET
        .SECTION       DATA, DATA, ALIGN=1
        .GLOBAL _a
_a:     .RES.H  1
```

■ Description by Pragma Instruction

The description between **`#pragma asm`** and **`#pragma endasm`** directly is expanded as the assembler instruction. This function makes it possible to write the statement inside and outside the function.

[General Format]

```
#pragma asm
     Assembler description
#pragma endasm
```

[Explanation]

When the statement is written inside the function, the assembler is expanded at the written position.

When the statement is written outside the function, it is expanded as an independent section. Therefore, if the statement is to be written outside the function, be sure to write the section definition pseudo instruction to define the section. If the section is not defined, no subsequent operations will be guaranteed.

When using a general-purpose register within the **`asm`** statement in the function during **`fcc907s`** or **`fcc896s`** command execution, the user is responsible for register saving and restoration. The accumulator can be freely used.

When using a general-purpose register within the **`asm`** statement in the function during **`fcc911s`** command execution, the user is responsible for register saving and restoration. However, the user need not to be conscious of general-purpose registers R0 to R3, R12, and R13 because saving and restoring are performed by the compiler.

If the assembler provided by **`#pragma asm/endasm`** exists in the C source program, various optimization features are inhibited even when the -O optimization option is specified.

[Output Example for **fcc907s** Command]

- Input:

```
/* When written inside the function */
sample(){
#pragma asm
        MOVN    A, #1
        MOVW    _temp, A
#pragma endasm
}
/* When written outside the function */
#pragma asm
        .SECTION        DATA, DATA, ALIGN=2
        .ALIGN  2
        .GLOBAL _a
_a:     .RES.B  2
#pragma endasm
```

- Output:

```
        .SECTION        DATA, DATA, ALIGN=2
;-------begin_of_function
        .GLOBAL _sample
_sample:
        LINK   #0
        MOVN   A, #1
        MOVW   _temp, A
        UNLINK
        RET
        .SECTION        DATA, DATA, ALIGN=2
        .ALIGN  2
        .GLOBAL _a
_a:     .RES.B  2
```

[Output Example for **fcc911s** Command]

- Input:

```
/* When written inside the function */
extern int temp;
sample(){
#pragma asm
        LDI     #1, R0
        LDI:32  #_temp, R12
        ST      R0, @R12
#pragma endasm
}
/* When written outside the function */
        .SECTION        DATA, DATA, ALIGN=4
        .GLOBAL _a
_a:
        .RES.B  4
#pragma endasm
```

- Output:

```
        .SECTION       CODE, CODE, ALIGN=2
;-------begin_of_function
        .GLOBAL _sample
_sample:
        ST      RP, @-SP
        ENTER   #4
        LDI     #1, R0
        LDI:32  #_temp, R12
        ST      R0, @R12
L_sample:
        LEAVE
        LD      @SP+, RP
        RET
        .SECTION        DATA, DATA, ALIGN=4
        .GLOBAL _a
_a:
        .RES.B  4
```

[Output Example for **fcc896s** Command]

- Input:

```
/* When written inside the function */
extern int temp;
sample(){
#pragma asm
        MOVW    A, #1
        MOVW    _temp, A
#pragma endasm
}
/* When written outside the function */
#pragma asm
        .SECTION        DATA, DATA, ALIGN=1
        .GLOBAL _a
_a:     .RES.H  1
#pragma endasm
```

- Output:

```
        .SECTION        CODE, CODE, ALIGN=1
        .GLOBAL _sample
_sample:
        MOVN   A, #1
        MOVW   _temp, A
L_sample:
        RET
        .SECTION        DATA, DATA, ALIGN=1
        .GLOBAL _a
_a:     .RES.H  1
```

5.2 INTERRUPT CONTROL FUNCITONS

There are the following five interrupt control functions.

- **Interrupt mask setup function**
- **Interrupt mask disable function**
- **Interrupt level setup function**
- **Interrupt function description function**
- **Interrupt vector table generation function**

■ Interrupt Mask Setup Function

[General Format]

```
void __DI(void);
```

[Explanation]

Expands the interrupt masking code

[Output Example]

- Input:

```
__DI();
```

- **fcc907s** Command Output:

```
AND     CCR, #191
```

- **fcc911s** Command Output:

```
ANDCCR  #0xef
```

- **fcc896s** Command Output:

```
CLRI
```

■ Interrupt Mask Disable Function

[General Format]

```
void __EI(void);
```

[Explanation]

Expands the interrupt masking disable code

[Output Example]

- Input:

```
__EI();
```

- **fcc907s** Command Output:

```
OR      CCR, #64
```

- **fcc911s** Command Output:

```
ORCCR   #0x10
```

- **fcc896s** Command Output:

```
SETI
```

■ Interrupt Level Setup Function

[General Format]

```
void__set_il(int level);
```

[Explanation]

Expands the code for changing the interrupt level to **`level`**

[Output Example]

- Input:

```
__set_il(2);
```

- **`fcc907s`** Command Output:

```
MOV     ILM, #2
```

- **`fcc911s`** Command Output:

```
STILM   #2
```

- **`fcc896s`** Command Output:

```
MOVW    A, PS
CLRI
MOVW    A, #207
ANDW    A
MOVW    A, #32
ORW     A
MOV     PS, A
```

■ Interrupt Function Description Function

[General Format 1]

```
__interrupt void  Interrupt function (void) { ... }
```

[General Format 2]

```
extern __interrupt void  Interrupt function (void);
```

[Explanation]

The interrupt function can be written by specifying the **`__interrupt`** type qualifier. Since the interrupt function is called by an interrupt, it is impossible to set up an argument or obtain a return value.

If a function declared or defined by the **`__interrupt`** type qualifier is called by performing the normal function calling procedure, no subsequent operations will be guaranteed.

[Output Example]

- Input:

```
__interrupt void sample(void){ ... }
```

- **`fcc907s`** Command Output:

```
_sample:
        LINK   #0
        ....
        UNLINK
        RETI
```

- **`fcc911s`** Command Output:

```
_func:
        STM     (R12, R13)
        ST      MDH, @-SP
        ST      MDL, @-SP
        ST      RP, @-SP
        ENTER   #4
        ....
L_func:
        LEAVE
        LD      @SP+, RP
        LD      @SP+, MDL
        LD      @SP+, MDH
        LDM     (R12, R13)
        RETI
```

- **`fcc896s`** Command Output:

```
_sample:
        PUSHW   A
        XCHW    A, T
        PUSHW   A
        MOVW    A, EP
        PUSHW   A
        MOV     A, R0
        SWAP
        MOV     A, R1
        PUSHW   A
L_sample:
        POPW    A
        MOV     R1, A
        SWAP
        MOV     R0, A
        POPW    A
        MOVW    EP, A
        POPW    A
        XCHW    A, T
        POPW    A
        RETI
```

■ Interrupt Vector Table Generation Function

[**`fcc907s`** Command General Format]

```
#pragma intvect  Interrupt function name  Vector number  [Mode value]
#pragma defvect  Interrupt function name
```

[Explanation]

`#pragma intvect` generates an interrupt vector table for which the interrupt function is set.

`#pragma defvect` specifies the default interrupt function to be set for interrupt vectors not specified by **`#pragma intvect`**.

The interrupt vector table is generated in an independent section named **`INTVEC`**.

When **`#pragma defvect`** is written, tables for all vectors are generated. Therefore, all vector tables must be defined using the same translation unit. If **`#pragma defvect`** is not used, **`#pragma intvect`** can be written using two or more translation units.

The definition cannot be formulated two or more times for the same vector number. However, no error occurs if the definitions are for the same translation unit and are identical.

No value other than an integer constant may be specified as the vector number. Specify a vector number between 0 and 255.

No value other than an integer constant may be specified as the mode value.

[**fcc911s** Command General Format]

```
#pragma intvect  Interrupt function name  Vector number

#pragma defvect  Interrupt function name
```

[Explanation]

#pragma intvect generates an interrupt vector table for which the interrupt function is set.

#pragma defvect specifies the default interrupt function to be set for interrupt vectors not specified by **#pragma intvect**.

The interrupt vector table is generated in an independent section named **INTVECT**.

All interrupt vector tables must be defined using the same translation unit (file). If **#pragma intvect** or **#pragma defvect** is specified using two or more translation units, no subsequent operations will be guaranteed.

The definition cannot be formulated two or more times for the same vector number. However, no error occurs if the definitions are identical.

No value other than an integer constant may be specified as the vector number. Specify a vector number between 0 and 255.

Reset vectors must always be arranged at 0xFFFFC. When setting TBR at locations other than 0xFFC00, the reset vectors should be defined separately by the asm statement.

[**fcc896s** Command General Format]

```
#pragma intvect  Interrupt function name  Vector number

#pragma defvect  Interrupt function name
```

[Explanation]

#pragma intvect generates an interrupt vector table for which the interrupt function is set.

#pragma defvect specifies the default interrupt function to be set for interrupt vectors not specified by **#pragma intvect**.

The interrupt vector table is generated in an independent section named **INTVEC**.

When **#pragma defvect** is written, tables for all vectors are generated. Therefore, all vector tables must be defined using the same translation unit. If **#pragma defvect** is not used, **#pragma intvect** can be written using two or more translation units.

The definition cannot be formulated two or more times for the same vector number. However, no error occurs if the definitions are for the same translation unit and are identical.

No value other than an integer constant may be specified as the vector number. Specify a vector number between 0 and 21.

No reset vector and reset mode are included in the vector table. They must be defined separately by the **asm** statement.

5.3 I/O AREA ACCESS FUNCTION

The I/O area operation variable can be defined by specifying the `__io` type qualifier.

■ I/O Area Access Function

[General Format]

```
extern __io  Variable definition;
```

[Explanation]

A variable operating an I/O area defined at addresses between 0x00 and 0xff can be defined by specifying the **`__io`** type qualifier.

Since a highly-efficient dedicated instruction is provided for I/O area access, a higher-speed, more-compact object can be generated. This instruction cannot be used for variables operating an I/O area positioned at addresses higher than 0xff. To define a variable that accesses such an area, use the **`volatile`** type qualifier.

The initial value cannot be specified for variables for which the **`__io`** type qualifier is specified.

When the specified variable is for a structure or union, it is assumed that all members are positioned in the I/O area. The variable cannot be specified for structure or union members. For the variable for which the **`__io`** type qualifier is specified, compilation is conducted on the assumption that the **`volatile`** type qualifier is specified.

When the **`-K NOVOLATILE`** option is specified, the **`volatile`** type qualifier is not assumed to be specified for the variable for which the **`__io`** type qualifier is specified.

[Output Example for **`fcc907s`** Command]

- Input:

```
#pragma section IOVAR=IOA,attr=IOSEG,locate=0x10
__io int a;
void func(void){ a=1;}
```

- Output:

```
        .SECTION        IOA, IO, LOCATE=H'0:H'10
        .ALIGN  2
        .GLOBAL _a
_a:
        .RES.B  2
        .SECTION        CODE, CODE, ALIGN=2
;-------begin_of_function
        .GLOBAL _func
_func:
        LINK   #0
        MOVN   A, #1
        MOVW   I:_a, A
        UNLINK
        RET
```

[Output Example for **fcc911s** Command]

- Input:

```
#pragma section IO=IOA,attr=DATA,locate=0x10
__io int a;
void func(void){ a=1;}
```

- Output:

```
        .SECTION        IOA, DATA, LOCATE=H'00000010
        .GLOBAL _a
_a:
        .RES.B  4
        .SECTION        CODE, CODE, ALIGN=2
;-------begin_of_function
        .GLOBAL _func
_func:
        ST      RP, @-SP
        ENTER   #4
        LDI     #1, R0
        MOV     R0, R13
        DMOV    R13, @_a
L_func:
        LEAVE
        LD      @SP+, RP
        RET
```

[Output Example for **fcc896s** Command]

- Input:

```
#pragma section IO=IOA,attr=DATA,locate=0x10
__io int a;
void func(void){ a=1;}
```

- Output:

```
        .SECTION        IOA, IO, LOCATE=H'0:H'10
        .GLOBAL _a
_a:
        .RES.H  1
        .SECTION        CODE, CODE, ALIGN=1
        .GLOBAL _func
_func:
        MOVW   A, #1
        MOVW   _a, A
L_func:
        RET
```

5.4 direct AREA ACCESS FUNCTION

The `direct` area operation variable can be defined by specifying the `__direct` type qualifier. It can be used with the `fcc907s` or `fcc896s` command only.

■ `direct` Area Access Function

[General Format]

