Application Note

RENESAS

H8S, H8/300 Series C/C++ Compiler Package

Application Note

Renesas Microcomputer Development Environment System

Renesas Electronics
www.renesas-electoronics.com

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Preface

This application note explains how to effectively create application programs that run on any of the following family of microcomputers by using the C/C++ compiler package: H8SX, H8S/2600, H8S/2000, H8/300H, H8/300, and H8/300L.

Further details of the topics covered in this application note may be found in the following related manuals:

High-prformance Embedded Workshop 3 User’s Manual

H8S and H8/300 Series High-prformance Embedded Workshop Tutorial

H8S and H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual

H8S and H8/300 Series Simulator Debugger User’s Manual

Hardware and Programming Manuals of each product

This application note is organized as follows:

Section 1 provides an overview and describes installation methods and the programming development procedure.

Section 2 illustrates the debugging process using various samples.

Section 3 explains the expansion functions used for user program development.

Section 4 explains HEW options.

Section 5 explains how to use the optimization feature and the optimization function for the inter-module optimizer.

Section 6 illustrates efficient programming techniques.

Section 7 illustrates the utilizing method using HEW.

Section 8 illustrates efficient C++ programming technique.

Section 9 explains how to use the Optimizing Linkage Editor.

Section 10 provides answers to questions frequently asked by the users.

The appendixes cover the following topics:

A: List of floating-point operation capabilities

B: Added Features

C: List of Limitations

D: ASCII code table

This application note mainly covers HEW3.0 and H8 Compiler Version 6.0. If operations of HEW1.2 and H8 Compiler Version 3.0 differ, the differences are explained separately.

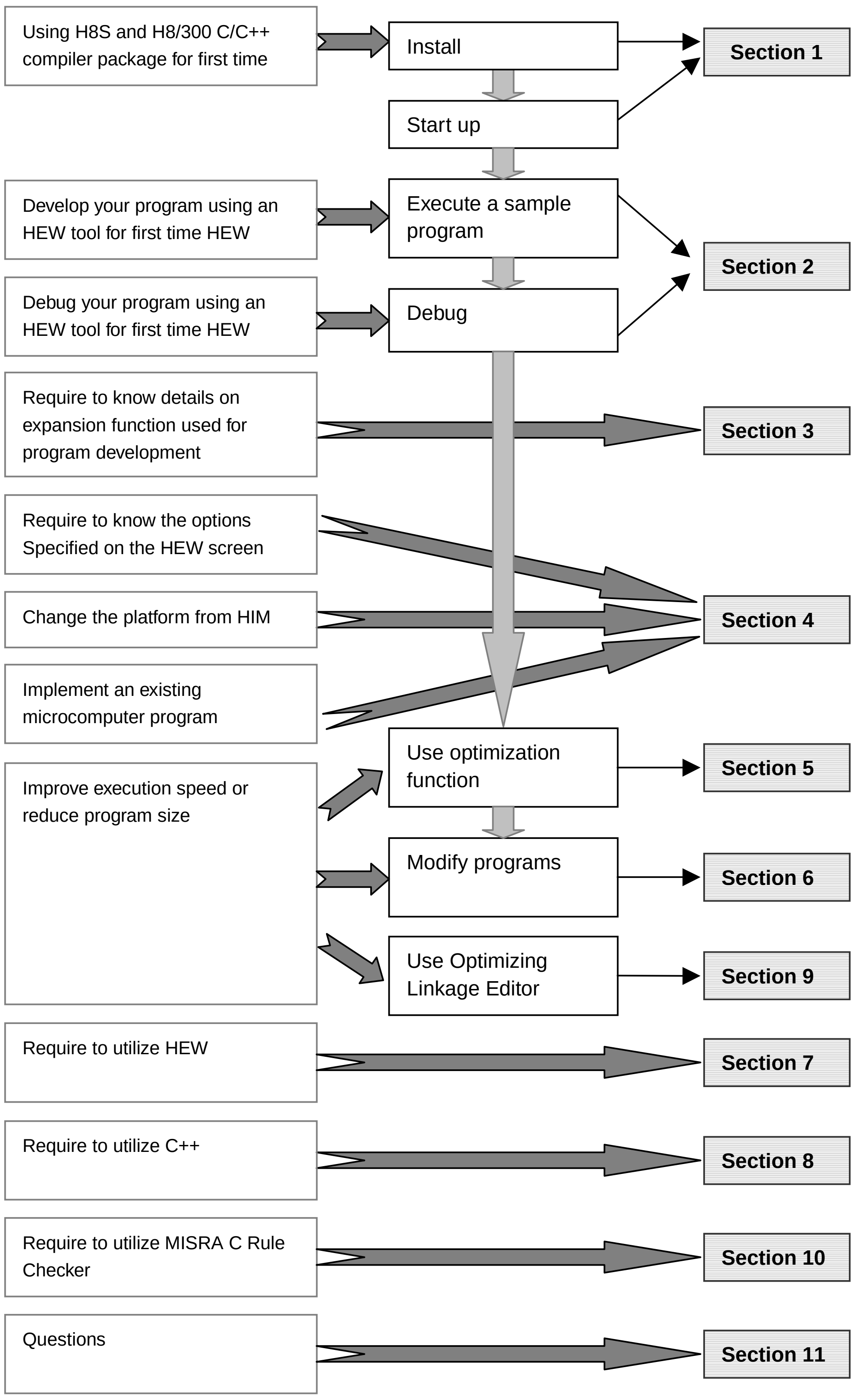
Symbols and Conventions used in this application note is as follows.

[]:	Indicates that the enclosed item can be omitted.
(RET):	Indicates the Return (Enter) key is to be pressed.
Δ:	Indicates one or more spaces or tabs.
Abc:	Boldfaced items are to be input by the user.
<>:	Items enclosed in these brackets should be specified.
…:	Indicates that the immediately preceding item is specified one or more times.
H':	Integer constants preceded by H' are in hexadecimal.
0x:	Integer constants preceded by 0x are in hexadecimal.

[Menu->Menu Option] : The boldfaced letter and the character -> indicate a menu option.

Using the application note

Renesas recommends that the application note be read as follows: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Section 1 Overview

1.1 Summary

The H8S and H8/300 C/C++ Compiler enables effective creation in either C or C++ language of programs which takes advantage of functions and performance of the Renesas Technology H8S and H8/300 series of single-chip microcomputers for embedded applications.

This compiler supports the following CPUs:

- H8SX Series (H8SX)
- H8S/2600 Series (H8S/2600)
- H8S/2000 Series (H8S/2000)
- H8/300H Series (H8/300H)
- H8/300 Series (H8/300)
- H8/300L Series (H8/300L)
- AE5 Series (AE5)

This document explains procedures for creating application programs using this C/C++ compiler.

This document mainly explains the Compiler Version 6.0 (HEW2.0 or later) and also explains the previous Version 3.0 (HEW1.2) where it is necessary.

1.2 Features

The H8S and H8/300 C/C++ compiler offers the following significant features.

Windows® Version

The H8S and H8/300 C/C++ compiler of Windows® version supports the integrated environment

HEW (High-performance Embedded Workshop) to allow the user to develop the programs thoroughly on the Windows® display.

The HEW provides the following features.

- Project generator
  Automatically generates template software projects for each CPU.
- Combination interface with version management tools
  Supports the interface with the version management tools provided by the third party.
- Hierarchy project support
  Can define multiple subprojects in a project and hierarchically manage them.
- Network support
  Provides development environment under WindowsNT® CSS.

UNIX Version

The H8S and H8/300 C/C++ compiler of UNIX version supports the integrated development manager (IDM) to allow the user to develop the programs from editing to debugging.

The IDM provides the following features.

- The editor can be started up when an error occurs during compilation or assembly.
  (A cursor appears on the source code line where an error occurs.)
- The program development can be automatically executed from assemble/compilation, object module linkage, to loading to the debugger.
- Debugging at source level is supported using the graphical user interface.

1.3 Installation Method

1.3.1 PC Version

This section describes the operating environment for the Windows®98, Windows®Me, WindoswsNT®4.0, Windows®2000 or Windows®XP compatible H8S and H8/300 C/C++ Compiler package and the procedures for installing it on a Windows®98, Windows®Me, WindowsNT®4.0, Windows®2000, or Windows®XP system.

(1) Operating environment

Host computer: IBM-PC compatible machine

(CPU: CPU capable of running Windows®98, Windows®Me, WindowsNT®4.0, Windows®2000, or Windows®XP)

OS: Windows®98, Windows®Me, WindowsNT®4.0, Windows®2000, or Windows®XP

Memory size: 128 MB or more recommended

Hard disk capacity for the integrated development environment: 100 MB or more free disk space required (for full installation)

Acrobat® Reader: 10 Mbytes or more free disk space required

Display: SVGA or better

I/O device: CD-ROM drive

Others: Mouse or other pointing devices

Perform the following procedures to install the compiler on your PC.
Before commencing the installation procedure, be sure to close all applications:

(a) Installing the H8S and H8/300 C/C++ compiler package:

(i) Insert the CD-ROM for the compiler package into the CD-ROM drive.
(Here it is assumed that the CD-ROM drive is drive D.)
(ii) From the Windows® Start menu, click on [Run …].
(iii)In the [Run…] dialog box, specify Setup.EXE that is in the root directory of the CD-ROM (example: D:\Setup.EXE), and then click [OK].
(iv)Follow the onscreen installation instructions.

Notes on the installation of the Integrated Development Environment:

Install the Integrated Development Environment in a directory path consisting solely of half-width alphanumeric characters and half-width underlines. Use a directory path that does not contain full-width characters or spaces.

(i) Be careful not to install HEW (High-performance Embedded Workshop) in the same directory as HIM (Hitachi Integration Manager) .
(ii) Even when using it on a network, install High-performance Embedded Workshop on each PC drive. The tool chain, the librarian interface, the Hitachi debugging interface, and the online manual can be installed on a network drive. For details on procedure to define the tool chain or library interface installed on another PC on your PC, refer to section 5, Tools Administration, in the High-performance Embedded Workshop V.4.00 User's Manual.
(iii)If [High-performance Embedded Workshop] fails to appear in the [Programs] on the Windows® Start Menu after HEW has been installed, restart Windows®.

(iv)If the installer terminates abnormally during installation under Windows®98, restart the computer and reinstall.

(b) Installing the Acrobat® Reader:

(i) Insert the CD-ROM for the compiler package into the CD-ROM drive. (Here it is assumed that the CD-ROM drive is drive D.)

(ii) From the Windows® Start menu, click on [Run …].

(iii)Specify in the [Run …] dialog box either Ar505jpn.exe (Japanese) in the [PDF_READ\Japanese] directory on the CD-ROM or Ar505eng.exe (English) in the [PDF_read\English] directory (example: D:\PDF_Read\Japanese\Ar505jpn.exe), and then click [OK].

(iv)Follow the onscreen installation instructions.

(c) Referencing the Online Manual and other documents

- If the Online Manual is installed:

  Click either the Online Manual [H8S,H8/300]-English(xx xx) (English) PDF file or the Online Manual [H8S,H8/300]-Japanese(xx xx) (Japanese) PDF file on the [High-performance Embedded Workshop] menu in the [Programs] on the Windows® Start menu, where (xx xx) denotes the year and the month.

  (Example: Online Manual [H8S,H8/300]-Japanese(01 10))

- If the Online Manual is not installed:

(i) Insert the CD-ROM for the compiler package into the CD-ROM drive. (Here it is assumed that the CD-ROM drive is drive D.)

(ii) From the Windows® Start menu, click on [Run …].

(iii)Specify in the [Run …] dialog box either jH8_xxxx.PDF (Japanese) or eH8_xxxx.PDF (English) (where xxxx denotes the year and the month) in the [Manuals] directory on the CD-ROM (example:D:\Manuals\jH8_0110.PDF), and then click [OK].

1.3.2 UNIX Version

The procedure for installing the H8S and H8/300 C/C++ compiler on a UNIX system is described below.

Caution: Do not use spaces in the name for the installation directory.

(1) Recording medium

The compiler is distributed on a single CD-ROM.

(2) Installation Method

Please use the following procedure to install the compiler. Wherever (RET) appears in the instructions, the Enter (Return) key is to be pressed.

(a) Installing the compiler package

The procedure for compiler package installation is as follows.

(i) Creating a path for the compiler package

Create a path for storage of the compiler files, using any arbitrary name.
(Hereinafter, installation directory is assumed to be /usr/cross_soft.)

```
% mkdirΔ/usr/cross_soft (RET)
```

(ii) Mounting the CD-ROM

Mount the CD-ROM as indicated below. If mounting is performed automatically, the following command is not required.

[For Solaris]

% mountΔ–rΔ–FΔhsfsΔ/dev/dsk/c0t6d0s2/h8s_sparcΔ/cdrom/h8s_sparc (RET)

[For HP-UX]

% mountΔ/dev/dsk/c201d2s0Δ/cdrom (RET)

(iii)Copying the compiler package

Move to the newly created path, and then decompress the files for the SuperH RISC engine C/C++ compiler package from the CD-ROM to the path created in (i) above.

[For Solaris]

```
% cdΔ/usr/cross_soft (RET)
% tarΔxvfΔ/cdrom/h8s_sparc/Program.tar (RET)
```

[For HP-UX]

```
% cdΔ/usr/cross_soft (RET)
% tarΔxvfΔ/cdrom/"PROGRAM.TAR;1" (RET)
```

(iv)Changing environment settings

Environment variables and pathnames are set as follows. (Double asterisks ** indicate an appropriate value should be specified.) For detailed on environment variables, refer to the H8S and H8/300 C/C++ Compiler User's Manual.

The following shows an example to set environment variables and pathnames for C shell.

% setenvΔCH38Δ/usr/cross_soft (RET)

Set the storage area for the system include file.

% setenvΔCH38TMPΔ/usr/tmp (RET)

Specify the directory for storing the intermediate files created by the compiler or by inter-module optimization. (Here it is assumed to be /usr/tmp.)

If no directory is specified, a current directory is used as default.

% setenvΔH38CPUΔ**:** (RET)**

Select the CPU operating mode as among 2000n, 2000a, 2600n, 2600a, 300hn, 300ha, 300, and 3001. If CPU is selected as 2000a, 2600a, or 300ha, the size of address space can also be specified.
(Example: % setenv H38CPU 2600a:24(RET))

% setenvΔHLNK_TMPΔ/usr/tmp (RET)

Specify the directory for storing the intermediate files created by the linkage editor or by inter-module optimization. (Here it is assumed to be /usr/tmp)

If no directory is specified, a current directory is used as default.

```
% setenvΔHLNK_LIBRARY1Δ/usr/cross_soft/******.lib (RET)
% setenvΔHLNK_LIBRARY2Δ/usr/cross_soft/******.lib (RET)
```

At linkage, a library can be input implicitly without using the LIBRARY option or subcommand option.

For details, refer to the H8S,H8S/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

(v) Unmount the CD-ROM.

[For Solaris]

% umountΔ/cdrom/h8s_sparc (RET)

[For HP-UX]

% umountΔ/cdrom (RET)

(b) Installing the integrated development manager and the integrated development manager definition files

(i) Load the installer from the tarfile on the CD-ROM. (This assumes that the CD-ROM driver device name is /cdrom.)

% tarΔxvfΔ/cdrom/idm.tarΔidm_install (RET) [For Solaris]

(ii) Start the installer.

% idm_install (RET)

Follow the onscreen installation instructions. For details, refer to the H8S and H8/300 definition file installer.

(c) Installing the Acrobat® Reader:

The manual can be viewed from within Windows®. The software used to view the manual (the Acrobat® Reader) should be installed on a computer running Windows®98, Windows®Me, Windows NT®4.0, Windows®2000, or Windows®XP.

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The following procedure is used to execute installation. Any running applications should be terminated before proceeding with installation.

(i) Insert the CD-ROM for the Integrated Development Environment into the CD-ROM drive. (Here it is assumed that the CD-ROM drive is drive D.)

(ii) From the Windows® Start menu, click on [Run …].

(iii)Specify in the [Run …] dialog box either Ar40jpn.exe (Japanese) in the [PDF_READ\Japanese] directory on the CD-ROM or Ar40eng.exe(English) in the [PDF_read\English] directory (example: D:\PDF_Read\Japanese\Ar40jpn.exe), and then click [OK].

(iv)Follow the onscreen installation instructions.

(d) Referencing the Online Manual and other documents

- If the Online Manual is installed:

  Click either the Online Manual [H8S,H8/300]-English(xx xx) (English) PDF file or the Online Manual [H8S,H8/300]-Japanese(xx xx) (Japanese) PDF file on the [High-performance Embedded Workshop] menu in the [Programs] on the Windows® Start menu, where (xx xx) denotes the year and the month. (Example: Online Manual [H8S,H8/300]-Japanese(01 10))
- If the Online Manual is not installed:

(i) Insert the CD-ROM for the Integrated Development Environment into the CD-ROM drive. (Here it is assumed that the CD-ROM drive is drive D.)

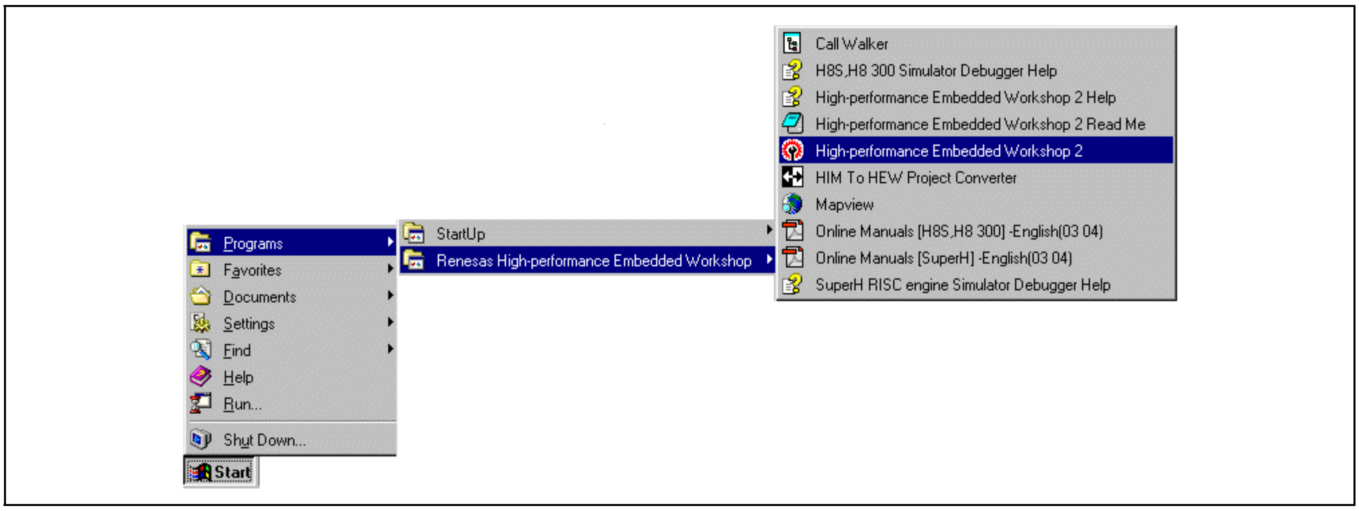
(ii) From the Windows® Start menu, click on [Run …].

(iii)Specify in the [Run …] dialog box either jH8_xxxx.PDF (Japanese) or eH8_xxxx.PDF (English) (where xxxx denotes the year and the month) in the [Manuals] directory on the CD-ROM (example:D:\Manuals\jH8_0110.PDF), and then click [OK].

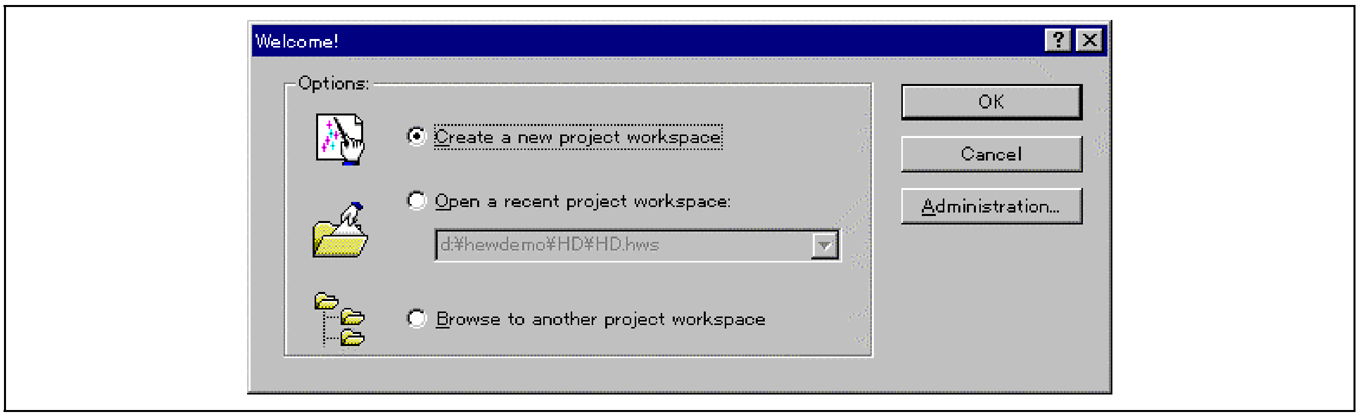
1.4 Startup Method

1.4.1 Stating the HEW

Upon completion of H8S and H8/300 C/C++ compiler package installation, the installer for the High-performance Embedded Workshop (HEW) creates a folder named "High-performance Embedded Workshop" within the Programs folder in the Windows® Start menu, and within this folder the program "High-performance Embedded Workshop" can be started up.


Call Walker
H8S,H8 300 Simulator Debugger Help
High-performance Embedded Workshop 2 Help
High-performance Embedded Workshop 2 Read Me
High-performance Embedded Workshop 2
HIM To HEW Project Converter
Mapview
Online Manuals [H8S,H8 300] -English(03 04)
Online Manuals [SuperH] -English(03 04)
SuperH RISC engine Simulator Debugger Help
StartUp
Renesas High-performance Embedded Workshop
Programs
Favorites
Documents
Settings
Find
Help
Run...
Shut Down...
Start

The following Welcome! dialog box appears:


Welcome!
Options:
Create a new project workspace
Open a recent project workspace:
d:¥hewdemo¥HD¥HD.hws
Browse to another project workspace
OK
Cancel
Administration...

Select the desired project workspace from the above screen:

Create a new project workspace	Create a new project workspace
Open a recent project workspace	Open an existing workspace that has been used recently.
Browse to another project workspace	Open another workspace.

By selecting [Administration], you can register or delete the system tool to be used.

1.4.2 Starting the Compiler Using a Command

In this subsection, the method for executing the H8S and H8/300 C/C++ Compiler is explained, along with examples. For details on compiler options, refer to section 2, C/C++ Compiler Operating Method, in the H8S and H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Below the basic procedures for using the compiler are explained.

(1) Starting up the compiler

This command displays a list of command input formats and compiler options on the standard output screen.

ch38 (RET)

(2) Compiling a program

The C source program test1.c is compiled.

ch38Δtest1.c (RET)

The C++ source program test2.cpp is compiled.

ch38Δtest2.cpp(RET)

Multiple C/C++ programs can be compiled at once.

ch38Δtest1.cΔtest2.cpp(RET)

(3) Specifying options

Options (goptimize, debug, show=object, allocation, etc.) are prefixed with a hyphen (-), and multiple options are separated by spaces ((Δ).

When specifying multiple suboptions, they should be separated by commas (,).

ch38Δ-goptimizeΔ-debugΔ-show=object,allocationΔtest1.c (RET)

The following short-format can also be used for option specification.

ch38Δ-gΔ-debΔ-sh=o,aΔtest1.c (RET)

When compiling multiple programs, whether the option is effective on the program differs according to the position where the option is specified.

<Example 1: The specified option is specified for all source programs>
The option specified prior to the first source program is effective for all source program.

ch38Δ-gΔ-debΔ-sh=o,aΔtest1.cΔtest2.cpp (RET)

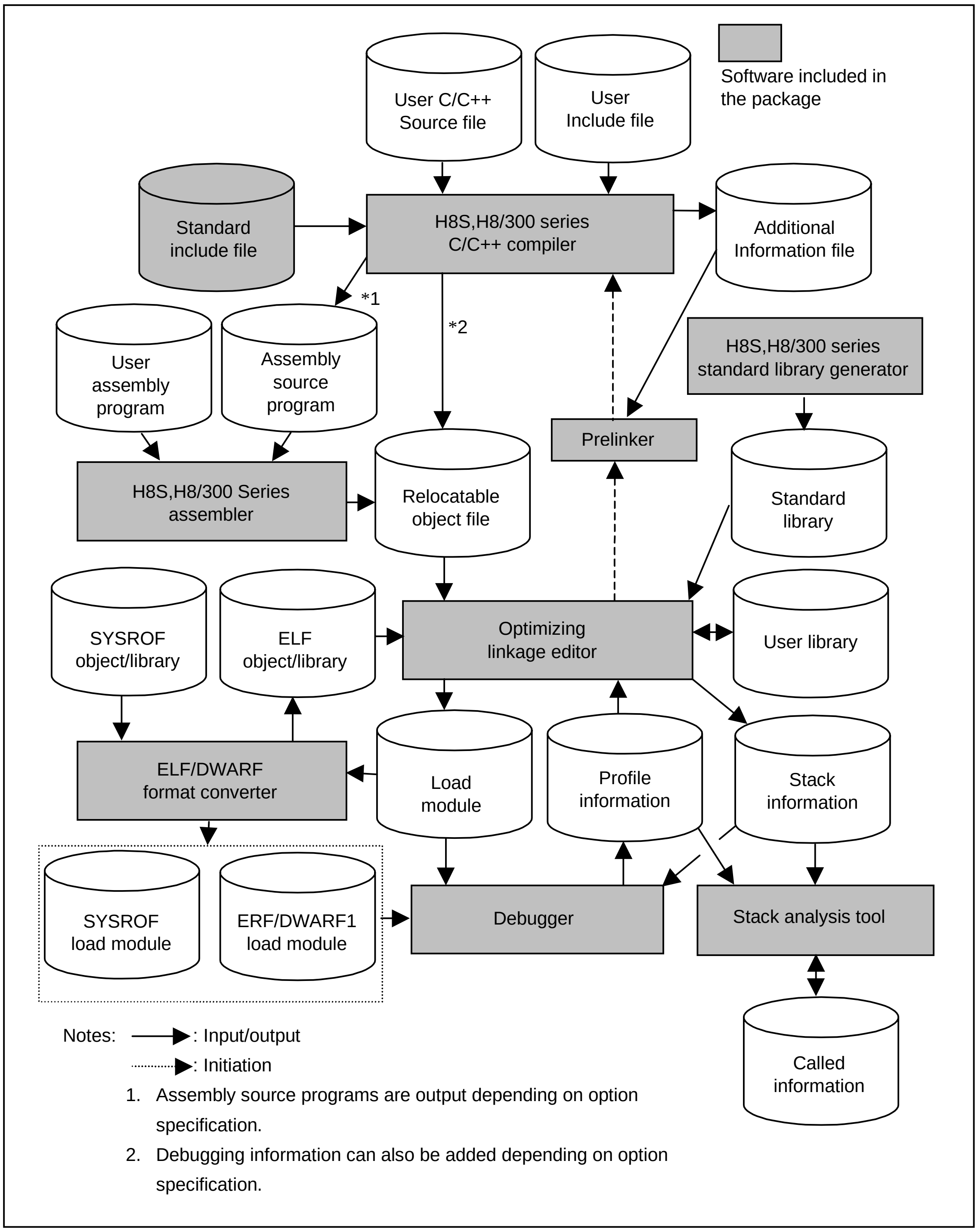
<Example 2: The option is specified separately for each program>
The option specified following the source program test2.cpp is effective only for test2.cpp.

ch38Δtest1.cΔtest2.cppΔ-debΔ-sh=o,a (RET)

Note: (1) The compiler distinguishes C and C++ files depending on file extensions, and –lang and lang options. For details on file extensions, refer to section 8, File Specifications, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual

1.5 Procedure for Program Development

Figure 1.5 shows the procedure used to develop a C/C++ language program.



Notes: ——▶: Input/output

┈┈▶: Initiation

1. Assembly source programs are output depending on option specification.
2. Debugging information can also be added depending on option specification.

Section 2 Procedure for Creating and Debugging a Program

2.1 Creating a project

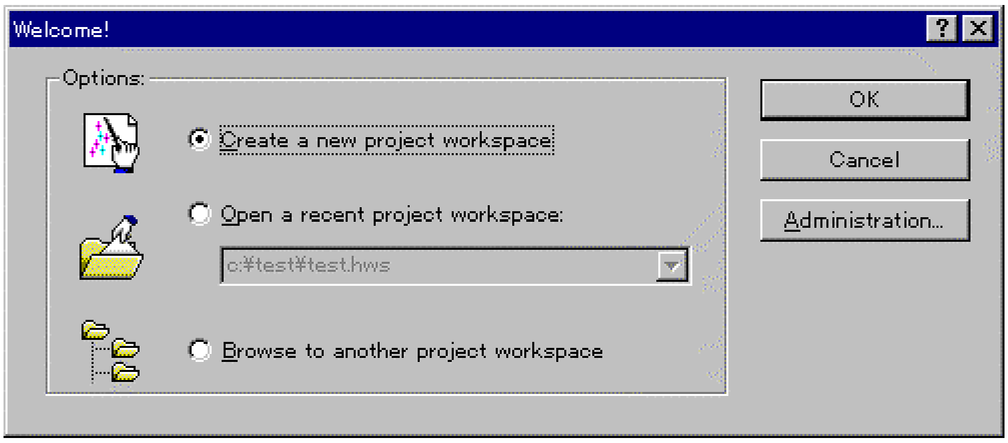
Procedures for the creation of a load module vary with the particular working environment in which it is created and HEW Version. Select your environment from the following list to appropriately create a load module.

Create a new project using HEW1 (HEW1.2).	→	Section 2.1.1
Create a new project using HEW2 (HEW2.0).	→	Section 2.1.2
Use a command line by bypassing HEW.	→	Section 2.1.3
Convert a HIM project to a HEW project.	→	Section 7.1.8
Create a project in HEW using existing files.	→	Section 4.3

The description in section 2.3, Debugging Using the HDI, assumes that a new project created under HEW is used.

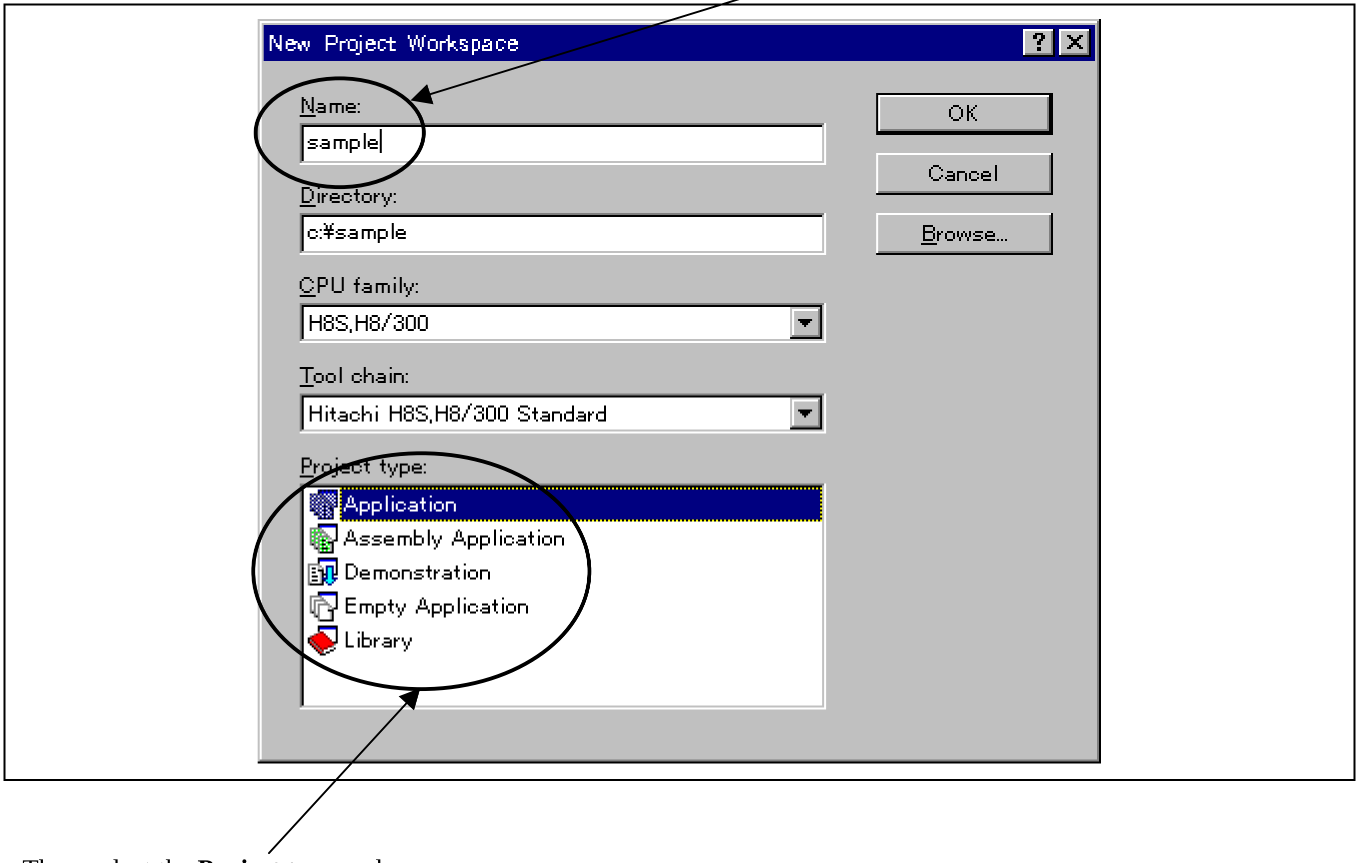
2.1.1 Creating a New Workspace 1 (HEW1.2)

To create a new project workspace, select Create a new project workspace from the Welcome! dialog box.


Welcome!
Options:
● Create a new project workspace
○ Open a recent project workspace:
c:¥test¥test.hws
○ Browse to another project workspace
OK
Cancel
Administration...

(1) Setting the Project type

When the following screen appears, enter the desired project name in the **Name** field:



Name:
sample

Directory:
c:¥sample

CPU family:
H8S,H8/300

Tool chain:
Hitachi H8S,H8/300 Standard

Project type:
Application
Assembly Application
Demonstration
Empty Application
Library

Then, select the **Project type**: column.

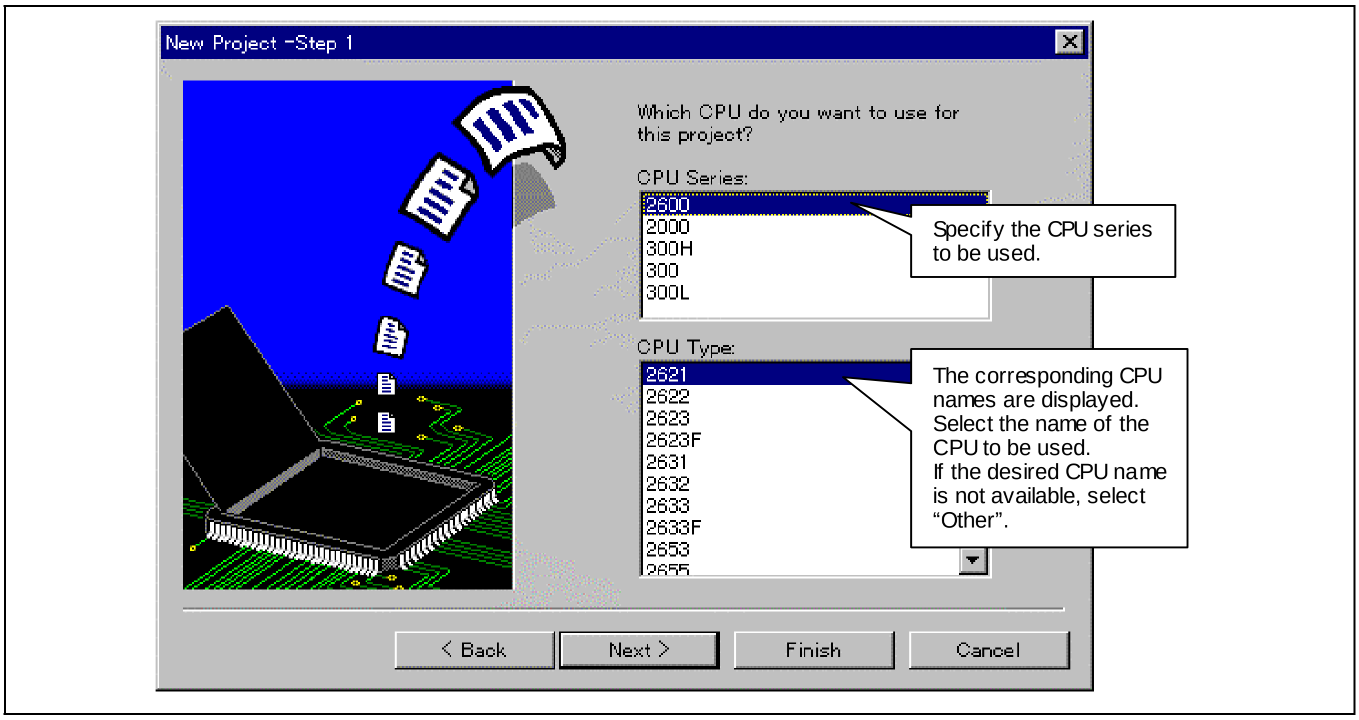
Project type	Description
Application	A project type when creating an application that includes C/C++ program files
Assembly Application	A project type when creating an application that includes assembly language programs only
Demonstration	Sample project type
Empty Application	Empty project creation
Library	Library creation project type

By clicking the [OK] button after selecting the desired project type, you can move on to the step for initializing the new project.

The explanation below assumes that you have selected Application as a project type.

(2) New project - Step 1

Specify the CPU to be used and press NEXT>.



New Project -Step 1

Which CPU do you want to use for this project?

CPU Series:

2600
2000
300H
300
300L

CPU Type:

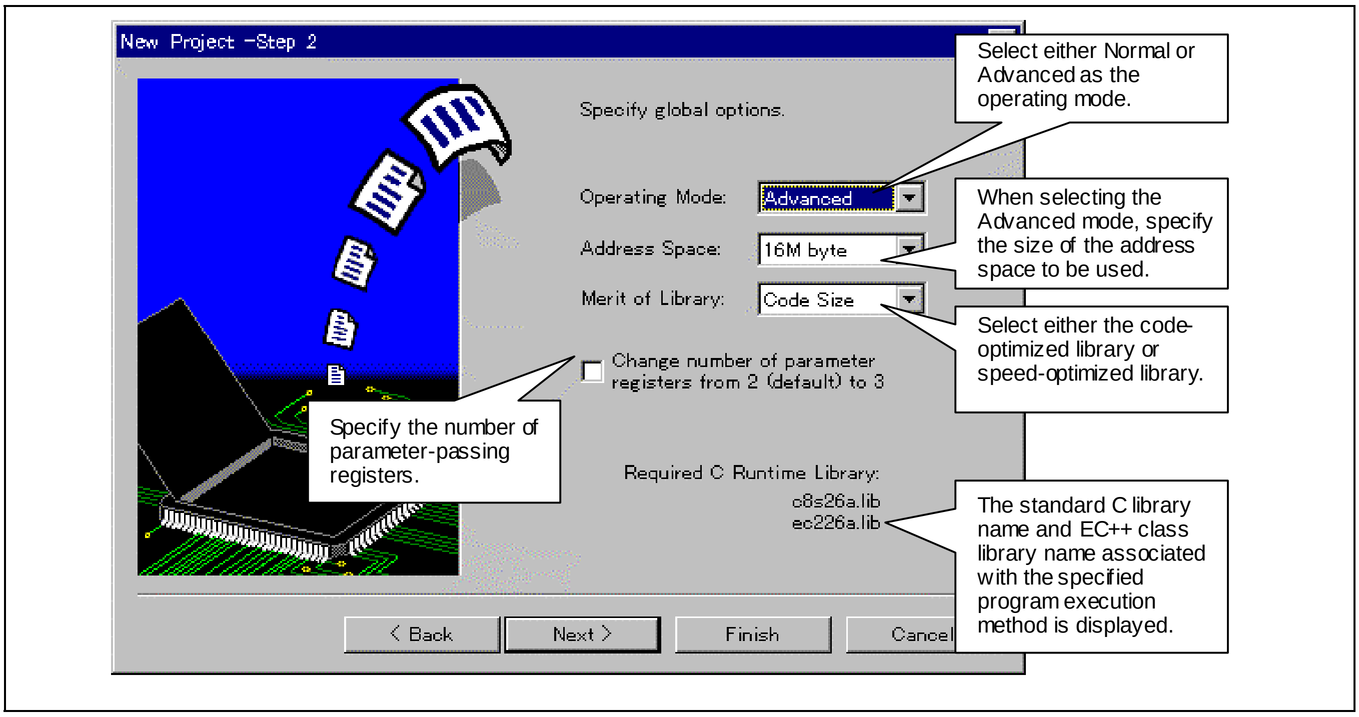
2621
2622
2623
2623F
2631
2632
2633
2633F
2653
2655

Specify the CPU series to be used.

The corresponding CPU names are displayed. Select the name of the CPU to be used. If the desired CPU name is not available, select "Other".

(3) New project - Step 2

Specify the desired global options and press NEXT>.



New Project -Step 2

Specify global options.

Operating Mode: Advanced

Address Space: 16M byte

Merit of Library: Code Size

Change number of parameter registers from 2 (default) to 3

Required C Runtime Library:
c8s26a.lib
ec226a.lib

Select either Normal or Advanced as the operating mode.

When selecting the Advanced mode, specify the size of the address space to be used.

Select either the code-optimized library or speed-optimized library.

Specify the number of parameter-passing registers.

The standard C library name and EC++ class library name associated with the specified program execution method is displayed.

The same set of global options should be used for all project files.

The following categories of global options are available:

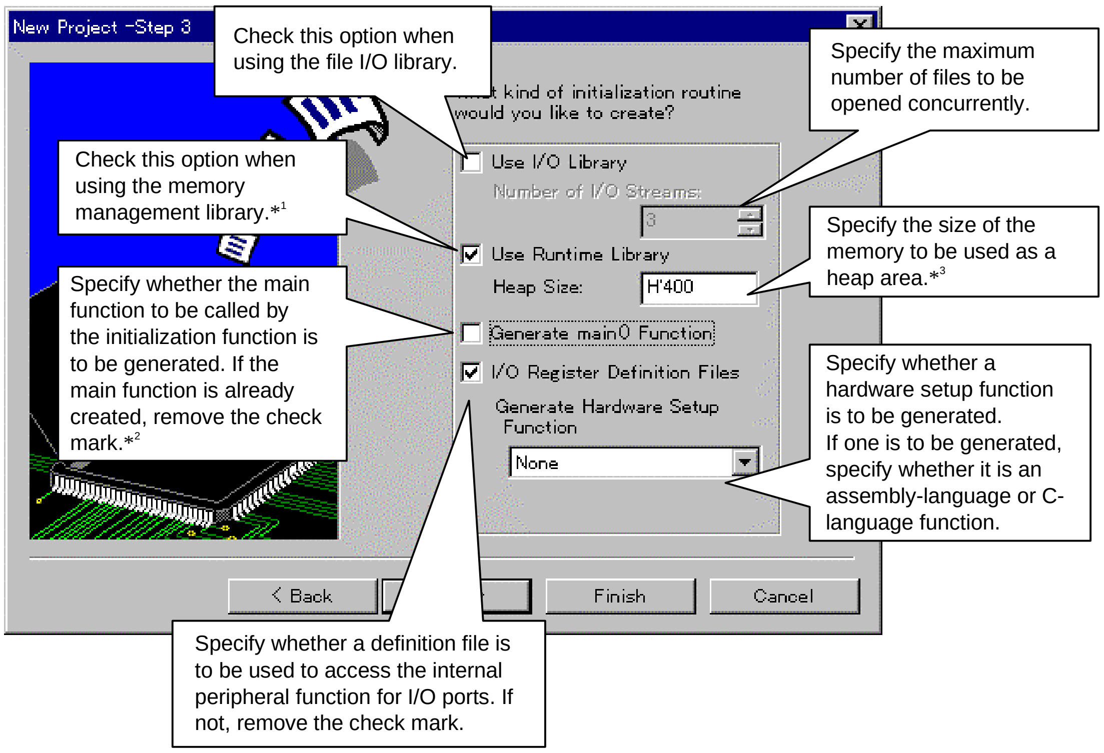
- CPU Type
- Number of argument-passing registers

To change the global options specified in this dialog box after the new project has been initialized, the specification of the standard library to be linked should be modified.

For details on how to change the global options and standard library, refer to section 11.2.1, Output of "Undefined External Symbol".

(4) New project - Step 3

On this screen, specify the contents of an initialization program and press NEXT>.



Check this option when using the file I/O library.

Specify the maximum number of files to be opened concurrently.

Check this option when using the memory management library.*1

Specify the size of the memory to be used as a heap area.*3

Specify whether the main function to be called by the initialization function is to be generated. If the main function is already created, remove the check mark.*2

Specify whether a hardware setup function is to be generated. If one is to be generated, specify whether it is an assembly-language or C-language function.

Specify whether a definition file is to be used to access the internal peripheral function for I/O ports. If not, remove the check mark.

New Project -Step 3

...t kind of initialization routine would you like to create?

- [ ] Use I/O Library
- Number of I/O Streams: 3
- [✓] Use Runtime Library
- Heap Size: H'400
- [ ] Generate main() Function
- [✓] I/O Register Definition Files
- Generate Hardware Setup Function: None

Notes: 1. Available memory library functions are malloc, realloc, calloc, and new.

2. On this dialog box, a main function should not be created. In Step (9), a sample program that contains the main function is added as a preparation for section 2.3, Debugging Using an HDI.

3. The required size for a heap area can be calculated as follows:

(Heap area size) ≥
(Area size allocated by memory management library) + (Management area size)

The management area sizes are as follows:

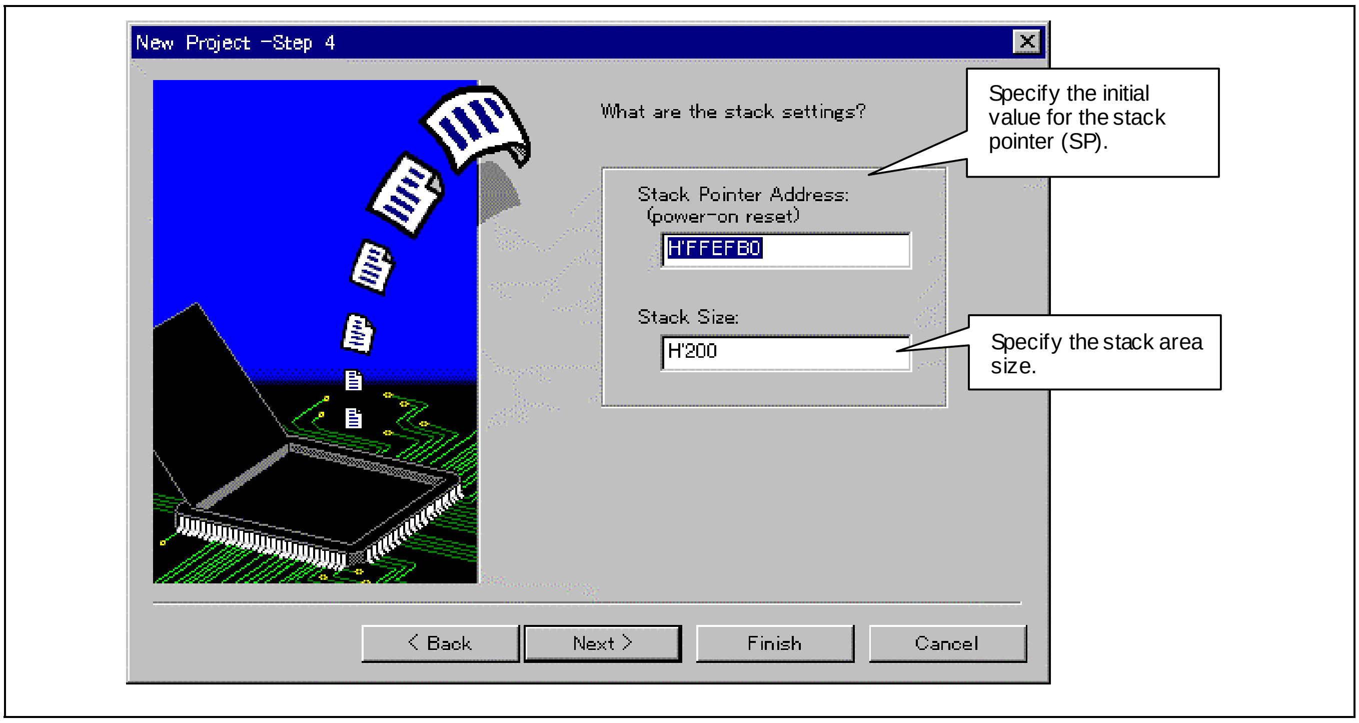
CPU Type	Management Area Size
H8S/2600 ADV,H8S/2000 ADV, H8/300H ADV	16 bytes
H8S/2600 NRM,H8S/2000 NRM,H8/300H NRM,H8/300	8 bytes

ADV: advanced mode; NRM: normal mode

To modify the heap area size specified in this section after the new project has been initialized, refer to section 2.2.1 (2), Allocating a heap area.

(5) New project - Step 4

Set the stack to be used and press NEXT>.


New Project -Step 4
Specify the initial value for the stack pointer (SP).
Specify the stack area size.
< Back
Next >
Finish
Cancel

What are the stack settings?

Stack Pointer Address:
(power-on reset)
H'FFEFB0

Stack Size:
H'200

The size of the stack to be used can be determined as follows:

Calculate the size of the stack area for the deepest nest of calls in the call relationships among the functions. The maximum value obtained in this manner is the stack area size.

For example, if the deepest function call nest is the following, sum all the stack sizes:

main function (stack size: 10 bytes) → func function (20 bytes) → sub function (30 bytes)

The stack size in this case will be 60 bytes.

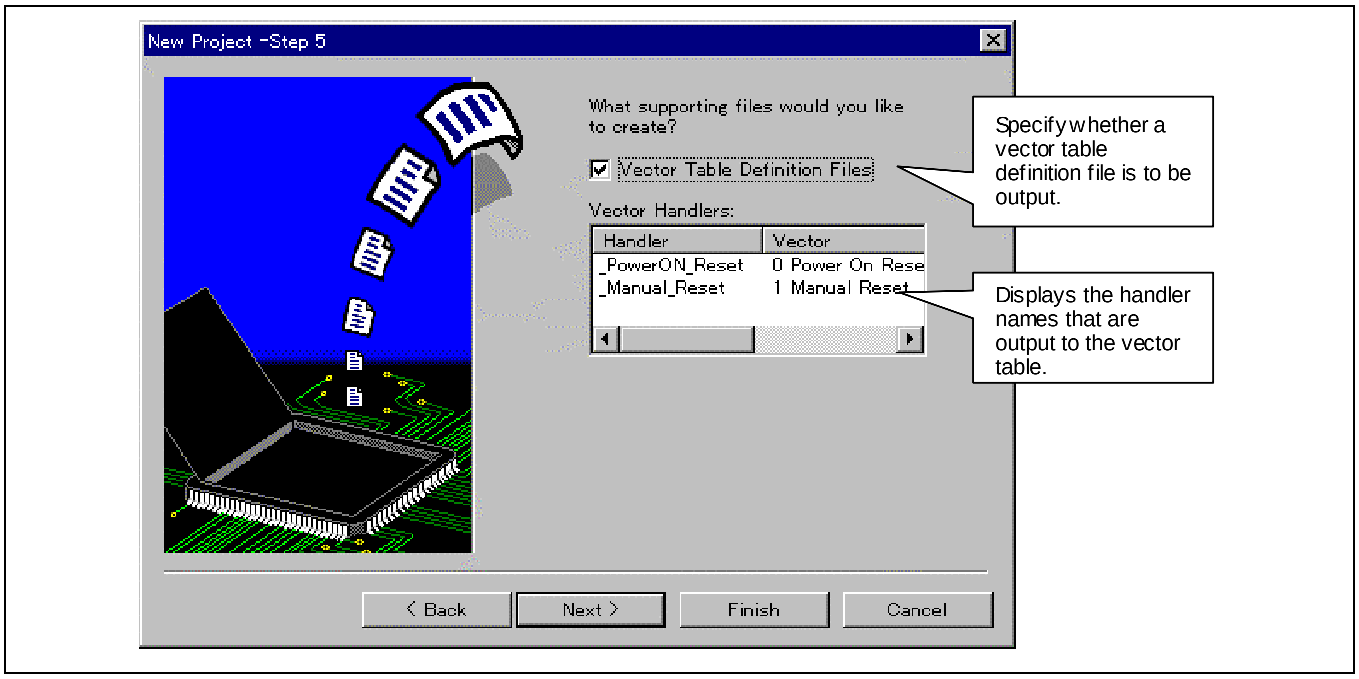
The stack sizes for functions are output when symbol allocation information output is specified as part of a specification for object list file output.

For a runtime routine, refer to the "List of Stack Sizes Used by the Standard Library" in the manual supplied with the H8S and H8/300 Series C/C++ Compiler.

When modifying the stack size specified in this section after the new project has been initialized, refer to section 2.2.1 (8), Setting the stack size.

(6) New project - Step 5

Specify the settings for a vector table and press NEXT>.


New Project -Step 5

What supporting files would you like to create?

[✓] Vector Table Definition Files

Vector Handlers:

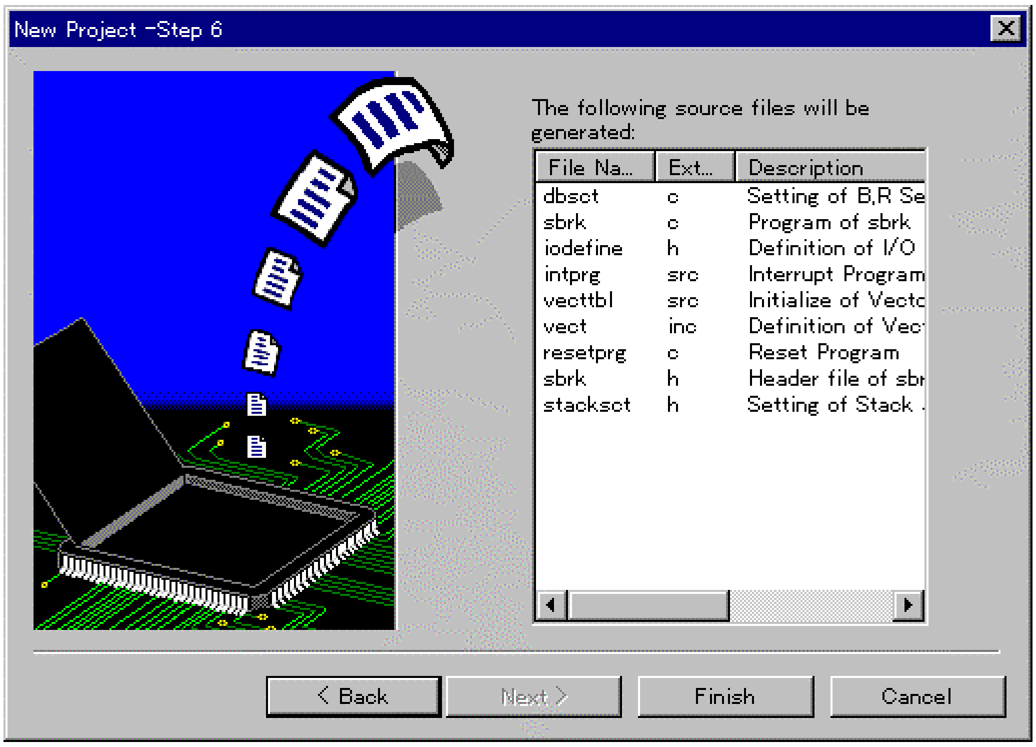
Handler	Vector
_PowerON_Reset	0 Power On Rese
_Manual_Reset	1 Manual Reset

Specify whether a vector table definition file is to be output.

Displays the handler names that are output to the vector table.

(7) New project - Step 6

Displays the files created by the project generator. Press FINISH to go to step 7.



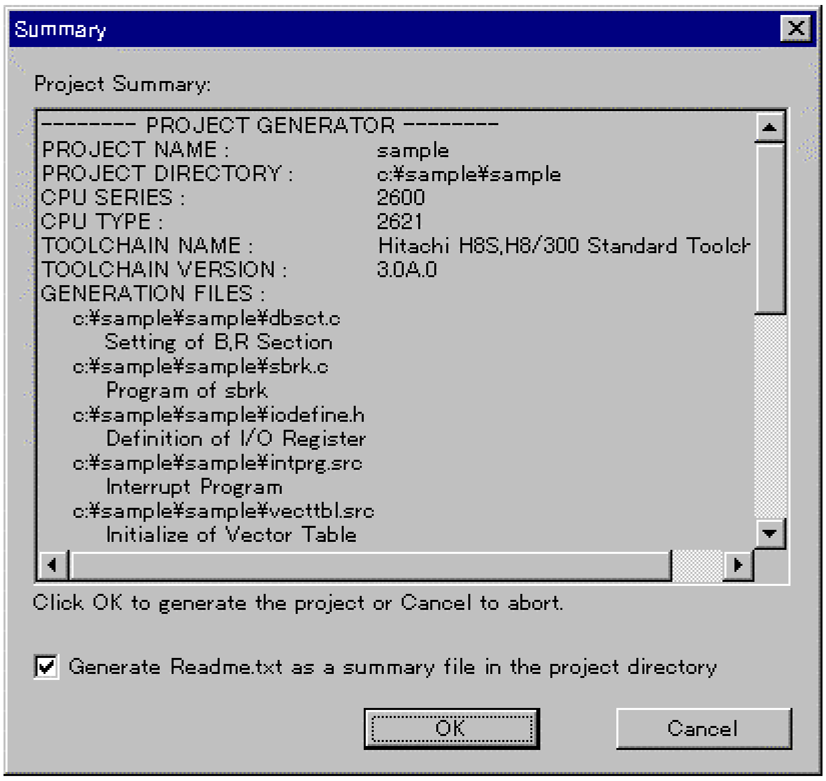
The following source files will be generated:

File Na...	Ext...	Description
dbsct	c	Setting of B,R Se
sbrk	c	Program of sbrk
iodefine	h	Definition of I/O
intprg	src	Interrupt Program
vecttbl	src	Initialize of Vecto
vect	inc	Definition of Vec
resetprg	c	Reset Program
sbrk	h	Header file of sbr
stacksct	h	Setting of Stack .

For details on the files created in this section, refer to section 2.2, Introduction of Sample Program.

(8) New project - Step7

Specifying “Finish” causes the display of the following screen:



```
-------- PROJECT GENERATOR --------
PROJECT NAME :              sample
PROJECT DIRECTORY :         c:¥sample¥sample
CPU SERIES :                2600
CPU TYPE :                  2621
TOOLCHAIN NAME :            Hitachi H8S,H8/300 Standard Toolch
TOOLCHAIN VERSION :         3.0A.0
GENERATION FILES :
    c:¥sample¥sample¥dbsct.c
        Setting of B,R Section
    c:¥sample¥sample¥sbrk.c
        Program of sbrk
    c:¥sample¥sample¥iodefine.h
        Definition of I/O Register
    c:¥sample¥sample¥intprg.src
        Interrupt Program
    c:¥sample¥sample¥vecttbl.src
        Initialize of Vector Table
```

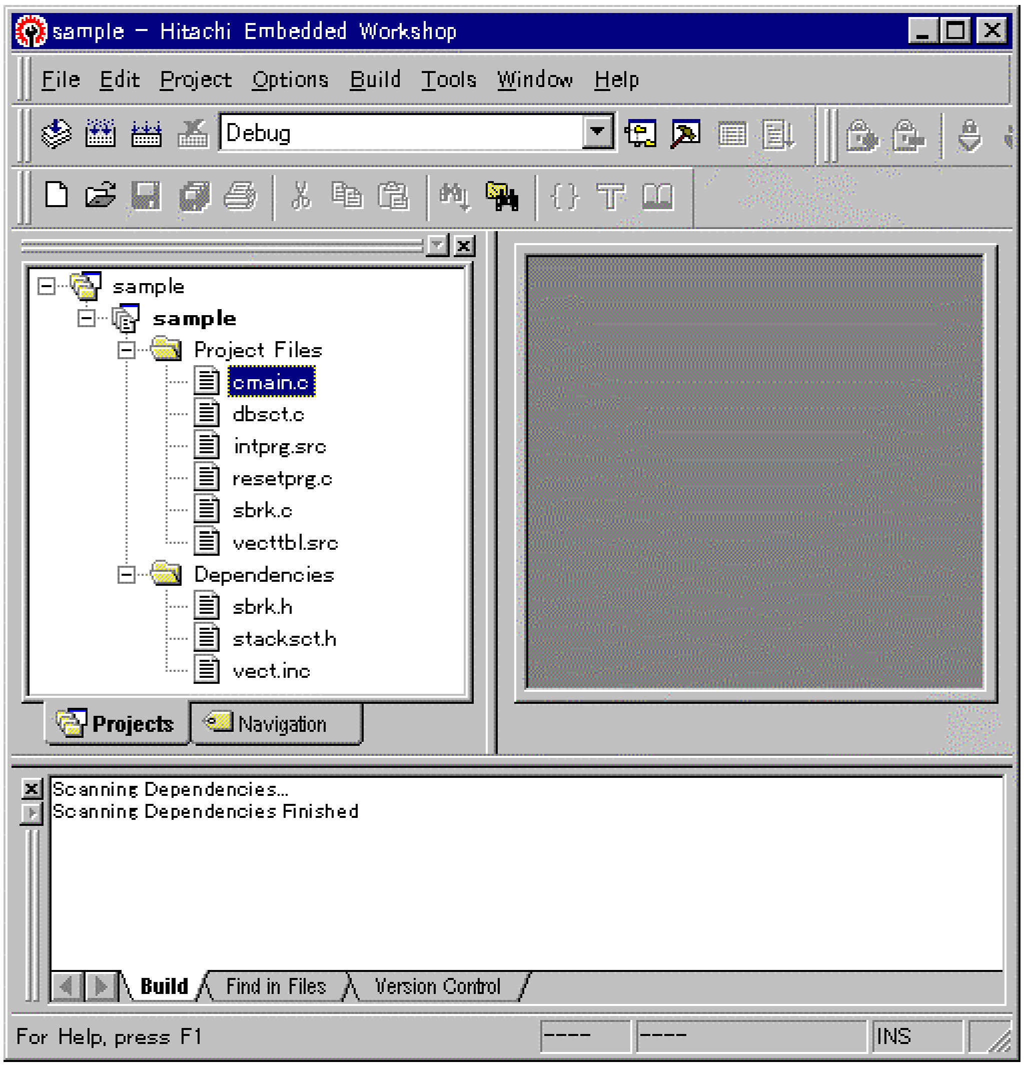
Click OK to generate the project or Cancel to abort.

[✓] Generate Readme.txt as a summary file in the project directory

(9) Adding a main file

Add the cmain.c file for main processing to the project that has been completed.

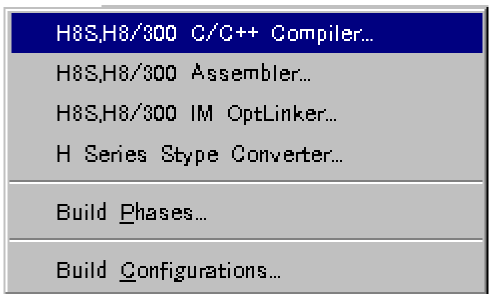
In [Project → Add Files…], specify the HEW directory \Tools\HITACHI\H8\3_0a_0\sample \cmain.c.



```
Scanning Dependencies...
Scanning Dependencies Finished
```

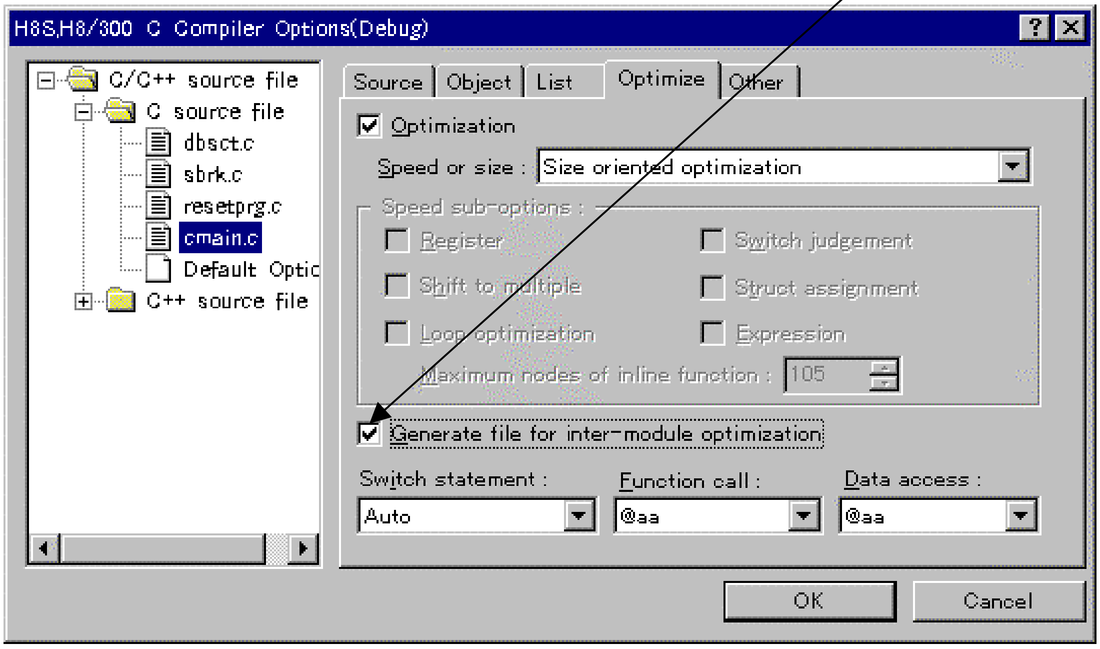
(10) Setting options

Select H8S, H8/300 C/C++ Compiler… from the option menu.


H8S,H8/300 C/C++ Compiler...
H8S,H8/300 Assembler...
H8S,H8/300 IM OptLinker...
H Series Stype Converter...
Build Phases...
Build Configurations...

Specify the compiler options for cmain.c.

On this dialog box, specify the output of an inter-module optimizer add-on information file by checking the item indicated below:



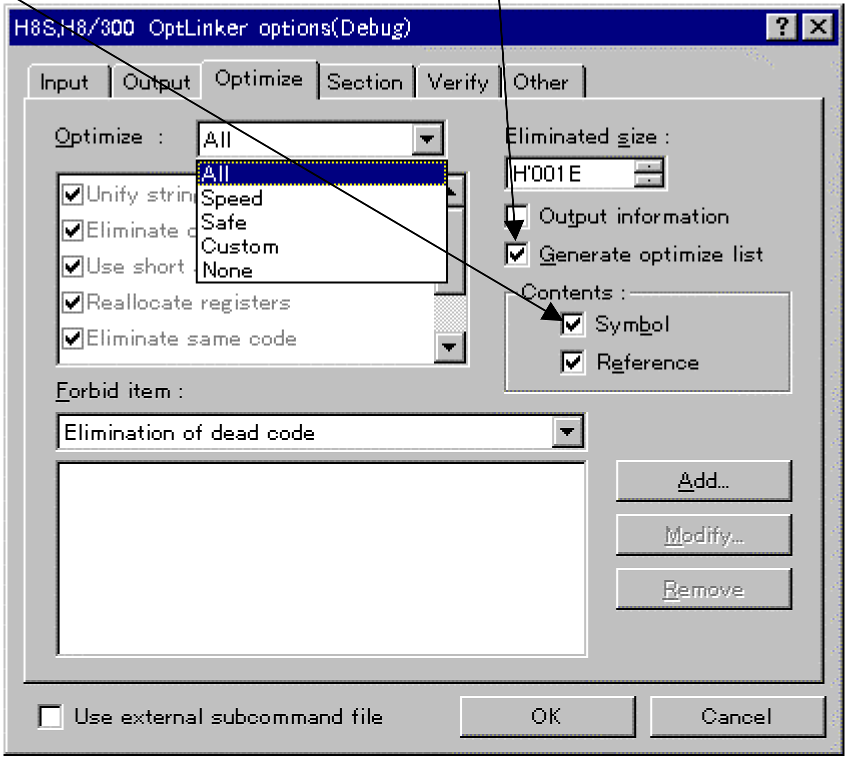
[✓] Optimization
Speed or size : Size oriented optimization
Maximum nodes of inline function : 105
[✓] Generate file for inter-module optimization
Switch statement : Auto
Function call : @aa
Data access : @aa

In the next step, select [Options → H8S,H8/300 IM Optlinker…] to specify options for the inter-module optimizer.

First, in the Optimize tab, specify All to enable all inter-module optimization features.

On this tab, specify the output of an optimization information list here.

Also specify here the output of symbol optimization information and the number of symbol references to this list.


H8S,H8/300 OptLinker options(Debug)

Input | Output | Optimize | Section | Verify | Other

Optimize : All
- All
- Speed
- Safe
- Custom
- None

- [✓] Unify strin
- [✓] Eliminate d
- [✓] Use short
- [✓] Reallocate registers
- [✓] Eliminate same code

Eliminated size : H'001E

- [ ] Output information
- [✓] Generate optimize list

Contents :
- [✓] Symbol
- [✓] Reference

Forbid item : Elimination of dead code

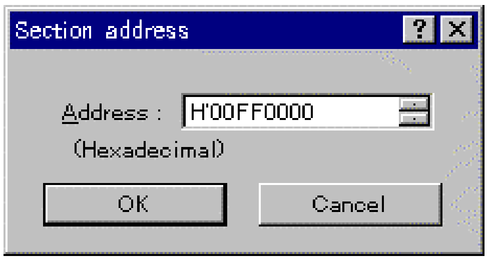
Add... | Modify... | Remove

[ ] Use external subcommand file

OK | Cancel

In the next step, specify in the section tab the way files are to be assigned at linkage.

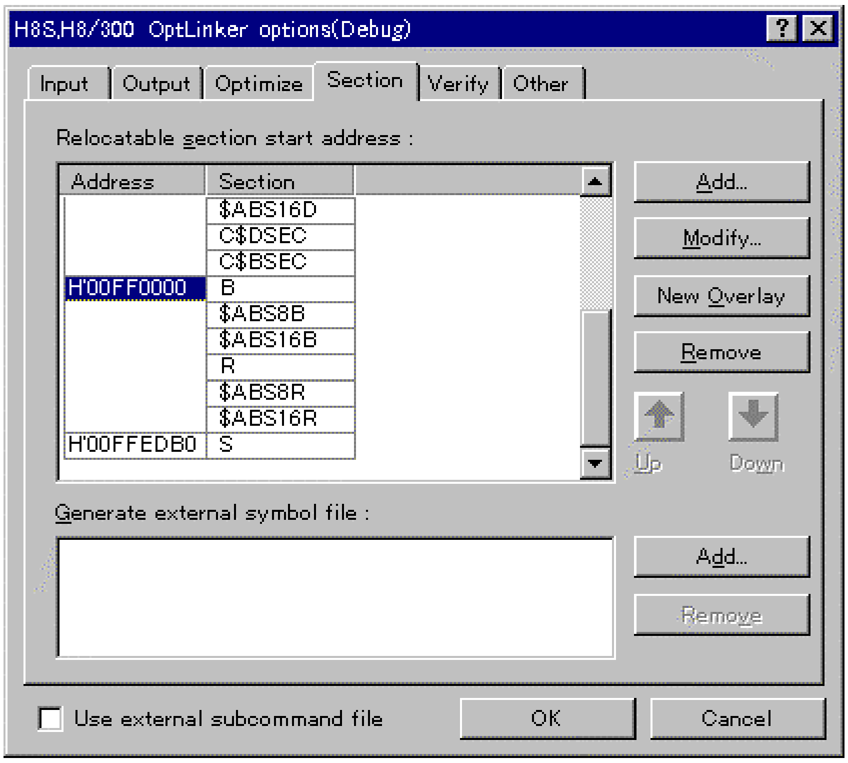
Here, change the address of section to which section B is assigned to H'00FF00. First click the Address field, and press the Modify button to specify the address.


Section address

Address : H'00FF0000
(Hexadecimal)

OK | Cancel

The address is modified as shown below.


H8S,H8/300 OptLinker options(Debug)

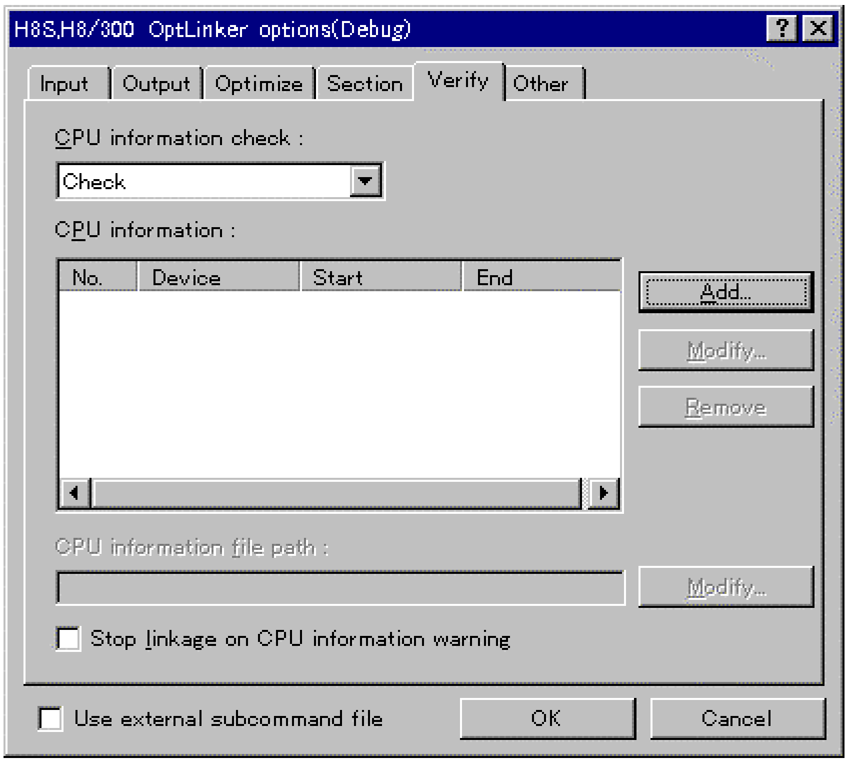
Input | Output | Optimize | Section | Verify | Other

Relocatable section start address :

Address	Section
	$ABS16D
	C$DSEC
	C$BSEC
H'00FF0000	B
	$ABS8B
	$ABS16B
	R
	$ABS8R
	$ABS16R
H'00FFEDB0	S

Generate external symbol file :

In the next step, in the Verify tab, create CPU information to check the CPU assignment.


H8S,H8/300 OptLinker options(Debug)

Input | Output | Optimize | Section | Verify | Other

CPU information check : Check

CPU information :

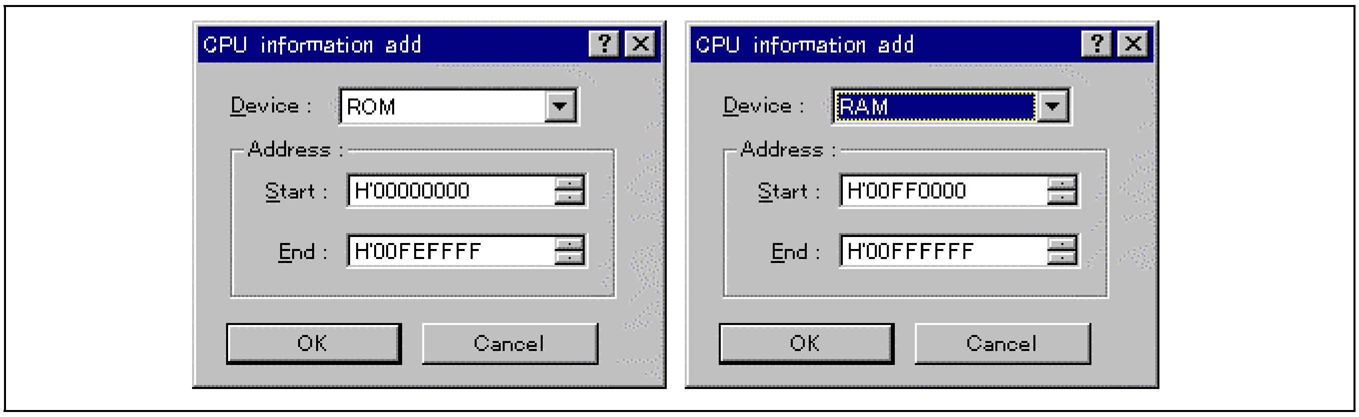
No.	Device	Start	End

CPU information file path :

Stop linkage on CPU information warning

Selecting the Check in the CPU information check field allows the user to check the CPU information.

Pressing the [Add…] button brings up a dialog box, on which the ROM and RAM areas can be specified as shown below.



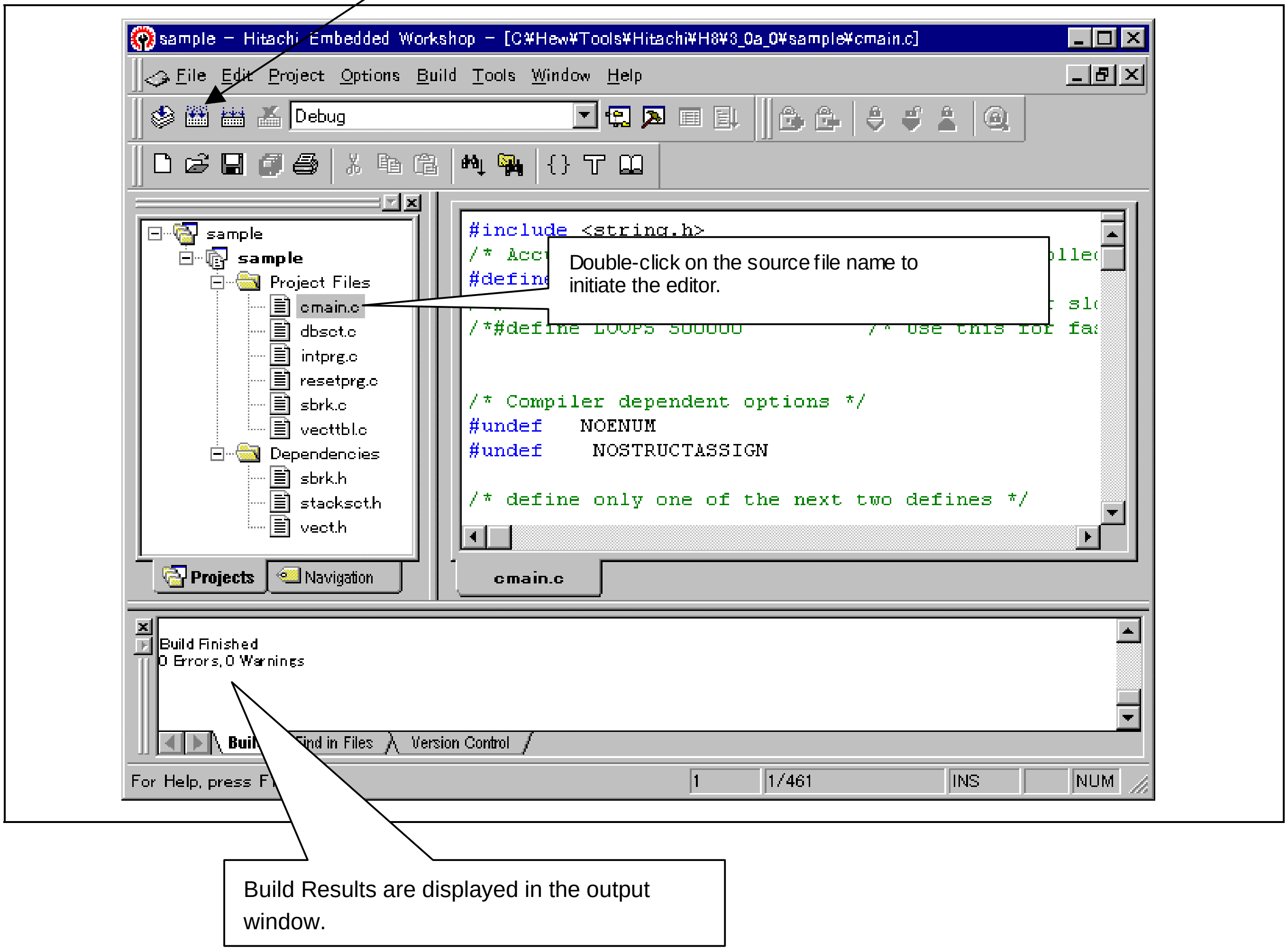
CPU information add
Device : ROM
Address :
Start : H'00000000
End : H'00FEFFFF

CPU information add
Device : RAM
Address :
Start : H'00FF0000
End : H'00FFFFFF

(11) Executing the building process

Execute the building process to generate a load module.

A build can be executed by pressing here on the command button.


sample - Hitachi Embedded Workshop - [C:¥Hew¥Tools¥Hitachi¥H8¥3_0a_0¥sample¥cmain.c]
File Edit Project Options Build Tools Window Help
Debug
sample
sample
Project Files
cmain.c
dbsct.c
intprg.c
resetprg.c
sbrk.c
vecttbl.c
Dependencies
sbrk.h
stacksct.h
vect.h
Projects
Navigation
cmain.c
Build
Find in Files
Version Control
For Help, press F
1
1/461
INS
NUM
Double-click on the source file name to initiate the editor.
Build Results are displayed in the output window.

```
#include <string.h>
/* Acc                                              olle
#defin
                                                  slo
/*#define LOOPS 500000          /* use this for fas

/* Compiler dependent options */
#undef    NOENUM
#undef     NOSTRUCTASSIGN

/* define only one of the next two defines */
```

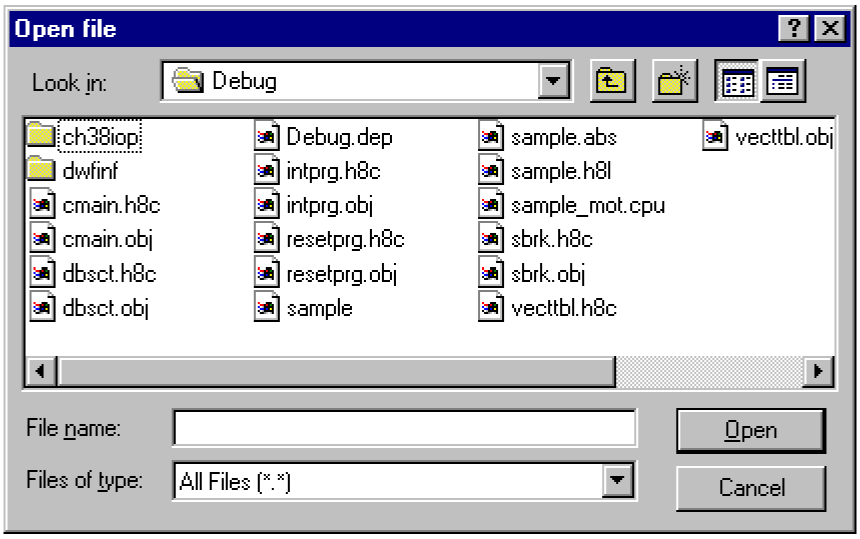
```
Build Finished
0 Errors, 0 Warnings
```

(12) Verifying the generated files

The following files are generated upon completion of the building process:

A directory with the same name as the project name is created under the project directory. The absolute load module is generated under the name format sample.abs in the debug directory in the new directory.

A map file and an optimization information list file generated during the building process are stored in the same directory, and these files can be opened and checked by clicking on [File→Open].

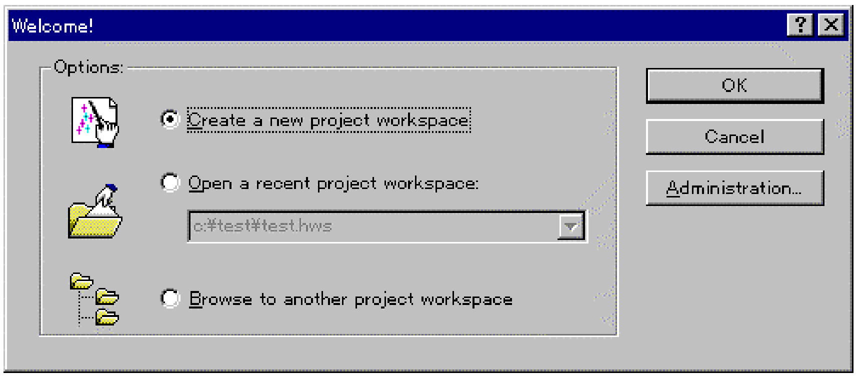


ch38iop	Debug.dep	sample.abs	vecttbl.obj
dwfinf	intprg.h8c	sample.h8l	
cmain.h8c	intprg.obj	sample_mot.cpu	
cmain.obj	resetprg.h8c	sbrk.h8c	
dbsct.h8c	resetprg.obj	sbrk.obj	
dbsct.obj	sample	vecttbl.h8c	

The map file is generated under the name sample.map; the optimization information list file is generated under the name sample.lop.

2.1.2 Creating a New Workspace 2 (HEW2.0)

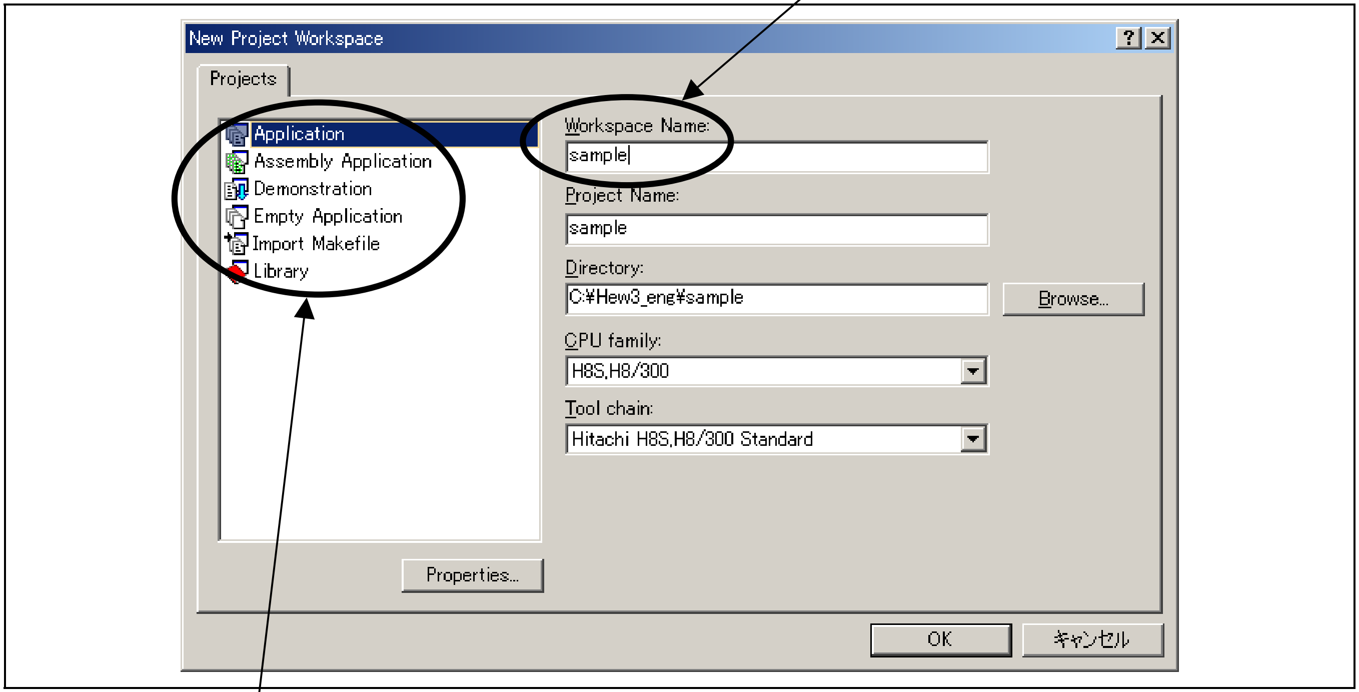
To create a new project workspace, select Create a new project workspace from the Welcome! dialog box.



[✓ Create a new project workspace]
Open a recent project workspace:
c:¥test¥test.hws
Browse to another project workspace

(1) Setting the Project type

When the following screen appears, enter the desired project name in the **Name** field:


New Project Workspace

Projects: Application, Assembly Application, Demonstration, Empty Application, Import Makefile, Library

Workspace Name: sample

Project Name: sample

Directory: C:¥Hew3_eng¥sample

CPU family: H8S,H8/300

Tool chain: Hitachi H8S,H8/300 Standard

Then, select the **Project type**: column.

Project type	**Description**
Application	A project type when creating an application that includes C/C++ program files
Assembly Application	A project type when creating an application that includes assembly language programs only
Demonstration	Sample project type
Empty Application	Empty project creation
Library	Library creation project type

In this dialog box, set a workspace name (when creating a new workspace project, the project name is the same by default), CPU type and a project type.

If you enter “sample” in the [Workspace Name] field as the workspace name, the [Project Name] will be “sample” and the [Directory] will also be “c:\hew2\ sample.”To change the project name, directly type a name in the [Project Name] field. To change the directory to be used as the workspace, select the Directory by clicking [Browse...] or directly enter a directory path in the [Directory] field.

By clicking the [OK] button after selecting the desired project type, you can move on to the step for initializing the new project.

The explanation below assumes that you have selected Application as a project type.

(2) New project – 1/9

Specify the CPU to be used and press NEXT>.

Clicking on the [OK] button in New Project Worksapce dialogue box starts up the project generator. First, select the CPU to be used. The type of CPU to be used ([CPU Type]) is classified for each CPU series ([CPU Series:]). Select the CPU type for the program to be developed because the files to be generated differ depending on the selection of [CPU Series:] and [CPU Type:]. If the desired CPU type is not available, select the CPU type with similar hardware specification or "other".

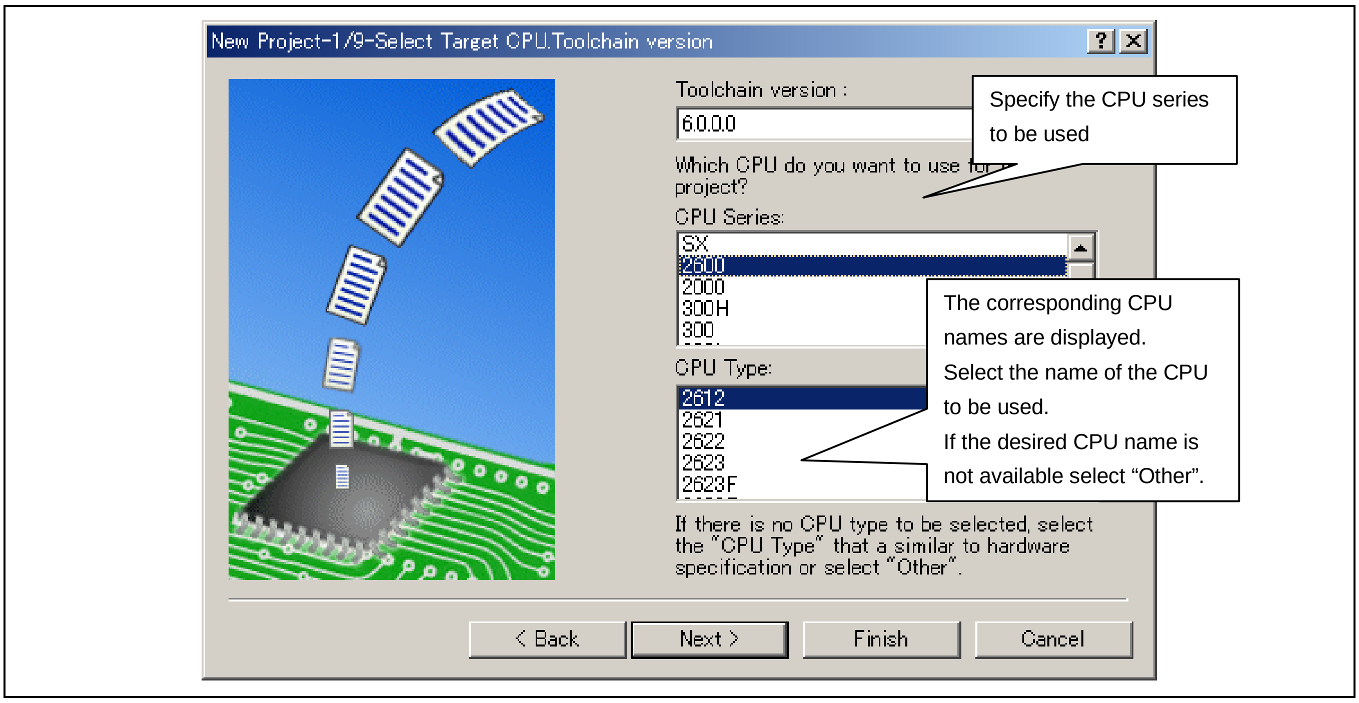
Click NEXT> to display the following screen.

Click <Back to display the previous screen or the previous dialog box after this screen.

Click Finish to open the Summary dialog box.

Click Cancel to retrieve New Workspace dialog box.

The functions of <Back, NEXT>, Finish, and Cancel are common on this wizard dialogue box.


New Project-1/9-Select Target CPU.Toolchain version

Toolchain version : 6.0.0.0

Which CPU do you want to use for project?

CPU Series: SX, 2600, 2000, 300H, 300

CPU Type: 2612, 2621, 2622, 2623, 2623F

If there is no CPU type to be selected, select the "CPU Type" that a similar to hardware specification or select "Other".

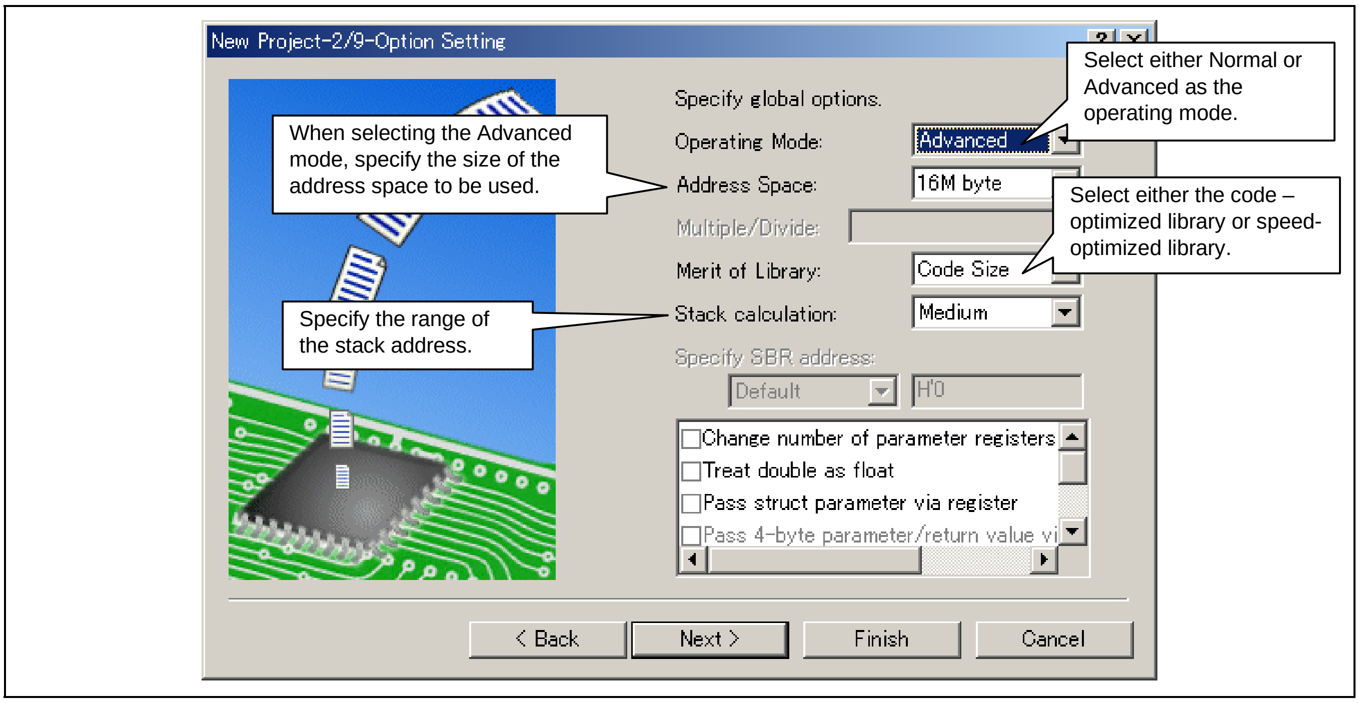
Specify the CPU series to be used

The corresponding CPU names are displayed. Select the name of the CPU to be used. If the desired CPU name is not available select "Other".

(3) New project – 2/9

Specify the desired global options and press NEXT>.

On this screen, set the options common to all the project files. Items for setting options may be changed according to the CPU series that has been selected on the Step 1 screen. If you change the options after the project has been created, you can do it on [CPU Tab] of [Options->H8S,H8/300 Standard Toolchain] in HEW.


New Project-2/9-Option Setting

Specify global options.

Operating Mode: Advanced

Address Space: 16M byte

Multiple/Divide:

Merit of Library: Code Size

Stack calculation: Medium

Specify SBR address: Default H'0

- [ ] Change number of parameter registers
- [ ] Treat double as float
- [ ] Pass struct parameter via register
- [ ] Pass 4-byte parameter/return value vi

When selecting the Advanced mode, specify the size of the address space to be used.

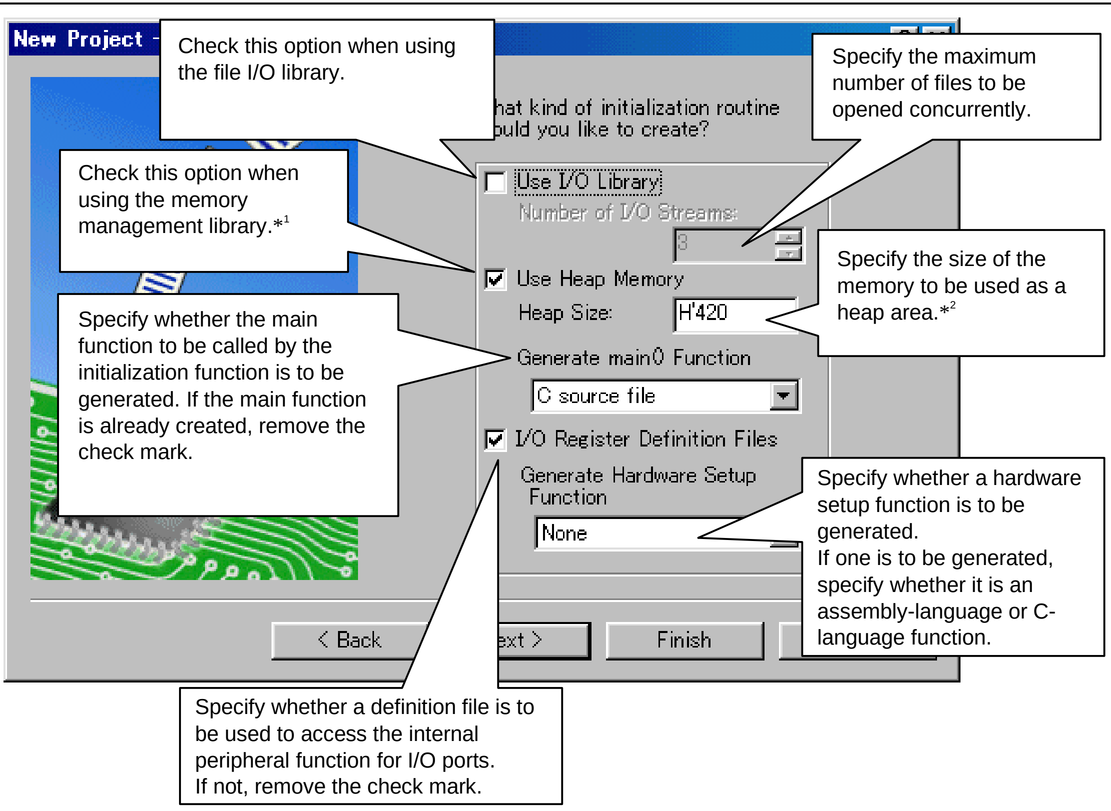
Specify the range of the stack address.

Select either Normal or Advanced as the operating mode.

Select either the code – optimized library or speed-optimized library.

(4) New project – 3/9

On this screen, specify the contents of an initialization program and press NEXT>.


New Project
hat kind of initialization routine
ould you like to create?
Use I/O Library
Number of I/O Streams:
3
Use Heap Memory
Heap Size:
H'420
Generate main() Function
C source file
I/O Register Definition Files
Generate Hardware Setup Function
None
< Back
ext >
Finish
Check this option when using the file I/O library.
Specify the maximum number of files to be opened concurrently.
Check this option when using the memory management library.*1
Specify the size of the memory to be used as a heap area.*2
Specify whether the main function to be called by the initialization function is to be generated. If the main function is already created, remove the check mark.
Specify whether a hardware setup function is to be generated. If one is to be generated, specify whether it is an assembly-language or C-language function.
Specify whether a definition file is to be used to access the internal peripheral function for I/O ports. If not, remove the check mark.

Notes: 1. Available memory library functions are malloc, realloc, calloc, and new.

2. The required size for a heap area can be calculated as follows:

(Heap area size) ≥
(Area size allocated by memory management library) + (Management area size)

The management area sizes are as follows:

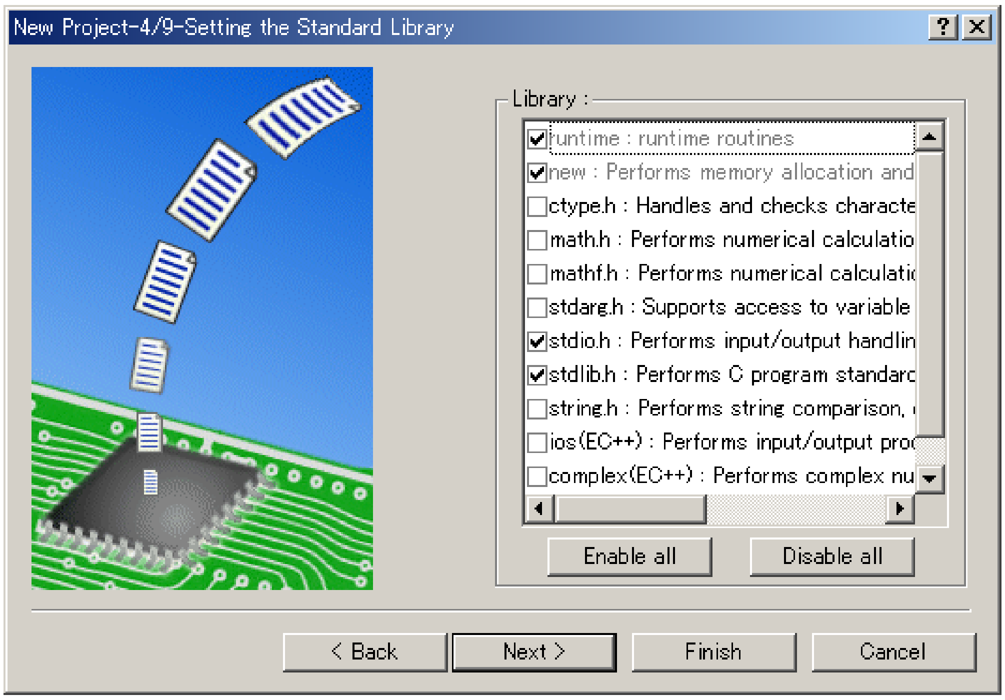
CPU Type	Management Area Size
H8S/2600 ADV,H8S/2000 ADV, H8/300H ADV	16 bytes
H8S/2600 NRM,H8S/2000 NRM,H8/300H NRM,H8/300	8 bytes

ADV: advanced mode; NRM: normal mode

To modify the heap area size specified in this section after the new project has been initialized, refer to section 2.2.1 (2), Allocating a heap area.

(5) New project – 4/9

On this screen, determine a standard library organization to be used by the C/C++ compiler. If you change the standard library organization after the project has been created, you can do it on [Standard Library Tab] of [Options->H8S,H8/300 Standard Toolchain...] in HEW.



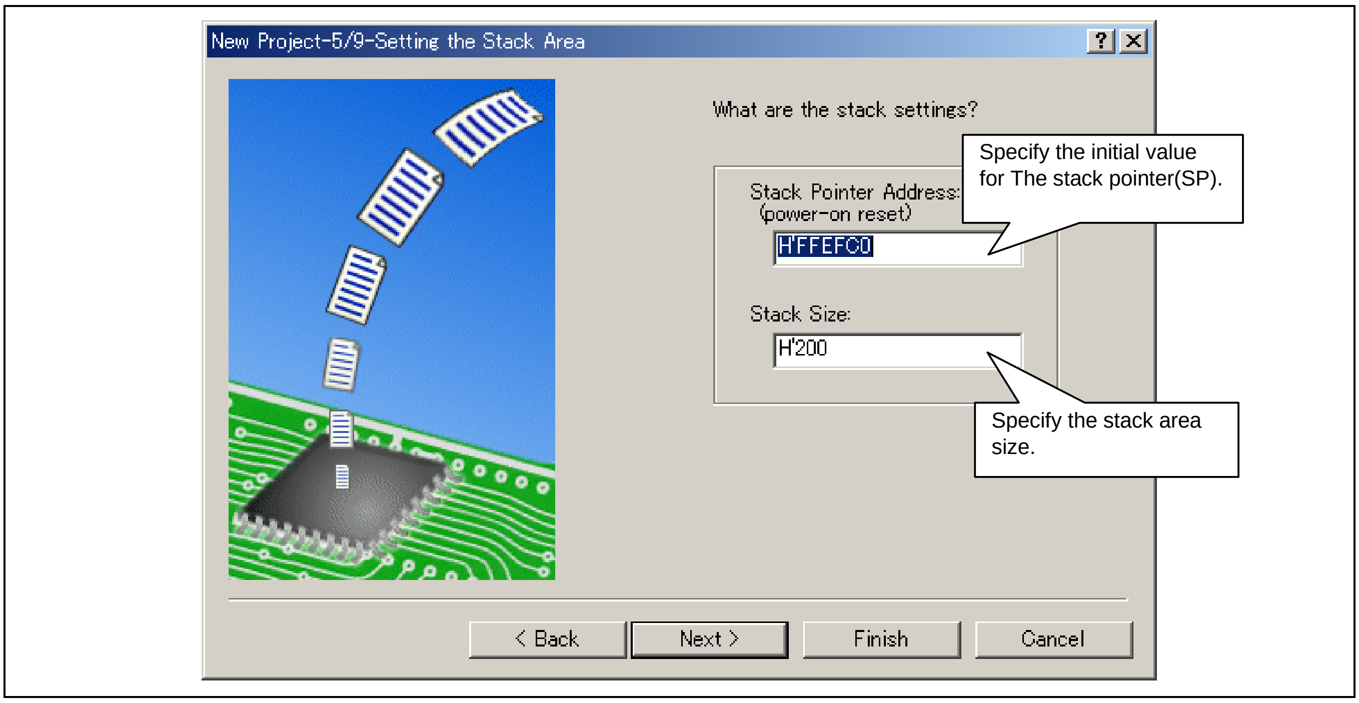
- [✓] runtime : runtime routines
- [✓] new : Performs memory allocation and
- [ ] ctype.h : Handles and checks characte
- [ ] math.h : Performs numerical calculatio
- [ ] mathf.h : Performs numerical calculati
- [ ] stdarg.h : Supports access to variable
- [✓] stdio.h : Performs input/output handlin
- [✓] stdlib.h : Performs C program standard
- [ ] string.h : Performs string comparison,
- [ ] ios(EC++) : Performs input/output proc
- [ ] complex(EC++) : Performs complex nu

(6) New project – 5/9

Set the stack to be used and press NEXT>.

On this screen, set the stack area. Initialized values to be set as stack area vary with [CPU Type:] on the Step 1 screen.

If you change the stack size after the project has been created, you can do it on [Project->Edit ProjectConfiguration] in HEW.


New Project-5/9-Setting the Stack Area

What are the stack settings?

Stack Pointer Address: (power-on reset) H'FFEFC0

Stack Size: H'200

Specify the initial value for The stack pointer(SP).

Specify the stack area size.

The size of the stack to be used can be determined as follows:

Calculate the size of the stack area for the deepest nest of calls in the call relationships among the functions. The maximum value obtained in this manner is the stack area size.

For example, if the deepest function call nest is the following, sum all the stack sizes:

main function (stack size: 10 bytes) → func function (20 bytes) → sub function (30 bytes)

The stack size in this case will be 60 bytes.

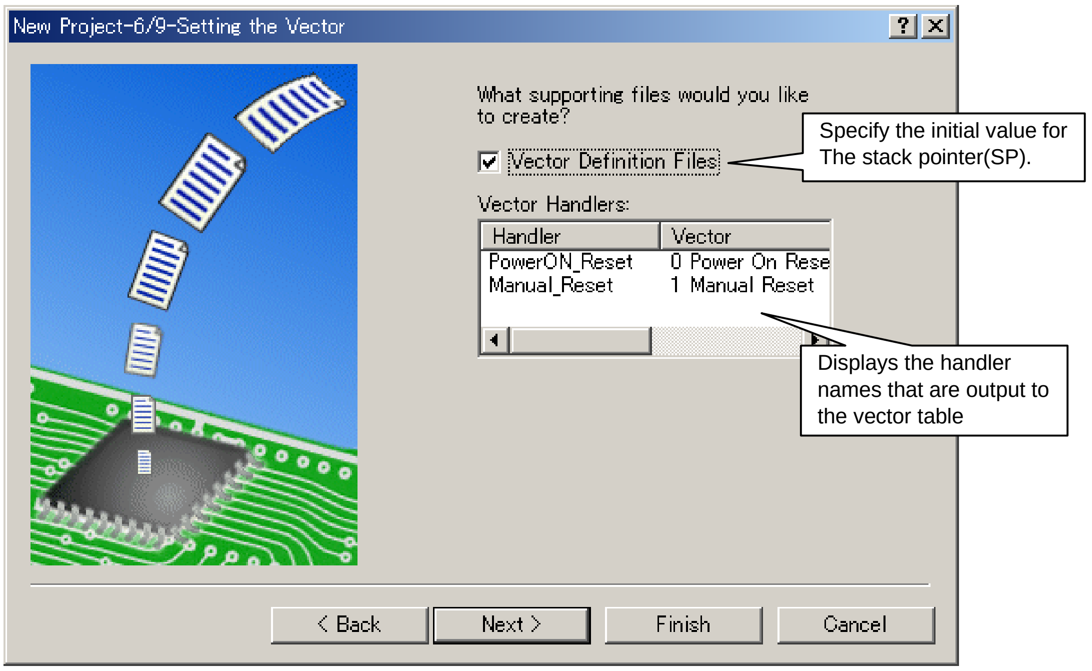
The stack sizes for functions are output when symbol allocation information output is specified as part of a specification for object list file output.

The maximum space of stack area to be used by C/C++ programs and standard library can be calculated by stack analysis tools when stack information file is output by specifying the stack option of Optimizing Linkage Editor. For details on how to use stack analysis tools, refer to section 6, Operating Stack Analysis Tool, in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

(7) New project – 6/9

Specify the settings for a vector table and press NEXT>.

To modify Handler Program, select the Handler Program name, click on it, and then enter. Note that the reset program (reserprg.c) is not generated once the Handler Program is modified.


New Project-6/9-Setting the Vector

What supporting files would you like to create?

☑ Vector Definition Files

Vector Handlers:

Handler	Vector
PowerON_Reset	0 Power On Rese
Manual_Reset	1 Manual Reset

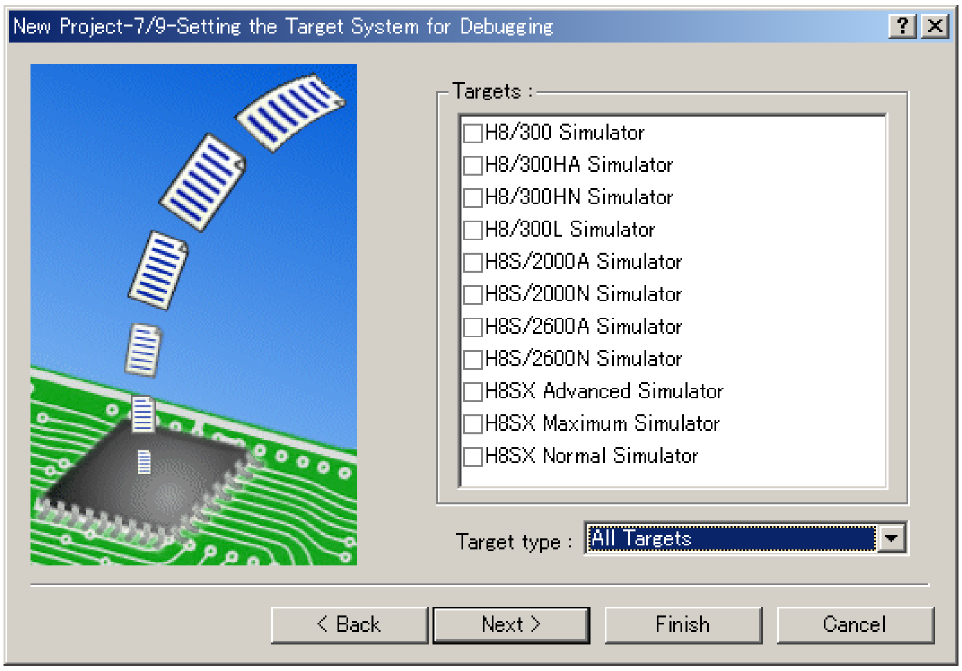
Specify the initial value for The stack pointer(SP).

Displays the handler names that are output to the vector table

(8) New project – 7/9

Specify the debugger target and press NEXT>.

Select (Check) the debugger target to be used from [Target:]. You can select either no debugger target or multiple debugger targets.