```
__direct  Variable definition;
```

[Explanation]

The **`direct`** area operation variable can be defined by specifying the **`__direct`** type qualifier.

It makes it possible to specify that the pointer-specified object is the **`direct`** area.

When the specified variable for a structure or union, it is assumed that all members are positioned in the **`direct`** area. The variable cannot be specified for structure or union members.

Since highly-efficient dedicated instructions are provided for **`direct`** area accessing, compact objection generation can be achieved at an increased speed.

In the **`fcc907s`** command, to make accessible the section (**`DIRVAR/DIRINIT`**) generated by **`__direct`** type qualifying the variable, it is necessary to properly set up the **`DPR`** with the startup routine.

In the **`fcc896s`** command, to make accessible the section (**`DIRVAR/DIRINIT`**) generated by **`__direct`** type qualifying the variable, the sections must be arranged in the 0x00 to 0xFF range. The area in this range is also used as the I/O area, so the sections should be arranged in an area that is not used as the I/O area.

[Output Example]

- Input:

```
int  __direct p;
void sample(void){ p=1;}
```

- **fcc907s** Command Output:

```
        .SECTION        DIRDATA, DIR, ALIGN=2
        .ALIGN  2
        .GLOBAL _p
_p:
        .RES.B  2
        .GLOAL LOADSPB
        .SECTION        CODE, CODE, ALIGN=2
;-------begin_of_function
        .GLOBAL _sample
_sample:
        LINK   #0
        MOVN   A, #1
        MOVW   S:_p, A
        UNLINK
        RET
```

- **fcc896s** Command Output:

```
        .SECTION        DIRDATA, DIR, ALIGN=1
        .GLOBAL _p
_p:
        .RES.H  1
        .SECTION        CODE, CODE, ALIGN=1
        .GLOBAL _sample
_sample:
        MOVW   A, #1
        MOVW   _p, A
L_sample:
        RET
```

5.5 16-BIT/24-BIT ADDRESSING ACCESS FUNCTION

The address space where variables are positioned can be specified by specifying the `__near/__far` type qualifier. A highly efficient program can be generated by specifying an appropriate address space. It is available for the `fcc907s` command only.

■ 16-bit/24-bit Addressing Access Function

[General Format]

```
__near  Variable definition;
__far   Variable definition;
```

[Explanation]

The variable arrangement address space can be specified by specifying the **`__near/__far`** type qualifier.

When the **`__near`** type qualifier is specified, variables can be positioned in the 16-bit address space.

When the **`__far`** type qualifier is specified, variables can be positioned in the 24-bit address space.

A highly efficient program can be generated by specifying an appropriate address space.

If the **`__near/__far`** type qualifier is omitted, the address space specified by the memory model employed at the time of compilation is used as the default choice.

The local variable cannot be qualified.

When the **`far`** pointer is type-converted to the **`near`** pointer, the eight high-order bits are discarded.

When the **`near`** pointer is type-converted to the **`far`** pointer, the DTB value is used for the eight high-order bits.

When the local variable address is stored in the **`far`** pointer, the USB (or SSB) value is used for the eight high-order bits. However, if the local variable address is stored in the **`far`** pointer after it has been substituted (or cast) into the **`near`** pointer, the DTB value is used so that erratic operations may result.

When a **`__near`** type qualified function is to be called from a **`__far`** type qualified function, both functions must be positioned in the same section. The reason is that the PCB set up for **`__far`** type qualified function calling is used as is for **`__near`** type qualified function calling.

Variables have to be adjusted to the bank boundary. If not, the generated code cannot access such variable correctly.

[Output Example]

- Input:

```
int  __near p;
int  __far q;
void sample(void){ p=1; q=2;}
```

- Output:

```
        .SECTION        DATA_e, DATA, ALIGN=2
FAR_DATA_S:
        .ALIGN  2
        .GLOBAL _q
_q:
        .RES.B  2
        .SECTION        DATA, DATA, ALIGN=2
        .ALIGN  2
        .GLOBAL _p
_p:
        .RES.B  2
        .SECTION        DATA_e, DATA, ALIGN=2
FAR_DATA_E:
        .SECTION        CODE, CODE, ALIGN=2
;-------begin_of_function
        .GLOBAL _sample
_sample:
        LINK    #0
        MOVN    A, #1
        MOVW    _p, A
        MOV     A, #bnksym_q
        MOV     ADB, A
        MOVN    A, #2
        MOVW    ADB:_q, A
        UNLINK
        RET
```

5.6 IN-LINE EXPANSION SPECIFYING FUNCTION

This function specifies the user definition function for in-line expansion. In-line expansion can be specified with the `-x` option.

■ In-line Expansion Specifying Function

[General Format]

```
#pragma inline  Function name [, Function name ...]
```

[Explanation]

Recursively called functions cannot be subjected to in-line expansion. It should also be noted that functions may not be subjected to in-line expansion depending on **`asm`** statement use, structure/union type argument presence, **`setjmp`** function calling, and other conditions.

When there are two or more descriptions for the same translation unit or in-line expansion is specified by an option, all the specified function names are valid.

The in-line expansion specifying is invalid if the **`-O`** option is not specified.

5.7 SECTION NAME CHANGE FUNCTION

This function is used to change the section name or section attribute and sets the section arrangement address.

■ Section Name Change Function

[General Format]

```
#pragma  section  DEFSECT[=NEWNAME][,attr=SECTATTR][,locate=ADDR]
```

[Explanation]

The section name output by the compiler is changed from **DEFSECT** to **NENAME** and the section type is changed to **SECTATTR**.

In the **fcc907s** command, large, compact and medium models, and __**far**-type qualified variables and functions can be assigned a section name by prefixing them with **FAR_**.

It is also possible to select an arrangement address of ADDR.

For the section name output by the compiler, see ***4.1, fcc907s Command Section Structure***, ***4.2,*** **fcc911s** ***Command Section Structure***, and ***4.3, fcc896s Command Section Structure***. For the section type, refer to the ***Assembler Manual***.

When an arrangement address is given, it cannot be specified for the section at linking.

This feature can be specified only once for the same section. When specifying it two or more times, only the last specification is effective.

When the same section name is changed by **-s** option, only specification by the option is effective.

[Output Example for **fcc907s** Command]

- Input:

```
#pragma section CODE=program,attr=CODE,locate=0xff
void main(void){}
```

- Output:

```
        .SECTION        program, CODE, LOCATE=H’0:H’FF
;-------begin_of_function
        .GLOBAL _main
_main:
        LINK    #0
        UNLINK
        RET
```

[Output Example for **fcc911s** Command]

- Output:

```
        .SECTION        program, CODE, LOCATE=H'000000FF
;-------begin_of_function
        .GLOBAL _main
_main:
        ST      RP, @-SP
        ENTER   #4
L_main:
        LEAVE
        LD      @SP+, RP
        RET
```

[Output Example for **fcc896s** Command]

- Output:

```
        .SECTION        program, CODE, LOCATE=H'FF
        .GLOBAL _main
_main:
L_main:
        RET
```

5.8 REGISTER BANK NUMBER SETUP FUNCTION

This function is used to specify the register bank that the function uses. It is available for the `fcc907s` or `fcc896s` command only.

■ Register Bank Number Setup Function

[General Format]

```
#pragma register(NUM)
#pragma noregister
```

[Explanation]

`#pragma register` specifies the register bank that the subsequently-defined function uses.

`#pragma noregister` clears the register bank specifying.

An integer constant between 0 and 31 can be specified in the **`NUM`** position to specify the register bank number. A hexadecimal, octal, or decimal number can be described.

Although the register bank number is changed at the beginning of the specified function, remember that the new number does not revert to the previous number at completion of function execution(the case of the interrupt function is excluded).

Always specify **`#pragma register`** and **`#pragma noregister`** as a set. Nesting is not possible.

[Output Example]

- Input:

```
#pragma register(2)
void func(void){}
#pragma noregister
```

- **`fcc907s`** Command Output:

```
_func:
         MOV     RP, #2
         LINK    #0
         UNLINK
         RET
```

`fcc896s` Command Output:

```
_func:
         MOVW    A, PS
         SWAP
         MOV     A, #16
         SWAP
         MOVW    PS, A
L_func:
         RET
```

5.9 INTERRUPT LEVEL SETUP FUNCTION

This function is used to set the function interrupt level.

■ interrupt Level Setup Function

[General Format]

```
#pragma ilm(NUM)
#pragma noilm
```

[Explanation]

`#pragma ilm` specifies the interrupt level for the subsequently defined function.

`#pragma noilm` clears the interrupt level specifying.

In the **`fcc907s`** command, the integer constants 0 to 7 can be specified as **`NUM`**. In the **`fcc911s`** command, the integer constants 0 to 31 can be specified as **`NUM`**. In the **`fcc896s`** command, the integer constants 0 to 3 can be specified as **`NUM`**.

A hexadecimal, octal, or decimal number can be described.

Although the interrupt level is changed at the beginning of the specified function, remember that the new interrupt level does not revert to the previous level at completion of function execution.

Always specify **`#pragma ilm`** and **`#pragma noilm`** as a set. Nesting is not possible.

[Output Example]

- Input:

```
#pragma ilm(1)
void func(void){}
#pragma noilm
```

- **`fcc907s`** Command Output:

```
_func:
         MOV     ILM, #1
         LINK    #0
         UNLINK
         RET
```

- **`fcc911s`** Command Output:

```
_func:
         STILM   #1
         ST      RP, @-SP
         ENTER   #4
L_func:
         LEAVE
         LD      @SP+, RP
         RET
```

- **`fcc896s`** Command Output:

```
_func:
         MOVW    A, PS
         AND     A, #207
         OR      A, #16
         MOVW    PS, A
L_func:
         RET
```

5.10 SYSTEM STACK USE SPECIFYING FUNCTION

This function is used to notify the compiler that the system stack is used by the function. It can be used with the `fcc907s` command only.

■ System Stack Use Specifying Function

[General Format]

```
#pragma ssb
#pragma nossb
```

[Explanation]

`#pragma ssb` notifies the compiler that the system stack is used by the subsequently-defined function.

`#pragma nossb` clears such a specifying.

Always specify **`#pragma ssb`** and **`#pragma nossb`** as a set. Nesting is not possible. **`#pragma ssb`** cannot be written between **`#pragma except`** and **`#pragma noexcept`**.

[Output Example]

- Input:

```
__far int *p;
#pragma ssb
void func(void){
  int a;
  p=&a;
]
#pragma nossb
```

- Output:

```
_func:
         LINK    #2
         MOV     A, SSB
         MOVEA   A, @RW3+-2
         MOVL    _p, A
         UNLINK
         RET
```

5.11 STACK BANK AUTOMATIC DISTINCTION FUNCTION

This function is used to notify the compiler that the function is operative in both the system stack and user stack. It can be used with the `fcc907s` command only.

■ Stack Bank Automatic Distinction Function

[General Format]

```
#pragma except
#pragma noexcept
```

[Explanation]

`#pragma except` notifies the compiler that the subsequently-defined function is operative in both the system stack and user stack.

`#pragma noexcept` clears such a specifying.

Always specify **`#pragma except`** and **`#pragma noexcept`** as a set. Nesting is not possible. **`#pragma except`** cannot be written between **`#pragma ssb`** and **`#pragma nossb`**.

[Output Example]

- Input:

```
__far int *p;
#pragma except
void func(void){
  int a;
  p=&a;
]
#pragma noexcept
```

- Output:

```
_func:
         LINK    #2
         CALLP   LOADSPB
         MOVEA   A, @RW3+-2
         MOVL    _p, A
         UNLINK
         RET
```

5.12 NO-REGISTER-SAVE INTERRUPT FUNC. FUNCTION

This function is used to specify "no function saving". It can be used with the `fcc907s` or `fcc896s` command only.

■ No-register-save Interrupt Func. Function

[General Format]

```
__nosavereg  Function definition
```

[Explanation]

The **`__nosavereg`** type qualifier can be specified to define a function that is not to be saved to a register. This function is used to inhibit the register save operation when it is not needed due to register bank switching.

Register bank switching can be performed using **`#pragma register`**. **`#pragma register`** is usually used with __interrupt.

[Output Example]

- Input:

```
extern void sub(void);
#pragma register(5)
  __nosavereg __interrupt void func(void){sub();}
#pragma noregister
```

- **`fcc907s`** Command Output:

```
_func:
         MOV     RP, #5
         LINK    #0
         CALL    _sub
         UNLINK
         RETI
```

5.13 BUILT-IN FUNCTION

The following built-in functions are available.

- **`__wait_nop`**
- **`__mul`**
- **`__div`**
- **`__mod`**
- **`__mulu`**
- **`__divu`**
- **`__modu`**

■ `__wait_nop` Built-in Function

[General Format]

```
void __wait_nop(void);
```

[Explanation]

To properly time I/O access and interrupt generation, formerly, the **`NOP`** instruction was inserted using the **`asm`** statement. However, when such a method is used, the **`asm`** statement may occasionally inhibit various forms of optimization and greatly degrade the file object efficiency.

When the **`__wait_nop()`** built-in function is written, the compiler outputs one **`NOP`** instruction to the function call entry position. If the function call entry is performed a count of times until all the issued **`NOP`** instructions are covered, timing control is exercised to minimize the effect on optimization.

[Output Example]

- Input:

```
void sample(void){__wait_nop();}
```

- **`fcc907s`** Command Output:

```
_sample:
        LINK    #0
        NOP
        UNLINK
        RET
CSEG    ENDS
        END
```

- **fcc911s** Command Output:

```
_sample:
        ST      RP, @-SP
        ENTER   #4
        NOP
L_sample:
        LEAVE
        LD      @SP+, RP
        RET
```

- **fcc896s** Command Output:

```
_sample:
        NOP
L_sample:
        RET
```

■ __mul Built-in Function

[General Format]

```
signed long __mul(signed int, signed int);
```

[Explanation]

This function multiplies signed 16-bit data by signed 16-bit data to return a signed 32-bit result.

It is possible to avert a 16-bit computation-induced overflow by using this built-in function, thereby increasing computation efficiency.

It can be used with the **fcc907s** command only. It expands only when the F2MC-16LX/16F family MB number is specified as the **-cpu** option. However, this function is not expanded in the MB90500 series when -div905 option is not specified.

[Output Example]

- Input:

```
extern signed int arg1,arg2;
extern signed long ans;
void sample(void){
  ans = __mul(arg1, arg2);
}
```

- **fcc907s** Command Output:

```
MOVW    A, _arg1
MOLW    A, _arg2
MOVL    _ans, A
```

■ `__div` Built-in Function

[General Format]

```
signed int __div(signed long, signed int);
```

[Explanation]

This function performs a division between signed 32-bit data and signed 16-bit data to return a signed 16-bit result.

It is possible to achieve increased computation efficiency by using this built-in function.

It can be used with the **fcc907s** command only. It expands only when the F^2MC-16LX/16F family MB number is specified as the **-cpu** option. However, this function is not expanded in the MB90500 series when -div905 option is not specified.

[Output Example]

- Input:

```
extern signed int arg2,ans;
extern signed long arg1;
void sample(void){
  ans = __div(arg1, arg2);
}
```

- **fcc907s** Command Output:

```
MOVL    A, _arg1
MOLW    RW0, _arg2
DIVW    A, RW0
MOVW    _ans, A
```

■ `__mod` Built-in Function

[General Format]

```
signed int __mod(signed long, signed int);
```

[Explanation]

This function performs a modulo operation between signed 32-bit data and signed 16-bit data to return a signed 16-bit result.

It is possible to achieve increased computation efficiency by using this built-in function.

It can be used with the **fcc907s** command only. It expands only when the F2MC-16LX/16F family MB number is specified as the **-cpu** option. However, this function is not expanded in the MB90500 series when -div905 option is not specified.

[Output Example]

- Input:

```
extern signed int arg2,ans;
extern signed long arg1;
void sample(void){
  ans = __mod(arg1, arg2);
}
```

- **fcc907s** Command Output:

```
MOVL    A, _arg1
MOLW    RW0, _arg2
MODW    RW0
MOVW    A, RW0
MOVW    _ans, A
```

■ __mulu Built-in Function

[General Format]

```
unsigned long __mulu(unsigned int, unsigned int);
```

[Explanation]

This function multiplies unsigned 16-bit data by unsigned 16-bit data to return an unsigned 32-bit result.

It is possible to avert a 16-bit computation-induced overflow by using this built-in function, thereby increasing computation efficiency.

It can be used with the **fcc907s** command only.

[Output Example]

- Input:

```
extern unsigned int arg1,arg2;
extern unsigned long ans;
void sample(void){
  ans = __mulu(arg1, arg2);
}
```

- **fcc907s** Command Output:

```
MOVW    A, _arg1
MULUW   A, _arg2
MOVL    _ans, A
```

■ __divu Built-in Function

[General Format]

```
unsigned int __divu(unsigned long, unsigned int);
```

[Explanation]

This function performs a division between unsigned 32-bit data and unsigned 16-bit data to return an unsigned 16-bit result.

It is possible to achieve increased computation efficiency by using this built-in function.

It can be used with the **fcc907s** command only.

[Output Example]

- Input:

```
extern unsigned int arg2,ans;
extern unsigned long arg1;
void sample(void){
  ans = __divu(arg1, arg2);
}
```

- fcc907s Command Output:

```
MOVL    A, _arg1
MOVW    RW0, _arg2
DIVUW   A, RW0
MOVW    _ans, A
```

■ __modu Built-in Function

[General Format]

```
unsigned int __modu(unsigned long, unsigned int);
```

[Explanation]

This function performs a modulo operation between unsigned 32-bit data and unsigned 16-bit data to return an unsigned 16-bit result.

It is possible to achieve increased computation efficiency by using this built-in function.

It can be used with the **fcc907s** command only.

[Output Example]

- Input:

```
extern unsigned int arg2,ans;
extern unsigned long arg1;
void sample(void){
  ans = __modu(arg1, arg2);
}
```

- **fcc907s** Command Output:

```
MOVL    A, _arg1
MOVW    RW0, _arg2
MODUW   RW0
MOVW    A, RW0
MOVW    _ans, A
```

5.14 PREDEFINED MACROS

This section describes the macro names predefined by the compiler.

■ Macros Stipulated by ANSI Standard

The ANSI standard stipulates the following macros.

Macro Name	Description
`__LINE__`	Defines line number of current source line
`__FILE__`	Defines source file name
`__DATA__`	Defines source file translation date
`__TIME__`	Defines source file translation time
`__STDC__`	Macro indicating that the processing system meets requirements When the **`-Ja`** option is specified, 0 is selected as the definition. When the **`-Jc`** option is specified, 1 is selected as the definition.

■ Macros Predefined by `fcc907s` Command

The **`fcc907s`** command predefines the following macros.

Macro Name	Description
`__COMPILER_FCC907S__`	Selects 1 as definition
`__CPU_MB number__`	Selects MB number specified by the **`-cpu`** option as definition
`__CPU_16L__`	Selects 1 as definition for macro of certain series name in accordance with MB number specified by the **`-cpu`** option
`__CPU_16LX__`	
`__CPU_16F__`	

■ Macros Predefined by `fcc911s` Command

The **`fcc911s`** command predefines the following macros.

Macro Name	Description
`__COMPILER_FCC911S__`	Selects 1 as definition
`__CPU_MB number__`	Selects MB number specified by the **`-cpu`** option as definition
`__CPU_FR__`	Selects 1 as definition

■ Macros Predefined by `fcc896s` Command

The **`fcc896s`** command predefines the following macros.

Macro Name	Description
`__COMPILER_FCC896S__`	Selects 1 as definition
`__CPU_MB number__`	Selects MB number specified by the **`-cpu`** option as definition
`__CPU_8L__`	Selects 1 as definition

5.15 LIMITATIONS ON COMPILER TRANSLATION

Table 5.15-1 shows the translation limitations to be imposed when the compiler is used. The table also indicates the minimum ANSI requirements to be met.

■ Limitations on Compiler Translation

Table 5.15-1 List of Translation Limitations

No.	Function	ANSI Standard	Compiler
1	Count of nesting levels for a compound statement, repetition control structure, and selection control structure	15	∞
2	Count of nesting levels for condition incorporation	8	∞
3	Count of pointers, arrays, and function declarators (any combinations of these) for qualifying one arithmetic type, structure type, union type, or incomplete type in a declaration	12	∞
4	Count of nests provided by parentheses for one complete declarator	31	∞
5	Count of nest expressions provided by parentheses for one complete expression	32	∞
6	Count of valid leading characters of internal identifier or macro name	31	∞
7	Count of valid leading characters of external identifier	6	254*
8	Count of external identifiers of one translation unit	511	∞
9	Count of identifiers having the block valid range in one block	127	∞
10	Count of macro names that can be simultaneously defined by one translation unit	1024	∞
11	Count of virtual arguments in one function definition	31	∞
12	Count of actual arguments for one function call	31	∞
13	Count of virtual arguments in one macro definition	31	∞
14	Count of actual arguments in one macro call	31	∞
15	Maximum count of characters in one logical source line	509	∞
16	Count of characters in a (linked) byte character string literal or wide-angle character string literal (terminal character included)	509	∞
17	Count of bytes of one arithmetic unit	32767	fcc896s: 65535 fcc907s: 65535 fcc911s: 4G
18	Count of nesting levels for **`#include`** file	8	252
19	Count of case name cards in one **`switch`** statement (excluding nested **`switch`** statements)	257	∞
20	Count of members of one structure or union	127	∞
21	Count of enumerated type constants in one enumerated type	127	∞
22	Count of structure or union nesting levels for one structure declaration array	15	∞

Note: Although the count of external identifier characters to be identified by the compiler is ∞, only 255 characters are output to the assembler. If there are identifiers whose 254 leading characters are the same, an error may occur in the assembler.

Remarks: The ∞ symbol in the above table indicates the dependence on the memory size available for the s ystem.

CHAPTER 6 EXECUTION ENVIRONMENT

This chapter describes the user program execution procedure to be performed in an environment where no operating system exists.
It is conceivable that a user program may be executed in an environment where the operating system exists or executed while no operating system support is provided.
In an environment in which the operating system exists, it is necessary to prepare the setup process suitable for the environment.

6.1 EXECUTION PROCESS OVERVIEW

In an environment where no operating system exists, it is necessary to prepare the startup routine which initiates user program execution.

■ Execution Process Overview

The main functions to be incorporated into the startup routine are as follows:

- Environment Initialization Necessary for Program Operation

  This initialization must be described by the assembler and completed before user program execution.

- User Program Calling

  The **`void main(void)`**, which is normally used as the function that the startup routine calls in the program start process, is to be called.

- Shutdown Process

  After a return from the user program is made, the shutdown process necessary for the system is to be performed to accomplish program termination.

Figure 6.1-1 shows the relationship between the startup routine and user function calling.

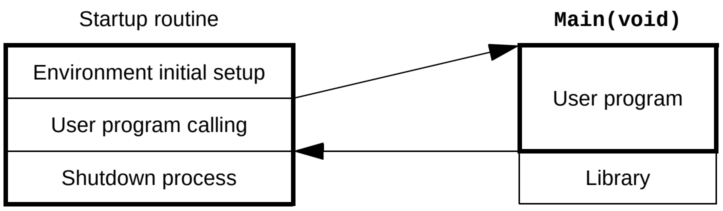


Figure 6.1-1 Relationship between Startup Routine and User Function Calling

The precautions to be observed in startup routine preparation are described below.

- Stack

  When the user program is executed, the stack is used for return address, argument storage area, automatic variable area, and register saving, etc. The stack must therefore be provided with an adequate space.

- Register

  When the startup routine calls the user program, it is essential that stack pointer setup be completed. The user program operates on the presumption that the stack top is set as the stack pointer. Further, when the startup routine returns from the user program, the register status is as shown in *Tables 6.1-1 to 6.1-3*. This is because the employed interface is the same as for register guarantee at the time of function calling.

For register guarantee, see ***4.15.5**, **`fcc907s` Command Register***, ***4.16.5**, **`fcc911s` Command Register***, and ***4.17.5**, **`fcc896s` Command Register***. If the guarantee of a register is called for by the system while the value of that register is not guaranteed by the user program, it is necessary to guarantee the value by the startup routine to initiate calling.

Table 6.1-1 `fcc907s` Command Register Status Prevailing at Return from User Program

Register	Value Guarantee at Return
A	Not provided
RW0 to RW2	Provided
RW3	Provided
RW4 and WR5	Not provided
RW6 and WR7	Provided
USP (SSP)	Provided

Table 6.1-2 `fcc911s` Command Register Status Prevailing at Return from User Program

Register	Value Guarantee at Return
R0 to R7	Not provided
R12 to R13	Not provided
R8 and R11	Provided
R14 (FP)	Provided
R15 (SP)	Provided

Table 6.1-3 `fcc896s` Command Register Status Prevailing at Return from User Program

Register	Value Guarantee at Return
A, T and EP	Not provided
R0 and R1	Not provided
R2 to R7	Provided
IX	Provided
SP	Provided

.

6.2 STARTUP ROUTINE CREATION

This section describes the processes necessary for startup routine creation.

■ fcc907s Command Startup Routine Creation

1.Register Initial Setup

Perform initial setup for RP, ILM, DRP, SSB, SSP, DTB, USB, and USP.The register bank uses one or more. Please setting DTB to 0.

2.Data Area Initialization

The C language specification guarantees the initialization of external variables without the initial value and static variables to 0. Therefore, initialize the data area to 0.

For the initialization of __**far** type qualified variable sections, the compiler generates the **DCLEAR** sections. These sections sequentially store the start addresses of the sections to be cleared to zero and the section sizes. Therefore, use this section when initialization to zero is intended.

For zero-clearing a section using the **DCLEAR** section, see ***Figure 6.2-1***. The **DATA** and **DIRDATA** sections cannot be zero-cleared by this method, so they should be zero-cleared by another method.

3.Initialization Data Area Duplication

When incorporating constant data or program into ROM, the default data positioned in the ROM area needs to be copied to the RAM area.

For the initialization of __**far** type qualified, initial value attached variable sections, the compiler generates the **DTRANS** section. This section sequentially stores the initial value storage section start address, copy destination section start address, and section size data. Therefore, use this section when performing the initial value duplication process.

For initialization of a section using the **DTRANS** section, see ***Figure 6.2-2***. The **INIT** and **DIRINIT** sections cannot be initialized by this method, so they should be initialized by another method.

4.Library Initial Setup

When using the libraries, open a file for standard input/output. For details, see ***8.2, Initialization/Termination Process Required for Library Use***.

5.User Program Calling

Call the user program.

6.Program Shutdown Process

The close process must be performed for opened files. The normal end and abnormal end processes must be prepared in accordance with the system.

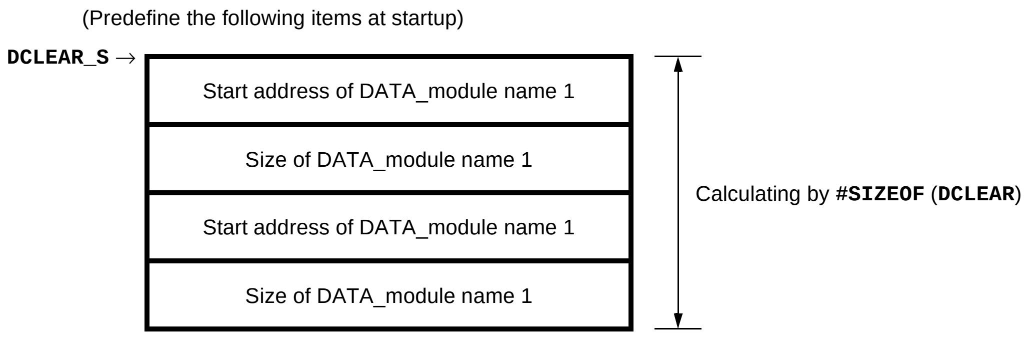

(Predefine the following items at startup)
DCLEAR_S →
Start address of DATA_module name 1
Size of DATA_module name 1
Start address of DATA_module name 1
Size of DATA_module name 1
Calculating by #SIZEOF (DCLEAR)

Figure 6.2-1 Example of DCLEAR Section

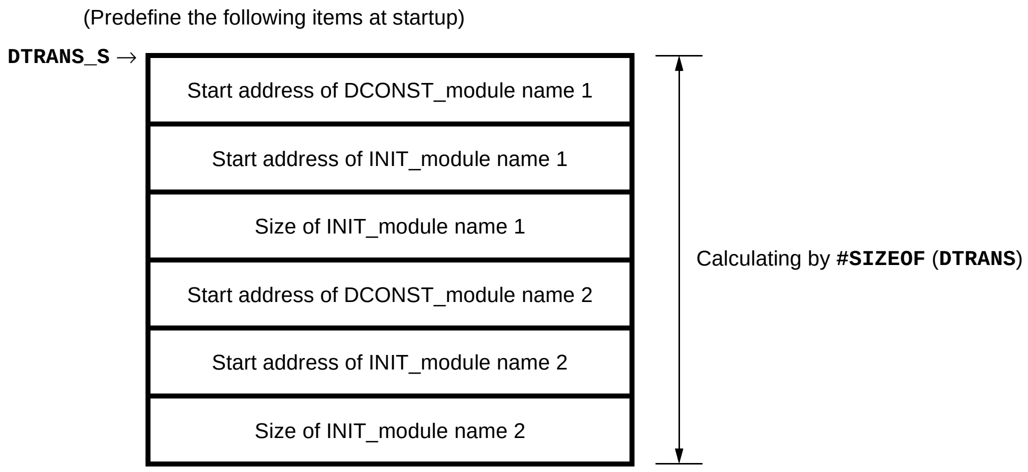

(Predefine the following items at startup)
DTRANS_S →
Start address of DCONST_module name 1
Start address of INIT_module name 1
Size of INIT_module name 1
Start address of DCONST_module name 2
Start address of INIT_module name 2
Size of INIT_module name 2
Calculating by #SIZEOF (DTRANS)

Figure 6.2-2 Example of DTRANS Section

■ fcc911s Command Startup Routine Creation

1.Register Initial Setup

Set the stack pointer (SP) to the top of the stack (stack top).

2.Data Area Initialization

The C language specification guarantees the initialization of external variables without the initial value and static variables to 0. Therefore, initialize the **`DATA`** sections to 0.

3.Initialization Data Area Duplication

When incorporating constant data or program into ROM, the data positioned in the ROM area needs to be copied to the RAM area. However, this duplication step is unnecessary if such a data rewrite operation will not performed within the user program.

The area to be incorporated into ROM is usually positioned in the **`INIT`** section. When incorporation into ROM is specified, the linker automatically generates the following symbols for the specified section name.

- **`ROM_ Specified section name`**
- **`RAM_ Specified section name`**

The above symbols indicate the ROM and RAM area start addresses, respectively. An example specifying of incorporation into ROM for the INIT section is shown below.