New Project-7/9-Setting the Target System for Debugging

Targets :

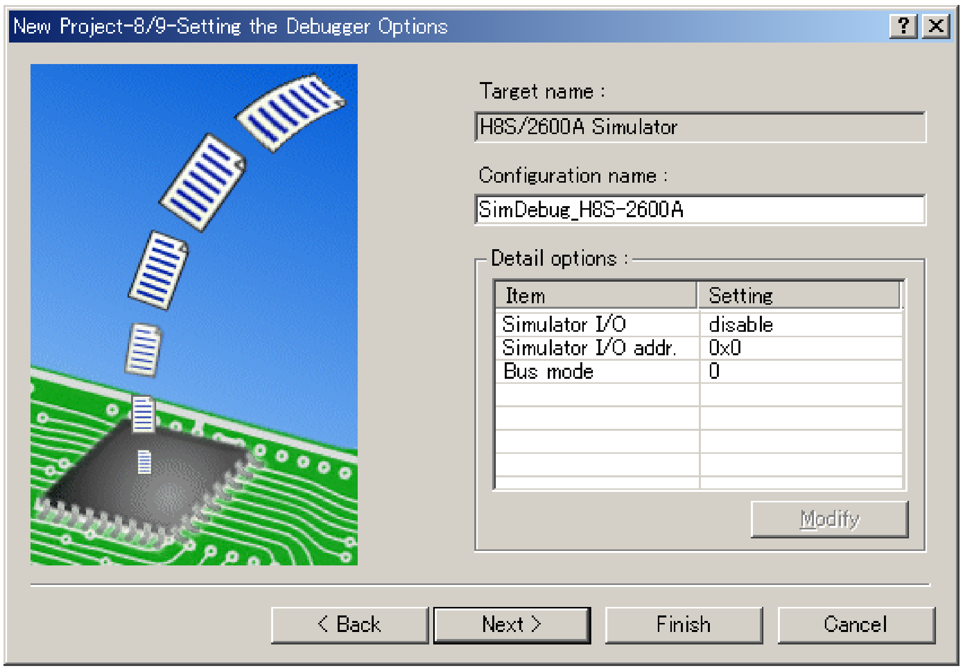
- [ ] H8/300 Simulator
- [ ] H8/300HA Simulator
- [ ] H8/300HN Simulator
- [ ] H8/300L Simulator
- [ ] H8S/2000A Simulator
- [ ] H8S/2000N Simulator
- [ ] H8S/2600A Simulator
- [ ] H8S/2600N Simulator
- [ ] H8SX Advanced Simulator
- [ ] H8SX Maximum Simulator
- [ ] H8SX Normal Simulator

Target type : All Targets

(9) New project – 8/9

Set the options for the selected debugger target and press NEXT>.

By default, the HEW creates two configurations, "Release" and "Debug". When a target for debugging is selected, the HEW creates another configuration. (The name of the target is included.) The name of the configuration can be modified in [Configuration name:]. Options to do with the target for debugging are displayed under [Detail options:]. To change the settings, select [Item] and then click [Modify]. When items for which modification is not possible are selected, [Modify] remains grayed even if [Item] is selected.



Target name :
H8S/2600A Simulator

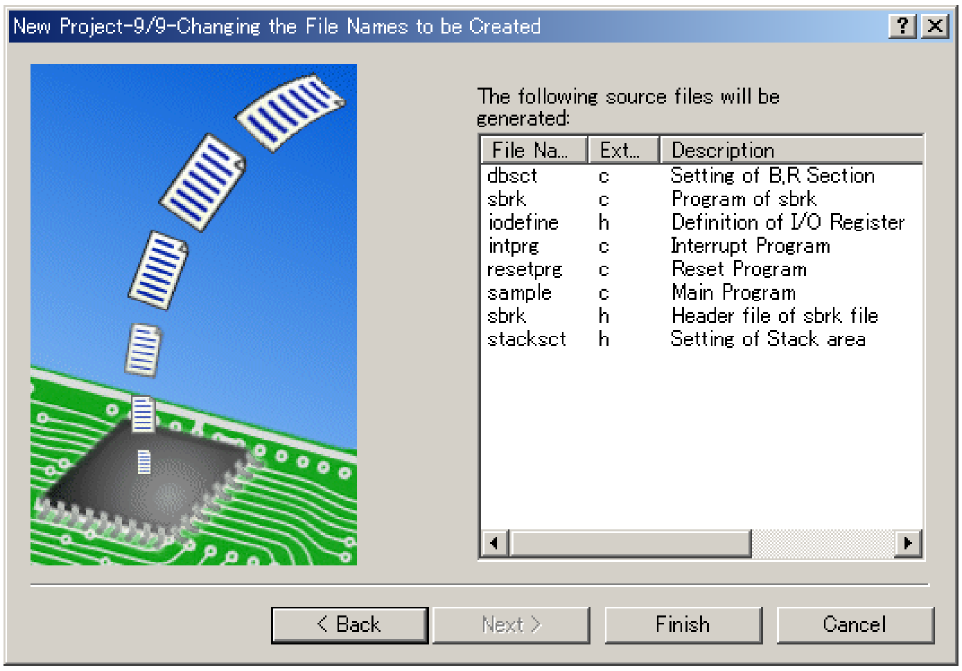
Configuration name :
SimDebug_H8S-2600A

Detail options :

Item	Setting
Simulator I/O	disable
Simulator I/O addr.	0x0
Bus mode	0

(10) New project – 9/9

Displays the files created by the project generator. Then press Finish.



The following source files will be generated:

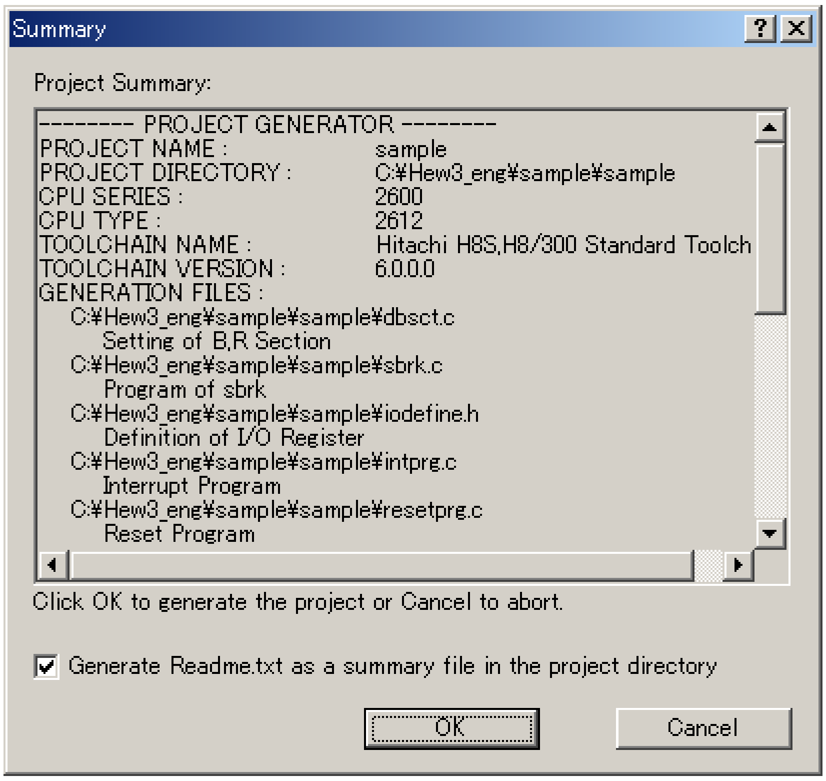
File Na...	Ext...	Description
dbsct	c	Setting of B,R Section
sbrk	c	Program of sbrk
iodefine	h	Definition of I/O Register
intprg	c	Interrupt Program
resetprg	c	Reset Program
sample	c	Main Program
sbrk	h	Header file of sbrk file
stacksct	h	Setting of Stack area

For details on the files created in this section, refer to section 2.2, Introduction of Sample Program.

(11) New project - Summary

Clicking [Finish >] on the Step 9 screen causes the project generator to display information on the projects to be generated in the Summary dialog box. Check them and then click [OK].

The information on the projects displayed in the Summary dialog box can be saved as a text file named “Readme.txt” in the Project Directory by checking [Generate Readme.txt as a summary file in the project directory].



```
-------- PROJECT GENERATOR --------
PROJECT NAME :              sample
PROJECT DIRECTORY :         C:¥Hew3_eng¥sample¥sample
CPU SERIES :                2600
CPU TYPE :                  2612
TOOLCHAIN NAME :            Hitachi H8S,H8/300 Standard Toolch
TOOLCHAIN VERSION :         6.0.0.0
GENERATION FILES :
   C:¥Hew3_eng¥sample¥sample¥dbsct.c
      Setting of B,R Section
   C:¥Hew3_eng¥sample¥sample¥sbrk.c
      Program of sbrk
   C:¥Hew3_eng¥sample¥sample¥iodefine.h
      Definition of I/O Register
   C:¥Hew3_eng¥sample¥sample¥intprg.c
      Interrupt Program
   C:¥Hew3_eng¥sample¥sample¥resetprg.c
      Reset Program
```

Click OK to generate the project or Cancel to abort.

[✓] Generate Readme.txt as a summary file in the project directory

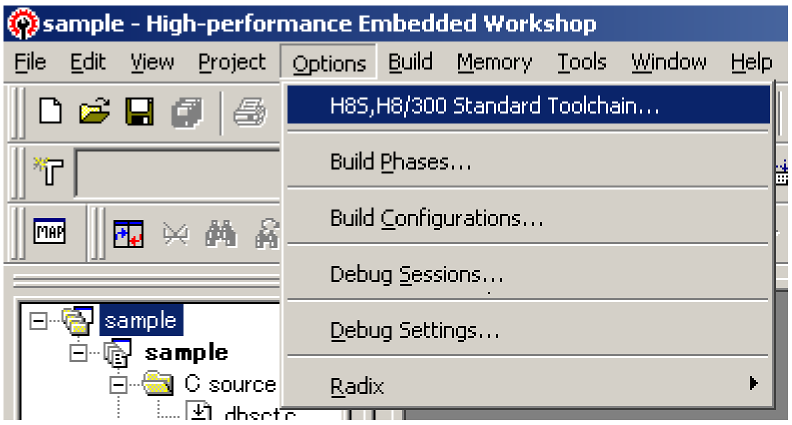
(12) Other

If demonstration is selected from Project Type, low-level library sample that can be used at simulator debugging will be included. The files to be added are as follows:

- lowlvl.src (Standard I/O Sample Assembler List)
- lowsrc.c (Low-level Library Source File)
- lowsrc.h (Low-level Library Header File)

(13) Setting options

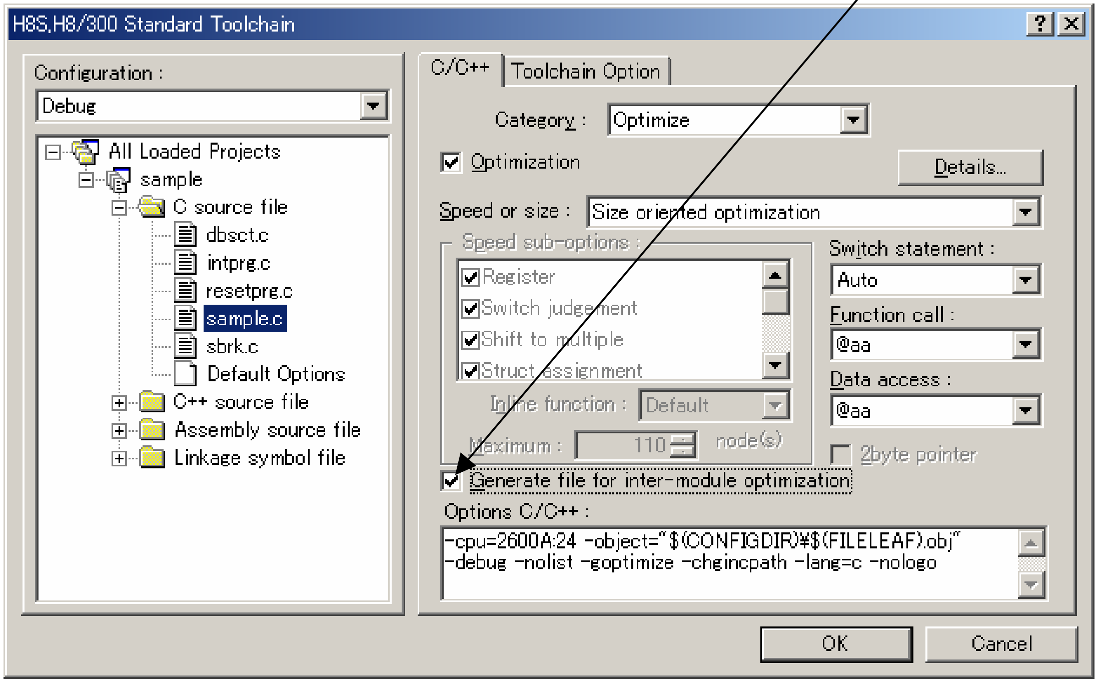
Select H8S, H8/300 Standard Toolchain... from the options menu.


sample - High-performance Embedded Workshop
File Edit View Project Options Build Memory Tools Window Help
H8S,H8/300 Standard Toolchain...
Build Phases...
Build Configurations...
Debug Sessions...
Debug Settings...
Radix
sample
sample
C source
dbsct.c

Specify the compiler options for sample.c.

Select [C/C++ Tab] [Category/Optimize] of [Options->H8S,H8/300 Standard Toolchain] in HEW.

On this dialog box, specify the output of an Inter-module optimizer add-on information by checking the item indicated below:



Configuration : Debug

Category : Optimize

☑ Optimization

Speed or size : Size oriented optimization

Inline function : Default

Maximum : 110

Switch statement : Auto

Function call : @aa

Data access : @aa

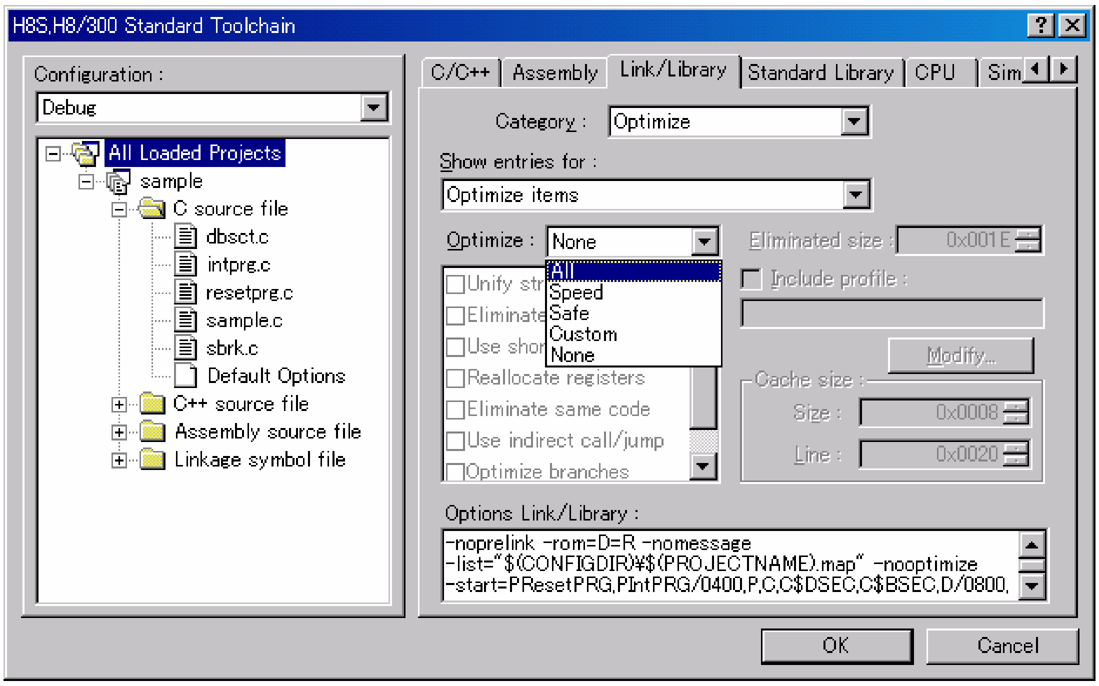
☑ Generate file for inter-module optimization

Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -nolist -goptimize -chgincpath -lang=c -nologo
```

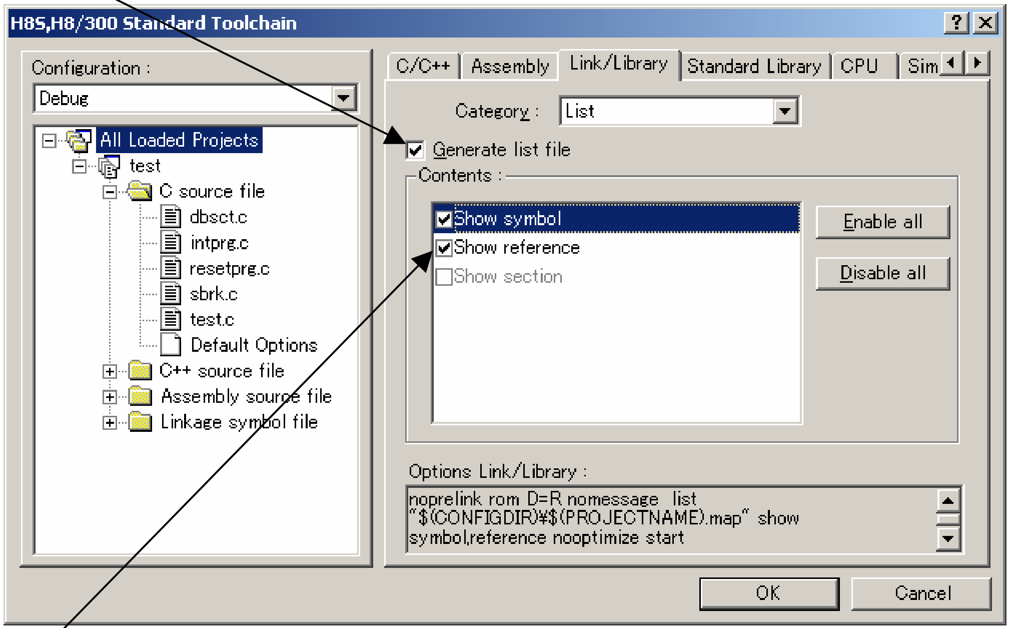
In the next step, specify All Loaded Project in the Project File List to select [Link/Library Tab] [Category/Optimize], and specify the options for inter-module optimizer.

First, in the Optimize tab, specify All to enable all inter-module optimization features.



```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

Also specify here to output an optimization information list on the [Link/Library Tab] [Category/List].

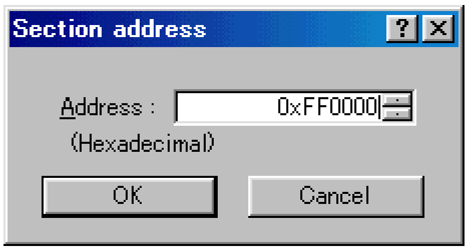


```
noprelink rom D=R nomessage  list
"$(CONFIGDIR)¥$(PROJECTNAME).map" show
symbol,reference nooptimize start
```

Also specify here the output of symbol optimization information and the number of symbol references to this list.

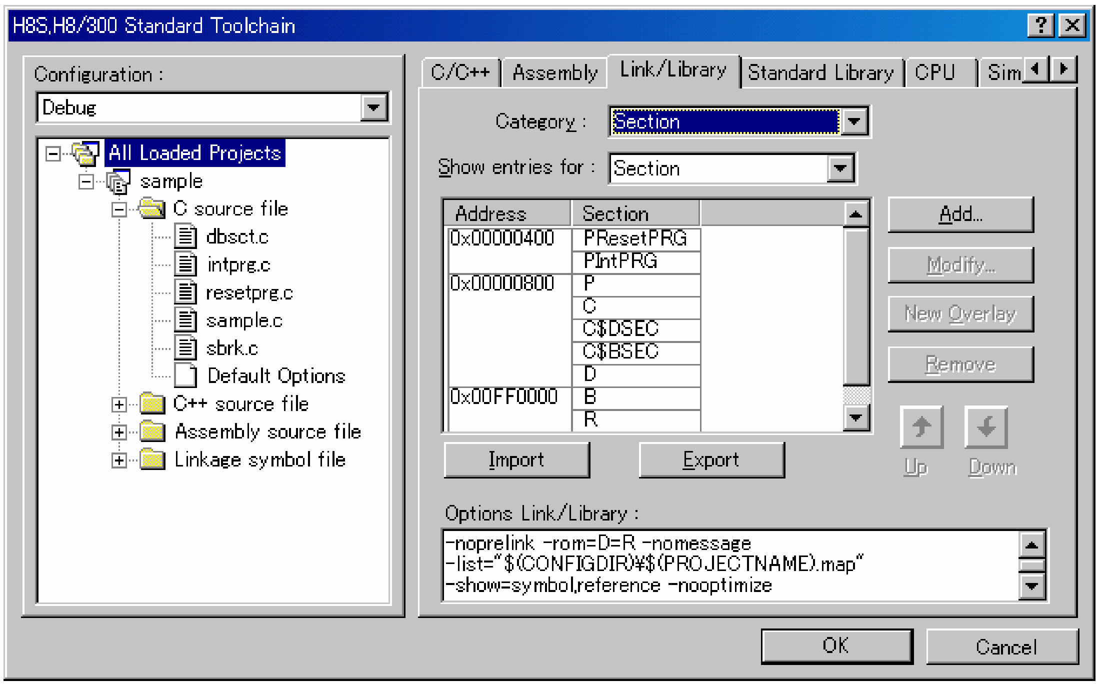
In the next step, specify in the [Link/Library Tab] [Category/Section] the way files are to be assigned at linkage.

Here, change the address of section to which section B is assigned to H’00FF0000. First click the Address field, and press the Modify button to specify the address.



Address : 0xFF0000

The address is modified as shown below.



Configuration : Debug

Category : Section

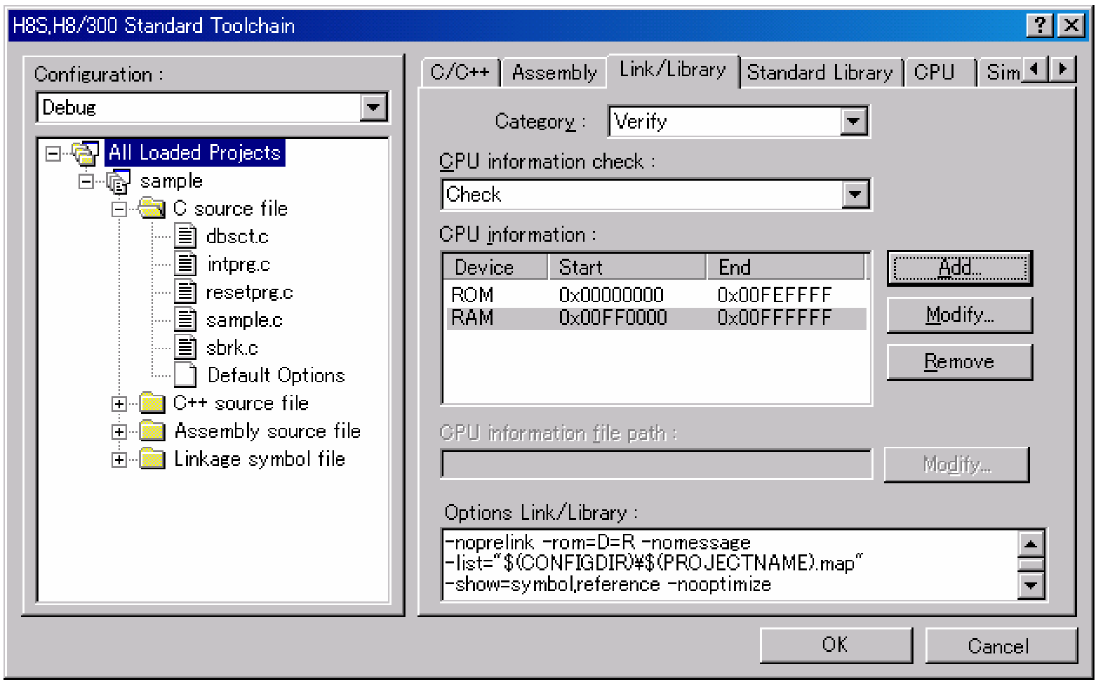
Show entries for : Section

Address	Section
0x00000400	PResetPRG
	PIntPRG
0x00000800	P
	C
	C$DSEC
	C$BSEC
	D
0x00FF0000	B
	R

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map"
-show=symbol,reference -nooptimize
```

In the next step, in the [Link/Library Tab] [Category/Verify], create CPU information to check the CPU assignment.



Category : Verify

CPU information check : Check

CPU information :

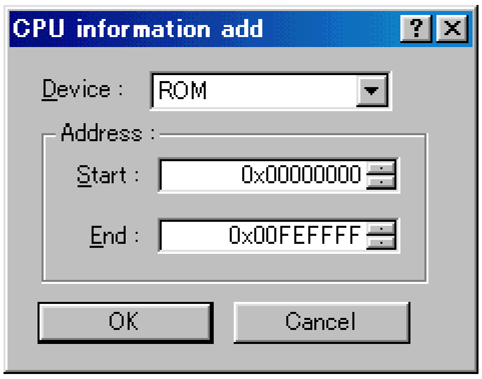
Device	Start	End
ROM	0x00000000	0x00FEFFFF
RAM	0x00FF0000	0x00FFFFFF

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map"
-show=symbol,reference -nooptimize
```

Selecting the Check in the CPU information check field allows the user to check the CPU information.

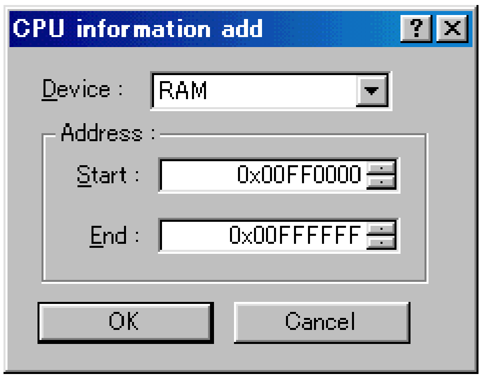
Pressing the [Add…] button brings up a dialog box, on which the ROM and RAM areas can be specified as shown below.



Device : ROM

Start : 0x00000000

End : 0x00FEFFFF



Device : RAM

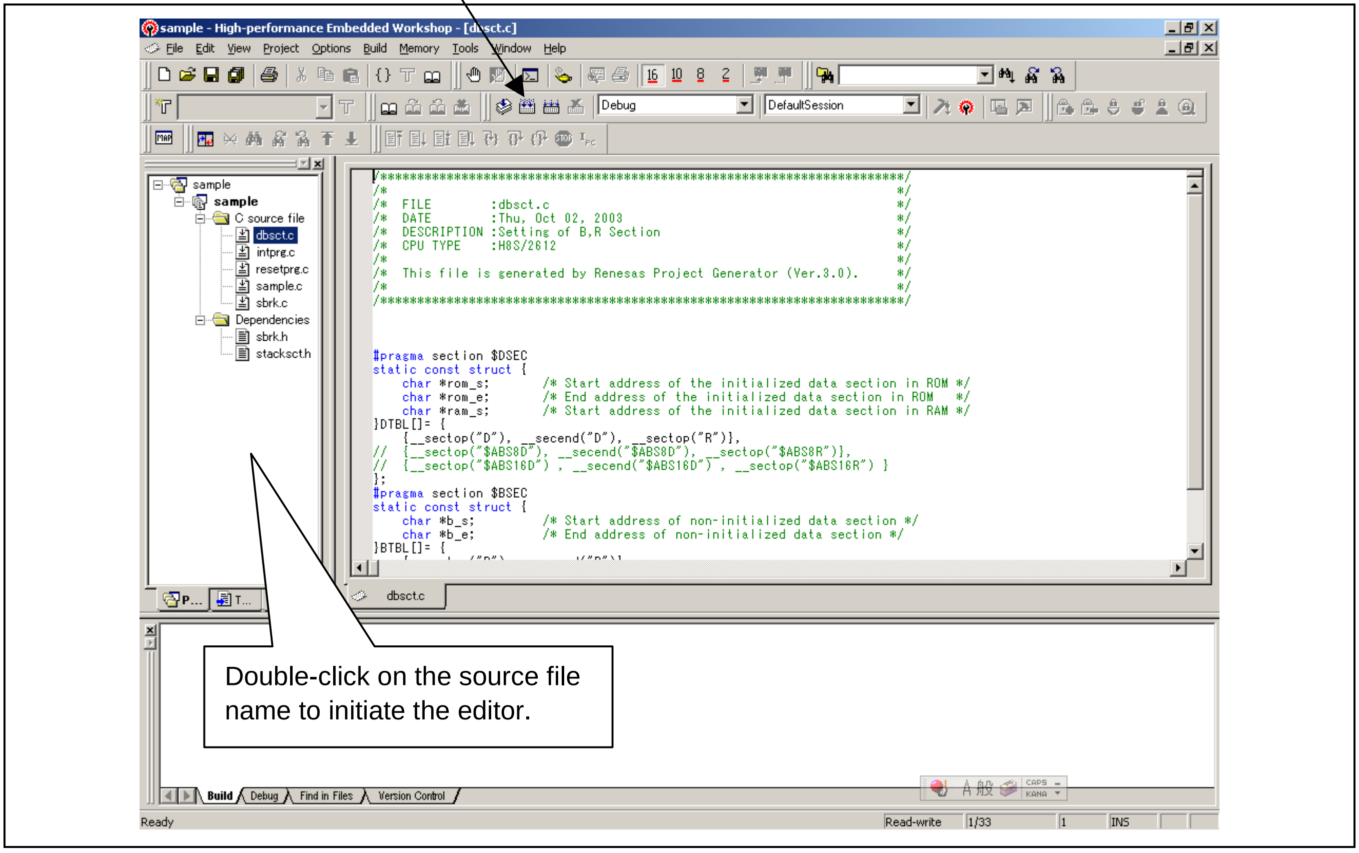
Start : 0x00FF0000

End : 0x00FFFFFF

(14) Executing the building process

Execute the building process to generate a load module.

A build can be executed by pressing here on the command button.



```
/***********************************************************************/
/*                                                                     */
/*  FILE        :dbsct.c                                               */
/*  DATE        :Thu, Oct 02, 2003                                     */
/*  DESCRIPTION :Setting of B,R Section                                */
/*  CPU TYPE    :H8S/2612                                              */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/



#pragma section $DSEC
static const struct {
    char *rom_s;        /* Start address of the initialized data section in ROM */
    char *rom_e;        /* End address of the initialized data section in ROM   */
    char *ram_s;        /* Start address of the initialized data section in RAM */
}DTBL[]= {
    {__sectop("D"), __secend("D"), __sectop("R")},
//  {__sectop("$ABS8D"), __secend("$ABS8D"), __sectop("$ABS8R")},
//  {__sectop("$ABS16D") , __secend("$ABS16D") , __sectop("$ABS16R") }
};
#pragma section $BSEC
static const struct {
    char *b_s;          /* Start address of non-initialized data section */
    char *b_e;          /* End address of non-initialized data section */
}BTBL[]= {
```

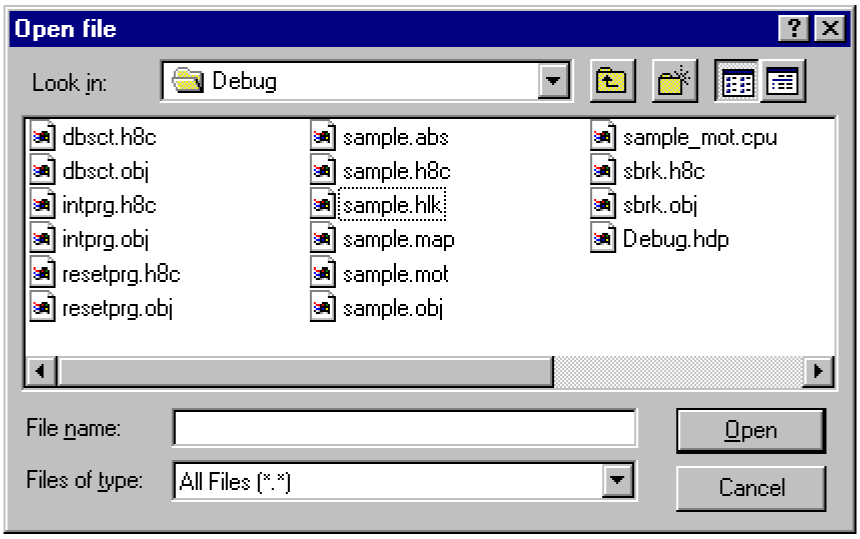
Double-click on the source file name to initiate the editor.

(15) Verifying the generated files

The following files are generated upon completion of the building process:

A directory with the same name as the project name is created under the project directory. The absolute load module is generated under the name format sample.abs in the debug directory in the new directory.

A map file generated during the building process is stored in the same directory, and this file can be opened and checked by clicking on [File→Open].



The map file is generated under the name sample.map.

2.1.3 Starting Tools from a Command Line

Tools can be started from a command line as follows:

This example uses an H8S/2600 advanced mode CPU.

In HEW1.2, sample programs are supplied in the HEW directory ¥Tools¥HITACHI\H8¥3_0a_0\sample.

No.	HEW1.2 File	Description
1	init.c	Initialization routine
2	vectbl.c	Vector table settings
3	scttbl.c	Section initialization routine
4	cmain.c	Main function file
5	2600a.cpu	CPU information file
6	c2600a.sub	Subcommand file for inter-module optimizer

Sample programs are not available with HEW2.0 or later. Therefore the sample programs of user's own make should be prepared or the following files to be generated when creating sample project should be used as sample programs.

Create a sample project by selecting Demonstration as the project type setting according to section 2.1.2, Creating a New Workspace 2 (HEW2.0).

No.	HEW2.0 or later File	Description
1	resetprg.c	Initialization routine
2	intprg.c	Vector table settings
3	dbsct.c	Section initialization routine
4	main.c	Main function file
5	2600a.sub(user's own make)	Subcommand file

(1) Set the desired environment

- PC version
  set path=<HEW install directory>\tools\hitachi\h8\v3_0a_0\bin;%path%
  set CH38=<HEW install directory>\tools\hitachi\h8\v3_0a_0\include
  set hlnk_linrary1=<HEW install directory>\tools\hitachi\h8\v3_0a_0\lib\c8s26a.lib
- unix version
  Refer to section 1.3, Installation Method.

(2) Compile

Compile the C program files.

ch38Δ–cpu=2600aΔ–debugΔinit.cΔvectbl.cΔscttbl.c (RET)

ch38Δ–cpu=2600aΔ–debugΔ-show=allocation,objectΔ-goptimizeΔcmain.c (RET)

(3) Create a CPU information file. (The address range can be specified only for HEW1.2 and not for HEW2.0 or later.)

In the unix version, start the cia38 to specify the ROM/RAM address range to be used.

For a description of how to use the cia38, refer to appendix J, Creating a CPU Information File, in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

In the PC version, you can use the HEW. Refer to section 2.1.1 (10), Setting options.

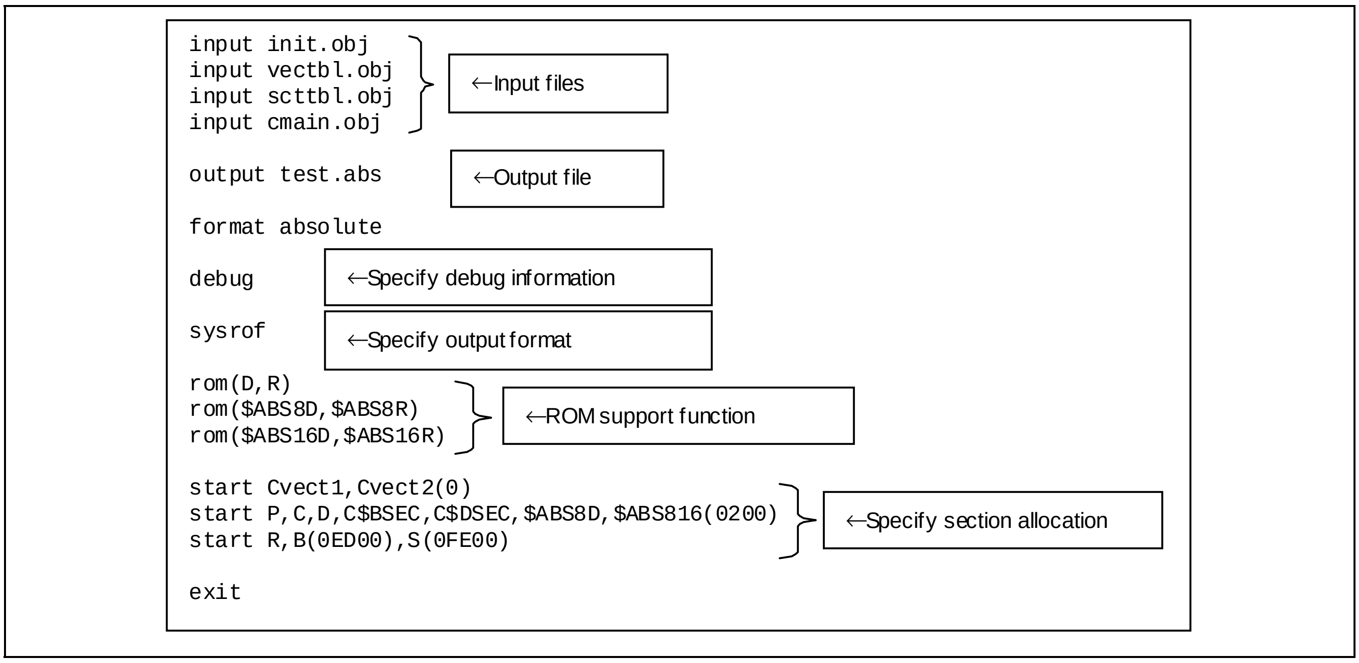
This example uses the CPU information file 2600a.cpu located in the sample directory.

Create a subcommand file for the inter-module optimization process.

Create the subcommand file to be specified in the inter-module optimization process.

This example uses the c2600a.sub file located in the sample directory. (The file can be used only for HEW1.2. The file of user's own should be made for HEW2.0 based on the following subcommand files.)

<c2600a.sub> (Modifying the subcommand file)



```
input init.obj
input vectbl.obj
input scttbl.obj
input cmain.obj

output test.abs

format absolute

debug

sysrof

rom(D,R)
rom($ABS8D,$ABS8R)
rom($ABS16D,$ABS16R)

start Cvect1,Cvect2(0)
start P,C,D,C$BSEC,C$DSEC,$ABS8D,$ABS816(0200)
start R,B(0ED00),S(0FE00)

exit
```

Use the following subcommand file to execute the inter-module optimization process:

optlnk38Δ–sub=test.sub (RET) **(HEW1.2 Command Line)**

optlnkΔ–sub=test.sub (RET) **(HEW2.0 Command Line)**

The optimization process outputs a load module file sample.abs;In HEW1.2 it also outputs memory allocation information to the linkage list sample.map and symbol optimization information to the optimization information list sample.lop. In HEW 2.0 it outputs memory allocation information and symbol optimization information to the linkage list sample.map.

(4) Convert the object file.

In order to create a ROM program, convert the object load module (in the SYSROF type in this case) into the S-type format as follows:

cnvsΔtest.abs (RET) **(HEW1.2 Command Line)**

As the Optimizing Linkage Editor has Converting Function for HEW2.0 or later, the S-type format can be converted without using the converter.

Describe form=stype in the subcommand file to output the S-type format.

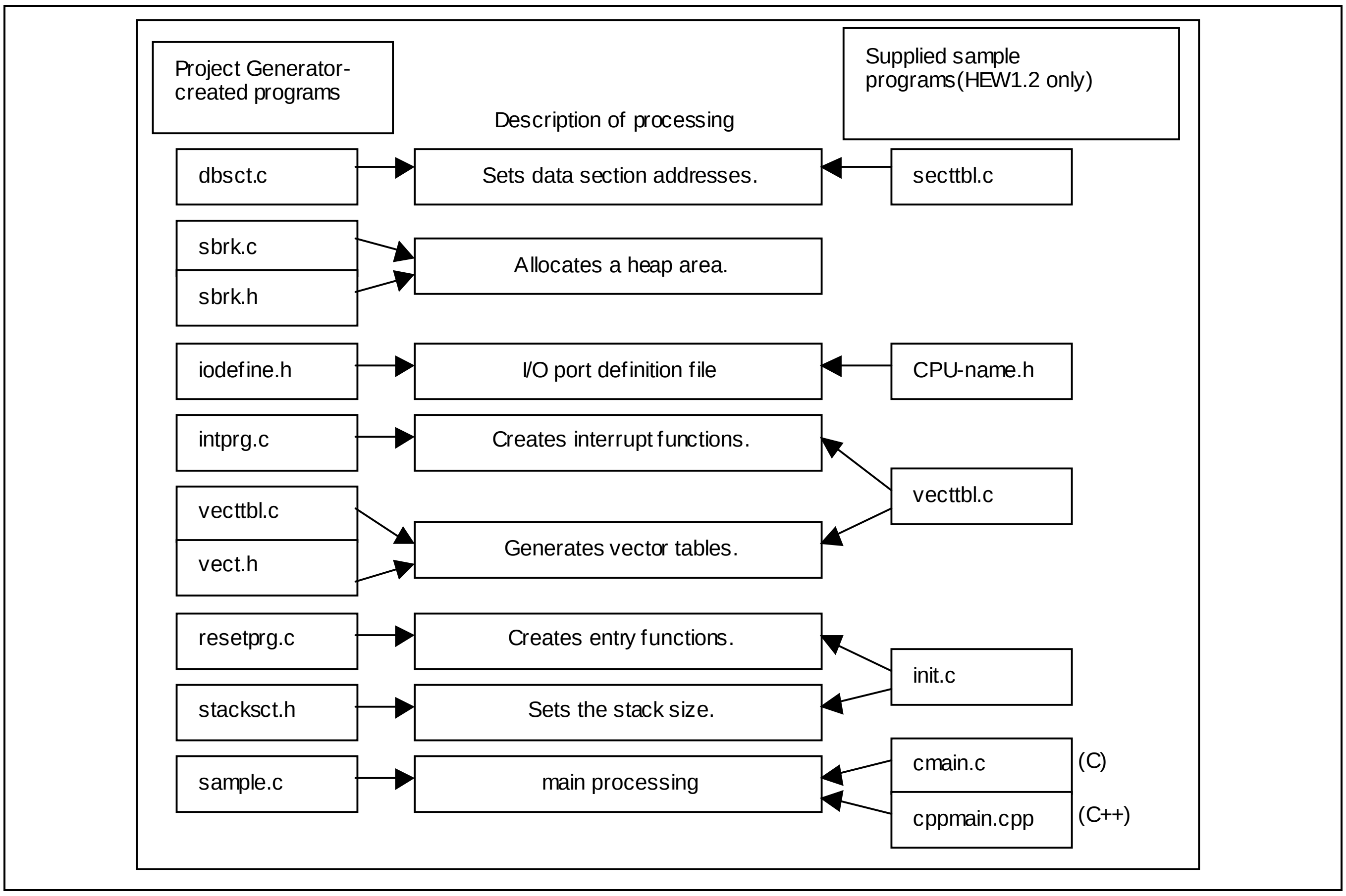
2.2 Introduction of Sample Program

2.2.1 Initialization Required for ROM Programs

The following description revolves around programs created by the project generator as an example.

The following diagram shows the file organizations of programs created by the project generator and sample programs that are supplied with this product.

(Sample programs are supplied with HEW1.2 and not with HEW2.0 or later. The sample programs vecttbl.c and vect.h are not generated under HEW2.0 or later any more due to a description of expansion functions of intprg.c.)



(1) Setting a data section address

(HEW project file name: dbsct.c, sample program name: scttbl.c)

```
/***********************************************************************/
/*                                                                     */
/*  FILE        :dbsct.c                                               */
/*  DATE        :Thu, Nov 04, 1999                                     */
/*  DESCRIPTION :Setting of B,R Section                                */
/*  CPU TYPE    :H8S/2621                                              */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/


#pragma section $DSEC          Sets the section address for an initialized data area.
static const struct {
   char *rom_s;       /* Start address of the initialized data section in ROM */
   char *rom_e;       /* End address of the initialized data section in ROM   */
   char *ram_s;       /* Start address of the initialized data section in RAM */
}DTBL[]= {
   {__sectop("D"), __secend("D"), __sectop("R")},
   {__sectop("$ABS8D"), __secend("$ABS8D"), __sectop("$ABS8R")},
   {__sectop("$ABS16D") , __secend("$ABS16D") , __sectop("$ABS16R") }

};

#pragma section $BSEC          Sets the section address for an uninitialized data area.
static const struct {
   char *b_s;         /* Start address of non-initialized data section */
   char *b_e;         /* End address of non-initialized data section */
}BTBL[]= {
   {__sectop("B"), __secend("B")},
   {__sectop("$ABS8B"), __secend("$ABS8B")},
   {__sectop("$ABS16B"), __secend("$ABS16B")}

};
```

Sets the addresses of the initialized and uninitialized data sections that are used by a routine that initializes them.

For adding an initialized data area section name, add the section name here as in the preceding line.

For adding an uninitialized data area section name, add the section name here as in the preceding line.

The _ _sectop and _ _secend are enhanced functions used to determine a section address.

These functions will be explained in section 3.3, Section Address Operators.

(2) Allocating a heap area

(HEW project file names: sbrk.c, sbrk.h, sample program names: sbrk.c, lowsrc.c, otherlb.c)
These programs generate a function that allocates the heap area to be used by the memory management library.

```
/****************************************************************************/
/*                                                                          */
/*  FILE          :sbrk.c                                                   */
/*  DATE          :Thu, Nov 04, 1999                                        */
/*  DESCRIPTION   :Program of sbrk                                          */
/*  CPU TYPE      :H8S/2621                                                 */
/*                                                                          */
/*  This file is generated by Renesas Project Generator (Ver.3.0).          */
/*                                                                          */
/****************************************************************************/
#include <stdio.h>
#include "sbrk.h"

//const size_t _sbrk_size=            /* Specifies the minimum unit of    */
                                      /* the defined heap area            */
extern char *_s1ptr;
extern void srand(unsigned int);

static  union  {
      long  dummy ;                   /* Dummy for 4-byte boundary        */
      char heap[HEAPSIZE];            /* Declaration of the area managed  */
                                      /* by sbrk                          */
 }heap_area ;

static  char  *brk=(char *)&heap_area;/* End address of area assigned     */

/****************************************************************************/
/*    sbrk:Data write                                                       */
/*    Return value:Start address of the assigned area (Pass)               */
/*                  -1              (Failure)                               */
/****************************************************************************/
char  *sbrk(unsigned long size)       /* Assigned area size               */
{
      char  *p;

      if(brk+size>heap_area.heap+HEAPSIZE)  /* Empty area size            */
      return (char *)-1 ;

      p=brk ;                         /* Area assignment                  */
      brk += size ;                   /* End address update               */
      return p ;
}

/****************************************************************************/
/* _INIT_OTHERLIB                                                           */
/* Initialize C library Functions, if necessary.                            */
/* Define OTHERLIB on Assembler Option.                                     */
/****************************************************************************/

void _INIT_OTHERLIB(void)
{
   srand(1);
   _s1ptr=NULL;
}
```

The method for creating low-level interface routines is described in "Low-level interface routines" in section 9.2.2, Execution Environment Settings, in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

(HEW project file name: sbrk.h)

```
/***********************************************************************/
/*                                                                     */
/*  FILE          :sbrk.h                                              */
/*  DATE          :Thu, Nov 04, 1999                                   */
/*  DESCRIPTION   :Header file of sbrk file                            */
/*  CPU TYPE      :H8S/2621                                            */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/
/* size of area managed by sbrk */
#define HEAPSIZE 0x400
```

This is an include file that is used for the definition of a low-level routine, sbrk. The include file indicates the size of the heap area. To change the size of the heap area after the project has been specified, modify this value.

Example: Changing the size of the heap area to 514 (0x202) bytes:

```
#define HEAPSIZE 0x202
```

(3) Defining an I/O port file

(HEW project file name: iodefine.h, sample program name: <CPU name>.h)
An I/O port file is defined so that I/O ports can be accessed using the variable names.

```
/***********************************************************************/
/*                                                                     */
/*  FILE          :iodefine.h                                          */
/*  DATE          :Thu, Nov 04, 1999                                   */
/*  DESCRIPTION   :Definition of I/O Register                          */
/*  CPU TYPE      :H8S/2621                                            */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/


/***********************************************************************/
/*      H8S/2623 Group Include File                   Ver 1.1          */
/***********************************************************************/
struct st_hcan {                                    /*   struct HACN  */
               union {                              /*   MCR          */
                     unsigned char BYTE;            /*   Byte Access  */
                     struct {                       /*   Bit  Access  */
                            unsigned char SLPME:1;  /*   SLPME        */
                            unsigned char      :1;  /*                */
                            unsigned char SLPM :1;  /*   SLPM         */
                            unsigned char      :2;  /*                */
                            unsigned char MSM  :1;  /*   MSM          */
                            unsigned char HALT :1;  /*   HALT         */
                            unsigned char RST  :1;  /*   RST          */
                     }             BIT;             /*                */
               }                MCR;                /*                */
               union {                              /*   GSR          */
                     unsigned char BYTE;            /*   Byte Access  */
                     struct {                       /*   Bit  Access  */
                            unsigned char wk  :4;   /*                */
                            unsigned char RSF :1;   /*   RSF          */
                            unsigned char MSEF:1;   /*   MSEF         */
                            unsigned char SRWF:1;   /*   SRWF         */
                            unsigned char BOF :1;   /*   BOF          */
                     }             BIT;             /*                */
               }                GSR;                /*                */
                                (omitted)

#define HCAN    (*(volatile struct st_hcan  *)0xFFF800) /* HCAN  Address*/
#define SCRX    (*(volatile union  un_scrx  *)0xFFFDB4) /* SCRX  Address*/
#define SBYCR   (*(volatile union  un_sbycr *)0xFFFDE4) /* SBYCR Address*/
#define SYSCR   (*(volatile union  un_syscr *)0xFFFDE5) /* SYSCR Address*/
#define SCKCR   (*(volatile union  un_sckcr *)0xFFFDE6) /* SCKCR Address*/

                                 (cont)
```

When not using the project generator, in the samples that are supplied with the product locate the include file and the C source file that are named identically with the CPU. Use these files after carefully checking that they are the correct files.

(4) Creating Interrupt Functions

(HEW project file name: intprg.c, sample program name: vecttbl.c)
These programs define functions that make interrupt calls.

<HEW1.2>

```
/***********************************************************************/
/*                                                                     */
/*  FILE          :intprg.c                                            */
/*  DATE          :Thu, Nov 04, 1999                                   */
/*  DESCRIPTION   :Interrupt Program                                   */
/*  CPU TYPE      :H8S/2621                                            */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/


#include    <machine.h>
#include    "vect.h"
#pragma section IntPRG
//  vector 2 Reserved

//  vector 3 Reserved              ← Defines a section name

//  vector 4 Reserved

//  vector 5 Treace
void    INT_Treace(void) {/* sleep(); */}
//  vector 6 Reserved

//  vector 7 NMI
void    INT_NMI(void) {/* sleep(); */}          ↓ Defines interrupt functions
//  vector 8 User breakpoint trap
void    INT_TRAP1(void) {/* sleep(); */}
//  vector 9 User breakpoint trap
void    INT_TRAP2(void) {/* sleep(); */}
//  vector 10 User breakpoint trap
void    INT_TRAP3(void) {/* sleep(); */}
//  vector 11 User breakpoint trap
void    INT_TRAP4(void) {/* sleep(); */}
//  vector 12 Reserved

//  vector 13 Reserved

//  vector 14 Reserved
```

Note: If #pragma section IntPRG is specified, the functions are assigned to the section named PIntPRG. Care must be taken before changing the section name by the inter-module optimizer.

<HEW2.0 or later>

```
/************************************************************************/
/*                                                                      */
/*  FILE        :intprg.c                                               */
/*  DATE        :Tue, Aug 20, 2002                                      */
/*  DESCRIPTION :Interrupt Program                                      */
/*  CPU TYPE    :H8S/2612                                               */
/*                                                                      */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                      */
/************************************************************************/


#include    <machine.h>
#pragma section IntPRG
//  vector 2 Reserved

//  vector 3 Reserved

//  vector 4 Reserved

//  vector 5 Trace
__interrupt(vect=5) void INT_Trace(void) {/* sleep(); */}
//  vector 6 Reserved

//  vector 7 NMI
__interrupt(vect=7) void INT_NMI(void)    {/* sleep(); */}
//  vector 8 User breakpoint trap
__interrupt(vect=8) void INT_TRAP0(void)  {/* sleep(); */}
//  vector 9 User breakpoint trap
__interrupt(vect=9) void INT_TRAP1(void)  {/* sleep(); */}
//  vector 10 User breakpoint trap
__interrupt(vect=10) void INT_TRAP2(void) {/* sleep(); */}
//  vector 11 User breakpoint trap
__interrupt(vect=11) void INT_TRAP3(void) {/* sleep(); */}
//  vector 12 Reserved

//  vector 13 Reserved

//  vector 14 Reserved

//  vector 15 Reserved
```

The description of _interrupt (vect=5) generates a vector table automatically.

For details on interrupt functions, refer to section3.1, Specifying an Interrupt Function.

(5) Creating Vector Tables

(HEW project file name: vecttbl.c, sample program name: vecttbl.c)

These programs set the addresses of the interrupt functions in vector tables. (To be generated under HEW1.2 only)

```
/***********************************************************************/
/*                                                                     */
/*  FILE          :vecttbl.c                                           */
/*  DATE          :Thu, Nov 04, 1999                                   */
/*  DESCRIPTION   :Initialize of Vector Table                          */
/*  CPU TYPE      :H8S/2621                                            */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/



#include    "vect.h"

#pragma section VECTTBL
void *RESET_Vectors[] = {
//;<<VECTOR DATA START (POWER ON RESET)>>
//;0 Power On Reset
   PowerON_Reset,
//;<<VECTOR DATA END (POWER ON RESET)>>
//;<<VECTOR DATA START (MANUAL RESET)>>
//;1 Manual Reset
   Manual_Reset
//;<<VECTOR DATA END (MANUAL RESET)>>
};
#pragma section INTTBL
void *INT_Vectors[] = {
   // 2 Reserved
   (void *) Dummy,
   // 3 Reserved
   (void *) Dummy,
   // 4 Reserved
   (void *) Dummy,
   // 5 Treace
   (void *) INT_Treace,
   // 6 Reserved
   (void *) Dummy,
   // 7 NMI
   (void *) INT_NMI,
   // 8 User breakpoint trap
   (void *) INT_TRAP1,
   // 9 User breakpoint trap
   (void *) INT_TRAP2,
   // 10 User breakpoint trap
   (void *) INT_TRAP3,
   // 11 User breakpoint trap
   (void *) INT_TRAP4,
   // 12 Reserved
   (void *) Dummy,
   // 13 Reserved
   (void *) Dummy,
```

Creates a vector table named RESET_Vectors in the CVECTTBL section.

Creates a vector table named INT_Vectors in the INTTBL section.

(cont)

Note: Specifying a section name in the #pragma section causes the name to be appended to the default section name. Therefore, when assigning an address using the inter-module optimizer, you need to change the section name.

(6) vect.h

This program declares the prototypes for the built-in function that are referenced when vector tables are set up.

(To be generated under HEW1.2 only)

```
; /***********************************************************************/
/*                                                                       */
/*  FILE          :vect.h                                                */
/*  DATE          :Thu, Nov 04, 1999                                     */
/*  DESCRIPTION   :Definition of Vector                                  */
/*  CPU TYPE      :H8S/2621                                              */
/*                                                                       */
/*  This file is generated by Renesas Project Generator (Ver.3.0).      */
/*                                                                       */
/***********************************************************************/





//;<<VECTOR DATA START (POWER ON RESET)>>
//;0 Power On Reset
extern void PowerON_Reset(void);
//;<<VECTOR DATA END (POWER ON RESET)>>
//;<<VECTOR DATA START (MANUAL RESET)>>
//;1 Manual Reset
extern void Manual_Reset(void);
//;<<VECTOR DATA END (MANUAL RESET)>>
// 2 Reserved

// 3 Reserved

// 4 Reserved

// 5 Treace
#pragma interrupt INT_Treace
extern void INT_Treace(void);
// 6 Reserved

// 7 NMI
#pragma interrupt INT_NMI
extern void INT_NMI(void);
// 8 User breakpoint trap
#pragma interrupt INT_TRAP1
extern void INT_TRAP1(void);
// 9 User breakpoint trap
#pragma interrupt INT_TRAP2
extern void INT_TRAP2(void);
// 10 User breakpoint trap
#pragma interrupt INT_TRAP3
extern void INT_TRAP3(void);
// 11 User breakpoint trap
#pragma interrupt INT_TRAP4
extern void INT_TRAP4(void);
// 12 Reserved

// 13 Reserved
```

<-By specifying #pragma interrupt as an interrupt function, RTE instruction is generated when returning a function value.
For details on interrupt functions, refer to section 3.1, Specifying an Interrupt Function.

(cont)

(7) Creating an entry function

(HEW project file name: resetprg.c, sample program name: init.c)

```
/***********************************************************************/
/*                                                                     */
/*  FILE          :resetprg.c                                          */
/*  DATE          :Thu, Nov 04, 1999                                   */
/*  DESCRIPTION   :Reset Program                                       */
/*  CPU TYPE      :H8S/2621                                            */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).    */
/*                                                                     */
/***********************************************************************/


#include <machine.h>
#include "stacksct.h"

#pragma entry PowerON_Reset

extern void main(void);

#ifdef __cplusplus
extern "C" {
#endif
extern void _INITSCT(void);
#ifdef __cplusplus
}
#endif

//#ifdef __cplusplus         // Remove the comment when you use SIM I/O
//extern "C" {
//#endif
//extern void _INIT_IOLIB(void);
//extern void _CLOSEALL(void);
//#ifdef __cplusplus
//}
//#endif

//extern void srand(unsigned int);  // Remove the comment when you use
rand()
//extern char *_s1ptr;          // Remove the comment when you use strtok()
```

Includes the embedded function include file

Specifies the PowerON_Reset as an entry function.
The compiler outputs a code for initializing the SP to the entry function.

(cont)

(continued from the previous page)

```
//#ifdef __cplusplus       // Remove the comment when you use Hardware Setup
//extern "C" {
//#endif
//extern void HardwareSetup(void);
//#ifdef __cplusplus
//}
//#endif


#pragma section ResetPRG

void PowerON_Reset(void);          Sets the CCR interrupt flag to enabled
void PowerON_Reset(void)
{
    set_imask_ccr(1);              Calls the section initialization routine

   _INITSCT();

// _INIT_IOLIB();          // Remove the comment when you use SIM I/O

// srand(1);               // Remove the comment when you use rand()
// _s1ptr=NULL;            // Remove the comment when you use strtok()

// HardwareSetup();        // Remove the comment when you use Hardware Setup

   main();                         Calls the main function

// _CLOSEALL();            // Remove the comment when you use SIM I/O

   sleep();                        Enters the low power consumption mode
}

void Manual_Reset(void);
void Manual_Reset(void)
{
}
```

(8) Setting the stack size

(HEW project file name: stacksct.h)

```
/***********************************************************************/
/*                                                                     */
/*  FILE          :stacksct.h                                          */
/*  DATE          :Thu, Nov 04, 1999                                   */
/*  DESCRIPTION   :Setting of Stack area                               */
/*  CPU TYPE      :H8S/2621                                            */
/*                                                                     */
/*  This file is generated by Renesas Project Generator (Ver.3.0).     */
/*                                                                     */
/***********************************************************************/
#pragma stacksize 0x200
```

Specify the desired stack size. This specification creates a 512-byte stack section, which has a fixed name of S.

The size of a stack section is equal to the stack size at the deepest nesting level in the function call relations.

Calculate the stack size by referencing the Total Frame Size that is output in the object list allocation information.

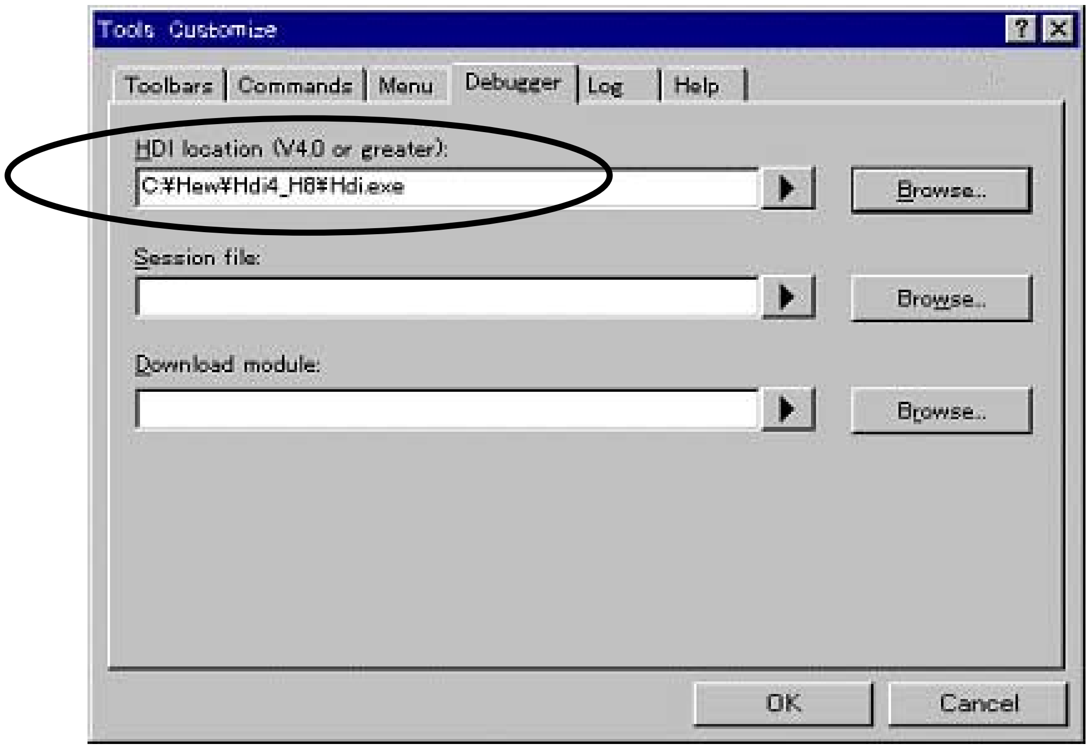
To change the stack size specification, modify the value in this program.

2.3 Debugging Using the HDI

Let us use the newly created HEW workspace to perform debugging with an HDI. (The HDI can be operated from both HEW1.2 and HEW2.0 or later.)

2.3.1 Running with HEW (1)

Select Customize... on the Tools in the HEW menu to open the Tools Customize dialog box and specify the location of the HDI.exe in the HDI location field. Then, the HDI can be started by pressing the Launch Debugger button on the HEW menu.



HDI location (V4.0 or greater): C:¥Hew¥Hdi4_H8¥Hdi.exe

Session file:

Download module:

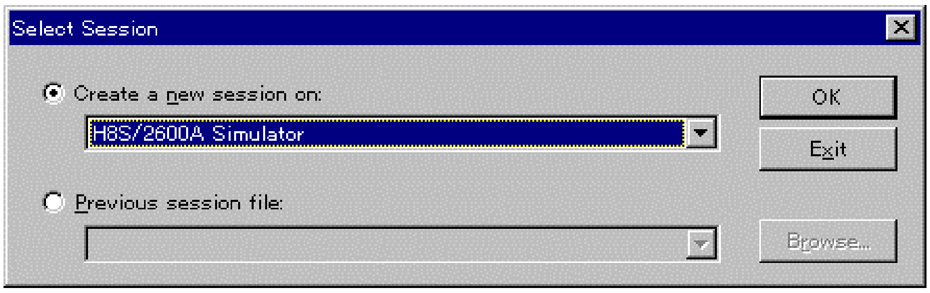
Launch Debugger

2.3.2 Selecting a Target

On the following screen, select the desired CPU type and debugger type.

This example, under the previously selected H8S/2600 advanced mode, selects the H8S/2600A Simulator.

After selecting a target, click [OK].

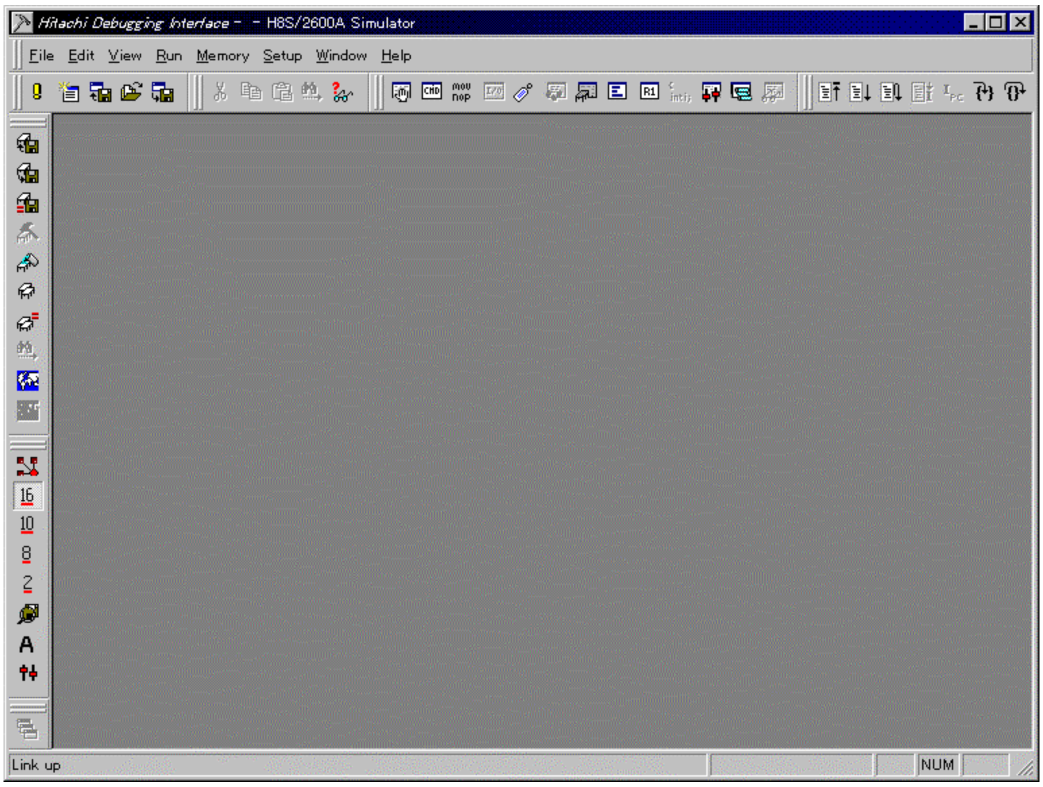


Select Session

[✓ Create a new session on:] H8S/2600A Simulator

Previous session file:

Following the display of a splash window, a Hitachi Debugging Interface window opens:



Hitachi Debugging Interface - - H8S/2600A Simulator

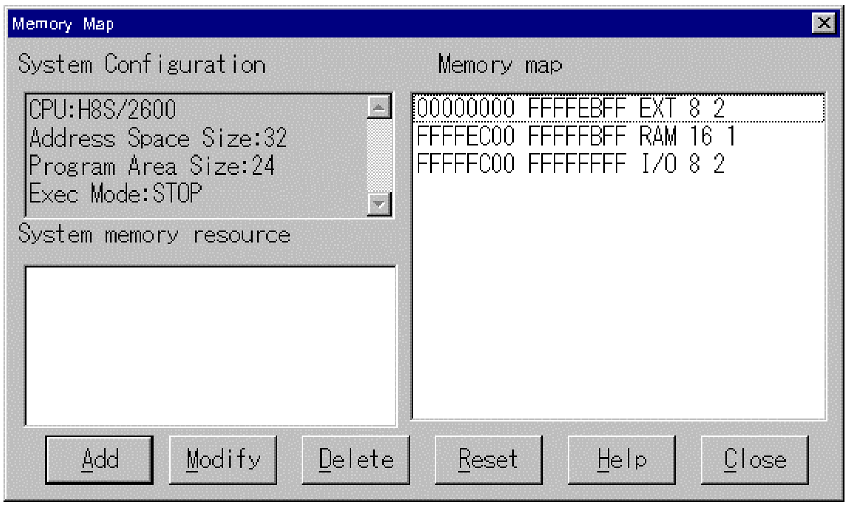
Link up

2.3.3 Allocating Memory Resources

In the next step, allocate memory resources necessary for operating the load module.
Either select [Memory Mapping Window] from the [View] menu or click on the Memory Mapping button on the Toolbar:

Memory Mapping

This displays a Memory Map dialog box:



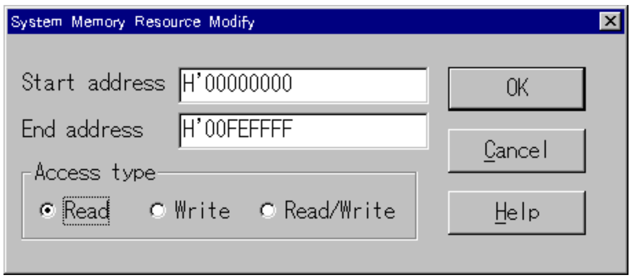
```
CPU:H8S/2600
Address Space Size:32
Program Area Size:24
Exec Mode:STOP
```

```
00000000 FFFFEBFF EXT 8 2
FFFFEC00 FFFFFBFF RAM 16 1
FFFFFC00 FFFFFFFF I/O 8 2
```

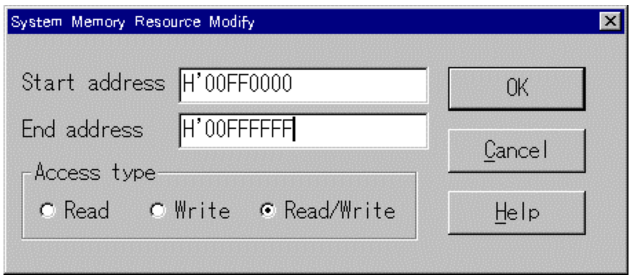
Press the [Add] button to allocate memory resources on the System Memory Resource Modify screen.

In this case, specify all areas. For a ROM area, specify the memory area from addresses H'0 to H'00FEFFFF; for a RAM area, specify H'00FF0000 through H'00FFFFFF. For the ROM area and RAM area access types, specify Read and Read/Write, respectively.

Press the [OK] button.

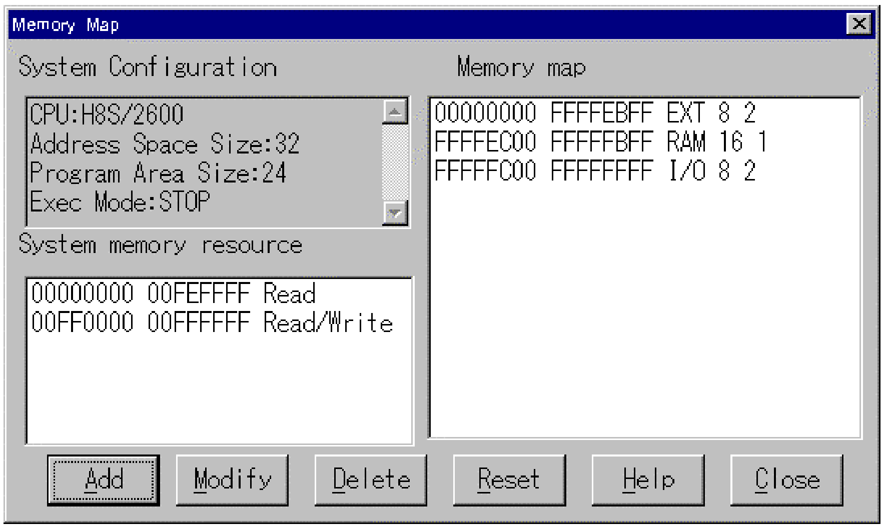


Start address H'00000000
End address H'00FEFFFF
Access type [✓ Read] Write Read/Write



Start address H'00FF0000
End address H'00FFFFFF
Access type Read Write [✓ Read/Write]

The memory resources are then specified as shown above.



Memory Map

System Configuration

```
CPU:H8S/2600
Address Space Size:32
Program Area Size:24
Exec Mode:STOP
```

System memory resource

```
00000000 00FEFFFF Read
00FF0000 00FFFFFF Read/Write
```

Memory map

```
00000000 FFFFEBFF EXT 8 2
FFFFEC00 FFFFFBFF RAM 16 1
FFFFFC00 FFFFFFFF I/O 8 2
```

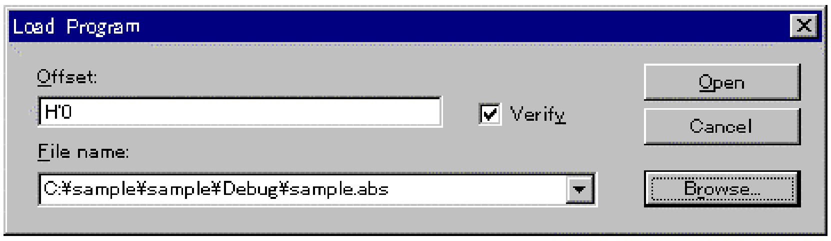
Press the [Close] button to close this window.

2.3.4 Downloading a Load Module

Select [Load Program] from the [File] menu. Select the absolute load module to be debugged. When using a button, click on the Load Program button on the Toolbar.

Load Program

Select the sample.abs file and click on [Open].



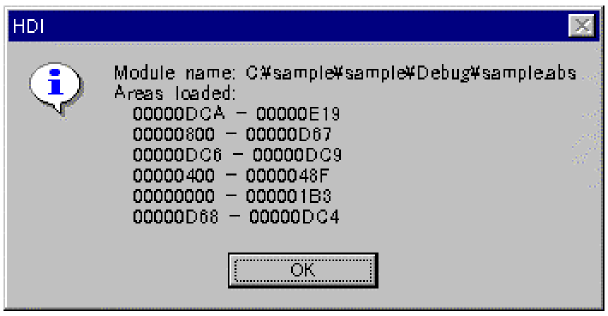
Load Program

Offset: H'0

[✓] Verify

File name: C:¥sample¥sample¥Debug¥sample.abs

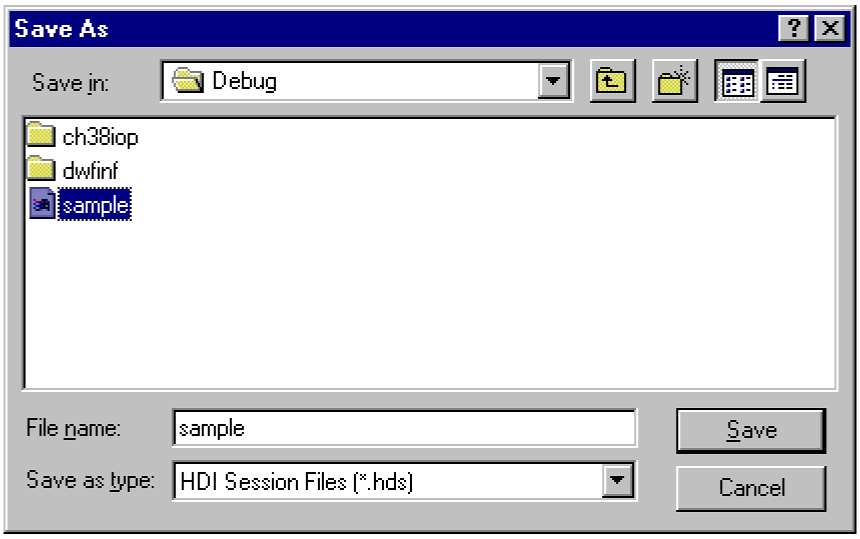
The following screen appears:
The file is loaded. The screen displays information on the memory areas into which the program code is written.



```
Module name: C:¥sample¥sample¥Debug¥sample.abs
Areas loaded:
  00000DCA - 00000E19
  00000800 - 00000D67
  00000DC6 - 00000DC9
  00000400 - 0000048F
  00000000 - 000001B3
  00000D68 - 00000DC4
```

2.3.5 Operating HDI with HEW (2)

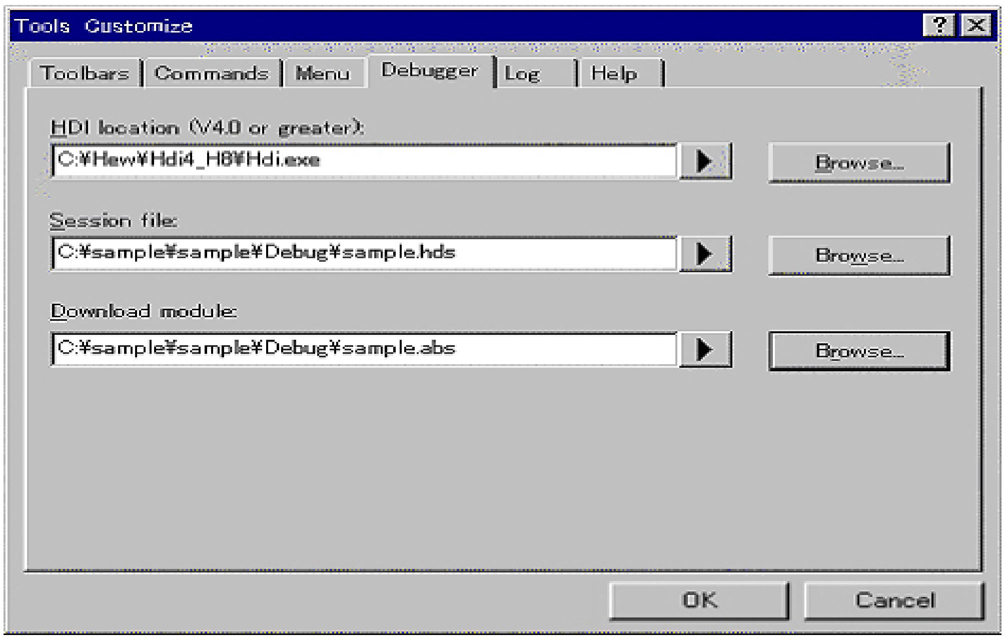
Select Save Session As… from the File menu.



File name: sample

Save as type: HDI Session Files (*.hds)

Selecting Customize... from Tools on the HEW menu opens the Tools Customize dialog box. In this dialog box, specify a session file name in the Session file field and a load module name in the Download module field. Then, the session can be loaded when the HDI is started by pressing the Launch Debugger button on the HEW menu.



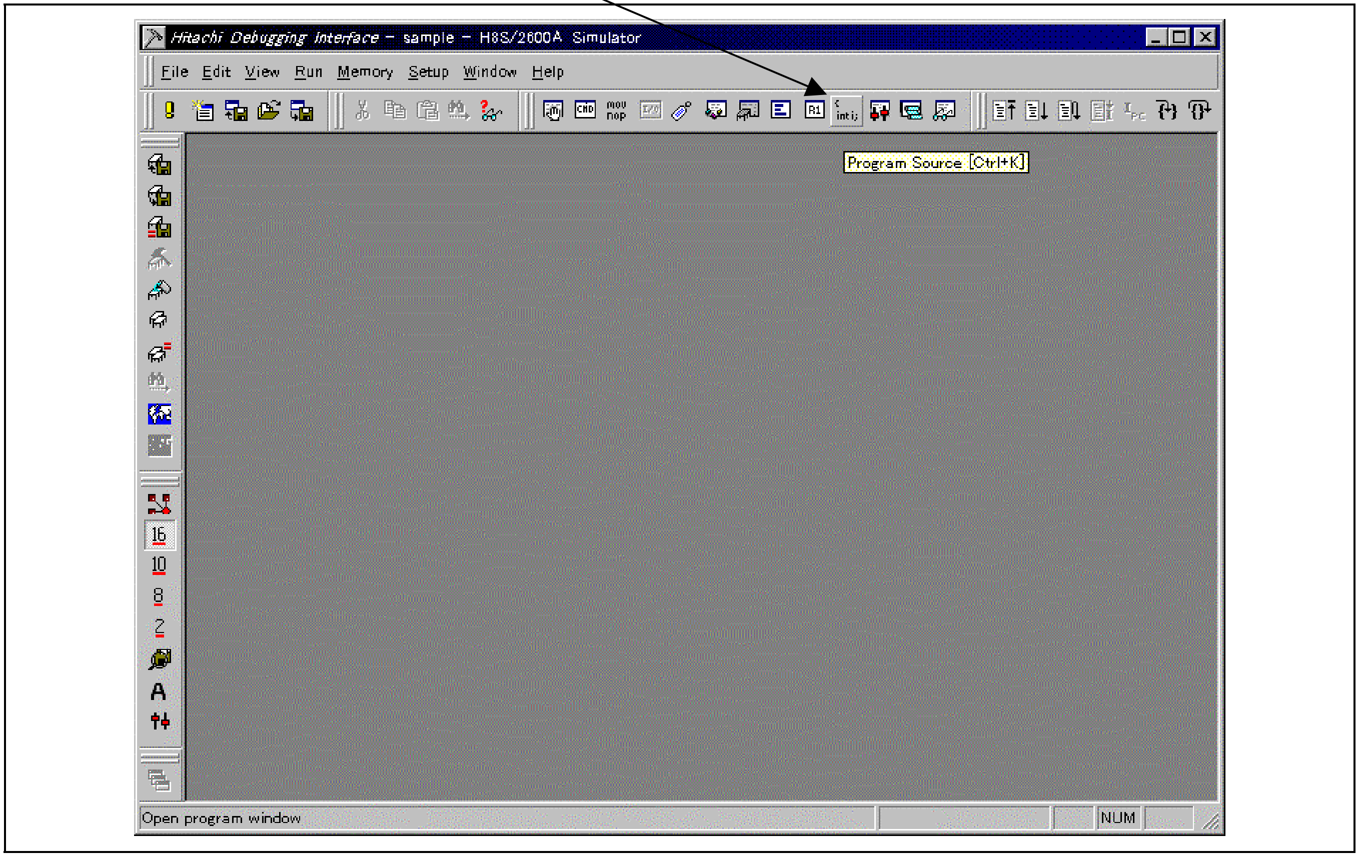
HDI location (V4.0 or greater):
C:¥Hew¥Hdi4_H8¥Hdi.exe

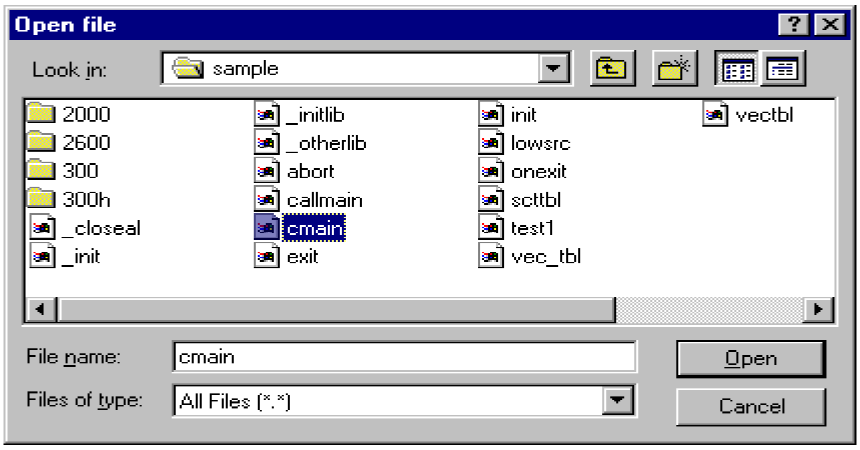
Session file:
C:¥sample¥sample¥Debug¥sample.hds

Download module:
C:¥sample¥sample¥Debug¥sample.abs

2.3.6 Displaying a Source Program

Click on the Program Source button.


Hitachi Debugging Interface - sample - H8S/2600A Simulator
File Edit View Run Memory Setup Window Help
Program Source [Ctrl+K]
16
10
8
2
A
Open program window
NUM

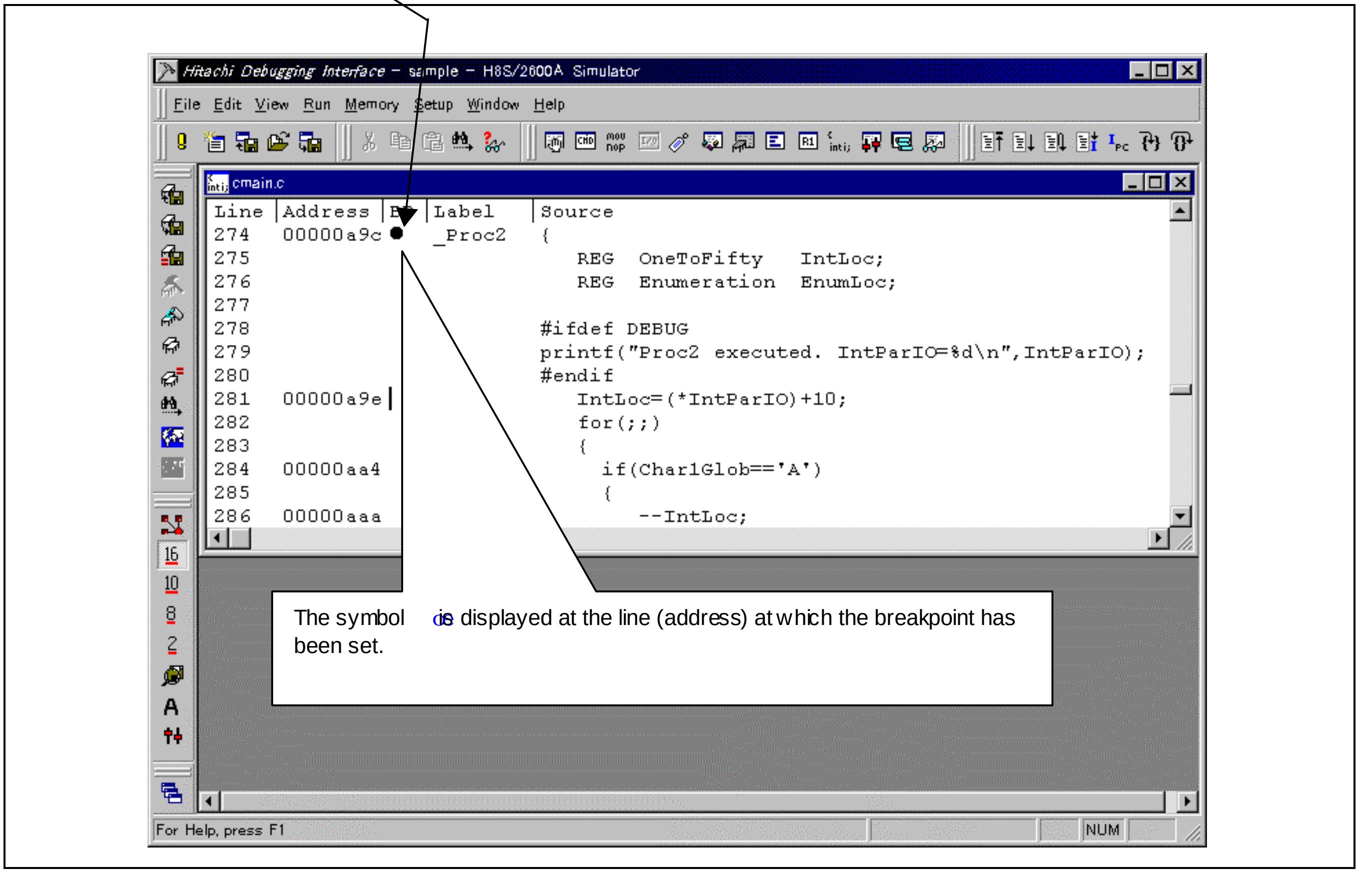


Select the cmain.c file.

2.3.7 Setting a Breakpoint

On the BP column in the program window, double-click on the source line at which a breakpoint is to be set.

For example, double-click here for setting a breakpoint when the main function is started.


Hitachi Debugging Interface - sample - H8S/2600A Simulator
File Edit View Run Memory Setup Window Help
cmain.c
For Help, press F1
NUM

```
Line  Address   BP  Label   Source
274   00000a9c  ●   _Proc2  {
275                            REG  OneToFifty   IntLoc;
276                            REG  Enumeration  EnumLoc;
277
278                         #ifdef DEBUG
279                         printf("Proc2 executed. IntParIO=%d\n",IntParIO);
280                         #endif
281   00000a9e                 IntLoc=(*IntParIO)+10;
282                            for(;;)
283                            {
284   00000aa4                   if(Char1Glob=='A')
285                              {
286   00000aaa                     --IntLoc;
```

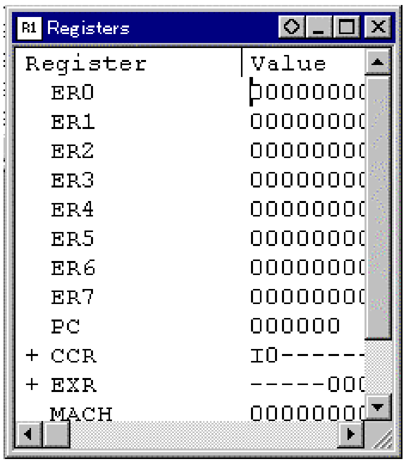
The symbol ● is displayed at the line (address) at which the breakpoint has been set.

2.3.8 Displaying the Register Status

Either select [Registers] from the [View] menu or click on the CPU Registers button on the Toolbar.

By opening the Register Window from the [View] menu, you can see the status of the registers.

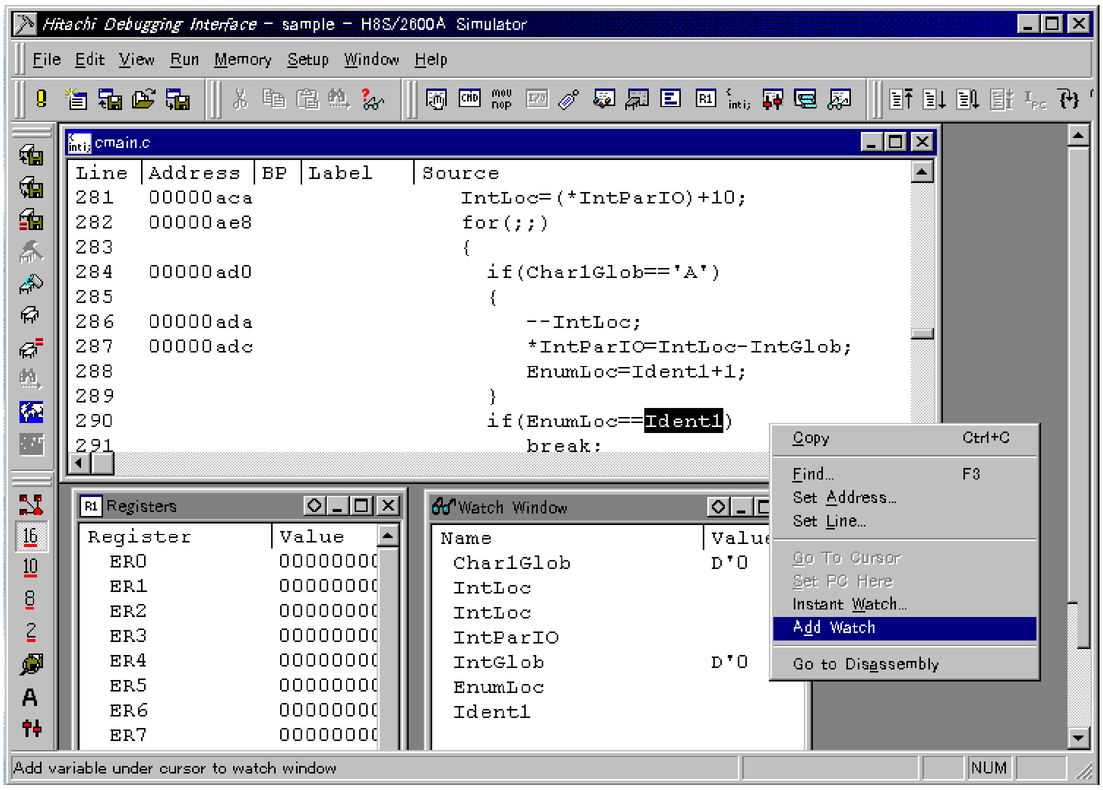
CPU Register



```
Register        Value
  ER0           0000000
  ER1           0000000
  ER2           0000000
  ER3           0000000
  ER4           0000000
  ER5           0000000
  ER6           0000000
  ER7           0000000
  PC            000000
+ CCR           I0-----
+ EXR           -----00
  MACH          0000000
```

2.3.9 Referencing to an External Variable

Select the name of the variable of interest. Click on the right button to select Add Watch from the popup menu. On the Watch Window, you can reference the value of the variable. Alternatively, you can display the value of a variable by placing the mouse cursor on the variable.



```
Line  Address   BP  Label     Source
281   00000aca                    IntLoc=(*IntParIO)+10;
282   00000ae8                    for(;;)
283                               {
284   00000ad0                      if(Char1Glob=='A')
285                                 {
286   00000ada                         --IntLoc;
287   00000adc                         *IntParIO=IntLoc-IntGlob;
288                                    EnumLoc=Ident1+1;
289                                 }
290                                 if(EnumLoc==Ident1)
291                                    break;
```

```
Register   Value
  ER0      0000000
  ER1      0000000
  ER2      0000000
  ER3      0000000
  ER4      0000000
  ER5      0000000
  ER6      0000000
  ER7      0000000
```

```
Name          Value
 Char1Glob    D'0
 IntLoc
 IntLoc
 IntParIO
 IntGlob      D'0
 EnumLoc
 Ident1
```

Add variable under cursor to watch window

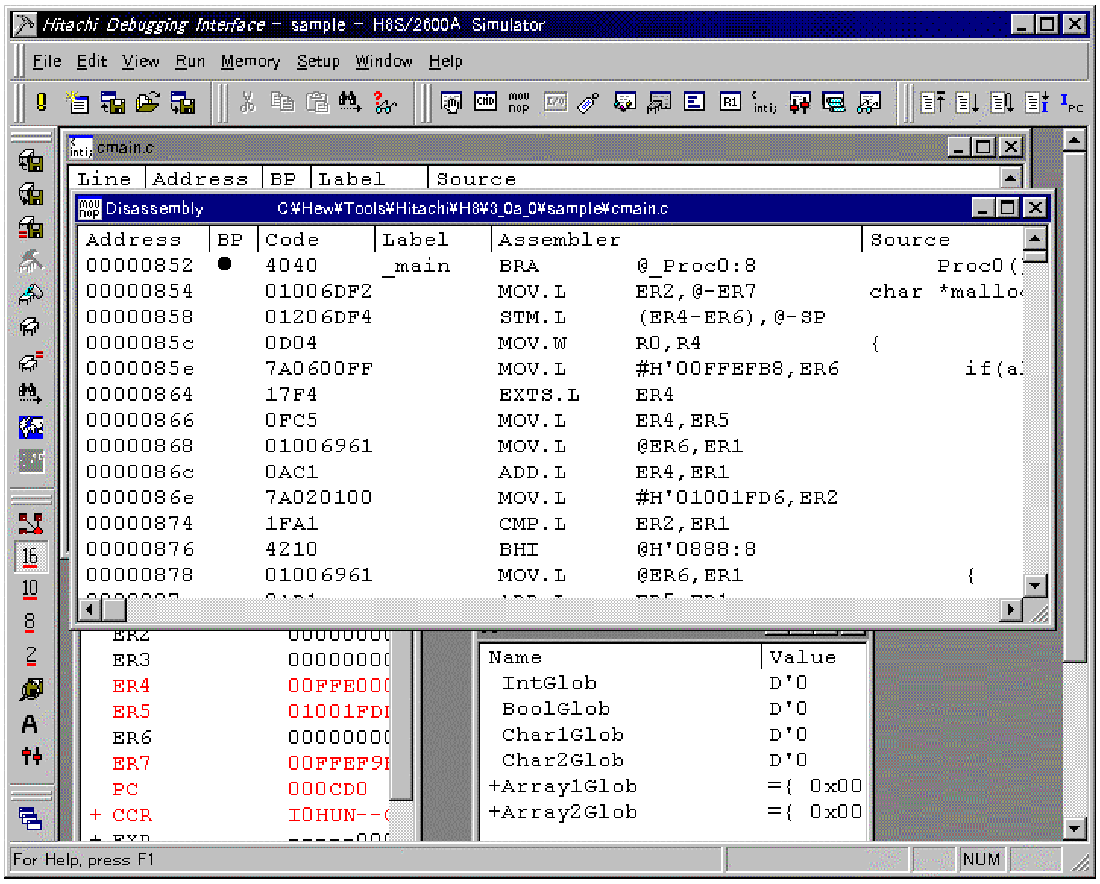
After making these preparations, try to execute the program.

2.3.10 ResetGo Command

Selecting RestGo from the [Run] menu causes the system to execute the program until the PC reaches the breakpoint.

ResetGo

On the C source program, right-click to display the popup menu and select Go to Disassembly to display a Disassembly window. The rightmost column on the Disassembly window is the Source column, where the C source program associated with the disassembled code is displayed.


Hitachi Debugging Interface - sample - H8S/2600A Simulator
File Edit View Run Memory Setup Window Help
cmain.c
Line Address BP Label Source
Disassembly C:¥Hew¥Tools¥Hitachi¥H8¥3_0a_0¥sample¥cmain.c
For Help, press F1
NUM

```
Address   BP Code      Label  Assembler                      Source
00000852  ●  4040      _main  BRA     @_Proc0:8                   Proc0(
00000854     01006DF2         MOV.L   ER2,@-ER7              char *mallo
00000858     01206DF4         STM.L   (ER4-ER6),@-SP
0000085c     0D04             MOV.W   R0,R4                  {
0000085e     7A0600FF         MOV.L   #H'00FFEFB8,ER6              if(a
00000864     17F4             EXTS.L  ER4
00000866     0FC5             MOV.L   ER4,ER5
00000868     01006961         MOV.L   @ER6,ER1
0000086c     0AC1             ADD.L   ER4,ER1
0000086e     7A020100         MOV.L   #H'01001FD6,ER2
00000874     1FA1             CMP.L   ER2,ER1
00000876     4210             BHI     @H'0888:8
00000878     01006961         MOV.L   @ER6,ER1                     {
```

```
  ER3     0000000
  ER4     00FFE00
  ER5     01001FD
  ER6     0000000
  ER7     00FFEF9
  PC      000CD0
+ CCR     I0HUN--
```

```
Name           Value
 IntGlob       D'0
 BoolGlob      D'0
 Char1Glob     D'0
 Char2Glob     D'0
+Array1Glob    ={ 0x00
+Array2Glob    ={ 0x00
```

2.3.11 Referencing to a Local Variable

Selecting [Locals] from the [View] menu causes the system to display a Locals window, which shows the local variables that can be referenced from the current PC position and their values.

Pressing the Step button allows the user to enter the function. The following section describes the step-execution of programs.

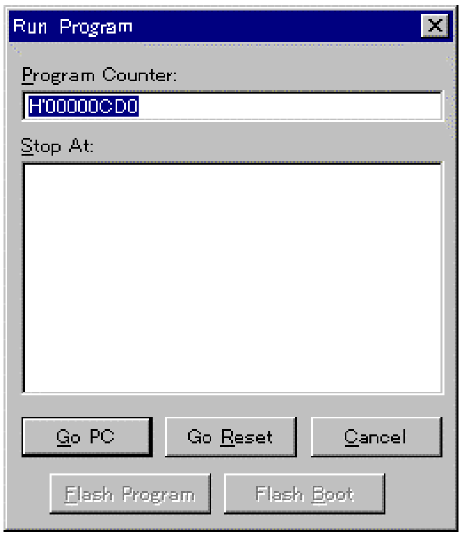
2.3.12 Step-Execution of a Program

Let us now execute the program in steps by using Step In, Step Over, and Step Out from the [Run] menu.

In the case of a subroutine call, Step In moves the PC into the subroutine.
Step Over moves the PC from one a subroutine call line to another.
Step Out moves the PC from a subroutine call line to the next line.

Step   Step Over   Step Out

Selecting [Run…] from the [Run] menu causes the system to open the Run dialog box, which allows the user to change the unit of steps.



Run Program

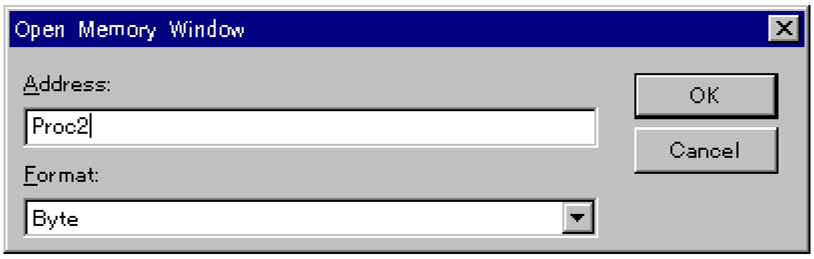
Program Counter: H'00000CD0

Stop At:

In this example, one step corresponds to one line of the C source program.

2.3.13 Displaying Memory Contents

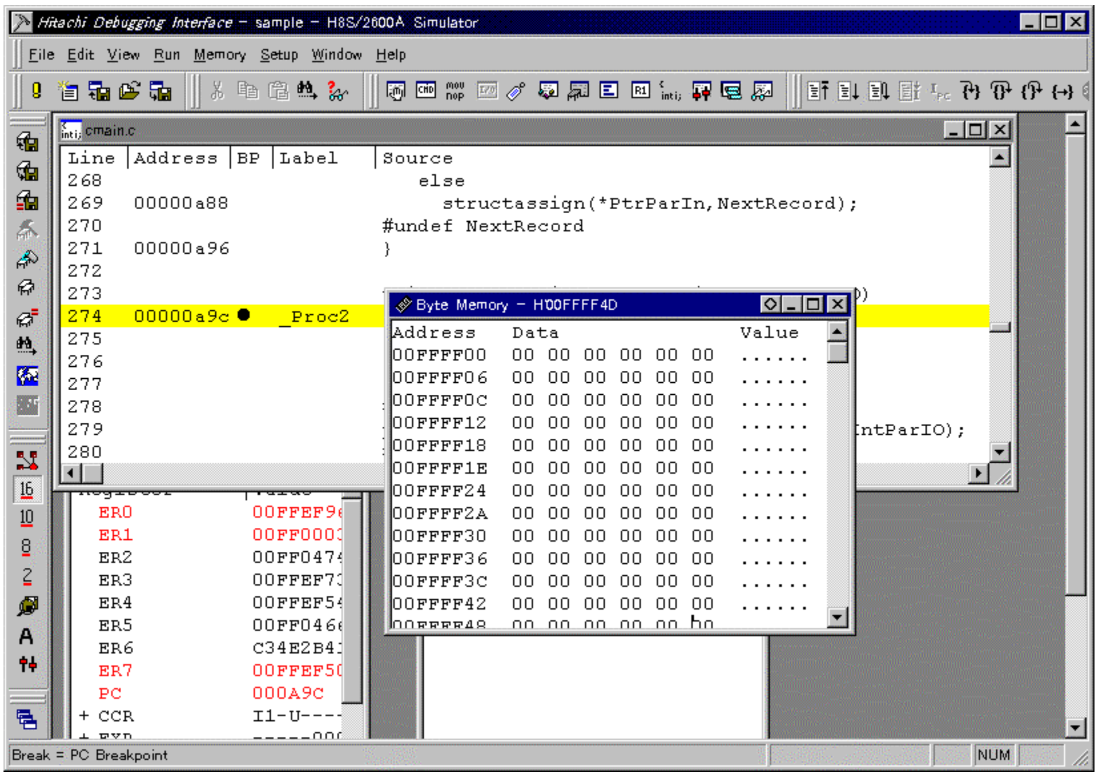
Specifying [View → Memory…] causes the display of an Open Memory Window dialog box. Enter a symbol name in the Address field.


Open Memory Window

Address: Proc2

Format: Byte

The contents of memory can be displayed in the following Byte Memory screen:


Hitachi Debugging Interface - sample - H8S/2600A Simulator

cmain.c

```
Line  Address   BP  Label    Source
268                              else
269   00000a88                      structassign(*PtrParIn,NextRecord);
270                              #undef NextRecord
271   00000a96                   }
272
273
274   00000a9c  ●   _Proc2
```

Byte Memory - H'00FFFF4D

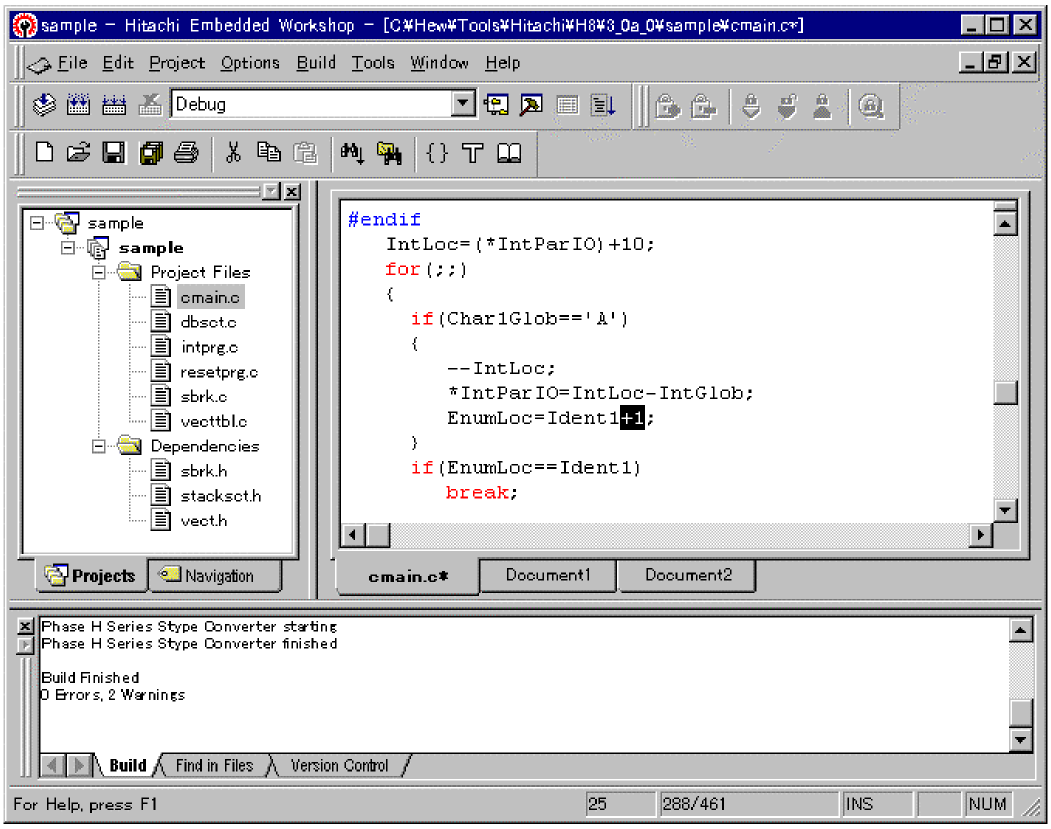
```
Address    Data                Value
00FFFF00   00 00 00 00 00 00   ......
00FFFF06   00 00 00 00 00 00   ......
00FFFF0C   00 00 00 00 00 00   ......
00FFFF12   00 00 00 00 00 00   ......
00FFFF18   00 00 00 00 00 00   ......
00FFFF1E   00 00 00 00 00 00   ......
00FFFF24   00 00 00 00 00 00   ......
00FFFF2A   00 00 00 00 00 00   ......
00FFFF30   00 00 00 00 00 00   ......
00FFFF36   00 00 00 00 00 00   ......
00FFFF3C   00 00 00 00 00 00   ......
00FFFF42   00 00 00 00 00 00   ......
```

```
ER0    00FFEF9
ER1    00FF000
ER2    00FF047
ER3    00FFEF7
ER4    00FFEF5
ER5    00FF046
ER6    C34E2B4
ER7    00FFEF5
PC     000A9C
+ CCR  I1-U----
```

Break = PC Breakpoint

2.3.14 Operating HDI with HEW (3)

To start the HDI from the HEW, open the desired file on the HEW Editor by double-clicking on the HDI source window.

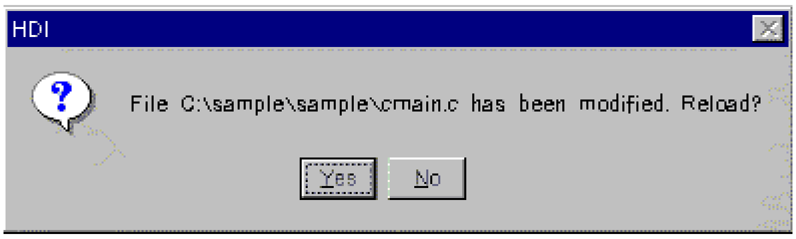


```
#endif
   IntLoc=(*IntParIO)+10;
   for(;;)
   {
     if(Char1Glob=='A')
     {
        --IntLoc;
        *IntParIO=IntLoc-IntGlob;
        EnumLoc=Ident1+1;
     }
     if(EnumLoc==Ident1)
        break;
```

```
Phase H Series Stype Converter starting
Phase H Series Stype Converter finished

Build Finished
0 Errors, 2 Warnings
```

Edit and save this file to recompile it. (Note that the sample programs cannot be modified because they are a read-only file.)

When activated, the HDI displays a message dialog box and asks whether the program is to be reloaded.

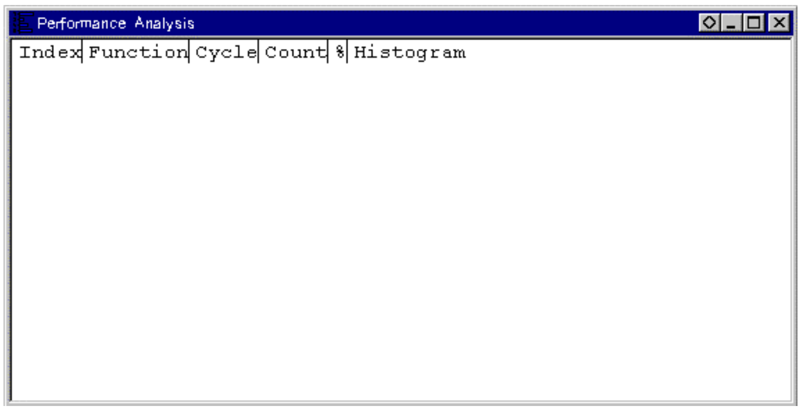


File C:\sample\sample\cmain.c has been modified. Reload?

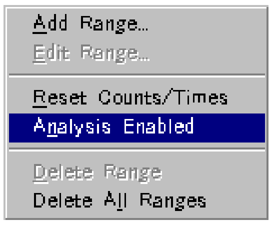
Selecting Yes causes the HDI to reload the program.

The debugging process can be performed in this manner.

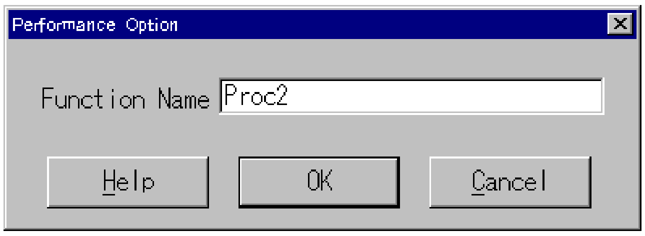
The HDI also provides the performance analysis function. To measure the performance of a program, select Performance Analysis from the [View] menu, which opens a Performance Analysis window.

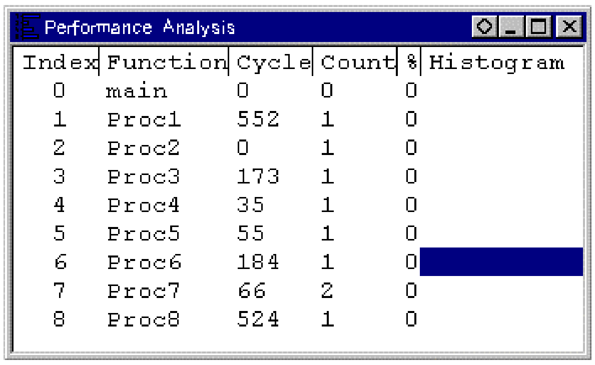


To measure performance, select Enable on the popup window:



On the Add Range option of the popup menu, specify the label on which performance is to be measured.





Index	Function	Cycle	Count	%	Histogram
0	main	0	0	0	
1	Proc1	552	1	0	
2	Proc2	0	1	0	
3	Proc3	173	1	0	
4	Proc4	35	1	0	
5	Proc5	55	1	0	
6	Proc6	184	1	0	
7	Proc7	66	2	0	
8	Proc8	524	1	0	

After executing the program, the performance of each label is displayed as a result.

For details of HDI features, refer to the Hitachi Debugging Interface User’s Manual.

2.4 Debugging Using the Simulator-Debugger

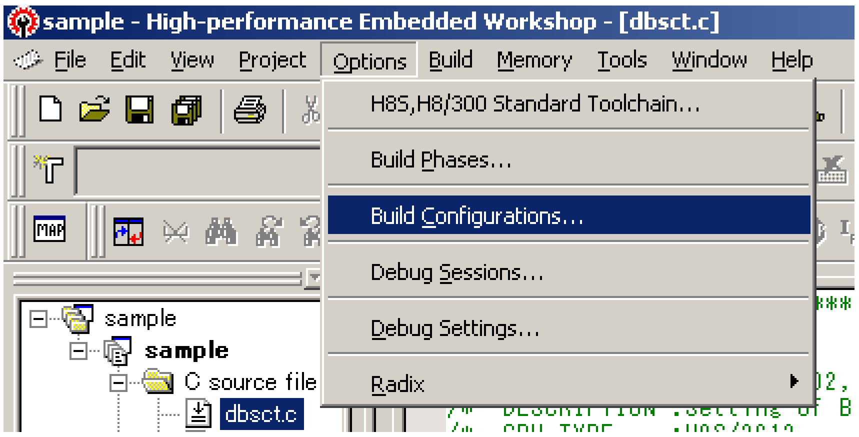
Debugging became enabled on the HEW beginning with HEW2.0. (Note that it is not available with HEW1.2.)

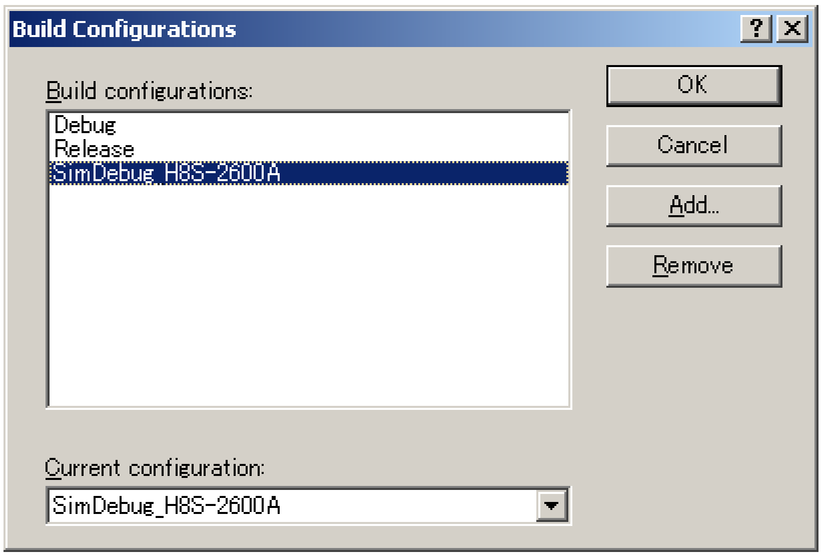
Use the sample project created by selecting Demonstration as the project type setting to execute the simulator-debugger.

2.4.1 Setting Configuration

- Select [Build Configrations...] from the [Option] menu to invoke the Build configurations screen and select the environment to be used. In this case, select [SimDebug_H8-2600A].