```
% fcc911s -ro ROM=ROM Address range -ra RAM=RAM Address
range -SC @INT=ROM, INIT=RAM ...
```

For the details of incorporation into ROM, refer to the ***Linkage Kit Manual***.

4.Library Initial Setup

When using the libraries, open a file for standard input/output. For details, see ***8.2, Initialization/Termination Process Required for Library Use***.

5.User Program Calling

Call the user program.

6.Program Shutdown Process

The close process must be performed for opened files. The normal end and abnormal end processes must be prepared in accordance with the system.

■ fcc896s Command Startup Routine Creation

1.Register Initial Setup

Set the stack pointer (SP) to the top of the stack (stack top).

2.Data Area Initialization

The C language specification guarantees the initialization of external variables without the initial value and static variables to 0. Therefore, initialize the **DATA** and **DIRDATA** sections to 0.

3.Initialization Data Area Duplication

When incorporating constant data or program into ROM, the data positioned in the ROM area needs to be copied to the RAM area. However, this duplication step is unnecessary if such a data rewrite operation will not performed within the user program.

The area to be incorporated into ROM is usually positioned in the **INIT** section. When incorporation into ROM is specified, the linker automatically generates the following symbols for the specified section name.

- **ROM_ Specified section name**
- **RAM_ Specified section name**

The above symbols indicate the ROM and RAM area start addresses, respectively. An example specifying of incorporation into ROM for the **INIT** section is shown below.

```
% fcc896s -ro ROM=ROM Address range -ra RAM=RAM Address
range -SC @INT=ROM, INIT=RAM ...
```

For the details of incorporation into ROM, refer to the ***Linkage Kit Manual***.

4.Library Initial Setup

When using the libraries, open a file for standard input/output. For details, see ***8.2, Initialization/Termination Process Required for Library Use***.

5.User Program Calling

Call the user program.

6.Program Shutdown Process

The close process must be performed for opened files. The normal end and abnormal end processes must be prepared in accordance with the system.

CHAPTER 7 LIBRARY OVERVIEW

This chapter outlines the C libraries by describing the organization of files provided by the libraries and the relationship to the system into which the libraries are incorporated.

7.1 FILE ORGANIZATION

This section describes the files furnished by the libraries. There are eighteen library files and fourteen header files.

■ File Types

The following types of library files and header files are provided.

- **`fcc907s`** Command Library Files

  Table 7.1-1 lists the general-purpose standard library for **`fcc907s`** command. *Table 7.1-2* lists the simulator debugger low-level function library for **`fcc907s`** command.

Table 7.1-1 General-purpose Standard Library for `fcc907s` Command

File Name	Memory Model
`lib907s.lib  lib905s.lib  lib902s.lib`	For small model
`lib907m.lib  lib905m.lib  lib902m.lib`	For medium model
`lib907c.lib  lib905c.lib  lib902c.lib`	For compact model
`lib907l.lib  lib905l.lib  lib902l.lib`	For large model
`lib907sr.lib  lib905sr.lib  lib902sr.lib`	For small model **`rasconst`**
`lib907mr.lib  lib905mr.lib  lib902mr.lib`	For medium model **`ramconst`**

Table 7.1-2 Simulator Debugger Low-level Function Library for `fcc907s` Command

File Name	Memory Model
`lib907sif.lib  lib905sif.lib  lib902sif.lib`	For small model
`lib907mif.lib  lib905mif.lib  lib902mif.lib`	For medium model
`lib907cif.lib  lib905cif.lib  lib902cif.lib`	For compact model
`lib907lif.lib  lib905lif.lib  lib902lif.lib`	For large model
`lib907srif.lib  lib905srif.lib lib902srif.lib`	For small model **`rasconst`***
`lib907mrif.lib  lib905mrif.lib lib902mrif.lib`	For medium model **`ramconst`***

Note*: The **`ramconst`** libraries serve programs for which the **`-ramconst`** option is specified. For the details of **`-ramconst`**, see ***3.5.3, Data Output Related Options***.

- fcc911s Command Library Files
  `lib911.lib` (General-purpose standard library)
  `lib911if.lib` (Simulator debugger low-level function library)
- fcc896s Command Library Files
  `lib896.lib` (General-purpose standard library)
  `lib896if.lib` (Simulator debugger low-level function library)
- Header Files
  `assert.h`
  `ctype.h`
  `float.h`
  `limits.h`
  `math.h`
  `setjmp.h`
  `stdarg.h`
  `stddef.h`
  `stdio.h`
  `stdlib.h`
  `string.h`

The following three header files define the macros and types that are used when the standard library calls the low-level function library.

`fcntl.h`
`unistd.h`
`sys/types.h`

■ Library Section Names

The **`fcc907s`** command library section names vary with the memory model. *Tables 7.1-3 to 7.1-5* show the section names used by the libraries.

Table 7.1-3 `fcc907s` Command Section Name

Section Type	Small	Medium	Compact	Large
Code section	CODE	LIBCODE	CODE	LIBCODE
Data section	DATA	DATA	LIBDATA	LIBDATA
Initial value of DINIT	DCONST	DCONST	LIBDCONST	LIBDCONST
Initialized section	INIT	INIT	LIBINIT	LIBINIT
Constant section	CONST	CONST	LIBCONST	LIBCONST
RAM area of CCONST	CINIT	CINIT		

Table 7.1-4 `fcc911s` Command Library Section Names

Section Type	Section Name
Code section	CODE
Data section	DATA
Initialized section	INIT
Constant section	CONST

Table 7.1-5 `fcc896s` Command Library Section Names

Section Type	Section Name
Code section	CODE
Data section	DATA
Initialized section	INIT
Constant section	CONST

7.2 RELATIONSHIP TO LIBRARY INCORPORATING SYSTEM

This section describes the relationship between the libraries and library incorporating system.

■ System-dependent Processes

File input/output, memory management, and program termination procedures are the processes dependent on the system. When such system-dependent processes are needed, the libraries issue a call as a low-level function. For the details of low-level functions, see ***Chapter 8, Library Incorporation***.

When using the libraries, prepare such low-level functions in accordance with the system.

■ Low-level Function (System-dependent Process) Types

The low-level function types and their roles are summarized below. For the detailed feature descriptions of low-level functions, see ***8.5, Low-level Function Specifications***.

• **`open`**	: Function for opening a file in the system
• **`close`**	: Function for closing a file in the system
• **`read`**	: Function for reading characters from a file
• **`write`**	: Function for writing characters into a file
• **`lseek`**	: Function for changing the file position
• **`isatty`**	: Function for checking whether a file is a terminal file
• **`sbrk`**	: Function for dynamically acquiring/changing the memory
• **`_exit`**	: Function for normal program ending
• **`_abort`**	: Function for abnormal program ending

CHAPTER 8 LIBRARY INCORPORATION

This chapter describes the processes and functions to be prepared for library use.

8.1 LIBRARY INCORPORATION OVERVIEW

This section outlines library incorporation.

■ Processes and Functions Required for Library Use

File input/output, memory management, and program termination procedures are the processes dependent on the system. Therefore, when such system-dependent processes are needed, such processes are separated from the library, and whenever such processes are needed, they will be called as a low-level function. Further, the stream area initialization and other processes are required for library use.

The following processes and functions must be prepared for library use.

- Stream area initialization
- Standard input/output and standard error output file open and close processes
- Low-level function creation

At the time of library incorporation, the above processes and functions must be prepared in accordance with the system.

8.2 INITIALIZATION/TERMINATION PROCESS REQUIRED FOR LIBRARY USE

This section describes the initialization/termination process required for library use.

■ Initialization/Termination Process

Some standard library functions require the following processes, which are detailed in this section.

- Steam area initialization
- Standard input/output and standard error output file opening and closing

For required functions, see ***8.4, Standard Library Functions and Required Processes/Low-level Functions***.

■ Stream Area Initialization

The **`_stream_init`** function initializes the stream area. This function must be called by the startup routine to initialize the stream area.

```
void  _stream_init( void);
```

■ Standard Input/Output and Standard Error Output File Opening and Closing

The standard input/output and standard error output are to be opened or closed in a program. Therefore, the opening process must be performed before **`main`** function calling and the closing process must be performed after **`main`** function execution.

Use the startup routine to perform the opening process before **`main`** function calling and the closing process after **`main`** function execution.

However, the **`_stream_init`** function correlates the file numbers 0, 1, and 2 to the **`stdin`**, **`stdout`**, and **`stderr`** streams. Therefore, the opening process need not be performed when the system's standard input, standard output, and standard error output are opened as the file numbers 0, 1, and 2.

If the system's standard input/output and standard error output are not opened or the file numbers do not match, perform the following process to open the system's files.

```
freopen( "Standard input name"  , "r", stdin );
freopen( "Standard output name" , "w", stdout);
freopen( "Standard error output name", "w" stderr);
```

Error detection concerning the above process should be conducted as needed.

Further, the file names specified by the **`open`** function must be written as the standard input/output and standard error output names.

For the closing process, use the **`fclose`** function.

8.3 LOW-LEVEL FUNCTION TYPES

This section outlines the standard library functions and required low-level functions. The following types of low-level functions are required for the standard library functions.

- **File opening and closing (open and `close`)**
- **Input and output relative to file (`read` and `write`)**
- **File position change (`lseek`)**
- **File inspection (`isatty`)**
- **Memory area dynamic acquisition (`sbrk`)**
- **Program abnormal end and normal end (`_abort` and `_exit`)**

The above processes are called from the associated standard libraries to manipulate the system's actual files or exercise program execution control.

■ Low-level Function Types

- File Opening and Closing

  When the **`open`** function is called, the **`fopen`** and all other file opening functions open the system's actual files.

  In like manner, the **`fclose`** and all other file closing functions close the system's actual files when the **`close`** function is called.

- Input and Output Relative to File

  The **`scanf`**, **`printf`**, and other input/output functions perform input/output operations relative to the system's actual files when the **`read`** and **`write`** functions are called.

- File Position Change

  The **`fseek`** and other file position manipulation functions acquire or change the system's actual file positions when the **`lseek`** function is called.

- File Inspection

  Checks whether an open file is a terminal file.

- Memory Area Dynamic Acquisition

  The **`malloc`** and other memory area dynamic acquisition functions acquire or free specific memory areas when the **`sbrk`** function is called.

- Program Abnormal End and Normal End

  The **`abort`** function and **`exit`** function call the **`_abort`** function and **`_exit`** function, respectively, as the termination process.

8.4 STANDARD LIBRARY FUNCTIONS AND REQUIRED PROCESS/LOW-LEVEL FUNCTIONS

This section describes the standard library functions and associated initialization/ termination processes and low-level functions.

■ Standard Library Functions and Required Process/Low-level Functions

Table 8.4-1 shows the relationship between the standard library functions that use the initialization and termination processes and low-level functions and the associated initialization and termination processes and low-level functions.

Table 8.4-1 Standard Library Functions and Required Processes/Low-level Functions

Standard Library Function	Low-level Function		Initialization/Termination Process

`assert ()`
`abort ()*`
	`open ()`
	`read ()`
	`lseek ()`
	`sbrk ()`
		`close ()`
		`write ()`
		`isatty ()`
		`_abort ()`
			Stream area initialization process standard input/output and standard error output opening and closing

All **`stdio.h`** functions	**`open ()`**
	`read ()`
	`lseek ()`
	`sbrk ()`
		`close ()`
		`write ()`
		`isatty ()`
			Stream area initialization process standard input/output and standard error output opening and closing

`calloc ()`
`malloc ()`
`realloc ()`
`free ()`
	`sbrk ()`		

`exit ()*`	**`open ()`**
	`read ()`
	`lseek ()`
	`sbrk ()`
		`close ()`
		`write ()`
		`isatty ()`
		`_exit ()`
			Stream area initialization process standard input/output and standard error output opening and closing

Note*: When the **`abort`** function and **`exit`** function are called, they perform the closing process for open files. Therefore, the file manipulation related low-level functions (**`open`**, **`close`**, **`read`**, **`write`**, **`lseek`**, and **`sbrk`**) and stream area initialization and like processes are required.

In a program that is not using a file, the **`_abort`** function can be directly called instead of the **`abort`** function.

In a program for which function registration is not completed using the **`atexit`** function, the **`_exit`** function can be directly called instead of the **`exit`** function while no file is being used.

In the above instances, file manipulation related low-level function use and stream area initialization are not required.

8.5 LOW-LEVEL FUNCTION SPECIFICAITONS

There are various low-level functions. The open, `close`, `read`, `write`, `lseek`, and `isatty` functions provide file processing. The `sbrk` function provides memory area dynamic allocation. The `_exit` or `_abort` function is used to terminate a program by calling the `exit` or `abort` function. These low-level functions must be created to suit the system.

■ Low-level Function Specifications

Create the low-level functions in compliance with the specifications stated in this section.

8.5.1 open Function

Create the open function in compliance with the specifications stated in this section.

```
#incllude       <fcntl.h>
int  open( char *fname, int fmode, int p  );
```

■ open Function

[Explanation]

In the mode specified by **`fmode`**, open the file having the name specified by **`fname`**. For fmode specifying, a combination of the following flags (logical OR) is used. The third argument **`p`** is a permission mode specified for the file when the specified file is newly made. Whenever standard function fopen and freopen call the open function, 0777 is passed.

- **`O_RDONLY:`**
  Opens a read-only file
- **`O_WRONLY:`**
  Opens a write-only file
- **`O_RDWR:`**
  Opens a read/write file

The above three flags are to be exclusively specified.

- **`O_CREAT:`**
  Create this flag when the specified file does not exist. If the specified file already exists, ignore this flag.
- **`O_TRUNC:`**
  If any data remains in the file, discard such data to empty the file.
- **`O_APPEND:`**
  Selects the append mode for file opening
  The file position prevailing at the time of opening must be set so as to indicate the end of the file. When writing into a file placed in this mode, start writing at the end of the file without regard to the current file position.
- **`O_BINARY:`**
  Specifies a binary file
  Therefore, the file opened must be treated as a binary file. Files for which this is not specified must be treated as text files.

When the name for standard input/output and standard error output, which is determined for system environment setup, is specified as the file name for the first argument, allocate the standard input/output and standard error output to the file to be opened.

[Return Value]

When file opening is successfully done, the file number must be returned. If file opening is not successfully done, on the other hand, the value -1 must be returned.

8.5.2 close Function

Create the `close` function in compliance with the specifications stated in this section.

```
int close( int fileno);
```

■ close Function

[Explanation]

The closing process must be performed for the file specified by **`fileno`**.

[Return Value]

When file closing is successfully done, the value 0 must be returned. If file closing is not successfully done, the value -1 must be returned.

8.5.3 read Function

Create the `read` function in compliance with the specifications stated in this section.

```
int read( int fileno, char *buf, int size);
```

■ read Function

[Explanation]

From the file specified by **`fileno`**, **`size`**-byte data must be input into the area specified by **`buf`**.

If the text file new line character is other than **\n** in the system environment at this time, perform setup with the new line character converted to **\n** by the **`read`** function.

[Return Value]

When the input from the file is successfully done, the input character count must be returned. If the input from the file is not successfully done, the value -1 must be returned. If the file ends in the middle of the input sequence, a value smaller than **`size`** can be returned as the input character count.

8.5.4 write Function

Create the `write` function in compliance with the specifications stated in this section.

```
int write (int fileno, char *buf, int size);
```

■ write Function

[Explanation]

To the file specified by **`fileno`**, **`size`**-byte data in the area specified by **`buf`** must be outputted. If the file is opened in the append mode, the output must always be appended to the end of the file. If the text file new line character is other than **`\n`** in the system environment at this time, the output must be generated with the system environment new line character converted to **`\n`** by the **`write`** function.

[Return Value]

When the output to the file is successfully done, the output character count must be returned. If it is not successfully done, the value -1 must be returned.

8.5.5 lseek Function

Create the `lseek` function in compliance with the specifications stated in this section.

```
#include <unistd.h>
long int lseek( int fileno, off_t offset, int whence);
```

■ lseek Function

[Explanation]

The file specified by **`fileno`** must be moved to a position that is **`offset`** bytes away from the position specified by **`whence`**. The file position is determined according to the byte count from the beginning of the file. The following three positions are to be specified by **`whence`**.

- **`SEEK_CUR:`**
  Adds the **`offset`** value to the current file position
- **`SEEK_END:`**
  Adds the **`offset`** value to the end of the file
- **`SEEK_SET:`**
  Ass the `offset` value to the beginning of the file

[Return Value]

When the file position is successfully changed, the new file position must be returned. If it is not successfully changed, -1L must be returned.

8.5.6 isatty Function

Create the `isatty` function in compliance with the specifications stated in this section.

```
int isatty( int fileno);
```

■ isatty Function

[Explanation]

The file specified by **`fileno`** is to be checked to see whether it is a terminal file. When the file is a terminal file, **`true`** must be returned. If not, **`false`** must be returned.

[Return Value]

When the specified file is a terminal file, **`true`** must be returned. If not, **`false`** must be returned.

8.5.7 sbrk Function

Create the `sbrk` function in compliance with the specifications stated in this section.

```
char *sbrk( INT SIZE);
```

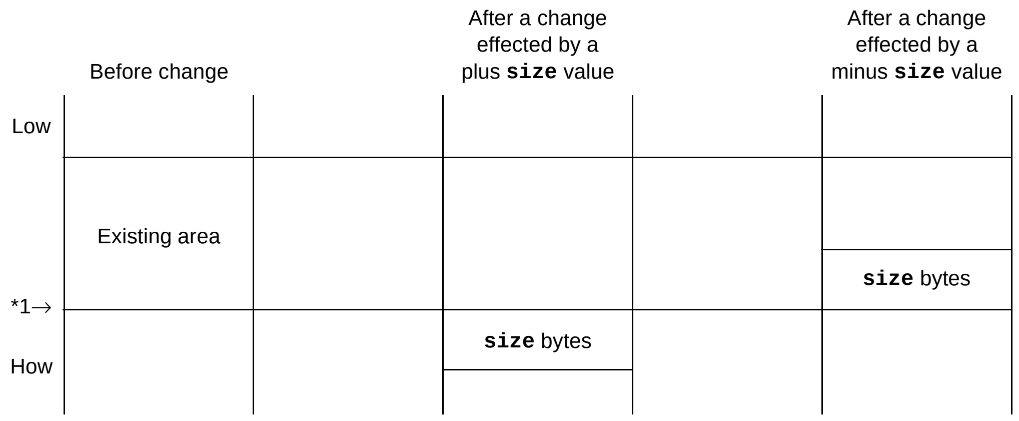
■ sbrk Function

[Explanation]

The existing area must be enlarged by **`size`** bytes. If **`size`** is a negative quantity, the area must be reduced.

If the **`sbrk`** function has not been called, furnish a **`size`**-byte area.

The area varies as shown below with sbrk function calling.


Before change
After a change effected by a plus size value
After a change effected by a minus size value
Low
Existing area
*1→
How
size bytes
size bytes

Return value = *1 (the end address of the area prevailing before the area change) + 1

Figure 8.5-1 Area Change Brought About by `sbrk` Function Calling

[Return Value]

When the area change is successfully made, the value to be returned must be determined by adding the value 1 to the end address of the area prevailing before the area change. If the **`sbrk`** function has not been called, the start address of the acquired area must be returned. If the area change is not successfully made, the value **`(char)-1`** must be returned.

8.5.8 _exit Function

Create the `_exit` function in compliance with the specifications stated in this section.