If you modify the configuration, execute the building process.


sample - High-performance Embedded Workshop - [dbsct.c]
File Edit View Project Options Build Memory Tools Window Help
H8S,H8/300 Standard Toolchain...
Build Phases...
Build Configurations...
Debug Sessions...
Debug Settings...
Radix
sample
sample
C source file
dbsct.c



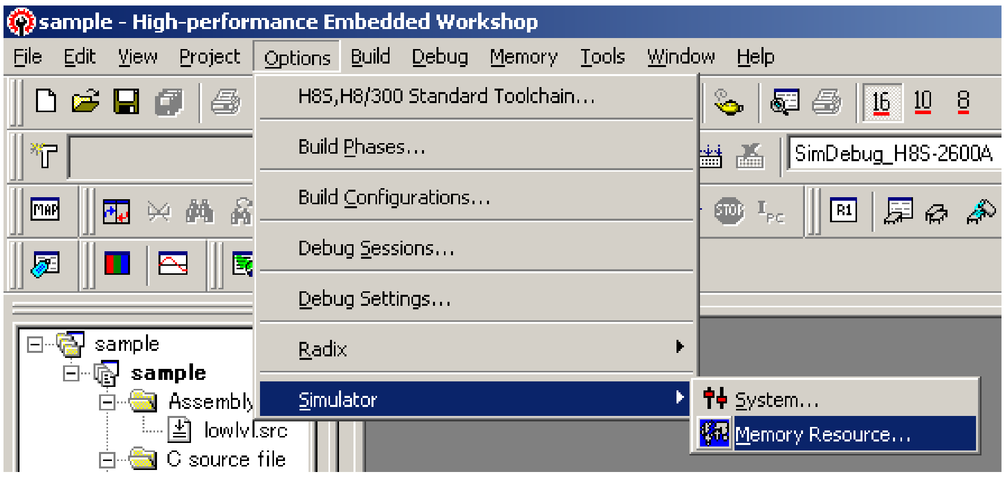
Build configurations:
Debug
Release
SimDebug_H8S-2600A

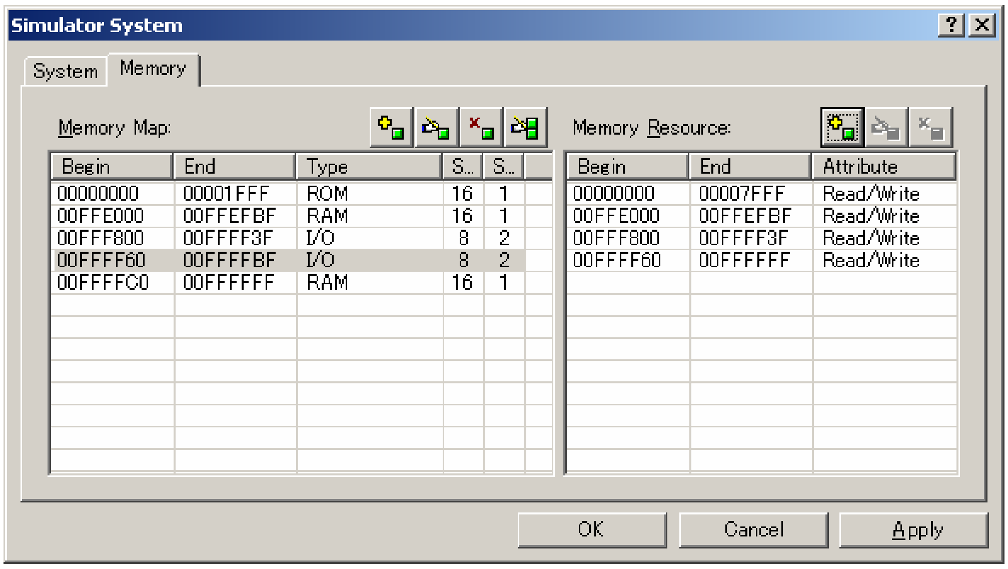
Current configuration:
SimDebug_H8S-2600A

2.4.2 Allocating Memory Resources

Memory resources should be allocated in order to run an application that has been developed. Check the settings because memory resources are automatically allocated in the Demonstration Project.

- Select [Simulator → Memory Resource...] from the [Option] menu to display the current memory resources.





Memory Map:

Begin	End	Type	S...	S...
00000000	00001FFF	ROM	16	1
00FFE000	00FFEFBF	RAM	16	1
00FFF800	00FFFF3F	I/O	8	2
00FFFF60	00FFFFBF	I/O	8	2
00FFFFC0	00FFFFFF	RAM	16	1

Memory Resource:

Begin	End	Attribute
00000000	00007FFF	Read/Write
00FFE000	00FFEFBF	Read/Write
00FFF800	00FFFF3F	Read/Write
00FFFF60	00FFFFFF	Read/Write

Readable/writable area from H'00000000 through H'00007FFF is allocated for a program area and the area from H'00FFEC00 through H'00FFFFFF is allocated for a stack area.

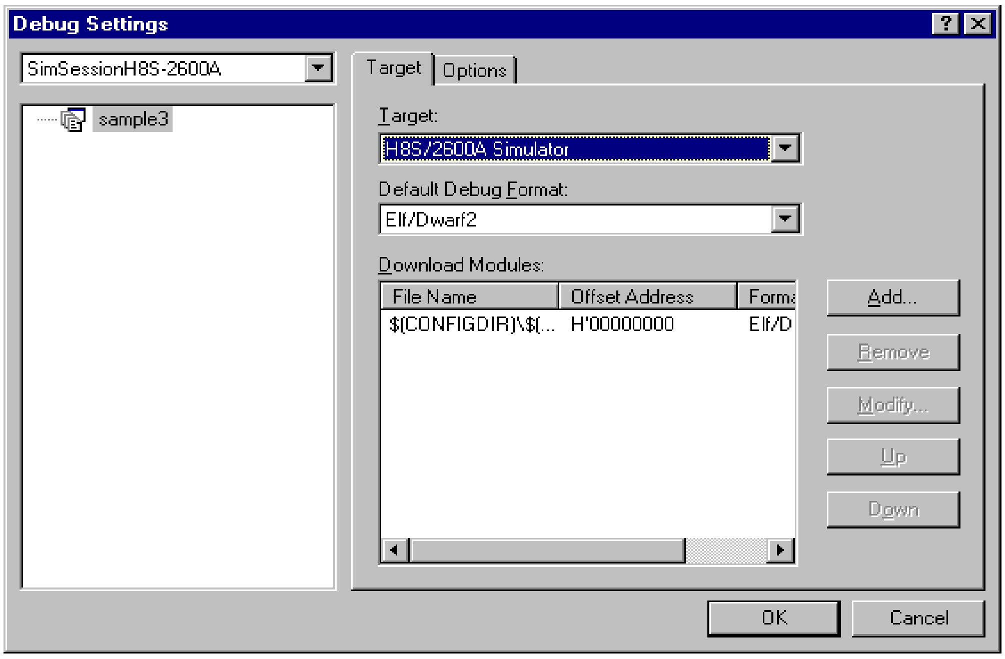
- Click on the [Close] button to close the dialog box.

Memory resources can also be referenced or modified on the [Simulator] tab of H8S, H8/300 Standard Toolchain dialog box. Mutual modification is reflected.

2.4.3 Downloading a Sample Program

Check the settings because a sample program to be downloaded is automatically set in the Demonstration Program.

- Select [Debug Settings...] from the [Option] menu to open the Debug Settings dialog box.



Debug Settings

SimSessionH8S-2600A

sample3

Target:
H8S/2600A Simulator

Default Debug Format:
Elf/Dwarf2

Download Modules:

File Name	Offset Address	Forma
$(CONFIGDIR)\$(...	H'00000000	Elf/D

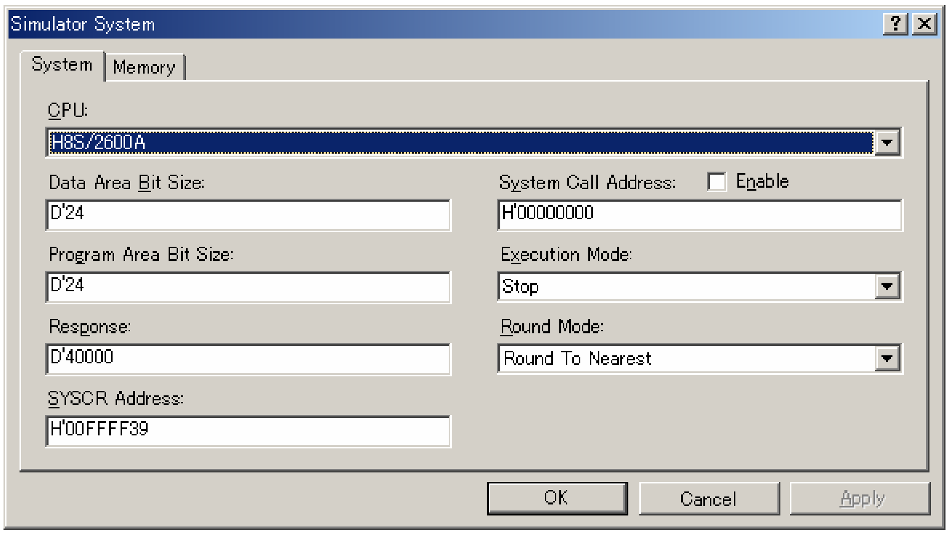
The files set in [Download Modules] will be downloaded.

- Click on the [OK] button to close Debug Settings dialog box.
- Select [Download Modules -> All Download Modules] from the [Debug] menu to download the sample program.

2.4.4 Setting Simulated I/O

Check the settings because Simulated I/O is automatically set in the Demonstration Project.

- Select [Simulator -> System] from the [Option] menu to open Simulator System dialog box.



CPU: H8S/2600A

Data Area Bit Size: D'24

System Call Address: Enable H'00000000

Program Area Bit Size: D'24

Execution Mode: Stop

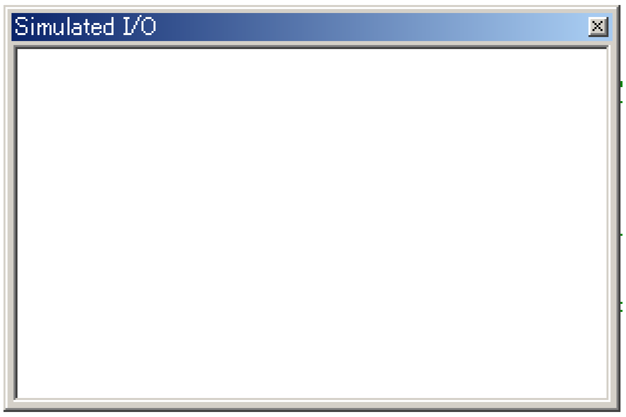
Response: D'40000

Round Mode: Round To Nearest

SYSCR Address: H'00FFFF39

- Check that [Enable] has been selected in [System Call Address].
- Click on the [OK] button to enable Simulated I/O.
- Select [Simulated I/O] from the [View] menu to open the Simulated I/O window.

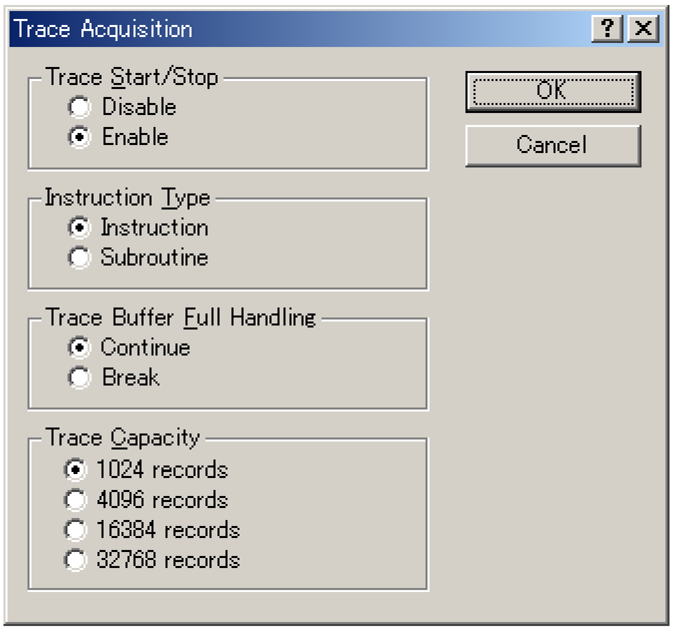
Without opening the Simulated I/O window, Simulated I/O is not enabled.



2.4.5 Setting Trace Information Acquisition Conditions

- Select [Code->Trace] from the [View] menu to open the Trace window. Then right-click on the Trace window to display the popup menu and select [Acquisition...].

The Trace Acquisition dialog box appears as shown below.


Trace Acquisition

Trace Start/Stop: Disable [✓ Enable]

Instruction Type: [✓ Instruction] Subroutine

Trace Buffer Full Handling: [✓ Continue] Break

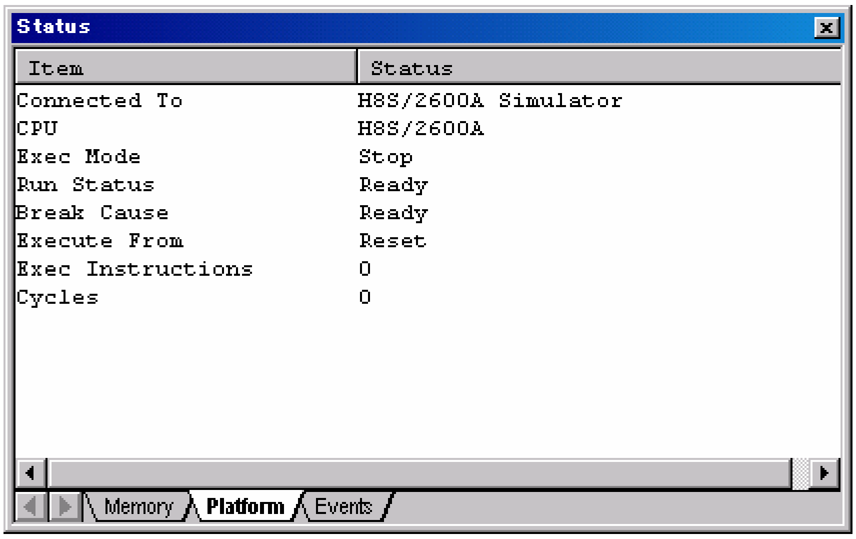
Trace Capacity: [✓ 1024 records] 4096 records 16384 records 32768 records

- Set [Enable] for [Trace start/Stop] in the Trace Acquisition dialog box and click on the [OK] button to enable Trace Information Acquisition.

2.4.6 Status Window

The termination cause can be confirmed on a Status window.

- Select [CPU->Status] from the [View] menu to open a Status window. Display [Platform] sheet from within the Status window.

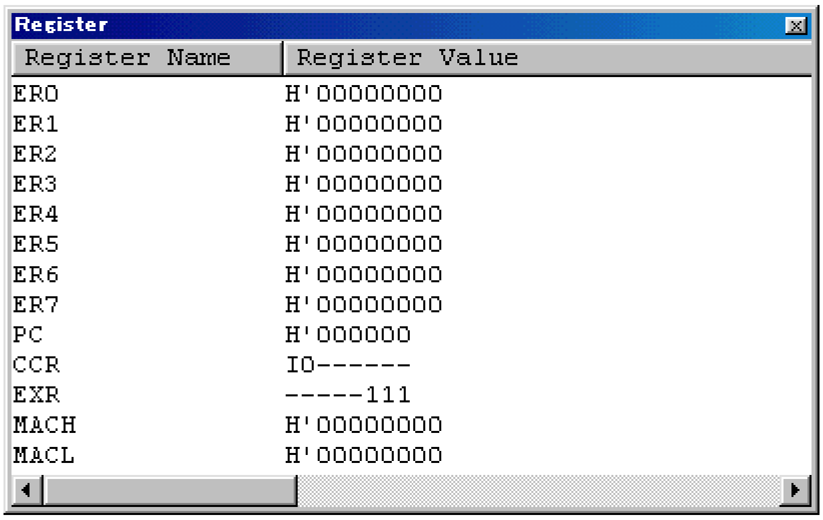


Item	Status
Connected To	H8S/2600A Simulator
CPU	H8S/2600A
Exec Mode	Stop
Run Status	Ready
Break Cause	Ready
Execute From	Reset
Exec Instructions	0
Cycles	0

2.4.7 Registers Window

Values of registers can be confirmed on a Registers window.

- Select [CPU->Registers...] from the [View] menu.



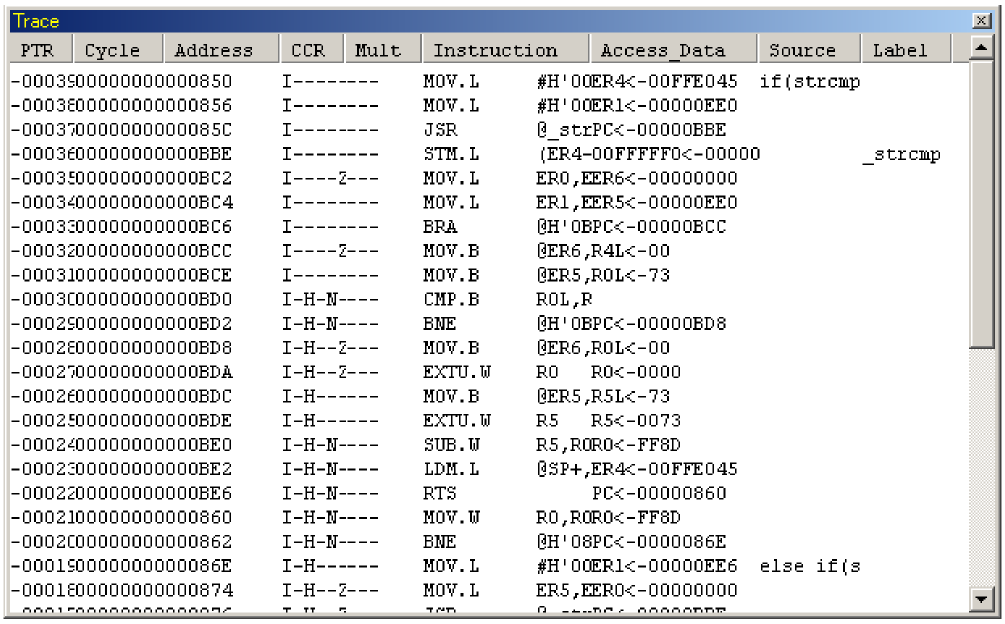
Register Name	Register Value
ER0	H'00000000
ER1	H'00000000
ER2	H'00000000
ER3	H'00000000
ER4	H'00000000
ER5	H'00000000
ER6	H'00000000
ER7	H'00000000
PC	H'000000
CCR	I0------
EXR	-----111
MACH	H'00000000
MACL	H'00000000

2.4.8 Using Trace

(1) Trace Buffer

By using the trace buffer, you can see the history of execution of instructions.

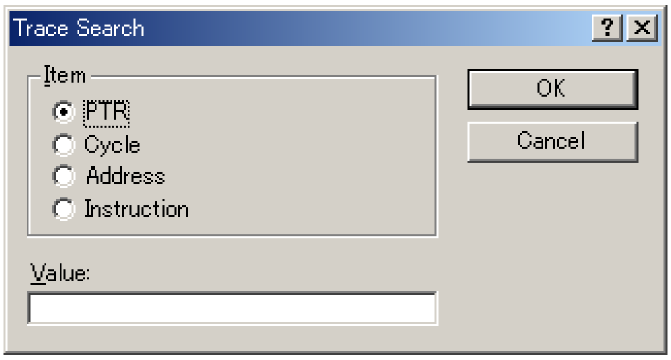
- Select [Code->Trace] from the [View] menu to open a Trace window. Scroll up to the top of the window.



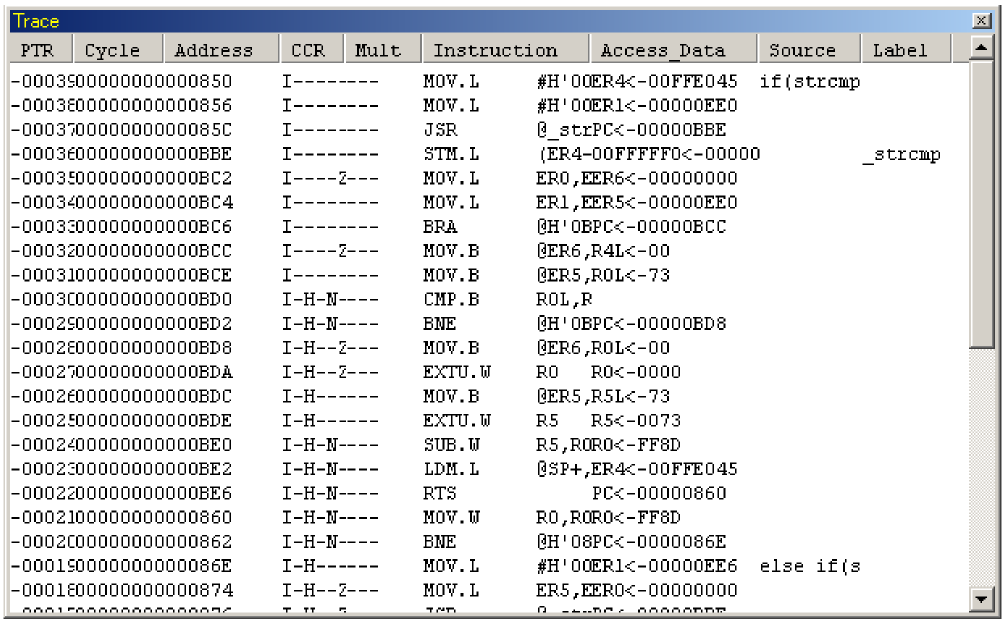
```
PTR  Cycle  Address  CCR  Mult  Instruction  Access_Data  Source  Label
-000390000000000000850   I--------   MOV.L     #H'00ER4<-00FFE045  if(strcmp
-000380000000000000856   I--------   MOV.L     #H'00ER1<-00000EE0
-00037000000000000085C   I--------   JSR       @_strPC<-00000BBE
-000360000000000000BBE   I--------   STM.L     (ER4-00FFFFF0<-00000        _strcmp
-000350000000000000BC2   I----Z---   MOV.L     ER0,EER6<-00000000
-000340000000000000BC4   I--------   MOV.L     ER1,EER5<-00000EE0
-000330000000000000BC6   I--------   BRA       @H'0BPC<-00000BCC
-000320000000000000BCC   I----Z---   MOV.B     @ER6,R4L<-00
-000310000000000000BCE   I--------   MOV.B     @ER5,R0L<-73
-000300000000000000BD0   I-H-N----   CMP.B     R0L,R
-000290000000000000BD2   I-H-N----   BNE       @H'0BPC<-00000BD8
-000280000000000000BD8   I-H--Z---   MOV.B     @ER6,R0L<-00
-000270000000000000BDA   I-H--Z---   EXTU.W    R0   R0<-0000
-000260000000000000BDC   I-H------   MOV.B     @ER5,R5L<-73
-000250000000000000BDE   I-H------   EXTU.W    R5   R5<-0073
-000240000000000000BE0   I-H-N----   SUB.W     R5,R0R0<-FF8D
-000230000000000000BE2   I-H-N----   LDM.L     @SP+,ER4<-00FFE045
-000220000000000000BE6   I-H-N----   RTS            PC<-00000860
-000210000000000000860   I-H-N----   MOV.W     R0,R0R0<-FF8D
-000200000000000000862   I-H-N----   BNE       @H'08PC<-0000086E
-00019000000000000086E   I-H------   MOV.L     #H'00ER1<-00000EE6  else if(s
-000180000000000000874   I-H--Z---   MOV.L     ER5,EER0<-00000000
```

(2) Trace Search

First, right-click on a Trace window to display the popup menu and select [Find...] to open the Trace Search dialog box.

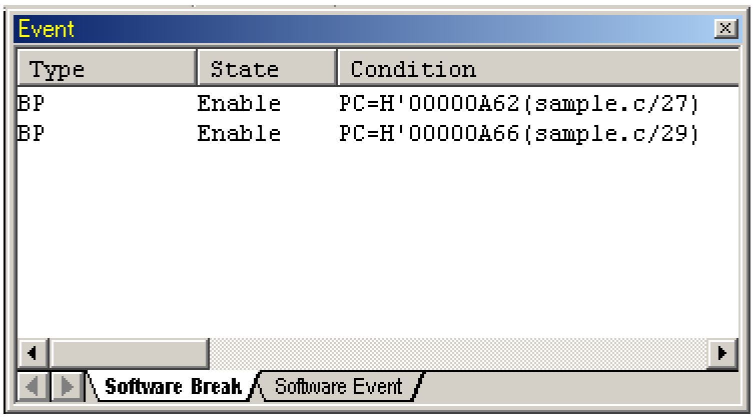


Set the search item [Item] and the search content [Value], click on the [OK] button, and execute Trace Search. If you find the applicable trace information, highlight the first line. If you continue Trace Search for the same search content [Value], right-click on the Trace window to display the popup menu and select [Find Next]. In the next step, highlight the next line.



```
PTR   Cycle   Address    CCR   Mult   Instruction   Access_Data   Source   Label
-00039000000000000850    I--------    MOV.L     #H'00ER4<-00FFE045  if(strcmp
-00038000000000000856    I--------    MOV.L     #H'00ER1<-00000EE0
-0003700000000000085C    I--------    JSR       @_strPC<-00000BBE
-00036000000000000BBE    I--------    STM.L     (ER4-00FFFFF0<-00000         _strcmp
-00035000000000000BC2    I----Z---    MOV.L     ER0,EER6<-00000000
-00034000000000000BC4    I--------    MOV.L     ER1,EER5<-00000EE0
-00033000000000000BC6    I--------    BRA       @H'0BPC<-00000BCC
-00032000000000000BCC    I----Z---    MOV.B     @ER6,R4L<-00
-00031000000000000BCE    I--------    MOV.B     @ER5,R0L<-73
-0003C000000000000BD0    I-H-N----    CMP.B     R0L,R
-00029000000000000BD2    I-H-N----    BNE       @H'0BPC<-00000BD8
-00028000000000000BD8    I-H--Z---    MOV.B     @ER6,R0L<-00
-00027000000000000BDA    I-H--Z---    EXTU.W    R0    R0<-0000
-00026000000000000BDC    I-H------    MOV.B     @ER5,R5L<-73
-00025000000000000BDE    I-H------    EXTU.W    R5    R5<-0073
-00024000000000000BE0    I-H-N----    SUB.W     R5,R0R0<-FF8D
-00023000000000000BE2    I-H-N----    LDM.L     @SP+,ER4<-00FFE045
-00022000000000000BE6    I-H-N----    RTS             PC<-00000860
-00021000000000000860    I-H-N----    MOV.W     R0,R0R0<-FF8D
-0002C000000000000862    I-H-N----    BNE       @H'08PC<-0000086E
-0001900000000000086E    I-H------    MOV.L     #H'00ER1<-00000EE6  else if(s
-00018000000000000874    I-H--Z---    MOV.L     ER5,EER0<-00000000
```

2.4.9 Displaying Breakpoints



```
Type     State     Condition
BP       Enable    PC=H'00000A62(sample.c/27)
BP       Enable    PC=H'00000A66(sample.c/29)
```

All the Breakpoints lists set in the program can be displayed on a Eventpoints window.

- Select [Code->Eventpoints] from the [View] menu.

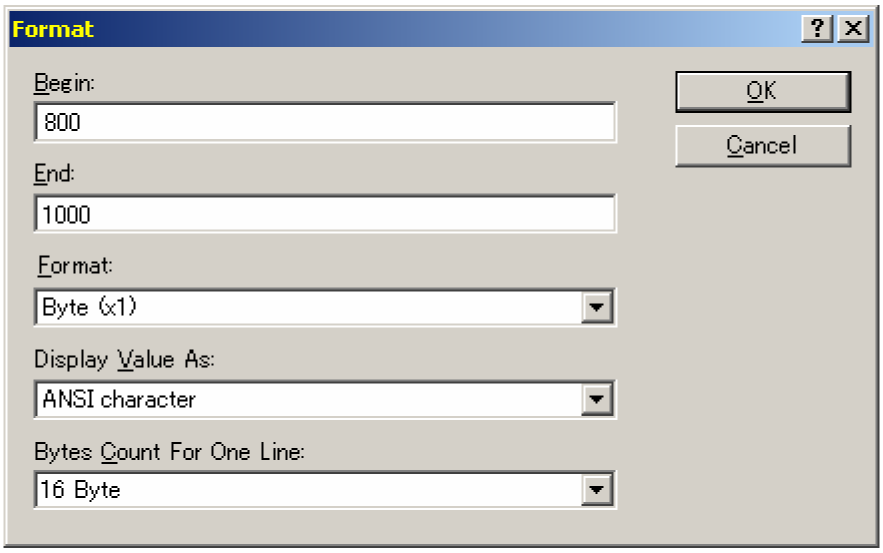
The Eventpoints window allows the user to set Breakpoints, define new Breakpoints and display Breakpoints.

Close the Breakpoints window.

2.4.10 Displaying Memory Contents

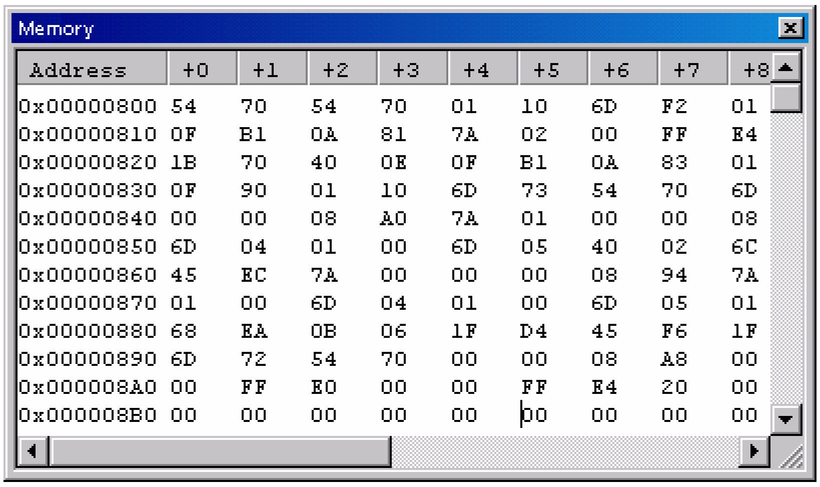
The contents of memory block can be displayed on a Memory window. For example, the procedure for displaying the memory for the main column in byte size is shown as below.

- Select [CPU->Memory…] from the [View] menu to enter memory area start address in the [Begin] field and end address in the [End] field.



Begin: 800
End: 1000
Format: Byte (x1)
Display Value As: ANSI character
Bytes Count For One Line: 16 Byte

- Click on the [OK] button to open the Memory window which shows the specified memory area.



```
Address     +0  +1  +2  +3  +4  +5  +6  +7  +8
0x00000800  54  70  54  70  01  10  6D  F2  01
0x00000810  0F  B1  0A  81  7A  02  00  FF  E4
0x00000820  1B  70  40  0E  0F  B1  0A  83  01
0x00000830  0F  90  01  10  6D  73  54  70  6D
0x00000840  00  00  08  A0  7A  01  00  00  08
0x00000850  6D  04  01  00  6D  05  40  02  6C
0x00000860  45  EC  7A  00  00  00  08  94  7A
0x00000870  01  00  6D  04  01  00  6D  05  01
0x00000880  68  EA  0B  06  1F  D4  45  F6  1F
0x00000890  6D  72  54  70  00  00  08  A8  00
0x000008A0  00  FF  E0  00  00  FF  E4  20  00
0x000008B0  00  00  00  00  00  00  00  00  00
```

Section 3 Compiler

This section describes effective functions used at the development of C/C++ programs.

The functions described below allow you to perform interrupt processing and other types of processing that cannot be supported in most C/C++ programs.

3.1 Specifying an Interrupt Function

Description

#pragma interrupt <function name> declares an interrupt function. The declared interrupt function, for which all the registers used in the function are guaranteed (saved and restored), returns on the RTE instruction. This enables the interrupt function to return from an exception processing.

[Format]

#pragma interrupt (<function name>[(<interrupt specs>)][,<function name>[(<interrupt specs>)]…])

Example

To declare an interrupt function f1. This function returns on the RTE instruction after completing its processing.

(C/C++ program)

```
extern unsigned char a;
#pragma interrupt (f1)
void f1(void)
{
    a=0;
}
```

← The function f1 is defined as an interrupt function.

(Compiled assembly-language expansion code)

```
_f1:
          PUSH.W      R0
          SUB.B       R0L,R0L
          MOV.B       R0L,@_a:32
          POP.W       R0
          RTE
          .END
```

← Interrupt function returns on RTE instruction.

Remarks and notes

Interrupt function declarations support the following features: stack-switching specification, trap instruction return specification, interrupt complete function specification, and vector table specification.

No.	Item	Format	Option	Description
1	Stack-switching specification	sp=	<variable>| &<variable>| <constant>| <variable>+<constant>| &<variable>+<constant>	Specifies a new stack address with a variable or constant. <valuable>: Valuable (pointer) &<valuable>: Valuable (object type) address <constant>: Constant value
2	Trap instruction return specification	tn=	<constant>	Specifies the end with the TRAPA instruction. <constant>: Constant value (trap vector number)
3	Interrupt complete function specification	sy=	<function name>| <constant>| $<function name>	Specifies the end with a jump to an interrupt function. <function name>: Name of interrupt function <constant>: Absolute address $< function name>: Name of interrupt function without an underscore

3.1.1 Stack-Switching Specification

Description

This function specifies a separate interrupt function stack area.

When an external interrupt occurs, the stack-switching specification (sp=) switches the stack pointer to a specified address so that the interrupt function can be operated using that stack. Upon return, this function resets the pointer to the condition that existed before the interrupt occurred.

Example

To specify a new stack address with a variable or constant. In the following example, the array STK[100] is set as a stack to be used by the interrupt function f:

(C/C++ program)

```
extern int STK [100];
extern unsigned char a;
#pragma interrupt (f(sp=STK+100))

void f(void)
{
    a=0;
}
```

← Specifies an interrupt function and switches the stack pointer.

(Compiled assembly-language expansion code)

```
_f:
          MOV.L       SP,@_STK+96:32
          MOV.L       #_STK+96:32,SP
          PUSH.W      R0
          SUB.B       R0L,R0L
          MOV.B       R0L,@_a:32
          POP.W       R0
          MOV.L       @SP,SP
          RTE
          .END
```

← Changes the stack pointer.

← Interrupt function returns on RTE instruction.

Remarks and notes

(i) This specification can be set together with a trap instruction return specification or an interrupt function complete specification.

(ii) The stack-switching specification "sp=" should always be specified in lowercase characters.

3.1.2 Trap Instruction Return Specification

Description

Functions that are declared in #pragma interrupt are normally returned by executing the RTE instruction. However, when a trap instruction return specification (tn=) is enabled, they are returned by executing the TRAPA instruction.

Example

To initiate a trap exception processing by executing the TRAPA #2 instruction upon completion of the interrupt function:

(C/C++ program)

```
extern unsigned char a;
#pragma interrupt (f(tn=2))

void f(void)
{
    a=0;
}
```

←The interrupt function f is returned on the execution of TRAPA instruction.

(Compiled assembly-language expansion code)

```
_f1:
          PUSH.W      R0
          SUB.B       R0L,R0L
          MOV.B       R0L,@_a:32
          POP.W       R0
          TRAPA       #2
          .END
```

← Returns on the execution of TRAPA instruction.

Remarks and notes

(i) This specification, which can be set with the stack-switching specification, cannot be set together with an interrupt function complete specification.

(ii) The trap-instruction return specification "tn=" should always be specified in lowercase characters.

(iii)This specification cannot be used when the CPU operating mode is specified as 300.

3.1.3 Interrupt Function Complete Specification

Description

Functions declared in #pragma interrupt are normally returned by executing the RTE instruction. However, when an interrupt function complete specification (sy=) is enabled, they jump to the specified address by the JMP instruction.

Example

To jump to the address of function f2 by the JMP instruction:

(C/C++ program)

```
extern int f2();
extern unsigned char a;
#pragma interrupt (f1(sy=$ f2))

void f1(void)
{
    a=0;
}
```

← At the end of interrupt function f1, jumps to the address of function f2 by executing the JMP instruction.

(Compiled assembly-language expansion code)

```
_f1:
          PUSH.W      R0
          SUB.B       R0L,R0L
          MOV.B       R0L,@_a:32
          POP.W       R0
          JMP         @f2:24
          .END
```

← Returns on the JMP instruction.

Remarks and notes

(i) This specification, which can be set together with a stack-switching specification, cannot be set with a trap instruction return specification.

(ii) If specified as $<function name>, the function name is referenced by an assembly language program as the name without an underscore.

(iii)The interrupt function complete specification "sp=" should always be specified in lowercase characters.

3.1.4 Vector Table Automatic Generation Functions

Description

By specifying the vector number of #pragma interrupt, the vector table of functions is automatically generated.

[Format]

#pragma interrupt (<function name>[(vect=<vector number>)])

Example

To specify a vector number to create a vector table.

(C/C++ program)

(CPU=2600a)

```
#pragma entry f1(vect=0)
void f1(){
}
#pragma interrupt (f2(vect=4))
void f2(voed){
}
#pragma indirect (f3(vect=5))
unsigned char f3(voed){
}
```

← Allocating the entry function f1 to the vector number 0.

← Allocating the interrupt function f2 to the vector number 4.

← Allocating the indirectmemory access function f3 to the vector number 5.

(memory map contents)

```
$VECT0  00000000  00000003
$VECT4  00000010  00000013
$VECT5  00000014  00000017
```

Remarks and notes

(i) The vector table specification "vect=" should always be specified in lowercase characters.
(ii) Be careful not duplicate an allocating vector number with other vector tables.
(iii)Vector Table automatic generation functions is supported by C/C++ Compiler Version 4.0 or later.

3.2 Built-in Functions

CPU instructions that are not supported in the C/C++ language specifications, such as the setting of the condition code register, are supported as expansion built-in functions.

When using a built-in function, be sure to declare the system include file machine.h.

No.	Item	Function	Referenced Section
1	Condition code register (CCR)	Sets an interrupt mask	3.2.1
2		References an interrupt mask	
3		Sets the CCR	
4		References the CCR	
5		Logically ANDs the CCR	
6		Logically ORs the CCR	
7		Logically XORs the CCR	
8	Extended register (EXR)	Sets an interrupt mask	3.2.2
9		References an interrupt mask	
10		Sets the EXR	
11		References the EXR	
12		Logically ANDs the EXR	
13		Logically ORs the EXR	
14		Logically XORs the EXR	
15	Vector Base Register (VBR)*	Setting VBR	3.2.3
16	Operation with overflow test	Performs 1-byte addition and sets the CCR according to the result	3.2.4
17		Performs 2-byte addition and sets the CCR according to the result	
18		Performs 4-byte addition and sets the CCR according to the result	
19		Performs 1-byte subtraction and sets the CCR according to the result	
20		Performs 2-byte subtraction and sets the CCR according to the result	
21		Performs 4-byte subtraction and sets the CCR according to the result	
22		Left-shifts 1-byte data and sets the CCR according to the result	
23		Left-shifts 2-byte data and sets the CCR according to the result	
24		Left-shifts 4-byte data and sets the CCR according to the result	
25		Performs the sign conversion of 1-byte data and sets the CCR according to the result	
26		Performs the sign conversion of 2-byte data and sets the CCR according to the result	
27		Performs the sign conversion of 4-byte data and sets the CCR according to the result	

No.	Item	Function	Referenced Section
28	Transfer instructions	MOVFPE instruction	3.2.5
29		MOVTPE instruction	
30	Arithmetic instructions	Decimal addition	3.2.6
31		Decimal subtraction	
32		TAS instruction	
33		MAC instruction	
34		64-bit multiplication*	
35	Shift instruction	Rotates 1-byte data to the left	3.2.7
36		Rotates 2-byte data to the left	
37		Rotates 4-byte data to the left	
38		Rotates 1-byte data to the right	
39		Rotates 2-byte data to the right	
40		Rotates 4-byte data to the right	
41	System control instructions	TRAPA instruction	3.2.8
42		SLEEP instruction	
43	Block transfer instruction	EEPMOV instruction	3.2.9
		EEPMOV instruction (Interrupt Request)	
44	Block transfer instruction (for H8SX)	MOVMD instruction	3.2.10
		MOVSD instruction	
45	NOP instruction	NOP instruction	

Note: * Can be used only in the case of H8SX.

3.2.1 Setting and Referencing the Condition Code Register (CCR)

Description

For setting and referencing the condition code register, the compiler provides the functions listed in the table below:

No.	Item	Format	Description
1	Setting an interrupt mask	void set_imask_ccr(unsigned char mask)	Sets a mask value (0 or 1) to the interrupt mask bit of the CCR.
2	Referencing an interrupt mask	unsigned char get_imask_ccr(void)	References the value (0 or 1) of interrupt mask bit (I) of the CCR.
3	Setting the CCR	void set_ccr(unsigned char ccr)	Sets the value of ccr (8 bits) to the CCR.
4	Referencing the CCR	unsigned char get_ccr(void)	References the value of the CCR.
5	ANDing the CCRs	void and_ccr(unsigned char ccr)	Logically ANDs the CCR and ccr; and stores the result in the CCR.
6	ORing the CCRs	void or_ccr(unsigned char ccr)	Logically ORs the CCR and ccr; and stores the result in the CCR.
7	XORing the CCRs	void xor_ccr(unsigned char ccr)	Logically XORs the CCR and ccr; and stores the result in the CCR.

Example

To operate the condition code register, and then, reset it to the condition existed before the CCR was operated:

(C/C++ program)

```
#include <machine.h>         ←The include file for built-in functions
void main(void)
{
    unsigned char mask;

    if (mask=get_imask_ccr()){         /* Saves the value of the interrupt mask */
        set_imask_ccr(1);              /* Specifies the beginning of exception */
        and_ccr((unsigned char)0xFC) ; /* Stores the AND of CCR and 0xFC. in CCR */
    }
    set_imask_ccr(mask);               /* Returns the value of the interrupt mask */
}
```

(Compiled assembly-language expansion code)

```
_main:   STC.B       CCR,R0L
          AND.B       #-128:8,R0L
          ROTL.B      R0L
          BEQ         L48:8
          ORC.B       #-128:8,CCR
          ANDC.B      #-4:8,CCR
L48:     STC.B       CCR,R0H
          BLD.B       #0,R0L
          BST.B       #7,R0H
          LDC.B       R0H,CCR
          RTS
          .END
```

Remarks and notes

The CCR is an 8-bit register that indicates the internal state of the CPU.

<Condition code register>

I	**UI**	**H**	**U**	**N**	**Z**	**V**	**C**

I:	Interrupt mask bit
UI:	User bit/interrupt master bit
H:	Half carry flag
U:	User bit
N:	Negative flag
Z:	Zero flag
V:	Overflow flag
C:	Carry flag

3.2.2 Setting and Referencing an Extended Register

Description

For setting and referencing an extended register, the compiler provides the following functions:

No.	Item	Format	Description
1	Setting an interrupt mask	void set_imask_exr(unsigned char mask)	Sets a mask value (0 to 7) to the interrupt mask bits (I2 to I0) of the EXR.
2	Referencing an interrupt mask	unsigned char get_imask_exr(void)	References the value (0 to 7) of the interrupt mask bits (I2 to I0) of the EXR.
3	Setting the EXR	voir set_exr(unsigned char exr)	Sets the value of exr (8 bits) in the EXR.
4	Referencing the EXR	unsigned char get_exr(void)	References the value of the EXR.
5	Taking the AND of EXRs	void and_exr(unsigned char exr)	Logically ANDs the EXR and exr; and stores the result in the EXR.
6	Taking the OR of EXRs	void or_exr(unsigned char exr)	Logically ORs the EXR and exr; and stores the result in the EXR.
7	Taking the XOR of EXRs	void xor_exr(unsigned char exr)	Logically XORs the EXR and exr; and stores the result in the EXR.

Example

To change the status of the EXR with keeping the value of the EXR interrupt mask bits unchanged:

(C/C++ program)

```
#include <machine.h>
extern unsigned char e;

void main()
{
    unsigned char mask;

    if (mask=get_imask_exr()){
        set_exr((unsigned char)0x05);
        xor_exr((unsigned char)0xff);
        e=get_exr();
    }
    set_imask_exr(mask);
}
```

←Saves the interrupt mask bits.

←Sets a value in EXR, logically XORs, and sets the result in external variable e.

←Restores the interrupt mask bits.

(Compiled assembly-language expansion code)

```
_main:
          STC.B       EXR,R1L
          AND.B       #7:8,R1L
          BEQ         L49:8
          MOV.B       #5:8,R0L
          LDC.B       R0L,EXR
          XORC.B      #-1:8,EXR
          STC.B       EXR,R0L
          MOV.B       R0L,@_e:32
L49:
          AND.B       #7:8,R1L
          STC.B       EXR,R1H
          AND.B       #-8:8,R1H
          OR.B        R1L,R1H
          LDC.B       R1H,EXR
          RTS
          .END
```

Remarks and notes

The built-in functions for setting and referencing extended registers are valid only when the CPU/operating mode is 2600n, 2600a, 2000n, or 2000a.

<Extended register>

T	–	–	–	–	I2	I1	I0

(T) Trace bit
(I2 to I0) Interrupt mask bits

3.2.3 Setting Vector Base Register

Description

H8SX has the function that can allocate the vector area for exception handling at any address.

In H8/300,H8/300H,H8S families, the vector area for exception handling is fixed from zero.

When CPU is H8SX, users can modify the allocation address of the vector area for exception handling by specifying Vector Base Register (VBR).

For setting Vector Base Register, the compiler provides the following functions:

No.	Item	Format	Description
1	Setting VBR	void set_vbr(void* vbr)	Sets the value of vbr (32 bits) to VBR.

Example

To set the value of Vector Base Register (VBR):

(C/C++ program)

←Include File for Built-in Functions

```
#include <machine.h>
void main(void)
{
    set_imask_ccr(1);            /* Set interrupt mask bit   */
    set_vbr((void*)0x20000);     /* Set 0x20000 to VBR       */
    set_imask_ccr(0);            /* Clear interrupt mask bit */
}
```

(Compiled assembly-language expansion code)

```
_main:
          ORC.B       #H'80:8,CCR
          SUB.L       ER0,ER0
          MOV.W       #2:3,E0
          LDC.L       ER0,VBR
          ANDC.B      #H'7F:8,CCR
          RTS
          .END
```

Remarks and notes

(1) The built-in functions for setting Vector Base Register are valid only when the CPU/operating mode is H8SXN, H8SXM, H8SXA, or H8SXX..

(2) When the CPU/operating mode is H8SXN, the lower 16 bits of the specified value for Vector Base Register are valid.

(3) For details about Switching Vector Table Address, refer to section 3.8.3, Switching Vector Table Address.

(4) Switching Vector Base Register (VBR) should be done in the interrupt mask state. Not in the interrupt mask state, when interrupt process occurs during switching Vector Base Register (VBR), the correct processing of the exception handling can not be guaranteed.

3.2.4 Opration with Overflow (V Flag) Test

Description

The following built-in functions are available for performing the operation with the overflow (V-flag) test:

(CC: condition code)

No.	Item	Format	Description
1	1-byte addition and CCR setting	int ovfaddc(char dst,char src,char *rst)	Adds dst and src, each 1-byte long; stores the result in area indicated by rst if rst≠0.
2	2-byte addition and CCR setting	int ovfaddw(int dst,int src,int *rst)	Adds dst and src, each 2-byte long; stores the result in area indicated by rst if rst≠0.
3	4-byte addition and CCR setting	int ovfaddl(long dst,long src,long *rst)	Adds dst and src, each 4-byte long; stores the result in area indicated by rst if rst≠0.
4	1-byte subtraction and CCR setting	int ovfsubc(char dst,char src,char *rst)	Subtracts src from dst, each 1-byte long; stores the result in area indicated by rst if rst≠0.
5	2-byte subtraction and CCR setting	int ovfsubw(int dst,int src,int *rst)	Subtracts src from dst, each 2-byte long; stores the result in area indicated by rst if rst≠0.
6	4-byte subtraction and CCR setting	int ovfsubl(long dst,long src,long *rst)	Subtracts src from dst, each 4-byte long; stores the result in area indicated by rst if rst≠0.
7	1-byte left-shift and CCR setting	int ovfshalc(char dst, char *rst)	Arithmetically shifts left the 1-byte data dst by 1 bit; stores the result in area indicated by rst if rst≠0.
8	2-byte left-shift and CCR setting	int ovfshalw(int dst, int *rst)	Arithmetically shifts left the 2-byte data dst by 1 bit; stores the result in area indicated by rst if rst≠0.
9	4-byte left-shift and CCR setting	int ovfshall(long dst, long *rst)	Arithmetically shifts left the 4-byte data dst by 1 bit; stores the result in area indicated by rst if rst≠0.
10	1-byte sign-conversion and CCR setting	int ovfnegc(char dst, char *rst)	Obtains the 2's complement of 1-byte data dst; stores the result in the area indicated by rst if rst≠0.
11	2-byte sign-conversion and CCR setting	int ovfnegw(int dst, int *rst)	Obtains the 2's complement of 2-byte data dst; stores the result in the area indicated by rst if rst≠0.
12	4-byte sign-conversion and CCR setting	int ovfnegl(long dst, long *rst)	Obtains the 2's complement of 4-byte data dst; stores the result in the area indicated by rst if rst≠0.

Example

To test to see whether the result of an addition has overflowed; perform the appropriate processing.

(C/C++ program)

```
#include <machine.h>
extern int dst, src;
void f()
{
    if (ovfaddw(dst,src,0))
        dst++;
    else
        dst--;
}
```

←Checks whether addition between dst and src generates an overflow.

(Compiled assembly-language expansion code)

```
_f:
          PUSH.L      ER6
          MOV.L       #_dst:32,ER6
          MOV.W       @ER6,R0
          MOV.W       @_src:32,R1
          ADD.W       R1,R0
          BVC         L48:8
          MOV.W       @ER6,R0
          INC.W       #1,R0
          BRA         L50:8
L48:
          MOV.W       @ER6,R0
          DEC.W       #1,R0
L50:
          MOV.W       R0,@ER6
          POP.L       ER6
          RTS
          .END
```

Remarks and notes

Condition code operation functions can be specified only in expressions that test the conditions in an if, do, while, or for statement.

3.2.5 Transfer Instructions

Description

The following functions are available to enhance the system control transfer instructions:

No.	Item	Format	Description
1	MOVFPE instruction	void movfpe(char *addr,char data) char _movfpe(char *addr) *[1]	Expands into the MOVFPE instruction that transfers data in synchronous with the E clock.
2	MOVTPE instruction	void movtpe(char data ,char *addr)	Expands into the MOVTPE instruction that transfers data in synchronous with the E clock.

Note: 1. valid only with H8SX

Example

(a) MOVFPE instruction

To load data from the memory address specified by a 16-bit absolute address synchronously with the E clock:_movfpe is the same as function as movfpe, except that it returns Destination data as its function value.

(C/C++ program)

```
#include <machine.h>
#define P1DR (*(unsigned char *)0x00FFFF60)
extern unsigned char data;
void f()
{
    movfpe((char*)&P1DR,data);
}
```

←Executes the MOVFPE instruction.

(Compiled assembly-language expansion code)

```
_f:
          MOVFPE.B    @16777056:16,R0L
          MOV.B       R0L,@_data:32
          RTS
          .END
```

(C/C++ program)

```
#include <machine.h>
#define P1DR (*(unsigned char *)0x00FFFF60)
extern unsigned char data;
void f()
{
    data =  movfpe((char*)&P1DR);
}
```

← Executes the MOVFPE instruction.

(Compiled assembly-language expansion code)

```
_f:
          MOVFPE.B    @16777056:16,R0L
          MOV.B       R0L,@_data:32
          RTS
          .END
```

(b) MOVTPE instruction

To store data to the memory area specified by a 16-bit absolute address synchronously with the E clock:

(C/C++ program)

```
#include <machine.h>
extern unsigned char data;
#define P1DR (*(unsigned char*)0x00FFFF60)
void f()
{
    movtpe(data,(char*)&P1DR);     ←Executes the  MOVTPE instruction.
}
```

(Compiled assembly-language expansion code)

```
_f:
          MOV.B       @_data:32,R0L
          MOVTPE.B    R0L,@16777056:16
          RTS
          .END
```

3.2.6 Arithmetic Operation Instructions

Description

The following functions are available to enhance arithmetic operation instructions:

No.	Item	Format	Description
1	Decimal addition	void dadd(unsiged char size, char*ptr1, char*ptr2, char*rst)	Performs decimal addition between size-byte data starting from ptr1 and size-byte data starting from prt2; and stores the result to the size-byte area starting from rst.
2	Decimal subtraction	void dsub(unsiged char size, char*ptr1, char*ptr2, char*rst)	Performs decimal subtraction between size-byte data starting from ptr1 and size-byte data starting from prt2; and stores the result to the size-byte area starting from rst.
3	TAS instruction	void tas(char*addr)	Expands into the test-and-set instruction TAS.
4	MAC instruction	long mac(long val, int*ptr1,int *ptr2, unsigned long count) long macl(long val, int*ptr1, int*ptr2, unsigned long count, unsigned long mask)	Expands into the multiply-accumulate instruction MAC.
5	64-bit multiplication*[1]	long mulsu(long val1,long val2) unsigned long muluu(unsigned long val1,unsigned long val2)	Expands into MULS/U,MULU/U

Note: 1. valid only with H8SX

Example

(1) Decimal operation

To add decimally the 6-digit 4-bit BCD data (3 bytes) starting from the address specified by ptr1 to the 4-bit BCD data starting from the address specified by ptr2 and store the result in a 3-byte area starting from the address specified by rst:

(C/C++ program)

```
#include <machine.h>
char ptr1[3]={0,1,2};
char ptr2[3]={2,1,0};
char rst[3];
void f()
{
    dadd((char)3,ptr1,ptr2,rst);    ←Outputs DAA instruction.
}
```

(Compiled assembly-language expansion code)

```
_f:      STM.L       (ER4-ER6),@-SP
          MOV.L       #_ptr1+2:32,ER0
          MOV.L       #_ptr2+2:32,ER1
          MOV.L       #_rst+3:32,ER5
          MOV.B       #3:8,R6L
          ANDC.B      #-34:8,CCR
L49:    MOV.B       @ER0,R4L
          MOV.B       @ER1,R4H
          ADDX.B      R4H,R4L
          DAA.B       R4L
          MOV.B       R4L,@-ER5
          DEC.L       #1,ER0
          DEC.L       #1,ER1
          DEC.B       R6L
          BNE         L49:8
          LDM.L       @SP+,(ER4-ER6)
          RTS
```

Remarks and notes

The first parameter for the functions dadd and dsub is a constant 1 to 255.

(2) TAS instruction

To set the MSB (bit 7) of the memory contents to "1" after testing the memory contents (by comparing with 0):

(C/C++ program)

```
extern unsigned char data;
#define ADR (*(volatile unsigned char *)0x00fff000)
#include <machine.h>
void main()
{
    tas((char*)&ADR);          ←Compares memory contents with 0; sets the result in
                                 CCR.
    if (data=get_ccr())
        and_ccr(data);
    else                       ←Stores either AND or OR to the CCR depending on
        or_ccr(data);            memory contents.
}
```

(Compiled assembly-language expansion code)

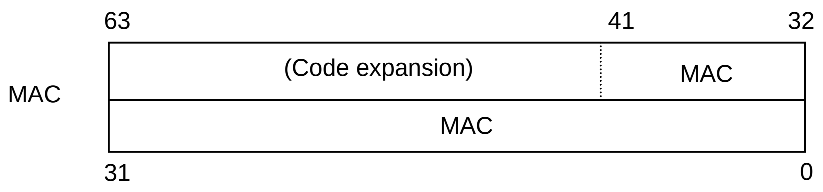
```
_main:  MOV.L       #16773120:32,ER0
          TAS         @ER0
          MOV.L       #_data:32,ER1
          STC.B       CCR,R0L
          MOV.B       R0L,@ER1
          BEQ         L47:8
          MOV.B       @ER1,R1L
          STC.B       CCR,R1H
          AND.B       R1L,R1H
          LDC.B       R1H,CCR
          RTS
L47:     MOV.B       @ER1,R1L
          STC.B       CCR,R1H
          OR.B        R1L,R1H
          LDC.B       R1H,CCR
          RTS
          .END
```

Remarks and notes

The function tas is valid only when the CPU operating mode is 2600a, 2600n, 2000a, or 2000n.

(3) MAC instruction

The H8S/2600 microcomputer contains the multiply-accumulate register (MAC),which is a 64-bit register that stores the results of multiply-accumulate operations. The following diagram shows how this register is organized.



The MAC instruction performs a multiplication between memory data items and adds the result to the MAC register. Using this register, 16 × 16 bits + 32 bits = 32 bits multiply-accumulate operations can be performed.

The following interpretations are made in the example given below:

<Function mac>

Assigns the value 100 to the MAC register as an initial value. Multiplies the 2-byte data items indicated by ptr1 and ptr2 on a signed basis, adds the resulting 4-byte data to the MAC register, and increments both ptr1 and ptr2 by 2. Repeats this operation four times, and at the end returns the contents of the MAC register.

<Function macl >

Performs a multiply-accumulate operation with ~4 because the function uses the data at ptr2 for ring-buffering.

Because the function uses ptr2&mask as an address, ptr2 must be assigned to an address that is an integral multiple of 8.

(C/C++ program)

```
#include <machine.h>
int ptr1[10]={0,1,2,3,4,5,6,7,8,9};
int ptr2[10]={9,8,7,6,5,4,3,2,1,0};
int ptr3[2]={9,8};
long l1,l2;
void func()
{
    l1=mac(100,ptr1,ptr2,4);
                                    /* l1=100+0*9+1*8+2*7+3*6 */
    l2=macl(100,ptr1,ptr3,4,~4);
                                    /* l2=100+0*9+1*8+2*9+3*8 */
}
```

← a multiply-accumulate operation

(Compiled assembly-language expansion code)

```
_func:   PUSH.L      ER2
          MOV.L       #100:32,ER0
          CLRMAC
          LDMAC.L     ER0,MACL
          MOV.L       #_ptr2:32,ER0
          MOV.L       #_ptr1:32,ER1
          MAC         @ER1+,@ER0+
          MAC         @ER1+,@ER0+
          MAC         @ER1+,@ER0+
          MAC         @ER1+,@ER0+
          STMAC.L     MACL,ER0
          MOV.L       ER0,@_l1:32
          MOV.L       #100:32,ER0
          CLRMAC
          LDMAC.L     ER0,MACL
          MOV.L       #_ptr3:32,ER0
          MOV.L       #_ptr1:32,ER1
          MOV.L       #-5:32,ER2
          MAC         @ER1+,@ER0+
          AND.L       ER2,ER0
          MAC         @ER1+,@ER0+
          AND.L       ER2,ER0
          MAC         @ER1+,@ER0+
          AND.L       ER2,ER0
          MAC         @ER1+,@ER0+
          AND.L       ER2,ER0
          STMAC.L     MACL,ER0
          MOV.L       ER0,@_l2:32
          POP.L       ER2
          RTS
```

Remarks and notes

The functions mac and macl can be used only when the CPU operating mode is specified as 2600a, 2600n, or H8SX.

(4) MULS/U,MULU/U instruction

mulsu/muluu is expanded to the MULS/U or MULU/U instruction, which performs 32-bit × 32-bit = 64-bit multiplication.

32-bit parameters (val1 and val2) for this intrinsic function are multiplied and the upper 32 bits are returned as the operation result.

(C/C++ program)

```
#include <machine.h>
long sval1, sval2, sans;
unsigned long uval1, uval2, uans;
void f(void)
{
   sans = mulsu(sval1, sval2);    ←Upper 32 bits of Signed 32-bit multiplication


   uans = muluu(uval1, uval2);    ←Upper 32 bits of Unsigned 32-bit multiplication
}
```

(Compiled assembly-language expansion code)

```
_f:
          PUSH.L      ER2
          MOV.L       @sval1:32,ER1
          MOV.L       @sval2:32,ER2
          MULS/U.L    ER2,ER1
          MOV.L       ER1,@sans:32
          MOV.L       @uval1:32,ER1
          MOV.L       @uval2:32,ER2
          MULU/U.L    ER2,ER1
          MOV.L       ER1,@uans:32
          RTS/L       ER2
```

Remarks and notes

This function mulsu/muluu is only valid when the CPU is H8SX with H8SX*:{M | MD}.

3.2.7 Shift Instructions

Description

The following built-in functions are available to enhance the rotate instructions:

No.	Item	Format	Description
1	Rotate 1-byte data to the left	char rotlc(int count,char data)	Rotates 1-byte data to the left by count bits; returns the result.
2	Rotate 2-byte data to the left	int rotlw(int count,int data)	Rotates 2-byte data to the left by count bits; returns the result.
3	Rotate 4-byte data to the left	long rotll(int count,long data)	Rotates 4-byte data to the left by count bits; returns the result.
4	Rotate 1-byte data to the right	char rotrc(int count,char data)	Rotates 1-byte data to the right by count bits; returns the result.
5	Rotate 2-byte data to the right	int rotrw(int count,int data)	Rotates 2-byte data to the right by count bits; returns the result.
6	Rotate 4-byte data to the right	long rotrl(int count,long data)	Rotates 4-byte data to the right by count bits; returns the result.

Example

To rotate bits of data.

(C/C++ program)

```
#include <machine.h>
extern unsigned char data;
char i;
void func()
{
    i=rotlc(2,data);
}
```

←Rotates left by 2 bits.

(Compiled assembly-language expansion code)

```
_func:
          MOV.B       @_data:32,R0L
          ROTL.B      #2,R0L
          MOV.B       R0L,@_i:32
          RTS
          .SECTION    B,DATA,ALIGN=2
_i:
          .RES.B      1
```

3.2.8 System Control Instructions

Description

The following functions are available to enhance system control instructions:

No.	Item	Format	Description
1	TRAPA instruction	void trapa(unsigned int trap_no)	Expands into unconditional trap TRAPA #trap_no.
2	SLEEP instruction	void sleep(void)	Expands into the low-power-consumption mode instruction SLEEP.

Example

(1) TRAPA instruction

To branch to the address indicated by the content of the vector address that is associated with a specified vector table number 0:

(C/C++ program)

```
#include <machine.h>
#define dummy (void*)0
extern void f1(void);
extern void f2(void);
extern void f3(void);
void (*const vect_table[])(void)={
    f1,dummy,f2,f3
};
void func()
{
    trapa(0);
}
```

←Trap instruction to function f1

Note: In this case, the vector table should be assigned to an interrupt vector address.

(Compiled assembly-language expansion code)

```
_func:
          TRAPA        #0
          RTS
          .SECTION     C,DATA,ALIGN=2
_vect_table:
          .DATA.L      _f1
          .DATA.L      H'00000000
          .DATA.L      _f2,_f3
          .END
```

Remarks and notes

(i) Only a constant 0 to 3 can be assigned to the parameter of the function trapa.

(ii) This function is valid only when the CPU operating mode is specified as other than 300.

(2) SLEEP instruction

Issues the SLEEP instruction to place the CPU in the low power consumption mode.

The low power consumption mode maintains the current CPU status, suspends the execution of any instructions after the SLEEP instruction, and waits until an interrupt request is generated. Upon an interrupt request, the CPU exits the low power consumption.

(C/C++ program)

```
#include <machine.h>
extern int a;
void func()
{
    while(a);
    sleep();                    ←Issues SLEEP instruction.
}
```

(Compiled assembly-language expansion code)

```
_func:
          MOV.W        @_a:32,R0
L49:
          BNE          L49:8
          SLEEP
          RTS
```

3.2.9 Block Transfer Instruction

Description

The following function is available to enhance the system control block transfer instruction:

No.	Item	Format	Description
1	EEPMOV instruction	void eepmov(void*dst, const void*src, unsigned char size) void eepmov(void*dst, const void*src, unsigned int size)	Expands into the block transfer instruction EEPMOV.
		void eepmovb(void*dst, const void*src, unsigned char size) *1	Always expanded to EEPMOV.B. Size can be a variable.
		void eepmovw(void*dst, const void*src, unsigned int size) *1	Always expanded to EEPMOV.W. Size can be a variable.
		void eepmovi(void*dst, const void*src, unsigned int size) *1	Expanded to EEPMOV. Can resume transfer after an Interrupt. Size can be a variable.
2	EEPMOV instruction (with ECR Setting)	void eepromb(void*dst, const void*src, unsigned char size, volatile unsigned char*ecr, unsigned char ecrval) void eepromw(void*dst, const void*src, unsigned int size, volatile unsigned char*ecr, unsigned char ecrval)	Sets the value to ECR. Expanded to EEPMOV.B,EEPMOV/P.W. Size can be a variable.
	EEPMOV instruction (with EPR and ECR Setting)	void eepromb_epr(void*dst, const void*src, unsigned char size, volatile unsigned char*ecr, unsigned char ecrval, volatile unsigned char*epr, unsigned char eprval) void eepromw_epr(void*dst, const void*src, unsigned int size, volatile unsigned char *ecr,unsigned char ecrval, volatile unsigned char*epr, unsigned char eprval)	Sets the value to ECR, EPR. Expanded to EEPMOV.B,EEPMOV/P.W. Size can be a variable.

Note: 1. valid only with H8SX

Example

(1) eepmov, eepmovb, eepmovw

To perform a block transfer from the address indicated by the second parameter to the address indicated by the first parameters in bytes indicated by the third parameter.

(C/C++ program)

```
#include <machine.h>
struct STR{
    char a[300];
}ST1;
struct STR ST2={0};
void f()
{
    eepmov((char*)&ST1,(char*)&ST2,255);
}
```

←Executes the EEPMOV instruction.

(Compiled assembly-language expansion code)

```
_f:
          STM.L       (ER4-ER6),@-SP
          MOV.L       #_ST2:32,ER5
          MOV.B       #-1:8,R4L
          MOV.L       #_ST1:32,ER6
          EEPMOV.B
          LDM.L       @SP+,(ER4-ER6)
          RTS
```

Remarks and notes

(i) When the CPU operating mode is 300, the maximum size of data that can be block-transferred is 255 bytes.

(ii) When the CPU operating mode is other than 300, the maximum size of data that can be block-transferred is 65535 bytes. When the data size is 256 to 65535 bytes, the instruction is expanded into EEPMOV.W, which may be subject to an NMI interrupt.

For details on this interrupt, refer to the applicable product programming manual.

(2) eepmovi

To perform a block transfer from the address indicated by the second parameter to the address indicated by the first parameters in bytes indicated by the third parameter.

This function is expanded so that the EEPMOV instruction can resume transfer after returning from an interrupt.

(C/C++ program)

```
#include <machine.h>
struct STR{
    char a[300];
}ST1;
struct STR ST2={0};
void f()
{
    eepmovi((char*)&ST1,(char*)&ST2,256);
}
```

←Executes the EEPMOV instruction.

(Compiled assembly-language expansion code)

```
_f:
         STM.L       (ER4-ER6),@-SP
         MOV.L       #_ST1,ER6
         MOV.L       #_ST2,ER5
         MOV.W       #256:16,R4
L28:
         EEPMOV.W
         MOV.W       R4,R4
         BNE         L28:8          ← Executes, until rest of transfer size is zero.
         RTS/L       (ER4-ER6)
```

Remarks and notes

This function eepmovi is valid only when the CPU is H8SX.

(3) eepromb,eepromw

To perform a block transfer from the address indicated by the second parameter to the address indicated by the first parameters in bytes indicated by the third parameter.

The **eepromb** intrinsic function transfers a memory block with the EEPMOV.B instruction, and **eepromw** with the EEPMOV/P.W instruction respectively.

These intrinsic functions set the first, second and third parameters to the registers, set **ecrval** to the address pointed by **ecr**, and then transfer the memory block.

If transfer completes successfully, 0 is returned. If transfer fails, the remaining size of the memory block left is returned.

The **size** of **eepromb** can take 0 to 255, and **size** of **eepromw** can take 0 to 65535. However, if **size** is 0, no transfer occurs.

(C/C++ program)

```
#include <machine.h>
#define ecr_ptr ((volatile unsigned char *)(0x123456))
char a[10], b[10];
unsigned char x;
void f(void)
{
    x = eepromw(b, a, 10, ecr_ptr, 1);     ←Executes the EEPMOV/P.W instruction.
}
```

(Compiled assembly-language expansion code)

```
_f:
         STM.L       (ER4-ER6),@-SP
         MOV.L       #_b,ER6
         MOV.L       #_a,ER5
         MOV.W       #H'000A:16,R4
         MOV.B       #1:4,@H'00123456:32
         EEPMOV/P.W
         MOV.B       R4L,@_x:32
         RTS/L       (ER4-ER6)
```

Remarks and notes

(i) This intrinsic function is valid when the CPU type is AE5, or when H8SX and the -eeprom option is specified.
(ii) Refer to the hardware manual for the details of ECR, EPR and other related issues.

(4) eepromb_epr,eepromw_epr

To perform a block transfer from the address indicated by the second parameter to the address indicated by the first parameters in bytes indicated by the third parameter.

The **eepromb_epr** intrinsic function transfers a memory block with the EEPMOV.B instruction, and **eepromw_epr** with the EEPMOV/P.W instruction respectively.

These intrinsic functions set the first, second and third parameters to the registers, set **eprval** to the address pointed by **epr**, set **ecrval** to the address pointed by **ecr**, and then transfer the memory block.

If transfer completes successfully, 0 is returned. If transfer fails, the remaining size of the memory block left is returned.

The **size** of **eepromb_epr** can take 0 to 255, and **size** of **eepromw_epr** can take 0 to 65535. However, if **size** is 0, no transfer occurs.

(C/C++ program)

```
#include <machine.h>
#define ecr_ptr ((volatile unsigned char *)(0x123456))
#define epr_ptr ((volatile unsigned char *)(0x123457))
char a[10], b[10];
unsigned char x;
void f(void)
{
    x = eepromw_epr(b, a, 10, ecr_ptr, 1, epr_ptr, 1);
}
```

←Executes the EEPMOV/P.W instruction.

(Compiled assembly-language expansion code)

```
_f:
          STM.L       (ER4-ER6),@-SP
          MOV.L       #_b,ER6
          MOV.L       #_a,ER5
          MOV.W       #H'000A:16,R4
          MOV.B       #1:4,@H'00123457:32
          MOV.B       #1:4,@H'00123456:32
          EEPMOV/P.W
          MOV.B       R4L,@_x:32
          RTS/L       (ER4-ER6)
```

Remarks and notes

(i) This intrinsic function is valid when the CPU type is AE5, or when H8SX and the -eeprom option is specified.
(ii) Refer to the hardware manual for the details of ECR, EPR and other related issues.

3.2.10 Block Transfer Instructions of H8SX

Description

The following function is available to enhance the block transfer instruction of H8SX.

No.	Item	Format	Description
1	MOVMD instruction	void movmdb(void*dst, const void*src, unsigned int count) void movmdw(int*dst, const int*src, unsigned int count) void movmdl(long*dst, const long*src, unsigned int count)	Expands into MOVMD instruction.
2	MOVSD instruction	unsigned int movsd(char*dst, const char*src, unsigned int size)	Expands into MOVSD instruction.

Example

(1) movmdb, movmdw, movmdl

The MOVMD.B, MOVMD.W or MOVMD.L instruction transfers a memory block of 1, 2, or 4 bytes, respectively, the number of times specified by **count** from the address specified by **src** to the address specified by **dst**.

In the following example, 100 bytes transfer, movmdb transfers 1 byte each 100 times, movmdw transfers 2 byte each 50 times, movmdl transfers 4 byte each 25 times

(C/C++ program)

```
#include <machine.h>
char s1[100], d1[100];
int s2[50], d2[50];
long s4[25], d4[25];
void f(void)
{
        movmdb(d1, s1, 100);
        movmdw(d2, s2, 50);
        movmdl(d4, s4, 25);
 }
```

←Executes the MOVMD instruction.

(Compiled assembly-language expansion code)

```
_f:
          STM.L       (ER4-ER6),@-SP
          MOV.L       # d1,ER6
          MOV.L       # s1,ER5
          MOV.W       #100:16,R4
          MOVMD.B
          MOV.L       # d2,ER6
          MOV.L       # s2,ER5
          MOV.W       #50:16,R4
          MOVMD.W
          MOV.L       # d4,ER6
          MOV.L       # s4,ER5
          MOV.W       #25:16,R4
          MOVMD.L
          RTS/L       (ER4-ER6)
```

Remarks and notes

(i) his function is valid only when the CPU is H8SX.

(ii) **count** takes the value from zero to 65535. If **count** is zero, however, it is interpreted as 65536.

(2) movsd

Transfers a memory block using the block transfer instruction MOVSD from the address specified by **src** to the address specified by **dst** either until a byte whose value is zero (H'00) has been transferred or until the transferred size has reached **size**. The return value is the value subtracting the size of actually-transferred bytes from the size given by **size**.

(C/C++ program)

```
#include <machine.h>
const char *s = “1234”;
cahr d[100];
unsigned int remain;
void f(void)
{
         remain = movsd(d, s, 100);

}
```

←Executes the MOVMD instruction within the limit of 100 bytes.

(Compiled assembly-language expansion code)

```
_f:
          STM.L       (ER4-ER6),@-SP
          MOV.L       # d,ER6
          MOV.L       @ s:32,ER5
          MOV.W       #100:16,R4
          MOVSD.B     ($+4)
          MOV.W       R4,@ remain:32
          RTS/L       (ER4-ER6)
```

←Set the value subtracting the size actually transferred from the given **size**.

Remarks and notes

(i) This function is valid only when the CPU is H8SX.

(ii) **size** takes the value from zero to 65535. If **size** is zero, however, it is interpreted as 65536.

3.3 Section Address Operators

Description

Section addresses can be specified with the compiler-supplied _ _sectop and _ _secend operators.

In objects output by the compiler, section addresses usually cannot be specified because the section assignment destination is undefined. However, with the _ _sectop and _ _secend operators, you can specify the final address of a section that will be set in the program linked using the Inter-Module Optimization Tool.

These two operators can be specified as follows:

[Format]

_ _sectop("<section name>")

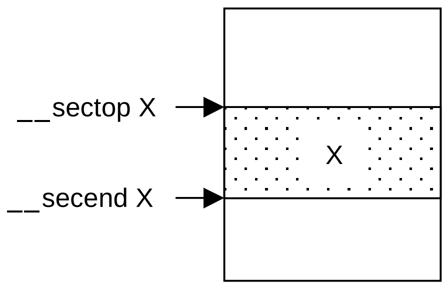
_ _secend("<section name>")

With a section named X, the statements including the operators are expanded as follows:

__sectop("X") → STARTOF X

__secend("X") → STARTOF X+SIZEOF X

Example of section status



STARTOF and SIZEOF are asembler operators.

STARTOF determines the start address of a section set after it has been linked.

SIZEOF determines the size of a section set after it has been linked.

Example

To copy the contents of section X to section Y:

(C/C++C/C++ program)

```
char *X_BGN;
char *X_END;
char *Y_BGN;
void func(void)
{
    char *p, *q;

    X_BGN=(char *)__sectop("X");
    X_END=(char *)__secend("X");
    Y_BGN=(char *)__sectop("Y");

    for (p=X_BGN,q=Y_BGN;p<X_END;p++,q++)
        *q = *p;
}
```

(Compiled assembly-language expansion code)

```
_func:
      STM.L       (ER4-ER5),@-SP
      MOV.L       #_X_END:32,ER4
      MOV.L       #STARTOF X:32,ER0
      MOV.L       ER0,@_X_BGN:32
      MOV.L       #STARTOF X+SIZEOF X:32,ER0
      MOV.L       ER0,@ER4
      MOV.L       #STARTOF Y:32,ER0
      MOV.L       ER0,@_Y_BGN:32
      MOV.L       @_X_BGN:32,ER1
      MOV.L       ER0,ER5
      BRA         L12:8
L11:
      MOV.B       @ER1,R0L
      MOV.B       R0L,@ER5
      INC.L       #1,ER1
      INC.L       #1,ER5
L12:
      MOV.L       @ER4,ER0
      CMP.L       ER0,ER1
      BCS         L11:8
      LDM.L       @SP+,(ER4-ER5)
      RTS
```

Remarks

If the section specified by the section address operator does not exist, the operator creates a section of size 0. The attribute of this section is *data*, with a boundary alignmet of 2.

3.4 C++ Language Settings

The C++ language requires the following settings in addition to the settings for the C language:

3.4.1 Setting an EC++ Class Library

In HEW1.2, the C++ language requires the linking of an EC++ class library in addition to the standard library. As in the case of the standard library, an EC++ class library must be selected as indicated below, depending on the type of the CPU used, the purpose of the optimization, and the number of parameter-passing registers used. EC++ class libraries that do not match with the specification of the standard library or from the compiler options cannot be linked.

In HEW2.0 or later, the Standard Library Generator Tool should be used to create an EC++ class library.

Select Category:[Standard Library] EC++ from Standard Library tab for settings.

CPU Series:	Operating Mode:	Merit of Library:	Change Number of Parameter …	EC++ Class Library
H8S/2600	Normal	Code Size	2	ec226n.lib
		Speed	2	ec226ns.lib
		Code Size	3	ec226n3.lib
		Speed	3	ec226ns3.lib
	Advanced	Code Size	2	ec226a.lib
		Speed	2	ec226as.lib
		Code Size	3	ec226a3.lib
		Speed	3	ec226as3.lib
H8S/2000	Normal	Code Size	2	ec226n.lib
		Speed	2	ec226ns.lib
		Code Size	3	ec226n3.lib
		Speed	3	ec226ns3.lib
	Advanced	Code Size	2	ec226a.lib
		Speed	2	ec226as.lib
		Code Size	3	ec226a3.lib
		Speed	3	ec226as3.lib
H8/300H	Normal	Code Size	2	ec2hn.lib
		Speed	2	ec2hns.lib
		Code Size	3	ec2hn3.lib
		Speed	3	ec2hns3.lib
	Advanced	Code Size	2	ec2ha.lib
		Speed	2	ec2has.lib
		Code Size	3	ec2ha3.lib
		Speed	3	ec2has3.lib
H8/300	-	Code Size	2	ec2reg.lib
		Speed	2	ec2regs.lib
		Code Size	3	ec2reg3.lib
		Speed	3	ec2regs3.lib

CPU Series:	**Operating Mode:**	**Merit of Library:**	**Change Number of Parameter …**	**EC++ Class Library**
H8/300L	-	Code Size	2	ec2reg.lib
		Speed	2	ec2regs.lib
		Code Size	3	ec2reg3.lib
		Speed	3	ec2regs3.lib

3.4.2 Changing the Initialization Method

In the C++ language, the initial settings must be modified as indicated below:

The following description illustrates the modification method by using the resetprg.c file in the workspace created in section 2.1.1, Creating a New Workspace 2 (HEW2.0):

▨ : Added

```
#include <machine.h>
#include "stacksct.h"

#pragma entry PowerON_Reset
extern void main(void);
#ifdef __cplusplus
extern “C” {
#endif
extern void _INITSCT(void);
#ifdef   USES_SIMIO
extern void _INIT_IOLIB(void);
extern void _CLOSEALL(void);
#endif
#ifdef OTHERLIB
extern void _INIT_OTHERLIB(void);
#endif
#ifdef   HWSETUP
extern void HardwareSetup(void);
#endif
#ifdef __cplusplus
}
#endif

#pragma section ResetPRG
void PowerON_Reset(void);
void PowerON_Reset(void)
{
    set_imask_ccr(1);
   _INITSCT();
#ifdef   USES_SIMIO
   _INIT_IOLIB();
#endif
#ifdef OTHERLIB
   _INIT_OTHERLIB();
#endif
#ifdef   HWSETUP
   HardwareSetup();
#endif
    _call_init();
   main();
#ifdef   USES_SIMIO
   _CLOSEALL();
#endif

    _call_end():
   sleep();
}
```

These functions are called if static data exists in the C++ program.

The _call_init function initializes the C++ initialized data area that stores the address of the constructor which is called with respect to a global class object.

The _call_end function initializes the C++ post-processing data area that stores the address of the destructor which is called with respect to a global class object.

Both functions are supplied in the standard library.

3.4.3 Changing a Structure Boundary Alignment

Description

Either the pack option or #pragma pack1/#pragma pack2/#pragma unpack can be used to change the boundary alignment for a structure.

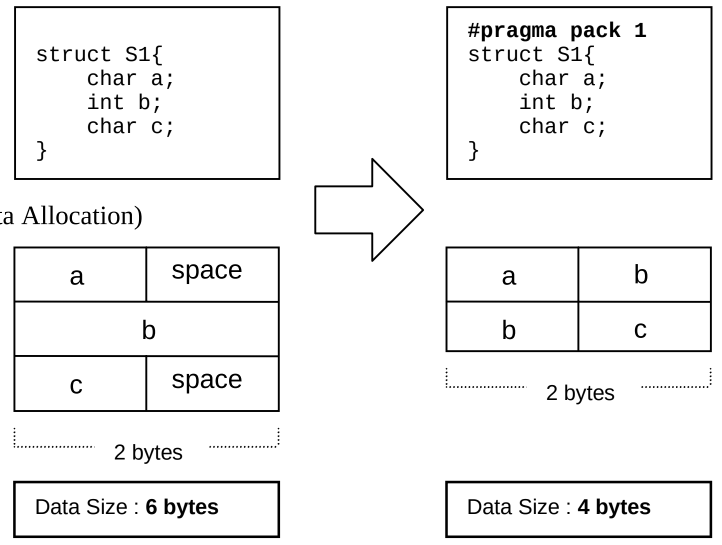
These specifications change the boundary alignment as follows:

Specification	#pragma pack1	#pragma pack2	#pragma unpack or none
[unsigned]char	1	1	1
[unsigned]short, [unsigned]int, [unsigned]long, floating-point type, pointer type	1	2	pack option specified
Structures, unions, and classes with a boundary alignment value of 1.	1	1	1
Structures, unions, and classes with a boundary alignment value of 2.	1	2	pack option specified

Changing a boundary alignment

When #pragma pack1 is specified, data except 1 byte can be allocated at an odd address in order not to make a space for boundary alignment. So data size may be reduced.

(C/C++ program)



```
struct S1{
    char a;
    int b;
    char c;
}
```

```
#pragma pack 1
struct S1{
    char a;
    int b;
    char c;
}
```

(Data Allocation)

Remarks

As changing a boundary alignment may reduce data size, it is useful for such as block transfer. However, when #pragma pack1 is specified, it may increases the necessary access code, which access word or long word members of structures one byte each.

When CPU is H8SX, word access for word or long word member at an odd address does not occur an address error because of the device specification. So these members can be accessed by word or long word instructions.

As a result, it does not increase the necessary access code.
When CPU is other than H8SX, members of structures must not be accessed via a pointer as the following example.

(C/C++ program)

```
struct S {
         char x;
         int y;
} s;                  ← address of s.y can be odd
int *p=&s.y;
void test()
{
         s.y=1;       ← accessed correctly

         *p =7;
}                     ← can be accessed incorrectly
```

3.5 New Expansion Functions of Compiler Ver.4.0

This section explains expansion functions that are newly added to the Compiler ver.4.0.

3.5.1 Vector Table Automatic Generation Functions

Description

By specifying the vector number of #pragma interrupt, #pragma inderect, and #pragma entry, the vector table of functions is automatically generated.

[Format]

#pragma interrupt (<function name>[(vect=<vector number>)])

#pragma inderect (<function name>[(vect=<vector number>)])

#pragma entry <function name>[(vect=<vector number>)]

Example

To specify a vector number to create a vector table.

(C/C++ program)

(CPU=2600a)

```
#pragma entry f1(vect=0)
void f1(){
}
#pragma interrupt (f2(vect=4))
void f2(void){
}
#pragma indirect (f3(vect=5))
unsigned char f3(void){
}
```

← Allocating the entry function f1 to the vector number 0.

← Allocating the interrupt function f2 to the vector number 4.

← Allocating the indirect memory access function f3 to the vector number 5.

(memory map contents)

```
$VECT0   00000000  00000003
$VECT4   00000010  00000013
$VECT5   00000014  00000017
```

Remarks and notes

(i) The vector table specification "vect=" should always be specified in lowercase characters.

(ii) Be careful not duplicate an allocating vector number with other vector tables.

3.5.2 Specifying the Number of Parameter-Passing Registers

Description

The number of parameter-passing registers can be specified for each function.

The function that is specified by _ _ regparam2 uses ER0, ER1 (R0 and R1 for H8/300), and the function that is specified by _ _ regparam3 uses ER0, ER1, ER2 (R0, R1, and R2 for H8/300).

[Format]

<type specifier> _ _ regparam2 <function name>

<type specifier> _ _ regparam3 <function name>

Example

This function specifies to store a variable to stack or allocate it to ER2.

(C/C++ program)

```
void _ _ regparam2 func1(long a, int b, int c, long d);
void _ _ regparam3 func2(long a, int b, int c, long d);
void main(void)
{
           ::
      func1(a,b,c,d);
          :
          :
          :
      func2(a,b,c,d);
          :
          :
          :
}
```

```
Variable allocation patterns
(CPU=2600a)
func1
      long a  :ER0
      int b   :E1
      int c   :R1
      long d  :stack
func2
      long a  :ER0
      int b   :E1
      int c   :R1
      long d  :ER2
```

Remarks and notes

(i) This function supports only keyword specifications.

(ii) Using the compiler CPU option regparam=3, parameter-passing registers use ER0, ER1, ER2 (R0, R1, and R2 for H8/300) for all functions.

3.5.3 Even Byte access Specification Features

Description

This feature always allows to access in even byte (not to access in byte) for 2 or 4 bytes of scalar type of variable/constant.

[Format]

_ _ evenaccess <type specifier> <variable name>

<type specifier> _ _ evenaccess <variable name>

Example

(C/C++ program)

```
#define A (*(volatile unsigned short __evenaccess
*)0xff01178)
void test(void)
{
   A &= ~0x2000 ;
}
```

(Compiled assembly-language expansion code)

_ _ evenaccess is not specified

```
_test:
      BCLR.B    #5,@15733112:32
      RTS
```

_ _ evenaccess is specified

```
_test:
      MOV.W    @15733112:32,R0
      BCLR.B   #5,R0H
      MOV.W    R0,@15733112:32
      RTS
```

Accesses in the word instruction

Remarks and notes

(i) In H8/300, the function allows to access in 2 bytes.
(ii) This function supports only keyword specifications.

3.6 New Expansion Functions of Compiler Ver.6.0

This section explains expansion functions that are newly added to the Compiler ver.6.0.

3.6.1 Bit Field Order Specification

Description

#pragma bit_order, bit_order option can specify the order of bit field members.

Sometimes Bit Field Order Rules are different between CPUs, this function may increase the compatibility of programs between different CPUs. When this option is omitted, BIt_order = Left is selected.

Specification Method

(1) Extended Function Format
   #pragma bit_order (left | right)

(2) Option
   BIt_order = {Left | Right}

Example

Switches the order of bit field assignment as the following examples.

When left is specified, bit field members are assigned from the most significant bit side.

When right is specified, members are assigned from the least significant bit side.

If #pragma bit_order is specified without left or right specifiler, the interpretation of the bit_order option is effective below the line.

(C/C++ program)

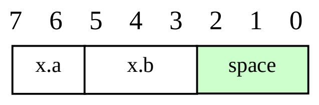
assigned from the most significant bit

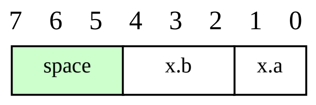
```
#pragma bit_order left
struct {
        unsigned char a:2;
        unsigned char b:3;
}x;
void func(void)
{
        x.a = 3;
        x.b = 5;
}
```

assigned from the least significant bit

```
#pragma bit_order right
struct {
        unsigned char a:2;
        unsigned char b:3;
}x;
void func(void)
{
        x.a = 3;
        x.b = 5;
}
```

(Assigned Data Order)





3.7 New Expansion Functions of Compiler Ver.6.1

This section explains options and expansion functions that are newly added to the Compiler Ver.6.1.

3.7.1 legacy=v4

Description

When specified this option, the C/C++ Compiler ver.6.1 outputs objects which are optimized by the same way as Ver.4.0.

This is useful for the process depending on timing, because the objects don't differ from Ver.4.0.

When NOT specified this option, the objects which are more strongly optimized than Ver.4.0.

Specification Method

Command line: *legacy = v4*

Notes and Remarks

This option is valid, when CPU type is 2600A,2600N,2000A or 2000N.

When **legacy=v4** is specified, the following options are NOT available.

opt_range, del_vacant_loop, max_unroll, infinite_loop, global_alloc, struct_alloc, const_var_propagate, volatile_loop, scope, strict_ansi, file_inline, file_inline_path, enable_register

3.7.2 cpuexpand=v6

Description

The **cpuexpand** option generates multiplication and division code for variables by expanding interpretation of the ANSI standard.

So the objects which are generated by specifying the **cpuexpand** option may be different between the C/C++ Compiler Ver.4.0 and Ver.6.0 or later, when CPU type is 2600A,2600N,2000A or 2000N.

If this difference makes some undesirable results, please use **cpuexpand=v6** option. The **cpuexpand=v6 option** doesn't make any difference of objects, so no undesirable results are made.

Specification Method

Command line: *cpuexpand = [v6]*

Expressions influenced

```
(a) signed long    =   signed int     <<       constant
(b) signed long    =  unsigned int    <<       constant
(c) unsigned long  =   signed int     <<       constant
(d) unsigned long  =  unsigned int    <<       constant
(e) signed int     = (  signed int    <<       constant)  /   signed int
(f) signed int     = (unsigned int    <<       constant)  /   signed int
(g) signed int     = (unsigned int    <<       constant)  / unsigned int
(h) unsigned int   = (  signed int    <<       constant)  /   signed int
```

(i) unsigned int	= (unsigned int	<<	constant) /	signed int
(j) unsigned int	= (unsigned int	<<	constant)	/ unsigned int

Examples of codes

Example of (unsigned signed long = unsigned signed int << constant)

-cpuexpand- legacy=v4	*-cpuexpand=V6 -legacy=v4*

`MOV.W       @_i1:32,R0`
`MOV.W       #1024,E0`
`MULXS.W     E0,ER0`
`MOV.L       ER0,@_l1:32`
	`MOV.B       @_i1+1:32,R0H`
	`SUB.B       R0L,R0L`
	`SHLL.W      #2,R0`
	`EXTU.L      ER0`
	`MOV.L       ER0,@_l1:32`

Shift result is stored to unsigned long.	Shift result is zero expanded, and stored to unsigned long.

Notes and Remarks

This option is valid, when CPU type is 2600A,2600N,2000A, or 2000N, and **legacy=v4** is specified.

3.7.3 Enabling Register Declarations

Description

The compiler allocates registers to variables in order, based on the analysis results in the compiler, regardless of whether or not the registers are declared.

When the "-enable_register" option is specified, the registers are allocated first to the variables with the register declaration.

Specification Method

-enable_register

Example of use

```
int g_i1;
void func()
{
register long Reg_l1 = 999;
long l2 = 126;
long l3 = 248;

        switch(g_i1){
        case 2:
                Reg_l1++;
        break;
        case 3:
            l2 += 5;
        break;
        case 4:
            l2 += 7;
        break;
        case 9:
                l3 -= 11;
        break;
        case 10:
                l3 -= 19;
        break;
        }
    printf("%d,%d,%d\n",Reg_l1,l2,l3); // Since the value of 'Reg_l1' is passed to printf via ER1,
                                          // allocating ER1 to ' Reg_l1' improves efficiency.
}
```

Examples of codes

-enable_register not specified

```
_func:
    STM.L       (ER4-ER6),@-SP
    SUB.W       #8:16,R7
    MOV.L       #H'000003E7,ER5
    SUB.L       ER6,ER6
    MOV.B       #H'7E:8,R6L
    SUB.L       ER4,ER4
    MOV.B       #H'F8:8,R4L
    MOV.W       @_g_i1:16,R0
    MOV.W       R0,R1
    MOV.B       R0H,R0H
    BNE         L26:8
    CMP.B       #2:8,R1L
    BEQ         L27:8
    CMP.B       #3:8,R1L
    BEQ         L28:8
    CMP.B       #4:8,R1L
    BEQ         L29:8
    CMP.B       #9:8,R1L
    BEQ         L30:8
    CMP.B       #H'0A:8,R1L
    BNE         L26:8
    MOV.B       #H'E5:8,R4L
    BRA         L26:8
L30:
    MOV.B       #H'ED:8,R4L
    BRA         L26:8
L29:
    MOV.B       #H'85:8,R6L
    BRA         L26:8
L28:
    MOV.B       #H'83:8,R6L
    BRA         L26:8
L27:
    MOV.B       #H'E8:8,R5L
L26:
    MOV.W       #LWORD L45:16,R0
    MOV.L       ER6,@SP
    MOV.L       ER4,@(4:16,SP)
    MOV.L       ER5,ER1
    JSR         @_printf:16
    ADD.W       #8:16,R7
    LDM.L       @SP+,(ER4-ER6)
    RTS
```

Since variable Reg_l1 gives higher priority, ER1 is allocated.

-enable_register

```
_func:
    STM.L       (ER4-ER6),@-SP
    SUB.W       #8:16,R7
    MOV.L       #H'000003E7,ER1
    SUB.L       ER4,ER4
    MOV.B       #H'7E:8,R4L
    SUB.L       ER6,ER6
    MOV.B       #H'F8:8,R6L
    MOV.W       @_g_i1:16,R0
    MOV.W       R0,R5
    MOV.B       R0H,R0H
    BNE         L26:8
    CMP.B       #2:8,R5L
    BEQ         L27:8
    CMP.B       #3:8,R5L
    BEQ         L28:8
    CMP.B       #4:8,R5L
    BEQ         L29:8
    CMP.B       #9:8,R5L
    BEQ         L30:8
    CMP.B       #H'0A:8,R5L
    BNE         L26:8
    MOV.B       #H'E5:8,R6L
    BRA         L26:8
L30:
    MOV.B       #H'ED:8,R6L
    BRA         L26:8
L29:
    MOV.B       #H'85:8,R4L
    BRA         L26:8
L28
    MOV.B       #H'83:8,R4L
    BRA         L26:8
L27:
    MOV.B       #H'E8:8,R1L
L26:
    MOV.W       #LWORD L45:16,R0
    MOV.L       ER4,@SP
    MOV.L       ER6,@(4:16,SP)

    JSR         @_printf:16
    ADD.W       #8:16,R7
    LDM.L       @SP+,(ER4-ER6)
    RTS
```

Notes and Remarks

If a register is not allocated, the following information message appears:

C0102 (I) Register is not allocated to "variable name" in "function name"

However, this message does not appear if an argument is not allocated to any register.

This option is valid, when CPU type is H8SX or H8S.

3.7.4 Specifying Absolute Addresses of Variables

Description

You can specify the absolute addresses of variables that are referenced externally, using a preprocessor directive. The compiler allocates the variables declared in the #pramga address directive to the corresponding absolute addresses. This feature enables easier access via variables to I/O allocated to a specific address.

Format

#pragma address (<variable name> = <address value>[,<variable name> = <address value> ...])

Example of use

Variable”io” is allocated to the absolute address 0x100.

C language code

```
#pragma address (io=0x100)
int io;
f()
{
     io = 10;
}
```

Expanded into assembly language code

```
_main:
          MOV.L       #H'0A:8,@_io:16
          RTS
          .SECTION    $ADDRESS$B100,DATA,LOCATE=H'100
_io:
          .RES.L      1
          .END
```

Important Information

This option is valid, when CPU type is H8SX or H8S.

(1) You must specify "#pragma address" before the variable declaration.
(2) An error will occur if you specify a compound type member or other than a variable.
(3) An error will occur if you specify an odd address for a variable or structure whose alignment number is 2.
(4) An error will occur if you specify "#pragma address" more than once for the same variable.
(5) An error will occur if you specify the same address for different variables or if you specify the same variable address more than once.
(6) An error will occur if you specify the following #pragma extensions at the same time, for the same variable:

#pragma section

#pragma abs8/abs16

#pragma global_register

3.7.5 Inter-file Inline Expansion

Description

The C/C++ Compiler is performed for each file. As a result, if a function is called across files, inline expansion is not applied to the function, even though the **–speed=inline** option, **#pragma inline** or keyword **inline** is specified in the function for inline expansion.

When inter-file inline expansion option is specified, inline expansion can be applied to the function, even if that function is called across files.

If the file, which includes the function for inline expansion, is on the other directory, inline expansion can be applied to the function by specifying the directory on which the function for inter-file inline expansion exists.

Specification Method

Inter-file Inline Expansion

Dialog menu: **C/C++** Tab **Category: [Optimize] [Details...][Inline][Inline file path]**

Command line: *FILe_inline=<file name>[,...]*

Inter-file Inline Expansion Directory Specification

Dialog menu: **C/C++** Tab **Category: [Source] [Show entries for :][File inline path]**

Command line: *file_inline_path=<path name> [,…]*

Files for inter-file inline expansion are searched in the order of the [File inline path] directory and the current directory.

Examples of use

In the following example, the function **func**, in which keyword **inline** is specified, is called from other file.

For inline expansion, specify the inter-file inline expansion option at compile of the calling function **test_1.c**.

(C/C++ program)

ch38 –cpu=h8sxa **–file_inline=test_2.c** test_1.c

ch38 –cpu=h8sxa test_2.c

```
[test_1.c]
void main(void);
void func(void);
int si1,si2;
void main(void)
{
    func();
}
```

```
[test_2.c]
extern int si1,si2;
void func(void);
__inline void func(void)
{
    si1 = 10;
    si2 = 20;
}
```

Examples of codes

When specified the inter-file inline expansion option, codes of **test_2.c** are expanded in the calling function.

Not specified

```
[test_1.c]
_main:
    JMP         @_func:24
```

```
[test_2.c]
_func:
    MOV.W       #H'A:4,@_si1:32
    MOV.W       #H'14:8,@_si2:32
    RTS
```

Specified

```
[test_1.c]
_main:
    MOV.W       #H'A:4,@_si1:32
    MOV.W       #H'14:8,@_si2:32
    RTS
```

```
[test_2.c]
_func:
    MOV.W       #H'A:4,@_si1:32
    MOV.W       #H'14:8,@_si2:32
    RTS
```

Notes and Remarks

This option is valid only when the CPU type is H8SX or H8S (without legacy=v4 option).

(1) When this option is specified, inline expansion is only applied to the functions specified with **#pragma inline** or keyword **inline** included in the file specified by <file name>. If the **–speed=inline** option is specified simultaneously, inline expansion is applied to all possible functions in the file.

(2) If a global function is defined twice or more in some files specified by this option, no operation is guaranteed
(using a single function definition randomly selected for inline expansion)

(3) The extension of the file name specified by <file name> cannot be omitted.

(4) A wild card (* or ?) cannot be specified for <file name>.

(5) If a file has #pragma asm-endasm, #pragma inline_asm or __asm, it will not be expanded.

3.7.6 Division of Optimizing Ranges

Description

When the Division of Optimizing Ranges option is specified, the compiler divides the optimizing ranges of the large-size functions into some blocks. When the Division of Optimizing Ranges option is NOT specified, the compiler does not divide the optimizing ranges.

When the optimizing range is expanded, the object performance is generally improved although the compilation time becomes longer. However, if registers are insufficient, the object performance may not be improved.

Use this option at performance tuning because it affects the object performance depending on the program.

Specification Method

Dialog menu: None

Command line: *SCOpe*
: *NOSCope*

Examples of use

In the following example, ROM size of the C program, which has 1000 variable declarations and each variable is set, is shown. When **noscope** option is specified, ROM size is reduced by 6 bytes.

The following message is output, when message option* is specified and scope option is specified for Division of Optimizing Ranges.

Note: * In HEW, **C/C++** Tab **Category: [Source] [Show entries for :][Messages][Display information level messages]**

(C/C++ program)

cpu=h8sxa

scope specified	8010 bytes
noscope specified	8004 bytes

(Message)

C0101 (I) Optimizing range divided in function "function name"

Notes and Remarks

This option is valid only when the CPU type is H8SX or H8S (without legacy=v4 option).

3.8 Features of H8SX

3.8.1 Address Space

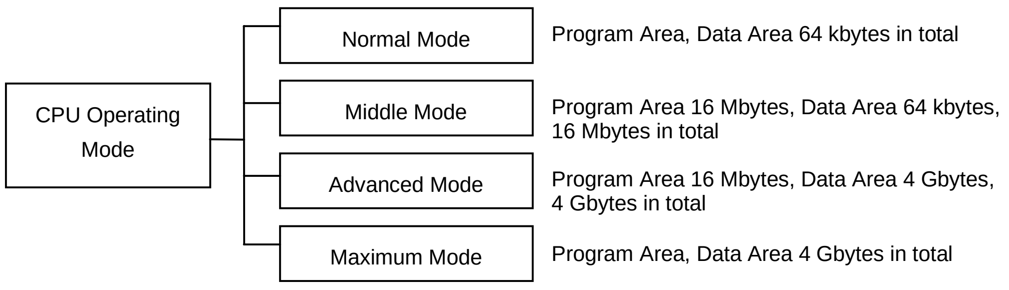
Description

H8/300,H8/300H,H8S/2000,H8S/2600 has two CPU mode at most, H8SX has the following four CPU operating mode.

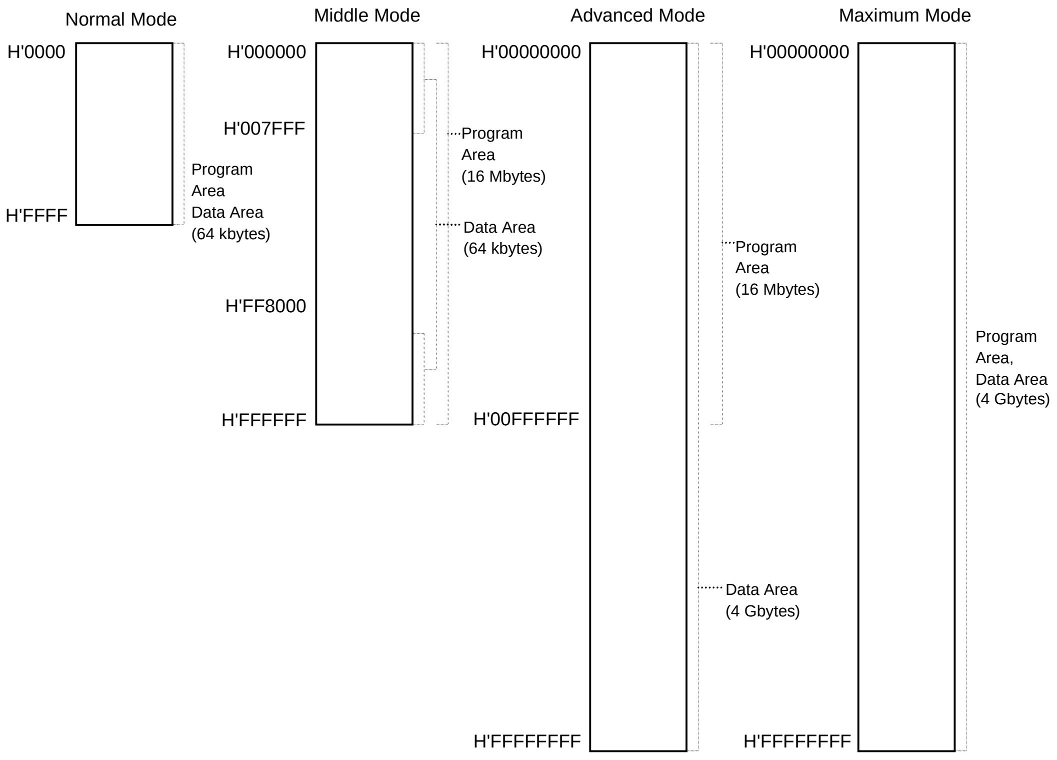
Each mode is selected with the mode pins of the LSI or other sources.

When compile, it is selected by specifying the CPU type and the operating mode options.

Since the usable modes and areas differ depending on the product, refer to the hardware manual when specifying CPU mode.


CPU Operating Mode
Normal Mode
Program Area, Data Area 64 kbytes in total
Middle Mode
Program Area 16 Mbytes, Data Area 64 kbytes, 16 Mbytes in total
Advanced Mode
Program Area 16 Mbytes, Data Area 4 Gbytes, 4 Gbytes in total
Maximum Mode
Program Area, Data Area 4 Gbytes in total

Address Space



3.8.2 Specifying 8-bit Absolute Address Space

Description

If data are allocated and accessed in 8-bit absolute address space, the objects can be small size and high speed.

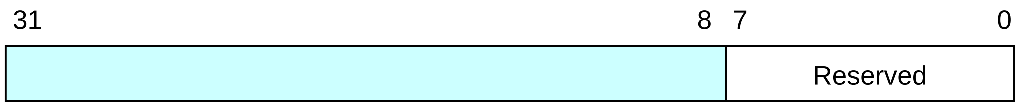
When CPU is H8SX, users can modify the access range of this 8-bit absolute address space.

In the old H8 family, 8-bit absolute address space is fixed from H'FFFF00 to H'FFFFFF, and duplicated internal I/O space.

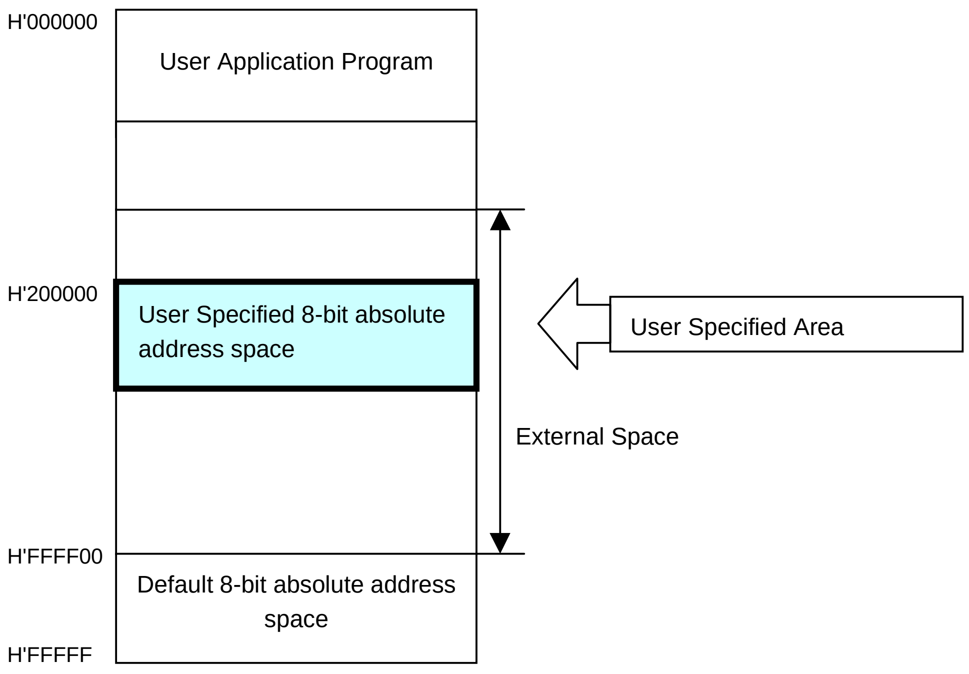
In H8SX, 256 bytes area from any address specified by SBR(Short Address Base Register) is set as 8-bit absolute address space.

Register Format

SBR (Short Address Base Register) is a 32-bit register that has the valid upper 24 bits. The lower eight bits are reserved and read as 0s.



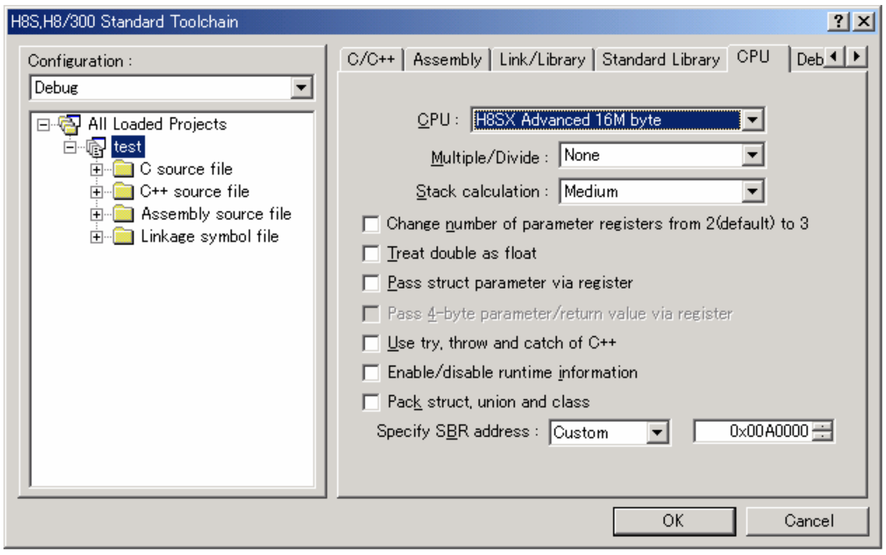
8-bit absolute address space



Specification Method

Dialog menu: **CPU** Tab, **Specify SBR address**

Command line: *sbr* = <*address*>


H8S,H8/300 Standard Toolchain

Configuration : Debug

All Loaded Projects
test
C source file
C++ source file
Assembly source file
Linkage symbol file

C/C++ | Assembly | Link/Library | Standard Library | CPU | Deb

CPU : H8SX Advanced 16M byte
Multiple/Divide : None
Stack calculation : Medium
☐ Change number of parameter registers from 2(default) to 3
☐ Treat double as float
☐ Pass struct parameter via register
☐ Pass 4-byte parameter/return value via register
☐ Use try, throw and catch of C++
☐ Enable/disable runtime information
☐ Pack struct, union and class
Specify SBR address : Custom 0x00A0000

OK Cancel

Example

As SBR(Short Address Base Register) can not be accessed from C/C++ language directly, SBR should be written in assembly instructions.

But by the compiler extended function **__asm** as follows, assembly-language instructions can be written in C/C++ language.

Though assembly-language instructions can be written by pragma_asm in the old version compiler, they should be translated into assembly source code after compile.

The assembly program written in the **__asm** block can be compiled into an object file directly, so the symbols can be referred in the source-level debugger.

For details about **__asm**, refer to section 10.2.1(3), in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

(C/C++ program)

```
__abs8 unsigned char a,b;
void main(void)
{
__asm{
    mov.l #0xa0000,er0
ldc.l er0,sbr
}
a = 7;
b = -1;
}
```

← 8-bit absolute address by __abs8

← Set 0xa0000 to SBR.

← Access 8-bit absolute address from 0xa0000

Section Allocation

As 8-bit absolute address space is declared by __abs8, $ABS8B section is output. Optimizing Linkage Editor allocates the $ABS8B section at 0xa0000 in the above example.

Examples of C/C++ Program

When using HEW, delete the comments of the following bold type parts in **resetprg.c** to make them available

When NOT using HEW, add the same expression in the initial routine.

```
__entry(vect=0) void PowerON_Reset(void)
{
// Remove the comment when you make the initial setting of SBR/VBR
for H8SX
        __asm{
                mov.l   #0xa0000,er0
                ldc.l   er0,sbr
                mov.l   #0x00000000,er0
                ldc.l   er0,vbr
        }
         set_imask_ccr(1);
        _INITSCT();
            :
```

(8-bit absolute address space is **NOT used)**

```
unsigned char c1,c2;
void main(void)
{
        c1 = 7;
        c2 = -1;
}
```

(8-bit absolute address space is **used)**

```
__abs8 unsigned char c1,c2;
void main(void)
{
        c1 = 7;
        c2 = -1;
}
```

Examples of assembly expansion code

Examples of H8SX advanced mode 16M

(8-bit absolute address space is **NOT used**)

```
_main:
    MOV.B       #7:4,@_c1:32
    MOV.B       #255:8,@_c2:32
    RTS
```

(8-bit absolute address space is **used**)

Access **0xa0000 – 0xa00FF**

```
_main:
MOV.B       #7:8,R0L
MOV.B       R0L,@_c1:8
MOV.B       #255:8,R0L
MOV.B       R0L,@_c2:8
RTS
```

Object Size [byte]

	H8SX		
CPU type	MAX	ADV	NML
Before Improvement	16	16	12
After Improvement	10	10	10

Execution Speed [cycle]

	H8SX		
CPU type	MAX	ADV	NML
Before Improvement	12	12	11
After Improvement	11	11	11

3.8.3 Switching Vector Table Address

Description

H8SX has the function that can allocate the vector area for exception handling at any address.

In H8/300,H8/300H,H8S family, the vector area for exception handling is fixed from zero.

When CPU is H8SX, users can modify the allocation address of the vector area for exception handling by specifying Vector Base Register (VBR).

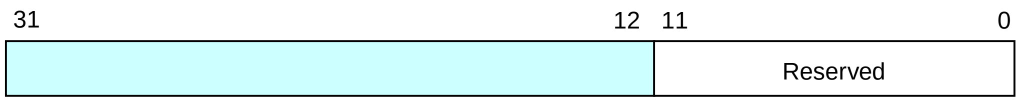
Merit of Vector Base Register

As the vector area for exception handling can be located at any address by Vector Base Register (VBR), the vector table can be made in fast internal RAM, even though for internal ROM less chip.

This can improve the response of exception handling.

Register Format

Vector Base Register (VBR) is a 32-bit register that has the valid upper 20 bits. The lower 12 bits of this register are reserved and read as 0s.



Setting Vector Base Register by Compiler Ver.6.1

The built-in function **set_vbr** can set Vector Base Register in the C/C++ language.

For details, refer to section 3.2.3, Setting Vector Base Register.

Example in Compiler Ver.6.0

In Compiler Ver.6.0, Vector Base Register (VBR) can not be accessed from C/C++ language directly, so it should be written in assembly instructions.

But by using the compiler extended function **__asm** as follows, assembly-language instructions can be written in C/C++ language.

Though assembly-language instructions can be written by **#pragma asm** in the old version compiler, they should be translated into assembly source code after compile.

The assembly program written in the **__asm** block can be compiled into an object file directly, so the symbols can be referred in the source-level debugger.

For details about **__asm**, refer to section 10.2.1(3), in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Switching Vector Base Register (VBR) should be done in the interrupt mask state.
Not in the interrupt mask state, when interrupt process occurs during switching Vector Base Register (VBR), the correct processing of the exception handling can not be guaranteed.

(C/C++ program)

```
void main(void)
{
__asm{
        orc.b #0x80,ccr          ← Set interrupt mask bit
        mov.l #0xffa000,er0
        ldc.l er0,vbr
        andc.b #0x7F,ccr         ← Clear interrupt mask bit
        RTS
}
}
```

Section 4 HEW

This section describes the relationship between the option screens and command options supported by the C/C++ compiler, assembler, inter-module optimizer, object converter, and librarian when using the HEW1.2 or 2.0 or later.

For details on each option, refer to the appropriate user's manual. (For details on options supported in the inter-module optimizer, refer to the description in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.)

Each option screen in HEW1.2 is selected by the following method.