```
#include       <stdlib.h>
void _exit( int status);
```

■ `_exit` Function

[Explanation]

The **`_exit`** function must bring the program to a normal end. When the **`status`** value is 0 or in the case of **`EXIT_SUCCESS`**, the successful end state must be returned to the system environment. In the case of **`EXIT_FAILURE`**, the unsuccessful end state must be returned to the system environment.

[Return Value]

The **`_exit`** function does not return to the caller.

8.5.9 _abort Function

Create the `_abort` function in compliance with the specifications stated in this section.

```
  void _abort( void);
```

■ _abort Function

[Explanation]

The **`_abort`** function must bring the program to an abnormal end.

[Return Value]

The **`_abort`** function does not return to the caller.

CHAPTER 9 COMPILER-DEPENDENT SPECIFICATIONS

This chapter describes the specifications that vary with the compiler. The descriptions set forth in this chapter relate to the JIS requirements which are standardized on the basis of the ANSI standard.

9.1 COMPILER-DEPENDENT LANGUAGE SPECIFICAITON DIFFERENTIALS

Table 9.1-1 lists the compiler-dependent language specification differentials.

■ Compiler-dependent Language Specification Differentials

Table 9.1-1 Compiler-dependent Language Specification Differentials

Specification Differentials	Associated JIS Requirements	Compiler
`Japanese language process support and code system`	*5.2.1 Character Set* *6.1.2 Identifier*	No support EUC and SJIS entries can be made only in the comment.
`Recognized character count of an identifier with an external binding`	*6.1.2 Identifier*	30 Leasing characters
`Differentiation between upper- and lower-case alphabetical characters of an identifier with an external binding`	*6.1.2 Identifier*	Treated as different characters
`Character set element expression code system`	*6.1.3 Constant*	ASCII code
`Char` type treatment and expressible value range	*6.2.1.1 Character Type and Integer Type*	Unsigned*1 0 to 255
Floating-point data formats and sizes **`float`** type **`double/long double`** type	*6.1.2.5 Type*	IEEE type*2 4 bytes 8 bytes
Whether or not to treat the start bit as signed bit when following types specified as bit field **`char, short int, int,`** and **`long int`** type	*6.5.2.1 Structure Specifier and Union Specifier*	Not treated as a sign*1
Types that can be specified as bit field	*6.5.2.1 Structure Specifier and Union Specifier*	**`char`** type **`signed char`** type **`unsigned char`** type **`short int`** type **`unsigned short int`** type **`int`** type **`unsigned int`** type **`long int`** type **`unsigned long int`** type
Structure or union type member boundary alignment value **`char`** type **`signed char`** type **`unsigned char`** type **`short int`** type **`unsigned short int`** type **`int`** type **`unsigned int`** type **`long int`** type **`unsigned long int`** type **`float`** type **`double`** type **`long double`** type **`Pointer`** type	*6.5.2.1 Structure Specifier and Union Specifier*	**`fcc907s`** command/**`fcc911s`** command 1 byte / 1 byte 1 byte / 1 byte 1 byte / 1 byte 2 byte / 2 byte 2 byte / 2 byte 2 byte / 4 byte 2 byte / 4 byte 2 byte / 4 byte 2 byte / 4 byte 2 byte / 4 byte 2 byte / 4 byte 2 byte / 4 byte 2 byte / 4 byte

Table 9.1-1 Compiler-dependent Language Specification Differentials *(Continued)*

Specification Differentials	Associated JIS Requirements	Compiler
Character constant expression code system for pre-processor	*6.8.1 Conditional Acquisition*	ASCII code
Registers that can be specified within **`asm`** statement		fcc911s:R0-R3,R12 and R13*3 fcc907s,fcc896s:A, AL, and AH*3
ANSI-compliant standard library function support		Refer to the volume entitled ***Libraries***.

*1:Alterable through option use.

*2:See ***9.2, Floating-point Data Format and Expressible Value Range***.

*3:The other registers can be used when they are saved and recovered by the user.

9.2 FLOATING-POINT DATA FORMAT AND EXPRESSIBLE VALUE RANGE

Table 9.2-1 shows the floating-point data format and expressible value range.

■ Floating-point Data Format and Expressible Value Range

Table 9.2-1 Floating-point Data Format and Expressible Value Range

Floating-point Data Format	Expressible Value Range
`float type`	The exponent part is a value between 2 – 126 and 2 + 127. The fractional portion of the mantissa (the integer portion is normalized to 1) is binary and has 24-digit accuracy.
`double type`	The exponent part is a value between 2 – 1022 and 2 + 1023. The fractional part of the mantissa (the integer part is normalized to 1) is binary and has 53-digit accuracy.
`long double type`	The exponent part is value between 2 – 1022 and 2 + 1023. The fractional part of the mantissa (the integer part is normalized to 1) is binary and has 53-digit accuracy.

CHAPTER 10 SIMULATOR DEBUGGER LOW-LEVEL FUNCTION LIBRARY

This chapter describes how to use the simulator debugger low-level function library. The simulator debugger low-level function library is a library of the low-level functions which are necessary when the standard library is used with the simulator debugger.

10.1 LOW-LEVEL FUNCTION LIBRARY OVERVIEW

This section outlines the low-level function library.

■ Low-level Function Library Overview

The low-level function library offers the functions that are necessary when the standard library is used with the simulator debugger. The main functions are as follows.

- File manipulation functions based on I/O port simulation (**`open`**, **`close`**, **`read`**, **`write`**, **`lseek`**, and **`isatty`**)
- Dynamic memory allocation function (**`sbrk`**)

In the simulator debugger, the program executed cannot terminate its own execution. Therefore, prepare the **`_abort`** and **`_exit`** functions.

■ File System Overview

The low-level function library uses the I/O port simulation function of the simulator debugger to carry out standard input/output operations and input/output operations relative to files. These operations are completed by performing input/output operations relative to one I/O port area which is regarded as one file.

When the **`open`** function is called, it allocates a 1-byte area of the I/O port simulation area (I/O section) defined by the low-level function library, and returns as the file number the offset from the beginning of the allocated area.

The **`read`** function and **`write`** function perform input/output operations relative to the 1-byte area allocated by the **`open`** function.

Input/output operations can be performed relative to the standard input/output and files when such standard input/output and files are allocated to the above-mentioned area prior to program execution using simulator debugger commands **`set inport`** and **`set outport`**.

The **`close`** function frees an already allocated area to render it reusable.

Since the file position cannot be changed in the simulator debugger, the value -1 is always returned for the **`lseek`** function.

■ Area Management

An already acquired external variable area is used as the area returned by the **`sbrk`** function.

When the **`sbrk`** function is called, area allocation begins with the lowest address of the area.

10.2 fcc911s COMMAND LOW-LEVEL FUNCITON LIBRARY USE

This section describes the load module creation and simulator debugger setup procedures to be performed for low-level function library use.

■ Initialization

No initialization is required except for **`_steam_init`** function calling.

When creating the startup routine in accordance with the system, call the **`_stream_init`** function prior to **`main`** function calling.

■ Load Module Creation

After completing creation of the necessary program, compile and link all the necessary modules. No special option specifying is needed.

The following libraries and startup routine are linked.

- **`startup.obj`**
- Standard library (**`lib911.lib`**)
- Low-level function library (**`lib911if.lib`**)

The sections are arranged at the following addresses.

- **`IOPORT`**: Address 0
- **`STACK`**: Address 0x100000
- **`Other`**: Address 0x1000

To change the **`IOPORT`** section arrangement, specify the **`-sc IOPORT=address`** option at compiling. Describe the section arrangement address at the **`address`** position.

■ Simulator Debugger Setup

[Setup for Standard Input/Output Use]

```
set inport/ascii  IOPORT, 0xff,$TERMINAL
set outport/ascii IOPORT+1, 0xff,$TERMINAL
```

Enter the address where the **`IOPORT`** section was positioned at linking in the above **`IOPORT`** position. If the **`-sc`** option is not specified at linking, the following results.

```
set inport/ascii  0, 0xff,$TERMINAL
set outport/ascii 1, 0xff,$TERMINAL
```

Since the first three areas of the **`IOPORT`** section are used for standard input, standard output, and standard error output, the other files are allocated to the fourth and subsequent areas (the offset from the beginning of the **`IOPORT`** section is 3).

In other words, allocation is performed sequentially in the order of file opening (offset 3, offset 4, etc.). Therefore, perform setup accordingly using the **`set inport`** and **`set outport`** commands.

To open **`a.doc`** as the input file and then open **`b.doc`** as the output file, setup as shown below.

```
set inport/ascii  IOPORT+3,h’ff,"a.doc"
set outport/ascii IOPORT+4,h’ff,"b.doc"
```

■ Example

Create a program that displays the character string "**`Hello!!`**" and initiate execution with the simulator debugger.

```
main()
{
   printf("Hello!!"n");
}
```

Create a C-source file named **`test.c`** as shown above.

Compile using the following command.

```
% fcc911s -cpu MB91F154 test.c
```

At completion of the preceding step, **`test.abs`** is created. Execute the created file with the simulator debugger.

After startup, input following commands.

```
> set inport/ascii h’0,h’ff,$TERMINAL
> set outport/ascii h’1,h’ff,$TERMINAL
> go , end
```

Since standard input is not involved in the above example, the **`set inport`** command can be omitted.

10.3 fcc907s COMMAND LOW-LEVEL FUNCITON LIBRARY USE

This section describes the load module creation and simulator debugger setup procedures to be performed for low-level function library use.

■ Initialization

No initialization is required except for **`_steam_init`** function calling.

When creating the startup routine in accordance with the system, call the **`_stream_init`** function prior to **`main`** function calling.

■ Load Module Creation

After completing creation of the necessary program, compile and link all the necessary modules.

Link the following libraries in accordance with the memory model. Select a low-level library in accordance with the host that starts the simulator debugger.

Table 0.3-1 Libraries to be Linked for Load Module Creation

Memory Model	`ramconst`	Standard Library	Low-level Library

Small model	Specified	`lib907s.lib`
		`lib905s.lib`
		`lib902s.lib`
			`lib907sif.lib`
			`lib905sif.lib`
			`lib902sif.lib`

	Not specified	`lib907sr.lib`
		`lib905sr.lib`
		`lib902sr.lib`
			`lib907srif.lib`
			`lib905srif.lib`
			`lib902srif.lib`

Medium model	Specified	`lib907m.lib`
		`lib905m.lib`
		`lib902m.lib`
			`lib907mif.lib`
			`lib905mif.lib`
			`lib902mif.lib`

	Not specified	`lib907mr.lib`
		`lib905mr.lib`
		`lib902mr.lib`
			`lib907mrif.lib`
			`lib905mrif.lib`
			`lib902mrif.lib`

Compact model	Specified	`lib907c.lib`
		`lib905c.lib`
		`lib902c.lib`
			`lib907cif.lib`
			`lib905cif.lib`
			`lib902cif.lib`

Large model	Specified	`lib907l.lib`
		`lib905l.lib`
		`lib902l.lib`
			`lib907lif.lib`
			`lib905lif.lib`
			`lib902lif.lib`

■ Simulator Debugger Setup

Setup for standard input/output use is as follows.

[Example of Debugger Setup]

```
set inport/ascii  0, 0xff,$TERMINAL
set outport/ascii 1, 0xff,$TERMINAL
```

Since the first three areas of the I/O section are used for standard input, standard output, and standard error output, the other files are allocated to the fourth and subsequent areas (the offset from the beginning of the I/O section is 3).

In other words, allocation is performed sequentially in the order of file opening (offset 3, offset 4, etc.). Therefore, perform setup accordingly using the **set inport** and **set outport** commands.

To open **a.doc** as the input file and then open **b.doc** as the output file, setup as shown below.

```
set inport/ascii  3,h’ff,"a.doc"
set outport/ascii 4,h’ff,"b.doc"
```

■ Example

Create a program that displays the character string "**Hello!!**" using the small model, and initiate execution with the simulator debugger

```
main()
{
   printf("Hello!!"n");
}
```

Create a C-source file named **test.c** as shown above.

Compile using the following command. Setup the corresponding directory for **LIBTOOL**.

```
fcc907s test.c -model SMALL -cpu MB90F553A
flink907s LIBTOOL/start905s.obj test.obj -L LIBTOOL
                       -l lib905s.lib -l lib905sif.lib
                       -O test.abs -cpu MB90F553A
```

At completion of the preceding step, **test.abs** is created. Execute the created file with the simulator debugger.

After startup, input following commands. **end** is a symbol defined within the startup routine. Create the startup routine object as the one with the debug information.