Tool Name	Selecting Method
C/C++ Compiler	**[Options->H8S,H8/300 C/C++ Compiler…]**
Cross Assembler	**[Options->H8S,H8/300 Assembler…]**
Inter-Module optimizer	**[Options->H8S,H8/300 IM Optlinker…]**
Object converter	**[Options->H Series Stype Converter…]**
Librarian	**[Options->H Series Librarian…]**

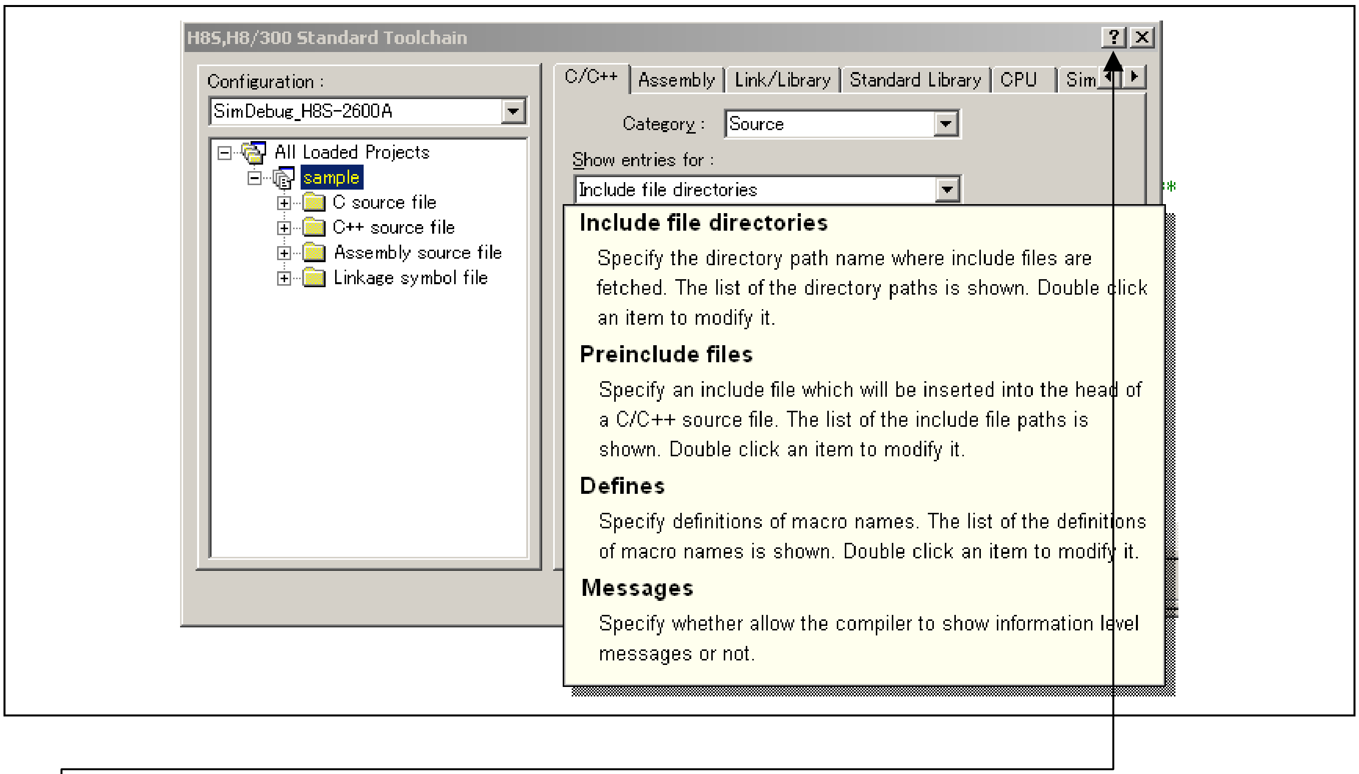
Note: If no appropriate tool is detected in the Options menu, add a tool using the [Options->Build Phases…]

Select H8S, H8/300 Standard Toolchain... from the option menu in HEW2.0 or later.

Select H8S, H8/300 Standard Toolchain... from the build menu in HEW4.0 or later.

Tool Name	Selecting Method
C/C++ Compiler	**[Options->H8S,H8/300 Standard Toolchain…->C/C++ Tab]**
Cross Assembler	**[Options->H8S,H8/300 Standard Toolchain…->Assembly Tab]**
Optimizing Linkage Editor	**[Options->H8S,H8/300 Standard Toolchain…->Link/Library Tab]**
Standard Library Generator	**[Options->H8S,H8/300 Standard Toolchain…->Standard Library Tab]**
CPU Option	**[Options->H8S,H8/300 Standard Toolchain…->CPU Tab]**

In addition, Help can be referenced from each option screen.



Include file directories

Specify the directory path name where include files are fetched. The list of the directory paths is shown. Double click an item to modify it.

Preinclude files

Specify an include file which will be inserted into the head of a C/C++ source file. The list of the include file paths is shown. Double click an item to modify it.

Defines

Specify definitions of macro names. The list of the definitions of macro names is shown. Double click an item to modify it.

Messages

Specify whether allow the compiler to show information level messages or not.

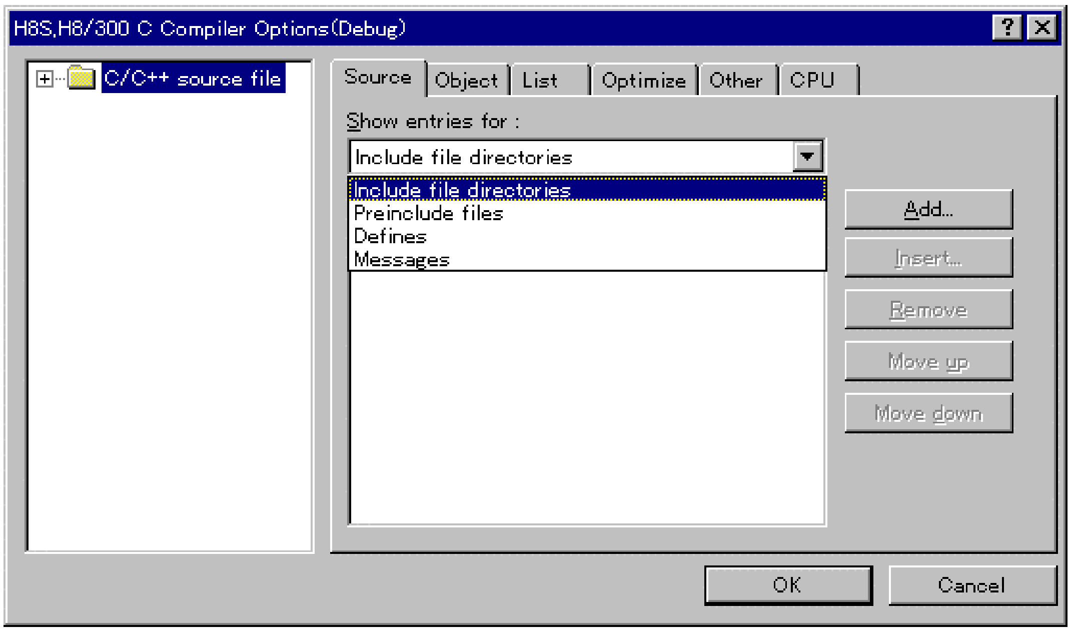
If $\boxed{?}$ at the upper right corner is clicked and then an item to be referenced is clicked, a description similar to that shown above appears.
Please use this help function for quick reference.

4.1 Specifying Options in HEW1.2

For details on specifying options in HEW2.0 or later, refer to section 4.2, Specifying Options in HEW2.0 or later.

4.1.1 C/C++ Compiler Options

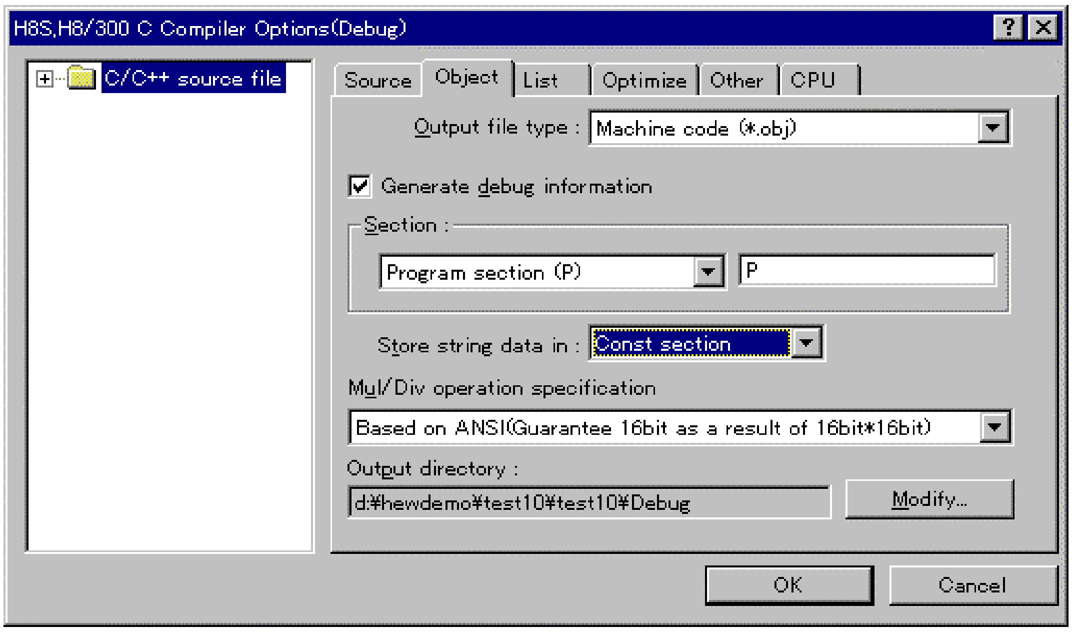
(1) Source Tab



Show entries for:

Dialog Menu	Command Option	Function
Include file directories	*include*	Specifies the path name of the include file directory
Preinclude files	*preinclude*	Specifies file contents as a include file at the beginning of a compilation unit
Defines	*define*	Defines the macro name
Messages	*message*	Outputs an information message

(2) Object Tab



Output file type : Machine code (*.obj)

☑ Generate debug information

Section : Program section (P) P

Store string data in : Const section

Mul/Div operation specification

Based on ANSI(Guarantee 16bit as a result of 16bit*16bit)

Output directory :

d:¥hewdemo¥test10¥test10¥Debug

Output file type:

Dialog Menu	Command Option	Function
Machine code (*.obj)	*code=machinecode*	Outputs a machine language program
Assembly source code (*.src)	*code=asmcode*	Outputs an assembly language program
Preprocessed source file (*.p/*.pp)	*preprocessor*	Outputs a source program after preprocessor expansion

Generate debug information

Check Box	Command Option	Function
☑	*debug*	Outputs debugging information
☐	*nodebug*	Outputs no debugging information

Section:

Dialog Menu	Command Option	Function
-	*section*	Changes the default section name

Store string data in:

Dialog Menu	Command Option	Function
Const section	*string=const*	Outputs string literal to the constant area
Data section	*string=data*	Outputs string literal to the initialization data area

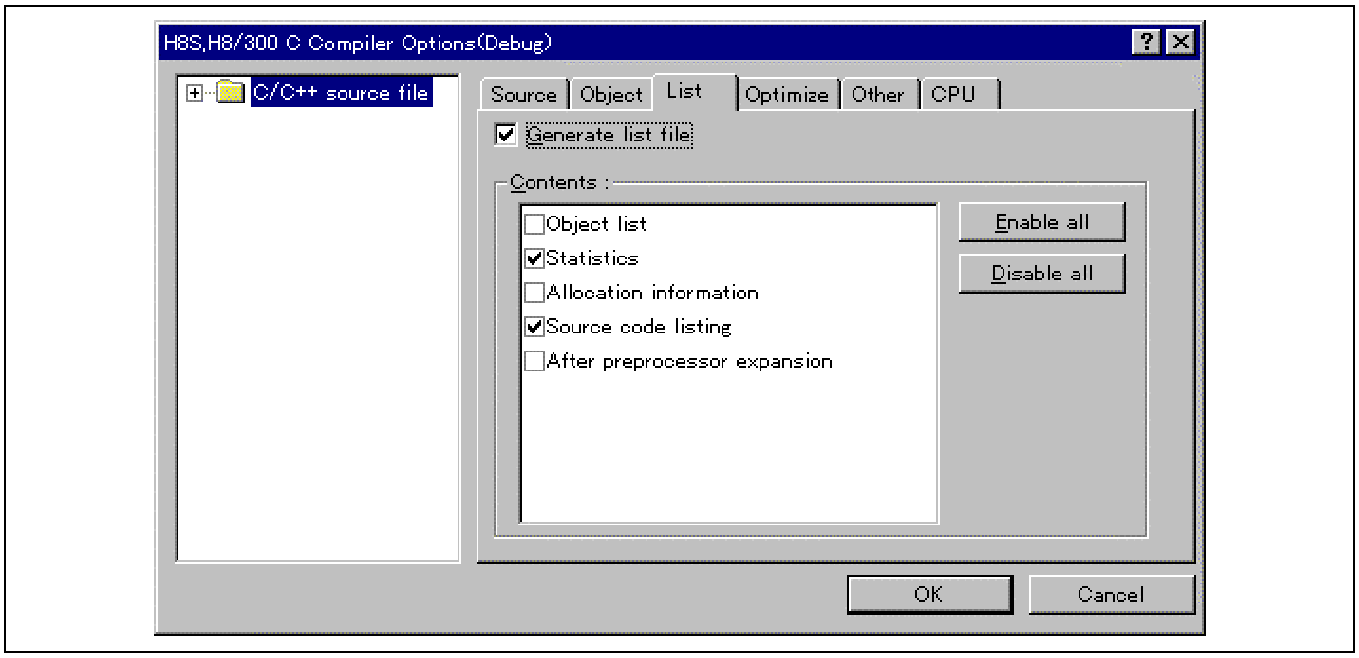
Mul/Div operation specifications

Dialog Menu	Command Option	Function
Based on ANSI (Guarantee 16bit as a result of 16bit*16bit)	*nocpuexpand*	Develops multiplication or division in codes according to the ANSI C language specifications
Non ANSI (Guarantee 32bit as a result of 16bit*16bit)	*cpuexpand*	Develops multiplication or division in codes according to the CPU instruction specifications

Output directory

Dialog Menu	Command Option	Function
-	*object*	Specifies object file output directory

(3) List Tab



☑ Generate list file

Contents :

☐ Object list
☑ Statistics
☐ Allocation information
☑ Source code listing
☐ After preprocessor expansion

Generate list file

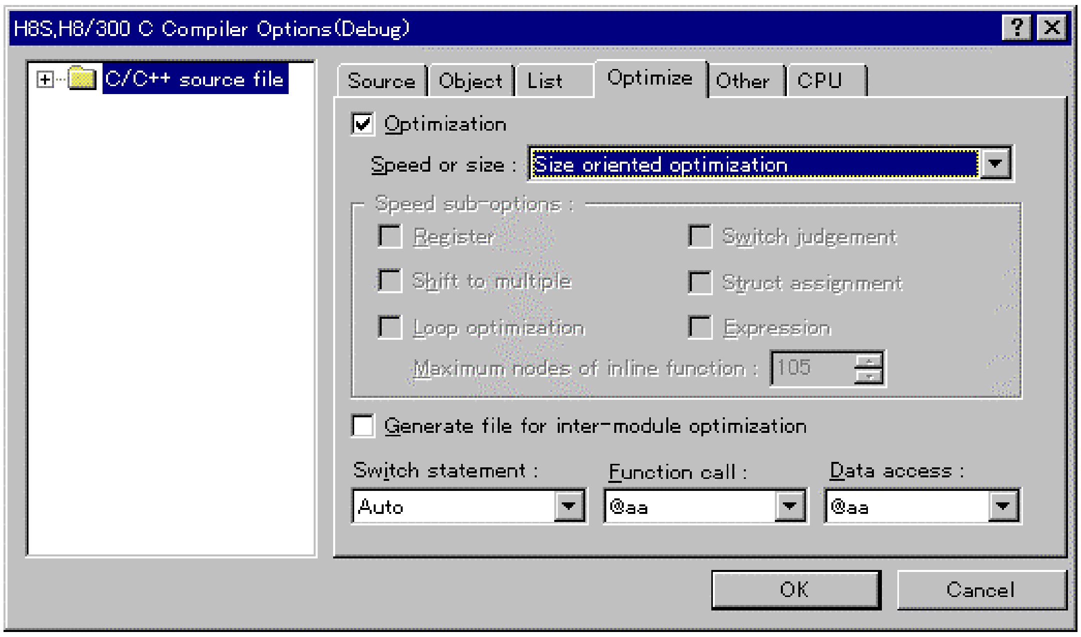
Check Box	Command Option	Function
☑	*list*	Outputs object list file
☐	*nolist*	Outputs no object list file

Contents: Specifies data to be output to the object file list.

Dialog Menu	Command Option	Function
Object list	*show=object*	Outputs object list
Statictics	*show=statictics*	Outputs statics information
Allocation information	*show=allocation*	Outputs symbol allocation list
Source code listing	*show=source*	Outputs source list
After preprocessor expansion	*show=expand*	Outputs list after macro expansion

If the [Enable all] button is pressed, all data items are output. On the other hand, if the [Disable all] button is pressed, all data items are disabled and no data item is output to the object list file.

(4) Optimize Tab



H8S,H8/300 C Compiler Options(Debug)

C/C++ source file

Source | Object | List | Optimize | Other | CPU

☑ Optimization

Speed or size : Size oriented optimization

Speed sub-options :

☐ Register ☐ Switch judgement

☐ Shift to multiple ☐ Struct assignment

☐ Loop optimization ☐ Expression

Maximum nodes of inline function : 105

☐ Generate file for inter-module optimization

Switch statement : Auto

Function call : @aa

Data access : @aa

OK Cancel

Optimization

Check Box	Command Option	Function
√	*optimize=1*	Specifies optimization
☐	*optimize=0*	Specifies no optimization

Speed or size: Specifies the optimization format.

Dialog Menu		Command Option	Function
Size oriented optimization		-	Performs optimization in size
Speed oriented optimization		*speed*	Performs optimization in speed
Speed sub-options	**Register**	*speed=register*	Performs register store/restore expansion by the PUSH and POP instruction at a higher speed
	Switch judgement	*speed=switch*	Develops the switch statement at a higher speed
	Shift to multiple	*speed=shift*	Develops the shift operation at a higher speed
	Struct assignment	*speed=struct*	Performs the expansion of structures and substitution expression at a higher speed
	Loop optimization	*speed=loop*	Develops the loop statement at a higher speed
	Expression	*speed=expression*	Performs arithmetic operation, comparison, and substitution expression processing at a higher speed
	Maximum nodes of inline function	*speed=inline [=<data>]*	Performs inline expansion automatically at a higher speed

Generate file for inter-module optimization

Check Box	Command Option	Function
☑	*goptimize*	Outputs inter-module optimization additional information file
☐	-	Outputs no inter-module optimization additional information file

Switch statement: Specifies the switch statement expansion method.

Dialog Menu	Command Option	Function
Auto	*case=auto*	Determines switch statement expansion method depending on the speed option specification
If then	*case=ifthen*	Performs switch statement expansion in if_then method
Table	*case=table*	Performs switch statement expansion in table jump method

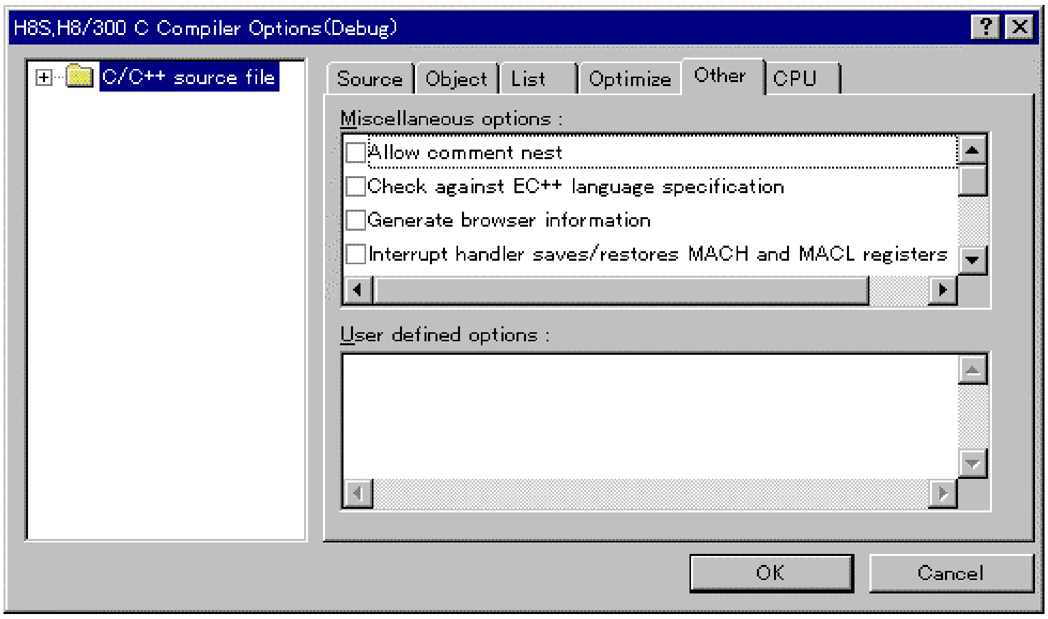
Function call: Selects the function call method.

Dialog Menu	Command Option	Function
@aa	-	Selects normal function call
@@aa:8	*indirect*	Selects memory indirect function call

Data access: Selects data access mode.

Dialog Menu	Command Option	Function
@aa	-	Selects normal data access
@aa:8	*abs8*	Selects 8-bit absolute address access
@aa:16	*abs16*	Selects 16-bit absolute address access

(5) Other Tab



Miscellaneous options :

☐ Allow comment nest
☐ Check against EC++ language specification
☐ Generate browser information
☐ Interrupt handler saves/restores MACH and MACL registers

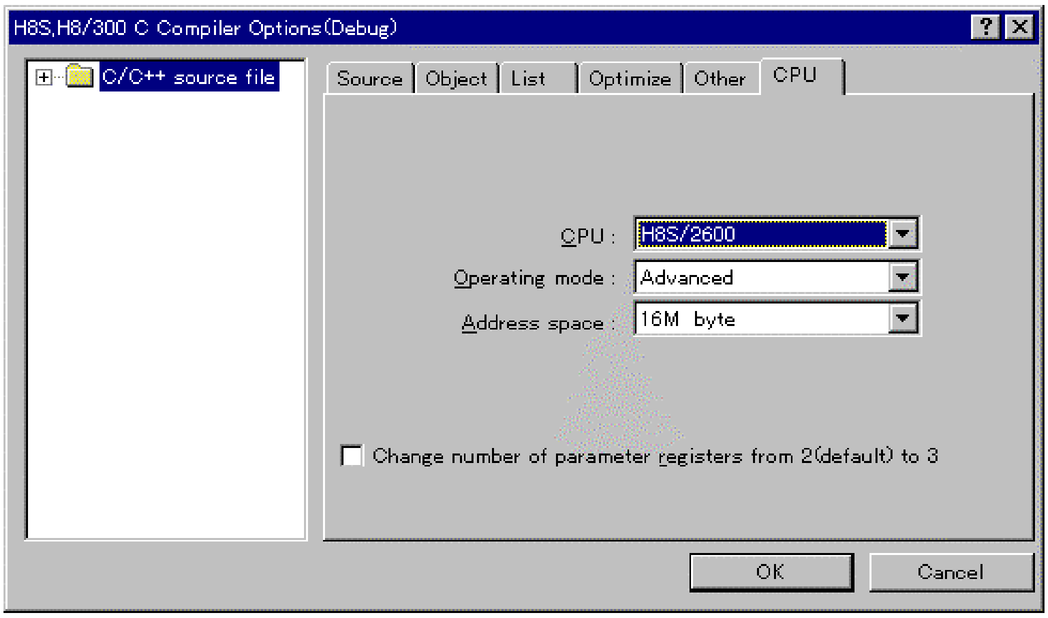
User defined options :

Miscellaneous options:

Dialog Menu	Command Option	Function
Allow comment nest	*comment*	Enables comment nesting
Check against EC++ language specification	*ecpp*	Checks syntax according to the EC++ language specifications
Generate browser information	*browser*	Outputs browser information
Interrupt handler saves/restores MACH and MACL registers if used	*macsave*	Guarantees MAC registers
Pack struct, union and class	*pack=1* | *2*	Specifies alignment
Avoid optimizing external symbols treating them as volatile	*volatile*	Enables or disables external variable optimization
Treat enum as char if it is in the range of char	*byteenum*	Handles enumeration-type data as char
Increase a register for register variable	*regexpansion* | *noregexpansion*	Specifies the number of variable-allocation registers as 2 or 3
Put common subexpression on a register temporarily	*cmncode*	Improves the optimization function for common expression deletion
Use EEPMOV in block copy	*eepmov*	Performs structure substitution using the EEPMOV instruction

User defined options: Specifies the command options.

(6) CPU Tab


H8S,H8/300 C Compiler Options(Debug)

C/C++ source file

Source | Object | List | Optimize | Other | CPU

CPU : H8S/2600

Operating mode : Advanced

Address space : 16M byte

☐ Change number of parameter registers from 2(default) to 3

CPU: Specifies the CPU types.

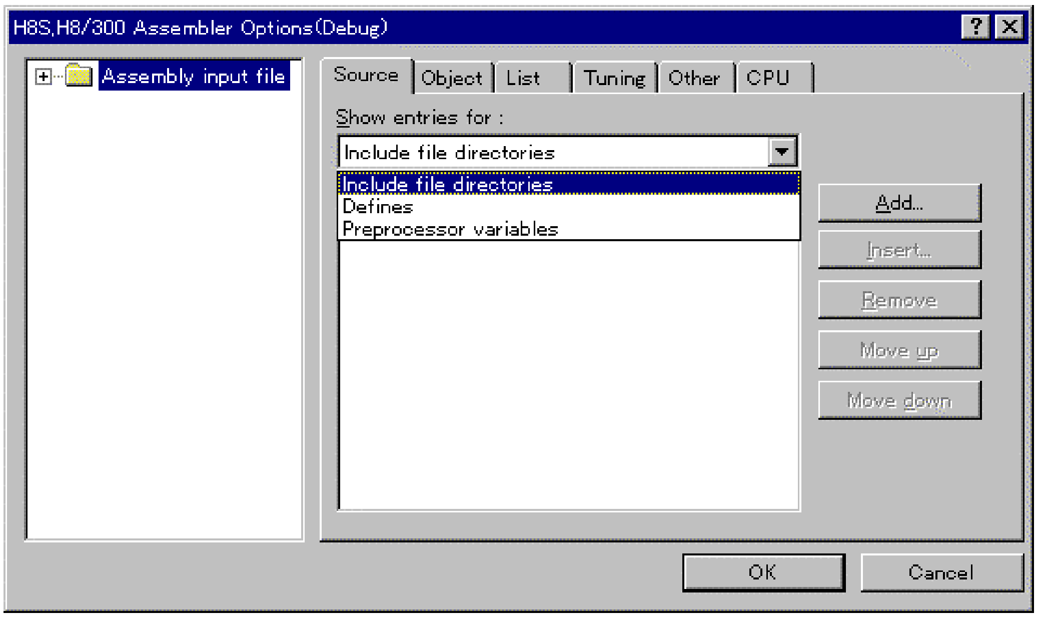
CPU	Operating Mode	Address Space:	Specification
Environment variable	-	-	Depends on environment variable H38CPU
H8S/2600	Normal		*cpu=2600N*
	Advanced	1 Mbytes	*cpu=2600A:20*
		16 Mbytes	*cpu=2600A:24*
		256 Mbytes	*cpu=2600A:28*
		4 Gbytes	*cpu=2600A:32*
H8S/2000	Normal		*cpu=2000N*
	Advanced	1 Mbytes	*cpu=2000A:20*
		16 Mbytes	*cpu=2000A:24*
		256 Mbytes	*cpu=2000A:28*
		4 Gbytes	*cpu=2000A:32*
H8/300H	Normal		*cpu=300HN*
	Advanced	1 Mbytes	*cpu=300HA:20*
		16 Mbytes	*cpu=300HA:24*
H8/300	-	-	*cpu=300*
H8/300L	-	-	*cpu=300*

Change number of parameter-passing registers from 2 (default) to 3

Check Box	Command line	Function
☑	*regparam=3*	Specifies the number of parameter-passing registers as 3
☐	*regparam=2*	Specifies the number of parameter-passing registers as 2

4.1.2 Assembler Options

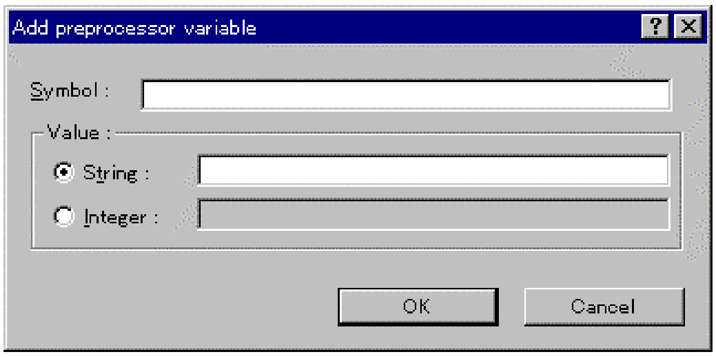
(1) Source Tab



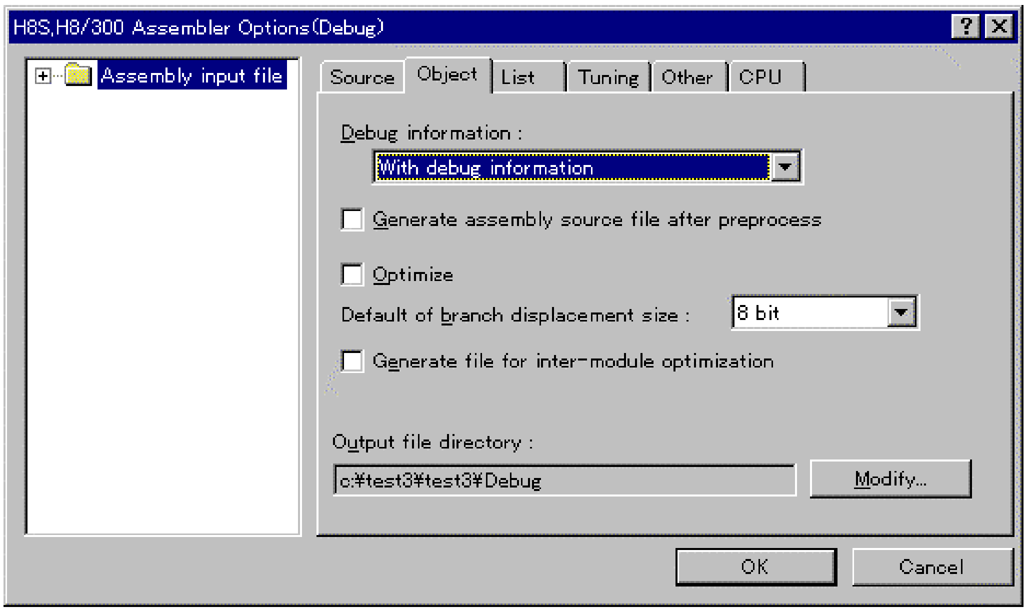
Show entries for:

Dialog Menu	Command Option	Function
Include file directories	*include*	Specifies include file directory
Defines	*define*	Defines string literal replacement
Preprocessor variable*	*assigna*	Defines integer-type preprocessor variable
	assignc	Defines character-type preprocessor variable

Note: * Specify using the following dialog box.



(2) Object Tab



Debug information : With debug information

☐ Generate assembly source file after preprocess

☐ Optimize

Default of branch displacement size : 8 bit

☐ Generate file for inter-module optimization

Output file directory : c:¥test3¥test3¥Debug

Debug information:

Dialog Menu	Command Option	Function
Default	-	Validates .DEBUG directive only
With debug information	*debug*	Enables debugging information output
Without debug information	*nodebug*	Disables debugging information output

Generate assembly source file after preprocess

Check Box	Command Option	Function
☑	*expand*	Outputs preprocessor expansion results
☐	-	Outputs no preprocessor expansion results

Optimize

Check Box	Command Option	Function
☑	*optimize*	Specifies optimization
☐	*nooptimize*	Specifies no optimization

Default of branch displacement size:

Dialog Menu	Command Option	Function
8bit	*br_relative=8*	Specifies the displacement size as 8 bits if the forward-reference displacement is selected for the branch instruction
16bit	*br_relative=16*	Specifies the displacement size as 16 bits if the forward-reference displacement is selected for the branch instruction

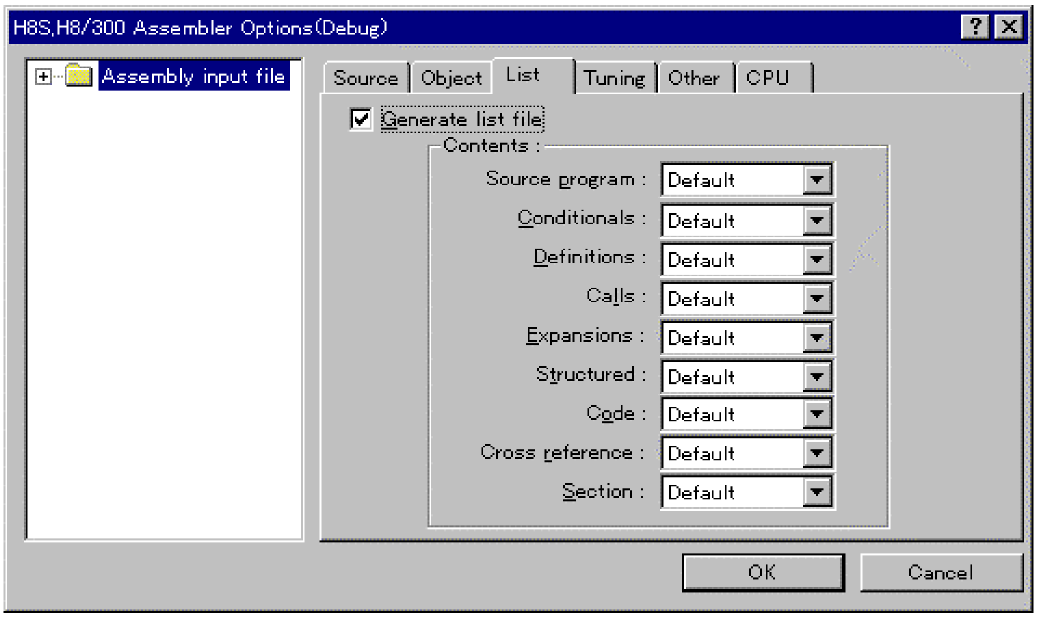
Generate file for inter-module optimization

Check Box	Command Option	Function
√	*goptimize*	Outputs inter-module optimization information
☐		Outputs no inter-module optimization information

Output directory

Dialog Menu	Command Option	Function
-	*object[=<file name>]*	Specifies object output directory

(3) List Tab



☑ Generate list file

Contents :

Source program :	Default
Conditionals :	Default
Definitions :	Default
Calls :	Default
Expansions :	Default
Structured :	Default
Code :	Default
Cross reference :	Default
Section :	Default

Generate list file

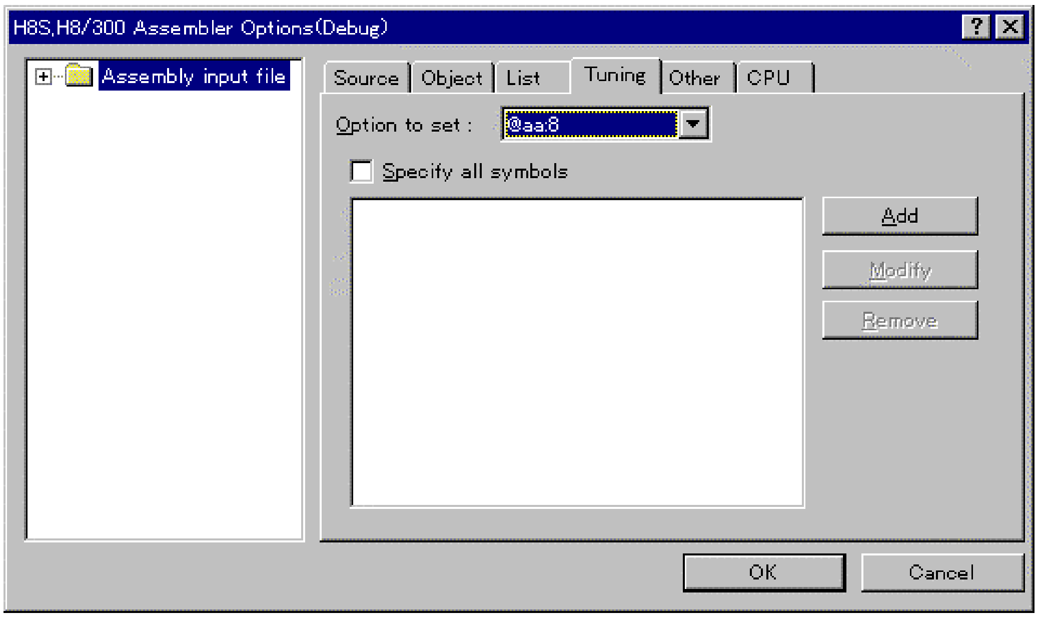
Check Box	Command Option	Function
√	*list*	Outputs assembly list
☐	*nolist*	Outputs no assembly list

Contents: Specifies the contents to be output on the list files.

Dialog Menu	Command Option	Function
Source program	*source*	Outputs the source program list corresponding to the assembly list
Conditionals	*show=conditionals*	Outputs the parts in which conditions specified in .AIF or .AIFDEF are not satisfied
Definitions	*show=definitions*	Outputs macro definitions, .AREPEAT and .AWHILE definitions, and .INCLUDE,.ASSIGNA, and .ASSIGNC directives
Calls	*show=calls*	Outputs macro-call statements and .AIF,.AIFDEF, and .AENDI directives
Expansions	*show=expansions*	Outputs macro expansions and .AREPEAT →.AWHILE expansions
Structured	*show=structured*	Outputs structured assembly expansions
Code	*show=code*	Outputs the lines that exceed the number of source statement lines to be displayed in the object code display
Cross reference	*cross_refernce*	Outputs a cross-reference list
Section	*section*	Outputs a section information list

Note: If default is selected for each option, directive in the source list is specified.

(4) Tuning Tab



Option to set : @aa:8

Specify all symbols

Option to set:

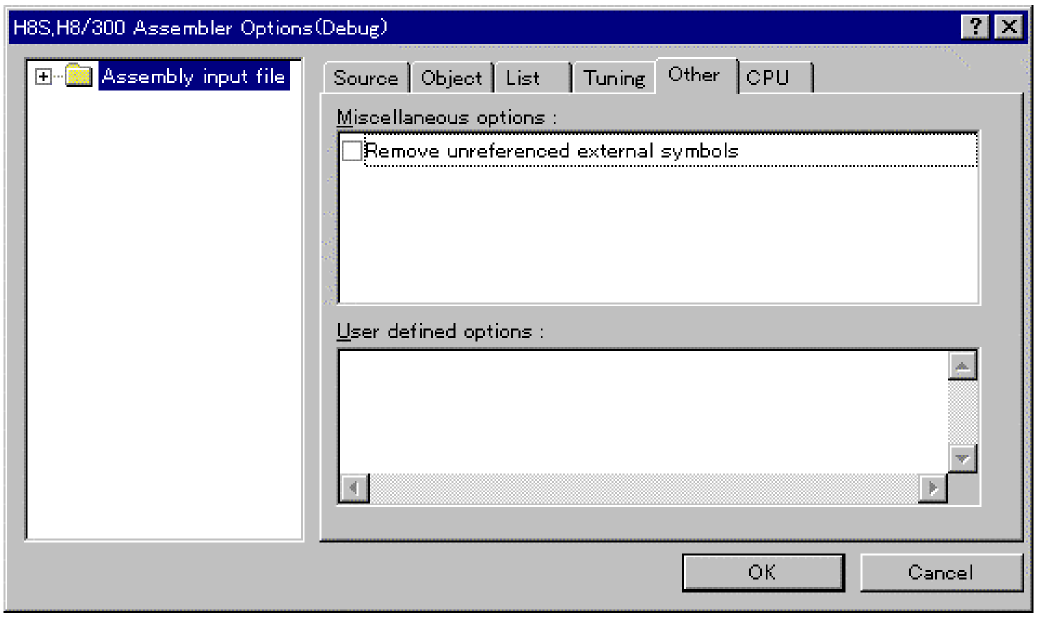
Dialog Menu	Command Option	Function
@aa:8	*abs8*	Specifies 8-bit absolute address symbol
@aa:16	*abs16*	Specifies 16-bit absolute address symbol

Note: Selects external reference symbols or external definition symbols.

Specify all symbols

Check Box	Function
√	Assigns the specified size to the external reference symbols and external definition symbols
☐	Assigns a specific size to each symbol or does not assign a size

(5) Other Tab


H8S,H8/300 Assembler Options(Debug)

Assembly input file

Source | Object | List | Tuning | Other | CPU

Miscellaneous options :

☐ Remove unreferenced external symbols

User defined options :

OK | Cancel

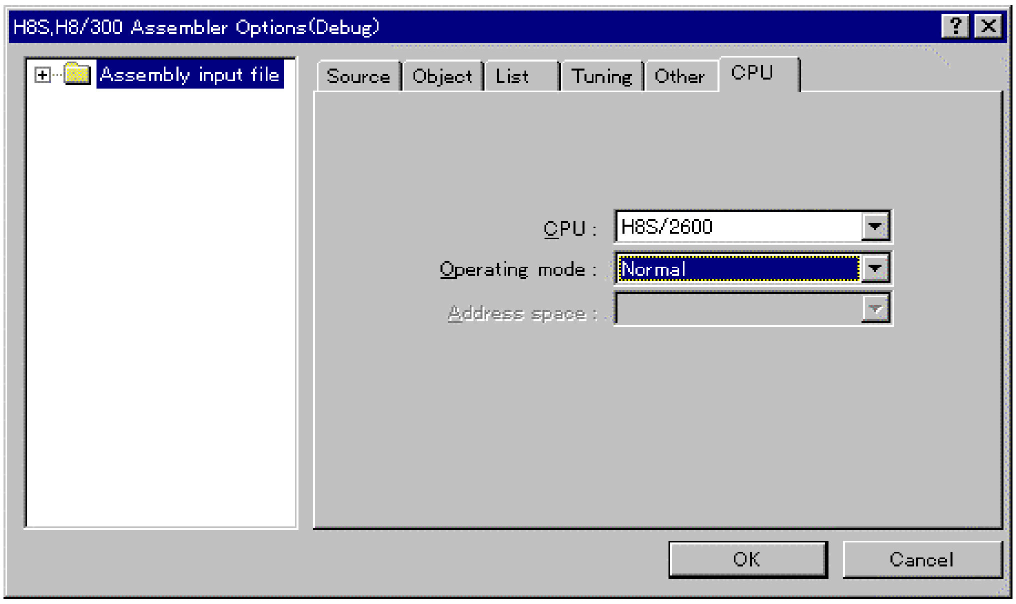
Miscellaneous options:

Dialog Menu	Check Box	Command Option	Function
Remove unreferenced external symbols	√	*exclude*	Disables unreferenced external-reference symbol information output
	☐	*noexclude*	Enables unreferenced external-reference symbol information output

User defined options:

Describes the command options.

(6) CPU Tab



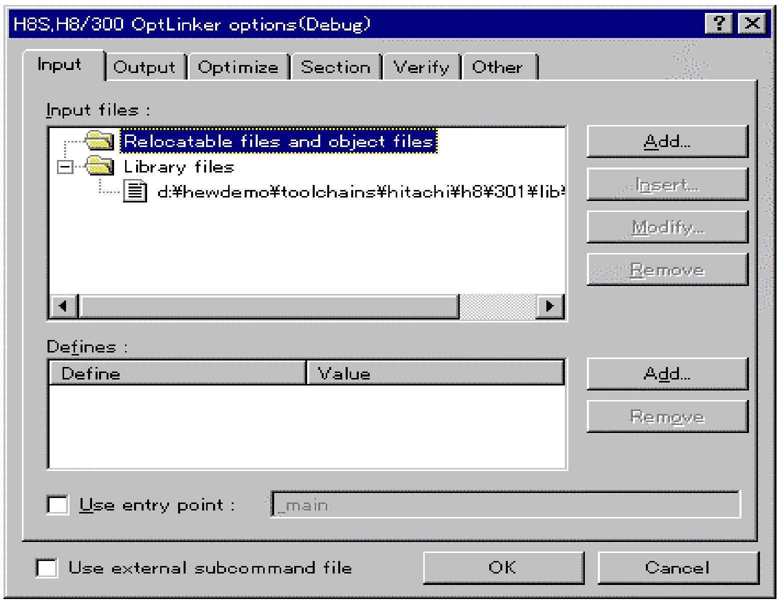
CPU : H8S/2600
Operating mode : Normal
Address space :

Dialog Menu

CPU:	Operating Mode:	Address Space:	Command Option	Function
default	-	-	-	Validates .CPU directive specification
H8S/2600	**Normal**	-	*cpu=2600n*	H8S/2600 normal mode
	Advanced	**1M byte**	*cpu=2600a:20*	H8S/2600 advanced mode
		16M bytes	*cpu=2600a[:24]*	H8S/2600 advanced mode
		256M bytes	*cpu=2600a:28*	H8S/2600 advanced mode
		4G bytes	*cpu=2600a:32*	H8S/2600 advanced mode
H8S/2000	**Normal**	-	*cpu=2000n*	H8S/2000 normal mode
	Advanced	**1M byte**	*cpu=2000a:20*	H8S/2000 advanced mode
		16M bytes	*cpu=2000a[:24]*	H8S/2000 advanced mode
		256M bytes	*cpu=2000a:28*	H8S/2000 advanced mode
		4G bytes	*cpu=2000a:32*	H8S/2000 advanced mode
H8/300H	**Normal**	-	*cpu=300hn*	H8/300H normal mode
	Advanced	**1M byte**	*cpu=300ha:20*	H8/300H advanced mode
		16M bytes	*cpu=300ha[:24]*	H8/300H advanced mode
H8/300	-	-	*cpu=300*	H8/300
H8/300L	-	-	*cpu=300l*	H8/300L

4.1.3 Inter-Module Optimizer Options

(1) Input Tab



Input files :
Relocatable files and object files
Library files
d:¥hewdemo¥toolchains¥hitachi¥h8¥301¥lib¥

Defines :

Define	Value

Use entry point : _main

Use external subcommand file

Input files: Specifies a load module and library to be linked.

Dialog Menu	Subcommand	Function
Relocatable files and object files	*input*	Specifies input file*
Library files	*library*	Specifies library file

Note: * This option is specified when inputting .obj other than a project file or when changing the project file input order.

Defines:

Dialog Menu	Subcommand	Function
-	*define*	Forcibly defines external-reference symbol

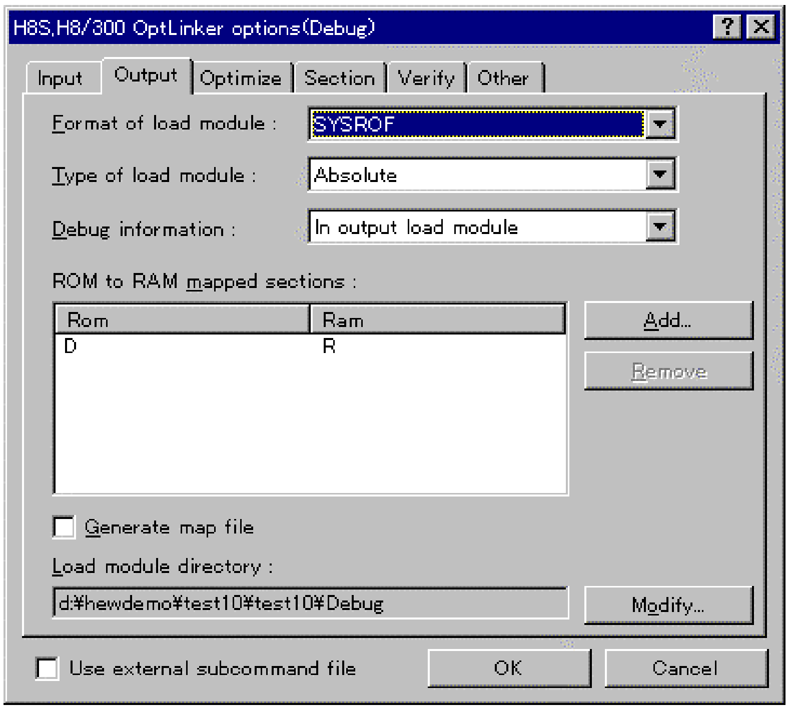
Use entry point:

Dialog Menu	Subcommand	Function
-	*entry*	Specifies execution start address

Use external subcommand file

Dialog Menu	Subcommand	Function
-	*subcommand*	Specifies the existing subcommand file

(2) Output Tab


H8S,H8/300 OptLinker options(Debug)

Input | Output | Optimize | Section | Verify | Other

Format of load module : SYSROF

Type of load module : Absolute

Debug information : In output load module

ROM to RAM mapped sections :

Rom	Ram
D	R

Add...

Remove

☐ Generate map file

Load module directory :

d:¥hewdemo¥test10¥test10¥Debug

Modify...

☐ Use external subcommand file

OK

Cancel

Format of load module: Specifies load module output format.

Dialog Menu	Subcommand	Function
ELF	*elf*	Outputs in ELF format
SYSROF	*sysrof*	Outputs in sysrof format
SYSROFPLUS	*sysrofplus*	Outputs dwarf debugging information in sysrof format

Type of load module: Specifies load module file output format.

Dialog Menu	Subcommand	Function
Absolute	*formΔabs*	Outputs in absolute format
Relocatable	*formΔrel*	Outputs in relocatable format

Debug information: Specifies debugging information output options.

Dialog Menu	Subcommand	Function
None	*nodebug*	Outputs no debugging information
In output load module	*debug*	Outputs debugging information to a load module
In separate debug file (*.dbg)	*sdebug*	Outputs debugging information to a file

ROM to RAM mapped sections:

Dialog Menu	Subcommand	Function
-	*rom*	Defines initialization data area both in ROM and RAM

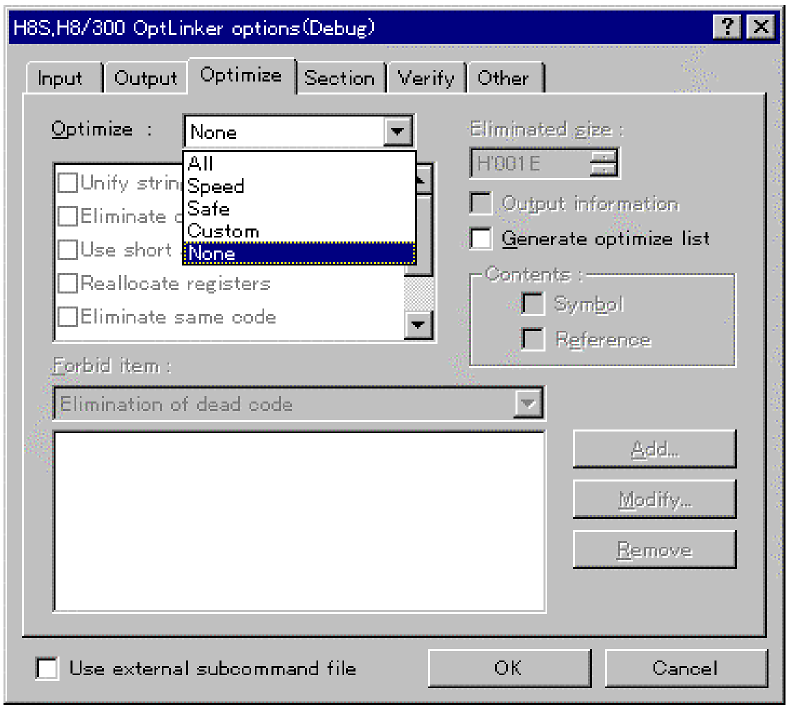
Generate map file

Check Box	Subcommand	Function
☑	*print [Δfile name]*	Outputs a linkage list file
☐	-	Outputs no linkage list file

Load module directory:

Dialog Menu	Subcommand	Function
-	*output*	Selects a load module output directory

(3) Optimize Tab



Optimize: Specifies optimization items.

Dialog Menu		Subcommand	Function
All		*Optimize*	Enables all optimization items
Speed		*OptimizeΔspeed*	Performs optimization in speed
Safe		*OptimizeΔsafe*	Performs safe optimization
Custom		*OptimizeΔ*	Enables optimization item selection
	Unify strings	*String_unify*	Unifies constant or string literal
	Eliminate dead code	*Symbol_delete*	Deletes unreferenced symbols
	Use short addressing	*Variable_access*	Uses short-absolute addressing mode
	Reallocate registers	*Register*	Reallocates registers
	Eliminate same code	*Same_code*	Eliminates same codes
	Eliminated size:	*Samesize*	Specifies the object size for same code elimination
	Use indirect call/jump	*Function_call*	Uses indirect addressing mode
	Optimize branches	*Branch*	Optimizes branch instructions
None		*Nooptimize*	Disables optimization

Output information

Check Box	Subcommand	Function
☑	*information*	Displays optimized function name
☐		Displays no optimized function name

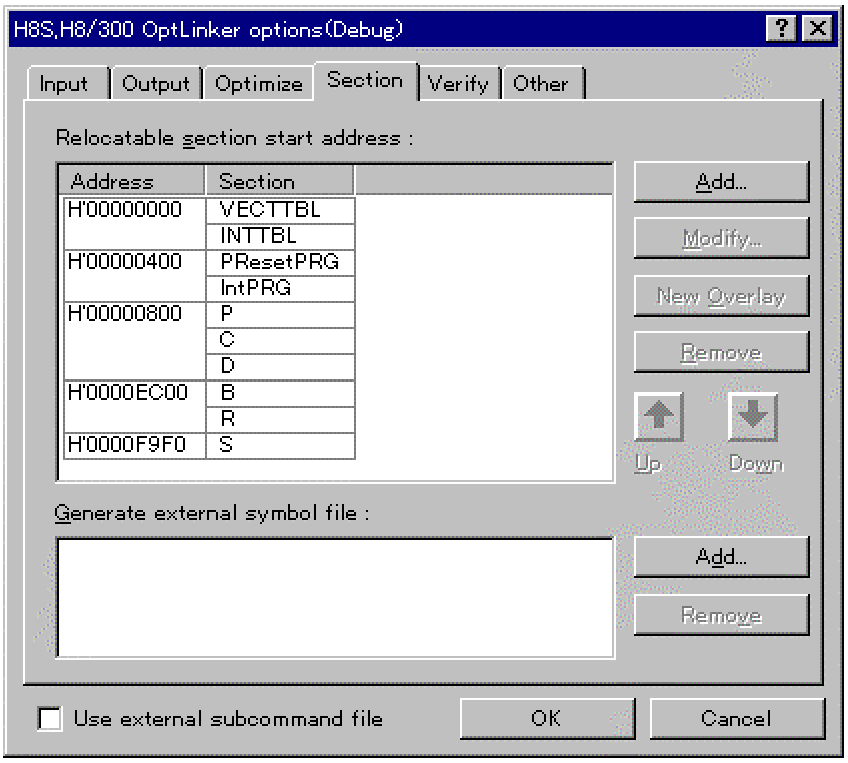
Generate optimize list

Dialog Menu		Subcommand	Function
-		*Mlist [Δfile name]*	Outputs optimization information list
Contents:	**Symbol**	*showΔsymbol*	Outputs symbol optimization information
	Reference	*showΔreference*	Outputs symbol reference count

Forbid item:

Dialog Menu	Subcommand	Function
Elimination of dead code	*Symbol_forbid*	Specifies the name of variable or function in which unreferenced symbol eliminating optimization is disabled
Elimination of same code	*Samecode_forbid*	Specifies the name of the function in which same code eliminating optimization is disabled
Use of short addressing to	*Variable_forbid*	Specifies the name of the variable in which optimization using short-absolute addressing mode is disabled
Use of indirect call/jump to	*Function_forbid*	Specifies the name of the function in which optimization using indirect addressing mode is disabled
Memory allocation in	*Absolute_forbid*	Specifies the address area to which address allocation is not performed

(4) Section Tab



Relocatable section start address :

Address	Section
H'00000000	VECTTBL
	INTTBL
H'00000400	PResetPRG
	IntPRG
H'00000800	P
	C
	D
H'0000EC00	B
	R
H'0000F9F0	S

Generate external symbol file :

☐ Use external subcommand file

Relocatable section start address:

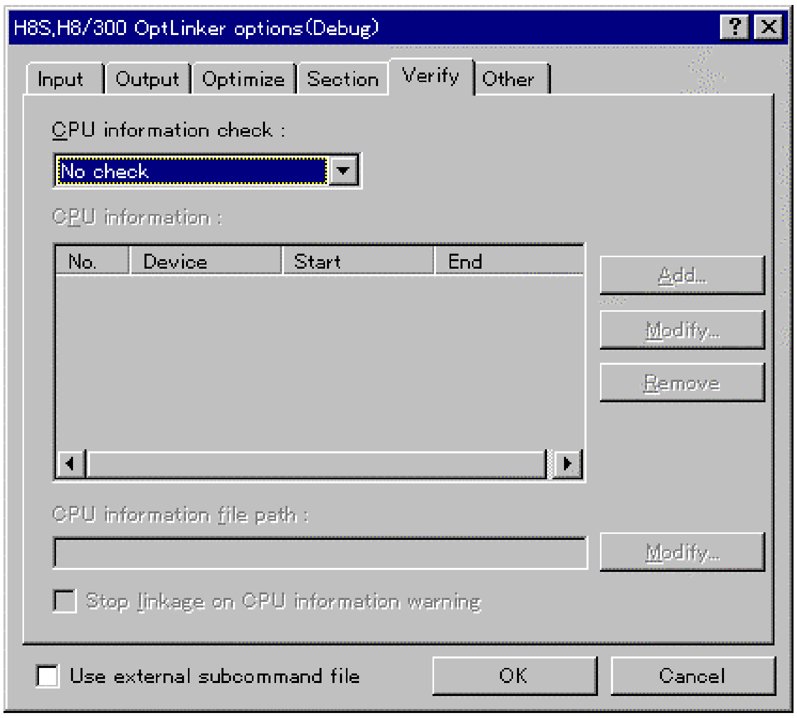
Dialog Menu	Subcommand	Function
-	*start*	Specifies each section start address and linkage order

Generate external symbol file:

Dialog Menu	Subcommand	Function
-	*fsymbol*	Outputs external definition symbols processed by linkage function to a file in assembler directive format

Note: Output file name is <project name>.fsy.

(5) Verify Tab



CPU information check:

Dialog Menu	Subcommand	Function
No check		Checks no CPU allocation
Check		Checks memory allocation according to the CPU information file
Use CPU information file	*CPU*	Checks memory allocation according to the existing CPU information file

CPU information

Dialog Menu	Subcommand	Function
-	-	Cerates or modifies CPU information file CPU Specifies memory types and then specifies each memory address

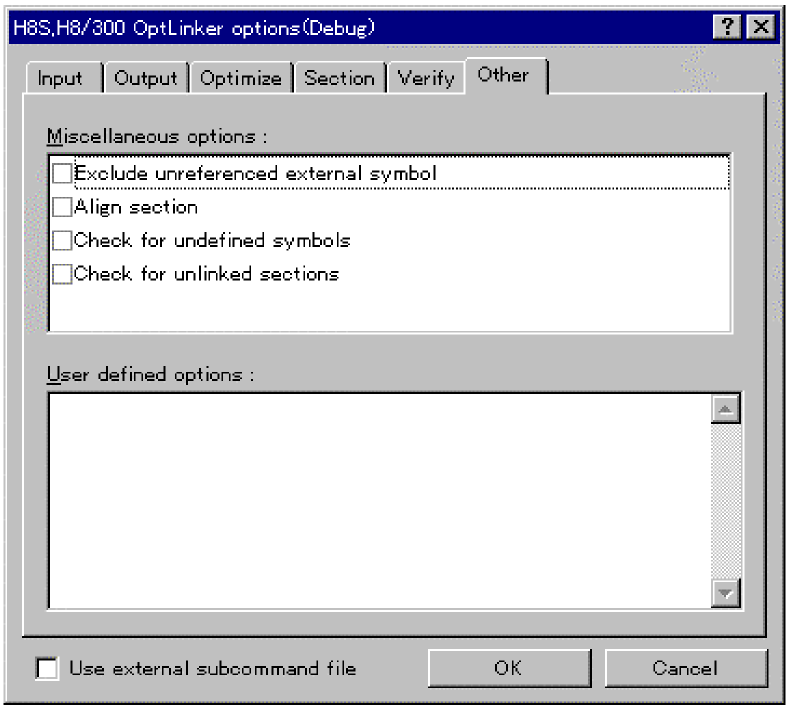
CPU information file path

Dialog Menu	Subcommand	Function
-	-	Specifies the existing CPU information file

Stop linkage on CPU information warning

Check Box	Subcommand	Function
☑	CPUCheck	Outputs error information during memory allocation check according to the CPU information file
☐	-	Outputs no error information during memory allocation check

(6) Other Tab


H8S,H8/300 OptLinker options(Debug)

Input | Output | Optimize | Section | Verify | Other

Miscellaneous options :

- [ ] Exclude unreferenced external symbol
- [ ] Align section
- [ ] Check for undefined symbols
- [ ] Check for unlinked sections

User defined options :

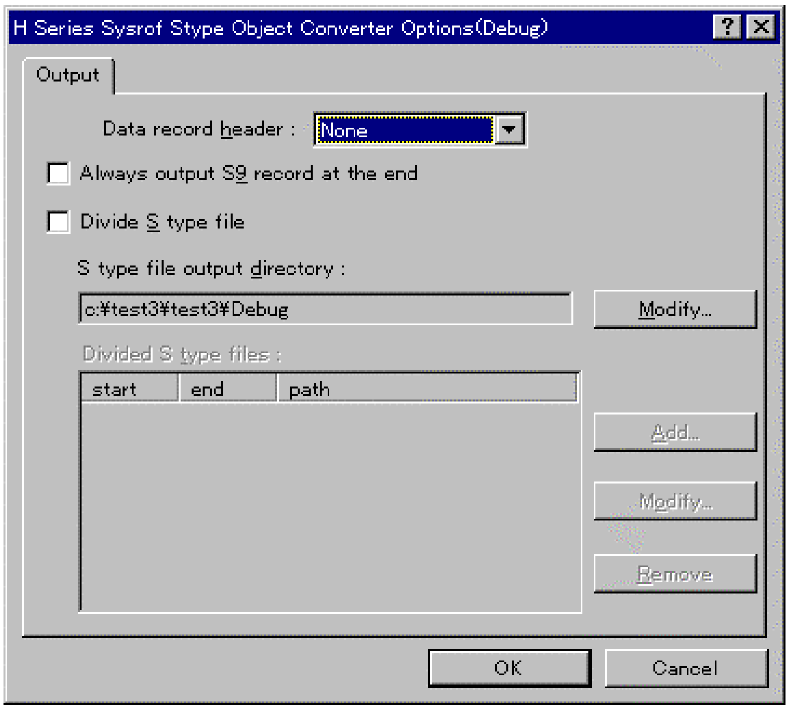
- [ ] Use external subcommand file

Miscellaneous options: Specifies other functions.

Dialog Menu	Subcommand	Function
Exclude unreferenced external symbols	*Exclude*	Disables unreferenced library linkage
Align section	*Align_section*	Checks sections having different alignments
Check for undefined symbols	*Udfcheck*	Outputs error information when undefined symbol is detected
Check for unlinked sections	*Check_section*	Checks sections to which addresses are not assigned

4.1.4 S-Type Converter Options

(1) Output Tab



Data record header:

Dialog Menu	Command Option	Function
None	-	-
S1	*record=s1*	Outputs in S1 data record
S2	*record=s2*	Outputs in S2 data record
S3	*record=s3*	Outputs in S3 data record

Always output S9 record at the end

Check Box	Command Option	Function
✓	s9	Outputs S9 record at the end, even if the entry address exceeds H'10000
☐	-	Always outputs

Divide S type file

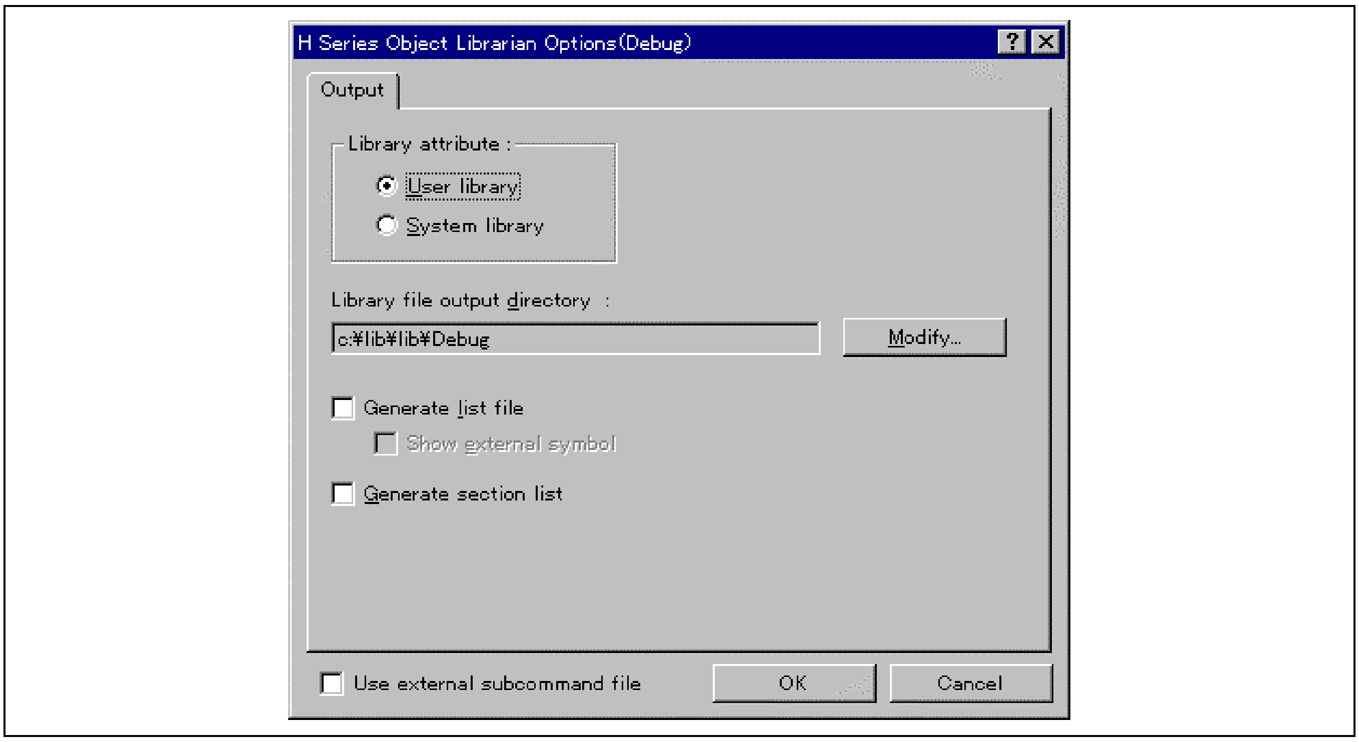
Check Box	Command Option	Function
✓	-	Outputs S-type file by separating it into arbitrary address areas
☐	-	Outputs S-type file without separation

S type file output directory

Dialog Menu	Command Option	Function
-	-	Specifies S-type file output directory

4.1.5 Librarian Options

(1) Output Tab


H Series Object Librarian Options(Debug)

Output

Library attribute :
(● User library) ○ System library

Library file output directory :
c:¥lib¥lib¥Debug

Modify...

☐ Generate list file
☐ Show external symbol
☐ Generate section list

☐ Use external subcommand file

OK Cancel

Library attribute: Specifies the attribute of a library to be output.

Dialog Menu	Option/Subcommand	Function
User library	*output*	Specifies user library as library attribute
System library	*output*	Specifies system library as library attribute

Library file output directory:

Dialog Menu	Option/Subcommand	Function
-	output	Specifies library output directory

Generate list file: Specifies whether the library list file is output.

Check Box	Option/Subcommand	Function
☑	*list*	Displays library file contents
☐	-	Displays no library file contents

Show external symbol: Specifies the output of external definition symbol names defined in a module.

Check Box	Option/Subcommand	Function
√	*list*	Displays external definition symbol names defined in a module
☐	-	Displays no external definition symbol names

Generate section list: Specifies section name list file output.

Check Box	Option/Subcommand	Function
√	*slist*	Displays section contents
☐	-	Displays no section contents

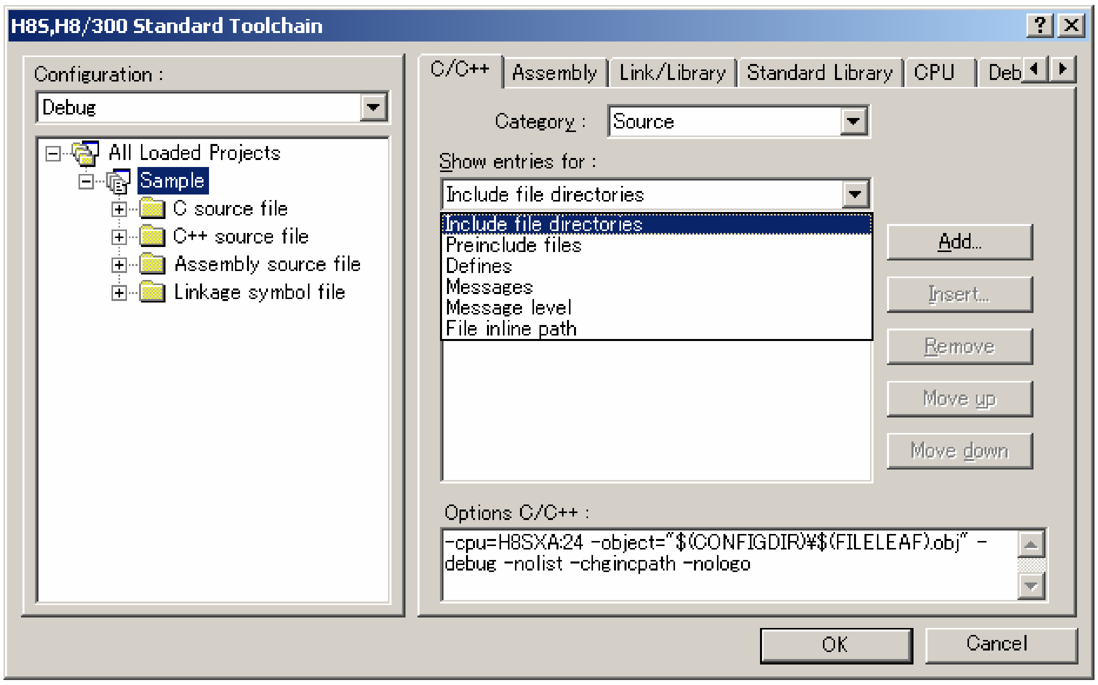
4.2 Specifying Options in HEW2.0 or Later

For details on specifying options in HEW1.2, refer to section 4.1, Specifying Options in HEW1.2.

4.2.1 C/C++ Compiler Options

Select C/C++ Tab from the H8S, H8300 Standard Toolchain dialog box.

(1) **Category:**[Source]



Options C/C++ :

```
-cpu=H8SXA:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj" -
debug -nolist -chgincpath -nologo
```

Show entries for:

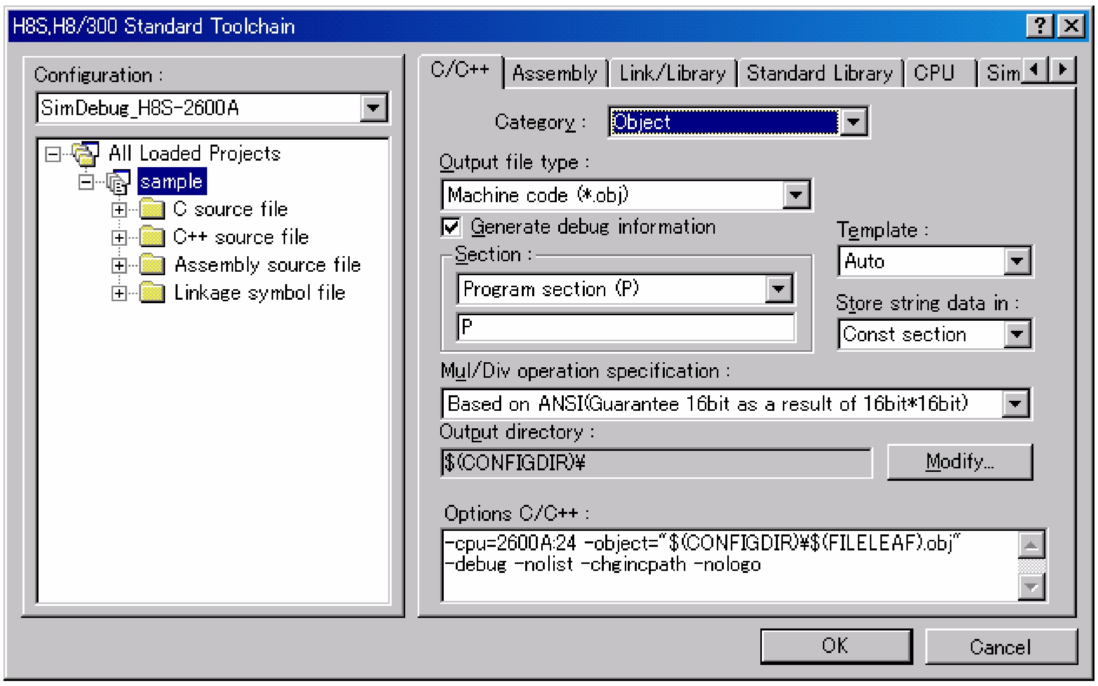
Dialog Menu	**Command Option**	**Function**
Include file directories	*include*	Specifies the path name of the include file directory
Preinclude files	*preinclude*	Specifies file contents as a include file at the beginning of a compilation unit
Defines	*define*	Defines the macro name
Messages	*message*	Outputs an information message
Message level	*charge_message*	Change message level
File inline path	*file_inline_path*	Specifies the path name where obtains a file that has function definitions to be expanded as inline functions

(2) **Category:**[Object]

[Object] Category in HEW 4.0 is different from that of the previous versions (HEW 3.0 or earlier).

Both of them are displayed in the following charts.

<HEW2.0 to HEW3.0>



SimDebug_H8S-2600A

Category : Object

Output file type : Machine code (*.obj)

[✓] Generate debug information

Section : Program section (P)

P

Template : Auto

Store string data in : Const section

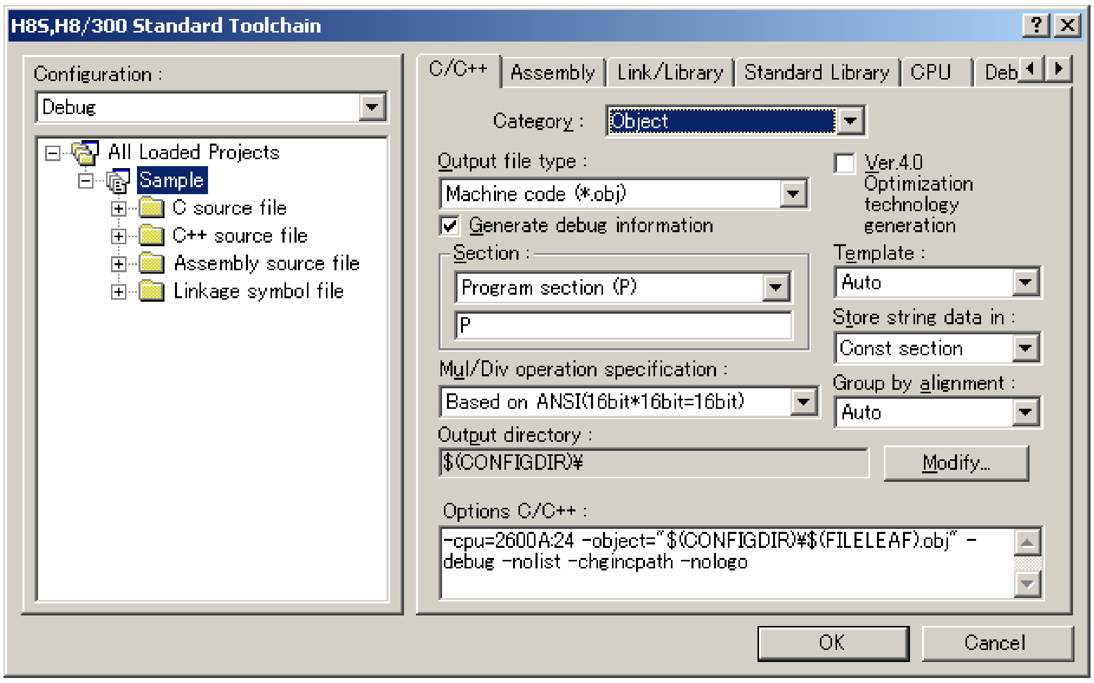
Mul/Div operation specification : Based on ANSI(Guarantee 16bit as a result of 16bit*16bit)

Output directory : $(CONFIGDIR)¥

Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -nolist -chgincpath -nologo
```

<HEW4.0>



Configuration : Debug

Category : Object

Output file type : Machine code (*.obj)

☑ Generate debug information

☐ Ver.4.0 Optimization technology generation

Section : Program section (P)

P

Template : Auto

Store string data in : Const section

Mul/Div operation specification : Based on ANSI(16bit*16bit=16bit)

Group by alignment : Auto

Output directory : $(CONFIGDIR)¥

Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj" -
debug -nolist -chgincpath -nologo
```

Output file type:

Dialog Menu	Command Option	Function
Machine code (*.obj)	*code=machinecode*	Outputs a machine language program
Assembly source code (*.src)	*code=asmcode*	Outputs an assembly language program
Preprocessed source file (*.p/*.pp)	*preprocessor*	Outputs a source program after preprocessor expansion

Generate debug information

Check Box	Command Option	Function
☑	*debug*	Outputs debugging Information
☐	*nodebug*	Outputs no debugging information

Section:

Dialog Menu	Command Option	Function
-	*section*	Changes the default section name

Store string data in:

Dialog Menu	Command Option	Function
Const section	*string=const*	Outputs string literal to the constant area
Data section	*string=data*	Outputs string literal to the initialization data area

Mul/Div operation specifications

Dialog Menu	Command Option	Function
Based on ANSI (Guarantee 16bit as a result of 16bit*16bit)	*nocpuexpand*	Develops multiplication or division in codes according to the ANSI C language specifications
Non ANSI (Guarantee 32bit as a result of 16bit*16bit)	*cpuexpand*	Develops multiplication or division in codes according to the CPU instruction specifications

Output directory

Dialog Menu	Command Option	Function
-	*object*	Specifies object file output directory

Template

Dialog Menu	Command Option	Function
None	*template=none*	Does not generates instances
static	*template=static*	Generates instance as internal linkage only for referenced templates
Used	*template=used*	Generates instance as external linkage only for referenced templates
All	*template=all*	Generates instances for templates declared or referenced
Auto	*template=auto*	Generates instances at linkage

Bit field allocation order (Specify the CPU tab from HEW4.0 or later)

Dialog Menu	Command Option	Function
Left	*bit_order=left*	Stores members from upper bit
Right	*bit_order=right*	Stores members from lower bit

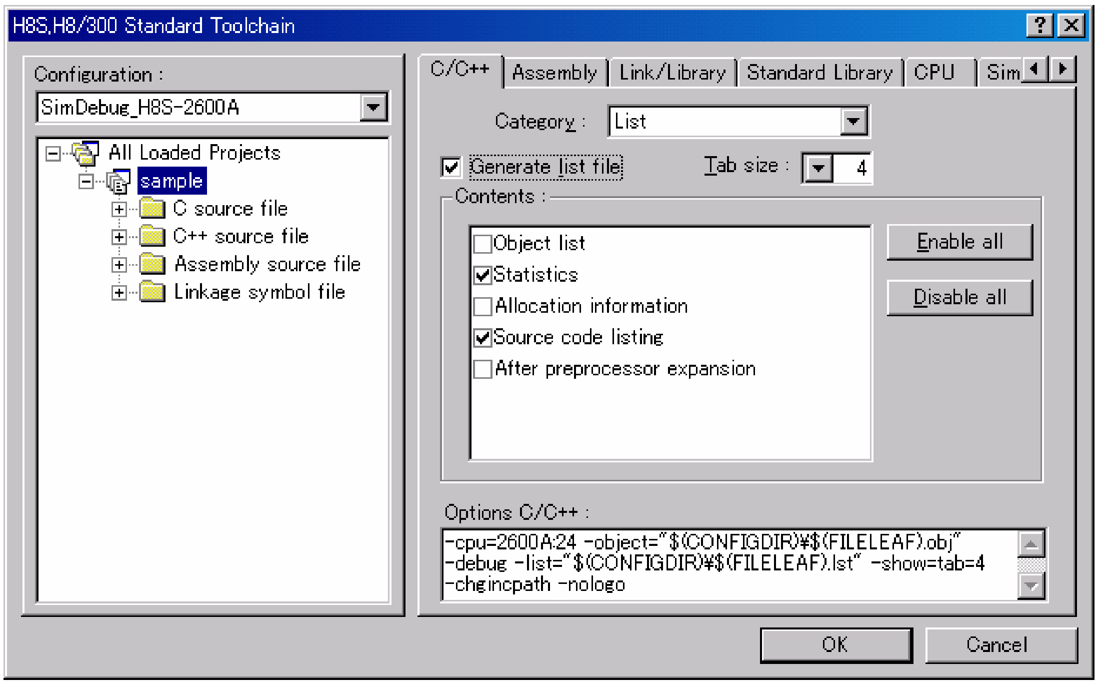
Group by alignment

Dialog Menu	Command Option	Function
None	*noalign*	Allocates defined variables in the defined order
Auto	*align*	Allocates variables so as to reduce space by boundary alignment
4byte	*align=4*	Divides a data section into 4,2,1-byte boundary alignment section, and allocates into multiple of 4,2,1 address, in order to improve the speed of access

Compatibility of output object code (HEW4.0 or later)

Check Box	Command Option	Function
☑	*legacy=v4*	Output objects generated by Ver.4.0 optimization technology of H8S
☐	-	Output objects generated by Ver.6.1 optimization technology of H8S

(3) **Category:**[List]



Configuration : SimDebug_H8S-2600A

- All Loaded Projects
  - sample
    - C source file
    - C++ source file
    - Assembly source file
    - Linkage symbol file

Category : List

✓ Generate list file   Tab size : 4

Contents :

- ☐ Object list
- ✓ Statistics
- ☐ Allocation information
- ✓ Source code listing
- ☐ After preprocessor expansion

Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -list="$(CONFIGDIR)¥$(FILELEAF).lst" -show=tab=4
-chgincpath -nologo
```

Generate list file

Check Box	Command Option	Function
√	*list*	Outputs object list file
☐	*nolist*	Outputs no object list file

Contents: Specifies data to be output to the object file list.

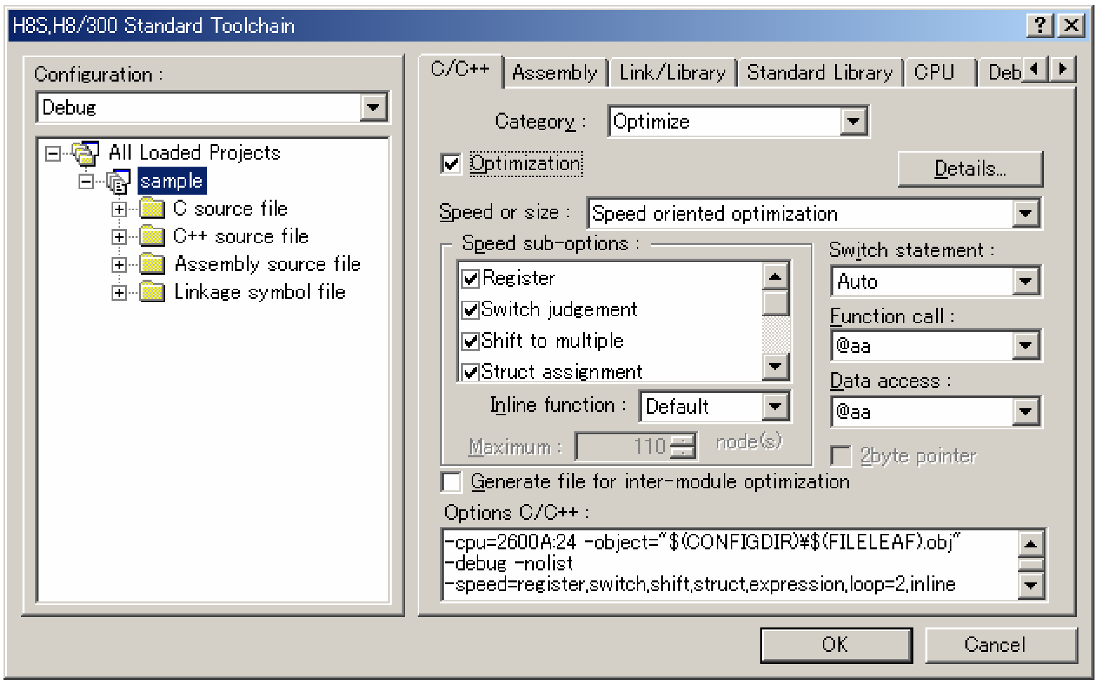
Dialog Menu	Command Option	Function
Object list	*show=object*	Outputs object list
Statistics	*show=statistics*	Outputs statics information
Allocation information	*show=allocation*	Outputs symbol allocation list
Source code listing	*show=source*	Outputs source list
After preprocessor expansion	*show=expansion*	Outputs source program listing after macro expansion

If the [Enable all] button is pressed, all data items are output. On the other hand, if the [Disable all] button is pressed, all data items are disabled and no data item is output to the object list file.

Tab size

Dialog Menu	Command Option	Function
4	*show=tab=4*	Specifies Tab size as 4 to appear in listing
8	*show=tab=8*	Specifies Tab size as 8 to appear in listing

(4) **Category:**[Optimize]



Category : Optimize

☑ Optimization

Speed or size : Speed oriented optimization

Speed sub-options :
☑ Register
☑ Switch judgement
☑ Shift to multiple
☑ Struct assignment

Inline function : Default

Maximum : 110 node(s)

Switch statement : Auto

Function call : @aa

Data access : @aa

☐ 2byte pointer

☐ Generate file for inter-module optimization

Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -nolist
-speed=register,switch,shift,struct,expression,loop=2,inline
```

Optimization

Check Box	Command Option	Function
☑	optimize=1	Specifies optimization
☐	optimize=0	Specifies no optimization

Speed or size: Specifies the optimization format.

Dialog Menu		Command Option	Function
Size oriented optimization		-	Performs optimization in size
Speed oriented optimization		*speed*	Performs optimization in speed
Speed sub-options	**Register**	*speed=register*	Performs register store/restore expansion by the PUSH and POP instruction at a higher speed
	Switch judgement	*speed=switch*	Develops the switch statement at a higher speed
	Shift to multiple	*speed=shift*	Develops the shift operation at a higher speed
	Struct assignment	*speed=struct*	Performs the expansion of structures and substitution expression at a higher speed
	Expression	*speed=expression*	Performs arithmetic operation, comparison, and substitution expression processing at a higher speed
	Loop optimization	*speed=loop1*	Deletion of induction variables
	Loop Unrolling	*speed=loop2*	Deletion of induction variables and loop expansion
	Inline function Maximum:node(s)	*speed=inline [=<data>]*	Performs or does not perform Automatic inline expansion

Generate file for inter-module optimization

Check Box	Command Option	Function
☑	*goptimize*	Outputs inter-module optimization add-on information file
☐	-	Outputs no inter-module optimization add-on information file

Switch statement: Specifies the switch statement expansion method.

Dialog Menu	Command Option	Function
Auto	*case=auto*	Determines switch statement expansion method depending on the speed option specification
If then	*case=ifthen*	Performs switch statement expansion in if_then method
Table	*case=table*	Performs switch statement expansion in table jump method

Function call: Selects the function call method.

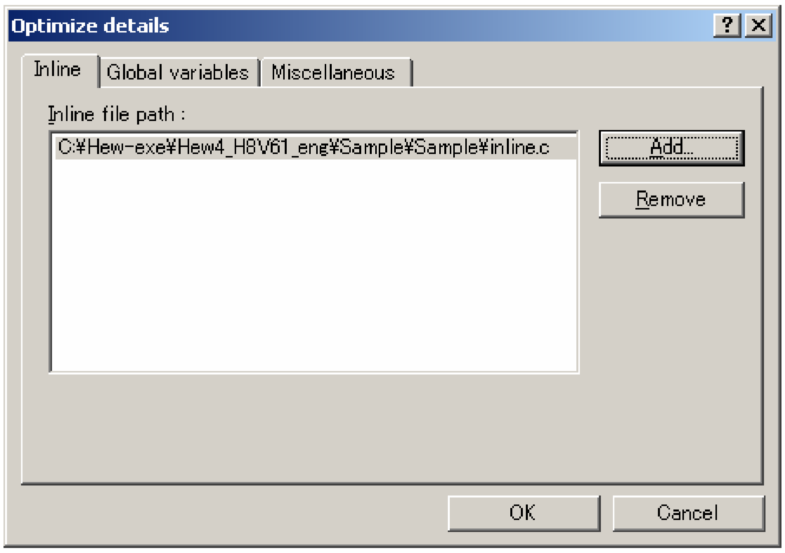
Dialog Menu	Command Option	Function
@aa	-	Selects normal function call
@@aa:8	*idirect=normal*	Selects memory indirect function call
@@vec:7	*idirect=extended*	Selects extended memory indirect function call

Data access: Selects data access mode.

Dialog Menu	Command Option	Function
@aa	-	Selects normal data access
@aa:8	*abs8*	Selects 8-bit absolute address access
@aa:16	*abs16*	Selects 16-bit absolute address access

(a) **[Details] Button:** [Inline] Tab

(Supported from HEW 4.0)



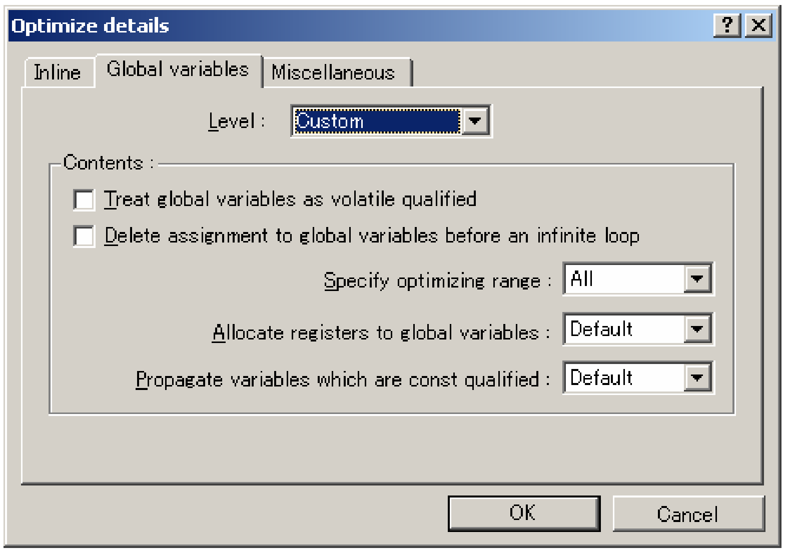
Inline file path :

C:¥Hew-exe¥Hew4_H8V61_eng¥Sample¥Sample¥inline.c

Specify optimizing range

Dialog Menu	Command Option	Function
Inline file path	*file_inline*	Specifies a file for inter-faile inline expansion.

(b) **[Details] Button:** [Global Variables] Tab



Level : Custom

Contents :

- [ ] Treat global variables as volatile qualified
- [ ] Delete assignment to global variables before an infinite loop

Specify optimizing range : All

Allocate registers to global variables : Default

Propagate variables which are const qualified : Default

Level: Specifies the level of external variable optimization

Dialog Menu	Command Option	Function
Level 1		Disables all of the external variable optimization.
	volatile	[Treat global …] = [Checked]
	infinite_loop=0	[Delete assignment …] = [Not checked]
	opt_range=noblock	[Specify optimizing …] = [No block]
	global_alloc=0	[Allocate registers …] = [Disable]
	const_var_propagate=0	[Propagate variables …] = [Disable]
Level 2		Optimizes external variables that do not have a volatile specifier. Disables optimization of external variables which extend across loops or branches.
	novolatile	[Treat global …] = [Not checked]
	infinite_loop=0	[Delete assignment …] = [Not checked]
	opt_range=noblock	[Specify optimizing …] = [No block]
	global_alloc=0	[Allocate registers …] = [Disable]
	const_var_propagate=0	[Propagate variables …] = [Disable]
Level 3		Optimizes external variables that do not have a volatile specifier within the entire function.
	novolatile	[Treat global …] = [Not checked]
	infinite_loop=0	[Delete assignment …] = [Not checked]
	opt_range=all	[Specify optimizing …] = [All]
	global_alloc=1	[Allocate registers …] = [Enable]
	const_var_propagate=1	[Propagate variables …] = [Enable]
Custom	-	Optimizes external variables according to the options specified by user

Treat global variables as volatile qualified

Check Box	Command Option	Function
☑	*volatile*	Disables external variable optimization.
☐	*novolatile*	Optimizes external variables that do not have a volatile specifier.

Delete assignment to global variables before an infinite loop

Check Box	Command Option	Function
☑	*infinite_loop=1*	Eliminates an assignment expression that is located immediately before an infinite loop and that is an assignment to the external variable that is not used in the infinite loop.
☐	*infinite_loop=0*	Disables elimination of an assignment expression for external variables preceding an infinite loop.

Specify optimizing range

Dialog Menu	Command Option	Function
All	*opt_range=all*	Optimizes external variables within the entire function.
No loop	*opt_range=noloop*	External variables in a loop and external variables used in a loop iteration condition are not to be optimized.
No block	*opt_range=noblock*	External variables extending across branches (including loops) are not to be optimized.

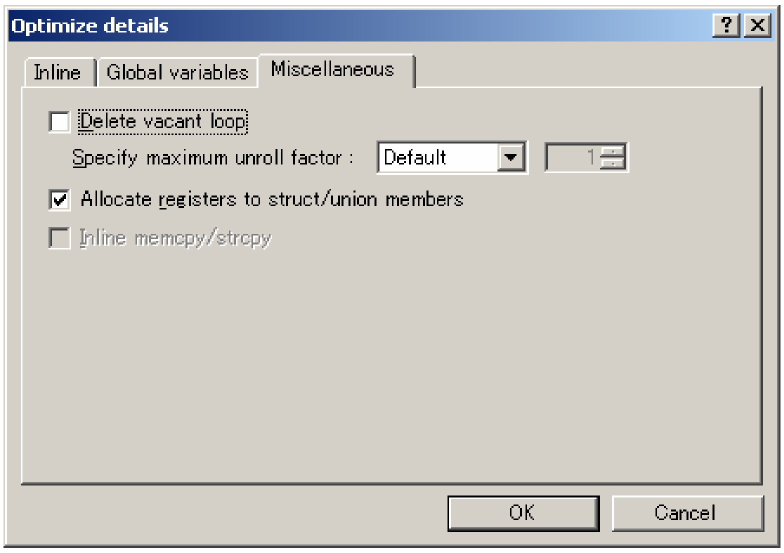
Allocate registers to global variables

Dialog Menu	Command Option	Function
Disable	*global_alloc=0*	Disables allocation of external variables to registers.
Enable	*global_alloc=1*	Allocates external variables to registers.
Default	*global_alloc=1*	Allocates external variables to registers.

Propagate variables which are const qualified

Dialog Menu	Command Option	Function
Disable	*const_var_propagate=0*	Disables constant propagation of external constants declared by **const**.
Enable	*const_var_propagate=1*	Performs constant propagation of external constants declared by **const**.
Default	*const_var_propagate=1*	Performs constant propagation of external constants declared by **const**.

(c) **[Details] Button:** [Miscellaneous] Tab



☐ Delete vacant loop
Specify maximum unroll factor : Default 1
☑ Allocate registers to struct/union members
☐ Inline memcpy/strcpy

Delete vacant loop

Check Box	Command Option	Function
☑	*del_vacant_loop=1*	Eliminates the loop without statements inside.
☐	*del_vacant_loop=0*	Disables elimination of vacant loops, even when there is no statements inside the loop.

Specify maximum unroll factor

Dialog Menu	Command Option	Function
Default	*max_unroll=2 or 1*	2 or 1 is assumed as the maximum number of loops to be expanded.
Custom	*max_unroll=< numeric value >*	Specifies the maximum number of loops to be expanded. An integer from 1 to 32 can be specified for <numeric value>.

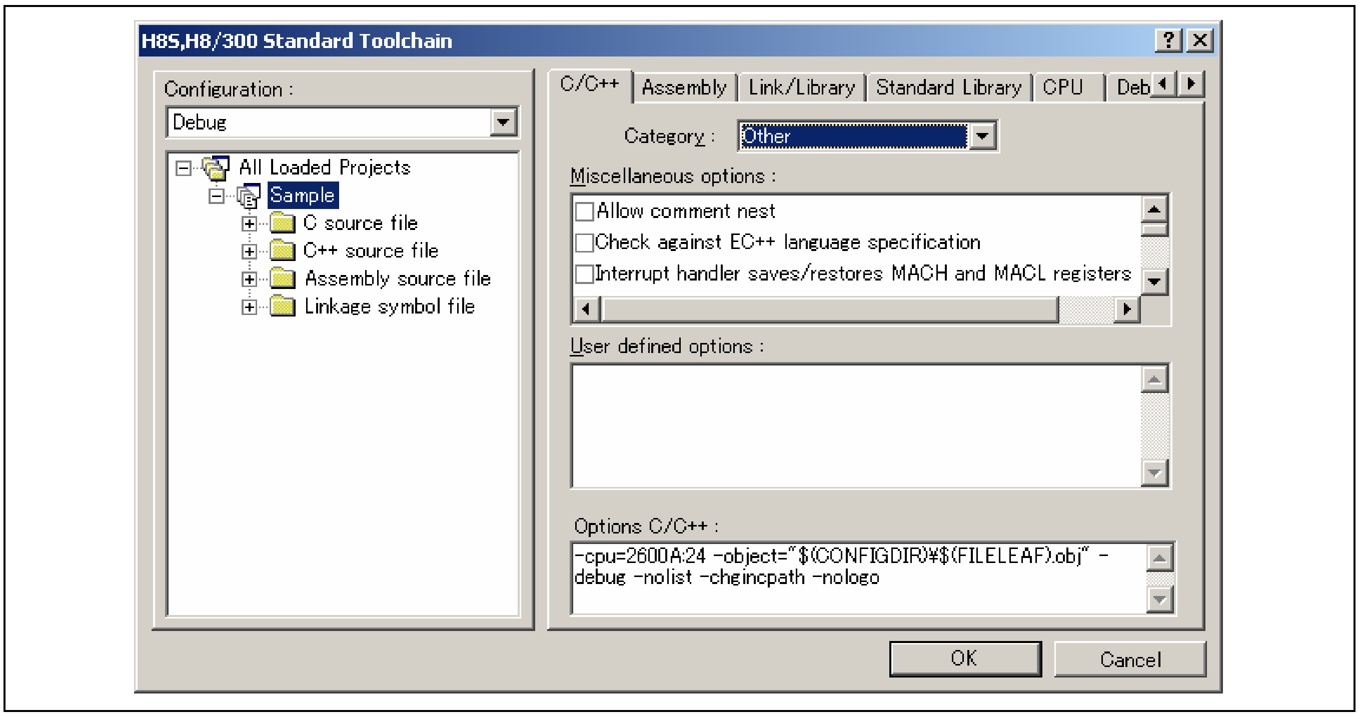
Allocate registers to struct/union members

Check Box	Command Option	Function
☑	*struct_alloc=1*	Allocates structure/union members to registers.
☐	*struct_alloc=0*	Disables allocation of structure/union members to registers.

Inline memcpy/strcpy

Check Box	Command Option	Function
☑	*library=intrinsic*	Performs inline expansion for **memcpy** and **strcpy**.
☐	*library=function*	Makes function calls for **memcpy** and **strcpy**.

(5) **Category:**[Other]



```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj" -
debug -nolist -chgincpath -nologo
```

Miscellaneous options:

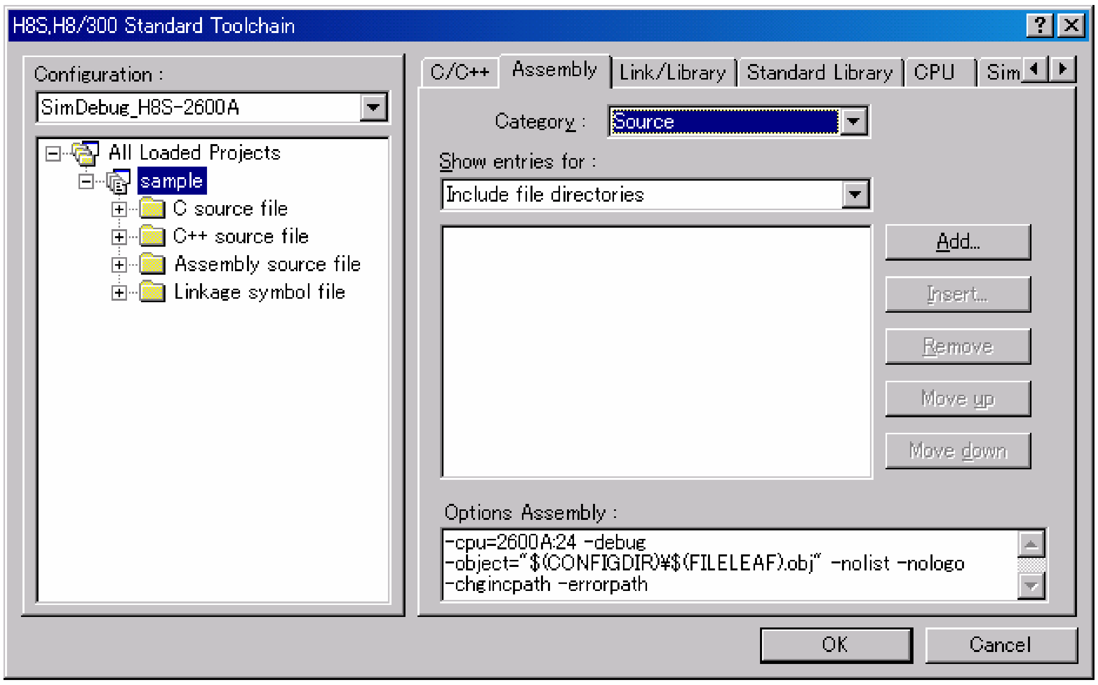
Dialog Menu	Command Option	Function
Allow comment nest	*comment*	Enables comment nesting
Check against EC++ language specification	*ecpp*	Checks syntax according to the EC++ language specifications
Interrupt handler saves/restores MACH and MACL registers if used	*macsave*	Guarantees MAC registers
Treate loop condition as volatile qualified	*volatile_loop*	Disables optimization of loop iteration condition.
Treat enum as char if it is in the range of char	*byteenum*	Handles enumeration-type data as char
Increase a register for register variable	*Regexpansion noregexpansion*	Specifies the number of variable-allocation registers as 2 or 3
Put common subexpression on a register temporarily	*cmncode*	Improves the optimization function for common expression deletion
Use EEPMOV in block copy	*eepmov*	Performs structure substitution using the EEPMOV instruction
Treats loop condition as volatile qualified	*volatile_loop*	Disables optimization of loop iteration.
Suppress #line in preprocessed source file	*noline*	Disables **#line** output at preprocessor expansion.
Enable register declaration	*enable_register*	Preferentially allocates the variables with register storage class specification to registers.
Obey ansi specifications more strictly	*strict_ansi*	Conforms to the ANSI standard for the following processing. - Associative rule of floating-point operations

User defined options: Specifies the command options.

4.2.2 Assembler Options

Select Assembly Tab from the H8S,H8/300 Standard Toolchain dialog box.

(1) **Category:**[Source]

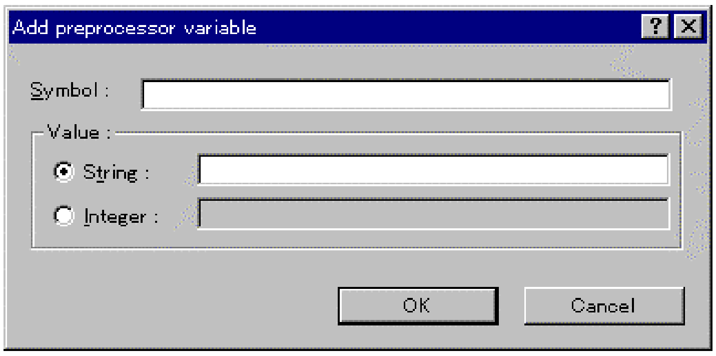


```
-cpu=2600A:24 -debug
-object="$(CONFIGDIR)¥$(FILELEAF).obj" -nolist -nologo
-chgincpath -errorpath
```

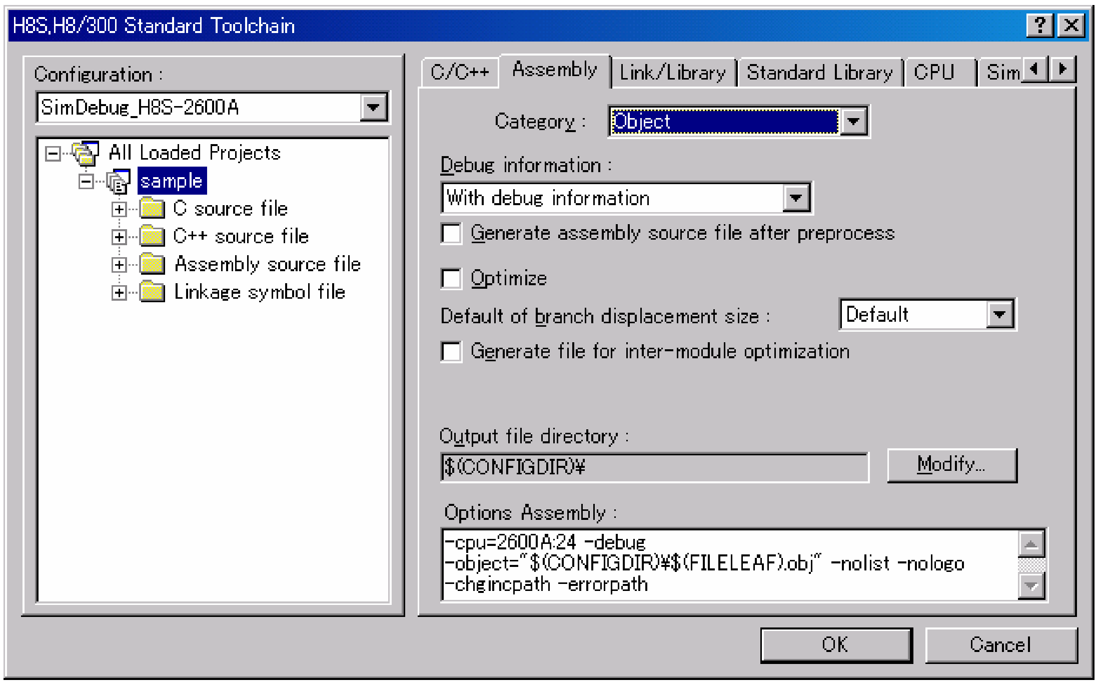
Show entries for:

Dialog Menu	Command Option	Function
Include file directories	*include*	Specifies include file directory
Defines	*define*	Defines string literal replacement
Preprocessor variable*	*assigna*	Defines integer-type preprocessor variable
	assignc	Defines character-type preprocessor variable

Note: * Specify using the following dialog box.



(2) **Category:**[Object]



```
-cpu=2600A:24 -debug
-object="$(CONFIGDIR)¥$(FILELEAF).obj" -nolist -nologo
-chgincpath -errorpath
```

Debug information:

Dialog Menu	Command Option	Function
Default	-	Validates .DEBUG directive only
With debug information	*debug*	Enables debugging information output
Without debug information	*nodebug*	Disables debugging information output

Generate assembly source file after preprocess

Check Box	Command Option	Function
√	*expand*	Outputs preprocessor expansion results
☐	-	Outputs no preprocessor expansion results

Optimize

Check Box	Command Option	Function
√	*optimize*	Specifies optimization
☐	*nooptimize*	Specifies no optimization

Default of branch displacement size:

Dialog Menu	Command Option	Function
Default		Specified by the directive descriptions in the source files
8bit	*br_relative=8*	Specifies the displacement size as 8 bits if the forward-reference displacement is selected for the branch instruction
16bit	*br_relative=16*	Specifies the displacement size as 16 bits if the forward-reference displacement is selected for the branch instruction

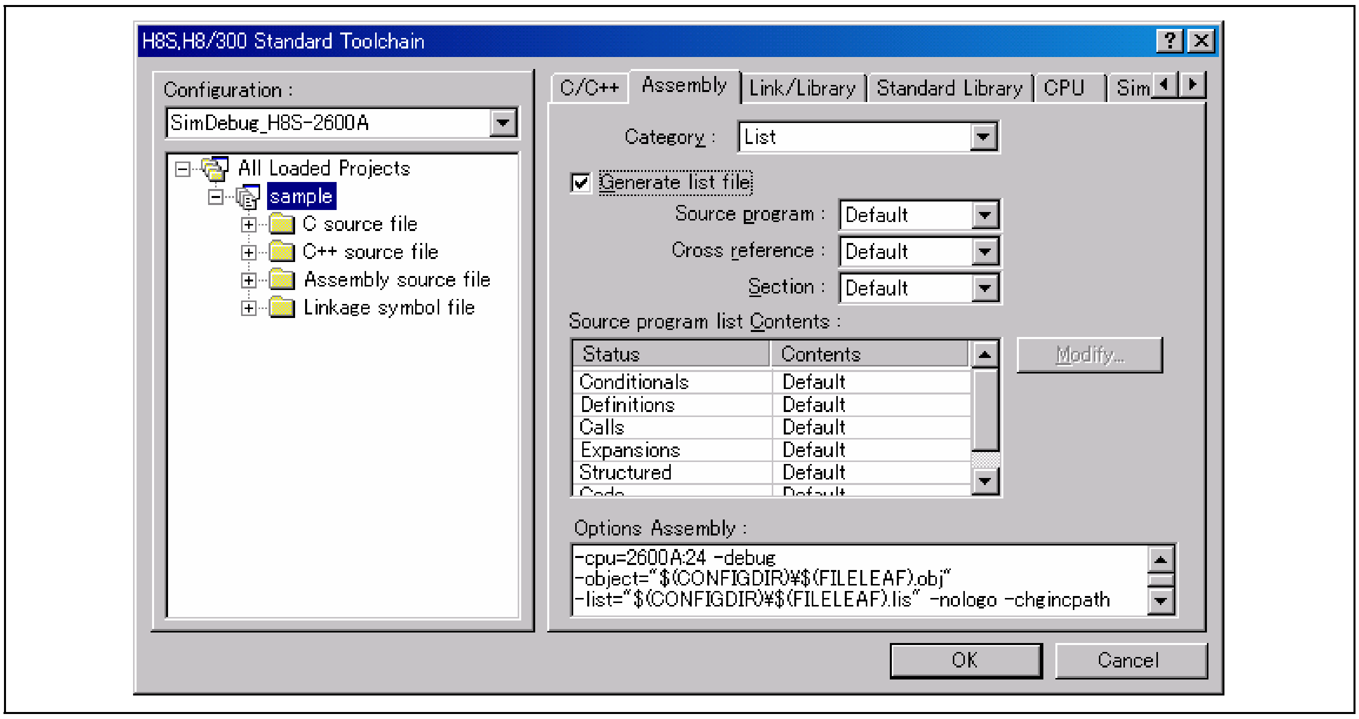
Generate file for inter-module optimization

Check Box	Command Option	Function
√	*goptimize*	Outputs inter-module optimization information
☐		Outputs no inter-module optimization information

Output directory

Dialog Menu	Command Option	Function
-	*object*	Specifies object output directory

(3) **Category:**[List]



Configuration : SimDebug_H8S-2600A

Category : List

[✓] Generate list file

Source program : Default

Cross reference : Default

Section : Default

Source program list Contents :

Status	Contents
Conditionals	Default
Definitions	Default
Calls	Default
Expansions	Default
Structured	Default
Code	Default

Options Assembly :

```
-cpu=2600A:24 -debug
-object="$(CONFIGDIR)¥$(FILELEAF).obj"
-list="$(CONFIGDIR)¥$(FILELEAF).lis" -nologo -chgincpath
```

Generate list file

Check Box	Command Option	Function
√	*list*	Outputs assembly list
☐	*nolist*	Outputs no assembly list

Source program:

Dialog Menu	Command Option	Function
Shown	*source*	Outputs source program list
Not shown	*nosource*	Outputs no source program list

Cross reference:

Dialog Menu	Command Option	Function
Shown	*cross_refernce*	Outputs cross reference list
Not shown	*nocross_refernce*	Outputs no cross reference list

Section:

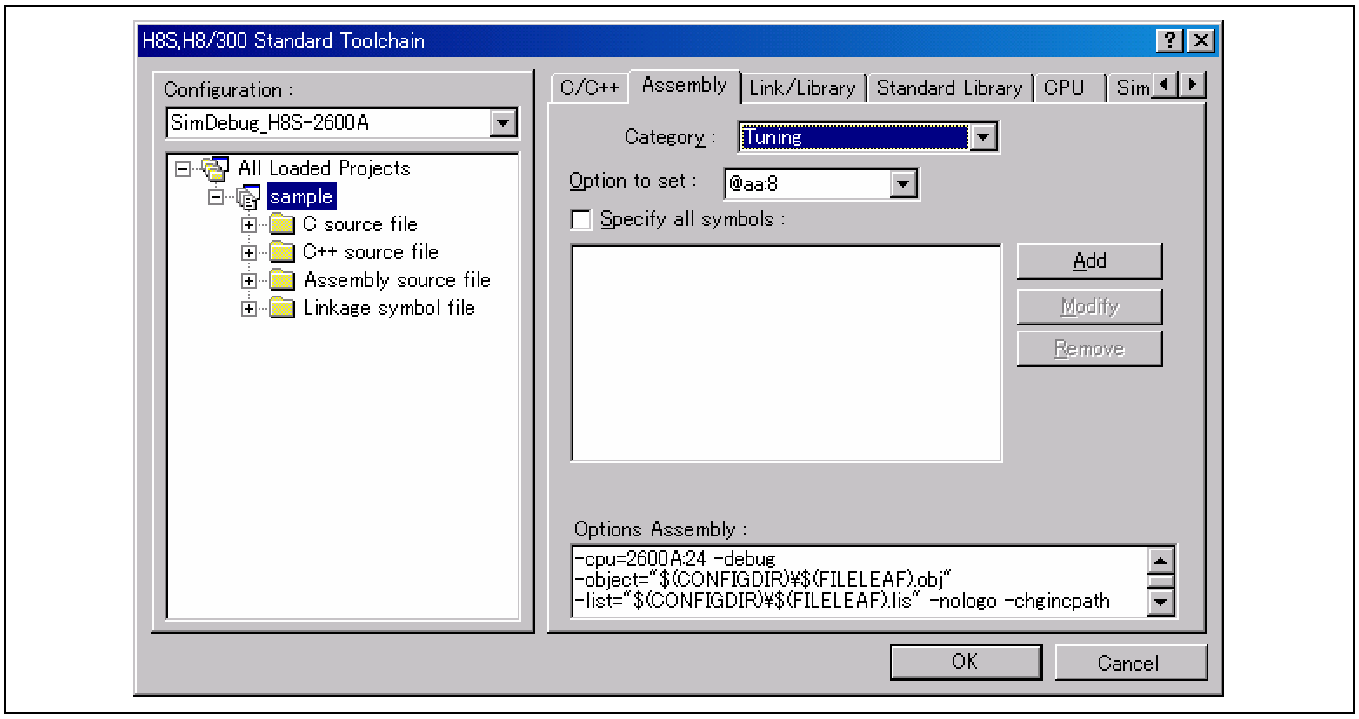
Dialog Menu	Command Option	Function
Shown	*section*	Outputs section information list
Not shown	*nosection*	Outputs no section information list

Source program list Contents: Specifies the contents to be output on the list files.

Dialog Menu	Command Option	Function
Conditionals	*show=conditionals*	Outputs the parts in which conditions specified in .AIF or .AIFDEF are not satisfied
Definitions	*show=definitions*	Outputs macro definitions, .AREPEAT and .AWHILE definitions , and .INCLUDE,.ASSIGNA, and .ASSIGNC directives
Calls	*show=calls*	Outputs macro-call statements and .AIF,.AIFDEF, and .AENDI directives
Expansions	*show=expansions*	Outputs macro expansions and .AREPEAT .AWHILE expansions
Structured	*show=structured*	Outputs structured assembly expansions
Code	*show=code*	Outputs the lines that exceed the number of source statement lines to be displayed in the object code display

Note: If default is selected for each option, directive in the source list is specified.