```
> set inport/ascii h’0,h’ff,$TERMINAL
> set outport/ascii h’1,h’ff,$TERMINAL
> go , end
```

Since standard input is not involved in the above example, the **set inport** command can be omitted.

10.4 fcc896s COMMAND LOW-LEVEL FUNCITON LIBRARY USE

This section describes the load module creation for low-level function library use.

■ About the low-level library for the simulator debugger in the fcc896s command

In the library of the fcc896s command, the file operation function of the low level library for the simulator debugger in the fcc896s command is not supported. Therefore, only the sbrk function is registered in low level library lib896if.lib for the simulator debugger.

■ Load Module Creation

Please compile and link all necessary modules after making a necessary program. It is not necessary to specify a special option. The following library and the startup routine are linked.

- **`startup.obj`**
- Standard library (**`lib896.lib`**)
- Low-level function library (**`lib896if.lib`**)

■ Example

The program which secures the area in 100 bytes by the malloc function is made and executes the simulator debugger.

```
#include <stdlib.h>
main()
{
    void *ptr;
    ptr = malloc(100);
}
```

Create a C-source file named **`test.c`** as shown above.

Compile using the following command. Setup the corresponding directory for **`LIBTOOL`**.

```
fcc896s test.c -cpu MB89P935B -L LIBTOOL -l fcc896.lib
-l fcc896if.lib
```

At completion of the preceding step, **`test.abs`** is created. Execute the created file with the simulator debugger.

After startup, input following commands. **end** is a symbol defined within the startup routine. Create the startup routine object as the one with the debug information.

```
> go , end
```

10.5 LOW-LEVEL FUNC. FUNCITON

This section describes the function specific to the simulator debugger low-level functions.

■ Special I/O Port

As far as the low-level functions are concerned, the first three bytes of the I/O section are specified to function as the standard input, standard output, and standard error output, respectively. For such bytes, files No. 1, 2, and 3 are allocated. They are initialized to the opened state.

Tables 10.4-1 and 10.4-2 show the predefined I/O port.

Table 0.5-1 `fcc907s` Command Predefined I/O Port

Address	File Number	File Type
0	0	Standard input
1	1	Standard output
2	2	Standard error output

Table 0.5-2 `fcc911s` Command Predefined I/O Port

Address	File Number	File Type
`IOPORT`	0	Standard input
`IOPORT` + 1	1	Standard output
`IOPORT` + 2	2	Standard error output

The input from the standard input (file No. 0) is output to the standard output (file No. 1). The input to the standard input (file No. 0) is discontinued if the new line character **\n** is entered. However, when the input is fed from some other port, the input continues until the required number of characters are read.

■ open Function

The **open** function finds an unused I/O port area and then returns as the file number the area's offset from the beginning of the I/O section. In such an instance, the file name and open mode are not to be specified. Even if files are opened using the same file name, differing file numbers are assigned to them.

Files No. 0, 1, and 2 are initialized to the opened state. Therefore, the **open** function begins allocation with file No. 3 unless files 0, 1, and 2 are subjected to the close process.

■ `read` Function

The **`read`** function reads data from the I/O port area specified by the address which is determined by adding the specified file number to the I/O section start address.

The input from file No. 0 is treated as a line input. When the new line character **`\n`** is entered, the **`read`** function terminates even if the required character count is not reached. Further, this input is output to the standard output (file No. 1). The input from a file numbered other than 0 is treated as a block input. Reading continues until the required character count is reached.

■ `write` Function

The **`write`** function writes data to the I/O port area specified by the address which is determined by adding the specified file number to the I/O section start address. Unlike the input, the operation does not vary with the I/O port area address.

■ `lseek` Function

The file position cannot be specified in the simulator debugger. Therefore, the value -1, which indicates an unsuccessful file position change, is always returned.

■ `isatty` Function

In the case of file No. 1, 2, or 3, **`true`** is returned. In the other cases, **`false`** is returned.

■ `close` Function

The **`close`** funciton releases the port related to the specified file number.

■ `sbrk` Function

The simulator debugger does not provide a means of dynamic memory allocation. Therefore, the **`sbrk`** function acquires a fixed area and uses it.

To change the area or its size, create an alternative function and substitute it for the **`sbrk`** function with a librarian. For details, see ***10.5, Low-level Function Library Change***.

10.6 LOW-LEVEL FUNCITON LIBRARY CHANGE

This section describes how to change the dynamic allocation area (heap).

■ `fcc907s` Command Dynamic Allocation Area Change

Locate the following line in the **`sbrk.c`** source program list. Change the value in this line to the dynamic allocation area size (in bytes).

```
#define HEEP_SIZE    16*1024
```

Use the following commands to compile and update the library. At compiling, specify the section name shown in *Table 7.1-1*.

- For Small Model:

```
% fcc907s -O sbrk.c -model SMALL -cpu MB90F553A
% flib907s -r sbrk.obj lib905sif.lib -cpu MB90F553A
```

- For Large Model:

```
% fcc907s -O sbrk.c -model LARGE -s FAR_CSEG=CLIB
-s FAR_DCONST=DLCONST -s FAR_DINIT=DLINIT -s FAR_DVAR=DLVAR
-s FAR_CCONST+CLCONST -cpu MB90F553A
% flib907s -r sbrk.obj lib905lif.lib -cpu MB90F553A
```

■ `fcc907s` Command `sbrk.c` Source Program List

The source program required for changing the dynamic area is shown below. The file name must be **`sbrk.c`**.

```
#define HEEP_SIZE       16*1024
static long     brk_siz = 0;
static char     _heep[HEEP_SIZE];
#define         _heep_size      HEEP_SIZE
extern char *sbrk(int size)
{
    if (brk_siz + size > _heep_size || brk_siz + size < 0)
        return((char*)-1);
    brk_siz += size;
    return(_heep + brk_siz - size);
}
```

■ fcc911s Command Dynamic Allocation Area Change

Locate the following line in the **sbrk.c** source program list. Change the value in this line to the dynamic allocation area size (in bytes).

```
#define HEEP SIZE    16*1024
```

Use the following commands to compile and update the library.

```
% fcc911s -O -c sbrk.c
% flib911s -r sbrk.obj lib911if.lib
```

When the above change is made, the dynamic allocation area is secured as the **sbrk.c** static external variable without being positioned at the beginning of the stack.

■ fcc911s Command sbrk.c Source Program List

The source program required for changing the dynamic area is shown below. The file name must be **sbrk.c**.

```
#define HEEP_SIZE    16*1024
static long brk_siz = 0;
#if HEEP_SIZE
typedef int _heep_t;
#define ROUNDUP(s) (((s)+sizeof(_heep_t)-1) & ~(sizeof(_heep_t)-1))
static _heep_t _heep[ROUNDUP(HEEP_SIZE)/sizeof(_heep_t)];
#define _heep_size   ROUNDUP(HEEP_SIZE)
#else
extern char *_heep;
extern long _heep_size;
#endif

extern char *sbrk(int size)
{
    if (brk_siz + size > _heep_size || brk_siz + size < 0)
        return ((char *)-1);
    brk_siz += size;
    return ((char *)_heep + brk_siz - size);
}
```

APPENDIX

The Appendix gives a list of types, macros, variables, **and functions provided by the library and the operations specific to the libraries(A,B). Notes when FFMC-16LX CPU is used are described(C).**

Appendix A LIST OF TYPE, MACRO, VARIABLE, AND FUNCITON

This section lists the types, macros, variables, **and functions provided by the libraries.**

■ assert.h

- Function

  assert

■ ctype.h

- Macros

isalnum	**isalpha**	**iscntrl**	**isdigit**	**isgraph**
islower	**isprint**	**ispunct**	**isspace**	**isupper**
isxdigit	**tolower**	**toupper**		

■ errno.h

- Macros

  EDOM ERANGE

- Variable

  errno

■ float.h

FLT_RADIX	**FLT_ROUNDS**	**FLT_MANT_DIGT**	**DBL_MANT_DIG**
LDBL_MANT_DIG	**FLT_DIG**	**DBL_DIG**	**LDBL_DIG**
FLT_MIN_EXP	**DBL_MIN_EXP**	**LDBL_MIN_EXP**	**FLT_MIN_10_EXP**
DBL_MIN_10_EXP	**LDBL_MIN_10_EXP**	**FLT_MAX_EXP**	**DBL_MAX_EXP**
LDBL_MAX_EXP	**FLT_MAX_10_EXP**	**DBL_MAX_10_EXP**	**LDBL_MAX_10_EXP**
FLT_MAX	**DBL_MAX**	**LDBL_MAX**	**FLT_EPSILON**
DBL_EPSILON	**LDBL_EPSILON**	**FLT_MIN**	**DBL_MIN**
LDBL_MIN			

■ limits.h

MB_LEN_MAX	**CHAR_BIT**	**SCHAR_MIN**	**SCHAR_MAX**	**UCHAR_MAX**
CHAR_MIN	**CHAR_MAX**	**INT_MIN**	**INT_MAX**	**UINT_MAX**
SHRT_MIN	**SHRT_MAX**	**USHRT_MAX**	**LOGN_MIN**	**LONG_MAX**
ULONG_MAX				

■ math.h

- Macros

  HUGE_VAL   EDOM   ERANGE

- Function

acos	**asin**	**atan**	**atan2**	**cos**
sin	**tan**	**cosh**	**sinh**	**tanh**
exp	**frexp**	**ldexp**	**log**	**log10**
modf	**pow**	**sqrt**	**ceil**	**fabs**
floor	**fmod**			

■ stdarg.h

- Type

  va_list

- Macros

  va_start   va_arg   va_end

■ stddef.h

- Type

  ptrdiff_t   size_t

- Macros

  NULL   offsetof

■ stdio.h(for the fcc911s command and the fcc907s command)

- Type

  ptrdiff_t   size_t   FILE   fpos_t

- Macros

NULL	**EOF**	**SEEK_SET**	**SEEK_CUR**	**SEEK_END**
_IONBF	**_IOLBF**	**_IOFBF**	**BUFSIZ**	**stdin**
stdoout	**stderr**	**putchar**	**putc**	**getchar**
getc	**offsetof**			

- Function

putchar	**putc**	**getchar**	**getc**	**fclose**
fflush	**fopen**	**freopen**	**setbuf**	**setvbut**
fprintf	**fscanf**	**printf**	**scanf**	**sprintf**
sscanf	**vfprintf**	**vprintf**	**vsprintf**	**fgetc**
fgets	**fputc**	**fputs**	**gets**	**puts**
ungetc	**fred**	**fwrite**	**fgetpos**	**fseek**
fsetpos	**ftell**	**rewind**	**clearerr**	**feof**
ferror				

■ stdio.h(for the fcc896s command)

- Macros

  BUFSIZ
- Function

  sprintf   sscanf   vsprintf

■ stdlib.h

- Type

  ptrdiff_t   size_t   div_t   ldiv_t
- Macros

  NULL   offsetof   EXIT_FAILUREEXIT_SUCCESSRAND_MAX
- Function

atof	**atoi**	**atol**	**strtod**	**strtol**
strtoul	**rand**	**srand**	**calloc**	**free**
malloc	**realloc**	**abort**	**atexit**	**exit**
bsearch	**qsort**	**abs**	**div**	**labs**
ldiv				

■ string.h

- Type

  ptrdiff_t   size_t
- Macros

  NULL   offsetof
- Function

memcppy	**memmove**	**strcpy**	**strncpy**	**strcat**
strncat	**memcmp**	**strcmp**	**strncmp**	**memchr**
strchr	**strcspn**	**strpbrk**	**strrchr**	**strspn**
strstr	**strtok**	**memset**	**strlen**	

■ fcntl.h

- Macros

O_RDONLY	**O_WRONLY**	**O_RDWR**	**0_APPEND**	**O_CREAT**
O_TRUNC	**O_BINARY**			

■ unistd.h

- Macros

  SEEK_SET   SEEK_CUR   SEEK_END

■ setjmp.h

- Type
  `jmp_buf`
- Macros
  `setjmp`
- Function
  `longjmp`

■ sys/types.hj

- Type
  `off_t`

Appendix B OPERATIONS SPECIFIC TO LIBRARIES

This section describes the operations specific to the libraries.

■ Operations Specific to Libraries

(1) Diagnostic information printed out by the assert function and assert function termination operation

[Diagnostic Information]

`< Program Diagnosis *** information of fail expression >`

`file`	: File name expanded by __**`FILE`**__
`line`	: Line number expanded by __**`LINE`**__
`expression`	: Expression

[Termination Operation]

Same as the **`abort`** function calling.

(2) Inspection character sets for isalnum, isalpha, iscntrl, islower, isprint, and isupper functions

- **`isalnum`**: **`0`** to **`9`**, **`a`** to **`z`**, or **`A`** to **`Z`**
- **`isalpha`**: **`a`** to **`z`** or **`A`** to **`Z`**
- **`iscntrl`**: \**`100`** to \**`037`**, or \**`177`**
- **`islower`**: **`a`** to **`z`**
- **`isprint`**: \**`040`** to \**`176`**
- **`isupper`**: **`A`** to **`Z`**

(3) Mathematical function return value upon definition area error occurrence

- **`qNaN`**

(4) Whether the mathematical function sets up the macro ERANGE value for errno upon underflow condition occurrence

- **`ERANGE`**
- The detectable result value must be +0 or –0.
- The undetectable result value is undefined. It depends on the function.

(5) When the second actual argument for the fmod function is 0, the definition area error must occur or the value 0 must be returned

The definition area error must occur.

(6) File buffering characteristics

[Input File Buffering Characteristics]

`IOLBF`, **`IOFBF`**: Full buffering.

`IONBF`: No buffering.

[Output File Buffering Characteristics]

IOFBF: Full buffering.

IOLBF: Line buffering.

IONBF: No buffering.

[Full Buffering]

Buffering is conducted using all the preset buffer areas.

When the input function is called at the time of input from a file, any data remaining in the buffer is returned as the input from the file. If the buffer is emptied of data or does not have sufficient data, the input from the file is received until the buffer is filled up and then only the necessary amount is returned as the input.

At the time of output to a file, the output function writes into the buffer instead of outputting into the file. When the buffer is filled up by the write operation, the buffer outputs its entire contents to the file.

[Line Buffering]

Buffering is conducted for each output line.

[No Buffering]

File input/output is implemented in compliance with the input/output request made by input/output function calling.

Unlike the other buffering operations, no data will be saved into the memory.

(7) Pointer size for `%p` format conversion

The **`fcc907s`** command handles the small model and medium model using 16 bits, and the large model and compact model using 32 bits.

(8) `%p` format conversion output format for `fprintf` function

– Small Model/Medium Model:
  If the digit count is less than 4 in cases where the 4-digit hexadecimal notation is employed, leading 0s are added as needed. The alphabetical characters used are uppercased.

– Large Model/Compact Model:
  Same as for the small model except that the digit count is 8.

Note: The **`fcc911s`** command handles using 32 bits.

(9) Expansion of format conversion specification in fprintf, printf, sprintf, vfprintf, vprintf and vsprintf function of the fcc907s command

Expansion of %s and %n format conversion specification

– Small Model/Medium Model:
  It can be ordered that it be a pointer from which __far is qualified to the corresponding argument by specifying ’F’.

[Example]