(4) **Category:**[Tuning]



Category : Tuning

Option to set : @aa:8

☐ Specify all symbols :

Options Assembly :

```
-cpu=2600A:24 -debug
-object="$(CONFIGDIR)¥$(FILELEAF).obj"
-list="$(CONFIGDIR)¥$(FILELEAF).lis" -nologo -chgincpath
```

Option to set:

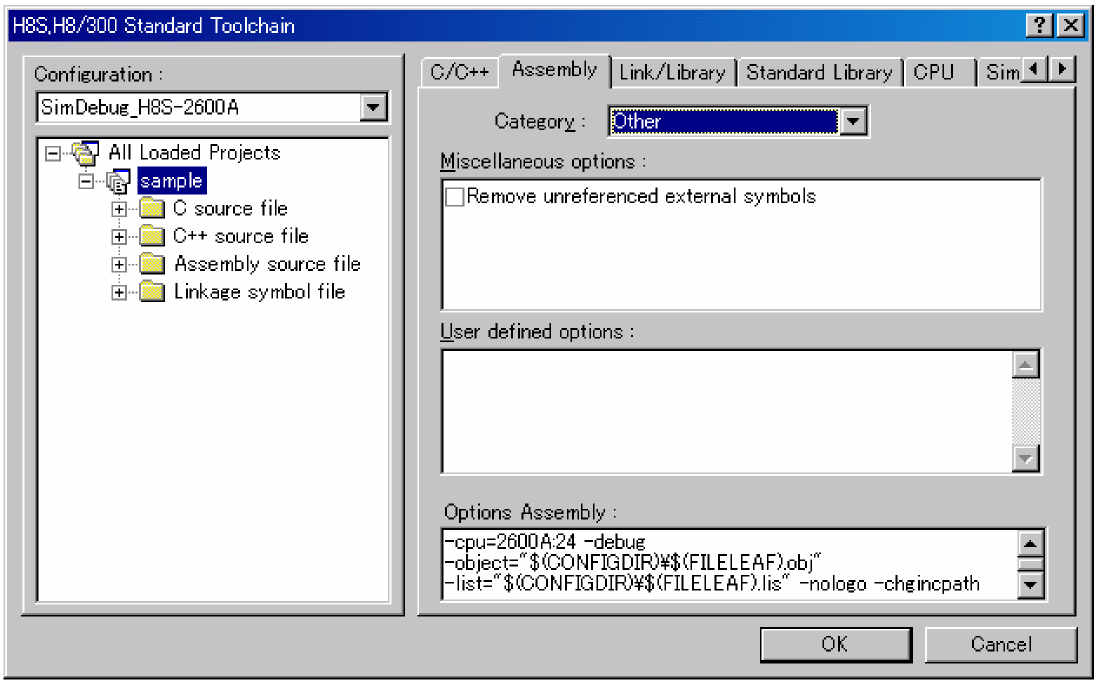
Dialog Menu	Command Option	Function
@aa:8	*abs8*	Specifies 8-bit absolute address symbol
@aa:16	*abs16*	Specifies 16-bit absolute address symbol

Note: Selects external reference symbols or external definition symbols.

Specify all symbols

Check Box	Function
☑	Assigns the specified size to the external reference symbols and external definition symbols
☐	Assigns a specific size to each symbol or does not assign a size

(5) **Category:**[Other]



Category : Other

Miscellaneous options :

☐ Remove unreferenced external symbols

User defined options :

Options Assembly :

```
-cpu=2600A:24 -debug
-object="$(CONFIGDIR)¥$(FILELEAF).obj"
-list="$(CONFIGDIR)¥$(FILELEAF).lis" -nologo -chgincpath
```

Miscellaneous options:

Dialog Menu	Check Box	Command Option	Function
Remove unreferenced external symbols	√	exclude	Disables unreferenced external-reference symbol information output
	☐	noexclude	Enables unreferenced external-reference symbol information output

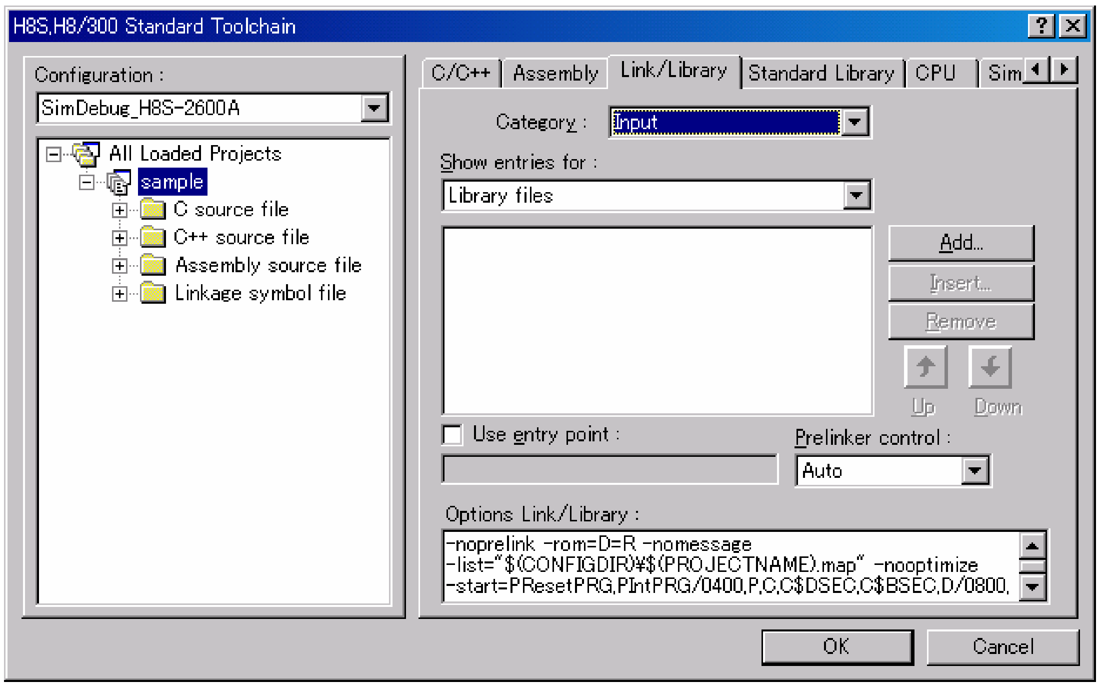
User defined options:

Describes the command options.

4.2.3 Optimizing Linkage editor Options

Select Link/Library Tab from the H8S, H8/300 Standard Toolchain dialog box.

(1) **Category:**[Input]



Configuration : SimDebug_H8S-2600A

Category : Input

Show entries for : Library files

Use entry point : ☐

Prelinker control : Auto

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

Show entries for:

Dialog Menu	Command Option	Function
Library files	*library*	Specifies an input library name
Relocatable files and object files	*input*	Specifies an input file
Binary files	*binary*	Specifies an input binary file
Defines	*define*	Forcibly defines undefined symbol

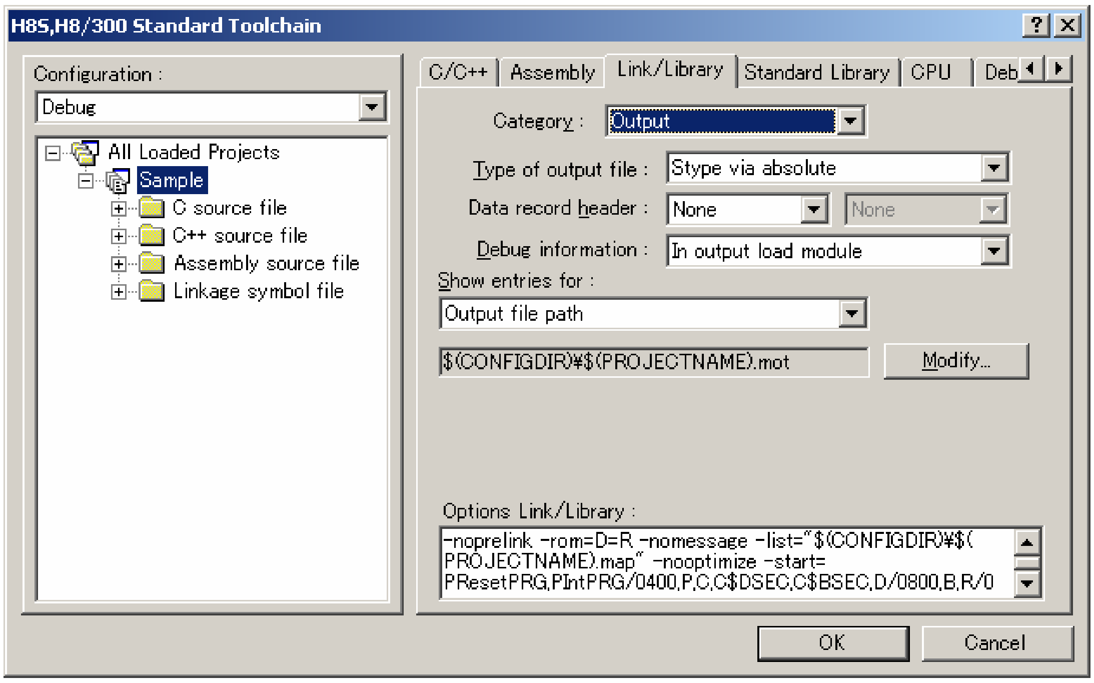
Use entry point:

Check Box	Command Option	Function
☑	*entry*	Specifies entry symbol and entry address
☐	-	Specifies no entry symbol and no entry address

Prelinker control:

Dialog Menu	Command Option	Function
Auto	-	If there is no instance information file, does not run prelinker
Skip prelinker	noprelink	Does not run prelinker
Run prelinker	-	Runs prelinker

(2) **Category:**[Output]



Category : Output

Type of output file : Stype via absolute

Data record header : None None

Debug information : In output load module

Show entries for :

Output file path

$(CONFIGDIR)¥$(PROJECTNAME).mot

Options Link/Library :

```
-noprelink -rom=D=R -nomessage -list="$(CONFIGDIR)¥$(
PROJECTNAME).map" -nooptimize -start=
PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,B,R/0
```

Type of output file:

Dialog Menu	Command Option	Function
Absolute(ELF/DWARF)	*form=absolute*	Outputs absolute load module in ELF/DWARF format
Absolute(SYSROF)	*form=absolute* *helfcnv.exe*	Outputs absolute load module in SYSROF format
Relocatable	*form=relocate*	Outputs relocatable load module
System library	*form=library=s*	Outputs system library
User library	*form=library=u*	Outputs user library
Hex via absolute	*form=hexadecimal*	Outputs a HEX file
Stype via absolute	*form=stype*	Outputs a S-type file
Binary via absolute	*form=binary*	Outputs a binary file

Data record header:

Dialog Menu	Command Option	Function
-		Outputs a record according to each address
H16	*record=h16*	Outputs a HEX record
H20	*record=h20*	Outputs an extended HEX record
H32	*record=h32*	Outputs a 32-bit HEX record
S1	*record=s1*	Outputs a S1 record
S2	*record=s2*	Outputs a S2 record
S3	*record=s3*	Outputs a S3 record

Debug information:

Dialog Menu	Command Option	Function
None	*nodebug*	Outputs no debugging information
In output load module	*debug*	Outputs debugging information to a load module
In Separate Debug File	*sdebug*	Outputs debugging information to a file

Show entries for:

Dialog Menu	Command Option	Function
Output file path	-	Specifies a path for an output file
ROM to RAM mapped sections	*rom*	Reserves an area of RAM to resolve symbol relocation by address in RAM
Divided output files	-	Sets or does not set output range
Specify value filled in unused area	-	Specifies a value to output to unused area
Output messages	-	Specifies whether information level messages are output
Reduce empty areas	-	Reduces empty areas generated as the boundary alignment of sections after compilation

Repressed information level messages:

Check Box	Command Option	Function
☑	*nomessage*	Outputs no information level messages
☐	*message*	Outputs information level messages

Notify unused symbol:

Check Box	Command Option	Function
☑	*msg_unused*	Notifies the user of the defined symbol which is never referenced
☐	-	NOT notify the user of the defined symbol which is never referenced

Divided output files:

Check Box	Command Option	Function
☑	*output*	Specifies an output file name and sets output range
☐	-	Specifies an output file name but does not set output range

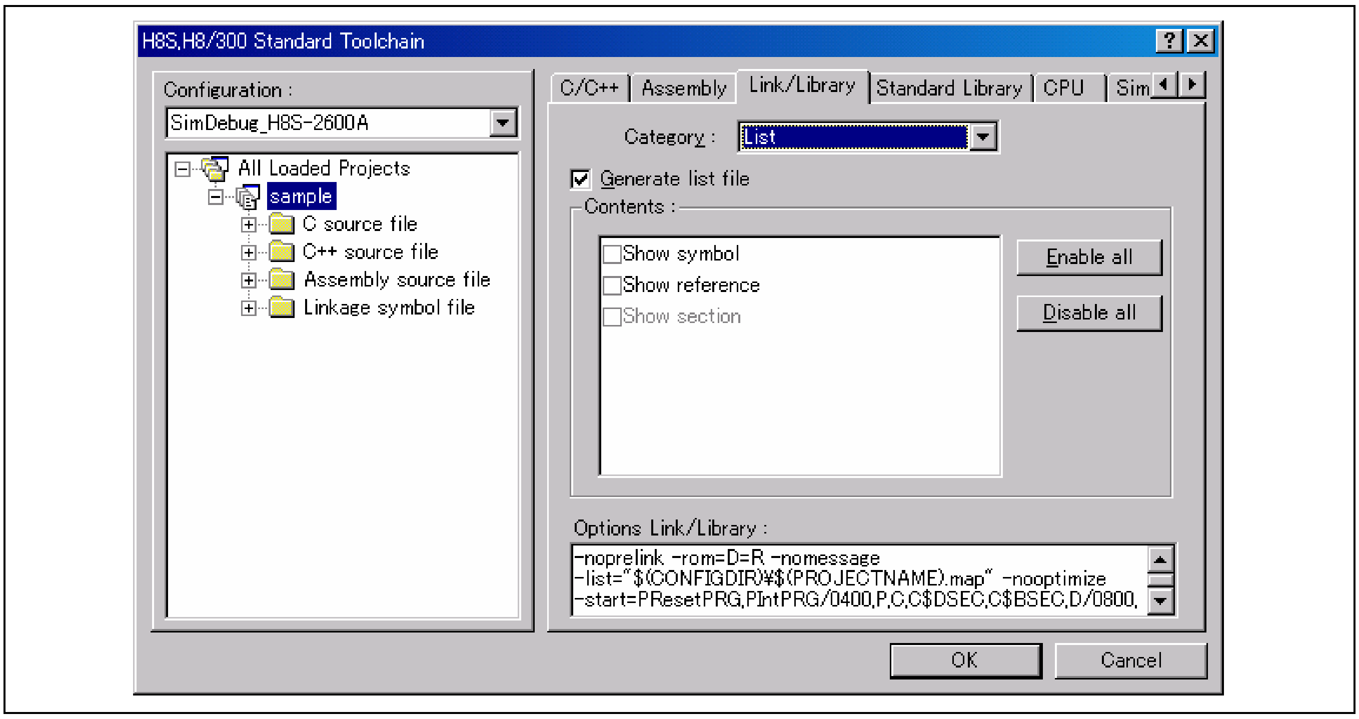
Output padding data:

Check Box	Command Option	Function
☑	*space= <numerical value>*	Specifies a value to output to unused area
☐	-	A value to output to unused area is not specified.

Reduce empty areas of boundary alignment:

Check Box	Command Option	Function
√	*data_stuff*	Reduces empty areas generated as the boundary alignment of sections after compilation
☐	-	NOT reduce empty areas generated as the boundary alignment of sections after compilation

(3) **Category:**[List]



```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

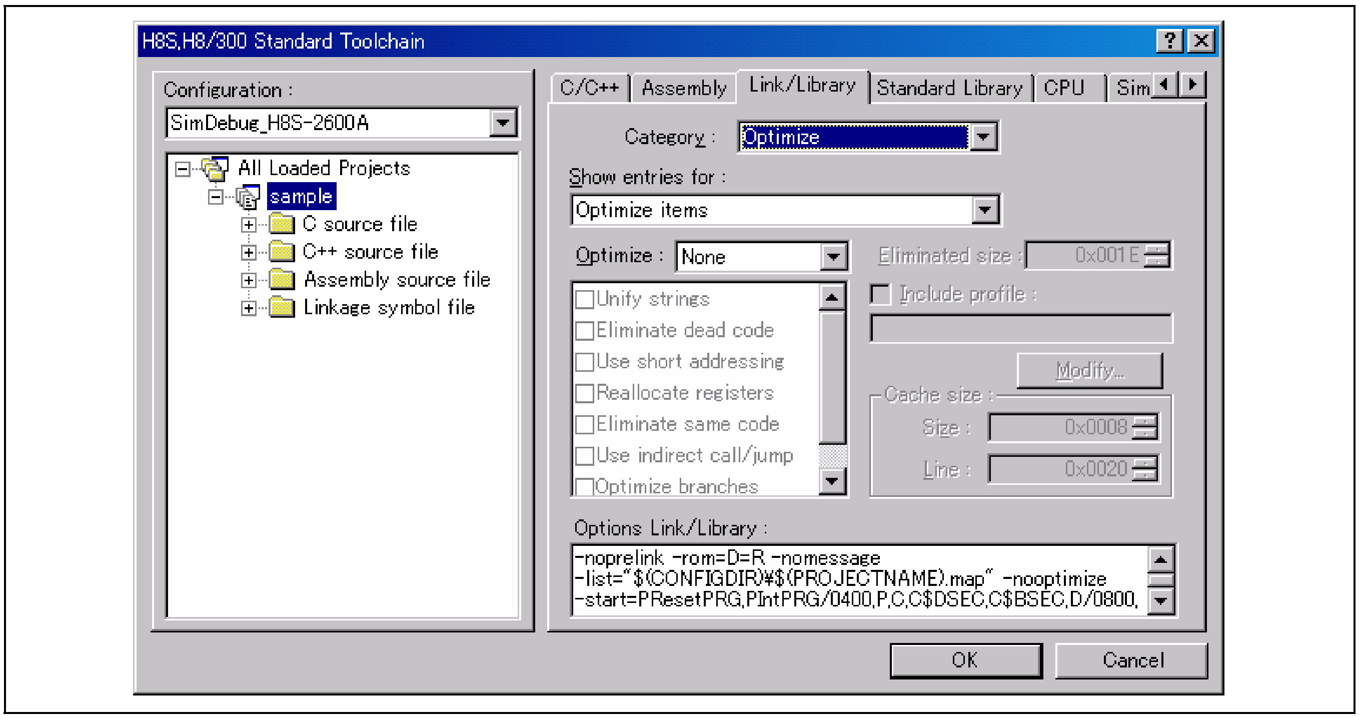
Generate list file:

Check Box	Command Option	Function
√	*list*	Outputs a list file
☐	-	Outputs no list file

Contents:

Dialog Menu	Command Option	Function
Show symbol	*show=symbol*	Outputs a list of symbol names
Show reference	*show=reference*	Outputs the number of symbol references
Show section	*sher=section*	Outputs a list of sections
Show cross reference	*show=xreference*	Outputs the cross-reference information

(4) **Category:**[Optimize]


H8S,H8/300 Standard Toolchain

Configuration : SimDebug_H8S-2600A

All Loaded Projects
sample
C source file
C++ source file
Assembly source file
Linkage symbol file

C/C++ | Assembly | Link/Library | Standard Library | CPU | Sim

Category : Optimize

Show entries for : Optimize items

Optimize : None

- [ ] Unify strings
- [ ] Eliminate dead code
- [ ] Use short addressing
- [ ] Reallocate registers
- [ ] Eliminate same code
- [ ] Use indirect call/jump
- [ ] Optimize branches

Eliminated size : 0x001E

- [ ] Include profile :

Modify...

Cache size :
Size : 0x0008
Line : 0x0020

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

OK | Cancel

Show entries for:

Dialog Menu	Command Option	Function
Optimize items	-	Specifies optimization
Forbid item	-	Disables optimization of specific symbol and address areas
Elimination of dead code	*Symbol_forbid*	Specifies the name of variable or function in which unreferenced symbol eliminating optimization is disabled
Elimination of same code	*Samecode_forbid*	Specifies the name of the function in which same code eliminating optimization is disabled
Use of short addressing to	*Variable_forbid*	Specifies the name of the variable in which optimization using short-absolute addressing mode is disabled
Use of indirect call/jump to	*Function_forbid*	Specifies the name of the function in which optimization using indirect addressing mode is disabled
Memory allocation in	*Absolute_forbid*	Specifies the address area to which address allocation is not performed

Optimize:

Dialog Menu		Command Option	Function
All		*Optimize*	Enables all optimization items
Speed		*OptimizeΔspeed*	Performs optimization in speed
Safe		*OptimizeΔsafe*	Performs safe optimization
Custom		*OptimizeΔ*	Enables optimization item selection
	Unify strings	*String_unify*	Unifies constant or string literal
	Eliminate dead code	*Symbol_delete*	Deletes unreferenced symbols
	Use short addressing	*Variable_access*	Uses short-absolute addressing mode
	Reallocate registers	*Register*	Reallocates registers
	Eliminate same code	*Same_code*	Unifies instruction codes
	Use indirect call/jump	*Function_call*	Uses indirect addressing mode
	Optimize branches	*Branch*	Optimizes branch instructions
	Eliminated size:	*Samesize*	Specifies the object size for same code elimination
None		*Nooptimize*	Disables optimization

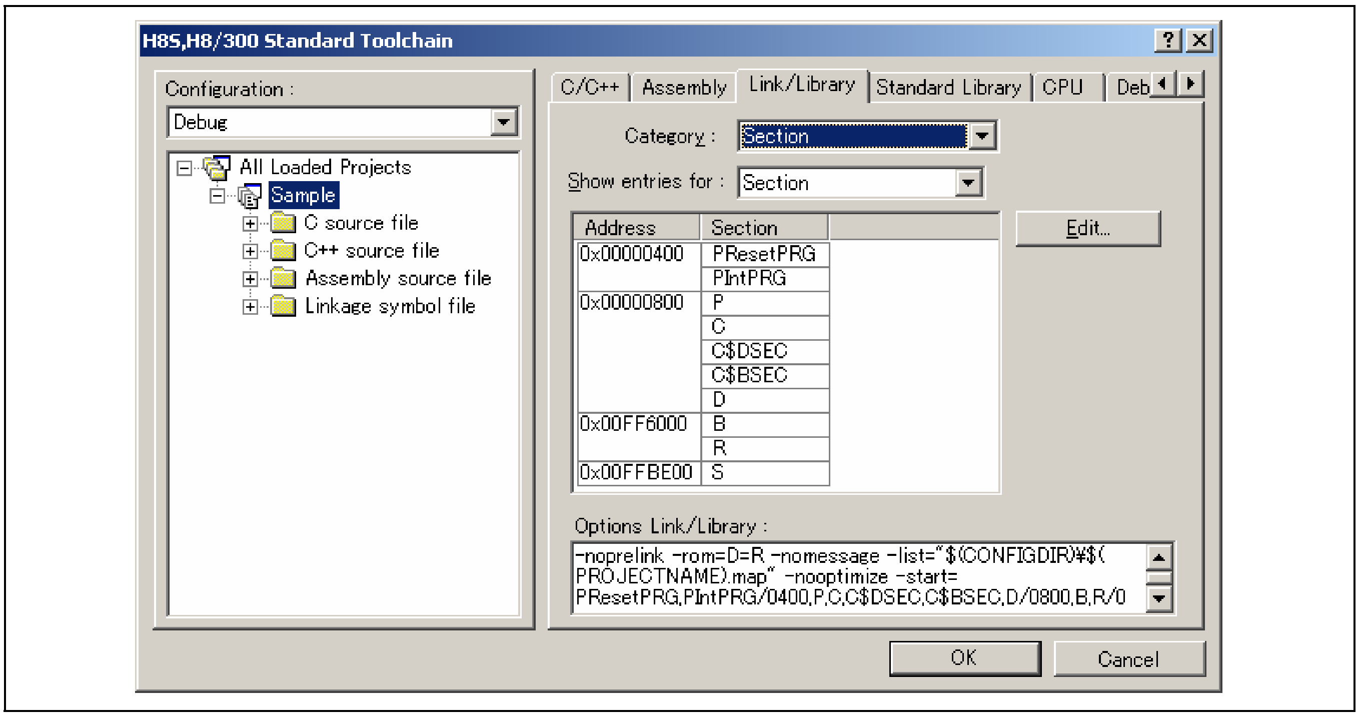
Include profile

Check Box	Command Option	Function
☑	profile	Specifies a profile information file
☐	-	Specifies no profile information file

Cache size:

Dialog Menu	Command Option	Function
Size	cachesize =sized	Specifies cache size
Line	cachesize =align	Specifies cache align size

(5) **Category:**[Section]



Category : Section

Show entries for : Section

Address	Section
0x00000400	PResetPRG
	PIntPRG
0x00000800	P
	C
	C$DSEC
	C$BSEC
	D
0x00FF6000	B
	R
0x00FFBE00	S

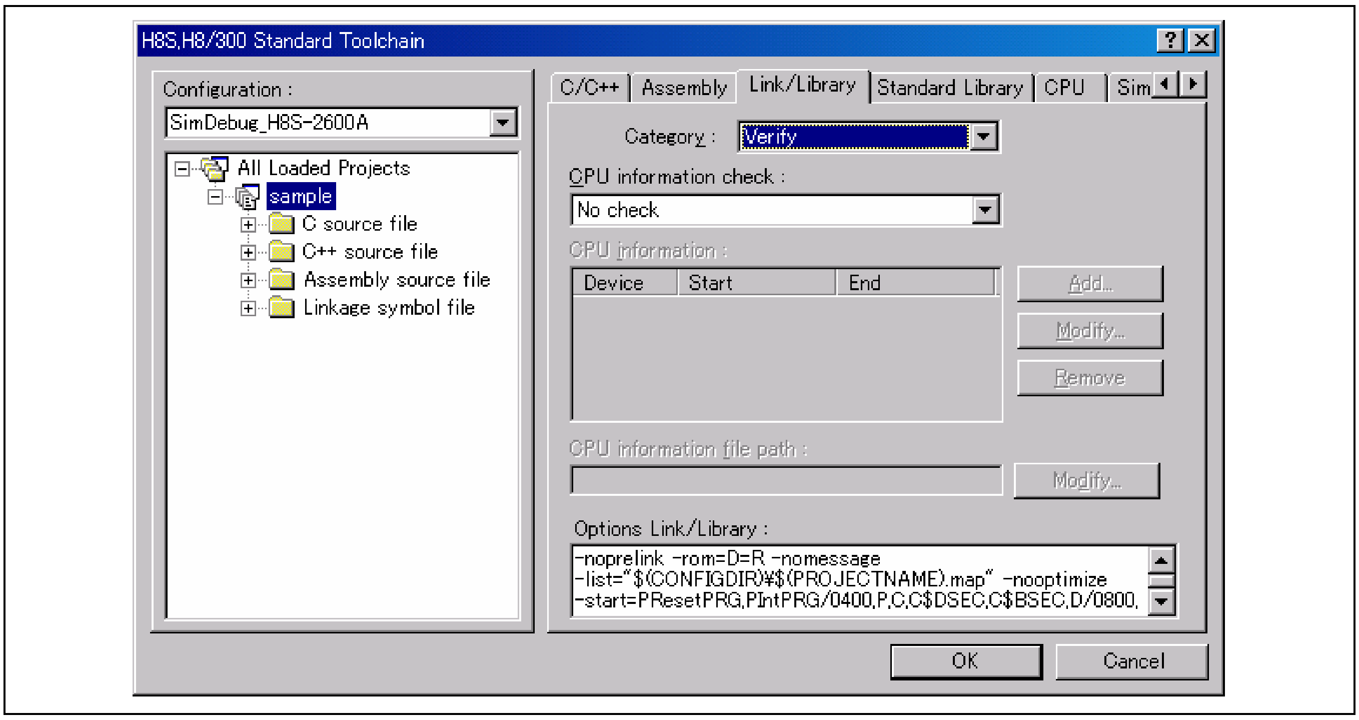
Options Link/Library :

```
-noprelink -rom=D=R -nomessage -list="$(CONFIGDIR)¥$(
PROJECTNAME).map" -nooptimize -start=
PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,B,R/0
```

Show entries for:

Dialog Menu	Command Option	Function
Section	*start-*	Specifies each section start address and linkage order
Symbol file	*fsymbol*	Outputs external definition symbols processed by linkage function to a file in assembler directive format

(6) **Category:**[Verify]



Category : Verify

CPU information check : No check

CPU information :

CPU information file path :

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

CPU information check:

Dialog Menu	Command Option	Function
No check	-	Checks no CPU allocation
Check	*CPU*	Checks memory allocation according to the CPU information file
Use CPU information file	*CPU*	Checks memory allocation according to the existing CPU information file

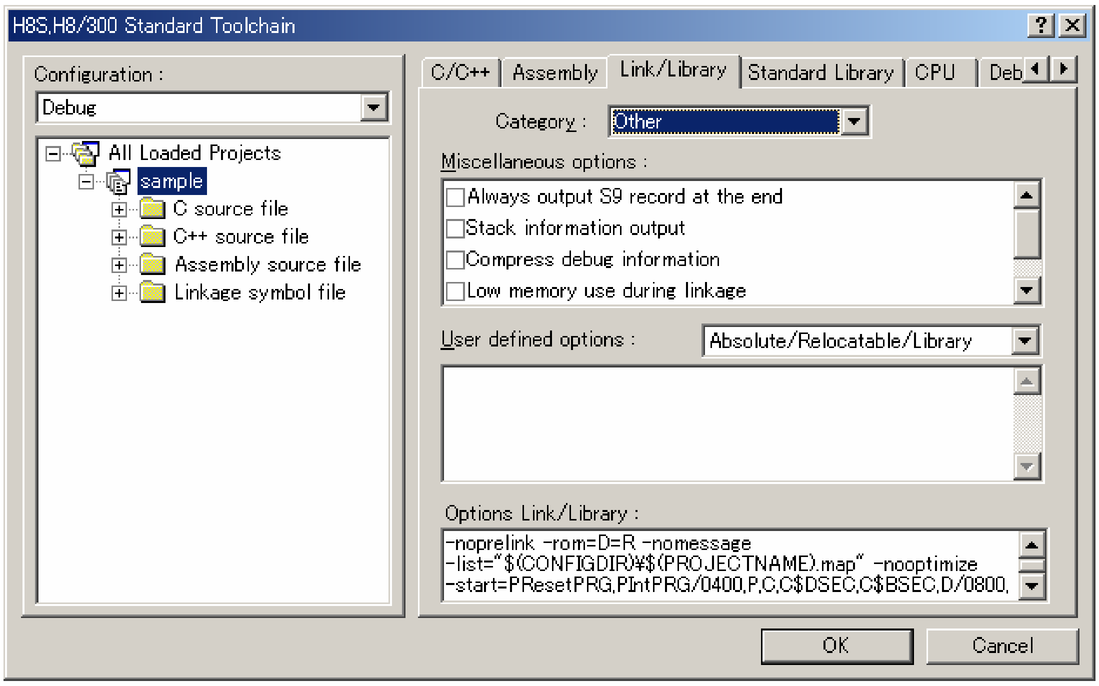
CPU information

Dialog Menu	Subcommand	Function
-	*{ROm | RAm}=* *<address range>*	Cerates or modifies CPU information file CPU Specifies memory types and then specifies each memory address

CPU information file path

Dialog Menu	Subcommand	Function
-	*<File name>*	Specifies the existing CPU information file

(7) **Category:**[Other]



Category : Other

Miscellaneous options :
- ☐ Always output S9 record at the end
- ☐ Stack information output
- ☐ Compress debug information
- ☐ Low memory use during linkage

User defined options : Absolute/Relocatable/Library

Options Link/Library :

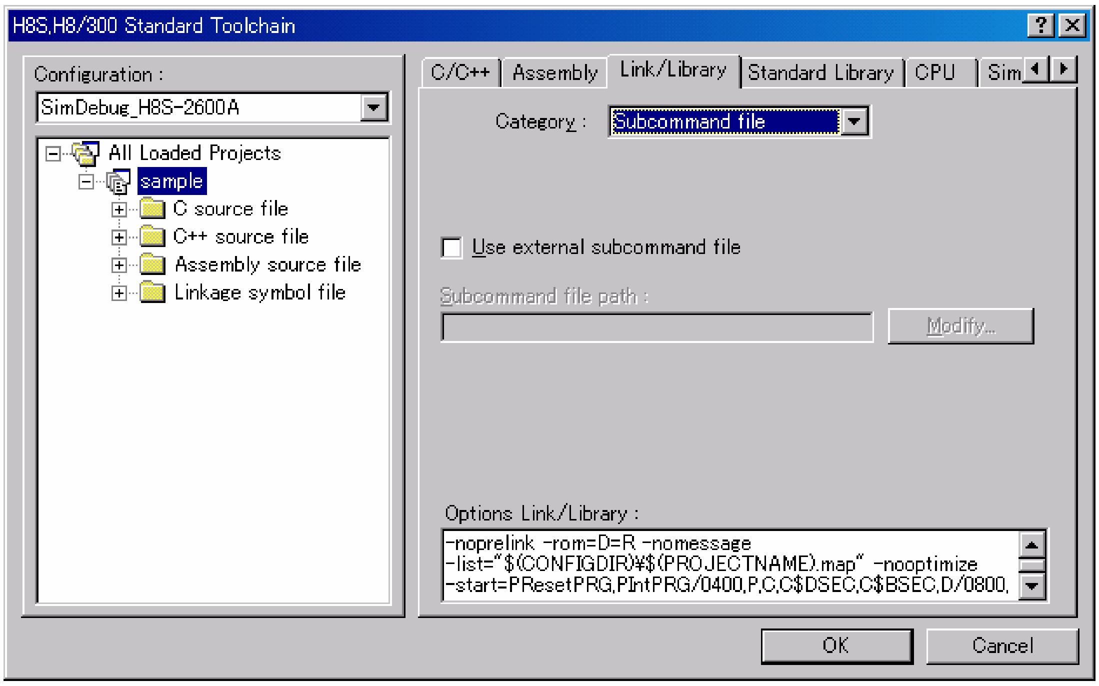
```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

Miscellaneous options: Specifies other functions.

Dialog Menu	Command Option	Function
Always output S9 record at the end	*S9*	Outputs S9 record consistently
Stack information output	*stack*	Outputs stack usage information files
Compress debug information	*compress*	Compresses debug information
	nocompress	Compresses no debug information
Low memory use during linkage	*Memory=high*	The occupied memory size is the same as usual.
	Memory=low	The occupied memory size is reduced.

User defined options: Specifies the command options.

(8) **Category:**[Subcommand file]



Configuration : SimDebug_H8S-2600A

Category : Subcommand file

☐ Use external subcommand file

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

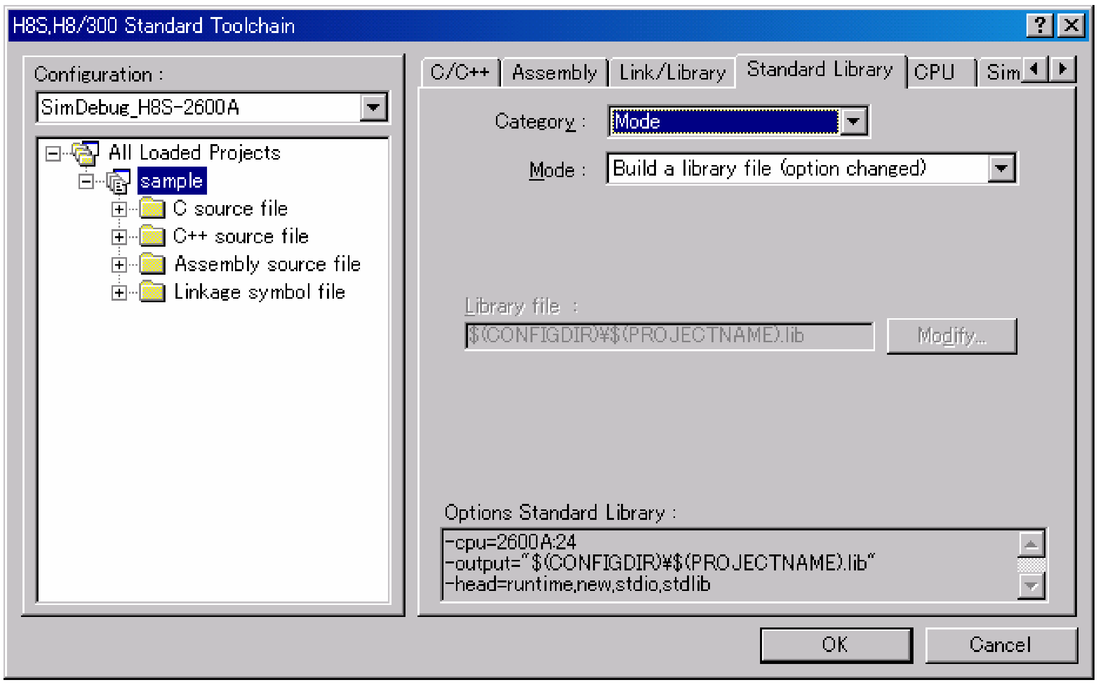
Use external subcommand file

Check Box	Command Option	Function
√	Subcommand	Specifies option by subcommand file
☐	-	Specifies no subcommand file

4.2.4 Standard Library Generator Options

Select Standard Library Tab from the H8S,H8/300 Standard Toolchain dialog box.

(1) **Category:**[Mode]

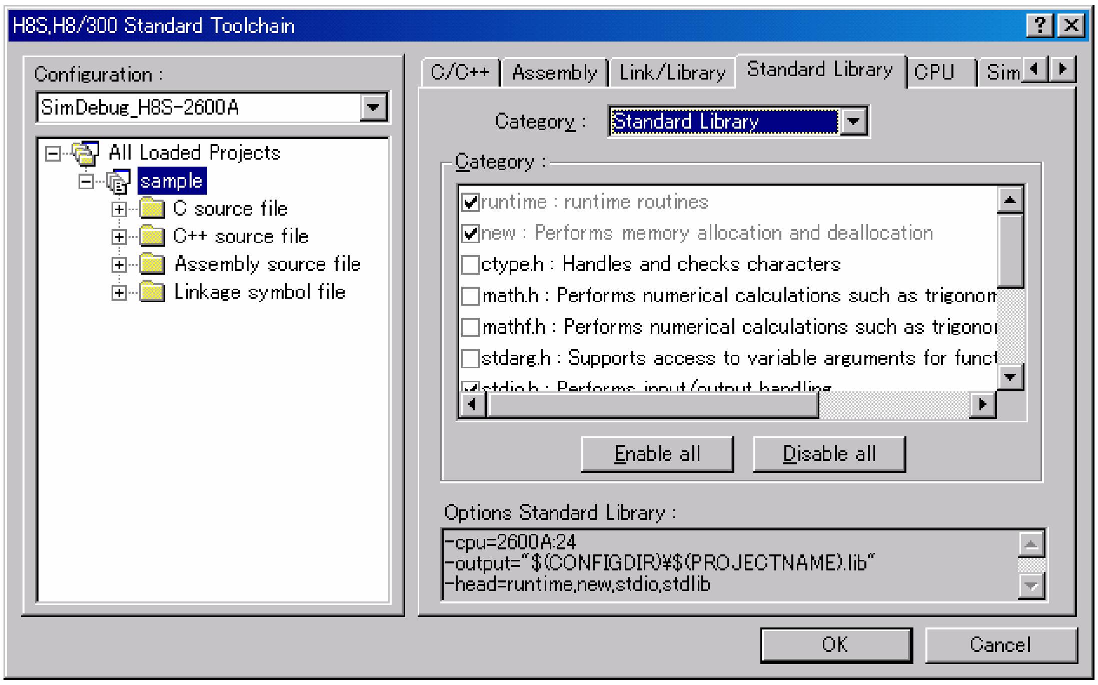


```
-cpu=2600A:24
-output="$(CONFIGDIR)¥$(PROJECTNAME).lib"
-head=runtime,new,stdio,stdlib
```

Mode:

Dialog Menu	Command Option	Function
Build a library file(anytime)	-	Creates a new standard library
Build a library file(Option Changed)	-	Creates a new standard library when option is changed
Use an existing library file	-	Links an existing standard library
Do not add a library file	-	Links no standard library

(2) **Category:**[Standard Library]



Category :

- [✓] runtime : runtime routines
- [✓] new : Performs memory allocation and deallocation
- [ ] ctype.h : Handles and checks characters
- [ ] math.h : Performs numerical calculations such as trigonom
- [ ] mathf.h : Performs numerical calculations such as trigonoi
- [ ] stdarg.h : Supports access to variable arguments for funct
- [✓] stdio.h : Performs input/output handling

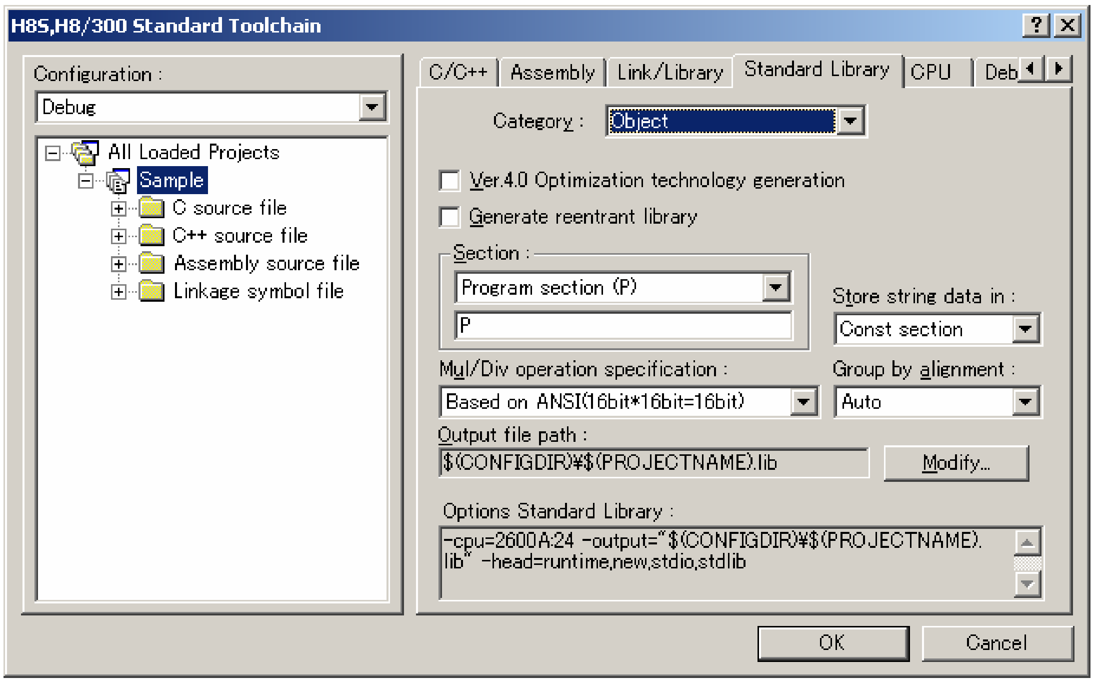
Options Standard Library :

```
-cpu=2600A:24
-output="$(CONFIGDIR)¥$(PROJECTNAME).lib"
-head=runtime,new,stdio,stdlib
```

Category:

Dialog Menu	Command Option	Function
runtime	*Head=RUNTIME*	Specifies a run-time routine
new	*Head=NEW*	Specifies EC++ declared by new
ctype.h	*Head=CTYPE*	Specifies ctype.h
math.h	*Head=MATH*	Specifies math.h
mathf.h	*Head=MATHF*	Specifies mathf.h
stdarg.h	*Head=STDARG*	Specifies stdarg.h
stdio.h	*Head=STDIO*	Specifies stdio.h
stdlib.h	*Head=STDLIB*	Specifies stdlib.h
string.h	*Head=STRING*	Specifies string.h
ios(EC++)	*Head=IOS*	Specifies ios(EC++)
complex(EC++)	*Head=COMPREX*	Specifies complex(EC++)
string(EC++)	*Head=CPPSTRING*	Specifies string(EC++)

(3) **Category:**[Object]


H8S,H8/300 Standard Toolchain

Configuration : Debug

All Loaded Projects
- Sample
  - C source file
  - C++ source file
  - Assembly source file
  - Linkage symbol file

C/C++ | Assembly | Link/Library | Standard Library | CPU | Deb

Category : Object

☐ Ver.4.0 Optimization technology generation

☐ Generate reentrant library

Section : Program section (P)

P

Store string data in : Const section

Mul/Div operation specification : Based on ANSI(16bit*16bit=16bit)

Group by alignment : Auto

Output file path : $(CONFIGDIR)¥$(PROJECTNAME).lib

Modify...

Options Standard Library :

```
-cpu=2600A:24 -output="$(CONFIGDIR)¥$(PROJECTNAME).
lib" -head=runtime,new,stdio,stdlib
```

OK | Cancel

Ver.4.0 Optimization technology generation (supported by the HEW Ver. 4.0 or later)

Check Box	Command Option	Function
√	*legacy=v4*	Output object which is compatible with that generated by Ver.4.0 optimization technology of H8S
☐	-	Output object generated by Ver.6.1 optimization technology of H8S

Generate reentrant library

Check Box	Command Option	Function
√	*reent*	Creates reentrant functions
☐	-	NOT create reentrant functions

Section:

Dialog Menu	Command Option	Function
-	section	Changes the default section name

Store string data in:

Dialog Menu	Command Option	Function
Const section	*string=const*	Outputs string literal to the constant area
Data section	*string=data*	Outputs string literal to the initialization data area

Mul/Div operation specifications

Dialog Menu	Command Option	Function
Based on ANSI (Guarantee 16bit as a result of 16bit*16bit)	*nocpuexpand*	Develops multiplication or division in codes according to the ANSI C language specifications
Non ANSI (Guarantee 32bit as a result of 16bit*16bit)	*cpuexpand*	Develops multiplication or division in codes according to the CPU instruction specifications

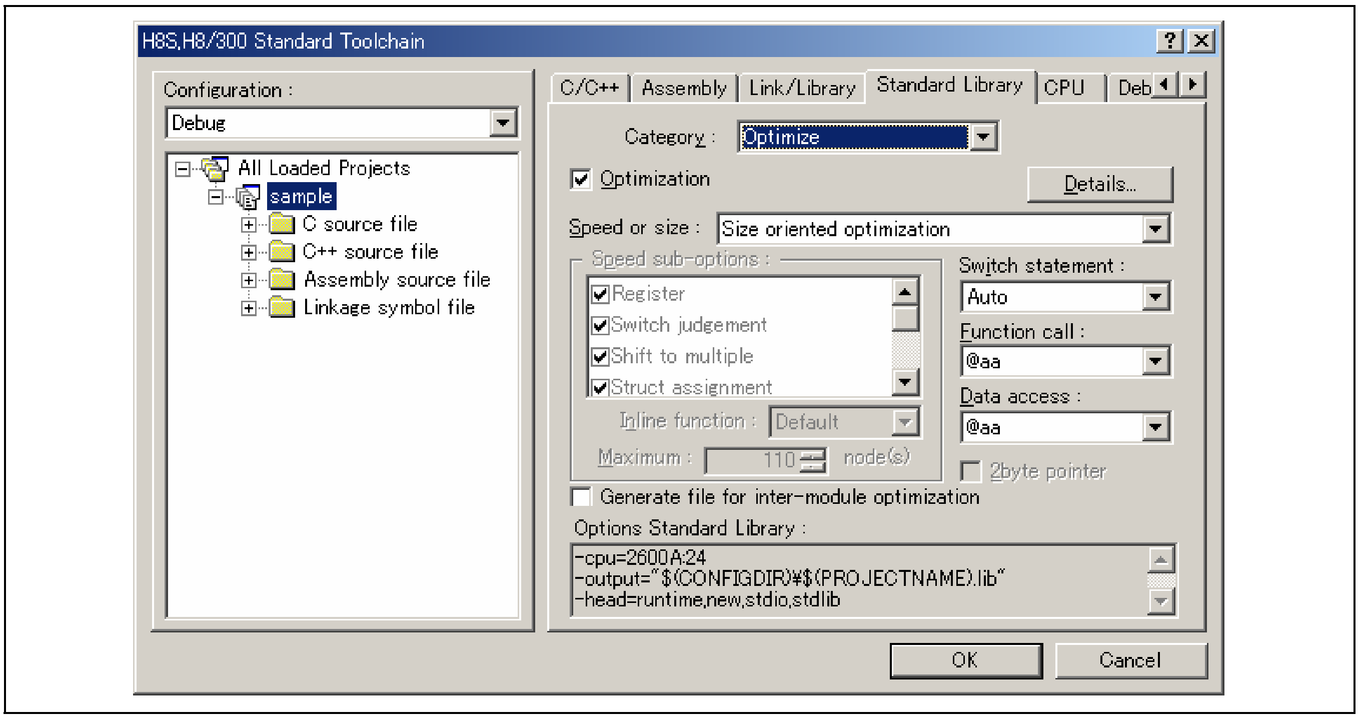
Output file path

Dialog Menu	Command Option	Function
-	output	Specifies library file output directory

Group by alignment

Dialog Menu	Command Option	Function
None	*noalign*	Allocates defined variables in the defined order
Auto	*align*	Allocates variables so as to reduce space by boundary alignment
4byte	*align=4*	Divides a data section into 4,2,1-byte boundary alignment section, and allocates into multiple of 4,2,1 address, in order to improve the speed of access

(4) **Category:**[Optimize]



Category : Optimize

☑ Optimization

Speed or size : Size oriented optimization

Speed sub-options :
☑ Register
☑ Switch judgement
☑ Shift to multiple
☑ Struct assignment

Inline function : Default

Maximum : 110 node(s)

Switch statement : Auto

Function call : @aa

Data access : @aa

☐ 2byte pointer

☐ Generate file for inter-module optimization

Options Standard Library :

```
-cpu=2600A:24
-output="$(CONFIGDIR)¥$(PROJECTNAME).lib"
-head=runtime,new,stdio,stdlib
```

Optimization

Check Box	Command Option	Function
√	optimize=1	Specifies optimization
☐	optimize=0	Specifies no optimization

Speed or size: Specifies the optimization format.

Dialog Menu		Command Option	Function
Size oriented optimization		-	Performs optimization in size
Speed oriented optimization		*speed*	Optimization for speed
Speed sub-options	**Register**	*speed=register*	Performs register store/restore expansion by the PUSH and POP instruction at a higher speed
	Switch judgement	*speed=switch*	Develops the switch statement at a higher speed
	Shift to multiple	*speed=shift*	Develops the shift operation at a higher speed
	Struct assignment	*speed=struct*	Performs the expansion of structures and substitution expression at a higher speed
	Expression	*speed=expression*	Performs arithmetic operation, comparison, and substitution expression processing at a higher speed
	Loop optimization	*speed=loop1*	Deletion of induction variables
	Loop unrolling	*speed=loop2*	Deletion of induction variables and loop expansion
	Inline function Maximum:node (s)	*speed=inline [=<data>]*	Automatic inline expansion

Generate file for inter-module optimization

Check Box	Command Option	Function
☑	*goptimize*	Outputs inter-module optimization add-on information
☐	-	Outputs no inter-module optimization add-on information

Switch statement: Specifies the switch statement expansion method.

Dialog Menu	Command Option	Function
Auto	*case=auto*	Determines switch statement expansion method depending on the speed option specification
If then	*case=ifthen*	Performs switch statement expansion in if_then method
Table	*case=table*	Performs switch statement expansion in table jump method

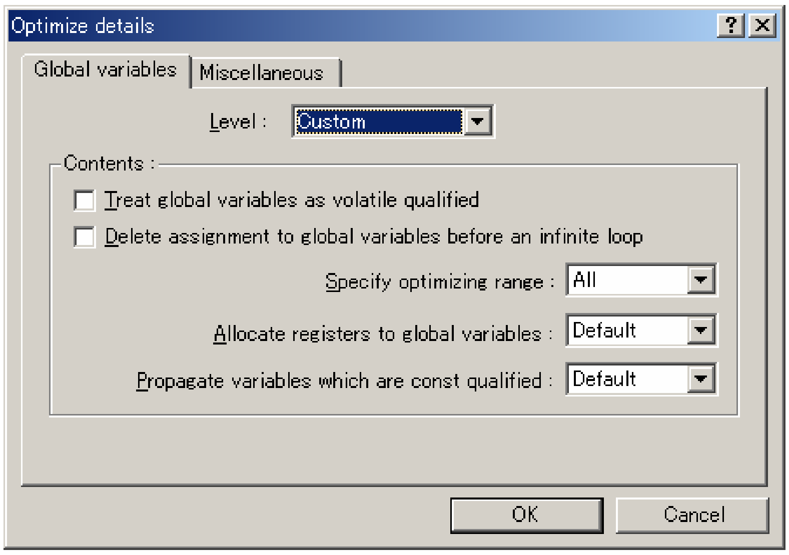
Function call: Selects the function call method.

Dialog Menu	Command Option	Function
@aa	-	Selects normal function call
@@aa:8	*idirect=normal*	Selects memory indirect function call
@@vec:7	*idirect=extended*	Selects extended memory indirect function call

Data access: Selects data access mode.

Dialog Menu	Command Option	Function
@aa	-	Selects normal data access
@aa:8	*abs8*	Selects 8-bit absolute address access
@aa:16	*abs16*	Selects 16-bit absolute address access

(a) **[Details] Button:** [Global variables] Tab


Optimize details

Global variables | Miscellaneous

Level : Custom

Contents :

☐ Treat global variables as volatile qualified

☐ Delete assignment to global variables before an infinite loop

Specify optimizing range : All

Allocate registers to global variables : Default

Propagate variables which are const qualified : Default

OK | Cancel

Level: Specifies the level of external variable optimization

Dialog Menu	Command Option	Function
Level 1		Disables all of the external variable optimization.
	volatile	[Treat global …] = [Checked]
	infinite_loop=0	[Delete assignment …] = [Not checked]
	opt_range=noblock	[Specify optimizing …] = [No block]
	global_alloc=0	[Allocate registers …] = [Disable]
	const_var_propagate=0	[Propagate variables …] = [Disable]
Level 2		Optimizes external variables that do not have a volatile specifier. Disables optimization of external variables which extend across loops or branches.
	novolatile	[Treat global …] = [Not checked]
	infinite_loop=0	[Delete assignment …] = [Not checked]
	opt_range=noblock	[Specify optimizing …] = [No block]
	global_alloc=0	[Allocate registers …] = [Disable]
	const_var_propagate=0	[Propagate variables …] = [Disable]
Level 3		Optimizes external variables that do not have a volatile specifier within the entire function.
	novolatile	[Treat global …] = [Not checked]
	infinite_loop=0	[Delete assignment …] = [Not checked]
	opt_range=all	[Specify optimizing …] = [All]
	global_alloc=1	[Allocate registers …] = [Enable]
	const_var_propagate=1	[Propagate variables …] = [Enable]
Custom	-	Optimizes external variables according to the options specified by user

Treat global variables as volatile qualified

Check Box	Command Option	Function
☑	*volatile*	Disables external variable optimization.
☐	*novolatile*	Optimizes external variables that do not have a volatile specifier.

Delete assignment to global variables before an infinite loop

Check Box	Command Option	Function
☑	*infinite_loop=1*	Eliminates an assignment expression that is located immediately before an infinite loop and that is an assignment to the external variable that is not used in the infinite loop.
☐	*infinite_loop=0*	Disables elimination of an assignment expression for external variables preceding an infinite loop.

Specify optimizing range

Dialog Menu	Command Option	Function
All	*opt_range=all*	Optimizes external variables within the entire function.
No loop	*opt_range=noloop*	External variables in a loop and external variables used in a loop iteration condition are not to be optimized.
No block	*opt_range=noblock*	External variables extending across branches (including loops) are not to be optimized.

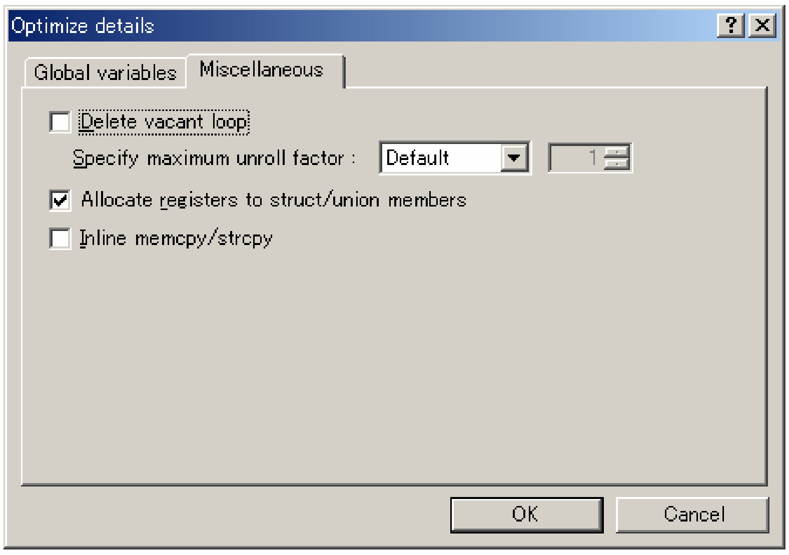
Allocate registers to global variables

Dialog Menu	Command Option	Function
Disable	*global_alloc=0*	Disables allocation of external variables to registers.
Enable	*global_alloc=1*	Allocates external variables to registers.
Default	*global_alloc=1*	Allocates external variables to registers.

Propagate variables which are const qualified

Dialog Menu	Command Option	Function
Disable	*const_var_propagate=0*	Disables constant propagation of external constants declared by **const**.
Enable	*const_var_propagate=1*	Performs constant propagation of external constants declared by **const**.
Default	*const_var_propagate=1*	Performs constant propagation of external constants declared by **const**.

(b) **[Details] Button:** [Miscellaneous] Tab



☐ Delete vacant loop
Specify maximum unroll factor : Default 1
☑ Allocate registers to struct/union members
☐ Inline memcpy/strcpy

Delete vacant loop

Check Box	Command Option	Function
√	*del_vacant_loop=1*	Eliminates the loop without statements inside.
☐	*del_vacant_loop=0*	Disables elimination of vacant loops, even when there is no statements inside the loop.

Specify maximum unroll factor

Dialog Menu	Command Option	Function
Default	*max_unroll=2 or 1*	2 or 1 is assumed as the maximum number of loops to be expanded.
Custom	*max_unroll=* *< numeric value >*	Specifies the maximum number of loops to be expanded. An integer from 1 to 32 can be specified for <numeric value>.

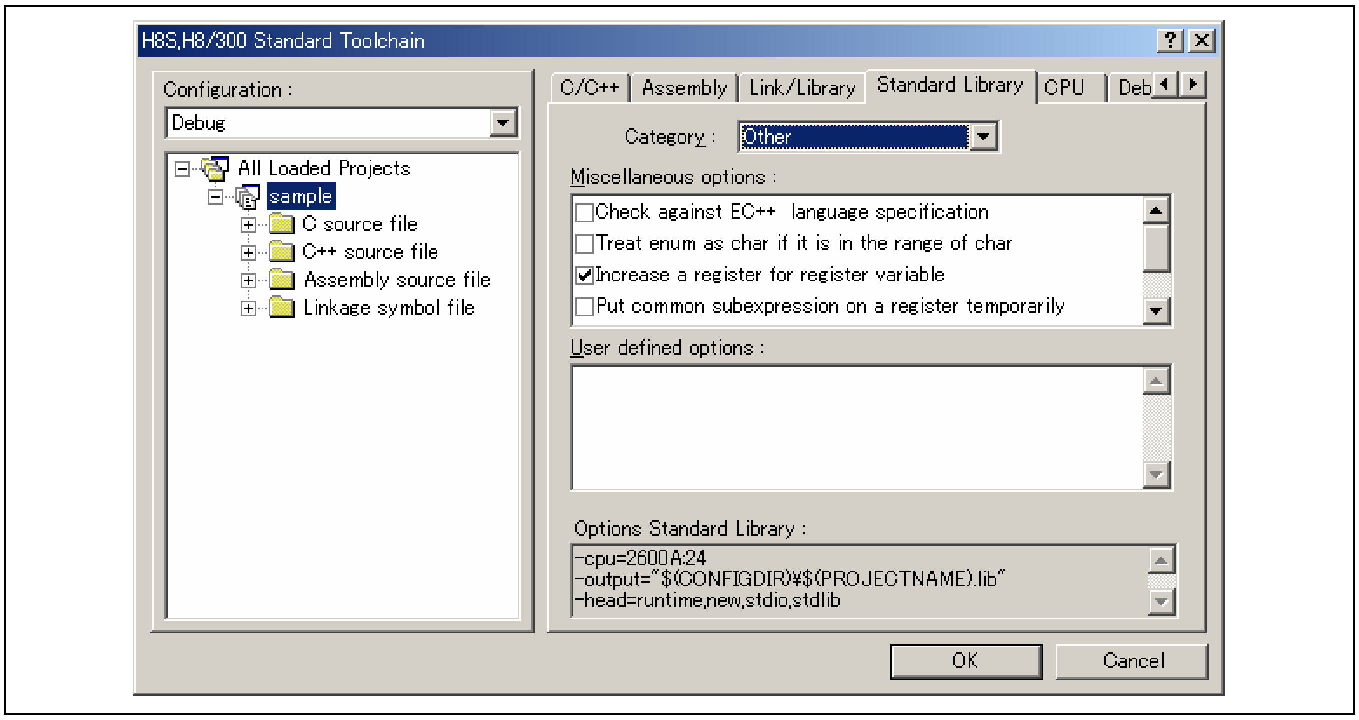
Allocate registers to struct/union members

Check Box	Command Option	Function
√	*struct_alloc=1*	Allocates structure/union members to registers.
☐	*struct_alloc=0*	Disables allocation of structure/union members to registers.

Inline memcpy/strcpy

Check Box	Command Option	Function
√	*library=intrinsic*	Performs inline expansion for **memcpy** and **strcpy**.
☐	*library=function*	Makes function calls for **memcpy** and **strcpy**.

(5) **Category:**[Other]



Configuration : Debug

Category : Other

Miscellaneous options :

- ☐ Check against EC++ language specification
- ☐ Treat enum as char if it is in the range of char
- ☑ Increase a register for register variable
- ☐ Put common subexpression on a register temporarily

User defined options :

Options Standard Library :

```
-cpu=2600A:24
-output="$(CONFIGDIR)¥$(PROJECTNAME).lib"
-head=runtime,new,stdio,stdlib
```

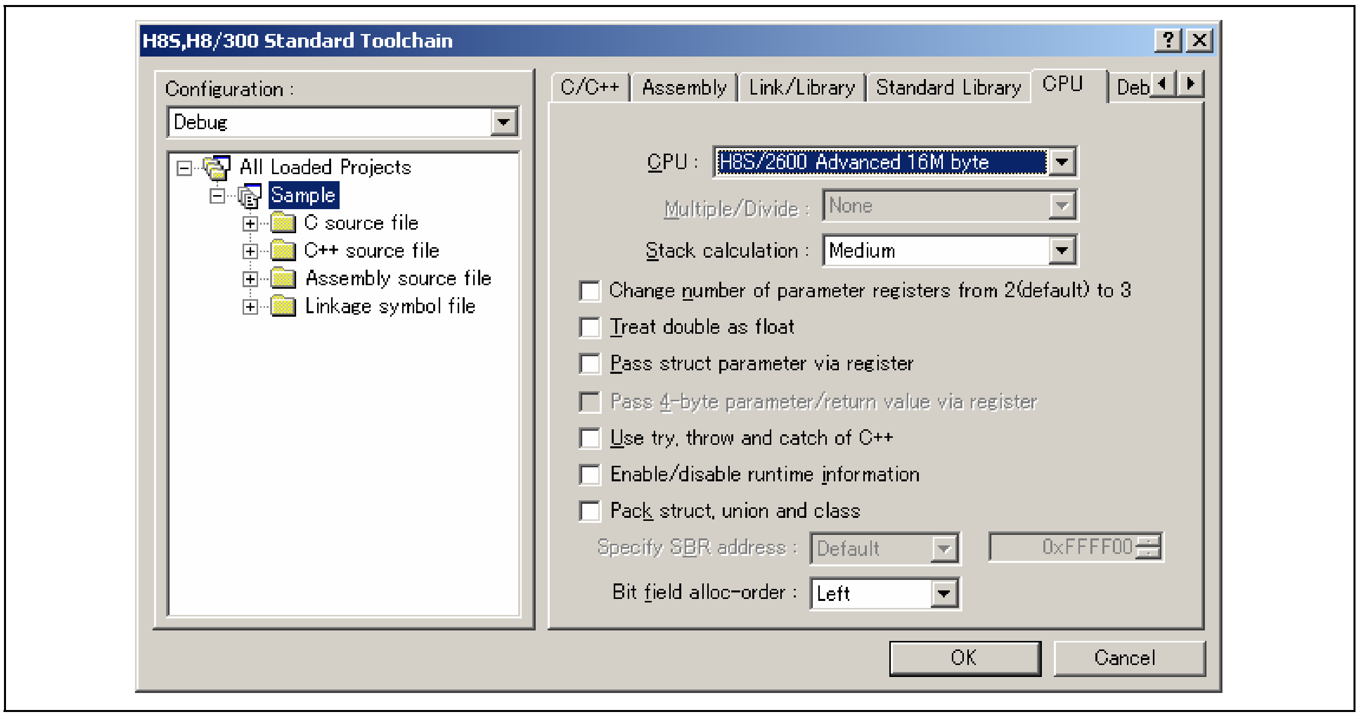
Miscellaneous options:

Dialog Menu	Command Option	Function
Check against EC++ language specification	*ecpp*	Checks syntax according to the EC++ language specifications
Treate loop condition as volatile qualified	*volatile_loop*	Disables optimization of loop iteration condition.
Treat enum as char if it is in the range of char	*byteenum*	Handles enumeration-type data as char
Increase a register for register variable	*Regexpansion* *noregexpansion*	Specifies the number of variable-allocation registers as 2 Specifies the number of variable-allocation registers as 3
Put common subexpression on a register temporarily	*cmncode*	Improves the optimization function for common expression deletion
Use EEPMOV in block copy	*eepmov*	Performs structure substitution using the EEPMOV instruction
Treats loop condition as volatile qualified	*volatile_loop*	Disables optimization of loop iteration.
Enable register declaration	*enable_register*	Preferentially allocates the variables with register storage class specification to registers.
Obey ANSI specifications more strictly	*strict_ansi*	Conforms to the ANSI standard for the following processing. - Associative rule of floating-point operations

User defined options: Specifies the command options.

4.2.5 CPU Options

Select CPU Tab from the H8S, H8/300 Standard Toolchain dialog box.



H8S,H8/300 Standard Toolchain

Configuration : Debug

All Loaded Projects
Sample
C source file
C++ source file
Assembly source file
Linkage symbol file

C/C++ | Assembly | Link/Library | Standard Library | CPU | Deb

CPU : H8S/2600 Advanced 16M byte

Multiple/Divide : None

Stack calculation : Medium

☐ Change number of parameter registers from 2(default) to 3

☐ Treat double as float

☐ Pass struct parameter via register

☐ Pass 4-byte parameter/return value via register

☐ Use try, throw and catch of C++

☐ Enable/disable runtime information

☐ Pack struct, union and class

Specify SBR address : Default   0xFFFF00

Bit field alloc-order : Left

OK   Cancel

CPU: Specifies the CPU types.

CPU	Specification
Environment variable	Depends on environment variable H38CPU
H8SX Maximum 4G byte	*cpu=h8sxx:32*
H8SX Maximum 256M byte	*cpu=h8sxx:28*
H8SX Advanced 4G byte	*cpu=h8sxa:32*
H8SX Advanced 256M byte	*cpu=h8sxa:28*
H8SX Advanced 16M byte	*cpu=h8sxa:24*
H8SX Advanced 1M byte	*cpu=h8sxa:20*
H8SX Middle 16M byte	*cpu=h8sxm:24*
H8SX Middle 1M byte	*cpu=h8sxm:20*
H8SX Normal	*cpu=h8sxn*
H8S/2600 Advanced 4G byte	*cpu=2600A:32*
H8S/2600 Advanced 256M byte	*cpu=2600A:28*
H8S/2600 Advanced 16M byte	*cpu=2600A:24*
H8S/2600 Advanced 1M byte	*cpu=2600A:20*
H8S/2600 Normal	*cpu=2600N*
H8S/2000 Advanced 4G byte	*cpu=2000A:32*
H8S/2000 Advanced 256M byte	*cpu=2000A:28*
H8S/2000 Advanced 16M byte	*cpu=2000A:24*

CPU	Specification
H8S/2000 Advanced 1M byte	*cpu=2000A:20*
H8S/2000 Normal	*cpu=2000N*
H8/300H Advanced 16M byte	*cpu=300HA:24*
H8/300H Advanced 1M byte	*cpu=300HA:20*
H8/300H Normal	*cpu=300HN*
H8/300	*cpu=300*
H8/300L	*cpu=300l*

Multiple/Divide :

Dialog Menu	Command Option	Function
None	*cpu=[...][][]*	no multiplier and divider
Multiple and Divide	*cpu=[...][][MD]*	multiplier and divider specification
Multiple	*cpu=[...][][M]*	multiplier specification
Divide	*cpu=[...][][D]*	divider specification

Stack calculation:

Dialog Menu	Command Option	Function
Small	*STAck=Small*	Calculates stack address by 1 byte
Medium	*STAck=Medium*	Calculates stack address by 2 bytes
Large	*STAck=Large*	Calculates stack address by 4 bytes

Change number of parameter-passing registers from 2 (default) to 3

Check Box	Command Option	Function
☑	*regparam=3*	Specifies the number of parameter-passing registers as 3
☐	*regparam=2*	Specifies the number of parameter-passing registers as 2

Treat double as float

Check Box	Command Option	Function
☑	*DOuble=Float*	Treats double type of variable/value as float type
☐	-	-

Pass struct parameter via register

Check Box	Command Option	Function
☑	*STRUctreg*	Allocates structure parameter to register
☐	*NOSTRUctreg*	Allocates no structure parameter to register

Pass 4-byte parameter/return value via register

Check Box	Command Option	Function
☑	*LONgreg*	Allocates 4 bytes parameter/return value to register
☐	*NOLONgreg*	Allocates no 4 bytes parameter/return value to register

Use try,throw and catch of C++

Check Box	Command Option	Function
☑	*EXception*	Enables an exception processing function
☐	*NOEXception-*	Disables an exception processing function

Enable/disable runtime information

Check Box	Command Option	Function
☑	*RTti=ON*	Enables dynamic_cast, typeid
☐	*RTti=OFF*	Disables dynamic_cast, typeid

Pack struct union and class

Check Box	Command Option	Function
☑	PAck=1	Specifies the boundary alignment of structures, unions, and classes to 1
☐	PAck=2	Follows the boundary alignment number of data

Specify SBR address :

Dialog Menu	Command Option	Function
Default	-	The default 8-bit absolute address is assumed
Custom	*sbr=<address>*	Specifies the start address of the 8-bit absolute area

Bit field allocation order

Dialog Menu	Command Option	Function
Left	*bit_order=left*	Stores members from upper bit
Right	*bit_order=right*	Stores members from lower bit

4.3 Building Existing Files with HEW

This section explains how to register as an HEW project files a series of load module creation procedures that has already been prepared without using the HIM.

In HEW1.2, sample programs are supplied in the HEW directory \Tools\HITACHI\H8\3_0a_0\sample.

No.	HEW1.2 File	Description
1	init.c	Initialization routine
2	vectbl.c	Vector table settings
3	scttbl.c	Section initialization routine
4	cmain.c	Main function file
5	c2600a.sub	Subcommand file for inter-module optimizer

Sample programs are not available with HEW2.0 or later. Therefore the sample programs of user's own make should be prepared or the following files to be generated when creating sample project should be used as sample programs.

Create a sample project by selecting **Demonstration** as the project type setting according to section 2.1.2, Creating a New Workspace 2(HEW2.0 or later).

No.	HEW2.0 or later File	Description
1	resetprg.c	Initialization routine
2	intprg.c	Vector table settings
3	dbsct.c	Section initialization routine
4	main.c	Main function file
5	2600a.sub(user's own make)	Subcommand file

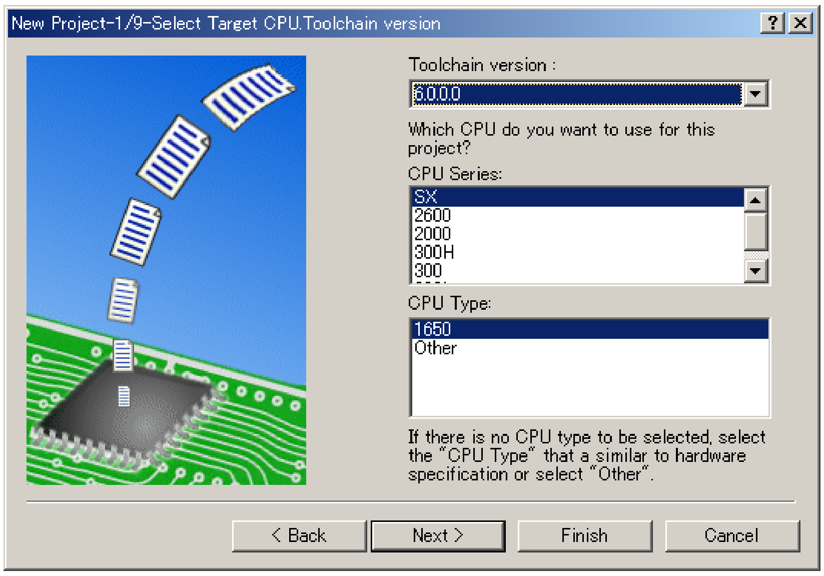
(1) Creating a new project

Create a new project according to section 2.1.1, Creating a New Workspace.

Select Empty Application as a project type.

(2) Selecting the CPU

Select the CPU type on the 1/9 screen.



Toolchain version : 6.0.0.0

Which CPU do you want to use for this project?

CPU Series: SX, 2600, 2000, 300H, 300

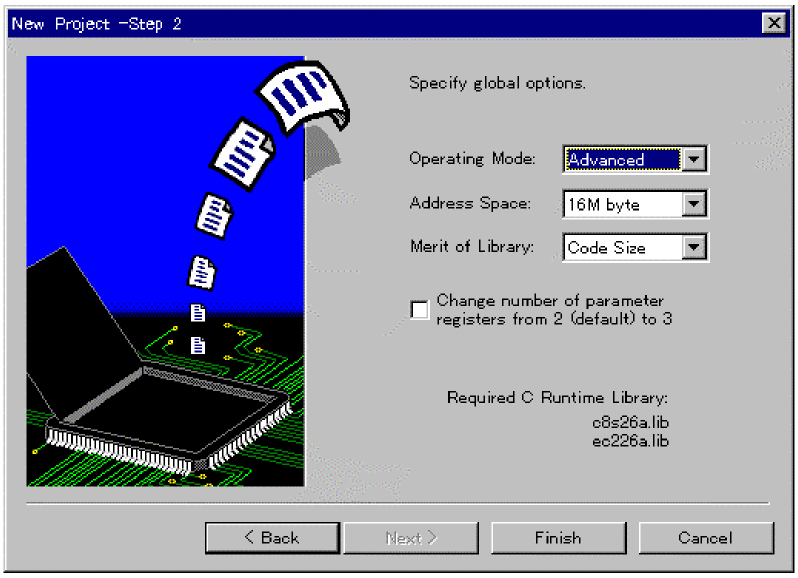
CPU Type: 1650, Other

If there is no CPU type to be selected, select the "CPU Type" that a similar to hardware specification or select "Other".

(3) Selecting global options

Select global options on the 2/9 screen.

<HEW1.2>



Specify global options.

Operating Mode: Advanced

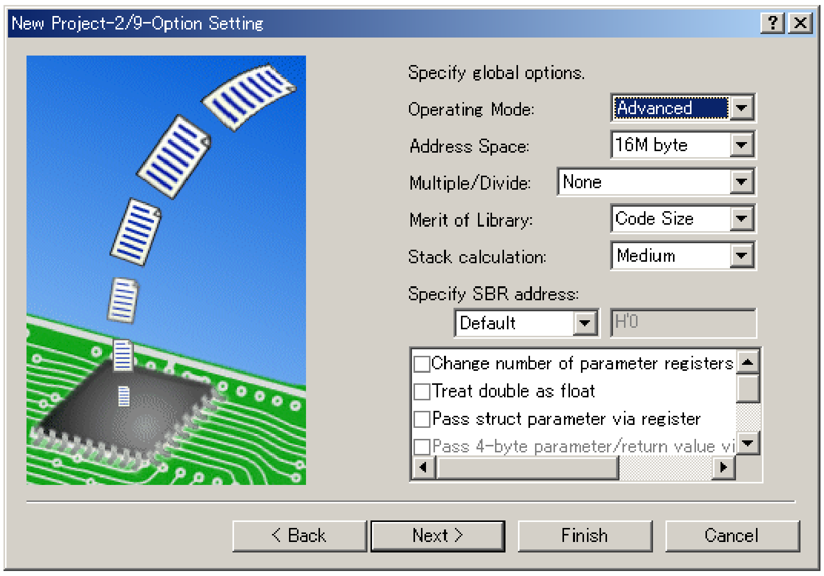
Address Space: 16M byte

Merit of Library: Code Size

☐ Change number of parameter registers from 2 (default) to 3

Required C Runtime Library:
c8s26a.lib
ec226a.lib

<HEW2.0 or later>



Specify global options.

Operating Mode: Advanced

Address Space: 16M byte

Multiple/Divide: None

Merit of Library: Code Size

Stack calculation: Medium

Specify SBR address:
Default H'0

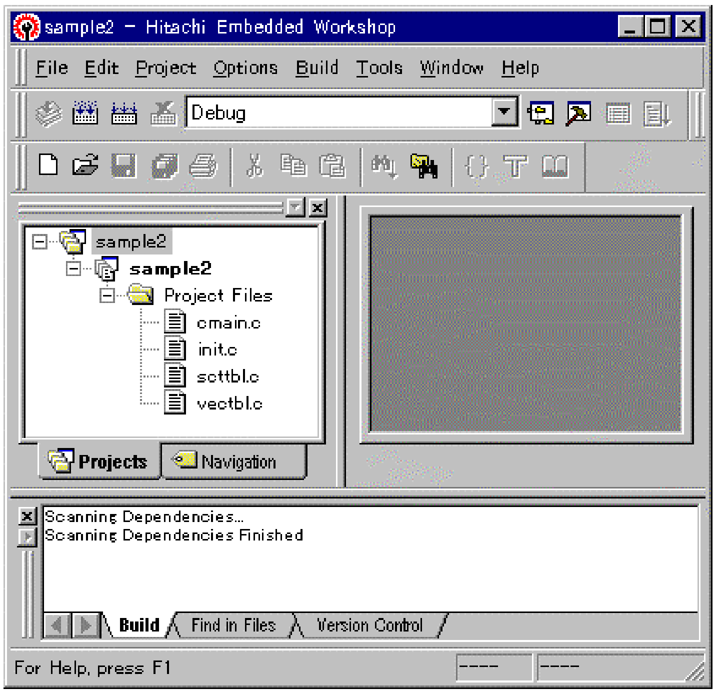
☐Change number of parameter registers
☐Treat double as float
☐Pass struct parameter via register
☐Pass 4-byte parameter/return value vi

For details on changing the global options after initialization, refer to section 11.2.1, Output of “Undefined External Symbol”.

(4) Adding files to the project

In the next step, use [Project → Add Files…] to specify the C source files to be added to the project.

Add the files init.c, vectbl.c, scttbl.c, and cmain.c for HEW1.2 and resetprg.c, intprg.c, dbsct.c, and main.c for HEW2.0.



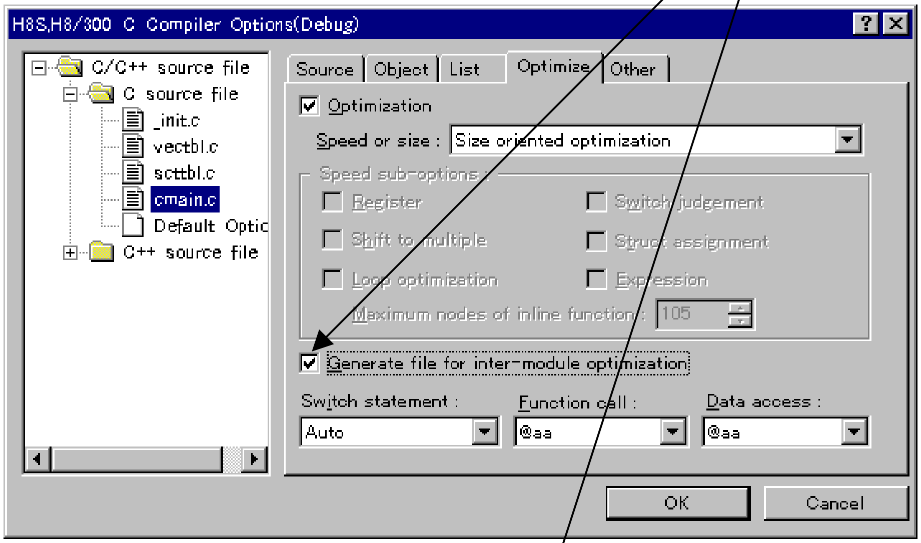
Scanning Dependencies...
Scanning Dependencies Finished

(5) Selecting compiler options

Use [Options->H8S,H8/300 C/C++ Compiler…] for HEW1.2 and [C/C++ Tab] [Category/Optimize] for HEW2.0 or later to specify compiler options.

In this step, specify the output of an Inter-Module Optimization add-on information tool here.

<HEW1.2>



☑ Optimization

Speed or size : Size oriented optimization

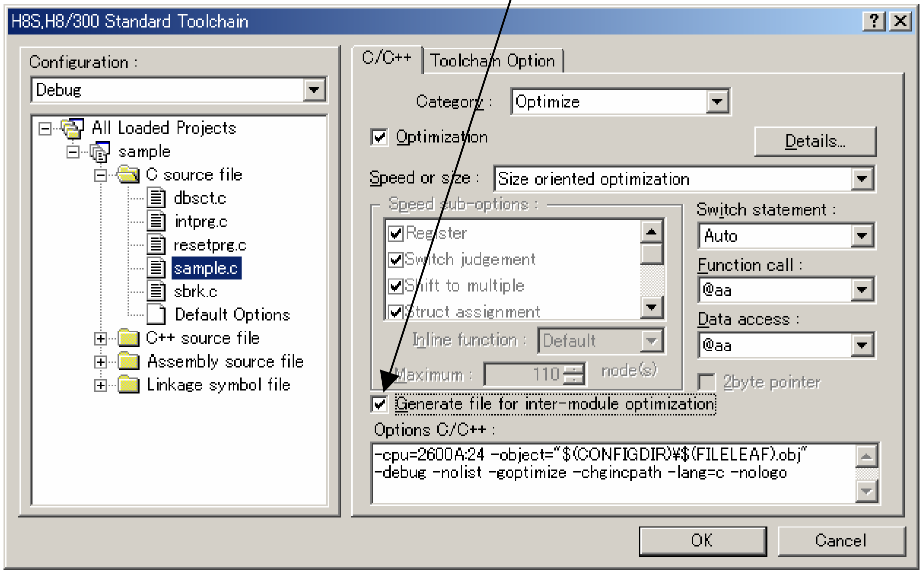
☑ Generate file for inter-module optimization

Switch statement : Auto

Function call : @aa

Data access : @aa

<HEW2.0 or later>



Category : Optimize

☑ Optimization

Speed or size : Size oriented optimization

Switch statement : Auto

Function call : @aa

Data access : @aa

☑ Generate file for inter-module optimization

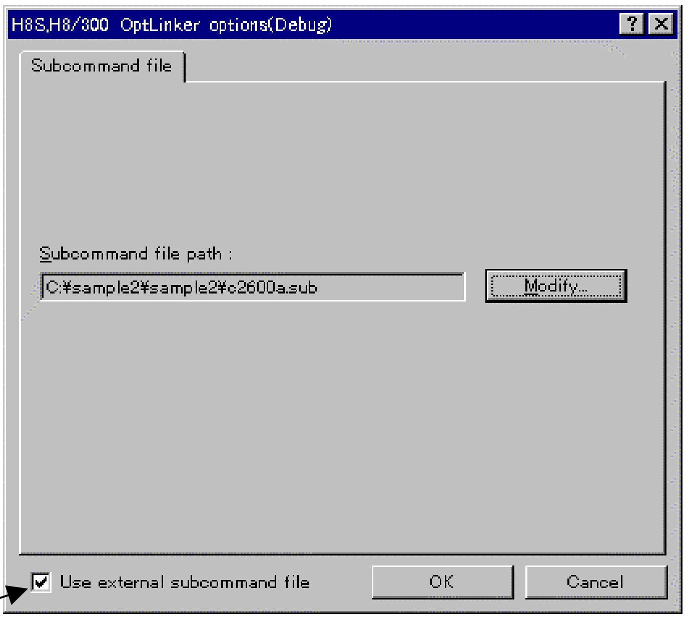
Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -nolist -goptimize -chgincpath -lang=c -nologo
```

(6) Specifying a subcommand file for the inter-module optimizer

Use [Options->H8S,H8/300 IM OptLinker…] for HEW1.2 and [Link/Library Tab] [Category/Subcommand file] for HEW2.0 or later to invoke an HEW option dialog box for the specification of a subcommand file for the inter-module optimizer.

<HEW1.2>


H8S,H8/300 OptLinker options(Debug)

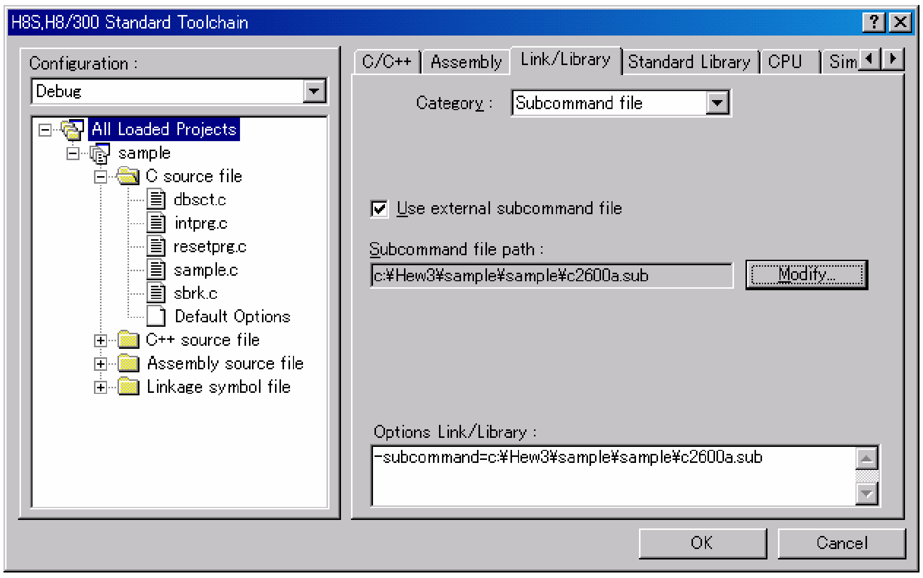
Subcommand file

Subcommand file path : C:¥sample2¥sample2¥c2600a.sub

[✓] Use external subcommand file

Check here to display a Subcommand file tab.

<HEW2.0 or later>


H8S,H8/300 Standard Toolchain

Configuration : Debug

All Loaded Projects
sample
C source file
dbsct.c
intprg.c
resetprg.c
sample.c
sbrk.c
Default Options
C++ source file
Assembly source file
Linkage symbol file

Category : Subcommand file

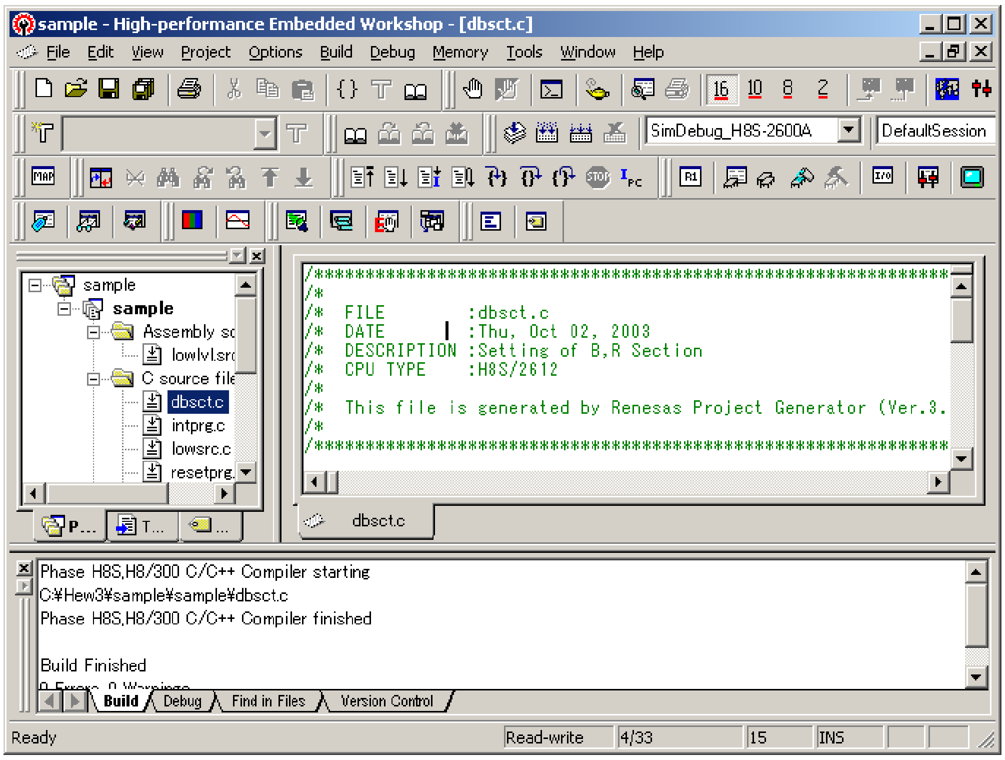
[✓] Use external subcommand file

Subcommand file path : c:¥Hew3¥sample¥sample¥c2600a.sub

Options Link/Library :
-subcommand=c:¥Hew3¥sample¥sample¥c2600a.sub

(7) Executing the building process

Executing the building process generates the load module.



```
/*********************************************************************
/*
/*  FILE        :dbsct.c
/*  DATE        :Thu, Oct 02, 2003
/*  DESCRIPTION :Setting of B,R Section
/*  CPU TYPE    :H8S/2612
/*
/*  This file is generated by Renesas Project Generator (Ver.3.
/*
/*********************************************************************
```

```
Phase H8S,H8/300 C/C++ Compiler starting
C:¥Hew3¥sample¥dbsct.c
Phase H8S,H8/300 C/C++ Compiler finished

Build Finished
0 Errors, 0 Warnings
```

Note: An error may occur if the user uses the subcommand file for the inter-module optimizer supplied as a sample of this product.

This is because the standard library has not been specified and the CPU information check file has not been defined in an appropriate directory.

To avoid this error, copy the subcommand file and CPU information check file and specify the standard library.

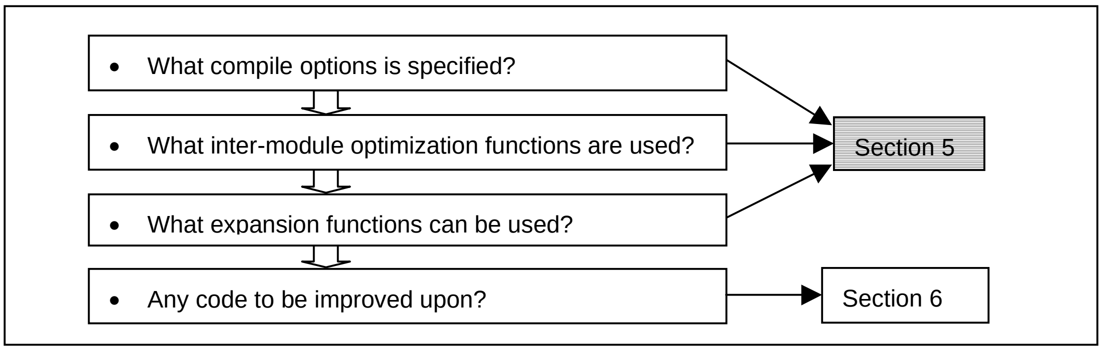
Section 5 Using the Optimization Functions

Once an operating load module has been prepared, the performance of the object program need to be improved to make the load module be more efficient and effective.

There are four approaches to improve the performance of an object program:

(i) Performs optimization by using various options.
(ii) Performs optimization by using the inter-module optimizer.
(iii)Performs optimization by using expansion functions.
(iv)Performs efficient programming by modifying codes.

Use the procedure below:


What compile options is specified?
What inter-module optimization functions are used?
What expansion functions can be used?
Any code to be improved upon?
Section 5
Section 6

This section explains the options to be specified at creating a load module, the expansion functions to be used, and the options of the inter-module optimizer to be used.

The following table lists the optimization functions supported by the compiler:

No.	Optimization Function	Specification Mode	Size	Speed
1	Uses the 1-byte enum type	Option	O	O
2	Extended interpretation of multiplication/division specifications	Option	O	O
3	Specifies the number of parameter-passing registers	Option	Δ	Δ
4	Increases the number of variable-allocation registers	Option	Δ	Δ
5	Optimization of external variables	Option	-	-
6	Block transfer instruction	Option	X	O
7	SPEED option	Option	X	O
8	Allocates global variables to registers	Expansion function	Δ	Δ
9	Controls the output of register save/restore codes at function entry and exit points	Expansion function	O	O
10	Specifies the inline expansion of a function	Expansion function	X	O
11	Inline expansion of an assembly language function	Expansion function	X	O
12	Uses 8-bit absolute address areas	Option/expansion function	O	O
13	Uses 16-bit absolute address areas	Option/expansion function	O	O
14	Allocates to a memory indirect area	Option/expansion function	O	X

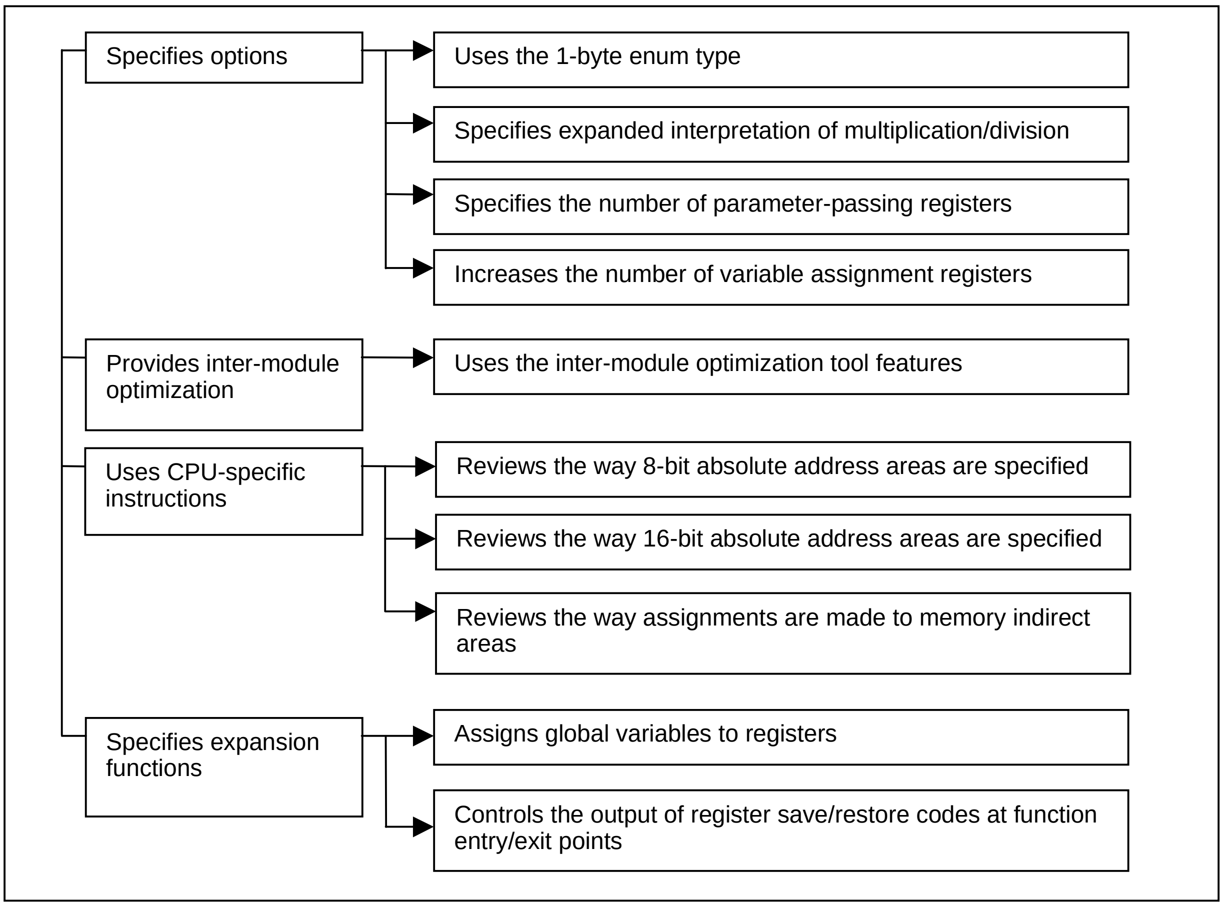
Legend:
O: effective; Δ: effective for some programs; X: reduces efficiency

The following table lists the optimization functions supported by the inter-module optimization tool:

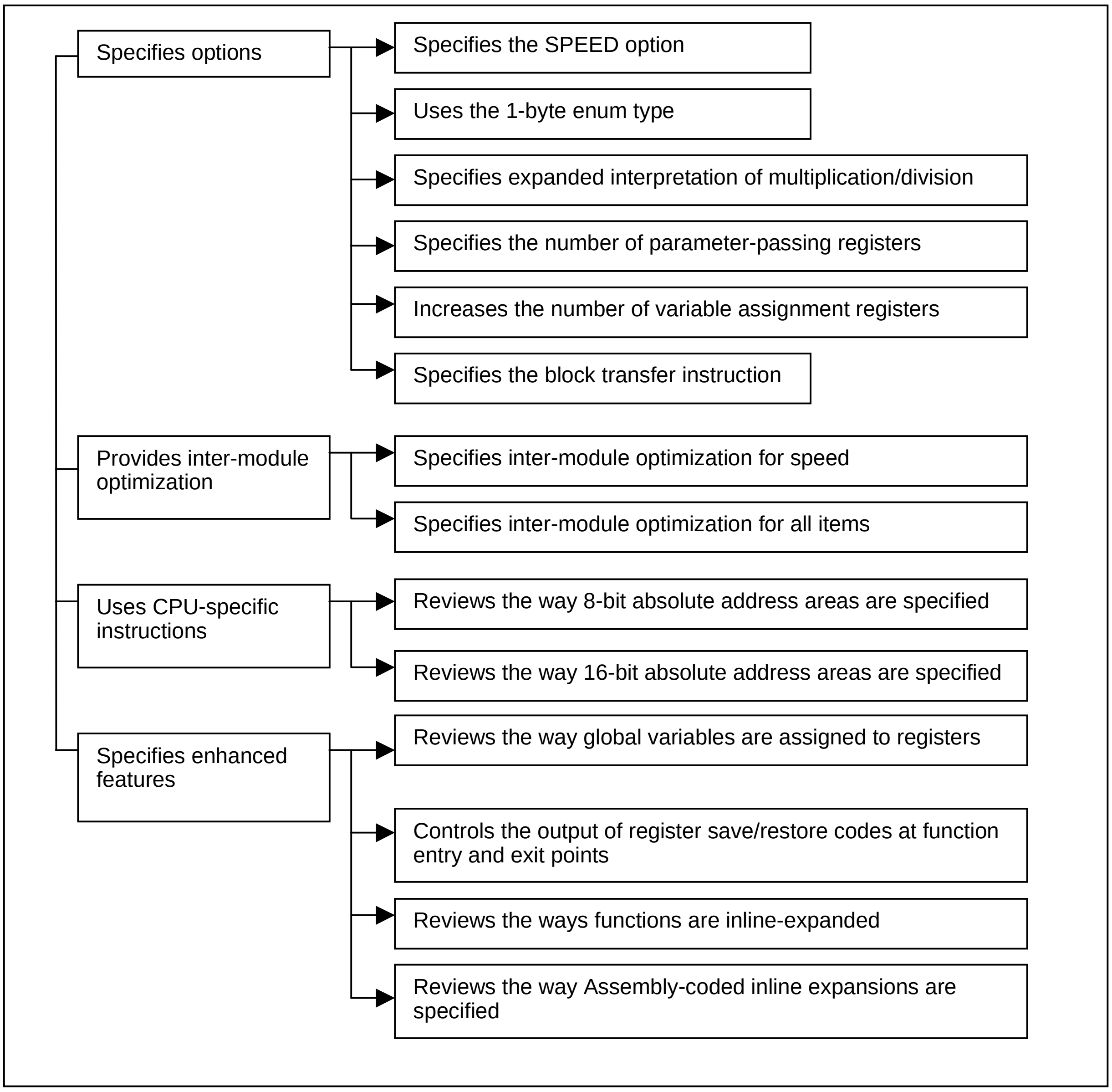
No.	Description	Specification Mode
1	Unifies constants and character strings	Option
2	Deletes unreferenced variables and functions	Option
3	Optimizes access to variables	Option
4	Optimizes access to functions	Option
5	Re-allocates registers	Option
6	Eliminates same codes	Option
7	Optimizes branch instructions	Option

This section describes these optimization functions, dividing them into two groups, the optimization for size and that for speed. The specification of each function is examined according to the following flowchart:

<Specification procedure at optimization for size>


Specifies options
Uses the 1-byte enum type
Specifies expanded interpretation of multiplication/division
Specifies the number of parameter-passing registers
Increases the number of variable assignment registers
Provides inter-module optimization
Uses the inter-module optimization tool features
Uses CPU-specific instructions
Reviews the way 8-bit absolute address areas are specified
Reviews the way 16-bit absolute address areas are specified
Reviews the way assignments are made to memory indirect areas
Specifies expansion functions
Assigns global variables to registers
Controls the output of register save/restore codes at function entry/exit points

<Specification procedure at optimization for speed>


Specifies options
Specifies the SPEED option
Uses the 1-byte enum type
Specifies expanded interpretation of multiplication/division
Specifies the number of parameter-passing registers
Increases the number of variable assignment registers
Specifies the block transfer instruction
Provides inter-module optimization
Specifies inter-module optimization for speed
Specifies inter-module optimization for all items
Uses CPU-specific instructions
Reviews the way 8-bit absolute address areas are specified
Reviews the way 16-bit absolute address areas are specified
Specifies enhanced features
Reviews the way global variables are assigned to registers
Controls the output of register save/restore codes at function entry and exit points
Reviews the ways functions are inline-expanded
Reviews the way Assembly-coded inline expansions are specified

5.1 Optimization for Size

In this section, a common benchmark program, Dhrystone Ver.2.1 is used as a sample program.

The data of size and speed given below reflect the results of a compilation in the H8S/2600 advanced mode.

5.1.1 Default Compilation

First, compile a program without any optimization option.

The following table shows the results of the object size and the execution cycle count:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580

Even if no optimization option is specified, the compiler performs basic optimization tasks because several optimization options are enabled by default.

5.1.2 Without Optimization Specification

When the optimization is not specified, the results are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
No optimization	3582	1713

[Specification method]

Dialog menu: **C/C++**Tab **Category: [Optimize]**, turn off the **Optimization** checkbox.

Command line: *optimize=0*

5.1.3 Optimization Tuning

(1) Specifying the 1-byte enum type

This option is valid only for a program containing enum-type data, however, we recommend to always specify it.

The object size and execution cycle count are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
1-byte enum-type specification	3050	1580

[Specification method]

Dialog menu: **C/C++**Tab **Category: [Other]**, select **Treat enum as char if it is in the range of char** for **Miscellaneous options**

Command line: *byteenum*

For further details, refer to section 5.4.1, Using 1-Byte enum Type.

(2) Specifying the number of parameter-passing registers

Increase the number of parameter-passing registers from 2 to 3, which results in the following performance characteristics:

Optimization Function	Size (ROM)	No. of Execution Cycles
2 parameter-passing registers	3048	1580
3 parameter-passing registers	3034	1528

[Specification method]

Dialog menu: On **CPU** tab, select **Change number of parameter registers from 2 (default) to 3**

Command line: *regparam=3*

These performance characteristics are related to the number of function parameters in the program. Choose between the 2 and 3 options by determining the number of parameters that are allocated to registers, the number of available registers, and the types of available registers.

If it is not possible to check all parameters, try different options and select the one that produces the smallest object size.

When combined with the specification of the 1-byte enum type, this item results in the following performance characteristics:

Optimization Function	Size (ROM)	No. of Execution Cycles
Default	3048	1580
1-byte enum type +3 parameter-passing registers	3034	1527

For further details, refer to section 5.4.3, Specifying the Number of Parameter-Passing Registers.

(3) Expanding the number of variable-allocation registers

By default, the compiler uses registers [E]R3 to [E]R6 as variable-allocation registers.

When this option is disabled, the compiler uses registers [E]R4 to [E]R6 as variable-allocation registers.

The following lists the performance characteristics of these two specifications:

Optimization Function	Size (ROM)	No. of Execution Cycles
Register variables [E]R3 to [E]R6	3048	1580
Register variables [E]R4 to [E]R6	3048	1580

[Specification method]

Dialog menu: **C/C++**Tab **Category: [Other]**, select **Increase a register for register variable** for **Miscellaneous option**

Command line: *regexpansion*

In this program, there is no difference. However, unless an expression statement is too complicated, the greater is the number of variable-allocation registers, the higher is the performance of the compiler in terms of object size.
In H8S V6.01, this option is not supported, so there is no difference in the performance.

For further details, refer to section 5.4.4, Increasing the Number of Variable-Allocation Registers.

(4) Optimization of external variables

The following table compares the results where the optimization of external variables is specified or disabled:

Optimization Function	Size (ROM)	No. of Execution Cycles
External variable optimization enabled (novolatile)	3048	1580
External variable optimization disabled (volatile)	3076	1592

[Specification method]

Dialog menu: **C/C++**Tab **Category: [Optimize]**, **[Details...][Global variables] [Treat global variables as volatile qualified]**

Command line: *volatile*

Note that some external variables should not be optimized:

(Example 1)

```
int a;
void f()
{
    a=1;
    a=2;
}
```

←First substitute is deleted

(Example 2)

```
volatile int a;
void f()
{
    a=1;
    a=2;
}
```

In Example 1, two substitutes are made consecutively to the variable *a*, which results in the deletion of the first substitute statement due to optimization. However, if an interrupt occurs between the two substitute statements and the value of *a* is referenced, the result will be in error.

When the *volatile* is specified, optimization is disabled and the code for the first substitute statement is generated, which avoids this problem. However, this approach disables the optimization of all external variables, which significantly reduces object performance.

To disable the optimization only for the appropriate external variables, specify a *volatile* declaration, in the source program, on the variables and I/O registers that are used in interrupt functions, as shown in Example 2. In this way, compile the program by turning off this option.

For further details, refer to section 5.4.5, Optimization of External Variables.

(5) Extended interpretation of multiplication/division specifications

An expanded interpretation of multiplication/division code expansion from the ANSI standard results in the following performance characteristics:

Optimization Function	Size (ROM)	No. of Execution Cycles
ANSI compliant	3048	1580
Extended interpretation	3048	1580

[Specification method]

Dialog menu: **C/C++**Tab **Category: [Object]**, select **Non ANSI(Guarantee 32bit as a result of 16bit*16bit)** for **Mul/Div operation specification**.

Command line: *cpuexpand*

In this program, the extended interpretation did not produce any significant performance difference.

However, an extended interpretation of the multiplication/division code can produce different computational results because the range of extended interpretation differs from that guaranteed in the language specifications. Therefore, the extended interpretation should be used only when it is deemed appropriate.

For further details, refer to section 5.4.2, Extended Interpretation of the Multiplication/Division Specifications.

5.1.4 Using the Inter-Module Optimization Features

By using the inter-module optimizer, a size-efficient object can be created more effectively.

Before specifying optimization with the inter-module optimizer, specify the output of an inter-module optimization add-on information file in either the compiler or cross assembler.

[Specification method]

C/C++ Compiler
Dialog menu: **C/C++**Tab **Category: [Optimize]**, select **Generate file for inter-module optimization**

Command line: *goptimize*

Cross Assembler
Dialog menu: **Assembly** Tab **Category: [Object]**, select **Generate file for inter-module optimization**

Command line: *goptimize*

In HEW1.2, an inter-module optimization add-on information file is also supplied for the standard library that is linked during inter-module optimization. As this file is supplied in the compressed form in the Windows version, decompress it before using.

By double-clicking on the compressed file (*.exe) that has the same name as the library name to be used; the file is self-extracted and a directory containing the information file is created.

For details on the inter-module optimization of this library, refer to the Supplement to the H8S, H8/300 Series C/C++ compiler.

In HEW2.0 or later, the inter-module optimization features of Standard Library Generator should be used to create the library. By checking **Standard Library** Tab **Category:[Optimize] Generate file for inter-module optimization**, an inter-module optimization add-on information file is output.

(1) Default optimization

The inter-module optimizer supports the following optimization functions:

No.	Description	Dialog Menu	Subcommand Option
1	Unifies constants/strings	Unify strings	String_Unify
2	Deletes unreferenced variables/functions	Eliminate same code	Symbol_delete
3	Optimizes access to variables	Use short addressing	Variable_access
4	Optimizes access to functions	Use indirect call/jump	Funcation_call
5	Reallocates registers	Reallocate registers	Register
6	Eliminates dead code	Eliminate dead code	Same_code
7	Optimizes branch instructions	Optimize branches	Branch

The following shows the most efficient optimization specifications with the compiler:

Optimization Function	Size (ROM)	No. of Execution Cycles
Valid compiler optimization options: 1-byte enum type specification +3 parameter-passing registers	3034	1527

In the inter-module optimizer, no optimization is performed by default if HEW is used and a simply linked module is produced. Therefore, the default produces the same result as the compiler optimization.

(2) Specifying inter-module optimization items

(a) Specify the optimization items for the inter-module optimizer one by one:

Optimization Function	Inter-Module Optimization	Size (ROM)	No. of Execution Cycles
Compiler optimization options specified	-	3034	1527
	Unifies constants/strings	3034	1527
	Deletes unreferenced variables/ functions	3034	1527
	Optimizes access to variables	2970	1513
	Optimizes access to functions	3024	1538
	Reallocates registers	3018	1535
	Eliminates dead code	3034	1527
	Optimizes branch instructions	3034	1527

(b) Enabling all inter-module optimization features

Enable all inter-module optimization features.

Optimization Function	Inter-Module Optimization	Size (ROM)	No. of Execution Cycles
Compiler optimization options specified	-	3034	1527
	Optimizes all	2946	1517

When this function is specified, optimization is performed even to the items which should not be optimized. In this case, specifying the _list option (_mlist option for HEW1.2) outputs all the symbols that have been deleted or relocated by the optimization process. Specify the symbols on which optimization should be disabled in the format of symbol_forbid_xxxx. This specification should be made upon careful consideration of the symbols.

5.1.5 Selecting Expansion Functions

(1) Allocating registers to global variables

By using #pragma global_register to assign external variables to fixed registers, the program size for access to variables can be reduced.

Variables to be allocated to the register is selected as follows:

Selects variables of the size that can be assigned to registers.

↓

Check the number of times each variable is accessed.

This can be checked by specifying the output of an optimization information list in the linkage editor (the inter-module optimizer for HEW1.2).

[Specification method]

Dialog menu: **Link/Library** Tab **Category: [List] Generate list file**
Link/Library Tab **Category: [List] Contents: Show reference**

Subcommand: *list*
show reference

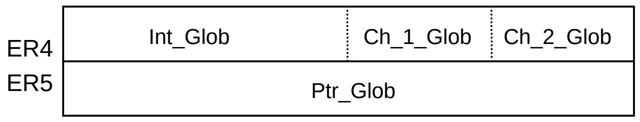
The following file is created as a result:

```
*** Variable Accessible with Abs8 ***

SYMBOL                                SIZE    COUNTS  OPTIMIZE

_Ch_1_Glob
                                         1         4
_Ch_2_Glob
                                         1         2

*** Variable Accessible with Abs16 ***

SYMBOL                                SIZE    COUNTS  OPTIMIZE

_Ptr_Glob
                                         4         4
_Next_Ptr_Glob
                                         4         2
_Int_Glob
                                         2         6
_Bool_Glob
                                         2         2
_Arr_2_Glob
                                      1388         1
_flmod
                                         3         2
_brk
                                         4         2
```

As the global registers are ER4 and ER5, a total of 8 bytes of data can be allocated.

The following is the explanation for the register allocation of the variables Int_Glob and Ptr_Glob which are most frequently accessed. Even when these variables are allocated, the registers can accommodate 2 additional bytes.

Allocate the variables Ch_1_Glob and Ch_2_Glob to the remaining 2 bytes:



Specify as follows:

```
#pragma global_register(Int_Glob=E4,Ch_1_Glob=R4H,Ch_2_Glob=R4L,Ptr_Glob=ER5)
```

The following compares the result with the default:

Optimization function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
#pragma global_register	2940	1512

In the above example, the object size is reduced and the execution speed is improved. However, in some cases, the allocation of external variables to registers may cause a shortage of work registers and other variables may be allocated to memory, which degrades the object performance.

Therefore, be careful at using this function.

The table below shows the results of combining size-efficient compiler options (1-byte enum type and 3 parameter-passing registers specified) with the variable-to-register assignment option.

Optimization Function	Size (ROM)	No. of Execution Cycles
Default	3048	1580
#pragma global_register	3010	1487

For further details, refer to section 5.4.8, Allocating Registers to Global Variables.

Note that global registers cannot be specified when a library is specified as the object of inter-module optimization in the inter-module optimization process. Therefore, this specification is not made in this section.

(2) Controlling the output of register save/restore code at function entry and exit points

The #pragma regsave statement declares the function that saves/restores all registers. It also generates an object that does not allocate guaranteed registers ([E]R2 to [E]R6) beyond function calls.

The #pragma noregsave statement declares the function that does not save/restore any register. This statement is also used as the first function to be started without being called by other functions; it is also used as function that is called by a function specifying #pragma regsave.

To use these features, create a function call relational diagram.

In HEW2.0 or later, the call relationships among the functions can be examined by outputting available stack space information file in creating the relational diagram and reading the information file into the simulator-debugger.

For a description of how to output the available stack space information file, select [Options->H8S, H8/300 Standard Toolchain…->Link/Library Tab] Category:[Other] Stack information output.

In the case of Dhrystone Ver.2.1, the following relationship holds:

```
main:
     malloc:
     strcpy:
     Proc_1:
         Proc_3:
             Proc_7:
         Proc_6:
             Func_3:
         Proc_7:
     Func_2:
         Func_1:
         strcmp:
     Func_1:
     Proc_8:
     Proc_7:
     Proc_6:
         Func_3:
     Proc_5:
     Proc_4:
     Func_2:
```

The function to be declared by #pragma noregsave:

Because main() is the function that performs the first processing, it is not necessary to save/restore any register used before that function. Therefore, this function is declared in the #pragma noregsave statement.

If the main() includes function calls only, all the functions called from main() can be declared in the #pragma noregsave statement.

<inc.h>

```
#pragma noregsave (main)
```

<dhrystone21.c>

```
#include "inc.h"
             :
```

The execution results are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
#pragma noregsave specified	3030	1580

Functions that are declared in the #pragma regsave/noregsave statement:

Check that there is any function, other than the *main* function, that only performs function calls.

Suppose that the interrupt function *intr1* only performs function calls with the following calling relationship:

```
intr1:
    proc1:
        func1:
    proc2:
    proc3:
```

```
Assume that proc1, proc2,
and proc3 are not called by
any other functions.
```

Declare intr1() in the #pragma regsave statement.

Similarly, declare proc1(), proc2(), and proc3() in the #pragma noregsave statement.

In this manner, register save/restore for three functions can be replaced by register save/restore for one function.

The following table shows the execution results when a combination of effective options (1-byte enum type and 3 parameter-passing registers specified) is specified with the inter-module optimization and the #pragma noregsave statement in the previous Dhrystone Ver.2.1 program:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
#pragma noregsave specified Compiler options Inter-module optimization	2944	1517

For further details, refer to section 5.4.9, Controlling Output of Register Save/Restore Codes at the Function Entry/Exit Points.

5.1.6 Using CPU-Specific Instructions

(1) Allocating to a short 8-bit absolute area

The following shows the results when data of the char/unsigned-char type is accessed with 8-bit absolute addresses.

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
8-bit absolute address specified	3014	1566

Note: In this case, when the 8-bit absolute address area is exceeded when a short 8-bit absolute address area assignment is specified as an option, the simulator does not operate correctly due to an insufficient area and the number of execution cycles cannot be measured.

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Optimize]**, select **Data access @aa:8**

Command line: *abs8*

The short 8-bit absolute address area must be allocated within the memory range H'FFFF00 to H'FFFFFF. If this range is exceeded, all sections in the $ABS8 cannot be allocated to the short 8-bit absolute address area.

Therefore, do not specify the abs8 option to the entire file but choose variables to be allocated to the short 8-bit absolute address area.

The criteria are <u>variables that can fit within the area and receives frequent access.</u>

The sizes of variables can be checked with a compiler-output object list, while the number of accesses can be checked with an optimization information list that is produced by the inter-module optimizer.

Specify the use of the short absolute address area with the optimization option of the inter-module optimizer, and examine the resulting optimization information list:

```
*** Variable Accessible with Abs8 ***

SYMBOL                                SIZE    COUNTS  OPTIMIZE

_Ch_1_Glob
                                         1         4
_Ch_2_Glob
                                         1         2
```

This file indicates the number of times variables are referenced.

Based on this information, make an appropriate specification in the #pragma abs8 statement:

```
#pragma abs8 (Ch_1_Glob,Ch_2_Glob)
```

The execution results are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
#pragma abs8 specified	3014	1566

If there are many other variables that can be allocated to the 8-bit absolute address area, check the number of accesses and assign the variables that receive the largest number of accesses.

In addition, specify some options to reduce the object size.

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
#pragma abs8(Char1Glob,Char2Glob) +#pragma noregsave specified +Compiler option +Inter-module optimization	2944	1517

It is clear that the above specifications yield slightly better results.

For further details on abs8, refer to section 5.4.11, Using 8-Bit Absolute Address Area.

(2) Allocating to a short 16-bit absolute address area

Generate codes to perform access with a 16-bit absolute address.

Optimization function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
abs16 option	2988	1558

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Optimize]**, select **Data access @aa:16**

Command line: *abs16*

The 16-bit absolute address area must be allocated in the memory ranges H'000000 to H'007FFF and H'FF8000 to H'FFFFFF.

Initially, specify abs16 as an option, which reveals what variables can be allocated to the ABS16 section. If the variables can fit within the range, they can be specified directly in the option. However, if there is any variable exceeding the range because the 16-bit absolute address overlap with many other areas, specify the #pragma abs16 statement in the main body of the program.

Check the access counts for the symbols with the optimization information list generated by the inter-module optimizer and assign the variables with large numbers of accesses to the ABS16 section.

When the use of the short absolute address mode is specified in the optimization option of the inter-module optimizer, the access counts can be examined as follows:

```
*** Variable Accessible with Abs16 ***

SYMBOL                                SIZE    COUNTS  OPTIMIZE
_Ptr_Glob
                                         4         4
_Next_Ptr_Glob
                                         4         2
_Int_Glob
                                         2         6
_Bool_Glob
                                         2         2
_Arr_2_Glob
                                      1388         1
_flmod
                                         3         2
_brk
                                         4         2
```

Based on the above results, specify the variables to be allocated to the 16-bit absolute address area in the #pragma abs16 statement:

```
#pragma abs16 (Int_Glob,Bool_Glob,Arr_2_Glob,Ptr_Glb,Next_Ptr_Glob)
```

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
abs16 option	2998	1558
#pragma abs16 specified	3012	1575

When the #pragma abs8 specification mentioned above is added, the execution results are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
abs16 option	2988	1558
#pragma abs16 specified	3012	1575
#pragma abs16 + #pragma abs8 specified	2980	1561

Next, examine whether the variable Int_Glob and Ptr_Glob should be allocated to the 16-bit absolute address area or to a global register. When combined with the options that have proved efficient, the following results are provided:

Optimization Function	Size (ROM)	No. of Execution Cycles
None (default)	3048	1580
#pragma abs16 (Bool_Glob, Arr_2_Glob, Next_Ptr_Glob Ptr_Glob,Int_Glob) +#pragma abs8(Ch_1_Glob,Ch_2_Glob) +#pragma noregsave specified +Compiler options	2920	1484

#pragma
global_register(Int_Glob=E4,Ptr_Glob=ER5)
+#pragma abs16 (Bool_Glob, Arr_2_Glob,
Next_Ptr_Glob)
+#pragma abs8(Ch_1_Glob,Ch_2_Glob)
+#pragma noregsave specified
+Compiler options
	2958	1486

The results indicate that it is more efficient to allocate the variables Int_Glob and Ptr_Glob to the 16-bit absolute address area instead of global registers.

For further details of the abs16 specification, refer to section 5.4.12, Using 16-bit Absolute Address Area.

Variables may be allocated to either the 8-bit or 16-bit absolute address area by the inter-module optimizer according to the CPU capacity.

(3) Allocating to a memory indirect area

Function calls are performed in the memory indirect format with this specification.

To reference the output object, specify list output as well.

The following table shows the result when the memory indirect area assignment option is specified by default (size efficient):

Optimization Function	Size (ROM)	No. of Execution Cycles
Default	3048	1580
Memory indirect area assignment specification	2994	1599

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Optimize]**, select **Function call: @@aa:8**

Command line: *indirect*

Runtime routines can also be allocated to this area.

When the #include <indirect.h> statement is specified, a runtime routine call is performed as a memory indirect call.

If the output of stack frame information is specified when the output of an object list is specified with the compiler, a runtime routine called in the functions is displayed.