```
#include <stdio.h>

__far char a[] = "abc";

main() { printf("%-16Fs\n", a); }
```

– Large Model/Compact Model:

It can be ordered that it be a pointer from which __near is qualified to the corresponding argument by specifying 'N'.

[Example]

```
#include <stdio.h>
__near char a[] = "abc";
main() { printf("%-16Ns\n", a); }
```

Expansion of %p format conversion specification

– Small Model/Medium Model:

  It can be ordered that it be a pointer from which __far is qualified to the corresponding argument by specifying 'l'.

[Example]

```
#include <stdio.h>
__far char a[] = "abc";
main() { printf("%lp\n", a); }
```

– Large Model/Compact Model:

  It can be ordered that it be a pointer from which __near is qualified to the corresponding argument by specifying 'h'.

[Example]

```
#include <stdio.h>
__near char a[] = "abc";
main() { printf("%hp\n", a); }
```

(10)%p format conversion input format for fscanf function

The fcc907s command adds leading 0s if the digit count is less than 4 (small model) or 8 (large model) when using upper- or lower-case alphabetic character-based hexadecimal notation. If the digit count is less than 4 (small model) or 8 (large model), leading 0s are added as needed. If the specified count of digits is exceeded, only the lower-order portion is valid.

The fcc911s command adds leading 0s if the digit count is less than 8 when using the upper- or lower-case alphabetic character-based hexadecimal notation. If the specified digit count (8 digits) is exceeded, only the lower-order part is valid.

(11) Expansion of format conversion specification in fscanf, scanf and sscanf function of the fcc907s command

– Small Model/Medium Model:

  'F' can be specified for all the format conversion specification except %%. It is shown that this 'F' is a pointer from which __far is qualified to the corresponding argument.

[Example]

```
#include <stdio.h>
__far int a;
int b;
main() { scanf("%Fd %d\n", &a, &b); }
```

– Large Model/Compact Model:

  'N' can be specified for all the format conversion specification except %%. It is shown that this 'N' is a pointer from which __near is qualified to the corresponding argument.

[Example]

```
#include <stdio.h>
__near int a;
int b;
main() { scanf("%Nd %d\n", &a, &b); }
```

(12) interpretation of a single "-" character appearing at a position other than the start and end of the scan-list relative to %[format conversion

A string of consecutive characters beginning with the character placed to the left of "-" and ending with the character placed to the right of "-" is handled.

[Example]

`%[a-c]` is equal to **`%[abc].`**

(13) abort function operation relative to an open file

Closing takes place after flushing of all streams.

(14) Status returned by the exit function when the actual argument value is other than 0, EXIT_SUCCESS, and EXIT_FAILURE

The status to be returned is the same as for EXIT FAILURE.

(15) Floating-point number limit values

– **FLT_MAX**	**7F7F FFFF**
– **DBL_MAX**	**7FEF FFFF FFFF FFFF**
– **BLT_EPSILON**	**3400 0000**
– **DBL_EPSILON**	**3CB0 0000 0000 0000**
– **FLT_MIN**	**0080 0000**
– **DBL_MIN**	**0010 0000 0000 0000**

(16) Limitations on setjmp function

The interrupt environment is not supported by the libraries. Therefore, the interrupt handler cannot achieve environment saving and the return to the interrupt handler cannot be made.

(17) Limitations on va_start macro

Do not use the following variable definitions for the **fcc896s** command **va_start** macro second argument.

- **`char`** type, **`unsigned char`** type, **`short`** type, or **`unsigned short`** type (however, the pointer type for these types can be used.)
- Type having the register storage area class
- Function type
- Array type
- Type different from the type derived from existing actual argument extension

Do not use the following variable definitions for the **`fcc907s`** command **`va_start`** macro second argument.

- **`char`** type or **`unsigned char`** type (however, the pointer type for these types can be used.)
- Type having the register storage area class
- Function type

- Array type
- Structure type
- Union type
- Type different from the type derived from existing actual argument extension

Do not use the following variable definitions for the **fcc911s** command **va_start** macro second argument.

- **char** type, **unsigned char** type, **short** type, or **unsigned short** type (however, the pointer type for these types can be used.)
- Type having the register storage area class
- Function type
- Array type
- Type different from the type derived from existing actual argument extension

(18)File types

Files that can be handled by the libraries are divided into two types; text files and binary files. The libraries treat the text files and binary files in the same manner except for the difference in the second argument of the **open** function called upon file opening.

When a binary file is specified, **O_BINARY** is added to the second argument of the **open** function. For the **open** function argument, see ***8.5.1***, ***open Function***.

(19) div_t type and ldiv_t type

```
div_t:struct {
            int  quot;
            int  rem;
        };
ldiv_t:struct {
            long int  quot;
            long int  rem;
        };
```

(20) abort function operations

When the **abort** function is called, all the open output streams are flushed and then all the open streams are closed. Finally, the **_abort** function is called.

(21)Maximum count of functions that can be registered by the atexit function

Up to 20 functions can be registered.

(22)exit function operations

When the **exit** function is called, all the functions registered by the **atexit** function are called in the reverse order of registration, all the open output streams are flushed, and then all the open streams are closed.

Finally, the **_exit** function is called with the **status** value, which is delivered as the argument, retained. When the **status** value is 0 or **EXIT_SUCCESS**, it indicates successful termination. When the **status** value is **EXIT_FAILURE**, it indicates the unsuccessful termination.

Appendix C NOTES OF SIGNED DIVISION INSTRUCTION OF FFMC-16LX CPU

Notes when FFMC-16LX CPU is used are described.

■ Devices

All devices (Eva, OTP, FLASH, Mask) of FFMC-16LX series.:

MB90520/A,MB90540,MB90550A,MB90560,MB90570/A,MB90580/B,MB90590,MB90595.

All devices of QCM16LX core.

■ Notes in use

Normally remainder of the execution result of the signed division instruction ("DIV A,Ri" and "DIVW A,RWi") is set bank "00" area. But above devices set remainder bank (DTB/ADB/USB/SSB) area. When you use the signed division instruction, remainder is set at a bank area of the DTB/ADB/USB/SSB registers value.

Details are shown as follows.

❍ Notes in use of "DIV A,Ri" and "DIVW A,RWi" instructions

The remainder of the execution result of the signed division instruction ("DIV A,Ri" and "DIVW A,RWi") is stored in the address (bit0-15) which corresponds to the register of the instruction operand of bank area (bit16-23) according to an undermentioned table. Therefore, please adjust the corresponding bank register to "00" and use the "DIV A,Ri" and "DIVW A,RWi" instructions.

Instruction	Bank Register	Address where the remainder is stored
DIV A,R0 DIV A,R1 DIV A,R4 DIV A,R5 DIVW A,RW0 DIVW A,RW1 DIVW A,RW4 DIVW A,RW5	DTB	(DTB:bit16-23)+(0180h+RPx10h+8h:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+9h:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+Ch:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+Dh:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+0h:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+2h:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+8h:bit0-15) (DTB:bit16-23)+(0180h+RPx10h+Ah:bit0-15)
DIV A,R2 DIV A,R6 DIVW A,RW2 DIVW A,RW6	ADB	(ADB:bit16-23)+(0180h+RPx10h+Ah:bit0-15) (ADB:bit16-23)+(0180h+RPx10h+Eh:bit0-15) (ADB:bit16-23)+(0180h+RPx10h+4h:bit0-15) (ADB:bit16-23)+(0180h+RPx10h+Ch:bit0-15)
DIV A,R3 DIV A,R7 DIVW A,RW3 DIVW A,RW7	USB *1 SSB *1	(USB *2:bit16-23)+(0180h+RPx10h+Bh:bit0-15) (USB *2:bit16-23)+(0180h+RPx10h+Fh:bit0-15) (USB *2:bit16-23)+(0180h+RPx10h+6h:bit0-15) (USB *2:bit16-23)+(0180h+RPx10h+Eh:bit0-15)

*1 select by S bit of CCR register

*2 S bit of CCR register is 0

When the value of the bank register is "00", the remainder is stored in the register of the instruction operand. However, the remainder is stored in bank (DTB/ADB/USB/SSB) area, except when the value of the bank register is "00".

Example:

Case of DTB = 053H and RP = 003H

Address of R0 is 00180H+003H*010H+08H = 0001B8H. Bank register which used "DIV A,R0" is DTB which address is 053H.

Therefore, the remainder of the execution result of "DIV A,R0" is preserved in memory which address is 05301B8H.

(Please refer to the explanation of the general register of the manual for Ri and RWi.)

■ About avoiding the Notes

Please use this compiler and the assembler when you use the MB905XX series because the one that the function to replace the signed division instruction with an equivalent instructions was added will be changed in the compiler so as not to generate the signed division instruction to have the program evade the Notes and developed and be offered in the assembler as follows.

The kind which will be developed in the future will improve the Notes as MB904XX series.

Measures assembler : asm907a V03L04 or later fasm907s V30L04(Rev.300004) or later

Measures compiler : cc907 V02L06 or later fcc907s V30L02 or later

Moreover, this Notes can be avoided by having use in the FFMC-16L mode in a present compiler.

■ Supplementation explanation

❍ About the influence on the program which has developed Notes

The Notes can be confirmed which the operation by Eva-device on a system. Therefore, the problem does not occur if a normal operation is confirmed in debugging though there is the signed division instruction in the program.

In the program development by the assembler:

(1) There is no problem if "DIV A,Ri" and "DIVW A,RWi" are not used.

(2) There is no problem if each bank register is "00" though "DIV A,Ri" and "DIVW A,RWi" are used.

(3) The DIV instructions excluding this does not have the problem.

In the program development by C compiler:

(1) In small model and medium model, there is no problem when the bank register which __far type qualified data and nor corresponds is used by "00"(initial value).

(In small model and medium model, C compiler does not change the value of each bank register initialized by the startup routine when there is no __far type qualified data.)

(2) There is a possibility that "DIV A,R2", "DIV A,R6", "DIVW A,RW2", and the "DIVW A,RW6" instructions are influenced for either by ADB as follows even if the corresponding bank register is used by "00h"(initial value).

- In small model and medium model, there is __far type qualified data.
- Compact model and large model are used.

(C compiler has the possibility to change the ADB register for the condition of (2))

However, there is no problem in the program if a normal operation is confirmed in debugging.

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