```
Function (File hv21_dhry_, Line   309): Proc_1

  Optimize Option Specified : No Allocation Information Available

Parameter Area Size     : 0x00000000 Byte(s)
Linkage Area Size       : 0x00000004 Byte(s)
Local Variable Size     : 0x00000000 Byte(s)
Temporary Size          : 0x00000000 Byte(s)
Register Save Area Size : 0x0000000c Byte(s)
Total Frame Size        : 0x00000010 Byte(s)

Used Runtime Library Name
$MVN$3
```

As a result, the call $MVN$3 has become a memory indirect call.

For specifying functions individually, specify #pragma indirect $MVN$3.

Because the memory indirect area is allocated in the range from 0x00000000 to 0x000000ff, all functions can be assigned in this area.

At this time, note that this area overlaps with the exception processing vector area.

It is necessary to divide the section in order to avoid overlapping at the assignment.

In this case, the function can fit within the area, however, if the $INDIRECT section exceeds the memory indirect area, those functions that receive frequent accesses should be assigned individually using the #pragma indirect statement. In addition, use the #pragma indirect section statement to divide the section at the assignment.

This option specification is the same as the following:

```
#pragma
indirect(main,malloc,Proc1,Proc2,Proc3,Proc4,Proc5,Proc6,Proc7,Proc8,Func1,
Func2,Func3)
#pragma indirect $MVN$3
```

When combined with the options that have proved efficient, the following results are provided:

Optimization Function	**Size (ROM)**	**No. of Execution Cycles**
None (default)	3048	1580
#pragma abs8(Ch_1_Glob,Ch_2_Glob) +#pragma abs16 (Bool_Glob, Arr_2_Glob, Ptr_Glob, Next_Ptr_Glob) +#pragma noregsave specified +Compiler options +inter-module optimization functions +#pragma indirect specified	2902	1496

For further details, refer to section 5.4.13, Using Indirect Memory Format.

Function calls may be performed in the memory indirect format with the inter-module optimization features according to the CPU capacity, even if this option is not specified.

5.2 Optimization for Speed

5.2.1 Specifying the SPEED Option

To provide the optimization for speed, specify the SPEED option.

The execution results are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
Default	3048	1580
SPEED option	3420	1325

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Optimize]**, select **Speed or size Speed oriented optimization**

Command line: *speed*

As a result, the speed is improved by 255 execution cycles though the object size is increased by 372 bytes in the program Dhrystone Ver.2.1.

(1) Selecting sub-options

When the SPEED option is specified, optimization for speed is performed, that may result in a size increase.

To avoid this problem, it may be necessary to provide detailed specifications using the tuning procedure. The recommended way is to use the effective functions of the various sub-options. The sub-options to be specified can be determined by combining their effects so that the size of the program will fit the target ROM size. Refer to the following data from the program Dhrystone Ver.2.1:

Optimization Function	Size (ROM)	No. of Execution Cycles
All specified	3420	1325
Register	3048	1580
Shift to multiple	3048	1580
Struct assignment	3074	1527
Switch judgement	3048	1580
Maximum nodes of inline function(105)	3314	1437
Loop optimization	3048	1580
Expression	3080	1526

Note: On the H8/300 and H8/300H, when the **Register** is not specified, the compiler performs the register save/restore task with a function call (using the runtime routine library). When the **Register** is specified, the compiler generates the PUSH/POP instruction instead of using a function call.

On the H8S/2000 and H8S/2600 Series, the register save/restore task is always performed by the STM/LDM instruction. (or the PUSH/POP instruction depending on the register involved). Therefore, in this case a **Register** specification will have no effect.

The following shows the execution results when the **Register** is specified in the H8/300H advanced mode:

Optimization Function	Size (ROM)	No. of Execution Cycles
All specified	3422	1598
Register	3262	1721

The number of function nodes that should be automatically inline-expanded is specified with the **Maximum nodes if inline function**.

The number of nodes indicates the units of the compiler internal processing, which cannot accurately be checked. However, generally the larger the size of a function is, the greater the number of nodes is. The default is a node count of 105.

To disable the inline expansion (a node count of 0), turn off the specification.

The following shows the execution results when the number of nodes is set to 0, the default value, and the maximum value:(The range from 1 through 65535 can be selected as the number of nodes.)

Optimization Function	Size (ROM)	No. of Execution Cycles
Maximum nodes of inline function(1)	3052	1549
Maximum nodes of inline function(105)	3314	1437
Maximum nodes of inline function(65535)	3314	1437

Sometimes, specifying the inline expansion to all functions may reduce efficiency not only in size but also in speed. It is because the increase of the function size disables optimization.

When using automatic inline expansion, be careful not to increase the number of nodes as much as possible. If a specific function must be inline expanded, specify it in the #pragma inline statement for efficiency.

For further details on the SPEED option, refer to section 5.4.7, speed Option.

5.2.2 Tuning the Optimization Options

(1) Using the block transfer instruction (eepmov)

Use the block transfer instruction (EEPMOV) for the substitute of structures.

The following shows the execution results:

Optimization Function	Size (ROM)	No. of Execution Cycles
SPEED option	3420	1325
SPEED option+block transfer instruction	3366	1285

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Other]**, select **Use EEPMOV in block copy** for **Miscellaneous option**

Command line: *eepmov*

The EEPMOV instruction includes the following restrictions with the CPU-specification:

EEPMOV.B → Does not detect interrupt other than NMI.

EEPMOV.W → Does not detect interrupt other than NMI.

If an NMI interrupt occurs during this instruction execution, transfer results are not guaranteed.

Open the compile list to search for the EEPMOV instruction in the object list. Make sure that the EEPMOV instruction is not influenced by the above usage restrictions.

When the EEPMOV instruction is used for the data transfer of specific structures rather than the entire file, use the built-in function eepmov();.

For further details, refer to section 5.4.6, Block Transfer Instruction.

(2) Tuning of other optimization options

The following describes the specification combined with the options that have proved efficient in size.

First, specify the 1-byte enum type.

Optimization Function	Size (ROM)	No. of Execution Cycles
SPEED option	3420	1325
SPEED option +block transfer instruction	3366	1285
SPEED option +block transfer instruction +1-byte enum type	3392	1296

The execution speed reduced slightly.

Next, specify three parameter-passing registers:

Optimization Function	Size (ROM)	No. of Execution Cycles
SPEED option	3420	1325
SPEED option +block transfer instruction	3366	1285
SPEED option +block transfer instruction +3 parameter-passing registers	3348	1249

The execution speed is improved.

Then, specify a variable-allocation register count:

Optimization Function	Size (ROM)	No. of Execution Cycles
SPEED option	3420	1325
SPEED option +block transfer instruction	3366	1285
SPEED option +block transfer instruction +no variable-allocation register count extension	3366	1285

Based on these results, the options of a block transfer instruction specification and three parameter-passing registers specification can be determined to be appropriate. For further details, refer to section 5.4.3, Specifying the Number of Parameters-Passing Registers.

5.2.3 Using the Inter-Module Optimization Features

This section describes the optimization using the inter-module optimizer to obtain an object program with higher execution efficiency.

Before performing optimization using the inter-module optimizer, specify the output of an inter-module optimization add-on information file in the compiler or cross assembler.

[Specification method]

C/C++ C Compiler
Dialog menu: **C/C++**Tab **Category: [Optimize]**, select **Generate file for inter-module optimization**

Command line: *goptimize*

Cross Assembler
Dialog menu: **Assembly** Tab **Category: [Object]**, select **Generate file for inter-module optimization**

Command line: *goptimize*

In HEW1.2, an inter-module optimization add-on information file is also prepared for the standard library that is linked during inter-module optimization. As this file is supplied in the compressed form in the Windows version, decompress it before using.

By double-clicking on the compressed file (*.exe) that has the same name as the library name to be used; the file is self-extracted, then a directory containing the information file is generated.

For details on the inter-module optimization of this library, refer to the Supplement to the H8S,H8/300 Series C/C++ Compiler.

In HEW2.0 or later, the inter-module optimization features of Standard Library Generator should be used to create the library. By checking **Standard Library** Tab **Category:[Optimize] Generate file for inter-module optimization**, an inter-module optimization add-on information file is output.

(1) Default optimization

The inter-module optimizer supports the following optimization functions:

No.	Description	Dialog Menu	Subcommand Option
1	Unifies constants/strings	**Unify strings**	*String_Unify*
2	Deletes unreferenced variables/functions	**Eliminate dead code**	*Symbol_delete*
3	Optimizes access to variables	**Use short addressing**	*Variable_access*
4	Optimizes access to functions	**Use indirect call/jump**	*Funcation_call*
5	Reallocates registers	**Reallocate registers**	*Register*
6	Eliminates same code	**Eliminate same code**	*Same_code*
7	Optimizes branch instructions	**Optimize branches**	*Branch*

The most efficient optimization with the compiler is shown below:

Optimization Function	Size (ROM)	No. of Execution Cycles
Valid compiler optimization option (SPEED option +block transfer instruction +3 parameter-passing registers)	3348	1249

In the inter-module optimizer, no optimization is performed by default and a simply linked module is produced. Therefore, the execution results are the same result as the compiler optimization.

(2) Specifying inter-module optimization items

Specify the optimization items in the inter-module optimizer one by one:

Optimization Function	Inter-Module Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler optimization options specified	-	3348	1249
	Unifies constants/strings	3348	1249
	Deletes unreferenced variables/ functions	2984	1249
	Optimizes access to variables	3258	1232
	Optimizes access to functions	3332	1250
	Reallocates registers	3332	1249
	Eliminates dead codes	3348	1249
	Optimizes branch instructions	3348	1249

(3) Enabling inter-module optimization for speed

Perform the following functions: the unification of constants/strings, deletion of unreferenced variables/functions, optimization of access to variables, reallocation of registers, and optimization of branch instructions.

Optimization Function	Inter-Module Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler optimization options specified	-	3348	1249
	Optimization for speed	2906	1232

(4) Enabling all inter-module optimization functions

Enable all inter-module optimization functions:

Optimization Function	Inter-Module Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler optimization options specified	-	3348	1249
	Optimizes all	2902	1232

When this function is specified, the optimization may be applied to the part where the optimization should be disabled. Check the list carefully before specifying this option.

5.2.4 Selecting Expansion Functions

(1) Allocating registers to global variables

Allocate the variables that were specified during size efficiency optimization to global registers:

(A)
```
#pragma global_register(Int_Glob=E4,Ch_1_Glob=R4H,Ch_2_Glob=R4L,Ptr_Glob=ER5)
```

Also specify as follows in order to increase the number of work registers:

(B)
```
#pragma global_register(Int_Glob=E4,Ch_1_Glob=R4H,Ch_2_Glob=R4L)
```

(C)
```
#pragma global_register(Ptr_Glob=ER5)
```

Optimization Function	Size (ROM)	No. of Execution Cycles
SPEED option	3420	1325
SPEED option +Block transfer instruction specified +3 parameter-passing registers	3348	1249
SPEED option +Block transfer instruction specified +3 parameter-passing registers+#pragma global_register (A) specified	3318	1246
SPEED option +Block transfer instruction specified +3 parameter-passing registers+#pragma global_register (B) specified	3370	1262
SPEED option +Block transfer instruction specified +3 parameter-passing registers+#pragma global_register (C) specified	3296	1246

For further details, refer to section 5.4.8,Allocating Registers to Global Variables.

(2) Controlling the output of register save/restore code at the function entry and exit points

Specify as follows according to the results at optimization for size:

```
#pragma noregsave (main)
```

The execution results are as follows:

Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler Option Inter-module optimization function	2906	1232
Compiler Option Inter-module optimization function +#pragma noregsave specified	2906	1232

The execution speed is improved. For further details, refer to section 5.4.9, Controlling Output of Register Save/Restore Codes at the Function Entry/Exit Points.

5.2.5 Using the Inline Expansion Features

(1) Specifying the inline expansion of a function

#pragma inline declares a function that performs inline expansion, instead of a function call. When an inline expansion is provided, the execution speed is improved though the object size increases.

However, as described in the section on the automatic inline expansion of the SPEED option, specifying the inline expansion of all functions not only reduces performance in object size but also in execution speed.

The #pragma inline statement should be used to declare functions that are called from a deep nesting level, which will improve the execution speed effectively.

Nesting relationships in the program Dhrystone Ver.2.1 are shown below:

```
main:
     malloc:
     strcpy:
     Proc_1:
         Proc_3:
             Proc_7:
         Proc_6:
             Func_3:
         Proc_7:
     Func_2:
         Func_1:
         strcmp:
     Func_1:
     Proc_8:
     Proc_7:
     Proc_6:
         Func_3:
     Proc_5:
     Proc_4:
     Func_2:
```

In this case, functions start to be specified from the deepest nesting level. The comparison with a node count of 105 for the automatic inline expansion (the inline expansion specified in the option) is shown below:

Optimization Function	**Size (ROM)**	**No. of Execution Cycles**
None (default)	3052	1549
Automatic inline expansion	3306	1445
Inline expansion specified (Proc7,Func3)	3048	1589
Inline expansion specified (Proc7,Func3,Func1,strcmp,Proc3,Proc6)	3048	1589
Inline expansion specified (Proc7,Func3,Func1,strcmp,Proc3,Proc6, malloc,strcpy,Proc5,Proc4,Proc1)	3048	1589
Inline expansion specified for all functions	3322	1445

Note: The functions Proc8 and Func2 are not inline-expanded.

These results indicate that the automatic inline expansion option makes a fast object program.

Thus, a high-performance object can be created by combining specifications appropriately considering function call relations, the number of execution cycles, and the object size.

The #pragma inline declaration is valid only when the function itself and the associated function call included within a file. If “static” is specified to the function to be inline-expanded, actual codes are not output and the codes are expanded only on the called function, which makes the object size be reduced. It is recommendable to always use this specification.

For further details, refer to section 5.4.10, Specifying Inline Expansion of Functions.

(2) Specifying Inline expansion of an assembly language function

At coding a program in C/C++, sections that require enhanced performance specially are sometimes written in the assembly language. In such a case, if the function written in assembly language is specified with the #pragma inline_asm , the function can be inline expanded at the location of the call.

For further details, refer to section 10.2.1, #pragma Extension and Keywords, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

5.2.6 Using CPU-Specific Instructions

(1) Allocating to a short 8-bit absolute address area

Allocate the variable selected during an optimization for size to 8-bit absolute address area:

```
#pragma abs8 (Ch_1_Glob,Ch_2_Glob)
```

The following shows the execution results:

Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler option Inter-module optimization function +#pragma noregsave specified	2906	1232
Compiler Option Inter-module optimization function +#pragma noregsave specified +#pragma abs8 specified	2906	1232

Different from the case of size-orientated optimization (5.1.6), there is no difference in this Dhrystone Ver.2.1 program. However, it is recommendable to use this specification.

For further details, refer to section 5.4.11, Using 8-bit Absolute Address Area.

(2) Allocating to a short 16-bit absolute address area

Allocate the variable selected during an optimization for size to 16-bit absolute address area:

```
#pragma abs16 (Int_Glob,Bool_Glob,Arr_2_Glob,Ptr_Glob,Ptr_Glb_Next)
```

The following shows the execution results:

Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler Option Inter-module optimization function +#pragma noregsave specified	2906	1232
Compiler Option Inter-module optimization function +#pragma noregsave specified+#pragma abs8 specified +#pragma abs16 specified	2894	1231

Thus, both the speed and the size are improved.

For further details, refer to section 5.4.12, Using 16-bit Absolute Address Area.

(3) Allocating to a memory indirect area

Allocate the variable selected during an optimization for size to a memory indirect area:

```
#pragma
indirect(Proc0,main,malloc,Proc1,Proc2,Proc3,Proc4,Proc5,Proc6,Proc7,Proc8,
Func1,Func2,Func3)
```

The following shows the execution results:

Optimization Function	Size (ROM)	No. of Execution Cycles
Compiler Option Inter-module optimization function +#pragma noregsave specified+#pragma abs8 specified +#pragma abs16 specified	2894	1231
Compiler Option Inter-module optimization function +#pragma noregsave specified+#pragma abs8 specified +#pragma abs16 specified+#pragma indirect specified	2892	1232

As a result, the execution speed is reduced, and this specification should not be used.

5.3 Combination of Size and Speed Efficiency

As described in the preceding sections, the compiler optimization supports functions reducing the size and those improving the execution speed. For each function and specification method, refer to the sections above. The best approach to create a high-performance program is that functions requiring compactness and functions requiring high-speed performance are separated in different files, and an optimization for size and that for speed can be chosen for each file.

Even if functions cannot be separated completely, it is important to know what part requires the high-speed performance most in the entire program. The object performance can be improved effectively by specifying (option + expansion functions + coding + inter-module optimization) for a file (or function) requiring high speed and providing optimization for size to the other parts.

The results of the investigation carried out thus far can be summarized as follows:

Following lists the examination results with option and expansion function specifications that implement the best size efficiency:

		Size		**Speed**	
Specification	**Description**	**Byte**	**%**	**Cycle**	**%**
Default	–	3048	100	1580	100
Compiler Options	1-byte enum type specified +3 parameter-passing registers	3034	99	1527	97
Compiler Options +inter-module optimization functions	1-byte enum type specified +3 parameter-passing registers +all inter-module optimization functions	2946	97	1517	96
Compiler Option +inter-module optimization functions +Expansion functions	1-byte enum type specified +3 parameter-passing registers +all inter-module optimization functions +#pragma abs8 specified +#pragma abs16 specified +#pragma noregsave specified +#pragam indirect specified	2902	95	1496	95

Following lists the examination results with option and expansion function specifications that implement the best speed efficiency:

		Size		Execution speed	
Specification	**Description**	**Byte**	**%**	**Cycle**	**%**
Default	–	3048	100	1580	100
Compiler Options	SPEED option +Block transfer instruction specified +3 parameter-passing registers	3348	110	1249	79
Compiler Options +inter-module optimization functions	SPEED option +Block transfer instruction specified +3 parameter-passing registers +speed-priority inter-module optimization features	2906	95	1232	78
Compiler Options +inter-module optimization functions +Expansion functions	SPEED option +Block transfer instruction specified +3 parameter-passing registers +speed-priority inter-module optimization features +#pragma noregsave specified +#pragma abs8 specified +#pragma abs16 specified	2894	95	1231	78

Thus, compared with the case when no option is specified, the performance of the program Dhrystone Ver.2.1 is improved a maximum of 5% in size and 22% in execution cycles by using options and expansion functions.

Specifications of the options and the expansion functions improve the program performance much more easily and effectively than modification of the codes. Make great use of these items to create high performance object programs.

5.4 Details of Optimization Functions

The compiler provides the following optimization functions. Items 1 through 23 represent functions with the compiler and items 24 through 30 with the inter-module optimizer:

The performance is measured under the following conditions.

[Cross Tools for Measurement]

H8S,H8/300 C/C++ Library Generator (Ver. 2.01.00.001)

H8S,H8/300 C/C++ Compiler (Ver. 6.01.00.009)

H8S,H8/300 Assembler (Ver. 6.01.01.000)

Optimizing Linkage Editor (Ver. 9.00.02.000)

[Option Specification]

Default options are used, when option specification methods are not described in each section.

[Measurement Conditions]

Conditions	H8/300, H8/300H	H8S/2600,H8S/2000	H8SX
Bus Width	16	16	32
Access State to Memory	2	1	1
Fetch Size	-	-	32

No.	Optimization Function	Size Reduction	Speed Improvement	Referenced Section
1	Uses 1-byte enum type	O	O	5.4.1
2	Extended interpretation of multiplication/division specifications	O	O	5.4.2
3	Specifies the number of parameter-passing registers	Δ	Δ	5.4.3
4	Increases the number of variable allocation registers	Δ	Δ	5.4.4
5	Optimizes external variables	–	–	5.4.5
6	Block transfer instruction	X	O	5.4.6
7	SPEED option			5.4.7
8	Speed-improving expansion of register save/restore codes	X	O	5.4.7(1)
9	Speed-improving code expansion of shift expressions	X	O	5.4.7(2)
10	Substitute code expansion of structures and double-type data	X	O	5.4.7(3)
11	Speed-efficiency code expansion for switch statement	X	O	5.4.7(4)
12	Inline expansion of small-size functions	X	O	5.4.7(5)
13	Speed-efficiency code expansion of loop expressions	Δ	O	5.4.7(6)
14	Disables run-time routine calls	X	O	5.4.7(7)
15	Allocates registers to global variables	Δ	Δ	5.4.8
16	Controls output of register save/restore codes at function entry/exit points	O	O	5.4.9
17	Specifies inline expansion of functions	X	O	5.4.10
18	Uses 8-bit absolute address area	O	O	5.4.11
19	Uses 16-bit absolute address area	O	O	5.4.12
20	Allocates to indirect memory area	O	X	5.4.13
21	Extended memory indirect	O	X	5.4.14
22	2 bytes pointer	O	O	5.4.15
23	Boundary alignment	O	O	5.4.16
24	Unifies constants/strings	–	–	5.4.17(1)
25	Eliminates unreferenced variables/functions	–	–	5.4.17(2)
26	Optimizes access to variables	–	–	5.4.17(3)
27	Optimizes access to functions	–	–	5.4.17(4)
28	Optimizes register save/restore codes	–	–	5.4.17(5)
29	Unifies common codes	–	–	5.4.17(6)
30	Optimizes branch instructions	–	–	5.4.17(7)

Legend:

O:	Improvements attained
Δ:	Improvements achieved in some programs
X:	Efficiency reduced

5.4.1 Using 1-Byte enum Type

Size	O	Speed	O

Description

If the value of an enum-type member is within the range from –128 to 127, 1-byte-type operations can be specified with this option.

An enum-type value usually occupies 2 bytes according to the language specifications, however, when the enum option is specified, a value of enum-type members is operated as 1-byte data.

Because this option is not based on the language specifications, it is set to be “not specified” in the default state of the compiler. However, it is recommended to always specify this option.

Specification Method

Dialog menu: **C/C++Tab Category: [Other] Treat enum as char if it is in the range of char**

Command line: *byteenum*

Example

To set enum-type data E1 to 1:

(C/C++ program)

```
enum EN1 {a=0,b,c,d,e}E1;
void func(void)
{
    E1=1;
}
```

←The value of the enum member is within the data range represented by one byte.

(Assembly expansion code)

Not specified

```
_func:
      MOV.W       #1,R0
      MOV.W       R0,@_E1:32
      RTS
      .SECTION    B,DATA,ALIGN=2
_E1:
      .RES.W      1
```

2-byte data

Specified

```
_func:
      MOV.B       #1,R0L
      MOV.B       R0L,@_E1:32
      RTS
      .SECTION    B,DATA,ALIGN=2
_E1:
      .RES.B      1
```

1-byte data

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	12	10	12	10	10
Specified	10	8	10	8	8

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	8	8	6
Specified	8	8	6

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	11	9	22	18	18
Specified	10	8	20	16	16

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	8	8	7
Specified	8	8	7

5.4.2 Extended Interpretation of Multiplication/Division Specifications

Size	O	Speed	O

Description

The code expansion of multiplication/division operations is output by expanding interpretation of the ANSI standard.

When this option is specified, calculation results may be different from those without this option because the interpretation differs as listed below:

Operand	Size of us1*us2 at Operation (for H8S/2600)	
	Expanded Interpretation	**ANSI Standard Interpretation**
unsigned short us1,us2; unsigned long ul; ul=us1*us2;	us1*us2 operated as unsigned long Output example: MOV.W @_us1.Rd MOV.W @_us2.Rs MULXU.W Rs,ERd MOV.L ERd,@_ul The result of us1*us2 is assigned to u1 with 4 bytes.	us1*us2 operated as unsigned short Output example: MOV.W @_us1.Rd MOV.W @_us2.Rs MULXU.W Rs,ERd EXTU.L ERd MOV.L ERd,@_ul Lower 2 bytes of the result of us1*us2 is assigned to ul by zero expansion.
Unsigned short us1,us2,us3 Unsigned short us; us=us1*us2/us3;	us1*us2 computed as unsigned long Output example: MOV.W @_us1.Rd MOV.W @_us2.Rs MULXU.W Rs,ERd MOV.L @_us3.Rs DIVXU.W Rs,ERd MOV.L Rd,@_us The 4 bytes of result of us1*us2 is assigned as the dividend of the operation instruction.	us1*us2 computed as unsigned short Output example: MOV.W @_us1.Rd MOV.W @_us2.Rs MULXU.W Rs,ERd EXTU.L ERd MOV.L @_us3.Rs DIVXU.W Rs,ERd MOV.L Rd,@_us The lower 2 bytes of the result of us1*us2 are zero expanded and assigned as the dividend of the division operation.

Specification Method

Dialog menu: **C/C++Tab Category: [Object] Mul/Div operation specification Non ANSI(Guarantee 32bit as a result of 16bit*16bit)**

Command line: *cpuexpand*

Example

To store multiplication results of two 2-byte data in 4-byte type data:

(C/C++ program)

```
unsigned long ll;
unsigned short a,b;
void func()
{
    ll=a*b;
}
```

(Assembly expansion code)

Not specified

```
_func:
    MOV.W       @_a:32,R0
    MOV.W       @_b:32,E0
    MULXU.W     E0,ER0
    EXTU.L      ER0
    MOV.L       ER0,@_ll:32
    RTS
```

Specified

```
_func:
    MOV.W       @_a:32,R0
    MOV.W       @_b:32,E0
    MULXU.W     E0,ER0

    MOV.L       ER0,@_ll:32
    RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	26	20	26	20	24
Specified	24	18	24	18	22

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	26	26	20
Specified	24	24	18

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	24	20	62	54	136
Specified	23	19	60	52	184

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	14	14	13
Specified	14	14	12

5.4.3 Specifying the Number of Parameter-Passing Registers

Size	Δ	Speed	Δ

Description

The number of registers to assign parameters can be set with this specification. When a parameter is assigned to a register, the access size is reduced than the case assigned to a stack. On the other hand, when the number of parameter-passing registers is increased, the work register area is reduced and, sometimes such as at a complicated operation, data is not assigned to registers. In this case, the object program efficiency is lowered.

The number of parameter-passing registers can also be specified with an option.

Compare execution results of both specifications and adopt the better one.

Specification Method

Dialog menu: **CPU tab, Change number of parameter-passing registers from 2(default) to 3**

Command line: *regparam=3*

Example

In the following example, the efficiency is improved when three parameter-passing registers are specified.

(C/C++ program)

```
extern short ee;
void func(short a,short b,short c,short d,long e)
{
    ee=a*b*c*d/e;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_func:
      PUSH.L      ER2
      SUBS.L      #2,SP
      MOV.W       R0,R2
      MULXU.W     E0,ER2
      MULXU.W     R1,ER2
      MOV.W       R2,R1
      MULXU.W     E1,ER1
      EXTS.L      ER1
      MOV.W       R0,@SP
      MOV.L       ER1,ER0
      MOV.L       @(10:16,SP),ER1
      JSR         @$DIVL$3:24
      MOV.W       R0,@_ee:32
      POP.L       ER2
      RTS
```

Specified

```
_func:
      PUSH.L      ER3
      SUBS.L      #2,SP
      MOV.W       R0,R3
      MULXU.W     E0,ER3
      MULXU.W     R1,ER3
      MOV.W       R3,R1
      MULXU.W     E1,ER1
      EXTS.L      ER1
      MOV.W       R0,@SP
      MOV.L       ER1,ER0
      MOV.L       ER2,ER1
      JSR         @$DIVL$3:24
      MOV.W       R0,@_ee:32
      ADDS.L      #2,SP
      POP.L       ER3
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	42	40	46	44	72
Specified	38	36	42	40	70

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	36	36	36
Specified	34	34	32

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	144	138	294	282	686
Specified	140	134	284	272	682

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	44	43	44
Specified	39	39	41

Remarks and Notes

This specification is applied to all the files and linked libraries. It cannot be specified individually to each file. Therefore, when modifying this specification, remember to change specifications of options in all files and linked libraries.

In addition, if the program being optimized is linked to an Assembly program, the interface to function calls also needs to be modified.

For a description of the linkage between a C/C++ program and an Assembly language program, refer to section 9.3, Linking C/C++ Programs and Assembly Programs in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

5.4.4 Increasing the Number of Variable-Allocation Registers

Size	Δ	Speed	Δ

Description

The number of registers to allocate variables can be set using this option (4 or 3 registers).

Most programs perform better when four registers are specified. However, if a program includes complicated expressions which cause a shortage of registers, the specification of three registers results in better performance.

Specify four variable-allocation registers for a usual execution, and compare the execution results of both specifications when necessary, such as at the program storage on ROM.

Specification Method

Dialog menu: **C/C++Tab Category: [Other] Increase a register for register variable**

Command line: *regexpansion*

Example

In the following example, the efficiency is improved when three variable-assignment registers are specified.

(C/C++ program)

```
long func(short a,long b,short c,char d,long e)
{
    long x,y,z;
    x=a+b;
    y=b*c;
    z=a/e;
    return (a*x*(z+y)*b*d+e*z-e/x*c/(x*y*a*z));
}
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Variable registers: 4	202	202	190	190	416
Variable registers: 3	202	202	190	190	416

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Variable registers: 4	150	150	150
Variable registers: 3	150	150	150

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Variable registers: 4	783	752	2158	2082	4836
Variable registers: 3	783	752	2158	2082	4836

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Variable registers: 4	174	187	169
Variable registers: 3	174	187	169

5.4.5 Optimization of External Variables

Size	–	Speed	–

Description

```
   :
 a=0;  //(1)
 a=1;  //(2)
   :
```

The compiler optimizes the above expressions by deleting the substitution of (1) above. If the substitution (1) should not be deleted, as for a variable in an I/O port or an interrupt processing, declare volatile for the variable.

By using the option, the optimization can be disabled for all external variables in the specified file.

However, that may reduce the object efficiency. When using the option, declare volatile to a variable that should not be optimized, such as that in an interrupt function or in an I/O register, in the source program, and then, compile the resulting program with disabling the optimization of external variables.

Specification Method

Dialog menu: **C/C++ Tab Category: [Other] Avoid optimizing external symbols treating them as volatile**

Command line: *volatile*

Example

To assign the values 0, 1, and 2 to the external variable a in this order:

(C/C++ program)

```
unsigned int a;
void func()
{
    a=0;
    a=1;
    a=2;
}
```

(Assembly expansion code)

Not specified

```
_func:
                              a=2 code only

      MOV.W       #2,R0
      MOV.W       R0,@_a:32
      RTS
```

Specified

```
_func:
      SUB.W       R0,R0          a=0
      MOV.W       R0,@_a:32
      MOV.B       #1,R0L
      MOV.W       R0,@_a:32      a=1
      MOV.B       #2,R0L
      MOV.W       R0,@_a:32
      RTS                        a=2
```

Remarks and Notes

When the optimization of external variables is disabled, all external variables in the file are changed into volatile variables. To set volatile individually to each variable, specify as follows:

```
volatile unsigned int a;
void func()
{
    a=0;
    a=1;
    a=2;
}
```

Outputs the same code as shown in the above example with the volatile option

By default, the optimization of external variables is enabled with the compiler option.

5.4.6 Block Transfer Instruction

Size	X	Speed	O

Description

Structure substitutions are usually processed by calling run-time routines. When this option is used, a block transfer instruction is output at the structure substitution expression, and then the execution speed is improved.

However, if NMI interrupt occurs during the EEPMOV.W instruction execution, the transfer results are not guaranteed.

Check this condition before specifying this option.

To output the EEPMOV instruction only in a part of the structure data transfer, specify the eepmov() built-in function.

Specification Method

Dialog menu: **C/C++ Tab Category: [Other] Use EEPMOV in block copy**

Command line: *eepmov*

Example

To substitute the structure s2 to s1:

(C/C++ program)

```
struct S{
    char  cc;
    short ss;
    long  ll;
    long  ll2;
}s1,s2;
void main()
{
    s1=s2;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_main:
      PUSH.L      ER2
      MOV.L       #_s2,ER0
      MOV.L       #_s1,ER1
      SUB.L       ER2,ER2
      MOV.B       #12,R2L
      JSR         @$MVN$3:24
  Processed by a run-time routine call
      POP.L       ER2
      RTS
```

Specified

```
_main:
      STM.L       (ER4-ER6),@-SP
      MOV.L       #_s2,ER5
      MOV.B       #12,R4L
      MOV.L       #_s1,ER6
      EEPMOV.B
   Expanded into EEPMOV instruction
      LDM.L       @SP+,(ER4-ER6)
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	30	22	30	22	22
Specified	28	24	26	22	22

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	28	26	22
Specified	22	22	18

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	117	102	270	224	256
Specified	58	55	226	210	168

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	66	66	57
Specified	24	24	24

5.4.7 speed Option

Description

The compiler usually outputs an object efficient in the code size. When this option is specified, an object efficient in the execution speed is output.

There are following items to specify the output of speed-efficiency objects rather than size-efficiency objects:

Description	Reference
Speed-efficiency code expansion of register save/restore codes	5.4.7(1)
Speed-efficiency code expansion of shift expressions	5.4.7(2)
Assignment code expansion of structures and double-type data	5.4.7(3)
Inline expansion of functions	5.4.7(4)
Speed-efficiency code expansion of loop expressions	5.4.7(5)
Speed-efficiency code expansion for switch statement	5.4.7(6)
Disabling run-time routine calls for arithmetic operation	5.4.7(7)

These items can be specified individually.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed oriented optimization**

Command line: *speed*

(1) Speed-efficiency Code Expansion of Register Save/Restore Codess

Size	X	Speed	O

Description

At entry and exit points of a function, registers used in the function are saved or restored. On the H8/300H or H8/300 series, registers are saved/restored by calling a run-time routine when the number of registers to be saved/restored is three or more.

When a run-time routine is used, the object size is reduced, however, the execution speed is lowered because of the processing for the function call or the save/restore of registers that are not needed. If only the necessary registers are saved/restored and a run-time routine is not called, the execution speed is improved though the object size is increased.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Register**

Command line: *speed=register*

Example

To define the function *sub* while specifying the 300HA CPU/operation mode:

(C/C++ program)

```
long a,b;
long sub(char c1,short s2,short s3)
{
    s3=a+b;
    return (c1+s2+s3);
}
```

The run-time routine called at register save/restore differs according to whether optimization is specified or not and the number of parameter-passing registers

(Assembly expansion code)

Not specified

```
_sub:
      JSR         @$sp_regsv$3:24

      MOV.B       R0L,R5L
      MOV.W       @_a+2:24,R1
      MOV.W       @_b+2:24,R2
      ADD.W       R2,R1
      EXTS.W      R5
      ADD.W       E0,R5
      ADD.W       R1,R5
      EXTS.L      ER5
      MOV.L       ER5,ER0
      JMP         @$spregld2$3:24
```

Specified

```
_sub:
      PUSH.L      ER5
      PUSH.W      R2
      MOV.B       R0L,R5L
      MOV.W       @_a+2:24,R1
      MOV.W       @_b+2:24,R2
      ADD.W       R2,R1
      EXTS.W      R5
      ADD.W       E0,R5
      ADD.W       R1,R5
      EXTS.L      ER5
      MOV.L       ER5,ER0
      POP.W       R2
      POP.L       ER5
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	24	20	28	24	38
Specified	24	20	28	24	44

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	24	24	20
Specified	24	24	20

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	18	15	48	42	134
Specified	18	15	48	42	94

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	17	15	14
Specified	17	15	14

(2) Speed-efficiency Code Expansion of Shift Expressions

Size	X	Speed	O

Description

Object codes for shift operations are generated with improving speed rather than reducing size.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Shift to multiple**

Command line: *speed=shift*

Example

To shift the variable *a* multiple times:

(C/C++ program)

```
unsigned char a=0x80;
int dat;
void main(void)
{
    a>>=dat;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_main:
      MOV.L       #_a,ER0
      MOV.W       @_dat:32,R1
      JSR         @$DSRUC$3:24
```

Processed by calling a run-time routine

```
      RTS
```

Specified

```
_main:
          MOV.B       @_a:32,R0L
          MOV.B       @_dat+1:32,R0H
L5:
          DEC.B       R0H
          BMI         L8:8
          SHLR.B      R0L
          BRA         L7:8
L6:
          MOV.B       R0L,@_a:32
          RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	25	19	19	15	15
Specified	49	43	29	23	23

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	25	25	19
Specified	25	25	19

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	39	33	78	64	64
Specified	29	25	40	32	32

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	14	14	12
Specified	14	14	12

(3) Assignment Code Expansion of Structures and Double-Type Data

Size	Δ	Speed	O

Description

When structures or double-type data are assigned, codes to call a run-time routine are usually output (except for the case of a small-size structure). Therefore, if processing is performed without calling the run-time routine, the execution speed is improved.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Struct assignment**

Command line: *speed=struct*

Example

To assign the structure s2 to s1:

(C/C++ program)

```
struct S{
    unsigned char cc;
    short ss;
    long ll;
}s1,s2;
void main(void)
{
    s1=s2;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_main:
      PUSH.L      ER2
      MOV.L       #_s2,ER0
      MOV.L       #_s1,ER1
      SUB.L       ER2,ER2
      MOV.B       #8,R2L
      JSR         @$MVN$3:24

      POP.L       ER2
      RTS
```

Run-time routine processing

Specified

```
_main:
      PUSH.L      ER2
      MOV.L       #_s2,ER0
      MOV.L       #_s1,ER1
      MOV.L       @ER0+,ER2
      MOV.L       ER2,@ER1
      MOV.L       @ER0,ER2
      MOV.L       ER2,@(4:16,ER1)
      POP.L       ER2
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	18	14	30	22	22
Specified	40	32	40	36	34

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	22	22	18
Specified	22	22	18

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	49	44	244	198	220
Specified	39	32	78	72	124

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	18	14	14
Specified	18	14	14

(4) Inline Expansion of Functions

Size	X	Speed	O

Description

When an inline expansion is specified with the option, small-size functions are inline-expanded, which improves the execution speed. However, if any of the following conditions is met, inline expansion is not performed:

- A function is defined prior to a #pragma inline specification.
- A variable parameter is included.
- An address of a parameter is referenced.
- The types of a real parameter and a dummy parameter are not the same.
- The size limitation of an inline expansion has been exceeded.

The size limitation of an inline expansion indicates the number of nodes of the specified function.

The number of nodes indicates the processing unit used in the compiler internal processing, which can be selected within the range from 1 to 65535. If a small number of nodes is specified, only a small function is inline-expanded, however, if a large number is specified, a large-size function can also be inline-expanded.

<u>The default number is 105.</u>

If #pragma inline is specified for a function, the function is inline-expanded regardless of the inline expansion size limitation.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Maximum nodes of inline function**

Command line: *speed=inline[=(node)]*

Example

To call a function named *func*:

(C/C++ program)

```
extern long a;
void func(void);
void sub(void)
{
    func();
    a+=2;
}
void func(void)
{
    a++;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_sub:
      BSR         _func:8     ◄ Function call


      MOV.L       #_a,ER0
      MOV.L       @ER0,ER1
      INC.L       #2,ER1
      MOV.L       ER1,@ER0
      RTS
_func:
      MOV.L       #_a,ER0
      MOV.L       @ER0,ER1
      INC.L       #1,ER1
      MOV.L       ER1,@ER0
      RTS
```

Specified

```
_sub:
      MOV.L       @_a:32,ER0
      INC.L       #1,ER0
      INC.L       #2,ER0
      MOV.L       ER0,@_a:32
      RTS
_func:
      MOV.L       #_a,ER0
      MOV.L       @ER0,ER1
      INC.L       #1,ER1
      MOV.L       ER1,@ER0
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	44	36	40	36	38
Specified	58	46	52	46	42

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	30	28	24
Specified	34	34	28

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	41	34	78	68	182
Specified	31	26	58	52	166

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	23	23	21
Specified	15	15	14

Remarks

If the called function is included in the same file of the calling side and the function is not called by any other file, no external definition of the function is generated and the function size is reduced when static is specified in the function declaration.

(5) Speed-efficiency Code Expansion of Loop Expressions

Size	Δ	Speed	O

Description

Loops satisfying all of the following conditions in the file are output with expanded codes:

- The initial value for the loop is a constant.
- The final judgement of the loop is a constant.
- The number of repetition for the loop is either a multiple of 3 or an even number.
- No goto labels is included in the loop.
- The loop contains expressions only and the number of expressions is 10 or less.
- The optimization is specified.

When a loop is expanded, the program size is increased. To improve the execution speed of a specific loop, provide loop-expanded coding in the program.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Loop optimization**

Command line: *speed=loop*

Example

To zero-clear the contents of the array *a*:

(C/C++ program)

```
int a[10];

void f(void)
{
    int i;

    for (i=0;i<10;i++)
        a[i]=0;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_f:
      PUSH.L      ER6
      SUB.W       R6,R6
      SUB.W       R1,R1
L6:
      EXTS.L      ER6
      MOV.L       ER6,ER0
      SHLL.L      ER0
      MOV.W       R1,@(_a:32,ER0)
      INC.W       #1,R6
      CMP.W       #10:16,R6
      BLT         L6:8
      POP.L       ER6
      RTS
```

Specified

```
_f:
      MOV.L       #_a,ER1
      SUB.L       ER0,ER0

L6:
      MOV.W       R0,@ER1
      INC.W       #1,E0
      INC.L       #2,ER1
      MOV.W       R0,@ER1
      INC.W       #1,E0
      INC.L       #2,ER1
      CMP.W       #10,E0
      BLT         L6:8
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	34	26	36	22	28
Specified	38	28	40	30	40

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	20	20	18
Specified	36	36	32

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	132	103	294	212	244
Specified	88	72	162	138	244

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	95	87	87
Specified	75	71	71

Remarks

This specification sometimes reduces the size of codes.

Try this option on and off at tuning options.

(6) Speed-Efficiency Code Expansion of switch Statement

Size	Δ	Speed	O

Description

The switch statement is expanded in the method outputting less number of execution cycles with this specification.

There are two methods to expand the switch statement, the table method and the if-then method.

Usually, the compiler determines which method is better to reduce the size.

In the if-then method, the value of the switch statement evaluation expression is compared with that of the case label. If they are the same, jumping to the case label statement is repeated the number of times the case labels are included. Therefore, in this method, the object code size is increased according to the number of case labels included in the switch statement.

In the table method, the destination of case label jumping is stored in a jump table and the jumping to the case label statement that matches the evaluation expression of the switch statement is performed with a single referencing of the jump table. In this case, the size of the jump table allocated in the constant area is increased in proportion to the number of case labels contained in switch statements, however, the execution speed is always constant.

When the SPEED option is specified, a processing method improving the execution speed is selected depending on the above-mentioned conditions.

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Switch judgement**

Command line: *speed=switch*

Example

To replace the value of the variable *a*:

(C/C++ program)

```
extern unsigned a;
void sub(void)
{
    switch(a){
    case 0: a=1;break;
    case 2: a=2;break;
    case 4: a=3;break;
    case 6: a=4;break;
    case 8: a=5;break;
    case 10: a=6;break;
    case 12: a=7;break;
    case 14: a=8;break;
    case 16: a=9;break;
    case 18: a=10;break;
    case 20: a=11;break;
    }
}
```

(Compiled result of assembly expansion code)

Not specified

```
_sub:MOV.L       #_a:32,ER1
      MOV.W       @ER1,R0
      MOV.B       R0H,R0H
      BNE         L16:8
      CMP.B       #0:8,R0L
      BEQ         L5:8
      CMP.B       #2:8,R0L
      BEQ         L6:8
      CMP.B       #4:8,R0L
      BEQ         L7:8
      CMP.B       #6:8,R0L
      BEQ         L8:8
      CMP.B       #8:8,R0L
      BEQ         L9:8
      CMP.B       #10:8,R0L
      BEQ         L10:8
      CMP.B       #12:8,R0L
      BEQ         L11:8
      CMP.B       #14:8,R0L
      BEQ         L12:8
      CMP.B       #16:8,R0L
      BEQ         L13:8
      CMP.B       #18:8,R0L
      BEQ         L14:8
      CMP.B       #20:8,R0L
      BEQ         L15:8
      RTS
L5:  MOV.W       #1:16,R0
      BRA         L26:8
L6:  MOV.W       #2:16,R0
      BRA         L26:8
L7:  MOV.W       #3:16,R0
      BRA         L26:8
L8:  MOV.W       #4:16,R0
      BRA         L26:8
L9:  MOV.W       #5:16,R0
      BRA         L26:8
L10: MOV.W       #6:16,R0
      BRA         L26:8
L11: MOV.W       #7:16,R0
      BRA         L26:8
L12: MOV.W       #8:16,R0
      BRA         L26:8
L13: MOV.W       #9:16,R0
      BRA         L26:8
L14: MOV.W       #10:16,R0
      BRA         L26:8
L15: MOV.W       #11:16,R0
L26: MOV.W       R0,@ER1
L16: RTS
```

Specified

```
_sub:MOV.L       #_a,ER1
      MOV.W       @ER1,R0
      CMP.W       #20,R0
      BHI         L18:8
      EXTU.L      ER0
      MOV.B
@(L19:32,ER0),R0L
      EXTU.W      R0
      EXTU.L      ER0
      ADD.L       #L7,ER0
      JMP         @ER0
L5:  MOV.W       #1,R0
      BRA         L27:8
L6:  MOV.W       #2,R0
      BRA         L27:8
L7:  MOV.W       #3,R0
      BRA         L27:8
L8:  MOV.W       #4,R0
      BRA         L27:8
L9:  MOV.W       #5,R0
      BRA         L27:8
L10: MOV.W       #6,R0
      BRA         L27:8
L11: MOV.W       #7,R0
      BRA         L27:8
L12: MOV.W       #8,R0
      BRA         L27:8
L13: MOV.W       #9,R0
      BRA         L27:8
L14: MOV.W       #10,R0
      BRA         L27:8
L15: MOV.W       #11,R0
L27: MOV.W       R0,@ER1
L16: RTS
      .SECTION    C,DATA,ALIGN=2
L17: .DATA.B     L5-L5
      .DATA.B     L16-L5
      .DATA.B     L6-L5
      .DATA.B     L16-L5
      .DATA.B     L7-L5
      .DATA.B     L16-L5
      .DATA.B     L8-L5
      .DATA.B     L16-L5
      .DATA.B     L9-L5
      .DATA.B     L16-L5
      .DATA.B     L10-L5
      .DATA.B     L16-L5
      .DATA.B     L11-L5
      .DATA.B     L16-L5
      .DATA.B     L12-L5
      .DATA.B     L16-L5
      .DATA.B     L13-L5
      .DATA.B     L16-L5
      .DATA.B     L14-L5
      .DATA.B     L16-L5
      .DATA.B     L15-L5
      .DATAB.B    1,0
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	136	120	126	114	120
Specified	136	120	126	114	120

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	118	118	108
Specified	118	118	108

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	44	33	66	52	66
Specified	44	33	66	52	66

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	23	24	18
Specified	23	24	18

Remarks

In the above example, codes with improved speed and reduced size are generated because the table method is adopted. However, depending upon the value of *a*, better codes may be output when this option is not specified.

(7) Disabling Run-Time Routine Calls

Size	X	Speed	O

Description

When this option is specified, arithmetic operations, comparison expressions, or assignment expressions are expanded into codes without using a run-time routine (for some expressions this option is disabled).

Specification Method

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options expression**

Command line: *speed=expression*

Example

To perform a multiplication:

(C/C++ program)

```
long a,b;
char c;
void main()
{
    a=b*c;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_main:

      MOV.B         @_c:32,R0L
      EXTS.W        R0
      EXTS.L        ER0
      MOV.L         @_b:32,ER1
      JSR           @$MULL$3:24





      MOV.L         ER0,@_a:32

      RTS
```

Specified

```
_main:
      STM.L         (ER2-ER3),@-SP
      MOV.B         @_c:32,R0L
      EXTS.W        R0
      EXTS.L        ER0
      MOV.L         @_b:32,ER1
      MOV.W         E0,R2
      MULXU.W       R1,ER2
      MOV.W         E1,R3
      MULXU.W       R0,ER3
      MULXU.W       R1,ER0
      ADD.W         R2,E0
      ADD.W         R3,E0
      MOV.L         ER0,@_a:32
      LDM.L         @SP+,(ER2-ER3)
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	32	26	32	26	38
Specified	52	46	48	42	46

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	30	30	24
Specified	30	30	24

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	63	57	180	168	410
Specified	54	50	266	248	366

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	18	18	17
Specified	18	18	17

5.4.8 Allocating Registers to Global Variables

Size	Δ	Speed	Δ

Description

When frequently-used external variables are allocated to registers, the access codes are shortened.

Note that external variables that are not optimized, such as I/O variables, cannot be allocated to registers.

Registers where external variables can be allocated to are shown below:

ER4	E4	R4H	R4L
ER5	E5	R5H	R5L

For the CPU of 300, R4 and R5 can be used.

[Format]

#pragma global_register (<variable name>=<register name>[,<variable name>=<register name>...])

Example

To assign 1-byte and 2-byte data to registers:

(C/C++ program)

```
#pragma global_register (a=R4,b=R5L)
int a; char b;
void func();
void main()
{
    a=10;
    b=20;
    func();
}
void func()
{
    a++;
    b-=2;
}
```

(Assembly expansion code)

Not specified

```
_main:
    MOV.W       #10,R0
    MOV.W       R0,@_a:32
    MOV.B       #20,R0L
    MOV.B       R0L,@_b:32
_func:
    MOV.L       #_a,ER0
    MOV.W       @ER0,R1
    INC.W       #1,R1
    MOV.W       R1,@ER0
    MOV.L       #_b,ER0
    MOV.B       @ER0,R1L
    ADD.B       #-2,R1L
    MOV.B       R1L,@ER0
    RTS
    .SECTION    B,DATA,ALIGN=2
_a:.RES.W      1
_b:.RES.B      1
```

Specified

```
_main:
    MOV.W       #10,R4
    MOV.B       #20,R5L
_func:
    INC.W       #1,R4
    ADD.B       #-2,R5L
    RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	52	40	48	40	40
Specified	20	20	16	16	16

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	38	36	28
Specified	18	16	16

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	37	30	70	60	60
Specified	15	14	26	24	24

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	21	21	18
Specified	12	12	12

Notes

(a) This option can be used for variable definitions and variable declarations after the #pragma global_register is declared.
(b) This option can be used for simple-type or pointer-type global variables. It cannot be used for double-type variables.
(c) The initial value cannot be specified. In addition, addresses cannot be referenced.
(d) Referencing a specific variable from a link destination (without a register specification in the file) is not guaranteed.
(e) Specifications or references in interrupt functions are not guaranteed.
(f) Variables and registers cannot be specified in duplicate. This option cannot be specified together with the #pragma abs8 or #pragma abs16 declaration.

When this option is specified, the inter-module optimization cannot be performed for libraries. Exclude all library functions from inter-module optimization objects, as described below:

[For PC]

<HEW1.2>

Delete directories having the same name as the library decompressed at its inter-module optimization.

<HEW2.0 or later>

With preinclude option in the Standard Library tag for Standard Library Generator, specify include to the header file containing #pragma global_register declaration.

[For UNIX]

Modify the name of directories having the same name as the library.

5.4.9 Controlling Output of Register Save/Restore Codes at Function Entry/Exit Points

Size	O	Speed	O

Description

For all functions, the compiler saves registers to be used in the function at the function entry point and restores them at the function exit point.

When register save/restore processings are controlled with this option, the size of register save/restore codes can be reduced for the main function or a function including function calls only.

When the #pragma regsave is specified, all registers are saved/restored. Registers guaranteeing values before and after function calls are not assigned.

When the #pragma noregsave is specified, register save/restores are disabled regardless of whether registers are used in the function or not.

[Format]

#pragma regsave (<function-name>[,…])

#pragma noregsave (<function-name>[,…])

Example

To call the function *noregf* from the function *regf*:

(C/C++ program)

Not specified

```
void regf();
void noregf(int);
void func();

extern int X,Y,Z,XX;
void regf(void)
{
    int A=X;
    Y=A;
    noregf(X);
    Z=A;
}
void noregf(int P)
{
    int B=P;
    Y=B;
    func(X);
    Z=B;
}
```

Specified

```
#pragma regsave (regf)
#pragma noregsave (noregf)
void regf();
void noregf(int);
void func();

extern int X,Y,Z,XX;
void regf(void)
{
    int A=X;
    Y=A;
    noregf(X);
    Z=A;
}
void noregf(int P)
{
    int B=P;
    Y=B;
    func(X);
    Z=B;
}
```

(Assembly expansion code)

Not specified

```
_regf:
      PUSH.W      R6
      MOV.W       @_X:32,R6
      MOV.W       R6,@_Y:32
      MOV.W       R6,R0
      BSR         _noregf:8
      MOV.W       R6,@_Z:32
      POP.W       R6
      RTS
_noregf:
      PUSH.W      R6
      MOV.W       R0,R6
      MOV.W       R6,@_Y:32
      MOV.W       @_X:32,R0
      JSR         @_func:24
      MOV.W       R6,@_Z:32
      POP.W       R6
      RTS
```

Specified

```
_regf:
      STM.L       (ER2-ER3),@-SP
      STM.L       (ER4-ER6),@-SP
      MOV.W       @_X:32,R6
      MOV.W       R6,@_Y:32
      MOV.W       R6,R0
      PUSH.W      R6
      BSR         _noregf:8
      POP.W       R6
      MOV.W       R6,@_Z:32
      LDM.L       @SP+,(ER4-ER6)
      LDM.L       @SP+,(ER2-ER3)
      RTS
_noregf:
      MOV.W       R0,R6
      MOV.W       R6,@_Y:32
      MOV.W       @_X:32,R0
      JSR         @_func:24
      MOV.W       R6,@_Z:32
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	66	52	66	52	52
Specified	80	66	68	54	54

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	68	66	52
Specified	78	76	62

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	66	54	132	108	108
Specified	91	79	266	232	190

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	46	43	38
Specified	60	58	60

5.4.10 Specifying Inline Expansion of Functions

Size	X	Speed	O

Description

When the inline expansion is specified, the expansion is performed within the calling function but the function is not called, and then the execution speed is improved.

There are the following two ways to specify the inline expansion:

(1) Specifying with an expansion function

[Format]

#pragma inline (<function-name>[,…])

(2) Specifying with an option

Dialog menu: **C/C++ Tab Category: [Optimize] Speed sub-options: Maximum nodes of inline function**

Command line: *speed=inline[=(node)]*

When a function is called, normally, the JSR or BSR instruction is output. However, when the inline expansion is specified, codes are expanded directly at the location where a function is called. Therefore, the JSR or BSR instruction at calling a function and the RTS instruction at returning from a function are not output, which improves the execution speed.

Example

To perform the inline expansion of the function *func*:

(C/C++ program)

Specification in the #pragma statement

```
#pragma inline func
int a,b;
void func()
{
    a+=b;
}
void main()
{
    a=0;
    func();
}
```

(Assembly expansion code)

Not specified

```
_func:
      MOV.W       @_b:32,R0
      MOV.L       #_a,ER1
      MOV.W       @ER1,E0
      ADD.W       R0,E0
      MOV.W       E0,@ER1
      RTS
_main:
      SUB.W       R0,R0
      MOV.W       R0,@_a:32
      BRA         _func:8
```

Specified

```
_func:
      MOV.W       @_b:32,R0
      MOV.L       #_a,ER1
      MOV.W       @ER1,E0
      ADD.W       R0,E0
      MOV.W       E0,@ER1
      RTS
_main:
      SUB.W       E0,E0
      MOV.W       @_b:32,R0
      ADD.W       R0,E0
      MOV.W       E0,@_a:32
      RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	32	24	30	24	24
Specified	36	26	38	30	30

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	22	22	16
Specified	28	28	20

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	25	20	48	40	40
Specified	13	10	30	24	24

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	16	16	15
Specified	11	11	10

Remarks and Notes

(1) The #pragma inline statement should be specified before the function is defined.

If the optimization is not specified, this specification is unavailable, however, the #pragma specification is available.

The inline expansion is not performed for the following functions:

- Functions including variable parameters
- Functions referencing addresses of parameters
- Functions in which the type of a real parameter and that of a dummy parameter do not match.
- Functions calling inline-expanded functions
- Functions that exceed the size limitation of the inline expansion

(2) When a function is specified as static, the function is expanded only in the called side, which improves size efficiency. In this case, the inline-expanded function is used only in the same file.

5.4.11 Using 8-Bit Absolute Address Area

Size	O	Speed	O

Description

The H8S or H8/300 Series provide an 8-bit absolute address area. When byte data frequently accessed are allocated to this area, those data can be accessed in the 8-bit absolute address format, which improves ROM efficiency, RAM efficiency, and the execution speed, compared with accessing normally in the absolute address format.

There are the following two ways to specify the 8-bit absolute address area:

(1) Specifying with an expansion function

[Format]

#pragma abs8 (<variable or structure-name, array-name>[,…])

(2) Specifying with an option

Dialog menu: **C/C++ Tab Category: [Optimize] Data access @aa:8**

Command line: *abs8*

When the #pragma abs8 is specified, variables to be accessed in the 8-bit absolute address format can be specified.

When this is specified using the option format, all 1-byte data in the file are set to be accessed in the 8-bit absolute address format.

The following lists the range of 8-bit absolute address area for each CPU/operation mode:

CPU Type	Address Space Size	8-Bit absolute Absolute Address Area
H8SX maximum mode	32	H'FFFFFF00 to H'FFFFFFFF
H8SX advanced mode	28	H'FFFFF00 to H'FFFFFFF
H8SX middle mode	24	H'FFFF00 to H'FFFFFF
H8S/2600 advanced mode	20	H'FFF00 to H'FFFFF
H8S/2000 advanced mode		
H8/300H advanced mode		
H8SX normal mode	16	H'FF00 to H'FFFF
H8S/2600 normal mode		
H8S/2000 normal mode		
H8/300H normal mode		
H8/300		

Example

To access the variables *a*, *b*, and *c* allocated in the 8-bit absolute address area:

(C/C++ program)

Specification using the #pragma statement

```
#pragma abs8 (a,b,c)

const char a=1;
      char b=1;
      char c;
void func(void)
{
    c=b=a;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_func:
    MOV.B       #1,R0L
    MOV.B       R0L,@_b:32
    MOV.B       R0L,@_c:32
    RTS
    .SECTION    C,DATA,ALIGN=2
_a: .DATA.B     H'01
    .SECTION    D,DATA,ALIGN=2
_b: .DATA.B     H'01
    .SECTION    B,DATA,ALIGN=2
_c: .RES.B      1
```

Specified

```
_func:
    MOV.B       #1,R0L
    MOV.B       R0L,@_b:8
    MOV.B       R0L,@_c:8
    RTS
    .SECTION    $ABS8C,DATA,ALIGN=2
_a: .DATA.B     H'01
    .SECTION    $ABS8D,DATA,ALIGN=2
_b: .DATA.B     H'01
    .SECTION    $ABS8B,DATA,ALIGN=2
_c: .RES.B      1
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	18	14	18	14	14
Specified	10	10	10	10	10

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	16	16	12
Specified	10	10	10

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	14	11	28	22	22
Specified	10	9	20	18	18

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	10	10	10
Specified	9	9	9

Remarks and Notes

The #pragma abs8 cannot be specified for data that have previously been declared.

This specification is valid only for 1-byte external variables.

At linkage, sections starting with $ABS8 are allocated to the 8-bit absolute address area.

5.4.12 Using 16-Bit Absolute Address Area

Size	O	Speed	O

Description

The H8S or H8/300 Series provide a 16-bit absolute address area. When byte data frequently accessed are allocated to this area, those data can be accessed in the 16-bit absolute address format, which improves ROM efficiency, RAM efficiency, and the execution speed, compared with accessing normally in the absolute address format.

There are the following two ways to specify the 16-bit absolute address area:

(1) Specifying with an expansion function

[Format]

#pragma abs16 (<variable or structure-name, array-name >[,…])

(2) Specifying with an expansion option

Dialog menu: **C/C++ Tab Category: [Optimize] Data access @aa:16**

Command line: *abs16*

When the #pragma abs16 is specified, variables to be accessed in the 16-bit absolute address format can be specified. When this is specified using the option format, all data in the file are set to be accessed in the 16-bit absolute address format.

The following lists the range of 16-bit absolute address area for each CPU/operation mode:

CPU Type	Address Space Size	16-Bit Absolute Address Area
H8SX maximum mode	32	0 to H'7FFF, H'FFFF0000 to H'FFFFFFFF
H8SX advanced mode	28	0 to H'7FFF, H'FFF0000 to H'FFFFFFF
H8SX middle mode	24	0 to H'7FFF, H'FF0000 to H'FFFFFF
H8S/2600 advanced mode H8S/2000 advanced mode H8/300H advanced mode	20	0 to H'7FFF, H'F0000 to H'FFFFF

Example

To access the variables *a*, *b*, and *c* allocated in the 16-bit absolute address area:

(C/C++ program)

Specification using the #pragma statement

```
#pragma abs16 (a,b,c)
const int a=1;
      int b=1;
      int c;

void func(void)
{
    c=b=a;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_main:
    MOV.W     #1,R0
    MOV.W     R0,@_b:32
    MOV.W     R0,@_c:32
    RTS
    .SECTION  C,DATA,ALIGN=2
_a:
    .DATA.W   H'0001
    .SECTION  D,DATA,ALIGN=2
_b:
    .DATA.W   H'0001
    .SECTION  B,DATA,ALIGN=2
_c:
    .RES.W    1
```

Specified

```
_main:
    MOV.W     #1,R0
    MOV.W     R0,@_b:16
    MOV.W     R0,@_c:16
    RTS
    .SECTION  $ABS16C,DATA,ALIGN=2
_a:
    .DATA.W   H'0001
    .SECTION  $ABS16D,DATA,ALIGN=2
_b:
    .DATA.W   H'0001
    .SECTION  $ABS16B,DATA,ALIGN=2
_c:
    .RES.W    1
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	22	18	22	18	18
Specified	18	18	18	18	18

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	18	18	14
Specified	14	14	14

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Not specified	15	12	30	24	24
Specified	13	12	26	24	24

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	10	10	9
Specified	9	9	9

Remarks and Notes

This specification is valid only with the CPU/operation mode, H8SXX, H8SXA, H8SXM, 2600a, 2000a, or 300ha.

The #pragma abs16 cannot be specified for data that have previously been declared.

This specification is valid only for external variables.

The name of the section to which data are output can be modified with the #pragma statement.

At linkage, sections starting with $ABS16 are allocated to the 16-bit absolute address area.

5.4.13 Using Indirect Memory Format

Size	O	Speed	X

Description

When frequently-used functions are accessed in the indirect memory format, ROM efficiency is improved. If a function address is stored in the indirect memory area at linkage, the function is called in the indirect memory format when it is called. In this case, the execution speed is lowered but the program size is reduced because the function can be called with a short instruction.

There are the following two ways to specify the indirect memory format:

(1) Specifying with an expansion function

[Format]

#pragma indirect (<function name>[(vect=<vector number>)][,…])
__indirect[(vect=<vector number>)] <type specifier> <function name>
<type specifier> __indirect[(vect=<vector number>)] <function name>

(2) Specifying with an option

Dialog menu: **C/C++ Tab Category: [Optimize] Function call: @@aa:8**

Command line : *indirect=Normal*

The indirect memory address area is the range from 00 to FF.

Specifying include to the include file indirect.h, all run-time routines to be used are called in the indirect memory format.

In addition, each run-time routine can be called in the indirect memory format individually.

Example

To call the function *func* in the indirect memory format:

(C/C++ program)

Specifying in the #pragma statement

```
#pragma indirect func
extern void func(int, int);
extern int a,b,c;
int d;
void main(void)
{
    b=0;
    func(a,b);
    func(b,c);
    func(c,a);
    d=c;
}
```

◄— specifies #pragma indirect

(Compiled result of assembly expansion code)

Not specified

```
_main:
    PUSH.L      ER6
    SUB.W       R0,R0
    MOV.W       R0,@_b:32
    MOV.W       R0,E0
    MOV.W       @_a:32,R0
    JSR         @_func:24
    MOV.L       #_c,ER6
    MOV.W       @ER6,E0
    MOV.W       @_b:32,R0
    JSR         @_func:24
    MOV.W       @_a:32,E0
    MOV.W       @ER6,R0
    JSR         @_func:24
    MOV.W       @ER6,R6
    MOV.W       R6,@_d:32
    POP.L       ER6
    RTS
```

Specified

```
_main:
    PUSH.L      ER6
    SUB.W       R0,R0
    MOV.W       R0,@_b:32
    MOV.W       R0,E0
    MOV.W       @_a:32,R0
    JSR         @@$func:8
    MOV.L       #_c,ER6
    MOV.W       @ER6,E0
    MOV.W       @_b:32,R0
    JSR         @@$func:8
    MOV.W       @_a:32,E0
    MOV.W       @ER6,R0
    JSR         @@$func:8
    MOV.W       @ER6,R6
    MOV.W       R6,@_d:32
    POP.L       ER6
    RTS
```

Object Size Comparison [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	58	52	70	54	54
Specified	66	48	68	50	50

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	70	64	50
Specified	62	62	46

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	75	58	152	118	118
Specified	78	58	158	118	118

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	49	46	43
Specified	50	50	44

Remarks and Notes

The $INDIRECT section should be allocated to the memory area 00 to FF where can be accessed in the indirect memory format at linkage.

The indirect memory area is output to the "$INDIRECT" section. The section name can be modified using the #pragma indirect section statement.

5.4.14 Using Extended Indirect Memory Format

Size	O	Speed	X

Description

When frequently-used functions are accessed in the indirect memory format, ROM efficiency is improved. When the CPU is H8SX, the extended memory indirect addressing mode can be used additionally. This can also improve ROM efficiency.

There are the following two ways to specify the extended indirect memory format:

(1) Specifying with an expansion function

[Format]

__indirect_ex[(vect=<vector number>)] <type specifier> <function name>
<type specifier> __indirect_ex[(vect=<vector number>)] <function name>

(2) Specifying with an option

Dialog menu: **C/C++ Tab Category: [Optimize] Function call: @@vec:7**

Command line : *indirect=Extended*

[The address ranges of the extended indirect memory addressing]

H8SX Normal Mode: the Area from 0x0100 to 0x01FF
H8SX Other Modes: the Area from 0x0200 to 0x03FF

Example

To call the function *func* in the extended indirect memory format:

When vector number is not specified by **vect**, the function address are stored in the section "$EXINDIRECT" as the address table.

When vector number is specified, the section "$VECT***" as the address table is stored. In linkage, the Optimizing Linkage Editor allocates the secttion to the corresponding address automatically.

(C/C++ program)

Specifying in the key word

```
__indirect_ex void func(int, int);   ◀— specifies __indirect_ex
extern int a,b,c;
int d;
void main(void)
{
    b=0;
    func(a,b);
    func(b,c);
    func(c,a);
    d=c;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_main:
    STM.L       (ER2-ER3),@-SP
    SUB.W       E0,E0
    MOV.W       E0,@_b:32
    MOV.L       #_func,ER2
    MOV.W       @_a:32,R0
    JSR         @ER2
    MOV.W       @_b:32,R0
    MOV.L       #_c,ER3
    MOV.W       @ER3,E0
    JSR         @ER2
    MOV.W       @_a:32,E0
    MOV.W       @ER3,R0
    JSR         @ER2
    MOV.W       @ER3,@_d:32
    RTS/L       (ER2-ER3)
```

Specified

```
_main:
    PUSH.L      ER2
    SUB.W       E0,E0
    MOV.W       E0,@_b:32
    MOV.W       @_a:32,R0
    JSR         @@$$func:7
    MOV.W       @_b:32,R0
    MOV.L       #_c,ER2
    MOV.W       @ER2,E0
    JSR         @@$$func:7
    MOV.W       @_a:32,E0
    MOV.W       @ER2,R0
    JSR         @@$$func:7
    MOV.W       @ER2,@_d:32
    RTS/L       ER2
```

Object Size Comparison [byte]

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	82	76	58
Specified	74	74	54

Execution Speed Comparison [cycle]

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	61	58	55
Specified	62	62	56

Remarks and Notes

When vector number is not specified, the $EXINDIRECT section should be allocated to the memory area where can be accessed in the extended indirect memory format at linkage.

The extended indirect memory area is output to the "$EXINDIRECT" section. The section name can be modified using the #pragma indirect section statement.

5.4.15 Specifying 2byte pointer

Size	O	Speed	O

Description

When frequently-used variables are allocated to the 16-bit absolute address area, size efficiency and execution speed are both improved. ABS16 option, which is specified by the ABS16 option or the #pragma abs16, allocates data to the 16-bit absolute address area.

This 2byte pointer option assumes the size of a pointer to data as two bytes.

There are the following two ways to specify this function:

(1) Specifying with an expansion function

[Format]

<type specifier> __ptr16 * <variable>

(2) Specifying with an option

Dialog menu: **C/C++ Tab Category: [Optimize] 2byte pointer**

Command line : *ptr16*

If this option is not specified, the size of the pointer indicating data is four bytes. If this option is specified and the data section is explicitly located in the 16-bit absolute address area, the size of the pointer indicating data is set to two bytes.

Example

To refer the variable *b* by the two bytes pointer:

(C/C++ program)

Specifying in key word

```
__abs16 int a;          ← specifies __abs16
int __ptr16 *b;         ← specifies __ptr16
int c;
void func(void);
void func(void)
{
    b = (int __ptr16 *)&a;
   *b = 10;
   c = *b;
}
```

(Compiled result of assembly expansion code)

Not specified

```
_func
          MOV.L       #_a:32,@_b:16
          MOV.L       @_b:16,ER0
          MOV.W       #10:8,@ER0
          MOV.L       @_b:16,ER0
          MOV.W       @ER0,@_c:16
          RTS
```

Specified

```
_func:
          MOV.L       #_a,ER1
          MOV.W       R1,@_b:16
          MOV.W       R1,R0
          EXTS.L      ER0
          MOV.W       #10:8,@ER0
          MOV.W       @_b:16,R0
          EXTS.L      ER0
          MOV.W       @ER0,@_c:16
          RTS
```

Object Size Comparison [byte]

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	36	36	24
Specified	34	34	24

Execution Speed Comparison [cycle]

	H8SX		
CPU Type	MAX	ADV	NML
Not specified	23	19	16
Specified	22	18	16

Remarks and Notes

This keyword is valid only with H8SX advanced mode and H8SX maximum mode.

This keyword must be specified before an indirection operator "*".

5.4.16 Boundary alignment value and boundary alignment

Size	O	Speed	O

Description

The **align** option relocates variables so as to reduce space by boundary alignment.

The **align=4** option divides a data section into a 4-byte boundary alignment section, a 2-byte boundary alignment section and a 1-byte boundary alignment section.
(align=4 is valid only with H8SX)

So size efficiency and execution speed are improved.*

Specification methods

Dialog menu: **C/C++ Tab Category: [Object] Group by alignment**

Command line : *ALign [=4] (Default is ALign)*
NOALign

Example

The explanations of data allocation order are as follows. They differ according to the option specification.

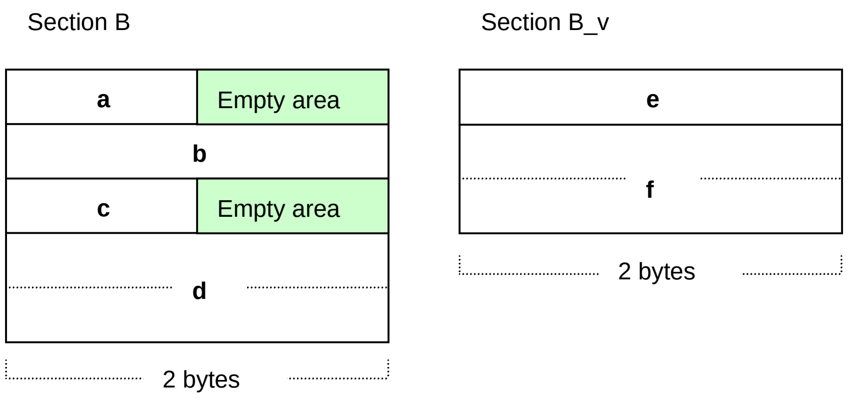
(C/C++ program)

```
char a;
short b;
char c;
long d;
#pragma section _v
short e;
long f;
#pragma section

void func(void)
{
    a = 127;
    b = 0x7fff;
    c = 30;
    d = 0x7fffffff;
    e = 0x1000;
    f = 0x1ffff;
}
```

(1) **noalign** specified

Data is located in the order of declaration to section B and section B_v.

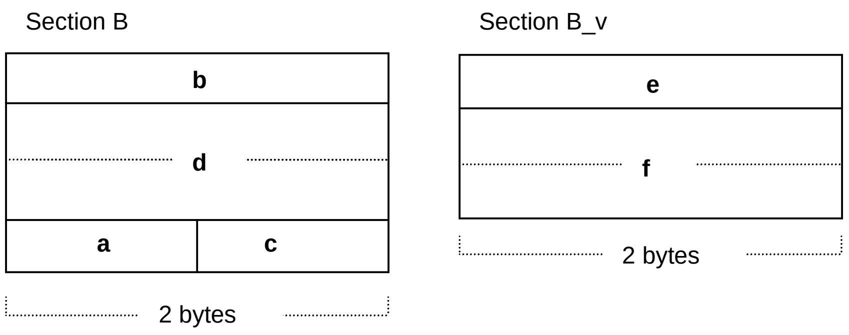
As follows, 2-byte-aligned data is always located at an even address, thus generating an empty area being unused after odd-size data.



(2) align specified

In order to minimize the empty area, 2-byte aligned data(short, long, float) is allocated before 1-byte aligned data to section B and section B_v.

Thus no empty area is generated as follows.



(3) **align**=4 specified

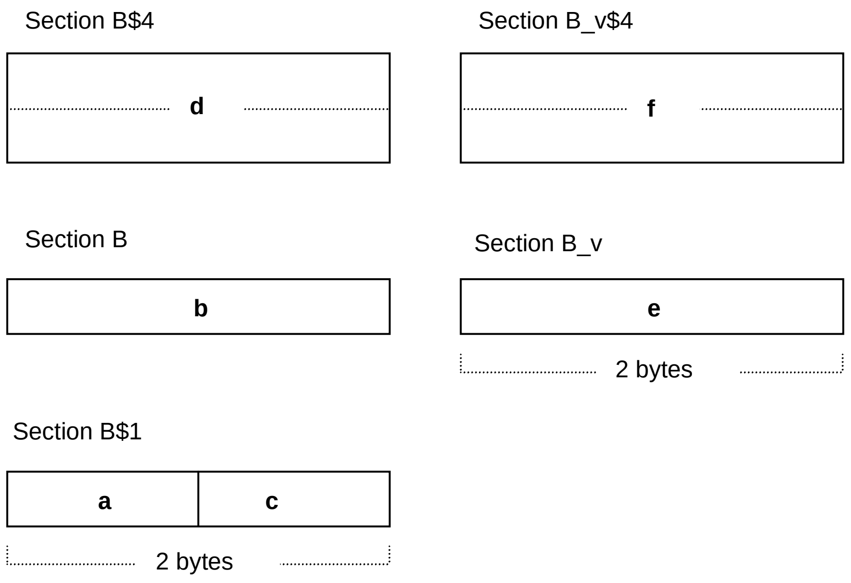
Data are categorized into the following 3 groups:

(a) data whose size is a multiple of 4
(b) data whose size is odd
(c) the others (data whose size is even but is not a multiple of 4)

And the section name is changed as follows, respectively.

(a) "$4" is appended after the original section name
(b) "$1" is appended after the original section name
(c) the section name is unchanged

When the CPU type is H8SX, the speed of access to a 4-byte data aligned on a 4-byte boundary address is improved.*



Section address allocation at align=4

To locate the 1-byte or 4-byte data section at specific addresses with **align=4** specified, each section needs to be explicitly specified with the **start** option of the optimizing linkage editor.

In HEW, Dialog menu: **Link/Library Tab Category: [Section]** is used.

Example

Allocate the section with $4 to a multiple of 4 addres.

Allocate the section with $1 in order to minimize the empty area.

Object Size Comparison [byte] (RAM size)

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	16	16	16	16	24
Specified	14	14	14	14	22

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	16	16	16
Specified	14	14	14

Execution Speed Comparison [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Not specified	45	38	90	76	156
Specified	45	38	90	76	156

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Not specified	28	28	24
Specified	27	26	23

Remarks and Notes

This option **align=4** is valid only with H8SX

Note: * Execution speed is improved only with H8SX.
Generally 4 bytes data is accessed by two accesses of word instruction. When a 4-byte data is aligned on a 4-byte boundary with **align=4** and bus width is 32-bits, H8SX can access a 4-bytes data by one access.
In 16-bits bus width, data is accessed by two accesses of word instruction. Thus the execution speed is not improved.

5.4.17 Explanation of Inter-Module Optimization Items

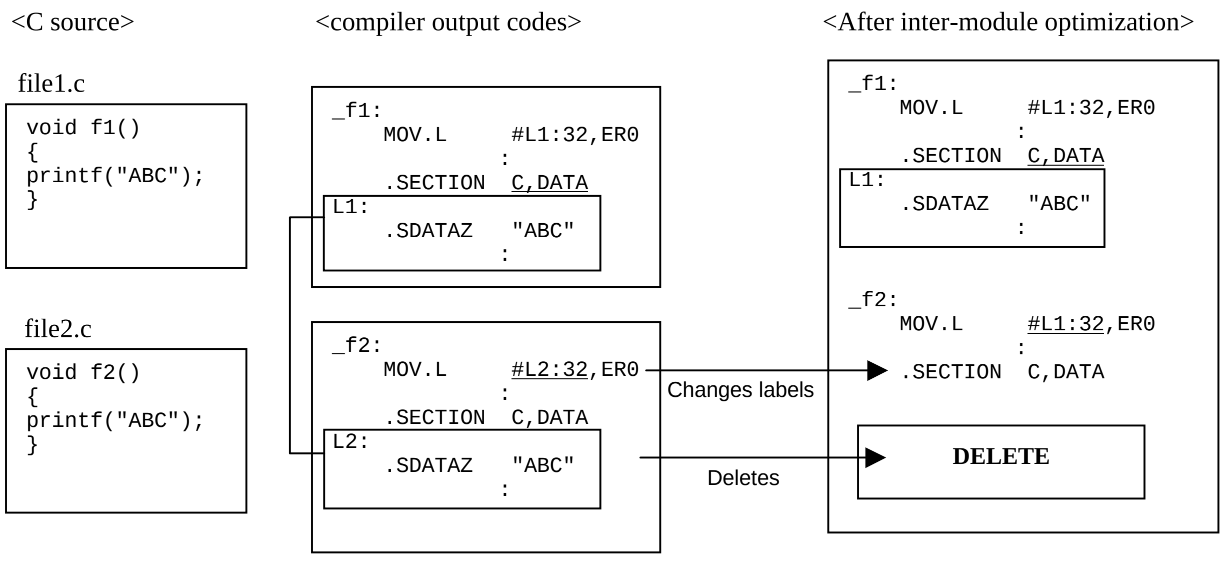
The inter-module optimizer supports the following optimization functions:

Description	Dialog Menu	Subcommand	Referenced Section
Unifies constants/strings	**Unify strings**	*String_Unify*	5.4.17(1)
Deletes unreferenced variables/functions	**Eliminate dead code**	*Symbol_delete*	5.4.17(2)
Optimizes access to variables	**Use short addressing**	*Variable_access*	5.4.17(3)
Optimizes access to functions	**Use indirect call/jump**	*Funcation_call*	5.4.17(4)
Optimizes register save/restore codes	**Reallocate registers**	*Register*	5.4.17(5)
Unifies instruction codes	**Eliminate same code**	*Same_code*	5.4.17(6)
Optimizes branch instructions	**Optimize branches**	*Branch*	5.4.17(7)

The following describes each optimization function.

(1) Unification of Constants/Strings

The same value constants and the same strings having the const attribute are unified across the modules. The following shows an example:



```
void f1()
{
printf("ABC");
}
```

```
void f2()
{
printf("ABC");
}
```

```
_f1:
    MOV.L      #L1:32,ER0
               :
    .SECTION   C,DATA
L1:
    .SDATAZ    "ABC"
               :
```

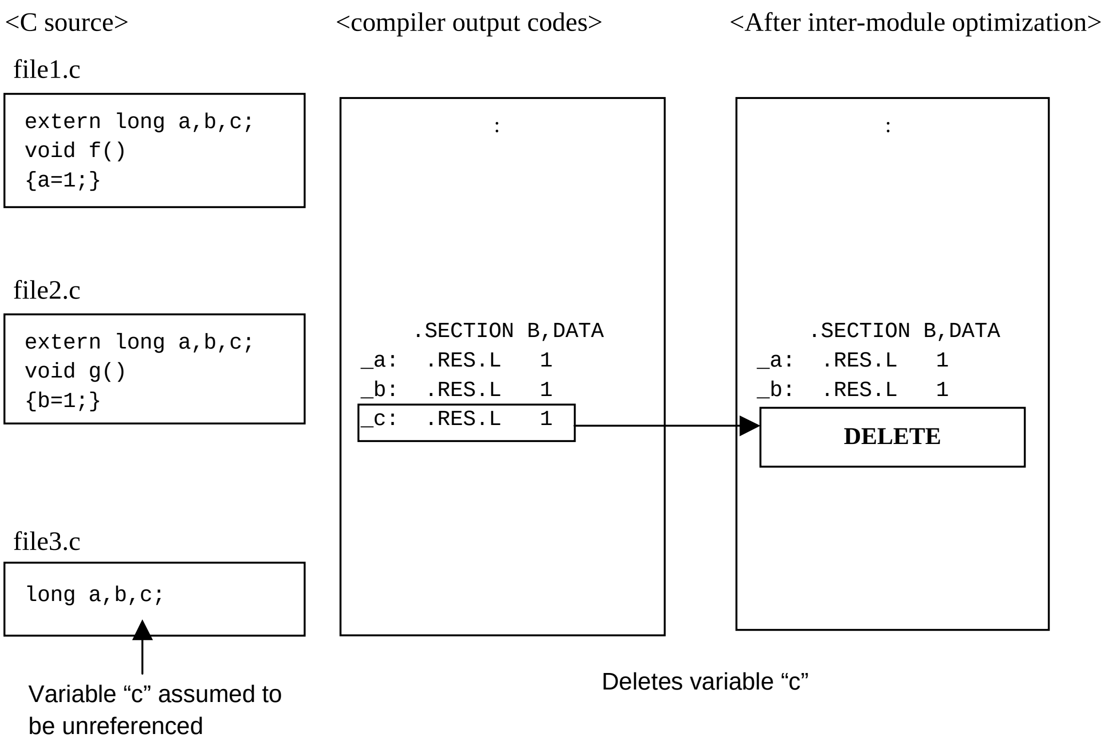
```
_f2:
    MOV.L      #L2:32,ER0
               :
    .SECTION   C,DATA
L2:
    .SDATAZ    "ABC"
               :
```

```
_f1:
    MOV.L      #L1:32,ER0
               :
    .SECTION   C,DATA
L1:
    .SDATAZ    "ABC"
               :

_f2:
    MOV.L      #L1:32,ER0
               :
    .SECTION   C,DATA
```

(2) Deletion of Unreferenced Variables/Functions

Variables/functions which are not referenced are deleted with this specification. When specifying this optimization, confirm to specify an entry function. Without an entry function, this optimization is not performed.

The following shows an example:



```
extern long a,b,c;
void f()
{a=1;}
```

```
extern long a,b,c;
void g()
{b=1;}
```

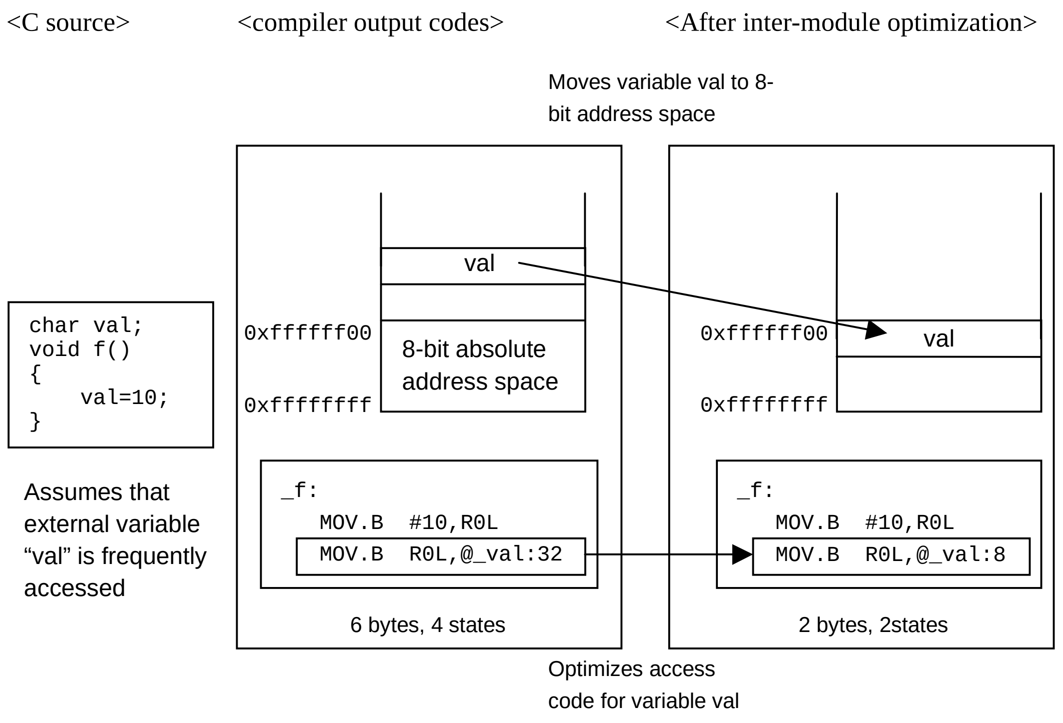
```
long a,b,c;
```

```
        :

   .SECTION B,DATA
_a:  .RES.L   1
_b:  .RES.L   1
_c:  .RES.L   1
```

```
        :

   .SECTION B,DATA
_a:  .RES.L   1
_b:  .RES.L   1
```

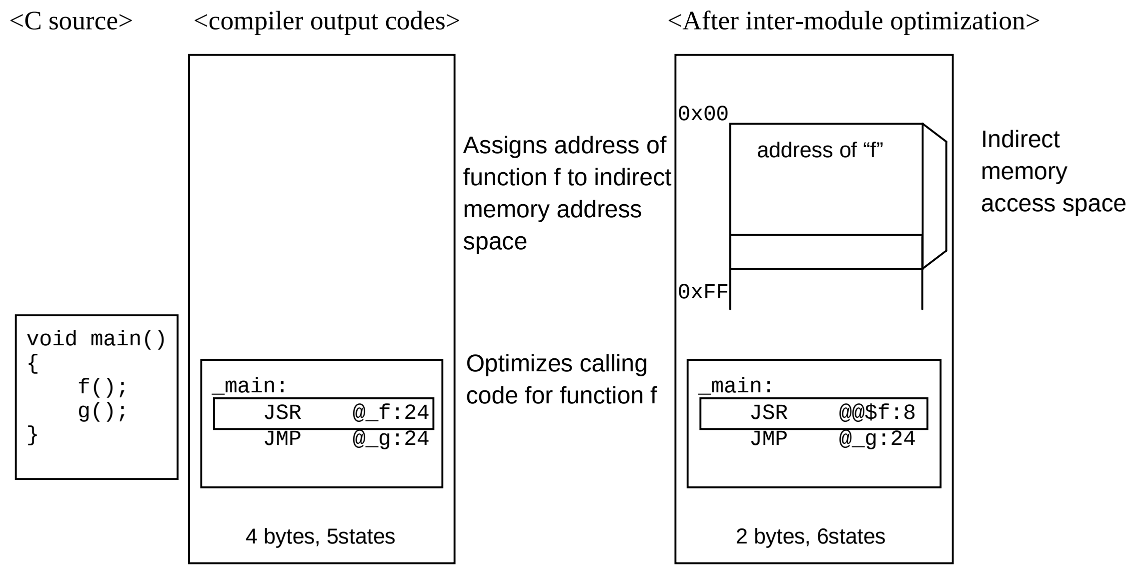
(3) Optimization of Access to Variables

If an area accessible in the 8- or 16-bit absolute addressing mode has space, frequently accessed variables are allocated, the optimization of the access codes for the variables are allocated, and the access codes of the variable are optimized by this specification.



(4) Optimization of Access to Functions

If the memory range from 0 to 0xFF has space, the optimization of assigning addresses of functions frequently accessed is performed.

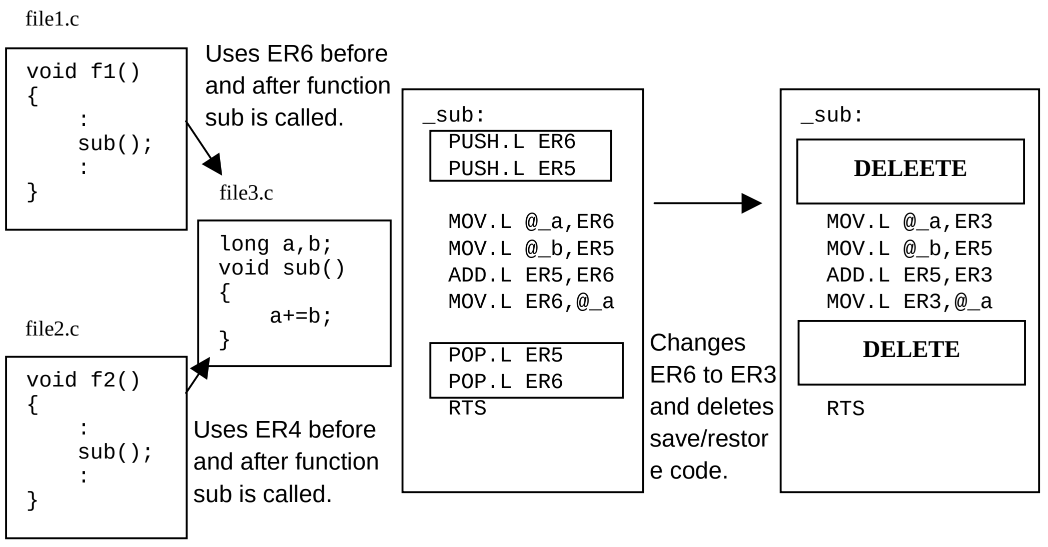


<C source>
<compiler output codes>
<After inter-module optimization>
void main()
{
f();
g();
}
_main:
JSR @_f:24
JMP @_g:24
4 bytes, 5states
Assigns address of function f to indirect memory address space
Optimizes calling code for function f
0x00
address of "f"
0xFF
Indirect memory access space
_main:
JSR @@$f:8
JMP @_g:24
2 bytes, 6states

(5) Reallocation of Registers

The relationships between function calls are analyzed and redundant register save/restore codes are deleted with this specification. In addition, depending on the register state before and after the function call, the register numbers to be used are modified.

<C source> <compiler output codes> <After inter-module optimization>


file1.c
Uses ER6 before and after function sub is called.
file3.c
file2.c
Uses ER4 before and after function sub is called.
Changes ER6 to ER3 and deletes save/restore code.
DELEETE
DELETE

```
file1.c
void f1()
{
    :
    sub();
    :
}

file2.c
void f2()
{
    :
    sub();
    :
}

file3.c
long a,b;
void sub()
{
    a+=b;
}
```

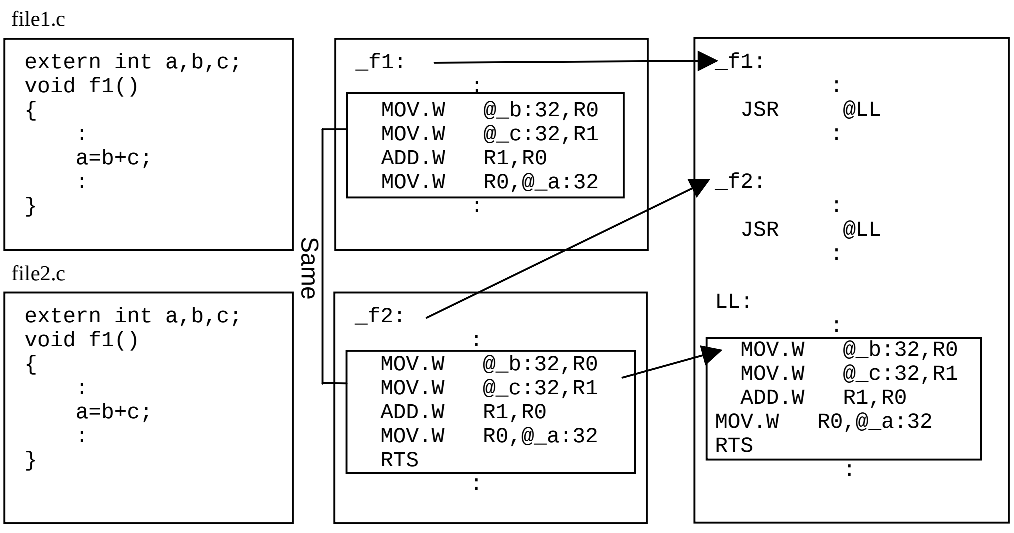
```
_sub:
  PUSH.L ER6
  PUSH.L ER5

  MOV.L @_a,ER6
  MOV.L @_b,ER5
  ADD.L ER5,ER6
  MOV.L ER6,@_a

  POP.L ER5
  POP.L ER6
  RTS
```

```
_sub:
    DELEETE
  MOV.L @_a,ER3
  MOV.L @_b,ER5
  ADD.L ER5,ER3
  MOV.L ER3,@_a
    DELETE
  RTS
```

(6) Unification of Common Code

Multiple strings representing the same instruction are unified into a subroutine and the code size is reduced with this specification.

<C source> <compiler output codes> <After inter-module optimization>



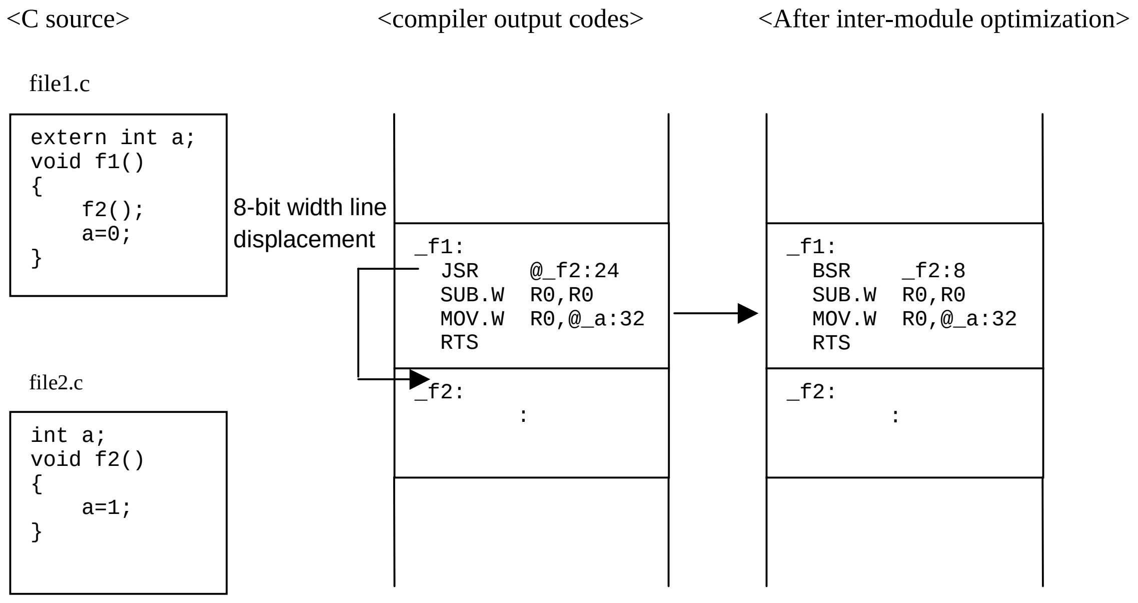
```
file1.c
extern int a,b,c;
void f1()
{
    :
    a=b+c;
    :
}

file2.c
extern int a,b,c;
void f1()
{
    :
    a=b+c;
    :
}
```

```
_f1:
             :
    MOV.W   @_b:32,R0
    MOV.W   @_c:32,R1
    ADD.W   R1,R0
    MOV.W   R0,@_a:32
             :

_f2:
             :
    MOV.W   @_b:32,R0
    MOV.W   @_c:32,R1
    ADD.W   R1,R0
    MOV.W   R0,@_a:32
    RTS
             :
```

```
_f1:
             :
   JSR      @LL
             :

_f2:
             :
   JSR      @LL
             :

LL:
             :
   MOV.W    @_b:32,R0
   MOV.W    @_c:32,R1
   ADD.W    R1,R0
MOV.W   R0,@_a:32
RTS
              :
```

(7) Optimization of Branch Instructions

Based on the program allocation information, the branch instruction size is optimized. If any other optimization item is executed, this optimization is always performed regardless of whether it is specified or not.



5.4.18 Disable of Inter-Module Optimization

The inter-module optimizer supports functions to disable a specific optimization function.

When this function is used for a program in which a specific optimization item should be disabled, detailed specification can be provided and then the disable of optimization is performed concisely.

The inter-module optimizer supports the following functions to disable optimization items:

Optimization-Disabled Item	Unit to Specify	Dialog Menu	Subcommand
Disables deletion of unreferenced symbols	Symbol name	**Elimination of dead code**	symbol_forbid
Disables elimination of same codes	Function Name	**Elimination of same code**	samecode_forbid
Disables allocation of short absolute address areas	Variable name	**Use of short addressing to**	variable_forbid
Disables indirect address calls	Function name	**Use of indirect call/jump to**	function_forbid
Disables register reallocations	Address[+size]	**Memory allocation**	absolute_forbid

Section 6   Efficient Programming Techniques

In addition to the optimization performed by the H8S and H8/300 C/C++ compiler, the performance of a program can further be improved by efficient programming techniques.

This section describes methods that the user might consider to create efficient programs.

(i) Rules for reducing program size

To reduce the program size, similar processing tasks should be commonly used and complex functions should be reviewed for potential improvement.

(ii) Rules for improving execution speed

The execution speed is largely a function of frequently executed statements and complex statements. The user should review the processing of these statements so that he or she can improve the program by focusing on critical points.

Because of compiler's optimization function, the actual execution speed may differ from the performance level determined on a priori basis. Improvements in performance should be pursued by employing a variety of techniques and by verifying the actual performance using the compiler.

In this section, the assembly language expansion code is supplied by assuming that the type of CPU used is the H8S/2600 Series running in the advanced mode. The assembly language expansion code provided in this section is subject to change as the compiler undergoes further improvements in its design.

The performance is measured under the following conditions.

[Cross Tools for Measurement]

H8S,H8/300 C/C++ Library Generator (Ver. 2.01.00.001)

H8S,H8/300 C/C++ Compiler (Ver. 6.01.00.009)

H8S,H8/300 Assembler (Ver. 6.01.01.000)

Optimizing Linkage Editor (Ver. 9.00.02.000)

[Option Specification]

Default options are used, when option specification methods are not described in each section.

[Measurement Conditions]

Conditions	**H8/300, H8/300H**	**H8S/2600,H8S/2000**	**H8SX**
Bus Width	16	16	32
Access State to Memory	2	1	1
Fetch Size	-	-	32

Following is a list of efficient programming techniques:

No.	Type	Item	Size	Speed	Referenced Section
1	Type declarations	Using 1-byte data types (char/unsigned char)	O	O	6.1.1
2		Using unsigned variables	O	O	6.1.2
3		Suppressing redundant type conversions	O	O	6.1.3
4		Using the const qualifier	O	O	6.1.4
5		Using consistent variable sizes	O	O	6.1.5
6		Specifying in-file functions as statics	O	–	6.1.6
7	Operations	Unifying common expressions	O	O	6.2.1
8		Improving the condition determination	O	O	6.2.2
9		Condition determination using substitution values	O	Δ	6.2.3
10		Using a suitable algorithm	O	O	6.2.4
11		Using formulas	O	O	6.2.5
12		Using local variables	O	O	6.2.6
13		Assigning an “f” to float-type constants	O	O	6.2.7
14		Specifying constants in shift operations	O	O	6.2.8
15		Using shift operations	O	O	6.2.9
16		Unifying consecutive ADD instructions	O	O	6.2.10
17	Loop processing	Selecting a Loop counter	O	O	6.3.1
18		Selecting a repeat control statement	O	O	6.3.2
19		Moving invariant expression from the inside to the outside of a loop	O	O	6.3.3
20		Merging loop conditions	O	O	6.3.4
21	Pointers	Using pointer variables	O	O	6.4.1
22	Data structures	Ensuring data compatibility	O	–	6.5.1
23		Techniques for data initialization	O	O	6.5.2
24		Unifying the initialization of array elements	O	O	6.5.3
25		Passing parameters as a structure address	O	O	6.5.4
26		Assigning structures to registers	O	O	6.5.5
27	Functions	Improving the program location in which functions are defined	–	O	6.6.1
28		Macro calls	O	O	6.6.2
29		Declaring a prototype	–	–	6.6.3
30		Optimization of tail recursions	O	O	6.6.4
31		Improving the way parameters are passed	O	O	6.6.5
32	Branches	Rewriting switch statements as tables	O	O	6.7.1
33		Coding a program in which case statements jump to the same label	O	O	6.7.2
34		Branching to a function coded directly below a given statement	O	O	6.7.3

Legend:
O: Higher efficiency   Δ: No change X: Lower efficiency –: Not applicable

6.1 Type Declarations

6.1.1 Using Byte Data Types (char/unsigned char)

Size	O	Speed	O	Stack size	Δ

Important Points

For improvements in ROM efficiency and execution speed, data that can be represented in 1-byte size should be declared as a char/unsigned char type.

Description

The H8S and H8/300 Series CPU provides an instruction set that can efficiently operate on byte-size data.

Therefore, both ROM efficiency and execution speed can be improved by declaring any byte-sized data as a char/unsigned char type before the data are used.

Example

Determine the logical product between the variable a and the constant 0x80, and store the result in the variable a.

(C language program before optimization)

```
int a;
void func(void)
{
    a&=0x80;
}
```

(C language program after optimization)

```
char a;
void func(void)
{
    a&=0x80;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      MOV.L       #_a,ER0
      MOV.W       @ER0,R1
      AND.W       #128,R1
      MOV.W       R1,@ER0
      RTS
_a:
     .RES.W      1
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.L       #_a,ER0
      MOV.B       @ER0,R1L
      AND.B       #-128,R1L
      MOV.B       R1L,@ER0
      RTS
_a:
      .RES.B      1
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	18	14	16	14	14
After	16	12	14	12	12

	H8SX		
CPU Type	MAX	ADV	NML
Before	12	12	10
After	10	10	8

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	15	12	28	24	24
After	14	11	26	22	22

	H8SX		
CPU Type	MAX	ADV	NML
Before	11	11	10
After	9	9	9

6.1.2 Using Unsigned Variables

Size	O	Speed	O	Stack size	Δ

Important Points

For improvements in both object efficiency and execution speed, any variable whose value is always positive should be declared as unsigned.

Description

When expanding a given data item into a larger data type, the compiler performs a sign expansion if the data item is signed data; if it is unsigned data, the compiler performs a zero expansion. Because the H8/300 series CPU does not have a data expansion instruction, for handling signed data the CPU requires a sign-determination object. For this reason, both ROM efficiency and execution speed can be improved by qualifying any variable whose value is always positive as an unsigned variable.

Notice that because the H8S and H8/300H CPUs are provided with a data expansion instruction, declaring a positive-value variable as an unsigned variable will have no effect on the performance of these CPUs.

Example

Expand the variable a into the int type; set the result to the variable b.

Following are the results of compiling the program on a 300 CPU:

(C language program before optimization)

```
char a;
int  b;
void func(void)
{
    b=a;
}
```

(C language program after optimization)

```
unsigned char a;
int  b;
void func(void)
{
    b=a;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      MOV.B       @_a:16,R0L
      BLD.B       #7,R0L
      SUBX.B      R0H,R0H
      MOV.W       R0,@_b:16
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.B       @_a:16,R0L
      SUB.B       R0H,R0H
      MOV.W       R0,@_b:16
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	16	12	16	12	14
After	16	12	16	12	12

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	16	16	12
After	16	16	12

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	14	11	28	22	24
After	14	11	28	22	22

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	11	11	10
After	11	11	10

6.1.3 Suppressing Redundant Type Conversions

Size	O	Speed	O	Stack size	Δ

Important Points

Both ROM efficiency and execution speed can be improved by ensuring that operations are performed between data items of the same size.

Description

Operations performed between data items of different sizes generate superfluous sign expansion instructions and zero expansion instructions, which causes a conversion of the smaller data type to the larger data type. Both ROM efficiency and execution speed can be improved by ensuring that the data items are of the same size.

Example

Add the variables a and b; set the results to the variable c.

(C language program before optimization)

```
unsigned char a;
         int  b,c;
void func(void)
{
    c=a+b;
}
```

(C language program after optimization)

```
int a,b,c;

void func(void)
{
    c=a+b;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      MOV.B       @_a:32,R0L
      EXTU.W      R0
      MOV.W       @_b:32,E0
      ADD.W       E0,R0
      MOV.W       R0,@_c:32
      RTS
_a:
      .RES.B      1
_b:
      .RES.W      1
_c:
      .RES.W      1
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.W       @_a:32,R0
      MOV.W       @_b:32,E0
      ADD.W       E0,R0
      MOV.W       R0,@_c:32
      RTS

_a:
      .RES.W      1
_b:
      .RES.W      1
_c:
      .RES.W      1
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	24	18	24	18	18
After	22	16	22	16	16

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	24	24	18
After	22	22	16

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	19	15	38	30	30
After	18	14	36	28	28

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	13	13	12
After	13	13	12

6.1.4 Using the const Qualifier

Size	O	Speed	O	Stack size	-

Important Points

Initialization data whose value remains unchanged should be const-qualified to save the RAM area.

Description

Data items that are initialized are often subject to change in values. These data items are allocated on the ROM during linking and copied into the RAM at the start of program execution, which causes them to be allocated in both ROM and RAM areas. Data items whose values remain unchanged throughout program execution can be const-qualified so that they are allocated only in a ROM area.

Example

Allocate 5 bytes of initialization data.

(C language program before optimization)

```
unsigned char a[5]=
    {1, 2, 3, 4, 5};
```

(C language program after optimization)

```
const unsigned char a[5]=
           {1, 2, 3, 4, 5};
```

(Expanded into assembly language code; before optimization)

```
   .SECTION  D,DATA,ALIGN=2
_a:
   .DATA.B   H'01,H'02,H'03,H'04,H'05
```

(Expanded into assembly language code; after optimization)

```
  .SECTION  C,DATA,ALIGN=2
_a:
   .DATA.B   H'01,H'02,H'03,H'04,H'05
```

Remarks and Notes

The program, before optimization, requires the allocation of a data area of the size listed in the object size table in the RAM in addition to the ROM.

In the case of character string data, its output destination can be specified in an option.

[Specification method]

Dialog menu: **C/C++Tab Category: [Object] Store string data in: Const section | Data section**

Command option: *string=const* | *data*

The default is data output to the Const section.

6.1.5 Using Consistent Variable Sizes

Size	O	Speed	O	Stack size	Δ

Important Points

When making comparisons in a loop statement, use a uniform variable size to eliminate the need for expansion code and to reduce the resulting code size.

Description

When comparing one data item with another, the compiler first makes sure that these data items are of the same size. By coding the program in such a way that these data items are of the same size, the user can eliminate the need for expansion code and improve the speed.

Example

Call the function *func1* by looping.

(C language program before optimization)

```
extern char tb[5];
void sub(void)
{
    int i;
    for (i=0; i<2L; i++)
       func1(tb[i]);
}
```

(C language program after optimization)

```
extern char tb[5];
void sub(void)
{
    unsigned int i;
    for (i=0; i<2L; i++)
        func1(tb[i]);
}
```

(Expanded into assembly language code; before optimization)

```
_sub:
       PUSH.L      ER6
       SUB.W       R6,R6
L6:
       EXTS.L      ER6
       MOV.B       @(_tb:32,ER6),R0L
       JSR         @_func1:24
       INC.W       #1,R6
       EXTS.L      ER6
       CMP.L       #2,ER6
       BLT         L6:8
       POP.L       ER6
       RTS
```

(Expanded into assembly language code; after optimization)

```
_sub:
       PUSH.L      ER6
       SUB.W       R6,R6
L6:
       EXTU.L      ER6
       MOV.B       @(_tb:32,ER6),R0L
       JSR         @_func1:24
       INC.W       #1,R6

       CMP.W       #2,R6
       BLO         L6:8
       POP.L       ER6
       RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	34	30	40	34	50
After	34	28	36	26	28

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	32	30	26
After	32	30	24

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	59	50	124	102	378
After	59	49	116	86	90

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	43	43	41
After	43	43	37

6.1.6 Specifying In-File Functions as static Functions

Size	O	Speed	O	Stack size	O

Important Points

Functions that are used only within a file should be *static* specified.

Description

Functions that are *static* specified are deleted if they are not called by an external function. When specified for inline expansion, such functions are also deleted, which improves size efficiency.

Example

Specify a function for inline expansion.

Call the function *func* from the function *main*.

(C language program before optimization)

```
#pragma inline func
int a,b;
void func()
{
    a+=10;
}
void main()
{
    a=1;
    func();
    b=a;
}
```

(C language program after optimization)

```
#pragma inline func
int a,b;
static void func()
{
    a+=10;
}
void main()
{
    a=1;
    func();
    b=a;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
    MOV.L     #_a,ER0
    MOV.W     @ER0,R1
    ADD.W     #10,R1
    MOV.W     R1,@ER0
    RTS
_main:
    MOV.W     #11,R0
    MOV.W     R0,@_a:32
    MOV.W     R0,@_b:32
    RTS
```

(Expanded into assembly language code; after optimization)

```
_main:
    MOV.W     #11,R0
    MOV.W     R0,@_a:32
    MOV.W     R0,@_b:32
    RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	36	28	34	28	28
After	18	14	18	14	14

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	26	26	20
After	14	14	10

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	15	12	30	24	24
After	15	12	30	24	24

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	10	10	8
After	10	10	8

6.2 Operations

6.2.1 Unifying Common Expressions

Size	O	Speed	O	Stack size	O

Important Points

Both ROM efficiency and execution speed can be improved by unifying common components in multiple arithmetic expressions.

Description

If common expressions occur in multiple expressions, the results of the operation on the first expression should be used in the second and subsequent expressions, which reduces the number of arithmetic operations performed. This improves both ROM efficiency and execution speed.

If a common expression occurs three or more times in a local variable, the compiler performs optimization.

Example

Add the variables *x*, *y*, and *z*; store the results in the variable *a*. Similarly, add variables *x*, *y*, and *w*; store the results in the variable *b*.

(C language program before optimization)

```
unsigned char a,b,w,x,y,z;
void func(void)
{
    a=x+y+z;
    b=x+y+w;
}
```

(C language program after optimization)

```
unsigned char a,b,w,x,y,z;
void func(void)
{
    unsigned char tmp;
    tmp=x+y;
    a=tmp+z;
    b=tmp+w;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      MOV.B       @_x:32,R1L
      MOV.B       @_y:32,R0H
      ADD.B       R1L,R0H
      MOV.B       R0H,R1H
      MOV.B       @_z:32,R0L
      ADD.B       R0L,R0H
      MOV.B       R0H,@_a:32
      MOV.B       @_w:32,R0L
      ADD.B       R0L,R1H
      MOV.B       R1H,@_b:32
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.B       @_x:32,R0H
      MOV.B       @_y:32,R0L
      ADD.B       R0L,R0H
      MOV.B       @_z:32,R0L
      ADD.B       R0H,R0L
      MOV.B       R0L,@_a:32
      MOV.B       @_w:32,R0L
      ADD.B       R0L,R0H
      MOV.B       R0H,@_b:32
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	44	32	46	34	34
After	46	34	44	32	32

	H8SX		
CPU Type	MAX	ADV	NML
Before	44	44	32
After	46	46	34

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	32	25	66	52	52
After	33	26	64	50	50

	H8SX		
CPU Type	MAX	ADV	NML
Before	21	21	19
After	22	22	19

Remarks and Notes

Although the compiler performs the optimization by unifying the common expressions for local variables, it does not perform that for external variables.

6.2.2 Improving the Condition Determination

Size	O	Speed	O	Stack size	Δ

Important Points

ROM efficiency can be improved by evaluating similar condition expressions in one operation.

Description

Similar condition expressions should be evaluated in on operation to reduce the number of times condition determination and condition expressions are evaluated. This improves both ROM efficiency and execution speed.

Example

Determine the logical product of variables *a* and *b*; return the results to the calling function.

(C language program before optimization)

```
unsigned char a,b;
unsigned char func(void)
{
    if (!a)    return(0);
    if (a&&!b) return(0);
    return(1);
}
```

(C language program after optimization)

```
unsigned char a,b;
unsigned char func(void)
{
    if (a&&b) return(1);
    else      return(0);
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      MOV.B       @_a:32,R0H
      BNE         L6:8
      SUB.B       R0L,R0L
      RTS
L6:  MOV.B       R0H,R0H
      BEQ         L7:8
      MOV.B       @_b:32,R0L
      BEQ         L8:8
L7:  MOV.B       #1,R0L
L8:  RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.B       @_a:32,R0L
      BEQ         L5:8
      MOV.B       @_b:32,R0L
      BEQ         L5:8
      MOV.B       #1,R0L
      RTS
L5:  SUB.B       R0L,R0L
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	26	22	30	24	24
After	26	22	26	20	20

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	26	26	22
After	26	26	22

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	18	15	42	36	36
After	18	15	36	30	30

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	15	15	14
After	15	15	14

Remarks and Notes

The execution speed is measured by assuming that *a*=1 and *b*=1.

6.2.3 Condition Determination Using Substitution Values

Size	O	Speed	O	Stack size	Δ

Important Points

When a substitution value is used in a condition expression for a determination statement, ROM efficiency can be improved by treating the assignment statement as a condition determination statement.

Description

The code size can be significantly reduced by performing the determination and substitution of a condition expression simultaneously.

Example

Copy character string *s*.

(C language program before optimization)

```
char *s,*d;
void func(void)
{
    while(*s){
        *d++ = *s++;
    }
    *d++ = *s++;
}
```

(C language program after optimization)

```
char *s,*d;
void func(void)
{
    while(*d++ = *s++);
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      STM.L       (ER4-ER5),@-SP
      MOV.L       #_s,ER5
      MOV.L       #_d,ER4
      BRA         L7:8
L6:   MOV.B       @ER0+,R1L
      MOV.L       ER0,@ER5
      MOV.L       @ER4,ER0
      MOV.B       R1L,@ER0
      MOV.L       @ER4,ER0
      INC.L       #1,ER0
      MOV.L       ER0,@ER4
L7:   MOV.L       @ER5,ER0
      MOV.B       @ER0,R1L
      BNE         L6:8
      MOV.B       @ER0+,R1L
      MOV.L       ER0,@ER5
      MOV.L       @ER4,ER0
      MOV.B       R1L,@ER0
      MOV.L       @ER4,ER0
      INC.L       #1,ER0
      MOV.L       ER0,@ER4
      LDM.L       @SP+,(ER4-ER5)
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      STM.L       (ER4-ER5),@-SP
      MOV.L       #_s,ER5
      MOV.L       #_d,ER4
L5:   MOV.L       @ER5,ER0
      MOV.B       @ER0+,R1L
      MOV.L       ER0,@ER5
      MOV.L       @ER4,ER0
      INC.L       #1,ER0
      MOV.L       ER0,@ER4
      MOV.B       R1L,@-ER0
      BNE         L5:8
      LDM.L       @SP+,(ER4-ER5)
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	80	62	74	54	54
After	52	32	44	36	34

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	70	70	56
After	52	52	32

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	59	48	232	84	84
After	45	26	218	74	74

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	37	43	31
After	26	27	20

6.2.4 Using a Suitable Algorithm

Size	O	Speed	O	Stack size	Δ

Important Points

Both ROM efficiency and execution speed can be improved by using mathematical techniques.

Description

If an arithmetic expression contains common terms, those terms should be factored out to reduce the number of arithmetic operations performed. This improves both ROM efficiency and execution speed.

Example

Solve a third-order equation.

(C language program before optimization)

```
unsigned char a,b,c,d,x,y;
void func(void)
{
    y=a*x*x*x+b*x*x+c*x+d;
}
```

(C language program after optimization)

```
unsigned char a,b,c,d,x,y;
void func(void)
{
    y=x*(x*(a*x+b)+c)+d;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      PUSH.W      R6
      MOV.B       @_x:32,R6L
      MOV.B       R6L,R0L
      MULXU.B     R6L,R0
      MOV.B       R0L,R6H
      MULXU.B     R6L,R0
      MOV.B       @_a:32,R0H
      MULXU.B     R0H,R0
      MOV.B       @_b:32,R1L
      MULXU.B     R6H,R1
      ADD.B       R1L,R0L
      MOV.B       @_c:32,R1L
      MULXU.B     R6L,R1
      ADD.B       R1L,R0L
      MOV.B       @_d:32,R0H
      ADD.B       R0H,R0L
      MOV.B       R0L,@_y:32
      POP.W       R6
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.B       @_x:32,R1L
      MOV.B       @_a:32,R0L
      MULXU.B     R1L,R0
      MOV.B       @_b:32,R0H
      ADD.B       R0H,R0L
      MULXU.B     R1L,R0
      MOV.B       @_c:32,R0H
      ADD.B       R0H,R0L
      MULXU.B     R1L,R0
      MOV.B       @_d:32,R0H
      ADD.B       R0H,R0L
      MOV.B       R0L,@_y:32
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	64	52	62	50	50
After	56	44	50	38	38

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	64	64	52
After	58	58	46

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	56	49	150	136	136
After	48	41	106	92	92

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	33	29	26
After	27	27	24

6.2.5 Using Formulas

Size	O	Speed	O	Stack size	Δ

Important Points

If an appropriate mathematical formula exists for a given arithmetic expression, both ROM efficiency and execution speed can be improved by using the formula.

Description

Use a mathematical formula to reduce the number of arithmetic operations required in an algorithm-oriented coding technique. This improves both ROM efficiency and execution speed.

Example

Calculate the sum of 1 through 100.

(C language program before optimization)

```
unsigned int s;
unsigned int n=100;
void func(void)
{
    unsigned int i;
    for (s=0,i=1;i<=n;i++)
        s+=i;
}
```

(C language program after optimization)

```
unsigned int s;
unsigned int n=100;
void func(void)
{
    s=n*(n+1)>>1;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      MOV.L       #_s:32,ER1
      SUB.W       R0,R0
      MOV.W       R0,@ER1
      MOV.W       #1:16,E0
      BRA         L7:8
L6:   MOV.W       @ER1,R0
      INC.W       #1,R0
      MOV.W       R0,@ER1
      INC.W       #1,E0
L7:   MOV.W       @_n:32,R0
      CMP.W       R0,E0
      BLS         L6:8
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.W       @_n:32,R1
      MOV.W       R1,R0
      INC.W       #1,R0
      MULXU.W     R1,ER0
      SHLR.W      R0
      MOV.W       R0,@_s:32
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	38	32	38	34	38
After	24	20	24	20	30

	H8SX		
CPU Type	MAX	ADV	NML
Before	36	36	30
After	24	24	20

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	1322	1118	2644	2438	2450
After	20	17	54	48	144

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	916	916	815
After	14	14	13

6.2.6 Using Local Variables

Size	O	Speed	O	Stack size	O

Important Points

In the case of temporary variables, loop counters, and so forth that can be used as local variables, both ROM efficiency and execution speed can be improved by declaring them as local variables.

Similarly, efficiency can be improved by assigning external variables that are common to multiple arithmetic expressions into local variables before operations are performed upon them.

Description

Because most local variables are assigned to registers, unlike external variables, the use of local variables can generate an object that does not contain data transfers between memory and registers.

In the case of variables that do not change values due to a function interrupt and other causes, those variables should be assigned to local variables before arithmetic operations are performed on them. This also improves both ROM efficiency and execution speed for the reasons stated above.

Example

Add the variable *a* to variables *b*, *c*, and *d*; store the results in the variables *b*, *c*, and *d*.

(C language program before optimization)

```
unsigned char a,b,c,d;
void func(void)
{
    b+=a;
    c+=a;
    d+=a;
}
```

(C language program after optimization)

```
unsigned char a,b,c,d;
void func(void)
{
    unsigned char wk;
    wk=a;
    b+=wk;
    c+=wk;
    d+=wk;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      STM.L       (ER2-ER3),@-SP
      MOV.L       #_a:32,ER3
      MOV.B       @ER3,R0L
      MOV.L       #_b:32,ER1
      MOV.B       @ER1,R2L
      ADD.B       R0L,R2L
      MOV.B       R2L,@ER1
      MOV.B       @ER3,R0L
      MOV.L       #_c:32,ER1
      MOV.B       @ER1,R2L
      ADD.B       R0L,R2L
      MOV.B       R2L,@ER1
      MOV.B       @ER3,R3L
      MOV.L       #_d:32,ER0
      MOV.B       @ER0,R1L
      ADD.B       R3L,R1L
      MOV.B       R1L,@ER0
      LDM.L       @SP+,(ER2-ER3)
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.B       @_a:32,R1H
      MOV.L       #_b:32,ER0
      MOV.B       @ER0,R1L
      ADD.B       R1H,R1L
      MOV.B       R1L,@ER0
      MOV.L       #_c:32,ER0
      MOV.B       @ER0,R1L
      ADD.B       R1H,R1L
      MOV.B       R1L,@ER0
      MOV.L       #_d:32,ER0
      MOV.B       @ER0,R1L
      ADD.B       R1H,R1L
      MOV.B       R1L,@ER0
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	50	36	60	50	50
After	50	36	48	40	40

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	32	32	24
After	32	32	24

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	36	28	156	64	64
After	36	28	56	48	48

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	20	20	18
After	20	20	18

Remarks and Notes

This technique is effective for the compilers before Ver.3.0.

Improvements with the compiler Ver.4.0 or higher made variables be assigned to registers, and therefore using local variables may expand the compiler the same assembly-language code.

Assembly expansion code, object size and execution speed in this section code the results of compiling by the compiler Ver.3.0 (other than H8SX).

In some cases, the local variable, to which an external variable is assigned, is not assigned to a register. Check the object list to determine which local variables are register-assigned.

6.2.7 Assigning an f to float-Type Constantss

Size	O	Speed	O	Stack size	O

Important Points

In the case of a floating-point arithmetic operation involving a constant that is within the allocable range of values for the float type (7.0064923216240862e-46f to 3.4028235677973364e+38f), assign the letter "f" following the numeric value to eliminate the possibility of a superfluous type conversion to the *double* type.

Description

Floating-point constants are normally treated as *double* type constants. If used directly, such constants are computed in the *double* type, which requires extensive operations. If the constant is a logarithmic constant whose value is within the range (7.0064923216240862e-46f to 3.4028235677973364e+38f), the letter "f" should be attached to the end of the constant so that it will be treated as a *float* type constant. This substantially reduces the number of instructions generated and improves ROM efficiency, RAM efficiency, as well as the execution speed.

Example

Assign the sum of the variable *b* and a constant to the variable *a*.

(C language program before optimization)

```
float a,b;
void func(void)
{
    a=b+1.0;
}
```

(C language program after optimization)

```
float a,b;
void func(void)
{
    a=b+1.0f;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      PUSH.L      ER2
      SUB.W       #16,R7
      MOV.L       @_b:32,ER1
      MOV.L       SP,ER0
      ADD.W       #8,R0
      JSR         @$FTOD$3:24
      MOV.L       ER0,ER1
      MOV.L       #L5,ER2
      MOV.L       SP,ER0
      JSR         @$ADDD$3:24
      JSR         @$DTOF$3:24
      MOV.L       ER0,@_a:32
      ADD.W       #16,R7
      POP.L       ER2
      RTS
L5:  .DATA.L   H'3FF00000,H'00000000
_a:  .RES.L      1
_b:  .RES.L      1
```

(Expanded into assembly language code; after optimization)

```
_func:
      MOV.L       @_b:32,ER0
      MOV.L       #1065353216,ER1
      JSR         @$ADDF$3:24
      MOV.L       ER0,@_a:32
      RTS
_a:   .RES.L    1
_b:   .RES.L    1
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	76	66	70	60	62
After	28	24	28	24	26

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	78	72	66
After	30	28	24

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	351	337	798	770	1076
After	124	119	260	250	352

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	259	260	261
After	96	97	103

6.2.8 Specifying Constants in Shift Operations

Size	O	Speed	O	Stack size	O

Important Points

For shift operations, if the shift count is a variable, the compiler calls a runtime routine to process the operation. If the shift count is a constant, the compiler does not call a runtime routine, which significantly improves the execution speed.

Description

If a constant is resolved, the compiler can process it directly.

Example

Shift the variable *data* by 8 bits.

(C language program before optimization)

```
int data;
int sht=8;
void func(void)
{
    data=data<<sht;
}
```

(C language program after optimization)

```
#define SHT 8
int data;
void func(void)
{
    data=data<<SHT;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
           MOV.L       #_data,ER0
           MOV.W       @_sht:32,R1
           JSR         @$DSLI$3:24
           RTS
_sht:
           .DATA.W     H'0008
_data:
           .RES.W      1
```

(Expanded into assembly language code; after optimization)

```
_func:
       MOV.B       @_data+1:32,R0H
       SUB.B       R0L,R0L
       MOV.W       R0,@_data:32
       RTS
_data:
       .RES.W      1
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	26	20	20	16	16
After	16	12	16	12	12

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	26	26	20
After	16	16	12

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	44	38	166	136	140
After	14	11	28	22	22

	H8SX		
CPU Type	MAX	ADV	NML
Before	14	14	12
After	11	11	10

6.2.9 Using Shift Operations

Size	O	Speed	O	Stack size	O

Important Points

In performing multiplication and addition operations, whenever possible use shift operations.

Description

Composite assignment operators (+=, -=, &=, |=. …and so forth) and shift operators are designed to take advantage of the performance characteristics of the CPU in which they are used. When used judiciously, these operators can reduce the code size and improve both size and speed. In particular, when multiplying a variable by a constant, the << (left shift operator) should be used.

Example

Assign the value of *data* three times to the variable *a*.

(C language program before optimization)

```
int data,a;
void main()
{
    a=data+data+data;
}
```

(C language program after optimization)

```
int data,a;
void main()
{
    a=(data<<1)+data;
}
```

(Expanded into assembly language code; before optimization)

```
_main:
    PUSH.L    ER6
    MOV.L     #_data:32,ER6
    MOV.W     @ER6,R0
    MOV.W     R0,R1
    ADD.W     R1,R0
    ADD.W     R1,R0
    MOV.W     R0,@_a:32
    POP.L     ER6
    RTS
```

(Expanded into assembly language code; after optimization)

```
_main:
    MOV.W     @_data:32,R0
    SHLL.W    R0
    MOV.W     @_data:32,R1
    ADD.W     R1,R0
    MOV.W     R0,@_a:32
    RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	30	22	30	22	22
After	24	18	24	18	18

	H8SX		
CPU Type	MAX	ADV	NML
Before	20	20	16
After	20	20	16

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	17	13	34	26	26
After	14	11	28	22	22

	H8SX		
CPU Type	MAX	ADV	NML
Before	12	12	11
After	13	13	12

Remarks and Notes

This technique can be used for the compilers before Ver.3.0.

Improvements with the compiler Ver.4.0 or higher made it possible to perform shift operations in multiplication and addition operations, and therefore the compiler expands the same assembly-language code.

Assembly expansion code, object size and execution speed in this section code the results of the compilation by the compiler Ver.3.0 (other than H8SX).

6.2.10 Unifying Consecutive ADD Instructions

Size	O	Speed	O	Stack size	Δ

Important Points

Addition should be coded consecutively to ensure unification and to reduce the code size.

Description

When encountering consecutive addition codes, the compiler performs a unification optimization. To take advantage of this optimization, whenever possible addition operations should be coded consecutively.

Example

Sum the value of the variable *a*.

(C language program before optimization)

```
int a,b;
void main()
{
    a+=10;
    b=10;
    a+=20;
}
```

(C language program after optimization)

```
int a,b;
void main()
{
    b=10;
    a+=10;
    a+=20;
}
```

(Expanded into assembly language code; before optimization)

```
_main:
     MOV.W       @_a:32,E0
     ADD.W       #10,E0
     MOV.W       #10,R0
     MOV.W       R0,@_b:32
     ADD.W       #20,E0
     MOV.W       E0,@_a:32
     RTS
```

(Expanded into assembly language code; after optimization)

```
_main:
     MOV.W       #10,R0
     MOV.W       R0,@_b:32
     MOV.W       @_a:32,E0
     ADD.W       R0,E0
     ADD.W       #20,E0
     MOV.W       E0,@_a:32
     RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	28	22	32	26	26
After	28	22	30	24	24

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	18	18	14
After	18	18	14

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	21	17	46	38	38
After	21	17	44	36	36

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	13	13	12
After	13	13	12

6.3 Loop Processing

6.3.1 Selecting a Loop Counter

Size	O	Speed	O	Stack size	Δ

Important Points

Both ROM efficiency and execution speed can be improved by using a decrement counter and comparing the end condition with zero.

Description

During the execution of a data transfer instruction (MOV instruction) in the H8S and H8/300 Series microcomputer, both N and Z flags of the condition code register change. This eliminates the need for a compare instruction immediately after the data transfer instruction, which improves both ROM efficiency and execution speed.

Example

Copy all elements of the array *a* to the array *b*.

(C language program before optimization)

```
unsigned char a[10],b[10];
         int  i;
void func(void)
{
    for(i=0; i<10; i++)
        b[i]=a[i];
}
```

(C language program after optimization)

```
unsigned char a[10],b[10];
         int  i;
void func(void)
{
    for(i=9; i>=0; i--)
        b[i]=a[i];
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      STM.L        (ER4-ER5),@-SP
      MOV.L        #_i,ER5
      MOV.W        #1,R0
      MOV.W        R0,@ER5
      BRA          L8:8
L6:  MOV.W        R0,R1
      EXTS.L       ER1
      MOV.L        ER1,ER4
      MOV.B        @(_a:32,ER4),R0L
      MOV.B        R0L,@(_b:32,ER4)
      INC.W        #1,R1
      MOV.W        R1,@ER5
L8:  MOV.W        @ER5,R0
      CMP.W        #10,R0
      BLT          L6:8
      LDM.L        @SP+,(ER4-ER5)
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      STM.L        (ER4-ER5),@-SP
      MOV.L        #_i,ER5
      MOV.W        #9,R0
      MOV.W        R0,@ER5
      BRA          L8:8
L6:  MOV.W        R0,R1
      EXTS.L       ER1
      MOV.L        ER1,ER4
      MOV.B        @(_a:32,ER4),R0L
      MOV.B        R0L,@(_b:32,ER4)
      DEC.W        #1,R1
      MOV.W        R1,@ER5
L8:  MOV.W        @ER5,R0
      BGE          L6:8
      LDM.L        @SP+,(ER4-ER5)
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	46	30	54	38	38
After	48	34	52	36	36

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	30	30	24
After	36	36	32

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	163	121	624	366	386
After	164	132	582	324	324

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	125	107	98
After	106	118	108

6.3.2 Selecting a Repeat Control Statementt

Size	O	Speed	O	Stack size	Δ

Important Points

Both ROM efficiency and execution speed can be improved by using a *do-while* statement for loop statements that are executed at least once.

Description

If a loop statement is executed at least once, it should be coded using a *do-while* statement to reduce the determination of the loop count by one operation, which improves both ROM efficiency and execution speed.

Example

Copy the contents of the array *p2* to the array *p1*.

(C language program before optimization)

```
unsigned char a[10],len=10;
unsigned char p1[10],p2[10];
void func(void)
{
    char i;
    for (i=len; i>0; i--)
        p1[i-1]=p2[i-1];
}
```

(C language program after optimization)

```
unsigned char a[10],len=10;
unsigned char p1[10],p2[10];
void func(void)
{
    char i=len;
    do{
        p1[i-1]=p2[i-1];
    } while(--i);
}
```

(Expanded into assembly language code; before optimization)

```
_func:
         PUSH.L   ER5
         MOV.B @_len:32,R1L
         BRA      L9:8
L8:      EXTS.W   R1
         EXTS.L   ER1
         MOV.L ER1,ER5
         MOV.B @(_p2-1:32,ER5),R0L
         MOV.B R0L,@(_p1-1:32,ER5)
         DEC.B R1L
L9:      MOV.B R1L,R1L
         BGT   L8:8
         POP.L ER5
         RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      PUSH.LER5
      MOV.B @_len:32,R1L
L9:
      EXTS.WR1
      EXTS.LER1
      MOV.L ER1,ER5
      MOV.B @(_p2-1:32,ER5),R0L
      MOV.B R0L,@(_p1-1:32,ER5)
      DEC.B R1L
      BNE   L9:8
      POP.L ER5
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	47	29	47	39	33
After	43	25	43	35	29

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	35	35	29
After	31	31	25

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	210	142	388	324	296
After	195	127	358	294	266

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	134	134	133
After	117	117	116

6.3.3 Moving Invariant Expression from the Inside to the Outside of a Loop

Size	O	Speed	O	Stack size	Δ

Important Points

The execution speed can be improved by defining invariant expression occurring inside a loop on the outside of the loop.

Description

If an inequality occurring inside a loop is defined outside of the loop, the inequality is evaluated only at the beginning of the loop, which reduces the number of instructions executed in the loop. The result is an improvement in execution speed.

Example

Initialize the array *a* using the sum of variables *b* and *c*.

(C language program before optimization)

```
unsigned char a[10],b,c;
         int  i;
void func(void)
{
    for (i=9; i>=0; i--)
        a[i]=b+c;
}
```

(C language program after optimization)

```
unsigned char a[10],b,c;
         int  i;
void func(void)
{
    unsigned char tmp;
    tmp=b+c;
    for (i=9; i>=0; i--)
        a[i]=tmp;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
      PUSH.L      ER5
      MOV.L       #_i,ER5
      MOV.W       #9,R0
      MOV.W       R0,@ER5
      BRA         L9:8
L7:   MOV.W       R0,R1
      MOV.B       @_b:32,R0L
      MOV.B       @_c:32,R0H
      ADD.B       R0H,R0L
      EXTS.L      ER1
      MOV.B       R0L,@(_a:32,ER1)
      DEC.W       #1,R1
      MOV.W       R1,@ER5
L9:   MOV.W       @ER5,R0
      BGT         L7:8
      POP.L       ER5
      RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
      PUSH.W      R4
      MOV.L       #_i,ER1
      MOV.B       @_b:32,R4L
      MOV.B       @_c:32,R0L
      ADD.B       R0L,R4L
      MOV.W       #9,R0
      BRA         L10:8
L8:   MOV.W       @ER1,R0
      EXTS.L      ER0
      MOV.B       R4L,@(_a:32,ER0)
      DEC.W       #1,R0
L10:  MOV.W       R0,@ER1
      BGT         L8:8
      POP.W       R4
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	50	40	58	42	42
After	50	40	50	38	38

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	46	46	38
After	46	46	38

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	119	109	516	404	400
After	119	109	322	254	254

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	101	95	83
After	101	95	83

6.3.4 Merging Loop Conditions

Size	O	Speed	O	Stack size	O

Important Points

In the case of identical or similar loop conditions, both ROM efficiency and execution speed can be improved by merging them.

Description

This technique reduces the object size for loop determination statements, which substantially improves the execution speed.

Example

Initialize the array *a* with 0, and the array *b* with 1.

(C language program before optimization)

```
int a[10],b[10];
void f(void)
{
    int i,j;
    for (i=0; i<10; i++)
        a[i]=0;
    for (j=0; j<10; j++)
        b[j]=1;
}
```

(C language program after optimization)

```
int a[10],b[10];
void f(void)
{
    int i;
    for (i=0; i<10; i++){
        a[i]=0;
        b[i]=1;
    }
}
```

(Expanded into assembly language code; before optimization)

```
_f:
       PUSH.L      ER6
       SUB.W       R6,R6
       SUB.W       R1,R1
L9:    EXTS.L      ER6
       MOV.L       ER6,ER0
       SHLL.L      ER0
       MOV.W       R1,@(_a:32,ER0)
       INC.W       #1,R6
       CMP.W       #10,R6
       BLT         L9:8
       SUB.W       R6,R6
       MOV.W       #1,R1
L10:   EXTS.L      ER6
       MOV.L       ER6,ER0
       SHLL.L      ER0
       MOV.W       R1,@(_b:32,ER0)
       INC.W       #1,R6
       CMP.W       #10,R6
       BLT         L10:8
       POP.L       ER6
       RTS
```

(Expanded into assembly language code; after optimization)

```
_f:
      PUSH.L      ER6
      SUB.W       R6,R6
      SUB.W       R1,R1
L7:   EXTS.L      ER6
      MOV.L       ER6,ER0
      SHLL.L      ER0
      MOV.W       R1,@(_a:32,ER0)
      INC.W       #1,R6
      CMP.W       #10,R6
      BLT         L7:8
      EXTS.L      ER6
      SHLL.L      ER6
      MOV.W       #1,R0
      MOV.W       R0,@(_b:32,ER6)
      POP.L       ER6
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	58	48	62	44	50
After	46	32	46	32	34

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	38	38	34
After	28	28	24

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	245	197	558	418	468
After	188	134	432	350	342

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	175	177	168
After	125	117	117

6.4 Pointers

6.4.1 Using Pointer Variables

Size	O	Speed	O	Stack size	O

Important Points

In cases where the same variable (external variable) is referenced several times or an array element must be accessed, both ROM efficiency and execution speed can be improved by using a pointer variable.

Description

The use of pointer variables can generate a code that incorporates an efficient addressing mode (@Rn, @Rn+, @-Rn).

Example

Copy the elements of the array *data2* to the array *data1*.

(C language program before optimization)

```
void func(int data1[],int data2[])
{
    int i;

    for (i=0; i<10; i++)
        data1[i]=data2[i];
}
```

(C language program after optimization)

```
void func(int *data1,int *data2)
{
    int i;

    for (i=0; i<10; i++){
        *data1=*data2;
        data1++; data2++;
    }
}
```

(Expanded into assembly language code; before optimization)

```
_func:
          PUSH.L      ER3
          STM.L       (ER4-ER6),@-SP
          MOV.L       ER0,ER4
          MOV.L       ER1,ER3
          SUB.W       R6,R6
L6:
          EXTS.L      ER6
          MOV.L       ER6,ER5
          SHLL.L      ER5
          MOV.L       ER4,ER0
          ADD.L       ER5,ER0
          MOV.L       ER3,ER1
          ADD.L       ER5,ER1
          MOV.W       @ER1,R1
          MOV.W       R1,@ER0
          INC.W       #1,R6
          CMP.W       #10:16,R6
          BLT         L6:8
          LDM.L       @SP+,(ER4-ER6)
          POP.L       ER3
          RTS
```

(Expanded into assembly language code; after optimization)

```
__func:
          PUSH.L      ER5
          MOV.L       ER0,ER5
          MOV.W       #10:16,E0
L7:
          MOV.W       @ER1,R0
          MOV.W       R0,@ER5
          INC.L       #2,ER5
          INC.L       #2,ER1
          DEC.W       #1,E0
          BNE         L7:8
          POP.L       ER5
          RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	46	38	40	38	40
After	24	22	28	26	30

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	42	42	34
After	18	18	18

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	171	152	482	336	428
After	107	102	216	208	238

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	156	164	155
After	79	81	80

6.5 Data Structures

6.5.1 Ensuring Data Compatibility

Size	O	Speed	O	Stack size	–

Important Points

Data items are allocated in the order in which they are declared. The efficiency of ROM and RAM utilization can be improved by effectively specifying the order in which data items are declared so as to eliminate the generation of dummy memory areas.

Description

If a variable greater than or equal to 2 bytes is allocated from an odd-numbered memory address when it is necessary to maintain even-numbered memory addressed, the compiler creates a 1-byte dummy area. To avoid this problem, variables of the same size should be declared in a single group to as to minimize the creation of dummy data areas for data alignment.

This consideration is applicable not only to external variables, but also to local variables, members of structures and commons, and function parameters.

Example

Allocate a total of 8 bytes of data.

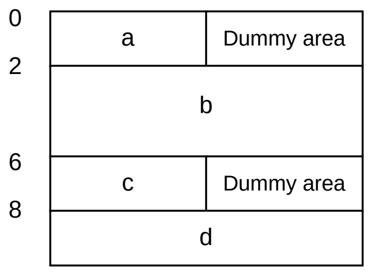
(C language program before optimization)

```
char  a;
long  b;
char  c;
short d;
```

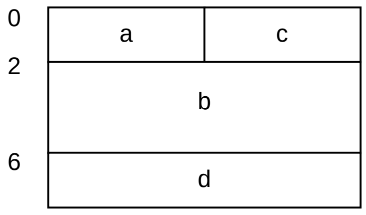
(C language program after optimization)

```
char  a;
char  c;
long  b;
short d;
```

(Data assignment, before optimization)



(Data assignment, after optimization)



Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	10	10	10	10	10
After	8	8	8	8	8

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	8	8	8
After	8	8	8

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	–	–	–	–	–
After	–	–	–	–	–

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	–	–	–
After	–	–	–

Remarks and Notes

The above results other than H8SX are those by Ver.3.0.

As **align** is default with the compiler Ver.4.0 or higher, the boundary alignment is automatically made in order to reduce empty areas. So this improvement makes no difference.

6.5.2 Techniques for Data Initialization

Size	O	Speed	O	Stack size	Δ

Important Points

To reduce program size, any variables that require initialization should be initialized when they are declared.

Description

Data that are initialized at the time of their declaration are first allocated in the initialization data area (D section) and then copied to the RAM when the program is executed. The assignment of initial values is performed only once at the beginning of program execution.

By contrast, any data that are not initialized at the time of their declaration are allocated in the uninitialized data area (B section), which requires only one half as much memory as the case where the data are allocated to the initialization data area.

On the other hand, the latter approach requires an increase in the size of the program area (P section) for setting initial values in the program by means of assignment statements.

For better efficiency, if multiple variables exist that require initial values, they should be initialized at the time of their declaration.

Example

Initialize the variable *a*.

(C language program before optimization)

```
int a;
void main(void)
{
    a=1;
}
```

(C language program after optimization)

```
int a=1;
void main(void)
{
}
```

(Expanded into assembly language code; before optimization)

```
_main:
          MOV.W       #1:16,R0
          MOV.W       R0,@_a:32
          RTS
          .SECTION    B,DATA,ALIGN=2
_a:
          .RES.W      1
```

(Expanded into assembly language code; after optimization)

```
_main:
          RTS
          .SECTION    D,DATA,ALIGN=2
_a:
          .DATA.W     H'0001
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	12	10	12	10	10
After	4	4	4	4	4

	H8SX		
CPU Type	MAX	ADV	NML
Before	8	8	6
After	4	4	4

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	11	9	22	18	18
After	5	4	10	8	8

	H8SX		
CPU Type	MAX	ADV	NML
Before	8	8	7
After	6	6	6

6.5.3 Unifying the Initialization of Array Elements

Size	O	Speed	O	Stack size	Δ

Important Points

In cases where several array elements must be initialized, ROM efficiency can be improved by grouping them into a structure so that they can be initialized in a single operation.

Description

By initializing data in a group, the number of transfer instruction executions that are required can be reduced to one.

Example

Initialize the arrays *a*, *b*, and *c* with respective values.

(C language program before optimization)

```
void f(void)
{
    unsigned char a[]={0,1,2,3};
    unsigned char b[]="abcdefg";
    unsigned char c[]="ABCDEFG";
}
```

(C language program after optimization)

```
void f(void)
{
    struct x{
        unsigned char a[4];
        unsigned char b[8];
        unsigned char c[7];
    } A
    ={0,1,2,3,"abcdefg","ABCDEFG"};
}
```

(Expanded into assembly language code; before optimization)

```
_f:
      PUSH.L      ER2
      SUB.W       #20,R7
      MOV.L       #L4,ER0
      MOV.L       SP,ER1
      ADD.W       #16,R1
      SUB.L       ER2,ER2
      MOV.B       #4,R2L
      JSR         @$MVN$3:24
      MOV.L       #L6,ER0
      MOV.L       SP,ER1
      ADD.W       #8,R1
      SUB.L       ER2,ER2
      MOV.B       #8,R2L
      JSR         @$MVN$3:24
      MOV.L       #L8,ER0
      MOV.L       SP,ER1
      SUB.L       ER2,ER2
      MOV.B       #8,R2L
      JSR         @$MVN$3:24
      ADD.W       #20,R7
      POP.L       ER2
      RTS
L4:      .DATA.B     H'00,H'01,H'02,H'03
L6:      .SDATAZ     "abcdefg"
L8:      .SDATAZ     "ABCDEFG"
```

(Expanded into assembly language code; after optimization)

```
_f:
          PUSH.L      ER2
          SUB.W       #20,R7
          MOV.L       #L4,ER0
          MOV.L       SP,ER1
          SUB.L       ER2,ER2
          MOV.B       #19,R2L
          JSR         @$MVN$3:24
          ADD.W       #20,R7
          POP.L       ER2
          RTS
L4:      .DATA.B   H'00,H'01,H'02,H'03
         .SDATAZ     "abcdefg"
         .SDATA      "ABCDEFG"
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	120	106	122	106	110
After	81	69	81	75	79

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	104	104	96
After	79	77	69

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	294	256	690	572	632
After	162	145	488	324	376

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	51	48	41
After	90	89	79

Remarks and Notes

H8SX can transfer data by transfer instructions, not by runtime functions. So the execution speed of before is faster than that of after.

6.5.4 Passing Parameters as a Structure Address

Size	O	Speed	O	Stack size	Δ

Important Points

Parameters that are not assigned to a register should be passed using the address of a structure to reduce the program size.

Description

The number of parameters used and their size should be adjusted appropriately so that they are assigned to registers. For a description of how to pass parameters to a register, refer to the appropriate user's manual.

In situations where large parameters are required or a large number of parameters are used, they should be grouped in a structure before they are passed to their intended function to reduce the program size. If parameters are declared as members of a structure and the starting address of the structure is passed as an parameter to the target function, the receiving function can access the members based upon the received address.

Example

Pass the long type data *a*, *b*, *c*, and *d* to the function *func*.

(C language program before optimization)

```
void sub(long,long,long,long);
long a,b,c,d;

void func(void)
{
    sub(a,b,c,d);
}
```

(C language program after optimization)

```
void sub(struct ctag *);
struct ctag{
    long a;
    long b;
    long c;
    long d;
}x;

void func(void)
{
    sub(&x);
}
```

(Expanded into assembly language code; before optimization)

```
_func:
          MOV.L       @_d:32,ER0
          PUSH.L      ER0
          MOV.L       @_c:32,ER0
          PUSH.L      ER0
          MOV.L       @_b:32,ER1
          MOV.L       @_a:32,ER0
          JSR         @_sub:24
          ADDS.L      #4,SP
          ADDS.L      #4,SP
          RTS
_a:      .RES.L      1
_b:      .RES.L      1
_c:      .RES.L      1
_d:      .RES.L      1
```

(Expanded into assembly language code; after optimization)

```
_func:
          MOV.L       #_x:32,ER0
          JMP         @_sub:24
_x:
          .RES.W      8
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	58	50	52	44	62
After	14	12	10	10	10

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	50	48	40
After	16	14	12

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	52	45	102	88	126
After	18	14	22	18	18

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	30	28	28
After	14	14	14

6.5.5 Assigning Structures to Registers

Size	O	Speed	O	Stack size	O

Important Points

When local variables are used as a structure, the members should be declared so that the variables can directly be assigned to registers.

Description

Because structures can also be assigned to registers, both size efficiency and processing speed can be improved by appropriately assigning the members of the structure.

Example

Pass the structure data to the function *func*.

(C language program before optimization)

```
struct ST {
    char  a;
    short b;
    char  c;
}pst;
void main()
{
    struct ST s;
    s.a=pst.a+10;
    s.b=s.a+s.c;
    func(s);
}
```

(C language program after optimization)

```
struct ST {
    short b;
    char  a;
    char  c;
}pst;
void main()
{
    struct ST s;
    s.a=pst.a+10;
    s.b=s.a+s.c;
    func(s);
}
```

(Expanded into assembly language code; before optimization)

```
_main:
      STM.L        (ER2-ER3),@-SP
      SUBS.L       #4,SP
      SUBS.L       #2,SP
      MOV.L        SP,ER3
      MOV.B        #10,R0L
      MOV.B        R0L,@_pst:32
      MOV.B        R0L,@ER3
      EXTS.W       R0
      MOV.B        @(4:16,ER3),R1L
      EXTS.W       R1
      ADD.W        R1,R0
      MOV.W        R0,@(2:16,ER3)
      MOV.L        ER3,ER0
      SUBS.L       #4,SP
      SUBS.L       #2,SP
      MOV.L        SP,ER1
      SUB.L        ER2,ER2
      MOV.B        #6,R2L
      JSR          @$MVN$3:24
      JSR          @_func:24
      ADDS.L       #4,SP
      ADDS.L       #4,SP
      ADDS.L       #4,SP
      LDM.L        @SP+,(ER2-ER3)
      RTS
```

(Expanded into assembly language code; after optimization)

```
_main:
      PUSH.L       ER6
      MOV.B        #10,R0L
      MOV.B        R0L,@_pst+2:32
      MOV.B        R0L,R6H
      EXTS.W       R0
      MOV.B        R6L,R1L
      EXTS.W       R1
      ADD.W        R1,R0
      MOV.W        R0,E6
      PUSH.L       ER6
      JSR          @_func:24
      ADDS.L       #4,SP
      POP.L        ER6
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	66	60	64	64	80
After	44	46	42	40	72

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	62	60	64
After	42	40	38

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	126	110	416	252	286
After	42	40	84	76	260

	H8SX		
CPU Type	MAX	ADV	NML
Before	40	40	36
After	31	29	32

6.6 Functions

6.6.1 Improving the Program Location in Which Functions Are Defined

Size	O	Speed	O	Stack size	Δ

Important Points

Both ROM efficiency and execution speed can potentially be improved by defining in the same file any functions that are frequently called in a module.

Description

In cases where the branch destination address is within the –128 to 127 byte range, the H8S or H8/300 Series microcomputer uses the PC relative addressing mode (BSR). Compared with the absolute addressing mode (JSR), which is declared by an externally referencing function, this mode can improve both ROM efficiency and execution speed.

Example

Call the function *func2* from the functions *func* and *func1*.

(C language program before optimization)

```
extern int func2(void);
int ret;
void func(void)
{
  int i;
  i=func2();
  ret = i;
}
void func1(void)
{
  int i;
  i=func2();
  ret = i;
}
```

(C language program after optimization)

```
int ret;
int func2(void)
{
  return 0;
}
void func(void)
{
  int i;
  i=func2();
  ret = i;
}
void func1(void)
{
  int i;
  i=func2();
}
```

(Expanded into assembly language code; before optimization)

```
_func:
          JSR         @_func2:24
          MOV.W       R0,@_ret:32
          RTS
_func1:
          JSR         @_func2:24
          MOV.W       R0,@_ret:32
          RTS
```

(Expanded into assembly language code; after optimization)

```
_func2:
          SUB.W       R0,R0
          RTS
_func:
          BSR         _func2:8
          MOV.W       R0,@_ret:32
          RTS
_func1:
          BSR         _func2:8
          MOV.W       R0,@_ret:32
          RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	28	24	28	24	24
After	24	20	24	20	20

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	32	28	24
After	24	24	20

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		**H8/300H**		**H8/300**
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	20	16	40	32	32
After	19	15	38	30	30

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	16	16	15
After	16	16	16

6.6.2 Macro calls

Size	O	Speed	O	Stack size	Δ

Important Points

Both size efficiency and processing speed can be improved by defining the frequently called functions as macros.

Description

When identical processing routines are defined as macros, they are inline-expanded at the location where they are called. This eliminates the generation of codes and improves efficiency.

Example

Call the function *abs*.

(C language program before optimization)

```
extern int a,b,c;
int abs(x)
int x;
{    return x>=0?x:-x;  }
void f(void)
{
    a=abs(b);
    b=abs(c);
}
```

(C language program after optimization)

```
#define abs(x) ((x)>=0?(x):-(x))
extern int a,b,c;
void f(void)
{
    a=abs(b);
    b=abs(c);
}
```

(Expanded into assembly language code; before optimization)

```
_abs:
          PUSH.W      R6
          MOV.W       R0,R6
          BLT         L9:8
          MOV.W       R6,R1
          BRA         L10:8
L9:       MOV.W       R6,R1
          NEG.W       R1
L10:      MOV.W       R1,R0
          POP.W       R6
          RTS
_f:       MOV.W       @_b:32,R0
          BSR         _abs:8
          MOV.W       R0,@_a:32
          MOV.W       @_c:32,R0
          BSR         _abs:8
          MOV.W       R0,@_b:32
          RTS
```

(Expanded into assembly language code; after optimization)

```
_f:
      PUSH.W      R6
      MOV.W       @_b:32,R6
      BLT         L7:8
      MOV.W       R6,R0
      BRA         L8:8
L7:   MOV.W       R6,R0
      NEG.W       R0
L8:   MOV.W       R0,@_a:32
      MOV.W       @_c:32,R6
      BLT         L9:8
      MOV.W       R6,R0
      BRA         L10:8
L9:   MOV.W       R6,R0
      NEG.W       R0
L10:  MOV.W       R0,@_b:32
      POP.W       R6
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	38	30	46	38	42
After	32	26	50	42	46

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	38	38	30
After	34	34	26

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	45	36	106	88	112
After	24	20	74	64	64

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	36	36	34
After	20	20	17

6.6.3 Declaring a Prototype

Size	O	Speed	O	Stack size	Δ

Important Points

Functions that have *char*-type or *unsigned char*-type parameters should be prototype-declared before they are called to eliminate the output of superfluous type conversion code.

Description

If called without a prototype declaration, functions that have *char*-type or *unsigned char*-type parameters are converted into the *int* type, which generates superfluous sign expansion instructions and zero expansion instructions.

In addition, parameters can fail to be passed properly.

Example

Call the function *sub1* that has *char*-type and *unsigned char*-type parameters.

(C language program before optimization)

```
char a;
unsigned char b;
void func(void)
{
    sub1(a,b);
}
```

(C language program after optimization)

```
void sub1(char, unsigned char);
char a;
unsigned char b;
void func(void)
{
    sub1(a,b);
}
```

(Expanded into assembly language code; before optimization)

```
_func:
          MOV.B       @_b:32,R0L
          EXTU.W      R0
          MOV.B       @_a:32,R1L
          EXTS.W      R1
          MOV.W       R0,E0
          MOV.W       R1,R0
          JMP         @_sub1:24
          RTS
```

(Expanded into assembly language code; after optimization)

```
_func:
          MOV.B       @_b:32,R0H
          MOV.B       @_a:32,R0L
          JMP         @_sub1:24
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	22	18	24	20	18
After	18	14	16	20	12

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	24	22	18
After	20	18	14

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	19	16	40	34	32
After	23	18	32	26	26

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	15	15	14
After	19	17	17

6.6.4 Optimization of Tail Recursions

Size	O	Speed	O	Stack size	O

Important Points

If a function makes a function call, investigate whether or not the function call can be moved to the end of the calling function. This can improve both ROM efficiency and execution speed.

Description

The tail recursion optimization is performed when all of the following conditions are satisfied:

- The calling function does not place its parameters or return-value address on the stack.
- The function call is followed by the RTS instruction.

Example

Call the function *sub* and update the value of an external variable.

(C language program before optimization)

```
void g(void);
int a;
void main(void)
{
    if (a==0)    a++;
    else{
        g();
        a+=2;
    }
}
```

(C language program after optimization)

```
void g(void);
int a;
void main(void)
{
    if (a==0)    a++;
    else{
        a+=2;
        g();
    }
}
```

(Expanded into assembly language code; before optimization)

```
_main:
      PUSH.L      ER6
      MOV.L       #_a,ER6
      MOV.W       @ER6,R0
      BNE         L6:8
      INC.W       #1,R0
      BRA         L8:8
L6:  JSR         @_g:24
      MOV.W       @ER6,R0
      INC.W       #2,R0
L8:  MOV.W       R0,@ER6
      POP.L       ER6
      RTS
```

(Expanded into assembly language code; after optimization)

```
_main:
      MOV.L       #_a64,ER1
      MOV.W       #1,R0
      INC.W       #2,R0
      MOV.W       R0,@ER1
      JMP         @_g:24
      RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	38	32	38	32	32
After	30	32	30	28	28

	H8SX		
CPU Type	MAX	ADV	NML
Before	36	34	30
After	30	28	34

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	37	29	74	58	58
After	20	27	40	36	36

	H8SX		
CPU Type	MAX	ADV	NML
Before	22	25	20
After	15	15	23

Remarks and Notes

The above program assumes that the variable *a* is not referenced within the function *g*.

6.6.5 Improving the Way Parameters Are Passed

Size	O	Speed	O	Stack size	O

Important Points

To reduce the code size, the order in which parameters are listed should be adjusted so that there is no gap between parameters.

Description

Parameters passed through the registers are assigned to the registers ER0 and ER1 (or R0 and R1 in the case of an H300 CPU) in the order in which they are declared. Therefore, the order in which the parameters are declared should be adjusted so as to minimize any gap between them to reduce the code size.

Example

Call the function *func*.

(C language program before optimization)

```
long rtn;
void func(char,short,char);
void main()
{
    short a;
    char  b,c;

    func(b,a,c);
}
void func(char x,short y,char z)
{
    rtn=x*y+z;
}
```

(C language program after optimization)

```
long rtn;
void func(char,char,short);
void main()
{
    short a;
    char  b,c;

    func(b,c,a);
}
void func(char x,char y,short z)
{
    rtn=x*y+z;
}
```

(Expanded into assembly language code; before optimization)

```
_main:
    SUBS.L    #4,SP
    SUBS.L    #2,SP
    MOV.B     @(5:16,SP),R0H
    MOV.W     @(2:16,SP),E0
    MOV.B     @SP,R0L
    BSR       _func:8
    ADDS.L    #2,SP
    ADDS.L    #4,SP
    RTS
_func:
    PUSH.L      ER6
    MOV.B       R0H,R6H
    EXTS.W      R0
    MOV.W       R0,R1
    MULXU.W     E0,ER1
    MOV.B       R6H,R6L
    EXTS.W      R6
    ADD.W       R6,R1
    EXTS.L      ER1
    MOV.L       ER1,@_rtn:32
    POP.L       ER6
    RTS
```

(Expanded into assembly language code; after optimization)

```
_main:
    SUBS.L  #4,SP
    MOV.W   @(2:16,SP),E0
    MOV.B   @(1:16,SP),R0H
    MOV.B   @SP,R0L
    BSR     _func:8
    ADDS.L  #4,SP
    RTS
_func:
    MOV.B   R0L,R1L
    MULXS.B R0H,R1
    ADD.W   E0,R1
    EXTS.L  ER1
    MOV.L   ER1,@_rtn:32
    RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	26	24	56	54	60
After	22	20	38	36	48

	H8SX		
CPU Type	MAX	ADV	NML
Before	26	26	24
After	22	22	20

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	29	25	120	112	228
After	26	22	82	74	174

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	25	21	21
After	21	19	19

Remarks and Notes

For a description of how to assign an parameter, refer to section 9.3.3, Examples of Parameter Assignment, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Note that when the number of registers that pass the parameters is changed by an option, the number of registers that receive the parameters also change.

6.7 Branches

6.7.1 Rewriting switch Statements as Tables

Size	O	Speed	O	Stack size	Δ

Important Points

If the processing tasks performed by the case statements associated with *switch* are alike, the *switch* statements should be coded using a table to reduce the object size.

Description

Rewriting *switch* statements using a table can substantially reduce the program size although data size increases. If the value of a *case* statement ranges widely, however, rewriting *switch* statements in terms of a table can lead to an overall increase in program size.

Example

Branch to a function depending upon the value of the function *a*.

(C language program before optimization)

```
extern void f1(void);
extern void f2(void);
extern void f3(void);
extern void f4(void);
extern void f5(void);
extern int a;
void sub(void)
{
    switch(a){
    case 0:f1();break;
    case 1:f2();break;
    case 2:f3();break;
    case 3:f4();break;
    case 4:f5();break;
    }
}
```

(C language program after optimization)

```
extern void f1(void);
extern void f2(void);
extern void f3(void);
extern void f4(void);
extern void f5(void);
extern int a;
void sub(void)
{
    static int (*key[5])()=
         {f1,f2,f3,f4,f5};

    (*key[a])();
}
```

(Expanded into assembly language code; before optimization)

```
_sub:    MOV.W       @_a:32,R0
          MOV.B       R0H,R0H
          BNE         L15:8
          CMP.B       #0:8,R0L
          BEQ         L10:8
          CMP.B       #1:8,R0L
          BEQ         L11:8
          CMP.B       #2:8,R0L
          BEQ         L12:8
          CMP.B       #3:8,R0L
          BEQ         L13:8
          CMP.B       #4:8,R0L
          BEQ         L14:8
          RTS
L10:     JMP         @_f1:24
L11:     JMP         @_f2:24
L12:     JMP         @_f3:24
L13:     JMP         @_f4:24
L14:     JSR         @_f5:24
L15:     RTS
```

(Expanded into assembly language code; after optimization)

```
_sub: MOV.W       @_a:32,R0
       EXTS.L      ER0
       SHLL.L      #2,ER0
       MOV.L       @(L9:32,ER0),ER0
       JSR         @ER0
       RTS
L9:   .DATA.L   _f1,_f2,_f3,_f4,_f5
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	ADV	NML	ADV	NML	NML
Before	78	64	66	62	76
After	56	36	56	34	34

	H8SX		
CPU Type	MAX	ADV	NML
Before	94	78	58
After	50	50	36

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	31	28	74	54	68
After	27	18	42	26	26

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	24	32	24
After	19	20	18

6.7.2 Coding a Program in Which Case Statements Jump to the Same Label

Size	O	Speed	O	Stack size	Δ

Important Points

case statement containing the same expression should be grouped together to minimize the number of branch instructions and to reduce the object size.

Description

In the case of an *if-then* expansion method for a *switch* statement, the smaller the number of branch instructions, the smaller the code size, and the greater is program efficiency.

Example

Assign a value to *ll* depending on the value of *c*.

(C language program before optimization)

```
long ll;
void func(void)
{
    char c;
    switch(c){
    case 0: ll=0; break;
    case 1: ll=0; break;
    case 2: ll=1; break;
    case 3: ll=1; break;
    case 4: ll=2; break;
    }
}
```

(C language program after optimization)

```
long ll;
void func(void)
{
    char c;
    switch(c){
    case 0:
    case 1: ll=0; break;
    case 2:
    case 3: ll=1; break;
    case 4: ll=2; break;
    }
}
```

(Expanded into assembly language code; before optimization)

```
_func:
          SUBS.L      #2,SP
          MOV.L       #_ll:32,ER1
          MOV.B       @(1:16,SP),R0L
          BEQ         L6:8
          CMP.B       #1:8,R0L
          BEQ         L7:8
          CMP.B       #2:8,R0L
          BEQ         L8:8
          CMP.B       #3:8,R0L
          BEQ         L9:8
          CMP.B       #4:8,R0L
          BEQ         L10:8
          BRA         L11:8
L6:
L7:       SUB.L       ER0,ER0
          BRA         L15:8
L8:       SUB.L       ER0,ER0
          MOV.B       #1:8,R0L
          BRA         L15:8
L9:       SUB.L       ER0,ER0
          MOV.B       #1:8,R0L
          BRA         L15:8
L10:      SUB.L       ER0,ER0
          MOV.B       #2:8,R0L
L15:      MOV.L       ER0,@ER1
L11:      ADDS.L      #2,SP
          RTS
_ll:      .RES.L      1
```

(Expanded into assembly language code; after optimization)

```
_func:
          SUBS.L      #2,SP
          MOV.L       #_ll:32,ER1
          MOV.B       @(1:16,SP),R0L
          BEQ         L6:8
          CMP.B       #1:8,R0L
          BEQ         L7:8
          CMP.B       #2:8,R0L
          BEQ         L8:8
          CMP.B       #3:8,R0L
          BEQ         L9:8
          CMP.B       #4:8,R0L
          BEQ         L10:8
          BRA         L11:8
L6:
L7:       SUB.L       ER0,ER0
          BRA         L13:8
L8:
L9:       SUB.L       ER0,ER0
          MOV.B       #1:8,R0L
          BRA         L13:8
L10:      SUB.L       ER0,ER0
          MOV.B       #2:8,R0L
L13:      MOV.L       ER0,@ER1
L11:      ADDS.L      #2,SP
          RTS
_ll:      .RES.L      1
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	49	45	63	59	69
After	45	43	57	53	61

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	55	55	47
After	51	51	45

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	33	30	82	72	68
After	20	18	82	72	68

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	24	24	23
After	13	14	12

Remarks

The above performance measurements are based on the case where *c* = 4.

This technique can be used for the compilers before Ver.3.0.

Improvements with the compiler Ver.4.0 or higher made it possible to group together the jumping destinations of case statements, and therefore the compiler expands the same assembly-language code (other than H8SX).

Assembly expansion code, object size and execution speed in this section code the results of the compilation by the compiler Ver.3.0 (other than H8SX).

As a general rule, of the values of *case* in a *switch* statement that are frequently executed should be tested first to improve the execution speed. The user is encouraged to try this technique during program execution.

6.7.3 Branching to a Function Coded Directly below a Given Statement

Size	O	Speed	O	Stack size	O

Important Points

If a function call occurs at the end of functions, the called function should be placed directly below the function call.

Description

If the tail recursion optimization is in effect, the called function should be placed directly below the function call to take advantage of the optimization, which has the effect of deleting the function call code.

Since the function call code is deleted, the program size is reduced and the processing speed is increased.

Example

Call the function *func* from the function *main*.

(C language program before optimization)

```
int a;
void func();
void func()
{
    a++;
}
void main()
{
    a=0;
    func();
}
```

(C language program after optimization)

```
int a;
void func();
void main()
{
    a=0;
    func();
}
void func()
{
    a++;
}
```

(Expanded into assembly language code; before optimization)

```
_func:
        MOV.L   #_a,ER0
        MOV.W   @ER0,R1
        INC.W   #1,R1
        MOV.W   R1,@ER0
        RTS
_main:
        SUB.W   R0,R0
        MOV.W   R0,@_a:32
        BRA     _func:8
```

(Expanded into assembly language code; after optimization)

```
_main:
        SUB.W   R0,R0
        MOV.W   R0,@_a:32
_func:
        MOV.L   #_a:32,ER0
        MOV.W   @ER0,R1
        INC.W   #1,R1
        MOV.W   R1,@ER0
        RTS
```

Object Size Table [byte]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	26	20	24	20	20
After	24	18	22	18	18

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	18	18	14
After	16	16	12

Execution Speed Table [cycle]

	H8S/2600, H8S/2000		H8/300H		H8/300
CPU Type	**ADV**	**NML**	**ADV**	**NML**	**NML**
Before	21	17	40	34	34
After	19	15	36	30	30

	H8SX		
CPU Type	**MAX**	**ADV**	**NML**
Before	14	14	13
After	12	12	11

Section 7 Using HEW

This chapter describes the use of HEW for build- and simulation-related processes.

Note that the supported functions and methods vary from one HEW version to another.

The appropriate version is indicated under [Comments] for each topic.

The following table shows a list of the items relating to the use of HEW.

No.	Category	Item	Section
1	Builds	Regenerating and Editing Automatically Generated Files	7.1.1
2		Makefile Output	7.1.2
3		Makefile Input	7.1.3
4		Creating Custom Project Types	7.1.4
5		Multi-CPU Feature	7.1.5
6		Networking Feature	7.1.6
7		Converting from Old HEW Version	7.1.7
8		Converting a HIM Project to a HEW Project	7.1.8
9		Add Supported CPUs	7.1.9
10	Simulations	Pseudo-interrupts	7.2.1
11		Convenient Breakpoint Functions	7.2.2
12		Coverage Feature	7.2.3
13		File I/O	7.2.4
14		Debugger Target Synchronization	7.2.5
15		How to Use Timers	7.2.6
16		Examples of Timer Usage	7.2.7
17		Reconfiguration of Debugger Target	7.2.8
18	Call Walker	Making stack information file	7.3.1
19		Starting Call Walker	7.3.2
20		File Open and Call Walker Window	7.3.3
21		Editing the stack information file	7.3.4
22		Stack area size of assembly program	7.3.5
23		Merging stack information	7.3.6
24		Other functions	7.3.7

7.1 Builds

7.1.1 Regenerating and Editing Automatically Generated Files

• Description:

HEW will automatically generate I/O register definition, interrupt function, and other various files if you select Application for the project type when creating a new workspace.

However, when creating a new project, you may sometimes skip this automatic file generation process because you then believe that the files are unnecessary.

You may also forget to edit or set such files.

If you do, you can use this feature to automatically generate and edit files after creating a project.

However, this feature is only available when you select Application for the project type when creating a new workspace.

• Usage:

HEW Menu: **Project > Edit Project Configuration...**

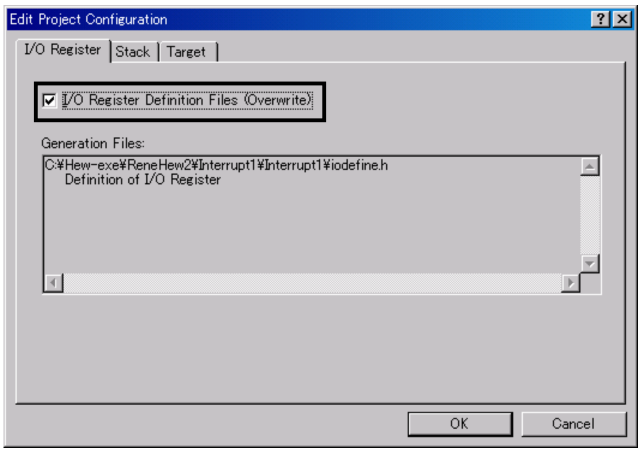
• Files that can be regenerated:

I/O Register Definition Files: iodefine.h

[Generation method]

You can regenerate iodefine.h by checking [I/O Register Definition Files (overwrite)] on the [I/O Register] tab in the [Edit Project Configuration] dialog box.

If you modify iodefine.h inadvertently, you can regenerate it and overwrite it on the modified file.



☑ I/O Register Definition Files (Overwrite)

Generation Files:

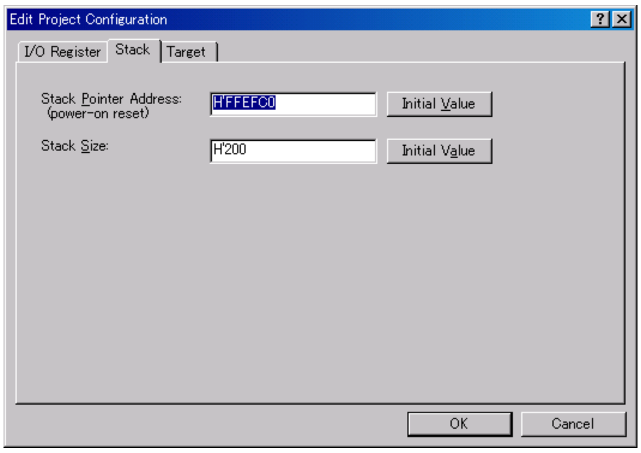
C:¥Hew-exe¥ReneHew2¥Interrupt1¥Interrupt1¥iodefine.h
Definition of I/O Register

• Files that can be re-edited:

Stack size setting file: stacksct.h

[Editing method]

You can edit the initial values of [Stack Pointer Address] and [Stack Size] on the [Stack] tab in the [Edit Project Configuration] dialog box.



Stack Pointer Address: (power-on reset) H'FFEFC0

Stack Size: H'200

• Note:

Regenerating and re-editing files are supported by HEW 2.0 or later.

7.1.2 Makefile Output

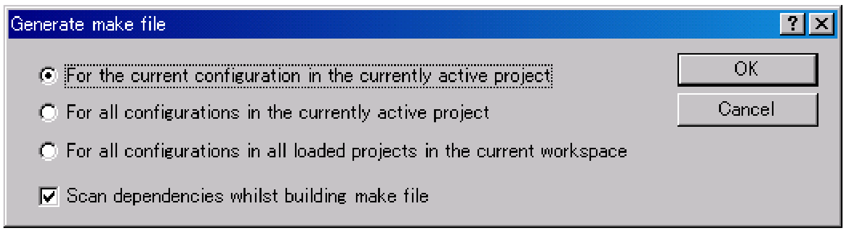
• Description:

HEW allows you to create a makefile based on the current option settings.

By using the makefile, you can build the current project without having to install HEW completely. This is convenient when you wan to send a project to a person who has not installed HEW or manage the version of an entire build, including the makefile.

• Makefile production method:

1. Make sure that the project that generates the makefile is the current project.
2. Make sure that the build configuration that builds the project is the current configuration.
3. Choose [Build > Generate make file].
4. You will see the following dialog box. In this dialog box, select one of the makefile generation methods.



● For the current configuration in the currently active project

○ For all configurations in the currently active project

○ For all configurations in all loaded projects in the current workspace

☑ Scan dependencies whilst building make file

• Makefile generation directory:

HEW creates a [make] subdirectory in the current workspace directory and generates makefiles in this subdirectory. The makefile name is the current project or configuration name followed by the extension .mak (debug.mak, for example). HEW-generated makefiles can be executed by the executable file HMAKE.EXE contained in the directory where HEW is installed. However, user-modified makefiles cannot be executed.

• Makefile execution method:

1. Open the [Command] window and move to the [make] subdirectory that contains the generated makefile.
2. Execute HMAKE.On the command line, enter HMAKE.EXE <makefile-name>.

• Note:

This feature is supported by HEW 1.1 or later.

7.1.3 Makefile Input

• Description:

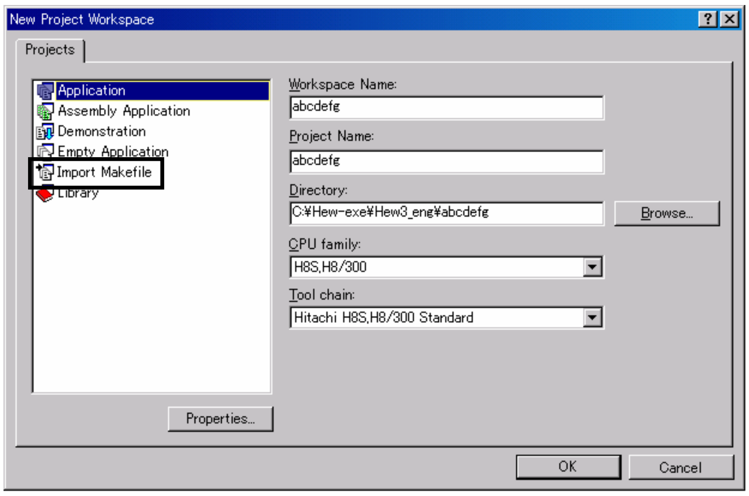
HEW allows to input the makefiles that were generated by HEW or used by UNIX environment.

From the makefile, you can automatically obtain the **file structure** of the project.

(However, you cannot obtain option settings or similar specifications.) This facilitates the migration from the command line to HEW.

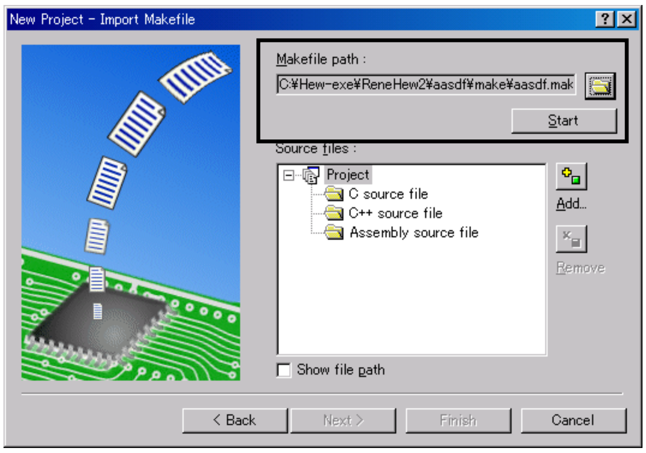
• Makefile input method:

1. When creating a new workspace, select [Import Makefile] from the project type options in the [New Project Workspace] dialog box.



Workspace Name: abcdefg
Project Name: abcdefg
Directory: C:¥Hew-exe¥Hew3_eng¥abcdefg
CPU family: H8S,H8/300
Tool chain: Hitachi H8S,H8/300 Standard

2. Specify the makefile path in the [Makefile path] field in the [New Project-Import Makefile] dialog box and click on the [Start] button.

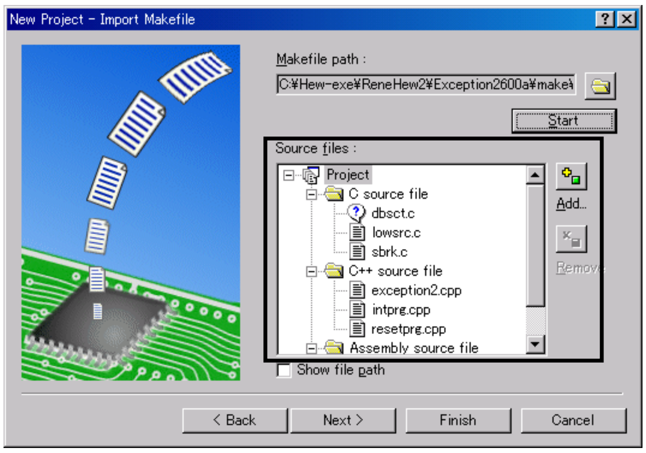


Makefile path : C:¥Hew-exe¥ReneHew2¥aasdf¥make¥aasdf.mak

Source files :
- Project
  - C source file
  - C++ source file
  - Assembly source file

☐ Show file path

3. The [Source files] pane displays the makefile source file structure. In this structure chart, any file marked ? is a file that has been proved through an analysis to contain no entity. This file will not be added to the project.(It is ignored.)



Makefile path : C:¥Hew-exe¥ReneHew2¥Exception2600a¥make¥

Source files :
- Project
  - C source file
    - dbsct.c
    - lowsrc.c
    - sbrk.c
  - C++ source file
    - exception2.cpp
    - intprg.cpp
    - resetprg.cpp
  - Assembly source file

☐ Show file path

4. By following the wizard, specify CPU and other options and open the workspace. You can then begin a development work.

• Note:

This feature is supported by HEW 3.0 or later.

7.1.4 Creating Custom Project Types

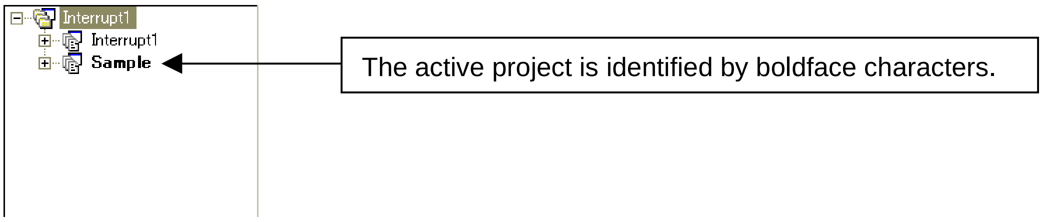
• Description:

This feature allows a project created by a user to be used by another user as a template for program development on another machine.

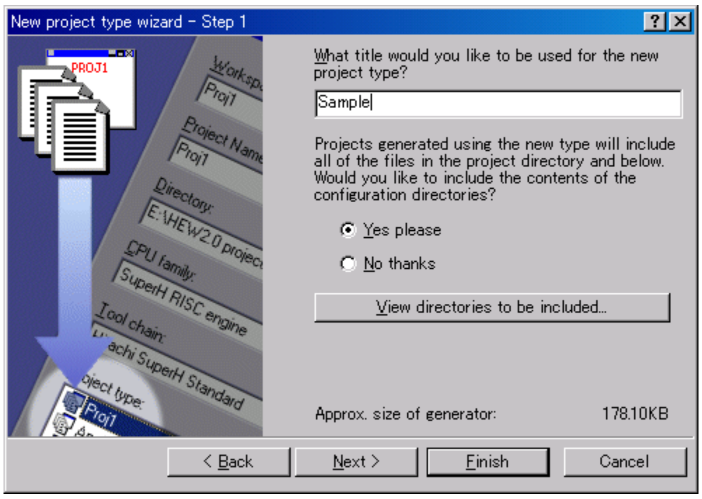
Information that can be contained in the template may concern the project file structure, build options, debugger settings, and anything else relating to the project.

• Project type storing method:

1. Activate the project you want to store project information in because the active project accepts project information when the workspace is open. To activate a project, select the project by choosing [Project -> Set Current Project].



2. Open the following project type wizard by choosing [Project -> Create Project Type...], assign a name to the project type you will use as the template and specify whether to include the configuration directory containing the post-build executable files and other resources in the template.
   You can quit the project type wizard here by clicking on the [Finish] button.



New project type wizard - Step 1

What title would you like to be used for the new project type?

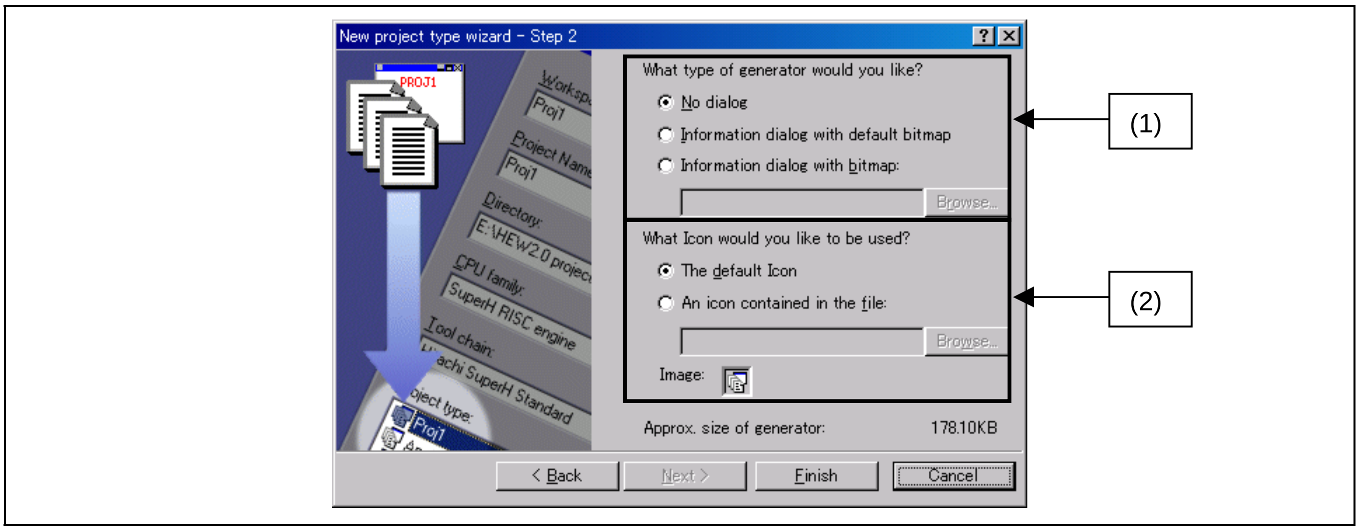
Sample

Projects generated using the new type will include all of the files in the project directory and below. Would you like to include the contents of the configuration directories?

[✓ Yes please] No thanks

Approx. size of generator: 178.10KB

3. At [New project type wizard – Step 1], click on the [Next] button to open the following wizard: When opening the project type templateat step (1), specify whether to display project information and bitmaps.
   At step (2), you can change the project type icon to a user-specified icon. Click on the [Finish] button.
   These settings are not mandatory.

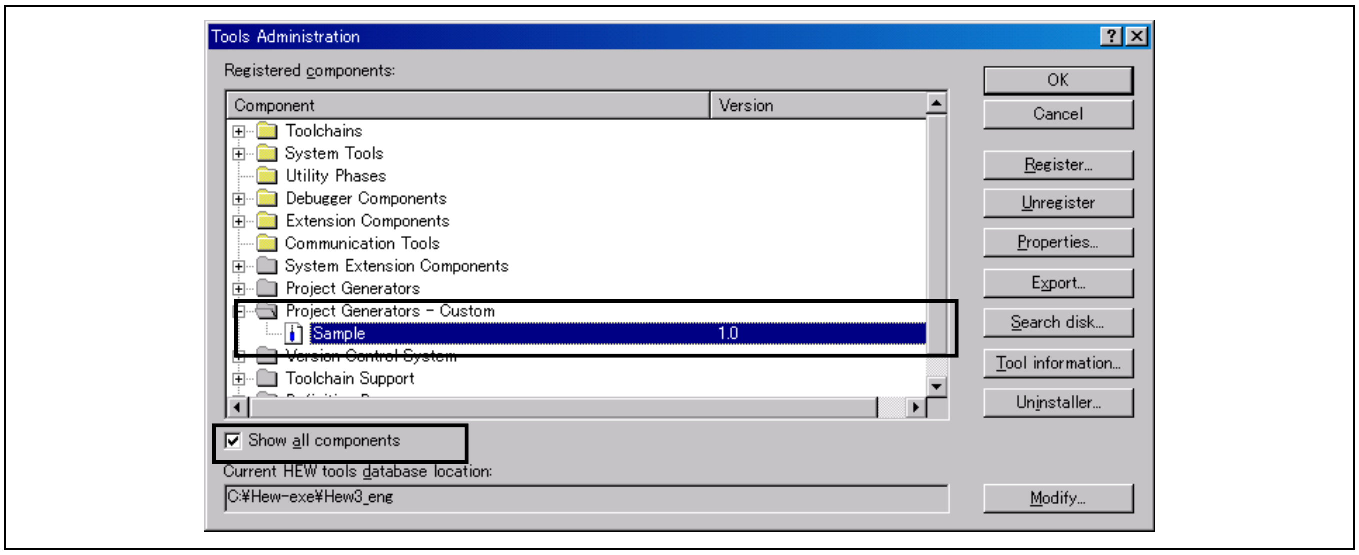

New project type wizard - Step 2

What type of generator would you like?
(●) No dialog
( ) Information dialog with default bitmap
( ) Information dialog with bitmap:
Browse...

What Icon would you like to be used?
(●) The default Icon
( ) An icon contained in the file:
Browse...
Image:

Approx. size of generator: 178.10KB

4. A project type template named “Custom Project Generator” has thus been created. To use this template on another machine, choose [Tools -> Administration...] to open the following dialog box:
   When you check the following [Show all components] check box, you will see [Project Generators – Custom].
   Click on the created project type and click on the [Export...] button.


Tools Administration

Registered components:

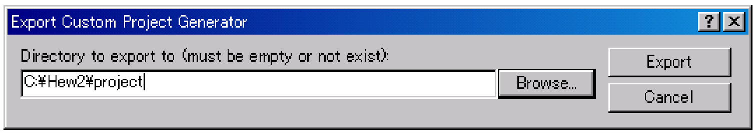
Component	Version
Toolchains	
System Tools	
Utility Phases	
Debugger Components	
Extension Components	
Communication Tools	
System Extension Components	
Project Generators	
Project Generators - Custom	
Sample	1.0
Version Control System	
Toolchain Support	

[✓] Show all components

Current HEW tools database location:
C:¥Hew-exe¥Hew3_eng

5. The following dialog box opens. Select a directory in which the Custom Project Generator template will be stored. The directory must be empty.

   The project type storage process is now complete.


Export Custom Project Generator

Directory to export to (must be empty or not exist):

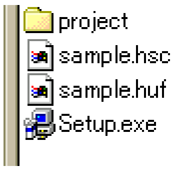
C:¥Hew2¥project

• Installing Custom Project Generator:

Use the following procedure to install the Custom Project Generator template created by the above project type storage method on another machine.

1. The following installation environment is created for the directory that was created at step 5 of the project type storage method:

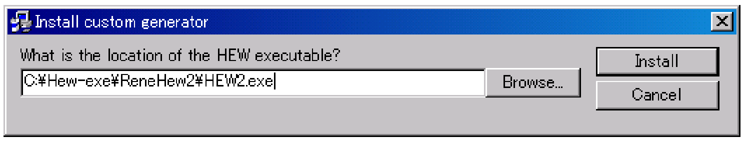
   (Installation environment directory)



2. Copy the above installation environment and install the copy on another machine.

   When you run Setup.exe, the following dialog box opens. Specify the location in which HEW2.exe is installed and click on the [Install] button.

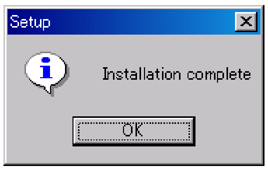
   (Directory example: c:¥Hew2¥HEW2.exe)


Install custom generator

What is the location of the HEW executable?

C:¥Hew-exe¥ReneHew2¥HEW2.exe

3. The environment has been built up completely.

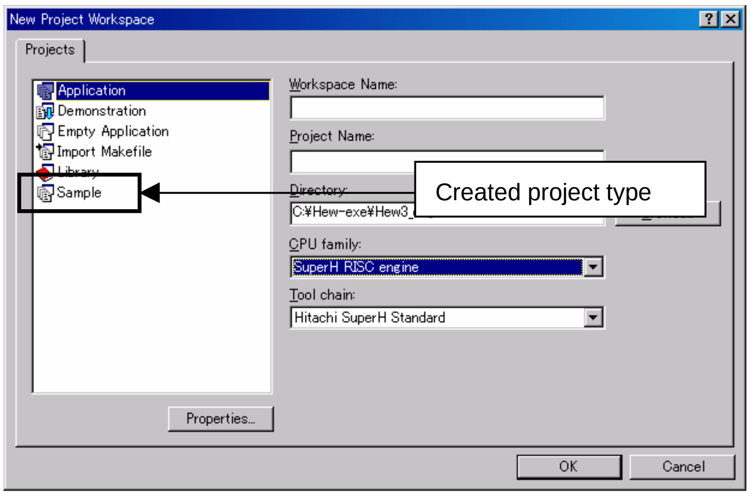

Setup

Installation complete

• Custom Project Generator usage example:

An example of using the installed Custom Project Generator template is provided below.

1. Start HEW and choose [Create a new project workspace] in the [Welcome!] dialog box. The installed project type is added to the [Projects] list. Click on the project type and click on the [OK] button.
   You can now proceed with program development using the stored project template for any new project.



• Note:

This feature is supported by HEW 2.0 or later.

7.1.5 Multi-CPU Feature

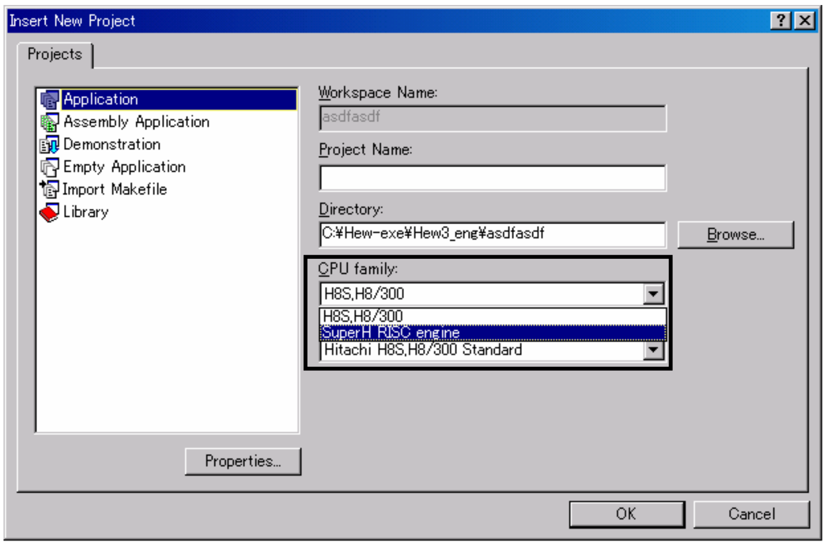
• Description:

When inserting a new project in the workspace, you can insert a CPU of another type. This enables SH and H8 projects to be managed in a single workspace.

• Example of inserting a different CPU family:

1. When an SH (H8) project is open, click on [Project -> Insert Project...]. In the [Insert Project] dialog box, select a new project and click on the [OK] button.

2. The following [Insert New Project] dialog box appears: Select a project name, select SH (H8) as the CPU type, and click on the [OK] button. You can place different CPU types in addition to the current CPU types in the workspace.



Insert New Project

Projects: Application, Assembly Application, Demonstration, Empty Application, Import Makefile, Library

Workspace Name: asdfasdf

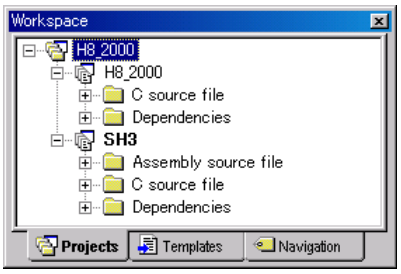
Project Name:

Directory: C:¥Hew-exe¥Hew3_eng¥asdfasdf

CPU family: H8S,H8/300 (H8S,H8/300; SuperH RISC engine)

Hitachi H8S,H8/300 Standard

3. With the procedure above, you can mix SH and H8 projects in a single workspace.



```
Workspace
H8_2000
  H8_2000
    C source file
    Dependencies
  SH3
    Assembly source file
    C source file
    Dependencies
```

• Note:

This feature is supported by HEW 3.0 or later.

7.1.6 Networking Feature

• Description:

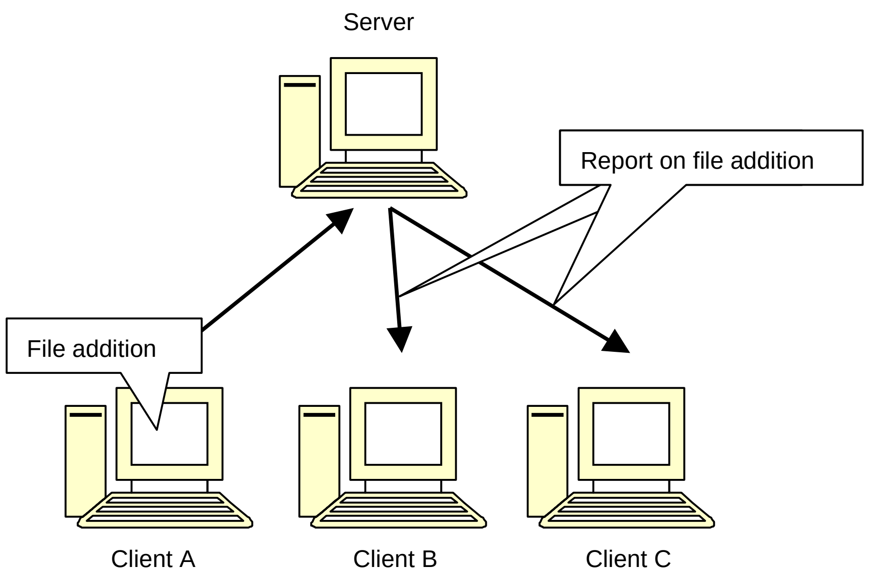
HEW allows workspaces and projects to be shared by different users via a network.

Therefore, users can learn changes that other users have made, by manipulating the shared project at the same time.

This system uses one computer as its server.

For example, if a client adds a new file to a project, the server machine is notified, and then notifies the other clients of the addition.

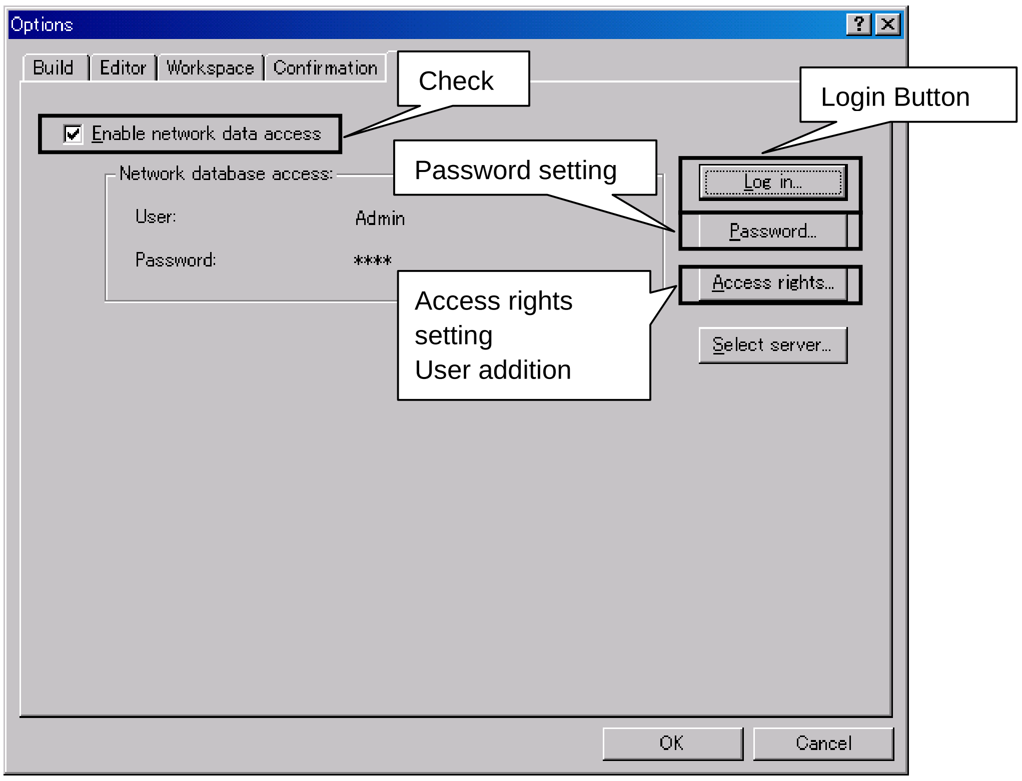
In addition, users can be granted rights for access to specific projects or files.



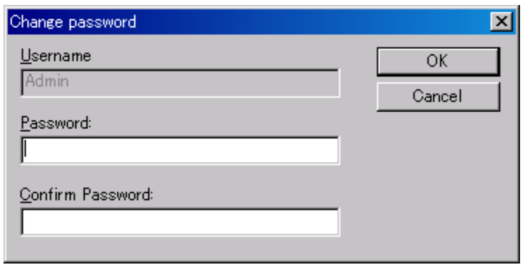
• Network access setup:

1. Choose [Tools -> Options...] and select the [Network] tab. Check the [Enable network data access] check box.
2. An administrator is added. Since the administrator does not have a password initially, you need to specify a password. The administrator should be granted the highest access right.
3. Click on the [Password…] button and specify a password for the administrator.
4. Click on the [OK] button. This allows the administrator access to the network.

[Network] Tab of the [Options] dialog box



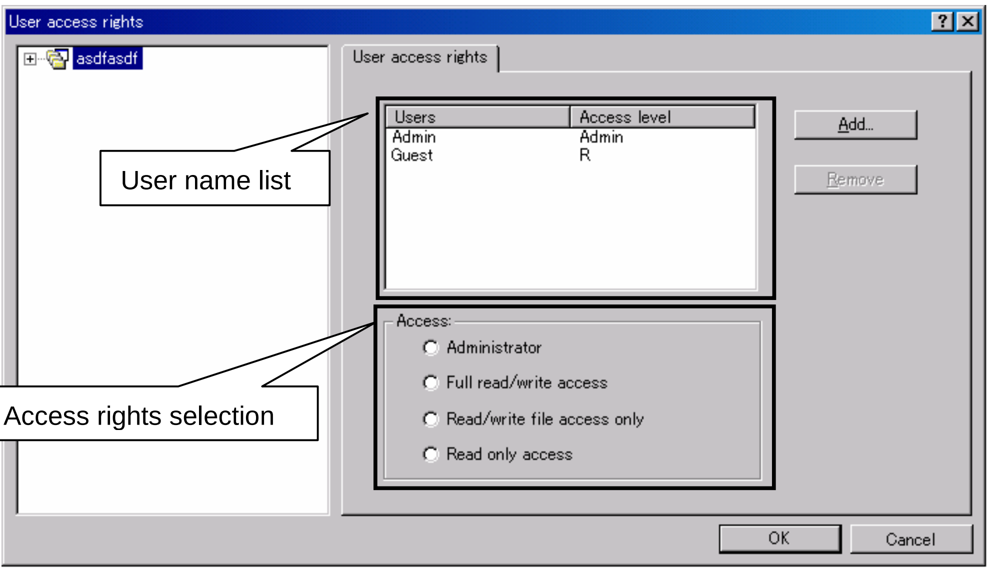
[Change password] dialog box



• Adding a new user:

By default, an administrator and a guest have been added. You can register new users.

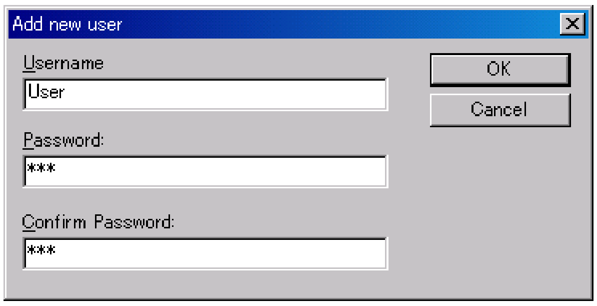
1. Click on the [Log in...] button shown on the previous page. Log in as a user granted administrator access right.



Users	Access level
Admin	Admin
Guest	R

Access:
- Administrator
- Full read/write access
- Read/write file access only
- Read only access

2. Click on the [Access rights…] button to open the following [User access rights] dialog box.
3. Click on the [Add…] button to open the [Add new user] dialog box.
4. Enter a new user name and password.(Password specification is mandatory.)



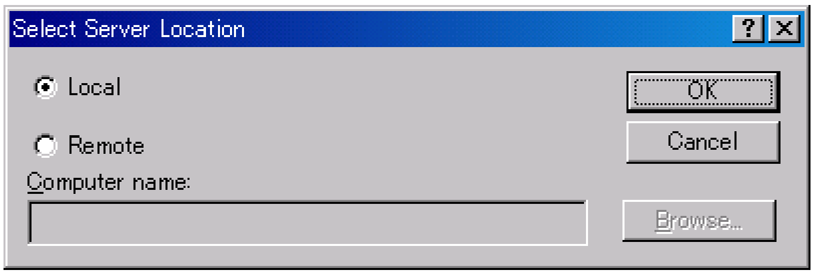
Username: User
Password: ***
Confirm Password: ***

• Selecting the server machine

Select the machine that will work as the server. If you want to make your own machine the server, you do not have to do anything.

If you want to specify another machine as the server, click on the [Select server…] button in the [Options] dialog box. Choose [Remote] in the following dialog box, and then specify a computer name.

Click on the [OK] button. Your specification will be put into effect.



[✓ Local] Remote
Computer name:

• Note:

This feature is supported by HEW 3.0 or later.

Use of this feature will lower the HEW performance.

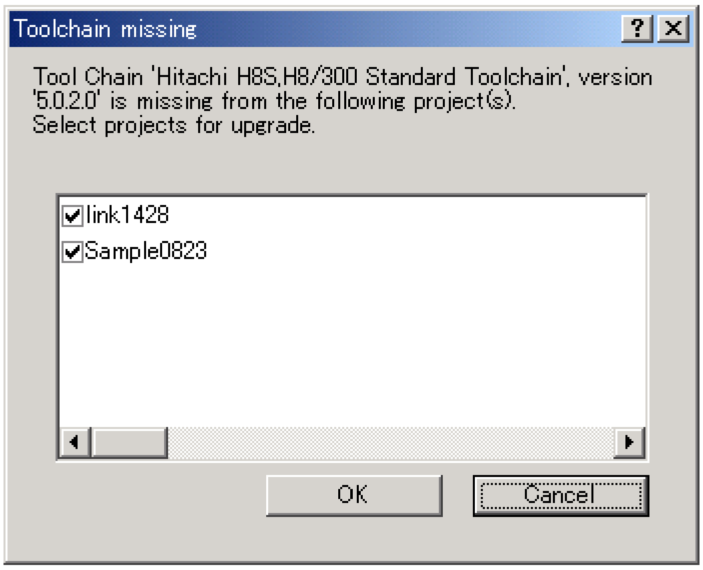
7.1.7 Converting from Old HEW Version

Here, the method for specifying the compiler version within the Renesas Integrated
Development Environment is explained. Compiler versions can be specified by upgrading the Renesas Integrated Development Environment.

If the workspace created in an old version (such as HEW1.1:H8C 3.0C) is opened in a new version (such as HEW3.0:H8C 6.0), the following dialog box appears.

(1) Checking the project to be upgraded.

Check the name of the project to be upgraded.


Toolchain missing

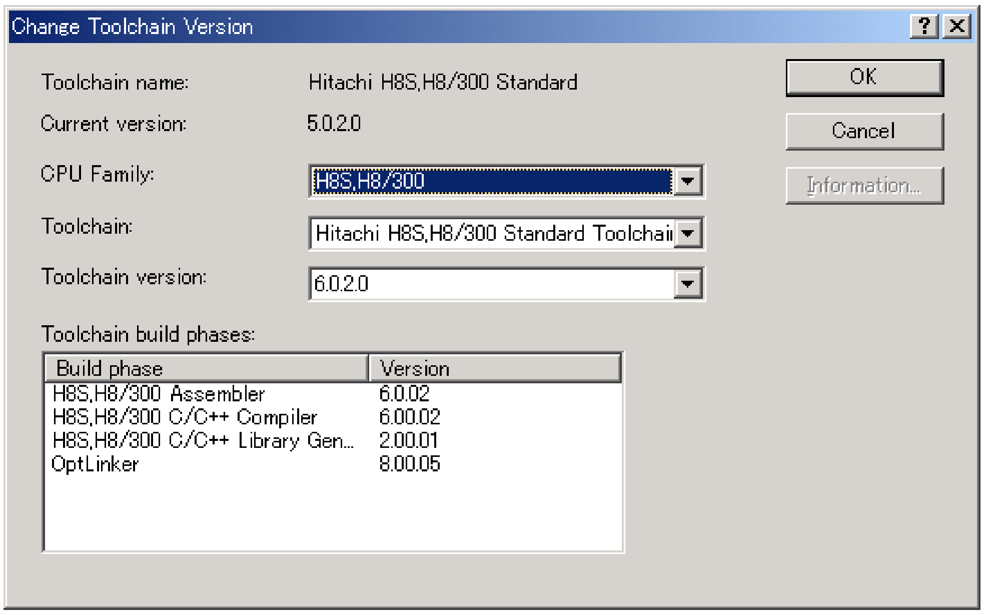
Tool Chain 'Hitachi H8S,H8/300 Standard Toolchain', version '5.0.2.0' is missing from the following project(s).
Select projects for upgrade.

✓ link1428
✓ Sample0823

High-performance Embedded Workshop

(2) Specifying the Compiler Version

Select the Compiler version which can be upgraded.


Change Toolchain Version

Toolchain name: Hitachi H8S,H8/300 Standard
Current version: 5.0.2.0
CPU Family: H8S,H8/300
Toolchain: Hitachi H8S,H8/300 Standard Toolchai
Toolchain version: 6.0.2.0

Toolchain build phases:

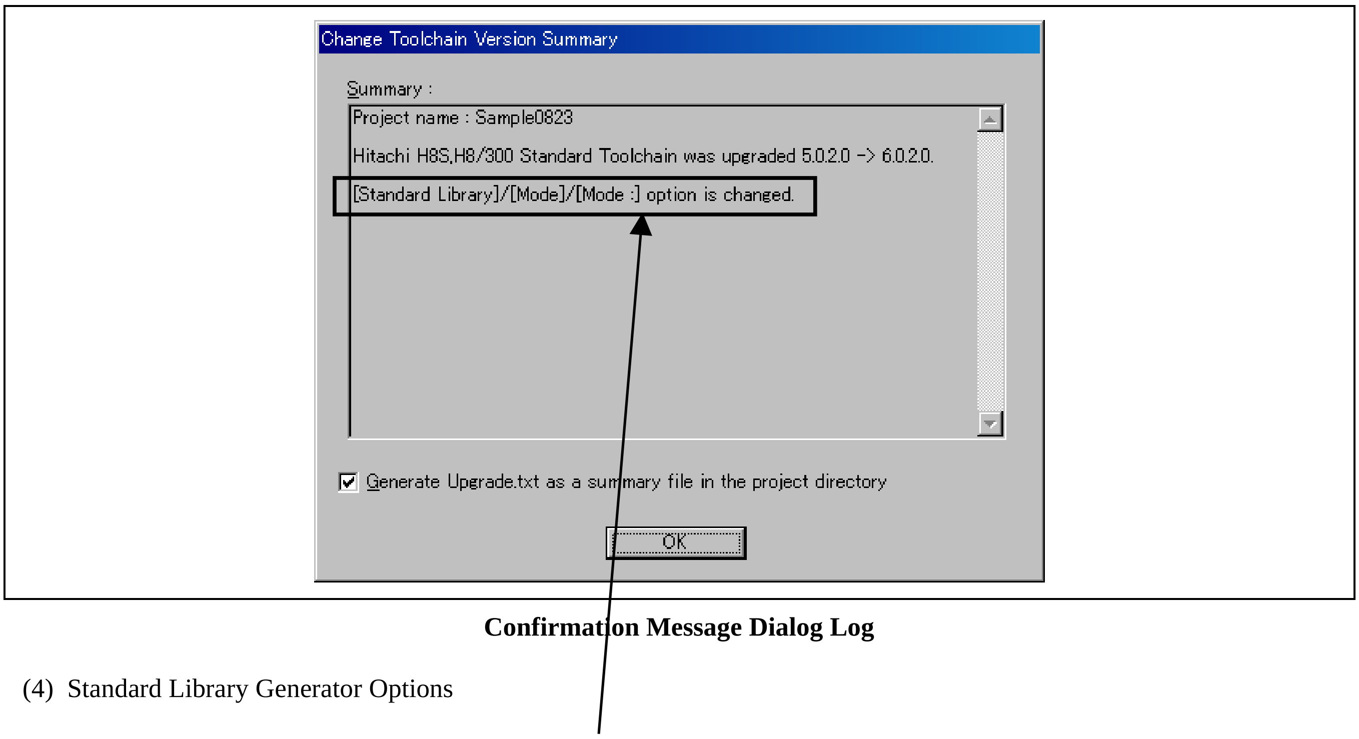
Build phase	Version
H8S,H8/300 Assembler	6.0.02
H8S,H8/300 C/C++ Compiler	6.00.02
H8S,H8/300 C/C++ Library Gen...	2.00.01
OptLinker	8.00.05

Change Toolchain Version Dialog Box

(3) Confirmation message

The C/C++ Compiler Ver.4.0 and later versions support only the file format ELF/DWARF for the object to be output.

The file format is changed to ELF/DWARF format at upgrading. If the current debugging environment does not support the ELF/DWARF format, convert the ELF/DWARF format to the format supported by the debugging environment after upgrading.


Change Toolchain Version Summary
Summary :
Generate Upgrade.txt as a summary file in the project directory
OK

Project name : Sample0823

Hitachi H8S,H8/300 Standard Toolchain was upgraded 5.0.2.0 -> 6.0.2.0.

[Standard Library]/[Mode]/[Mode :] option is changed.

Confirmation Message Dialog Log

(4) Standard Library Generator Options

After upgrading, **Standard Library** Tab Category: [**Mode**] in the Standard Library Generator is changed to **Build a library file(anytime)**, so should be careful.

7.1.8 Converting a HIM Project to a HEW Project

By using the HimToHew tool supplied with the HEW system, you can convert HIM projects into HEW projects.

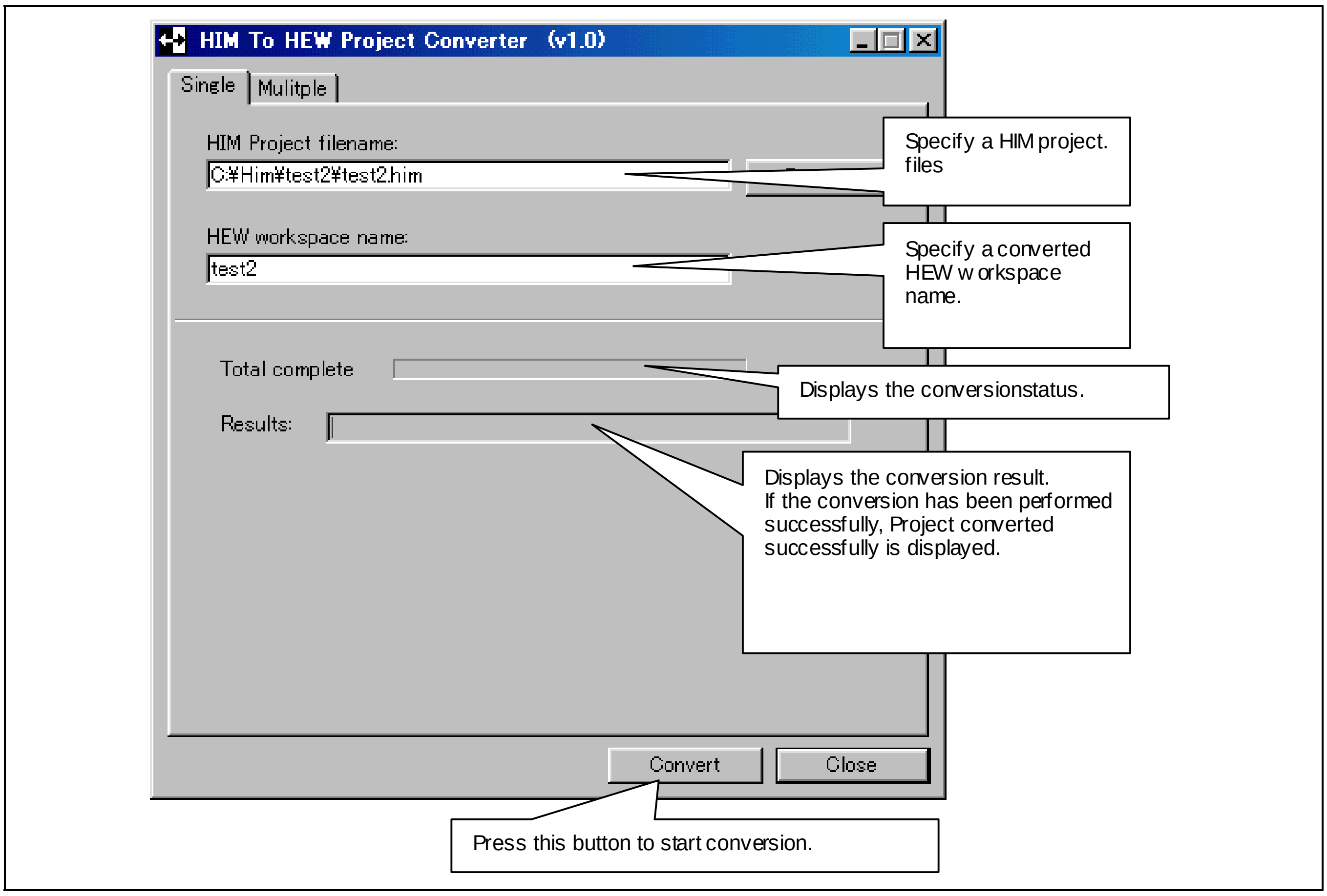
In the [Programs (P)] on the Windows® [Start Menu], select [Him To Hew Project Converter] from [Renesas High-performance Embedded Workshop].

You will find Single and Multiple tabs.

Select the Single tab when generating an HEW workspace and an HEW project from one HIM project.

Select the Multiple tab when converting multiple HIM projects into HEW projects and registering them in an HEW workspace in batch.

(1) Single tab


HIM To HEW Project Converter (v1.0)

Single | Mulitple

HIM Project filename: C:¥Him¥test2¥test2.him

HEW workspace name: test2

Total complete

Results:

Convert | Close

Specify a HIM project. files

Specify a converted HEW workspace name.

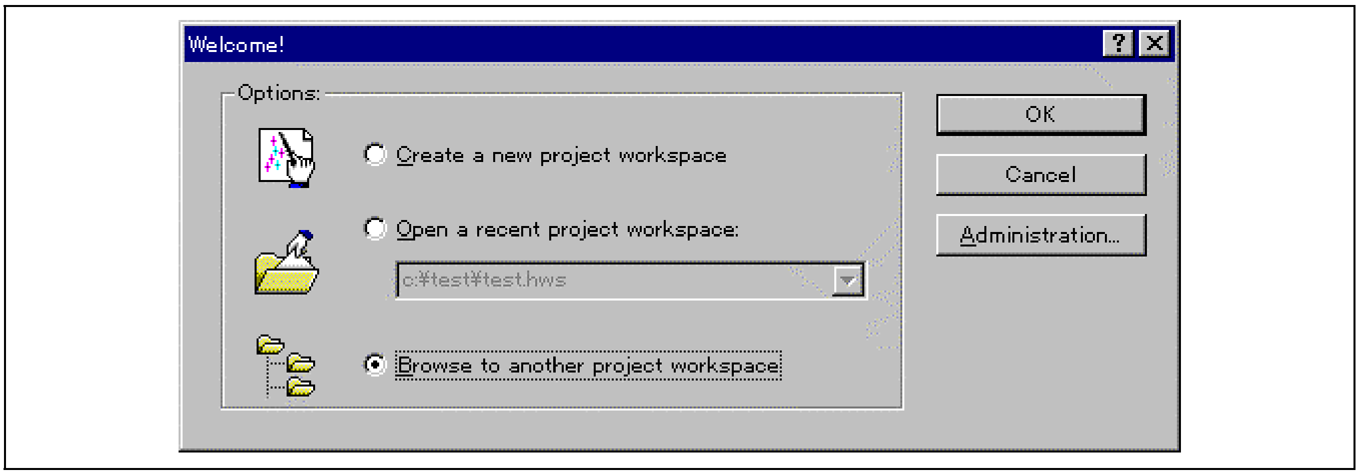
Displays the conversionstatus.

Displays the conversion result.
If the conversion has been performed successfully, Project converted successfully is displayed.

Press this button to start conversion.

In the next step, start the HEW.

Select **Browse to another project workspace**, click on the [OK] button, and specify the HEW project that has been converted.


Welcome!

Options:

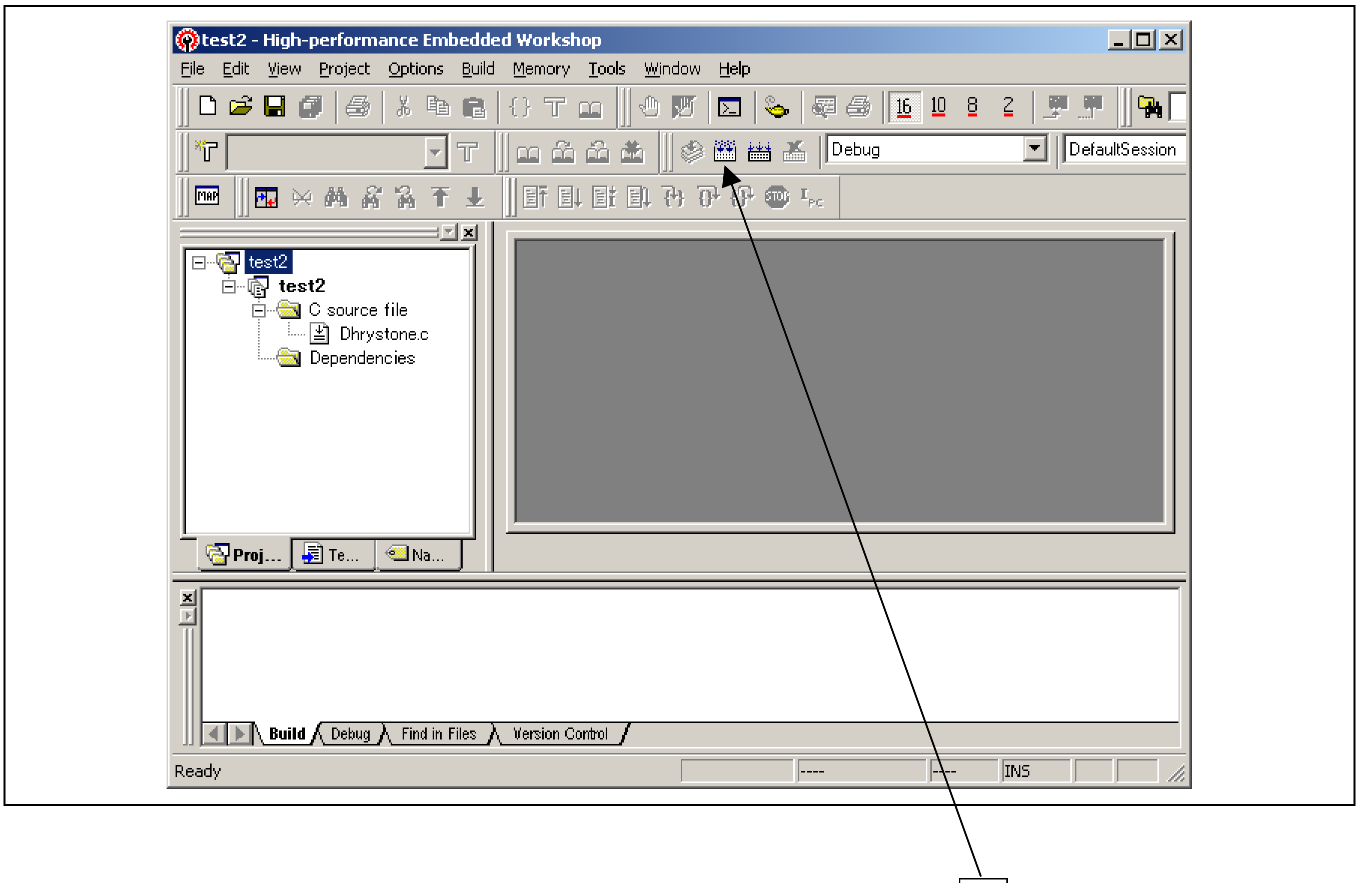
( ) Create a new project workspace

( ) Open a recent project workspace: c:¥test¥test.hws

(●) Browse to another project workspace

OK | Cancel | Administration...

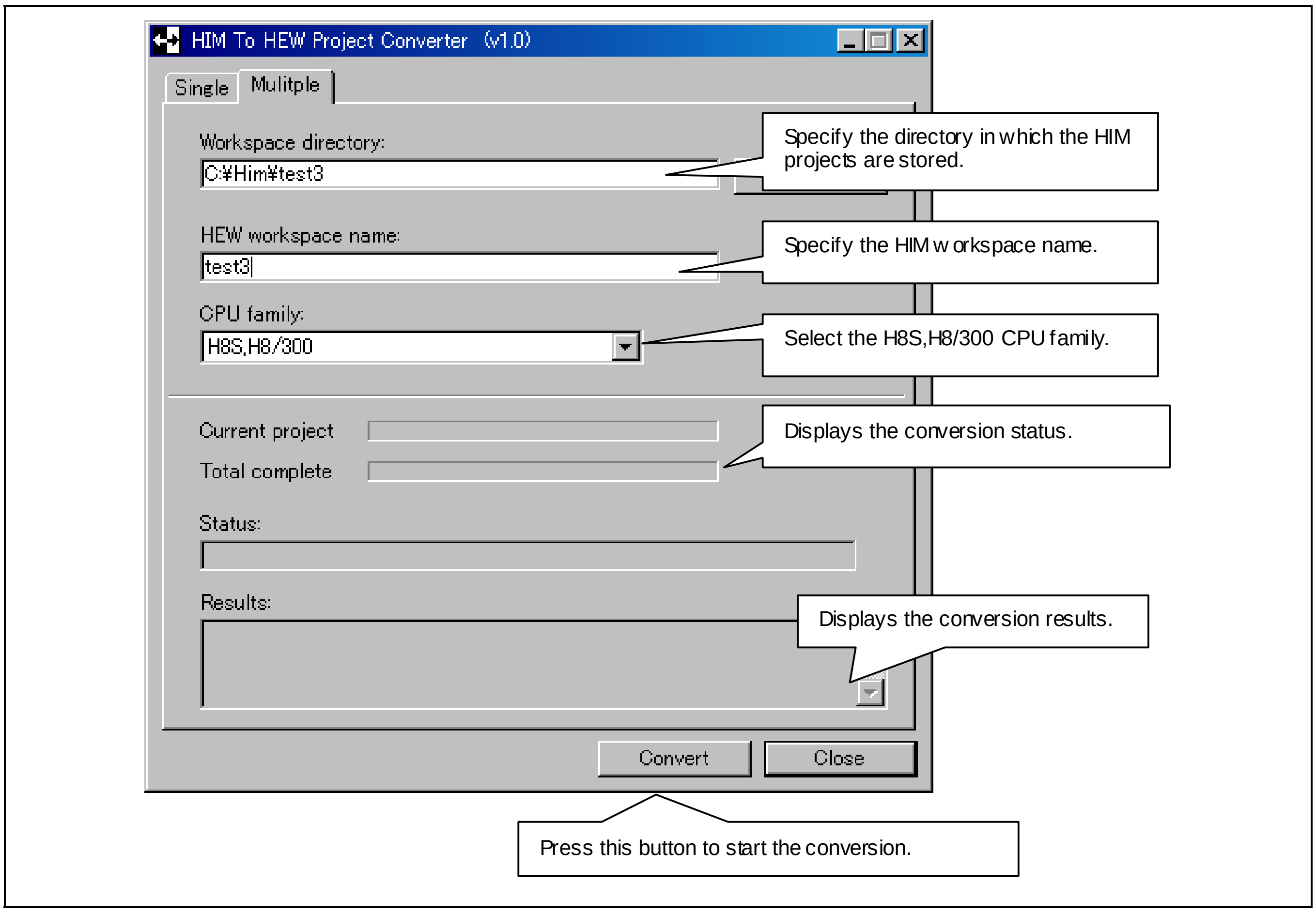
The HEW project is opened as shown below:



Specify [Build → Build] to execute the building process. On the command menu, click here.

(2) Multiple tab

This tab converts multiple HIM projects into HEW projects.


HIM To HEW Project Converter (v1.0)
Single
Mulitple
Workspace directory:
C:¥Him¥test3
Specify the directory in which the HIM projects are stored.
HEW workspace name:
test3
Specify the HIM workspace name.
CPU family:
H8S,H8/300
Select the H8S,H8/300 CPU family.
Current project
Total complete
Displays the conversion status.
Status:
Results:
Displays the conversion results.
Convert
Close
Press this button to start the conversion.

After the conversion, start the HEW as in the case of the Single tab in order to build the converted HEW workspace.

7.1.9 Add Supported CPUs

• Description:

HEW can automatically generate I/O register definition and vector table files, but HEW cannot support new CPUs which are released after HEW release.

In this case, the tool **DeviceUpdater** can make HEW support new CPUs.

And this tool can update generated files to bug fixed version.

• How to get **DeviceUpdater**

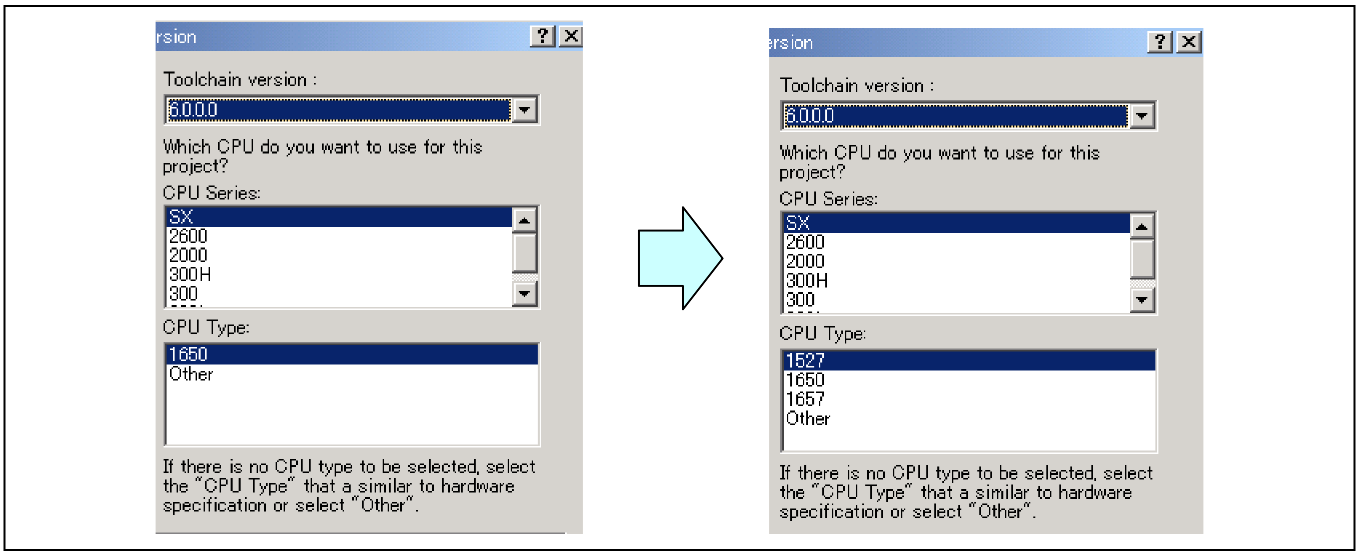
Download from the following URL of Renesas Technology Corp.

Please refer to Notes of this page, too.

http://www.renesas.com/

• Execution Results of **DeviceUpdater**

CPU types are added as follows.


Toolchain version :
6.0.0.0
Which CPU do you want to use for this project?
CPU Series:
SX
2600
2000
300H
300
CPU Type:
1650
Other
If there is no CPU type to be selected, select the "CPU Type" that a similar to hardware specification or select "Other".

Toolchain version :
6.0.0.0
Which CPU do you want to use for this project?
CPU Series:
SX
2600
2000
300H
300
CPU Type:
1527
1650
1657
Other
If there is no CPU type to be selected, select the "CPU Type" that a similar to hardware specification or select "Other".

• Notes

This feature is supported by HEW 2.2 or later.

7.2 Simulations

7.2.1 Pseudo-interrupts

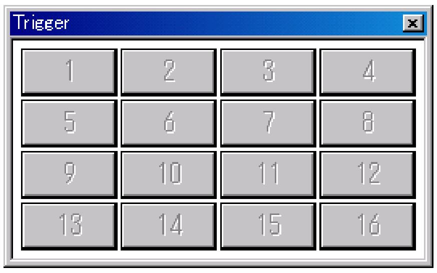
• Description:

Pseudo-interrupt buttons, which simulate certain interrupt causes, when clicked on, can cause pseudo-interrupts manually.

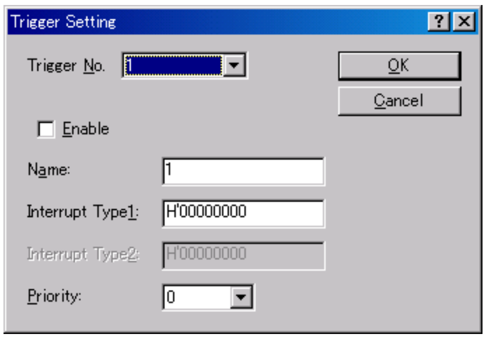
For each button, specify an interrupt priority and interrupt condition.

• Usage:

1. When you choose [View -> CPU -> Trigger], the following view appears:



2. Click the right mouse button on this view and choose [Setting…].The [Trigger Setting] dialog box appears.
   If you check the [Enable] check box, the interrupt identified by trigger number 1 is enabled.
   In addition, specify an interrupt name, interrupt priority, and interrupt condition (vector number).
   The interrupt button identified by trigger number 1 becomes active.



Trigger No.: 1
☐ Enable
Name: 1
Interrupt Type1: H'00000000
Interrupt Type2: H'00000000
Priority: 0

3. The setting is now complete. When one of the buttons that was set during the above procedure is clicked on, the program will stop as specified by the pertinent vector table.

• Note:

This feature is supported by HEW 2.1 or later.

7.2.2 Convenient Breakpoint Functions

• Description:

The HEW breakpoint facility includes the following convenient functions, which will be activated not only upon ordinary breaks, but when a break condition is satisfied.

File input
File output
Interrupt

• How to display a breakpoint view:

HEW 2.2 or earlier: Choose [View -> Code -> Breakpoints]
HEW 3.0 or later: Choose [View -> Code -> Eventpoints]

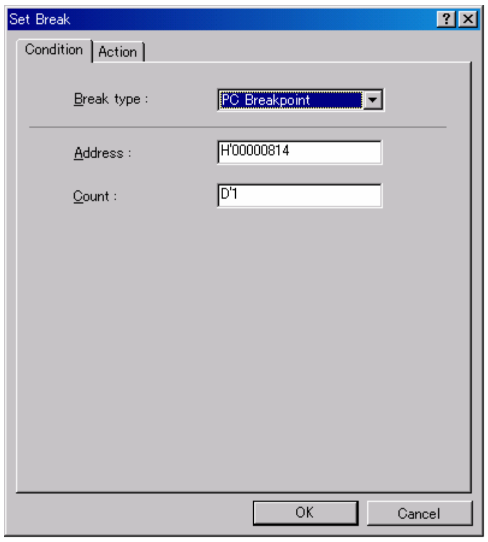
Note: For HEW 3.0 or later, go to the [Breakpoints] view and click on the [Software Event] tab.

• File input setting example:

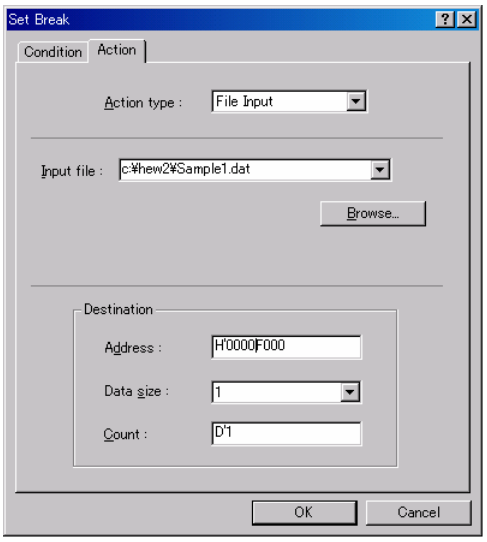
Right-click on the [Breakpoints] view and choose [Setting…] to open the following [Set Break] dialog box. As shown below, PC breakpoint is used so that a break condition is considered as satisfied when the PC reaches the following address. The setting method is similar for other breakpoint types.

Click on the [Action] tab, select [File Input] in the [Action type] field, specify an input file name, an input address, and other items, and then click on the [OK] button.

([Condition] tab) ([Action] tab)



Break type : PC Breakpoint
Address : H'00000814
Count : D'1



Action type : File Input
Input file : c:¥hew2¥Sample1.dat
Address : H'0000F000
Data size : 1
Count : D'1

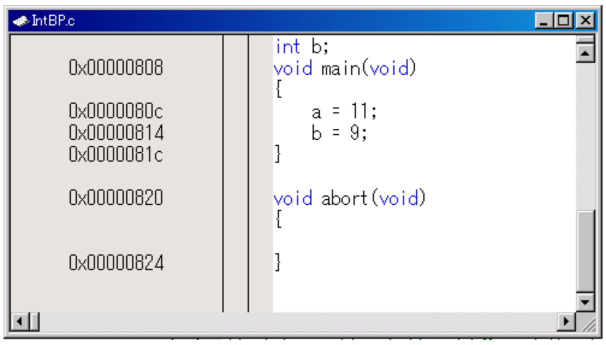
• File input action example:

Let’s see the following practical action example:

As the result of the above setting, the breakpoint is at [H'00000814] and the input file contains [H'FF].

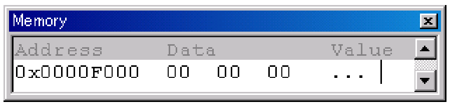
Run the program using the Go command or similar method.

(Source code fragment)

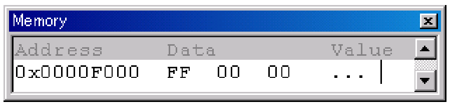


```
            int b;
0x00000808  void main(void)
            {
0x0000080c      a = 11;
0x00000814      b = 9;
0x0000081c  }

0x00000820  void abort(void)
            {

0x00000824  }
```

You can see that, when the PC reaches [H'00000814], the break condition is satisfied and, as a consequence, the memory contents of address H'F000 change.



```
Address     Data          Value
0x0000F000  00  00  00    ...
```

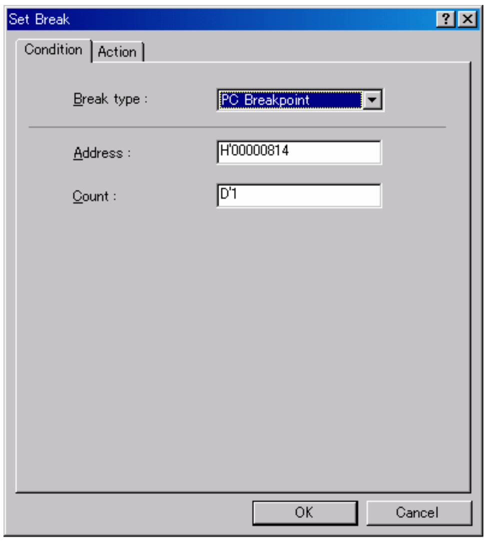


```
Address     Data          Value
0x0000F000  FF  00  00    ...
```

• **File output** setting example:

The method for file output setting in the [Set Break] dialog box is similar to the method for file input setting. For file output breakpoints, PC breakpoint is also used so that a break condition is considered as satisfied when the PC reaches the following address. Click on the [Action] tab, select [File Output] in the [Action Type] field, specify an output file name, an output address, and other items, and then click on the [OK] button.

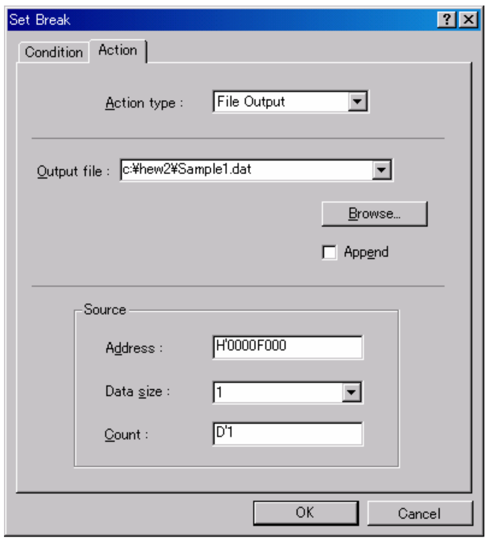
([Condition] tab) ([Action] tab)



Break type : PC Breakpoint

Address : H'00000814

Count : D'1



Action type : File Output

Output file : c:¥hew2¥Sample1.dat

☐ Append

Address : H'0000F000

Data size : 1

Count : D'1

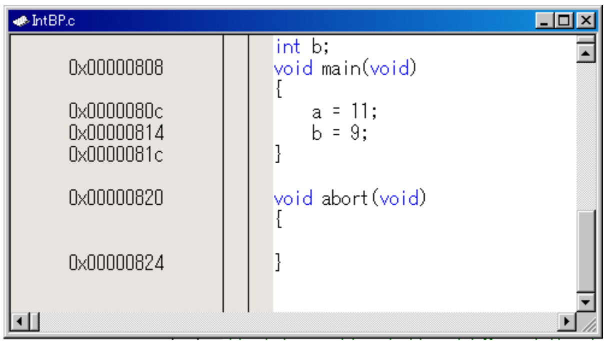
• File output action example:

Let’s see the following practical action example:

As the result of the above setting, the breakpoint is at [H'00000814] and the contents of address H'F000 are [H'FF].

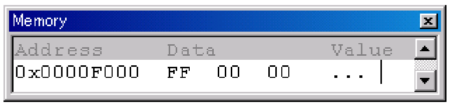
Run the program using the Go command or similar method.

(Source code fragment)



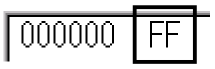
```
                int b;
0x00000808      void main(void)
                {
0x0000080c          a = 11;
0x00000814          b = 9;
0x0000081c      }

0x00000820      void abort(void)
                {

0x00000824      }
```

You can see that, when the PC reaches [H'00000814], the break condition is satisfied and, as a consequence, the contents of address H'F000 are output to the file.



```
Address      Data        Value
0x0000F000   FF  00  00  ...
```

(Sample.dat contents as seen on a binary editor)



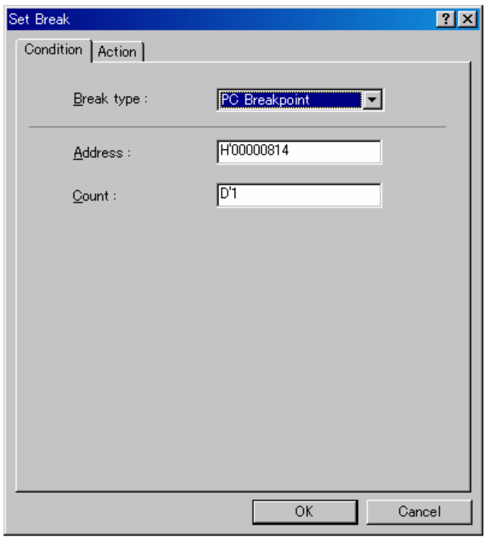
• **Interrupt** setting example:

The method for file output setting in the [Set Break] dialog box is similar to the method for file input setting. As shown below, PC breakpoint is used so that a break condition is considered as satisfied when the PC reaches the following address. The setting method is similar for other breakpoint types.

Click on the [Action] tab, select [Interrupt] in the [Action Type] field, specify an interrupt priority and an interrupt type (vector number 7), and click on the [OK] button.

([Condition] tab)

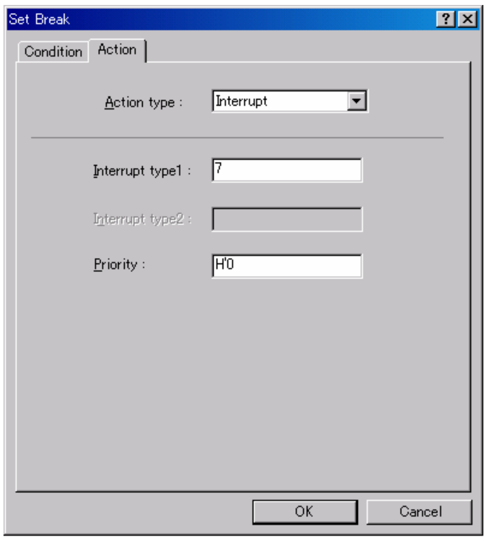
([Action] tab)



Break type : PC Breakpoint

Address : H'00000814

Count : D'1



Action type : Interrupt

Interrupt type1 : 7

Interrupt type2 :

Priority : H'0

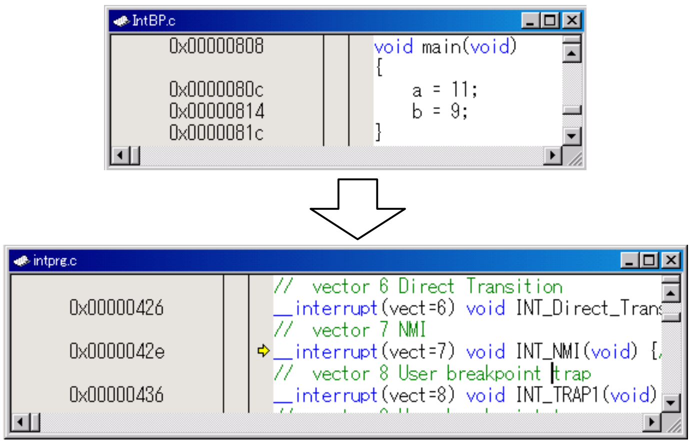
• **Interrupt** action example:

Let’s see the following practical action example:

While the breakpoint is set at [H'00000814] as the result of the above setting, run the program by the Go command or similar method.

You can see that, when the PC reaches [H'00000814], a non-maskable interrupt (NMI) of vector number 7 will occur.

(Source code fragment)



IntBP.c

```
0x00000808      void main(void)
                {
0x0000080c          a = 11;
0x00000814          b = 9;
0x0000081c      }
```

intprg.c

```
                // vector 6 Direct Transition
0x00000426      __interrupt(vect=6) void INT_Direct_Trans
                // vector 7 NMI
0x0000042e    ⇨ __interrupt(vect=7) void INT_NMI(void) {/
                // vector 8 User breakpoint trap
0x00000436      __interrupt(vect=8) void INT_TRAP1(void)
```

7.2.3 Coverage Feature

• Description:

HEW allows users to collect statement coverage information within a user-specified address range during program execution. By using statement coverage information, you can observe how each statement is being executed. In addition, you can easily identify program code that has not been executed.

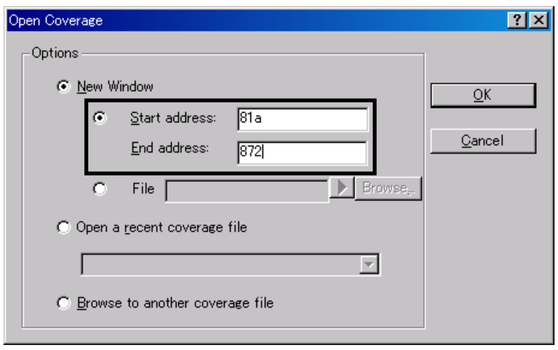
• How to open the [Open Coverage] dialog box:

[View -> Code -> Coverage...]

• How to collect new coverage information:

1. Open the [Open Coverage] dialog box, choose [New Window], and enter the start and end addresses that identify the range from which you want to obtain coverage information. If the HEW version is 3.0 or later, you can specify a C or C++ source file name to identify the information you want to collect.
   To complete the above specification, click on the [OK] button.

(Address specification)



Open Coverage

Options

[✓ New Window]

[✓ Start address:] 81a

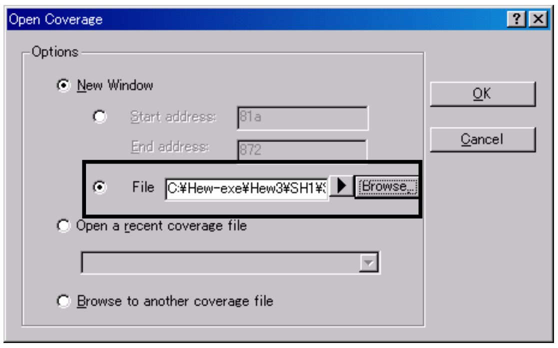
End address: 872

File

Open a recent coverage file

Browse to another coverage file

(File name specification) * Supported by HEW 3.0 or later



Open Coverage

Options

[✓ New Window]

Start address: 81a

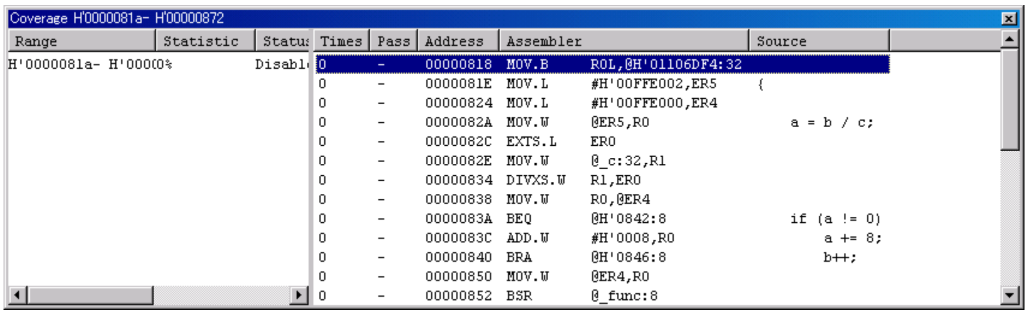
End address: 872

[✓ File] C:¥Hew-exe¥Hew3¥SH1¥ Browse...

Open a recent coverage file

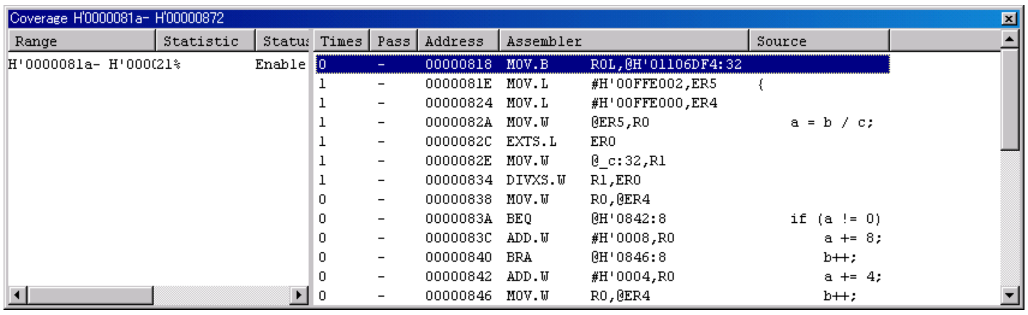
Browse to another coverage file

2. When you click on the [OK] button, the following coverage view appears:
   On the right view, click the right mouse button and choose [Enable]. The coverage is enabled.



```
Coverage H'0000081a- H'00000872
Range                Statistic  Statu  Times Pass  Address   Assembler                   Source
H'0000081a- H'000(0%            Disabl 0     -     00000818  MOV.B     ROL,@H'01106DF4:32
                                       0     -     0000081E  MOV.L     #H'00FFE002,ER5   {
                                       0     -     00000824  MOV.L     #H'00FFE000,ER4
                                       0     -     0000082A  MOV.W     @ER5,R0               a = b / c;
                                       0     -     0000082C  EXTS.L    ER0
                                       0     -     0000082E  MOV.W     @_c:32,R1
                                       0     -     00000834  DIVXS.W   R1,ER0
                                       0     -     00000838  MOV.W     R0,@ER4
                                       0     -     0000083A  BEQ       @H'0842:8             if (a != 0)
                                       0     -     0000083C  ADD.W     #H'0008,R0                a += 8;
                                       0     -     00000840  BRA       @H'0846:8                 b++;
                                       0     -     00000850  MOV.W     @ER4,R0
                                       0     -     00000852  BSR       @_func:8
```

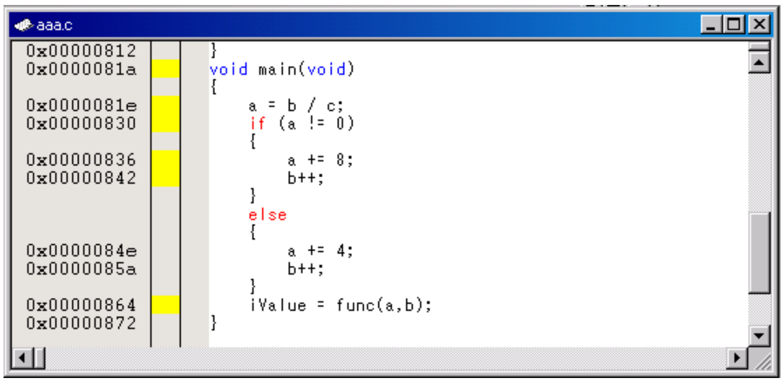
3. Let’s run the program. Notice that the right coverage view contains a line with the [Times] column changed to 1. This indicates that the statement at the address corresponding to this line has been executed.
   On the left view, the C0 coverage value within the address range is displayed.



```
Coverage H'0000081a- H'00000872
Range                Statistic  Statu  Times Pass  Address   Assembler                   Source
H'0000081a- H'000(21%           Enable 0     -     00000818  MOV.B     ROL,@H'01106DF4:32
                                       1     -     0000081E  MOV.L     #H'00FFE002,ER5   {
                                       1     -     00000824  MOV.L     #H'00FFE000,ER4
                                       1     -     0000082A  MOV.W     @ER5,R0               a = b / c;
                                       1     -     0000082C  EXTS.L    ER0
                                       1     -     0000082E  MOV.W     @_c:32,R1
                                       1     -     00000834  DIVXS.W   R1,ER0
                                       0     -     00000838  MOV.W     R0,@ER4
                                       0     -     0000083A  BEQ       @H'0842:8             if (a != 0)
                                       0     -     0000083C  ADD.W     #H'0008,R0                a += 8;
                                       0     -     00000840  BRA       @H'0846:8                 b++;
                                       0     -     00000842  ADD.W     #H'0004,R0                a += 4;
                                       0     -     00000846  MOV.W     R0,@ER4                   b++;
```

Note: The left coverage view exists when the HEW version is 3.0 or later.

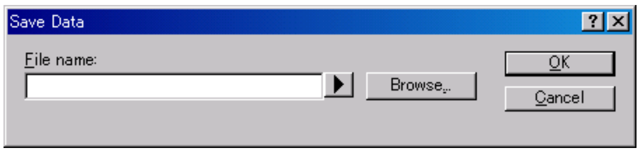
4. In addition to the coverage view, you can use another method to see coverage information. A left column on the editor screen indicates whether program execution has passed a particular source line.



```
0x00000812      }
0x0000081a      void main(void)
                {
0x0000081e          a = b / c;
0x00000830          if (a != 0)
                    {
0x00000836              a += 8;
0x00000842              b++;
                    }
                    else
                    {
0x0000084e              a += 4;
0x0000085a              b++;
                    }
0x00000864          iValue = func(a,b);
0x00000872      }
```

• Save Data:

To save coverage information, click the right mouse button on the right coverage view and enter a file name with the extension* .cov.

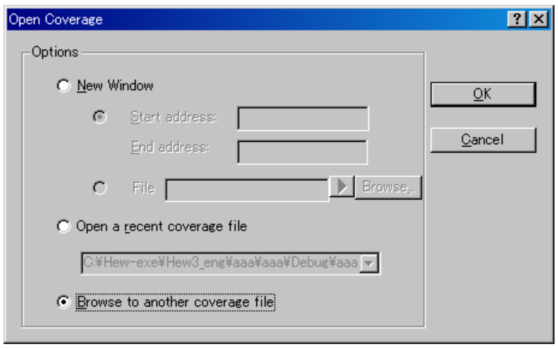


• Information collection using existing coverage information:

You can rarely obtain a single collection of coverage information that covers the entire program.

You may want to increase the coverage percentage while repeating coverage collection steps, each of which is performed under a different test condition.

For this purpose, specify a file that has been saved in the [Save Data] and select [Open a recent coverage file] or [Browse to another coverage file] in the [Open Coverage] dialog box. Then click on the [OK] button.

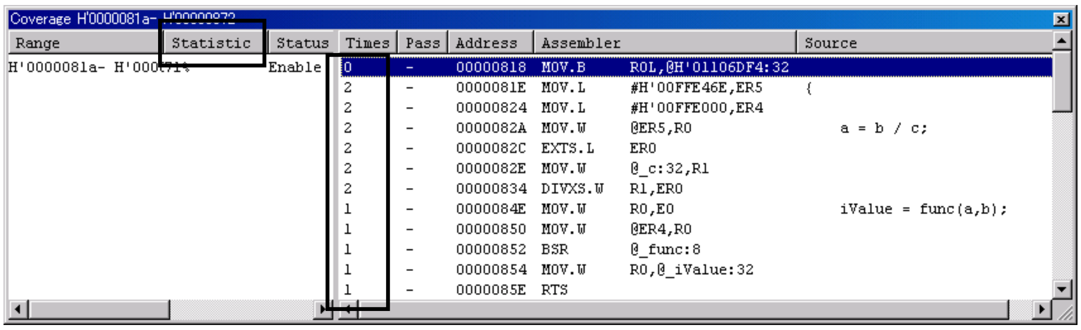


Open a recent coverage file: C:¥Hew-exe¥Hew3_eng¥aaa¥aaa¥Debug¥aaa

[✓ Browse to another coverage file]

The coverage view opens. Run the program again under a new condition.

As shown below, the coverage view and the editor display new information reflecting the current run, such as the number of runs and the new C0 coverage value.



Coverage H'0000081a- H'00000872

```
Range              Statistic  Status  Times  Pass  Address   Assembler                        Source
H'0000081a- H'00071%          Enable  0      -     00000818  MOV.B     R0L,@H'01106DF4:32
                                      2      -     0000081E  MOV.L     #H'00FFE46E,ER5        {
                                      2      -     00000824  MOV.L     #H'00FFE000,ER4
                                      2      -     0000082A  MOV.W     @ER5,R0                    a = b / c;
                                      2      -     0000082C  EXTS.L    ER0
                                      2      -     0000082E  MOV.W     @_c:32,R1
                                      2      -     00000834  DIVXS.W   R1,ER0
                                      1      -     0000084E  MOV.W     R0,E0                      iValue = func(a,b);
                                      1      -     00000850  MOV.W     @ER4,R0
                                      1      -     00000852  BSR       @_func:8
                                      1      -     00000854  MOV.W     R0,@_iValue:32
                                      1      -     0000085E  RTS
```

7.2.4 File I/O

• Description:

HEW used to rely on the I/O simulation feature in order to simulate file I/O operations instead of actually performing file I/O.

However, HEW now allows actual files to be input or output if the following files are replaced.

• How to obtain files:

Download the files from the "Guideline for File Operatable Low-Level Interface Routines for Simulator and Debugger" page on the following URL of Renesas Technology Corp.

http://www.renesas.com/

• How to create the environment:

(1) Create a project by HEW.
Select [Application] or [Demonstration] as the project type.
A number of files are created automatically under the created project.
(If you have selected [Application] as the project type, check the [Use I/O Library] check box at project creation step 3.
The value specified in the [Number of I/O Stream] field must be at least the number of actually handled files + 3 (number of standard I/O files.

(2) Of the created files, replace "lowsrc.c" and "lowlvl.src".*[1]

(3) Create the "C:\Hew2\stdio" directory.*[2]

(4) Perform a rebuild to create a simulator/debugger environment in which file I/O is possible.

Notes: 1. lowsrc.c-
These files are common to SH and H8.
Replace the file with the "lowsrc.c" file contained in the project.
-lowlvl.src-
This file varies from one CPU to another.
Replace this file with the "lowlvl.src" file contained in the folder corresponding to the CPU that has created the project.

2. In the created environment, standard I/O files will be actually opened when program code for file I/O processing is encountered, unlike the practice performed so far – simulation of file opening.

   Since these files are defined so that they should be created in "C:\Hew2\stdio", you must create the directory as explained in Item (3).If this directory does not exist, HEW will not work normally.

   When the simulator runs, these files are opened by INIT_IOLIB() in the "lowsrc.c" file contained in the project.

   stdin = 0

   stdout = 1

   stderr = 2

• Example of Use:

As in the following example, consider the use of printf or a similar method to output characters to the standard output (stdout):

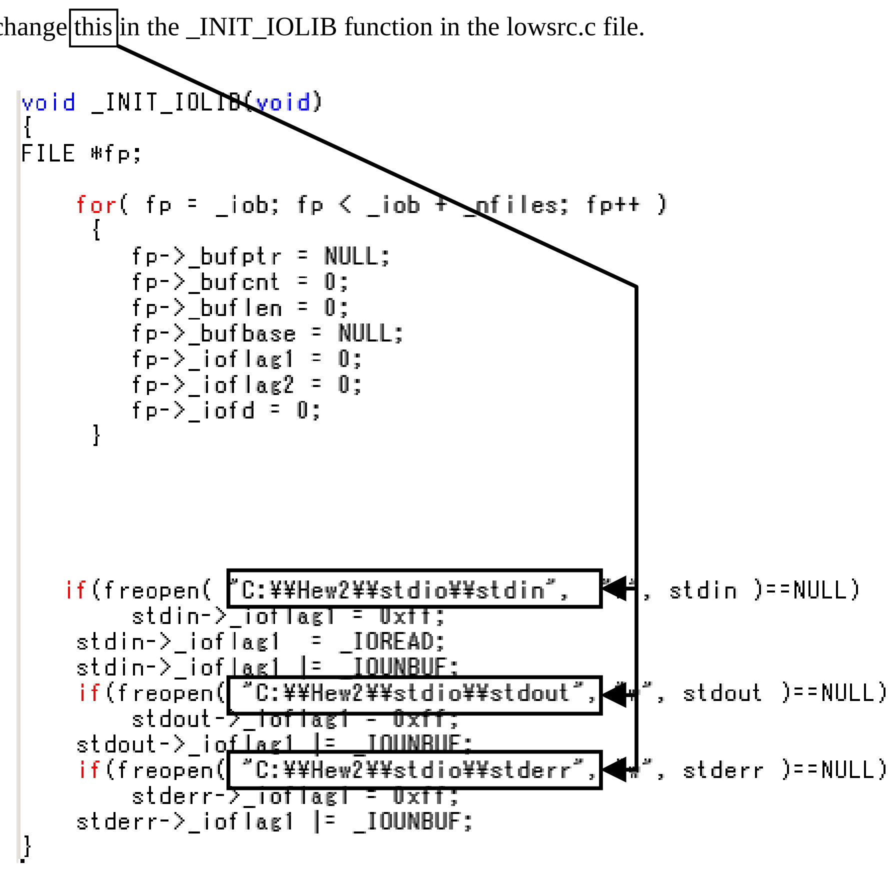
```
(Sample program code)

void main(void)
{
        printf("***** ID-1 OK *****\n");
}
```

When you run this program, it creates a file named stdout in the "c:\Hew2\stdio" directory you have already created. The file contents are as follows:

```
(Contents of stdout)

***** ID-1 OK *****
```

• How to redirect I/O:

To redirect I/O, change this in the _INIT_IOLIB function in the lowsrc.c file.



```
void _INIT_IOLIB(void)
{
FILE *fp;

    for( fp = _iob; fp < _iob + _nfiles; fp++ )
     {
        fp->_bufptr = NULL;
        fp->_bufcnt = 0;
        fp->_buflen = 0;
        fp->_bufbase = NULL;
        fp->_ioflag1 = 0;
        fp->_ioflag2 = 0;
        fp->_iofd = 0;
     }



   if(freopen( "C:¥¥Hew2¥¥stdio¥¥stdin",  "r", stdin )==NULL)
        stdin->_ioflag1 = 0xff;
    stdin->_ioflag1  = _IOREAD;
    stdin->_ioflag1 |= _IOUNBUF;
    if(freopen( "C:¥¥Hew2¥¥stdio¥¥stdout", "w", stdout )==NULL)
        stdout->_ioflag1 = 0xff;
    stdout->_ioflag1 |= _IOUNBUF;
    if(freopen( "C:¥¥Hew2¥¥stdio¥¥stderr", "w", stderr )==NULL)
        stderr->_ioflag1 = 0xff;
    stderr->_ioflag1 |= _IOUNBUF;
}
```

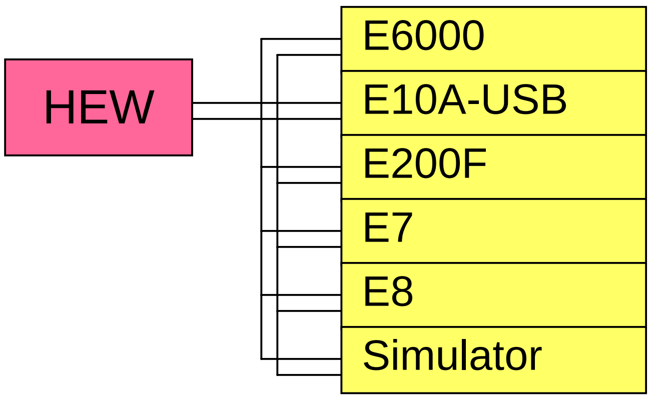
7.2.5 Debugger Target Synchronization

• Description:

HEW allows you to debug multiple targets on a single instance of HEW.

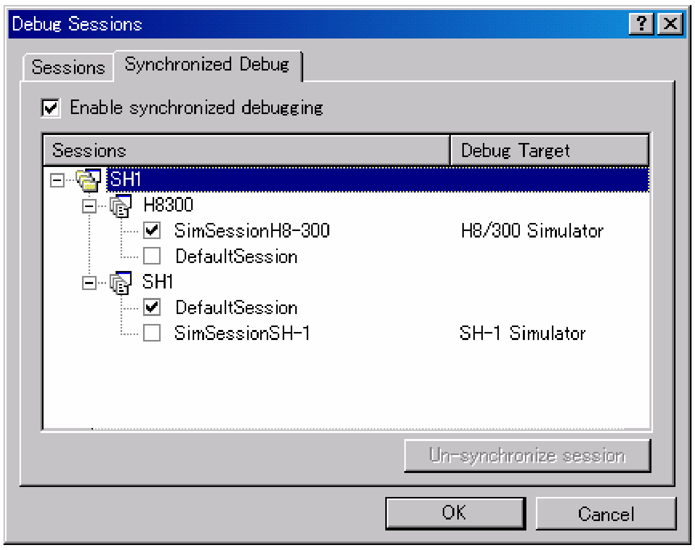
This means that you can debug multiple targets at the same time while synchronizing them with each other.

In addition, you can raise an event (such as a step or Go) in one session in synchronization with the same event in another session.



• How to synchronize debugger targets:

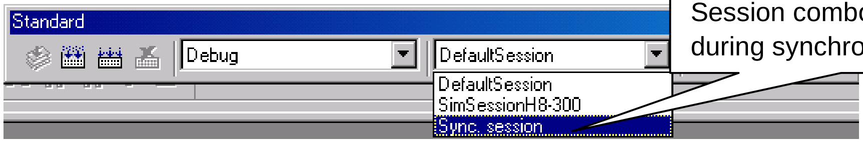
1. Choose [Options -> Debug sessions...] to open the following dialog box and click the [Synchronized Debug] tab. Check any session you want to synchronize and check the [Enable synchronized debugging] check box.



☑ Enable synchronized debugging

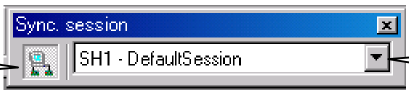
Sessions	Debug Target
SH1	
H8300	
☑ SimSessionH8-300	H8/300 Simulator
☐ DefaultSession	
SH1	
☑ DefaultSession	
☐ SimSessionSH-1	SH-1 Simulator

2. Select [Sync. session] from the session combo box on the [Standard] tool bar.



Session combo box displayed during synchronized debug

3. The [Sync. session] tool bar appears in the tool bar. The setting is now complete.



Enable/disable synchronized debug

Synchronized debug Session list

• Available commands:

When synchronized debug is enabled, you can perform the following actions in synchronized mode:

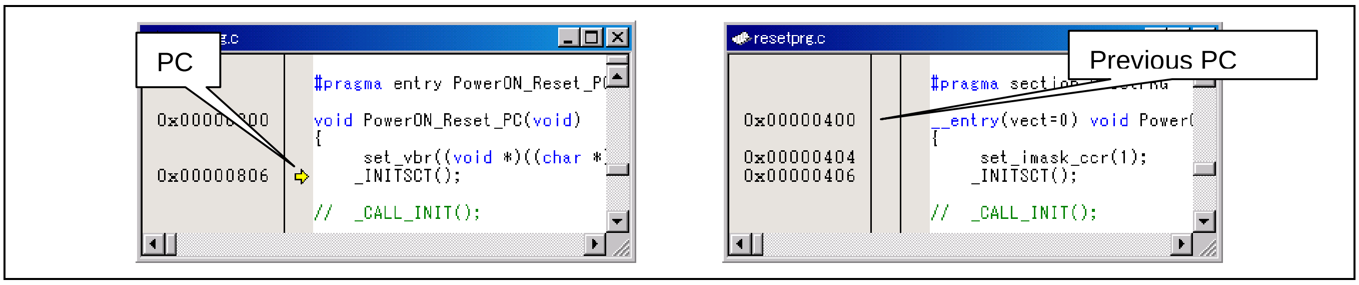
User action	Target debugger session 1	Target debugger session 2
[Run] during one of the sessions	"Run"	"Run"
[Step] during one of the sessions	"Step"	"Step"
ESC pressed during one of the sessions	"Stop"	"Stop"
-	"Stop" due to a breakpoint or user program error	Stop (same as when ESC is pressed)
-	Stop (same as when ESC is pressed)	"Stop" due to a breakpoint or user program error
[CPU reset] during one of the sessions	"CPU reset"	"CPU reset"

• Synchronized debug example

An example of executing the step command is provided below.

1. Execute the step during [SH1 – SimSessionSH-1].The following condition results:

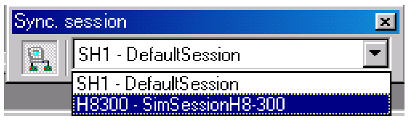
SH – SimSessionSH-1 state   H8300 - SimSessionH8-300 state



```
0x00000800   #pragma entry PowerON_Reset_PC
0x00000806   void PowerON_Reset_PC(void)
             {
                 set_vbr((void *)((char *
                _INITSCT();

             //  _CALL_INIT();
```

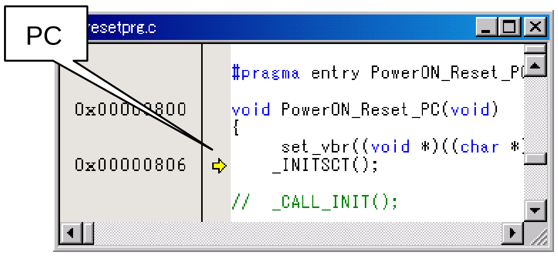
```
0x00000400   #pragma section
             __entry(vect=0) void Power(
             {
0x00000404       set_imask_ccr(1);
0x00000406      _INITSCT();

             //  _CALL_INIT();
```

2. Change the session using the [Sync. session] tool bar.



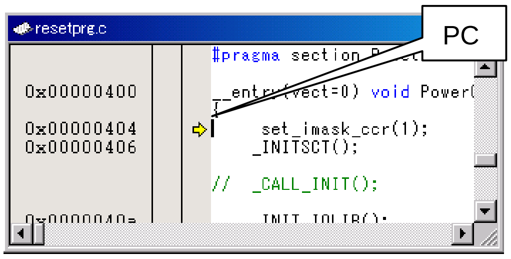
3. As shown below, you can see that the PC has also moved to the next line during the [H8300 – SimSessionH8-300] session.

SH – SimSessionSH-1 state



```
0x00000800    #pragma entry PowerON_Reset_PC

              void PowerON_Reset_PC(void)
              {
                  set_vbr((void *)((char *
0x00000806        _INITSCT();

              //  _CALL_INIT();
```

H8300 SimSessionH8-300 state



```
              #pragma section P
0x00000400    __entry(vect=0) void Power(
              {
0x00000404        set_imask_ccr(1);
0x00000406        _INITSCT();

              //  _CALL_INIT();
```

• Note:

This feature is supported by HEW 3.0 or later.

7.2.6 How to Use Timers

• Description:

HEW supports prioritization of timers and interrupts.

For each timer, only channel 0 is supported.

HEW support is limited to overflow and compare match interrupts. HEW does not support interrupts that involve terminal I/O, such as input capture interrupts.

• Supported timer control registers

In the Supported column on the following table, O indicates that the register is supported and Δ indicates that only the bits associated with the feature described in the paragraph under [Description] are supported.

Debug platform name	Timer name	Supported control register	Supported
H8SX	TPU0	TSTR	Δ
		TCR	Δ
		TIER	O
		TSR	O
		TCNT	O
		TGRA	O
		TGRB	O
		TGRC	O
		TGRD	O

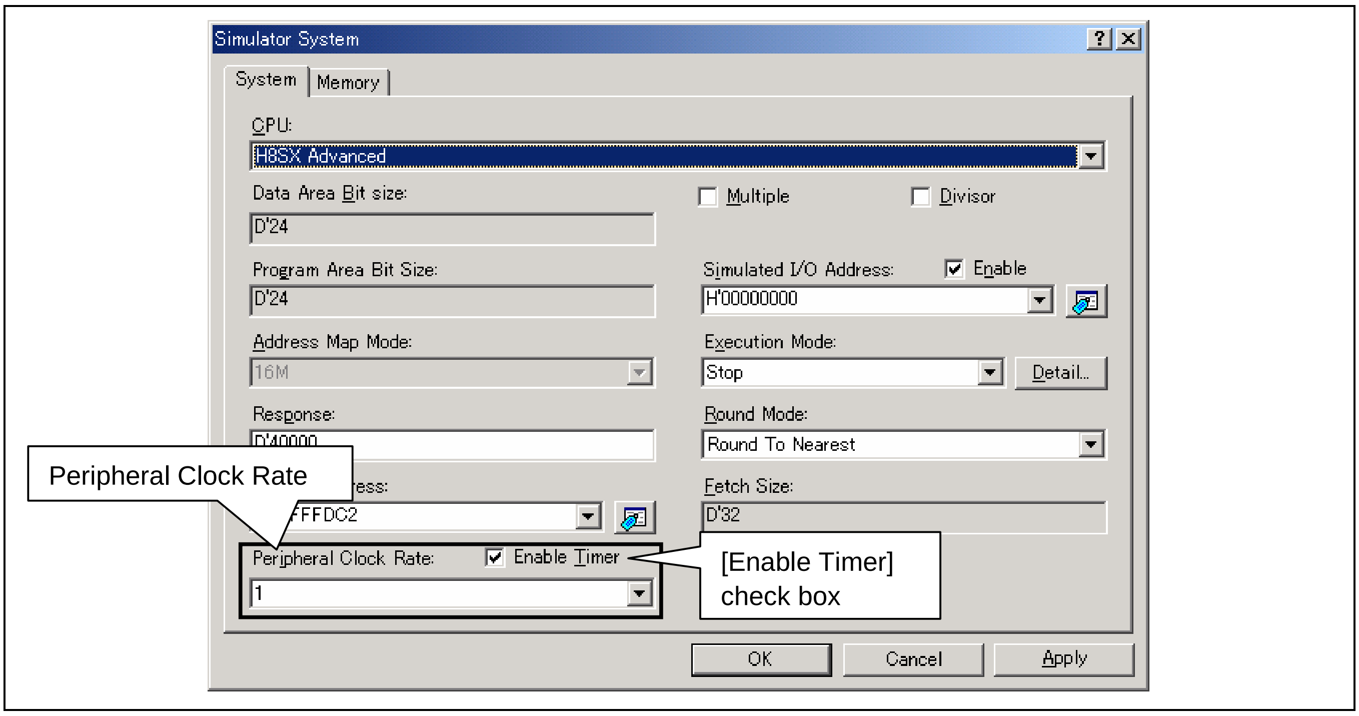
• Supported interrupt priority level setting registers

In the Supported column on the following table, O indicates that the register is supported and Δ indicates that only the bits associated with the feature described in the paragraph under [Description] are supported.

Debug platform name	Supported control register	Supported
H8SX	IPRF	Δ

• Timer simulation method:

Choose [Options -> Simulator -> System...] to open the following [Simulator System] dialog box, check the [Enable Timer] check box, and specify a ratio between the external clock and the peripheral module clock.



CPU: H8SX Advanced
Data Area Bit size: D'24
Multiple
Divisor
Program Area Bit Size: D'24
Simulated I/O Address: H'00000000 ☑ Enable
Address Map Mode: 16M
Execution Mode: Stop
Response: D'40000
Round Mode: Round To Nearest
…ess: …FFFDC2
Fetch Size: D'32
Peripheral Clock Rate: 1 ☑ Enable Timer

In addition, you can use timer control registers and write program code to enable them as shown below.

If you create a clock that drives timers via a peripheral module, specify the frequency division ratio using an appropriate timer control register.

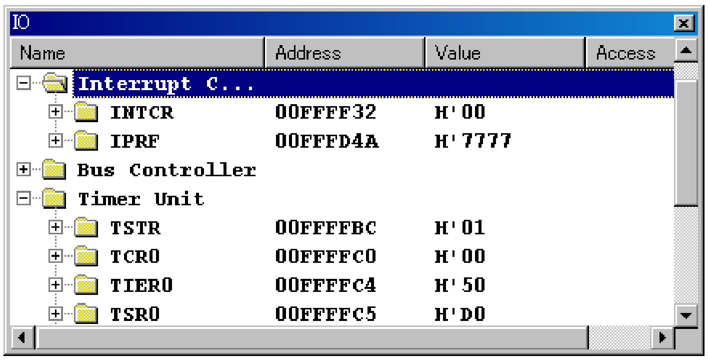
```
// TPU0 start
TPU.TSTR.BIT.CST0 = 1;
// TPU0 Overflow interrupt enable
TPU0.TSR.BIT.TCFV = 1;
TPU0.TIER.BIT.TCIEV = 1;
while(1);
```

Enable timer ITU0.

Note: Before setting the value to the timer registers, confirm that the access to the timer registers can be done in the memory tab on the Simulator System dialog box. If the access isn't permitted, you can nither set the value to the registers, nor use the timer.

• How to view timer register settings:

To view settings on timer registers and interrupt priority level setting registers, choose [View -> CPU -> I/O] to open the following I/O window.



Name	Address	Value	Access
Interrupt C...			
INTCR	00FFFF32	H'00	
IPRF	00FFFD4A	H'7777	
Bus Controller			
Timer Unit			
TSTR	00FFFFBC	H'01	
TCR0	00FFFFC0	H'00	
TIER0	00FFFFC4	H'50	
TSR0	00FFFFC5	H'D0	

• Note:

This feature is supported by HEW 3.1 or later.

This is valid only with H8SX.

7.2.7 Examples of Timer Usage

• Description:

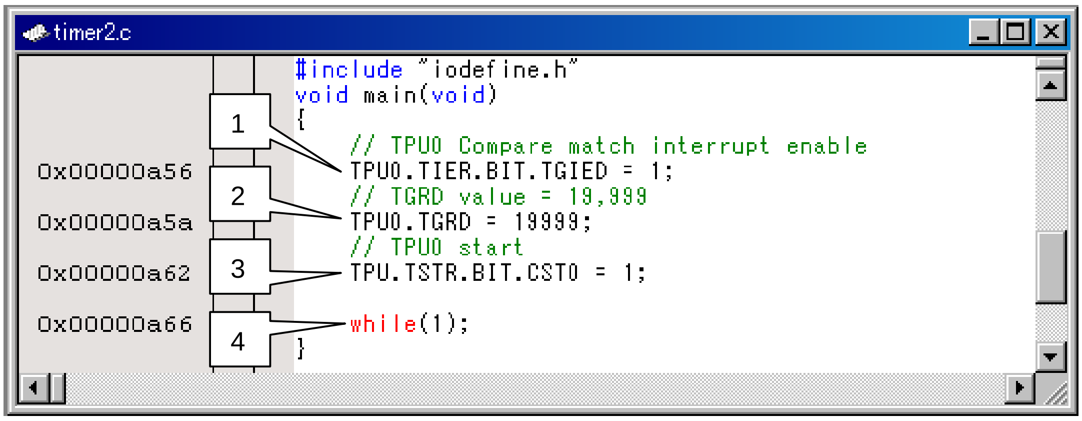
This subsection outlines how to use compare match and cyclic handler interrupts, using TPU in the H8SX/1650(H8SX) as an example.

• HEW setup:

Enable the timers by referring to the paragraph entitled “Timer simulation method” in subsection 7.2.6, How to Use Timers.

• Sample program containing code that raises a compare match interrupt:

The following sample program contains code that raises a compare match interrupt.



```
                    #include "iodefine.h"
                    void main(void)
                    {
                        // TPU0 Compare match interrupt enable
0x00000a56              TPU0.TIER.BIT.TGIED = 1;
                        // TGRD value = 19,999
0x00000a5a              TPU0.TGRD = 19999;
                        // TPU0 start
0x00000a62              TPU.TSTR.BIT.CST0 = 1;

0x00000a66              while(1);
                    }
```

[Explanation of an interrupt generation program]

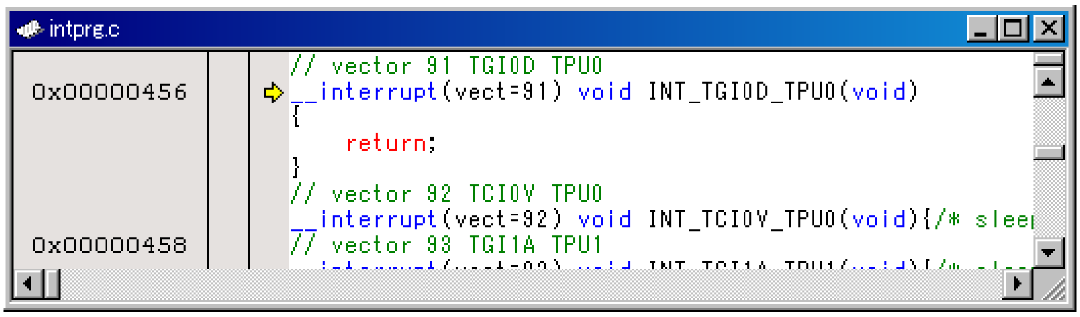
1. When the TGIED (TGR Interrupt Enable D) bit in TIER (Timer Interrupt Enable register) becomes 1, the interrupt is enabled.
2. Set the value of TGRD.
3. Start the TPU0 timer.
4. Wait until the value of TCNT0 and TGRD match. (Wait for a compare match)

• Program execution:

Wait until TCNT0 (timer counter 0) and TGRD (timer general register D) match (a compare match occurs) at step 4 in the paragraph entitled "Explanation of an interrupt generation program."

When the two match, a compare match interrupt occurs, with the result of calling the following interrupt routine:

For further information, refer to the pertinent hardware manual.



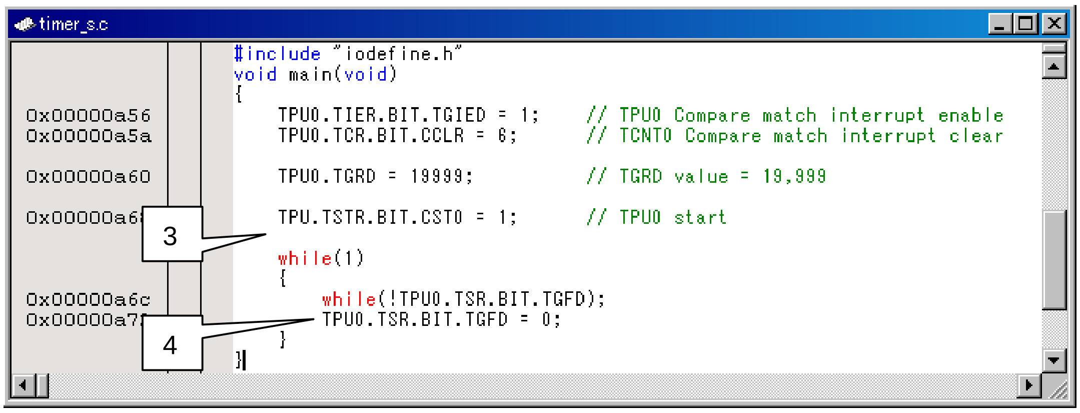
```
0x00000456    // vector 91 TGI0D TPU0
              __interrupt(vect=91) void INT_TGI0D_TPU0(void)
              {
                  return;
              }
              // vector 92 TCI0V TPU0
              __interrupt(vect=92) void INT_TCI0V_TPU0(void){/* sleep
0x00000458    // vector 93 TGI1A TPU1
```

• Sample program containing code for a cyclic handler

The following sample program contains code for a cyclic handler.

When a compare match occurs, the program clears the timer, and then branches control to an interrupt handler.

After the interrupt is serviced, the program lowers the interrupt priority in IPRF (interrupt priority register).



```
              #include "iodefine.h"
              void main(void)
              {
0x00000a56        TPU0.TIER.BIT.TGIED = 1;     // TPU0 Compare match interrupt enable
0x00000a5a        TPU0.TCR.BIT.CCLR = 6;       // TCNT0 Compare match interrupt clear

0x00000a60        TPU0.TGRD = 19999;           // TGRD value = 19,999

0x00000a6         TPU.TSTR.BIT.CST0 = 1;       // TPU0 start

                  while(1)
                  {
0x00000a6c            while(!TPU0.TSR.BIT.TGFD);
0x00000a7             TPU0.TSR.BIT.TGFD = 0;
                  }
              }
```

1. When the TGIED (TGR Interrupt Enable D) bit in TIER (Timer Interrupt Enable register) becomes 1, the interrupt is enabled.
2. Set the value of TGRD.
3. Start the TPU0 timer.
4. Clear the compare match flag.

• Program execution:

The program waits until a compare match occurs. When a compare match occurs, the program passes control to the following interrupt routine.

The interrupt routine services the interrupt, lowers the interrupt priority level in IMFA, and returns control to the program.

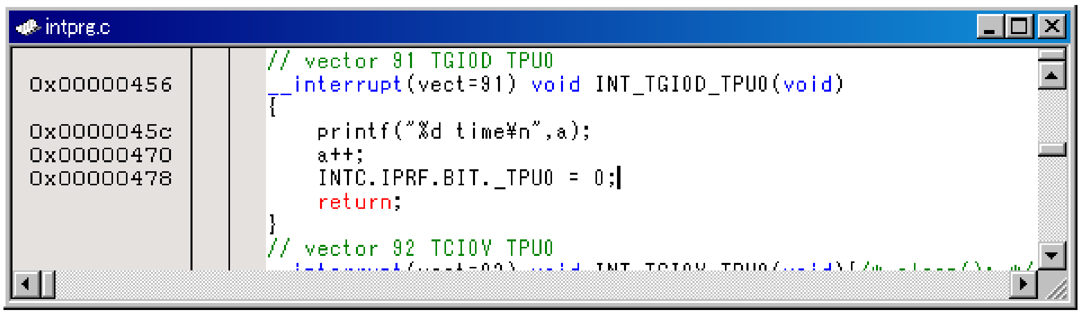
Interrupt processing can be completed in this way.

The program can then be ready to accept the next compare match interrupt.

For further information, refer to the pertinent hardware manual.

In accordance with the HEW specification, when an interrupt occurs, the PC stops at the beginning of the function that has caused the interrupt.

When simulating a cyclic handler, you need to advance the PC at each cycle by using the Go command or similar method.



```
             // vector 91 TGI0D TPU0
0x00000456   __interrupt(vect=91) void INT_TGI0D_TPU0(void)
             {
0x0000045c       printf("%d time¥n",a);
0x00000470       a++;
0x00000478       INTC.IPRF.BIT._TPU0 = 0;
                 return;
             }
             // vector 92 TCI0V TPU0
```

7.2.8 Reconfiguration of Debugger Target

• Description:

HEW can configure Debugger Target, if you select Application for the project type when creating a new workspace.

However, when creating a new project, you may sometimes not configure this, because you then believe that this is unnecessary.

If you do, you can use this feature to reconfigure Debugger Target after creating a project.

However, this feature is only available when you select Application for the project type when creating a new workspace.

• Usage:

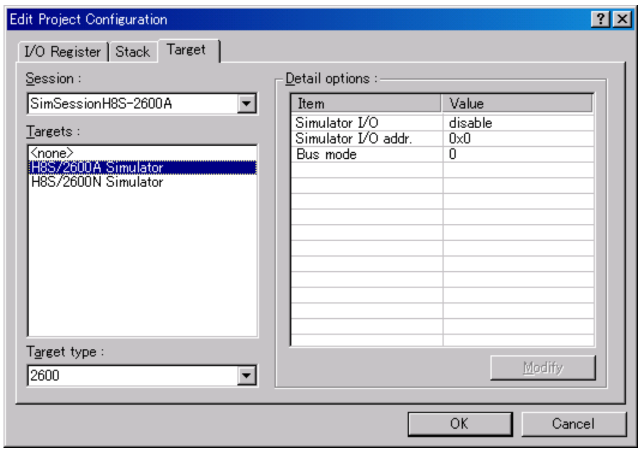
HEW Menu: **Project > Edit Project Configuration...**

• Functions that can be reconfigured:

[Setting method]

You can set a simulator and other debugger targets on the [Target] tab in the [Edit Project Configuration] dialog box.

If a debugger is already connected to the session, you will see a message saying, “This target has already existed. It does not support duplicated targets” and cannot connect to the debugger target.



Session : SimSessionH8S-2600A

Targets :
<none>
H8S/2600A Simulator
H8S/2600N Simulator

Target type : 2600

Detail options :

Item	Value
Simulator I/O	disable
Simulator I/O addr.	0x0
Bus mode	0

• Note:

Reconfiguring a file is supported by HEW 2.1 or later.

7.3 Call Walker

Call Walker (stack analysis tool) displays the stack amount by reading the stack information file (*.sni) output by the optimizing linkage editor or the profile information file (*.pro) output by the simulator debugger.

For the stack amount of the assembly program that cannot be output in the stack information file, the information can be added or modified by using the edit function.

In addition, the stack amount of whole systems can be calculated.

The information on the edited stack amount can be saved and read as the call information file (*.cal).

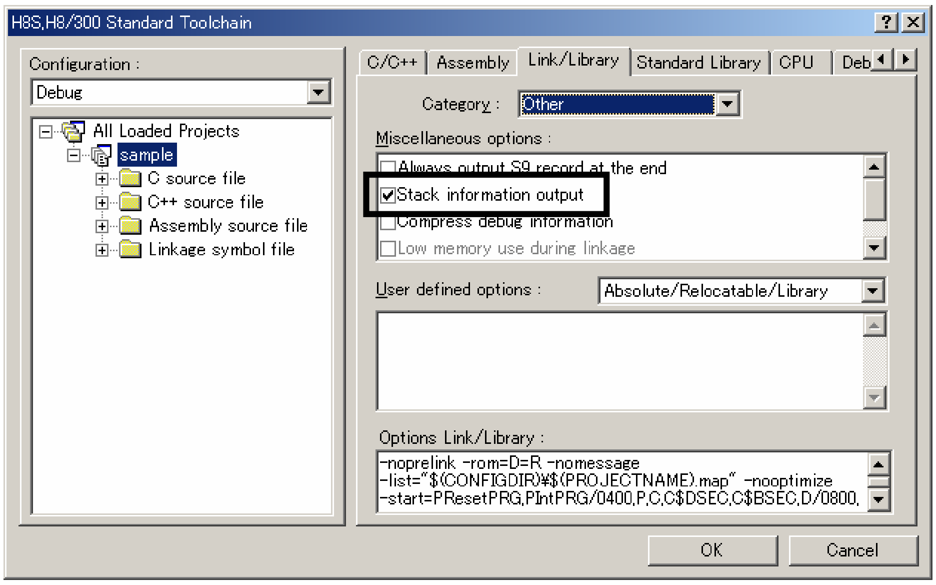
And, some call information files can be merged.

7.3.1 Making Stack Information File

According to the following procedures, you can make a stack information file or a profile information file.

• Making stack information file (*.sni)

You can make a stack information file by the following option of the Optimizing Linkage Editor.



H8S,H8/300 Standard Toolchain

Configuration : Debug

Category : Other

Miscellaneous options :

- [ ] Always output S9 record at the end
- [✓] Stack information output
- [ ] Compress debug information
- [ ] Low memory use during linkage

User defined options : Absolute/Relocatable/Library

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

Specification Method

Dialog menu: **Link/Library Tab Category: [Other] Stack information output**

Command line: *STACk*

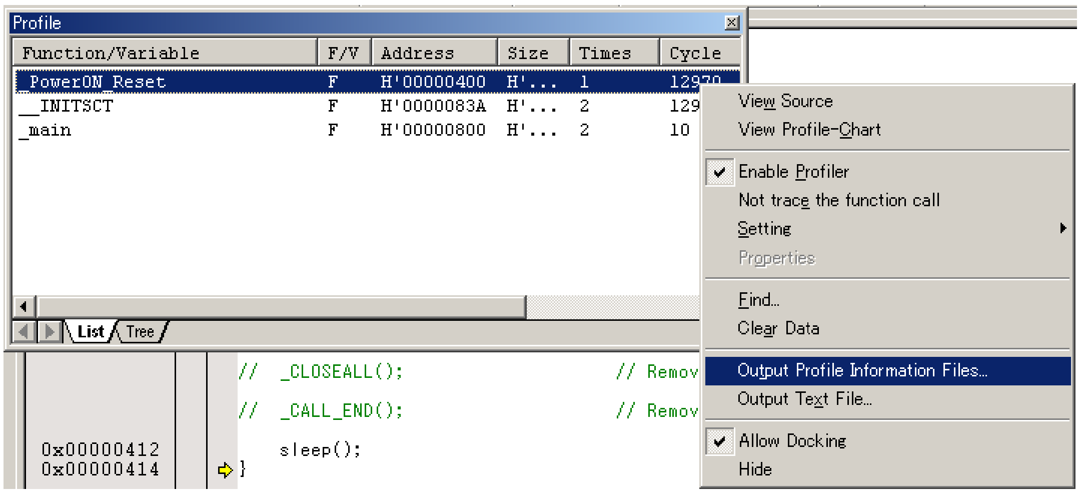
• Making profile information file (*.pro)

Execute user program by the following [Profile] function.

After the execution, click the right mouse button on [Profile] window, and choose [Output Profile Information Files...] in order to make a profile information file (*.pro).

For more information about making profile information file, refer to "H8S,H8/300 Series High-performance Embedded Workshop 3 User’s Manual, 4.12 Viewing the Function Call History".

Choose [View->Performance->Profile] to open the [Profile] window.



```
Function/Variable    F/V  Address     Size   Times  Cycle
_PowerON_Reset       F    H'00000400  H'...  1      12970
__INITSCT            F    H'0000083A  H'...  2      129
_main                F    H'00000800  H'...  2      10
```

```
        //  _CLOSEALL();          // Remov
        //  _CALL_END();          // Remov
0x00000412    sleep();
0x00000414  }
```

7.3.2 Starting Call Walker

Use the following procedure to start Call Walker.

• Starting from start menu

Click [Program-> Renesas High-performance Embedded Workshop->Call Walker]

• Starting from HEW

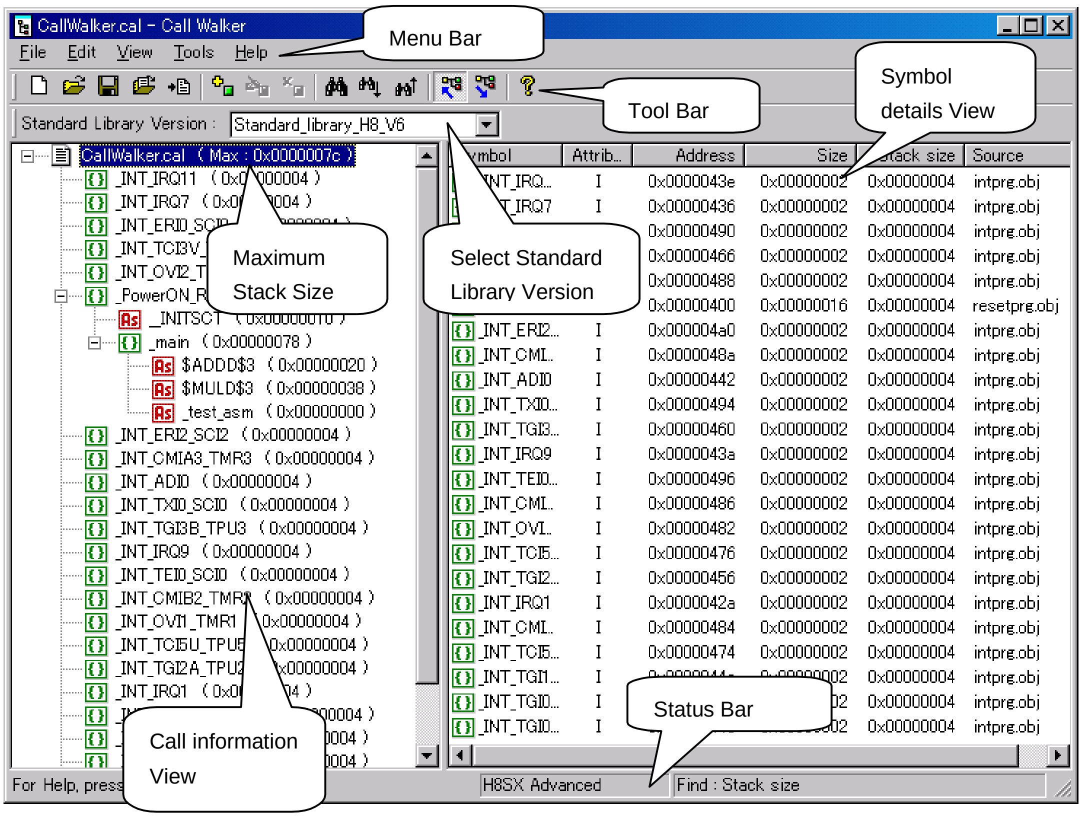
Click [Tools->Call Walker]

7.3.3 File Open and Call Walker Window

After starting Call Walker, choose [File-> Import Stack File...] to open a stack information file (*.sni) or a profile information file (*.pro).

Choose [File->Open...] to open an existing call information file (*.cal).

After that, the following window is displayed.


CallWalker.cal - Call Walker
File Edit View Tools Help
Menu Bar
Tool Bar
Symbol details View
Maximum Stack Size
Select Standard Library Version
Call information View
Status Bar

Standard Library Version : Standard_library_H8_V6

```
CallWalker.cal ( Max : 0x0000007c )
    _INT_IRQ11 ( 0x0 000004 )
    _INT_IRQ7 ( 0x0 004 )
    _INT_ERI0_SCI0
    _INT_TCI3V_
    _INT_OVI2_T
    _PowerON_R
        _INITSCT ( 0x00000010 )
        _main ( 0x00000078 )
            $ADDD$3 ( 0x00000020 )
            $MULD$3 ( 0x00000038 )
            _test_asm ( 0x00000000 )
    _INT_ERI2_SCI2 ( 0x00000004 )
    _INT_CMIA3_TMR3 ( 0x00000004 )
    _INT_ADI0 ( 0x00000004 )
    _INT_TXI0_SCI0 ( 0x00000004 )
    _INT_TGI3B_TPU3 ( 0x00000004 )
    _INT_IRQ9 ( 0x00000004 )
    _INT_TEI0_SCI0 ( 0x00000004 )
    _INT_CMIB2_TMR2 ( 0x00000004 )
    _INT_OVI1_TMR1 0x00000004 )
    _INT_TCI5U_TPU5 0x00000004 )
    _INT_TGI2A_TPU2 x00000004 )
    _INT_IRQ1 ( 0x0 04 )
    _I 00004 )
    _ 004 )
    _ 004 )
For Help, press
```

ymbol	Attrib...	Address	Size	tack size	Source
INT_IRQ...	I	0x0000043e	0x00000002	0x00000004	intprg.obj
T_IRQ7	I	0x00000436	0x00000002	0x00000004	intprg.obj
		0x00000490	0x00000002	0x00000004	intprg.obj
		0x00000466	0x00000002	0x00000004	intprg.obj
		0x00000488	0x00000002	0x00000004	intprg.obj
		0x00000400	0x00000016	0x00000004	resetprg.obj
_INT_ERI2...	I	0x000004a0	0x00000002	0x00000004	intprg.obj
_INT_CMI...	I	0x0000048a	0x00000002	0x00000004	intprg.obj
_INT_ADI0	I	0x00000442	0x00000002	0x00000004	intprg.obj
_INT_TXI0...	I	0x00000494	0x00000002	0x00000004	intprg.obj
_INT_TGI3...	I	0x00000460	0x00000002	0x00000004	intprg.obj
_INT_IRQ9	I	0x0000043a	0x00000002	0x00000004	intprg.obj
_INT_TEI0...	I	0x00000496	0x00000002	0x00000004	intprg.obj
_INT_CMI...	I	0x00000486	0x00000002	0x00000004	intprg.obj
_INT_OVI...	I	0x00000482	0x00000002	0x00000004	intprg.obj
_INT_TCI5...	I	0x00000476	0x00000002	0x00000004	intprg.obj
_INT_TGI2...	I	0x00000456	0x00000002	0x00000004	intprg.obj
_INT_IRQ1	I	0x0000042a	0x00000002	0x00000004	intprg.obj
_INT_CMI...	I	0x00000484	0x00000002	0x00000004	intprg.obj
_INT_TCI5...	I	0x00000474	0x00000002	0x00000004	intprg.obj
_INT_TGI1...	I	[illegible]	0x00000002	0x00000004	intprg.obj
_INT_TGI0...	I		2	0x00000004	intprg.obj
_INT_TGI0...	I		02	0x00000004	intprg.obj

H8SX Advanced | Find : Stack size

Note:

The stack amount of the assembly functions except the standard library is displayed as zero.

Refer to section 7.3.4, Editing the Stack Information File, to set the stack amount.

• Call information view

Linked-level structure between symbols is displayed.

The amount used by stack is displayed at the left side of each symbol.

(1) Symbol display

Symbol classification (Category) signs are displayed at the left side of each symbol by icon.

Symbol classification (Category) signs are as follows:

📄 : Editing file

As : Assembler label

{} : C/C++ function

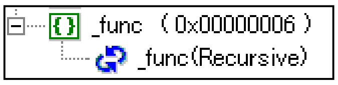
🔄 : Recursive call function or Circulation function

(a) Recursive call function

Displayed, when the same function is called in itself.

Example:

```
void func(int x)
{
    x++;
    if(x != OFF)
        func(x);

    if(x == MAX)
        return;
}
```



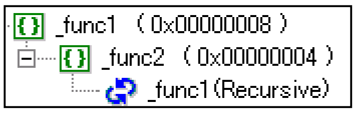
```
⊟ {} _func  ( 0x00000006 )
      🔄 _func(Recursive)
```

(b) Circulation function

Displayed, when the same function is called indirectly.

Example:

```
void func1(int a)
{
    func2(10);
}
void func2(int b)
{
    func1(9);
}
```



```
{} _func1  ( 0x00000008 )
⊟ {} _func2  ( 0x00000004 )
      🔄 _func1(Recursive)
```

: RTOS function (Example: ITRON symbols)

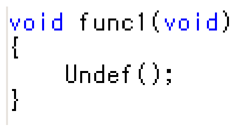
: Function of which the reference source is unknown. (Referenced by unknown)

In the following example, function(**func1**) calls function(**Undef**). When function(**Undef**) is not defined, this icon is displayed at function(**Undef**).

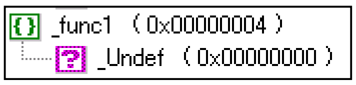
Undefined function call is error at linkage, but link option **change_message** can modify error to warning. The load module file is made at warning, so the stack information file is also made.

For more about **change_message**, refer to 4.2.7 Other Options, Change_message, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Example:



```
void func1(void)
{
    Undef();
}
```

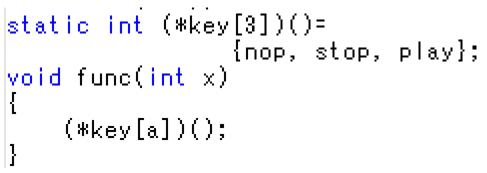


```
{} _func1 (0x00000004)
  └ ? _Undef (0x00000000)
```

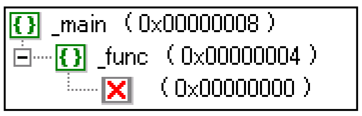
: Function of which the address reference has not been resolved. (Address not resolved)

Displayed, when a function is called by the table as follows.

Example:



```
static int (*key[3])()=
                    {nop, stop, play};
void func(int x)
{
    (*key[a])();
}
```



```
{} _main (0x00000008)
⊟ {} _func (0x00000004)
     └ ✗ (0x00000000)
```

: Omitted symbol

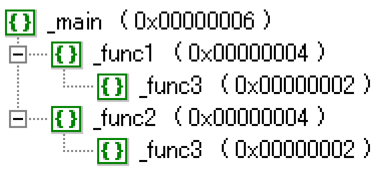
Since this tool displays all linking layers, the display amounts will be very large if the size is large.

So, only the first layer is displayed and other same parts are omitted by omitted symbols in order to reduce the display amounts.

Choose [View->Show All Symbols / Show Simple Symbols] to switch this display format.

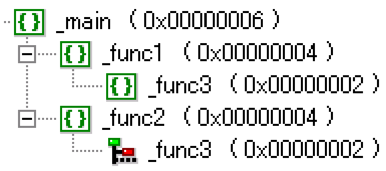
Example:

Show All Symbols



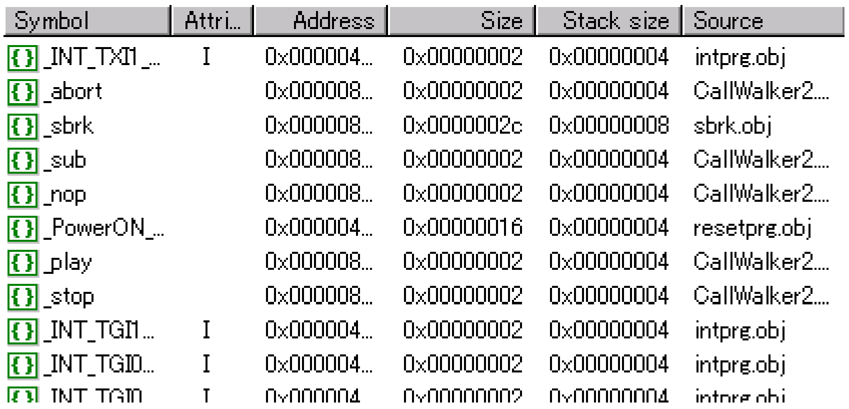
```
{} _main (0x00000006)
⊟ {} _func1 (0x00000004)
     └ {} _func3 (0x00000002)
⊟ {} _func2 (0x00000004)
     └ {} _func3 (0x00000002)
```

Show Simple Symbols



```
{} _main (0x00000006)
⊟ {} _func1 (0x00000004)
     └ {} _func3 (0x00000002)
⊟ {} _func2 (0x00000004)
     └ _func3 (0x00000002)
```

• Symbol details view

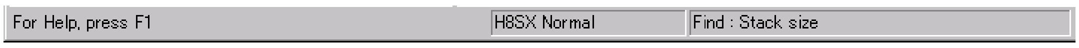


Symbol	Attri...	Address	Size	Stack size	Source
{} _INT_TXI1_...	I	0x000004...	0x00000002	0x00000004	intprg.obj
{} _abort		0x000008...	0x00000002	0x00000004	CallWalker2....
{} _sbrk		0x000008...	0x0000002c	0x00000008	sbrk.obj
{} _sub		0x000008...	0x00000002	0x00000004	CallWalker2....
{} _nop		0x000008...	0x00000002	0x00000004	CallWalker2....
{} _PowerON_...		0x000004...	0x00000016	0x00000004	resetprg.obj
{} _play		0x000008...	0x00000002	0x00000004	CallWalker2....
{} _stop		0x000008...	0x00000002	0x00000004	CallWalker2....
{} _INT_TGI1...	I	0x000004...	0x00000002	0x00000004	intprg.obj
{} _INT_TGI0...	I	0x000004...	0x00000002	0x00000004	intprg.obj
{} _INT_TGI0	I	0x000004	0x00000002	0x00000004	intprg.obj

For each symbol, address, attribute and the amount used by stack are displayed.

After click symbol, click the right mouse button to execute each editing command.

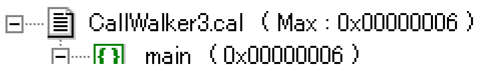
• Status bar



For Help, press F1 | H8SX Normal | Find : Stack size

Function information, CPU type and other information of the current stack information file are displayed.

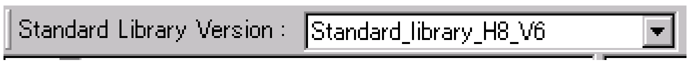
• Maximum stack size



CallWalker3.cal （Max : 0x00000006 ）
main （0x00000006 ）

The static maximum amount used by stack of the current stack information file is displayed

• Selecting standard library version



Standard Library Version : Standard_library_H8_V6

The standard library version of the current stack information file can be selected.

Using this information, the stack amount of the assembly functions in the standard library is displayed.

When only one HEW package is installed, there is no need to select this.

7.3.4 Editing the Stack Information File

After selecting a symbol in the symbol details view (right frame on the screen), choose Add…, Modify…, Delete… command in Edit menu to add, change, delete the symbol.

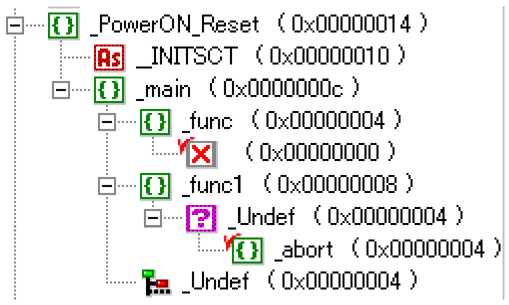
Click the right mouse button at the symbol details view, to execute the same editing command.

This tool can measure the static maximum amount used by stack.

In the case such as multiple interrupt, users should edit the file information to measure the dynamic maximum amount used by stack.

Drag and drop a symbol in the call information view (left frame on the screen) to move the symbol.

While a symbol is moved or edited, a check mark is displayed at the side of the symbol in the call information view (left frame on the screen) as follows.


```
_PowerON_Reset (0x00000014)
    _INITSCT (0x00000010)
    _main (0x0000000c)
        _func (0x00000004)
             (0x00000000)
        _func1 (0x00000008)
            _Undef (0x00000004)
                _abort (0x00000004)
        _Undef (0x00000004)
```

The editing commands are explained in the following section.

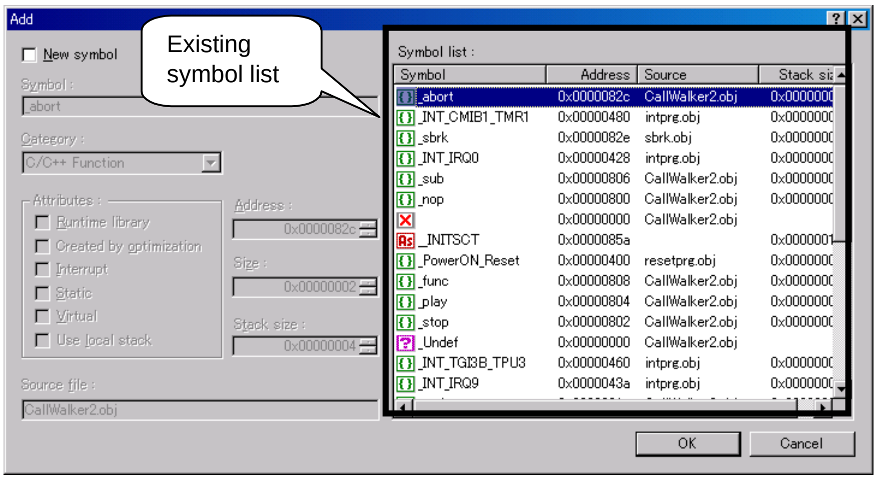
• Add command

(1) Adding an existing symbol

Click [Add…] to display the following dialog box.

The right frame is the existing symbol list of the current file.

Choose a symbol in this list and click on the [OK] button to add the existing symbol.



☐ New symbol

Symbol : _abort

Category : C/C++ Function

Attributes :
☐ Runtime library
☐ Created by optimization
☐ Interrupt
☐ Static
☐ Virtual
☐ Use local stack

Address : 0x0000082c

Size : 0x00000002

Stack size : 0x00000004

Source file : CallWalker2.obj

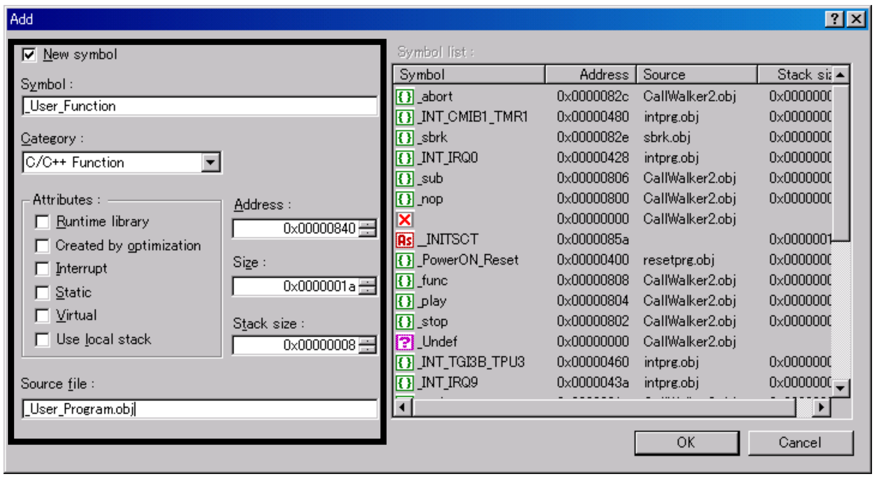
Symbol list :

Symbol	Address	Source	Stack si
_abort	0x0000082c	CallWalker2.obj	0x000000
_INT_CMIB1_TMR1	0x00000480	intprg.obj	0x000000
_sbrk	0x0000082e	sbrk.obj	0x000000
_INT_IRQ0	0x00000428	intprg.obj	0x000000
_sub	0x00000806	CallWalker2.obj	0x000000
_nop	0x00000800	CallWalker2.obj	0x000000
	0x00000000	CallWalker2.obj	
_INITSCT	0x0000085a		0x000000
_PowerON_Reset	0x00000400	resetprg.obj	0x000000
_func	0x00000808	CallWalker2.obj	0x000000
_play	0x00000804	CallWalker2.obj	0x000000
_stop	0x00000802	CallWalker2.obj	0x000000
_Undef	0x00000000	CallWalker2.obj	
_INT_TGI3B_TPU3	0x00000460	intprg.obj	0x000000
_INT_IRQ9	0x0000043a	intprg.obj	0x000000

(2) Adding a new symbol

Check the following [New symbol] check box to add a new symbol.

Symbol name, category, attribute, address, stack size can be specified here.



☑ New symbol

Symbol : _User_Function

Category : C/C++ Function

Attributes :
☐ Runtime library
☐ Created by optimization
☐ Interrupt
☐ Static
☐ Virtual
☐ Use local stack

Address : 0x00000840

Size : 0x0000001a

Stack size : 0x00000008

Source file : _User_Program.obj

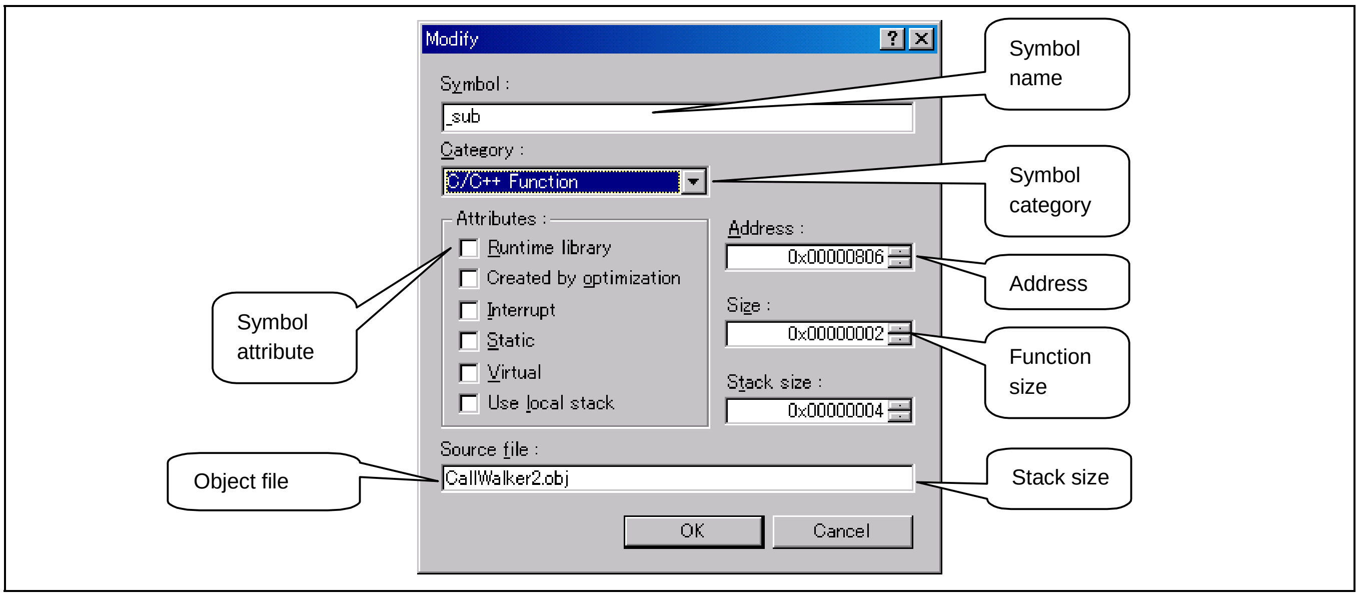
Symbol list :

Symbol	Address	Source	Stack si
_abort	0x0000082c	CallWalker2.obj	0x000000
_INT_CMIB1_TMR1	0x00000480	intprg.obj	0x000000
_sbrk	0x0000082e	sbrk.obj	0x000000
_INT_IRQ0	0x00000428	intprg.obj	0x000000
_sub	0x00000806	CallWalker2.obj	0x000000
_nop	0x00000800	CallWalker2.obj	0x000000
	0x00000000	CallWalker2.obj	
_INITSCT	0x0000085a		0x000000
_PowerON_Reset	0x00000400	resetprg.obj	0x000000
_func	0x00000808	CallWalker2.obj	0x000000
_play	0x00000804	CallWalker2.obj	0x000000
_stop	0x00000802	CallWalker2.obj	0x000000
_Undef	0x00000000	CallWalker2.obj	
_INT_TGI3B_TPU3	0x00000460	intprg.obj	0x000000
_INT_IRQ9	0x0000043a	intprg.obj	0x000000

• Modify command

Choose the symbol of which the information is to be changed, and click [Modify…] to display the following dialog box.

Some kind of information can be modified here.


Modify

Symbol : _sub

Category : C/C++ Function

Attributes :
- [ ] Runtime library
- [ ] Created by optimization
- [ ] Interrupt
- [ ] Static
- [ ] Virtual
- [ ] Use local stack

Address : 0x00000806

Size : 0x00000002

Stack size : 0x00000004

Source file : CallWalker2.obj

• Delete command

Choose the symbol of which the information is not to be used in the measurement of the amount used by stack, and click [Delete…] to delete the symbol.

7.3.5 Stack Area Size of Assembly Program

Unlike by C/C++ program, the stack area size used by assembly program cannot be calculated automatically in assembling. Therefore the stack area size used by assembly functions should be edited by using Call Walker.
But the stack area size is specified in the assembly function by using **.STACK** directive. Call Walker displays the value specified by **.STACK** directive.

• Description of **.STACK** directive

Defines the stack amount for a specified symbol referenced by using Call Walker.

The stack value for a symbol can be defined only one time; the second and later specifications for the same symbol are ignored. A multiple of 2 in the range from H'00000000 to H'FFFFFFFE can be specified for the stack value, and any other value is invalid.

The stack value must be specified as follows:
- A constant value must be specified.
- Forward reference symbol, external reference symbol and relative address symbol must not be used.

• Specification Method of **.STACK** assembler directive

Δ.STACKΔ<symbol> = <stack value>

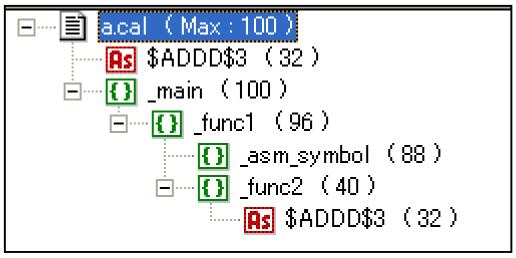
• Example of assembly program

```
          .CPU        H8SXA:24
          .EXPORT     _asm_symbol
          .SECTION    P,CODE,ALIGN=2
_asm_symbol:
          .STACK      _asm_symbol=88
           :
          RTS
          .END
```

← Stack Size of **_asm_symbol** function

• Displayed Example by Call Walker

As the following example, the stack area size used by _asm_symbol function is displayed "88" in Call Walker.



```
a.cal ( Max : 100 )
  $ADDD$3 ( 32 )
  _main ( 100 )
    _func1 ( 96 )
      _asm_symbol ( 88 )
      _func2 ( 40 )
        $ADDD$3 ( 32 )
```

• Remarks

(1) **.STACK** assembler directive can only make Call Walker display stack size, and does NOT affect the behavior of program.

(2) This assembler directive is supported in H8S, H8/300 Series Assembler Ver.6.01 or later.

7.3.6 Merging Stack Information

Saved or editing stack information file can be merged with other stack information file.

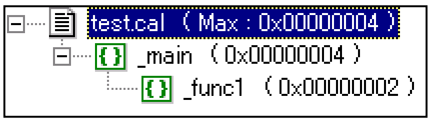
By using this function, the edited stack information cannot be overwritten with rebuilt stack information.

• Merge example

(1) **test.c**

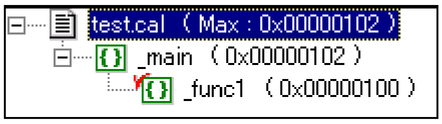
```
void main(void)
{
    func1();
}
```

(2) Open a stack information file in Call Walker



```
test.cal ( Max : 0x00000004 )
  _main ( 0x00000004 )
    _func1 ( 0x00000002 )
```

(3) Change stack size of **func1** to 100



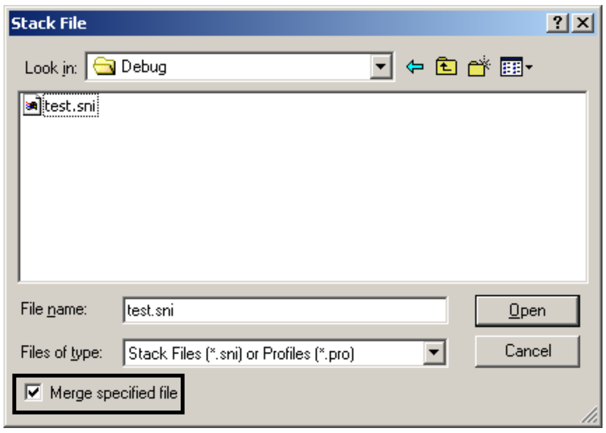
```
test.cal ( Max : 0x00000102 )
  _main ( 0x00000102 )
    _func1 ( 0x00000100 )
```

(4) Change **test.c** and rebuild (add **func2** call)

```
void main(void)
{
    func1();
    func2();
}
```

(5) Open **test.sni**, while opening **test.cal**

Check the following [Merge specified file] check box, and click on the [Open] button.



Stack File

Look in: Debug

test.sni

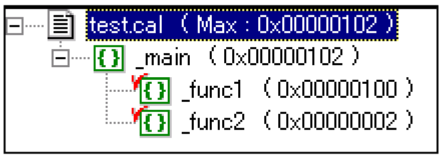
File name: test.sni

Files of type: Stack Files (*.sni) or Profiles (*.pro)

[✓] Merge specified file

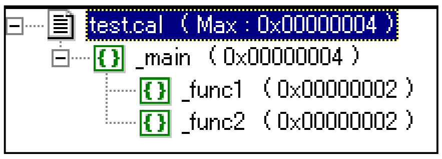
(6) After that, the stack information is merged.

The stack size of **func1** that is changed at (3) is used and the information of **func2** is added.



```
test.cal ( Max : 0x00000102 )
  _main ( 0x00000102 )
    _func1 ( 0x00000100 )
    _func2 ( 0x00000002 )
```

When [Merge specified file] check box is not checked at (5), the stack size of **func1** that is changed at (3) is overwritten with the rebuilt value, which is the same as before changed.



```
test.cal ( Max : 0x00000004 )
  _main ( 0x00000004 )
    _func1 ( 0x00000002 )
    _func2 ( 0x00000002 )
```

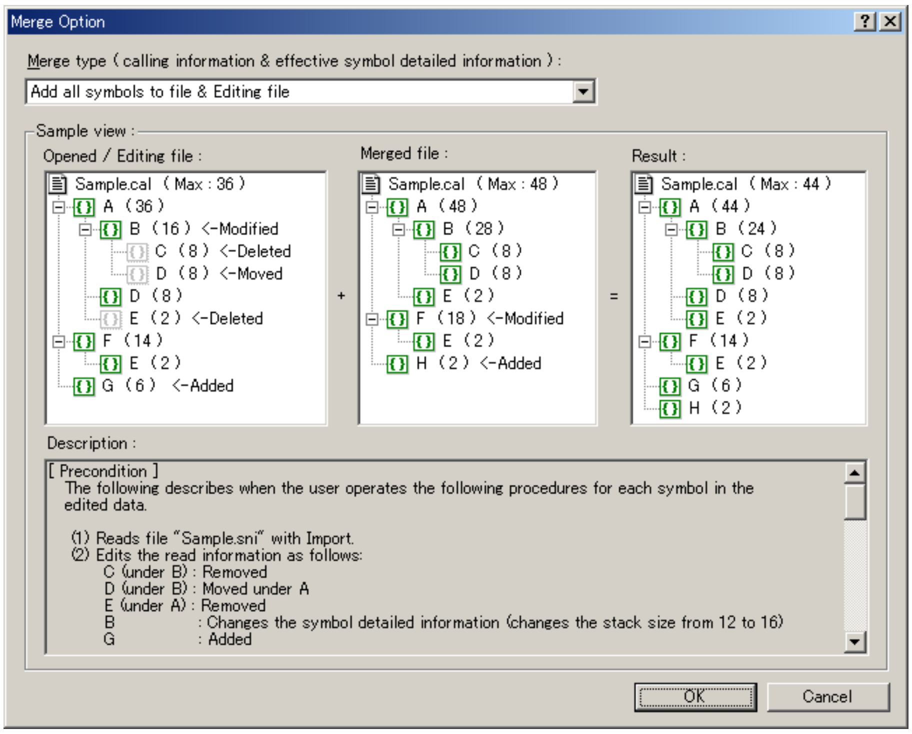
• Merge option

Merge method can be modified by possible five ways.

For more about this, refer to **Description** in this dialog.

[Specification method]

Tools menu->**Merge Option…**



Merge Option

Merge type (calling information & effective symbol detailed information) :

Add all symbols to file & Editing file

Sample view :

Opened / Editing file :

```
Sample.cal ( Max : 36 )
  A ( 36 )
    B ( 16 ) <-Modified
      C ( 8 ) <-Deleted
      D ( 8 ) <-Moved
    D ( 8 )
    E ( 2 ) <-Deleted
  F ( 14 )
    E ( 2 )
  G ( 6 ) <-Added
```

+

Merged file :

```
Sample.cal ( Max : 48 )
  A ( 48 )
    B ( 28 )
      C ( 8 )
      D ( 8 )
    E ( 2 )
  F ( 18 ) <-Modified
    E ( 2 )
  H ( 2 ) <-Added
```

=

Result :

```
Sample.cal ( Max : 44 )
  A ( 44 )
    B ( 24 )
      C ( 8 )
      D ( 8 )
    D ( 8 )
    E ( 2 )
  F ( 14 )
    E ( 2 )
  G ( 6 )
  H ( 2 )
```

Description :

```
[ Precondition ]
  The following describes when the user operates the following procedures for each symbol in the
  edited data.

   (1) Reads file "Sample.sni" with Import.
   (2) Edits the read information as follows:
        C (under B) : Removed
        D (under B) : Moved under A
        E (under A) : Removed
        B            : Changes the symbol detailed information (changes the stack size from 12 to 16)
        G            : Added
```

• Remarks

This merge function is valid in Call Walker Ver.1.3 or later.

7.3.7 Other Functions

• Realtime OS symbol

Specify the following, to display a realtime OS symbol as RTOS in the call information view (left frame on the screen).

[Specification method]

Tools menu->**Realtime OS Option…**

• Output list

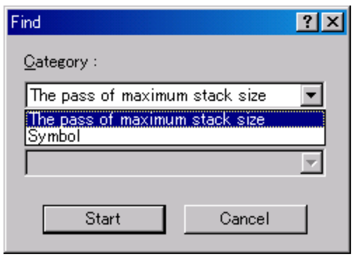
The stack information is output to the text file.

[Specification method]

File menu->**Output List…**

• Find

Two ways of search are available in the call information view by the following dialog.


Find
Category :
The pass of maximum stack size
The pass of maximum stack size
Symbol
Start
Cancel

(1) Search the pass of maximum stack size

(2) Search the symbol name

[Specification method]

Edit menu->**Find…**
Edit menu->**Find Next…** (Search next)
Edit menu->**Find Previous…** (Search previous)

• Setting display format in the call information view

Two ways of display format for the amount used by stack are available by the following command.

(1) Show Required Stack
Stack size is added from lower symbol to upper.

(2) Show Used Stack
Stack size is added from upper symbol to lower.

[Specification method]

View menu-> **Show Required Stack** or **Show Used Stack**

Section 8 Efficient C++ Programming Techniques

The Compiler supports the C++ and C languages.

This chapter describes in detail the options of an object-oriented language C++ and how to use the various C++ functions.

Code a C++ program for an embedded system with caution. Otherwise, the program will have a larger object size or a lower processing speed than expected.

Therefore, this chapter presents some cases in which the performance of a C++ program is deteriorated compared with C as well as codes with which you can work around such performance deterioration.

The following table shows a list of efficient C++ programming techniques:

No.	**Category**	**Item**	**Section**
1	Initialization Processing/Post-processing	Initialization Processing and Post-processing of Global Class Object	8.1.1
2	Introduction to C++ Functions	How to Reference a C Object	8.2.1
3		How to Implement *new* and *delete*	8.2.2
4		Static member variable	8.2.3
4	How to Use Options	C++ Language for Embedded Applications	8.3.1
5		Run-time Type Information	8.3.2
6		Exception Handling Function	8.3.3
7		Disabling Startup of Prelinker	8.3.4
8	Advantages and Disadvantages of C++ Coding	Constructor (1)	8.4.1
9		Constructor (2)	8.4.2
10		Default Parameter	8.4.3
11		Inline Expansion	8.4.4
12		Class Member Function	8.4.5
13		*operator* Operator	8.4.6
14		Function Overloading	8.4.7
15		Reference Type	8.4.8
16		Static Function	8.4.9
17		Static Member Variable	8.4.10
18		Anonymous *union*	8.4.11
19		Virtual Function	8.4.12

8.1 Initialization Processing/Post-Processing

8.1.1 Initialization Processing and Post-Processing of Global Class Object

• Important Points:

To use a global class object in C++, you need to call the initialization processing function (_CALL_INIT) and the post-processing function (_CALL_END) before and after the *main* function, respectively.

• What is a global class object?

A global class object is a class object that is declared outside of a function.

(Class object declaration inside a function)

```
void main(void)
{
   X XSample(10);
   X* P = &XSample;

   P->Sample2();
}
```

(Global class object declaration)

```
X XSample(10);
void main(void)
{
   X* P = &XSample;

   P->Sample2();
}
```

Declared outside of a function

• Why is initialization processing/post-processing necessary?

If a class object is declared inside a function as shown above, the constructor of class *X* is called when function *main* is executed.

In contrast, a global class object declaration is not executed even when a function is executed.

Thus, you need to call _CALL_INIT before calling the *main* function in order to explicitly call the constructor of class *X*. Likewise, call _CALL_END after calling the *main* function in order to call the destructor of class *X*.

• Operations when using and not using _CALL_INIT/_CALL_END:

The following shows the values obtained when the value of member variable *x* of class *X* is referenced.

When not using _CALL_INIT/_CALL_END, no correct value can be obtained and no expression in the *while* statement will be executed as follows:

(Value of member variable *x*)

When using **_CALL_INIT --> 10**

When not using **_CALL_INIT --> 0**

```
class X{
   int x;
public:
     X(int n){x = n}; // constructor
     ~X(){}            // destructor
   void Sample2(void);
};
X XSample(10); // global class object
void X::Sample2(void)
{
   while(x == 10)
   {
   }
}
void main(void)
{
   X* P = &XSample;

   P->Sample2();
}
```

<-- Reference position

• How to call _CALL_INIT/_CALL_END:

Provide the following code before and after calling the *main* function.

```
void INIT(void)
{
   _INITSCT();
   _CALL_INIT();
   main();
   _CALL_END();
}
```

If HEW is used, remove the comment characters in the section for calling _CALL_INIT/_CALL_END of *resetprg.c*.

(*PowerON_Reset* function of *resetprg.c*)

```
__entry(vect=0) void PowerON_Reset(void)
{
   set_imask_ccr(1);
   _INITSCT();

   _CALL_INIT();      // Remove the comment when you use global class object

// _INIT_IOLIB();     // Remove the comment when you use SIM I/O

// errno=0;            // Remove the comment when you use errno
// srand(1);           // Remove the comment when you use rand()
// _s1ptr=NULL;       // Remove the comment when you use strtok()

   HardwareSetup();  // Use Hardware Setup
   set_imask_ccr(0);

   main();

// _CLOSEALL();       // Remove the comment when you use SIM I/O

   _CALL_END();       // Remove the comment when you use global class object

   sleep();
}
```

8.2 Introduction to C++ Functions

8.2.1 How to Reference a C Object

• Important Points:

Use an '*extern* "*C*"' declaration to directly use in a C++ program the resources in an existing C object program.

Likewise, the resources in a C++ object program can be used in a C program.

• Example of Use:

1. Use an '*extern* "*C*"' declaration to reference a function in a C object program.

(C++ program)

```
extern "C" void CFUNC();
void main(void)
{
X XCLASS;
XCLASS.SetValue(10);

CFUNC();
}
```

(C program)

```
extern void CFUNC();
void CFUNC()
{
    while(1)
    {
        a++;
    }
}
```

2. Use an '*extern* "*C*"' declaration to reference a function in a C++ object program.

(C program)

```
void CFUNC()
{
    CPPFUNC();
}
```

(C++ program)

```
extern "C" void CPPFUNC();
void CPPFUNC(void)
{
while(1)
{
        a++;
}
}
```

• Important Information:

1. A C++ object generated by a previous-version compiler cannot be linked because the encoding and executing methods have been changed.
   Be sure to recompile it before using it.
2. A function called in the above method cannot be overloaded.

8.2.2 How to Implement *new* and *delete*

• Important Points:

To use *new*, implement a low-level function.

• Description:

If *new* is used in an embedded system, the dynamic allocation of actual heap memory is realized using *malloc*.

Thus, implement a low-level interface routine (*sbrk*) to specify the size of heap memory to be allocated just as when using *malloc*.

• Implementation Method:

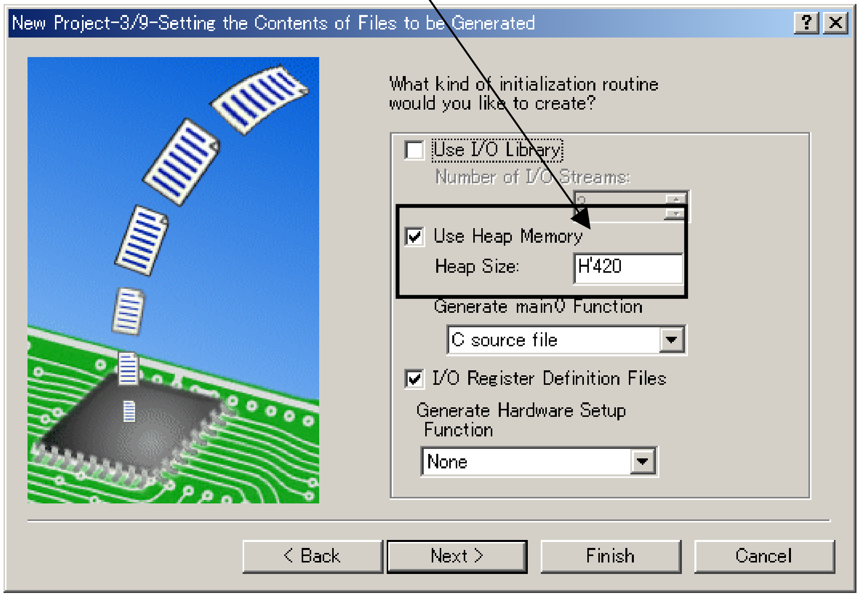
To use HEW, make sure that [Use Heap Memory] is checked when a workspace is created.

If this option is checked, *sbrk.c* and *sbrk.h* shown on the next page will be automatically created.

Specify the size of heap memory to be allocated in Heap Size.

To change the size after creating a workspace, change the value defined in HEAPSIZE in *sbrk.h*.

If HEW is not used, create a file shown on the next page and implement it in a project.


New Project-3/9-Setting the Contents of Files to be Generated

What kind of initialization routine would you like to create?

☐ Use I/O Library

Number of I/O Streams:

☑ Use Heap Memory

Heap Size: H'420

Generate main() Function: C source file

☑ I/O Register Definition Files

Generate Hardware Setup Function: None

```
(sbrk.c)

#include <stdio.h>
#include "sbrk.h"

//const size_t _sbrk_size=   /* Specifies the minimum unit of    */
                             /* the defined heap area            */

static  union  {
   long  dummy ;           /* Dummy for 4-byte boundary        */
   char heap[HEAPSIZE];    /* Declaration of the area managed  */
                           /*                          by sbrk */
 }heap_area ;

static  char  *brk=(char *)&heap_area;/* End address of area assigned     */

/*****************************************************************************/
/*     sbrk:Data write                                                      */
/*     Return value:Start address of the assigned area (Pass)               */
/*                   -1                (Failure)                             */
/*****************************************************************************/
char  *sbrk(size_t size)     /* Assigned area size  */
{
   char  *p;

   if(brk+size>heap_area.heap+HEAPSIZE) /* Empty area size        */
     return (char *)-1 ;

   p=brk ;                   /* Area assignment         */
   brk += size ;             /* End address update  */
   return p ;
}
```

```
(sbrk.h)

/* size of area managed by sbrk */
#define HEAPSIZE 0x420
```

8.2.3 Static Member Variable

• Description:

In C++, a class member variable with the *static* attribute can be shared among multiple objects of a class type.

Thus, a static member variable comes in handy because it can be used, for example, as a common flag among multiple objects of the same class type.

• Example of Use:

Create five class-A objects within the main function.

Static member variable *num* has an initial value of 0. This value will be incremented by the constructor every time an object is created.

Static member variable num, shared among objects, will have a value of 5 at the maximum.

• FAQ:

The following lists some frequently asked questions on using a static member variable.

[L2310 Error Occurred]

When a static member variable is used, message "** L2310 (E) Undefined external symbol "class-name::static-member-variable-name" referenced in "file-name"" is output at linkage.

[Solution]

This error occurs because the static member variable is not defined.

Add either of the following definition as shown on the next page:

If there is an initial value: `int A::num = 0;`
If there is no initial value: `int A::a;`

[Unable to assign an initial value]

No initial value is assigned to a *static* member variable to be initialized.

[Solution]

A *static* member variable to be initialized, handled as a variable with an initial value, is created in the D-section by default. Thus, specify the ROM implementation support option of the optimization linkage editor and, in the initial routine, copy the D-section from the ROM to the RAM using the *_INITSCT* function.

Note: This solution is not required if HEW automatically creates an initial routine.

(C++ program)

```
class A
{
private:
   static int num;
public:
   A(void);
   ~A(void);
};

int A::num = 0;               Defining a static member variable

void main(void)
{
   A a1;                      Creating a class A-type class object
   A a2;
   A a3;
   A a4;
   A a5;
}

A::A(void)
{
   ++num;                     Incrementing a static member variable
}

A::~A(void)
{
   --num;
}
```

8.3 How to Use Options

8.3.1 C++ Language for Embedded Applications

• Description:

The ROM/RAM sizes and the execution speed are important for an embedded system.

The C++ language for embedded applications (EC++) is a subset of the C++ language. For EC++, some of the C++ functions not appropriate for an embedded system have been removed.

Using EC++, you can create an object appropriate for an embedded system.

• Specification method:

Dialog menu: C/C++ tab Category: Other tab, Check against EC++ language specification

Command line: *eccp*

• Unsupported keywords:

An error message will be output if either of the following keywords is included.

catch, const_cast, dynamic_cast, explicit, mutable, namespace, reinterpret_cast, static_cast, template, throw, try, typeid, typename, using

• Unsupported language specifications:

A warning message will be output if either of the following language specifications is included.

Multiple inheritance, virtual base class

8.3.2 Run-time Type Information

• Description:

In C++, a class object with a virtual function may have a type identifiable only at run-time.

A run-time identification function is available to provide support in such a situation.

To use this function in C++, use the *type_info* class, *typeid* operator, and *dynamic_cast* operator.

For the Compiler, specify the following option to use run-time type information.

Additionally, specify the following option at linkage to start up the prelinker.

• Specification method:

Dialog menu: CPU tab, Enable/disable runtime type information

Command line: *rtti=on | off*

Dialog menu: Link/Library tab, Category: Input tab, Prelinker control
Then, select Auto or Run prelinker.

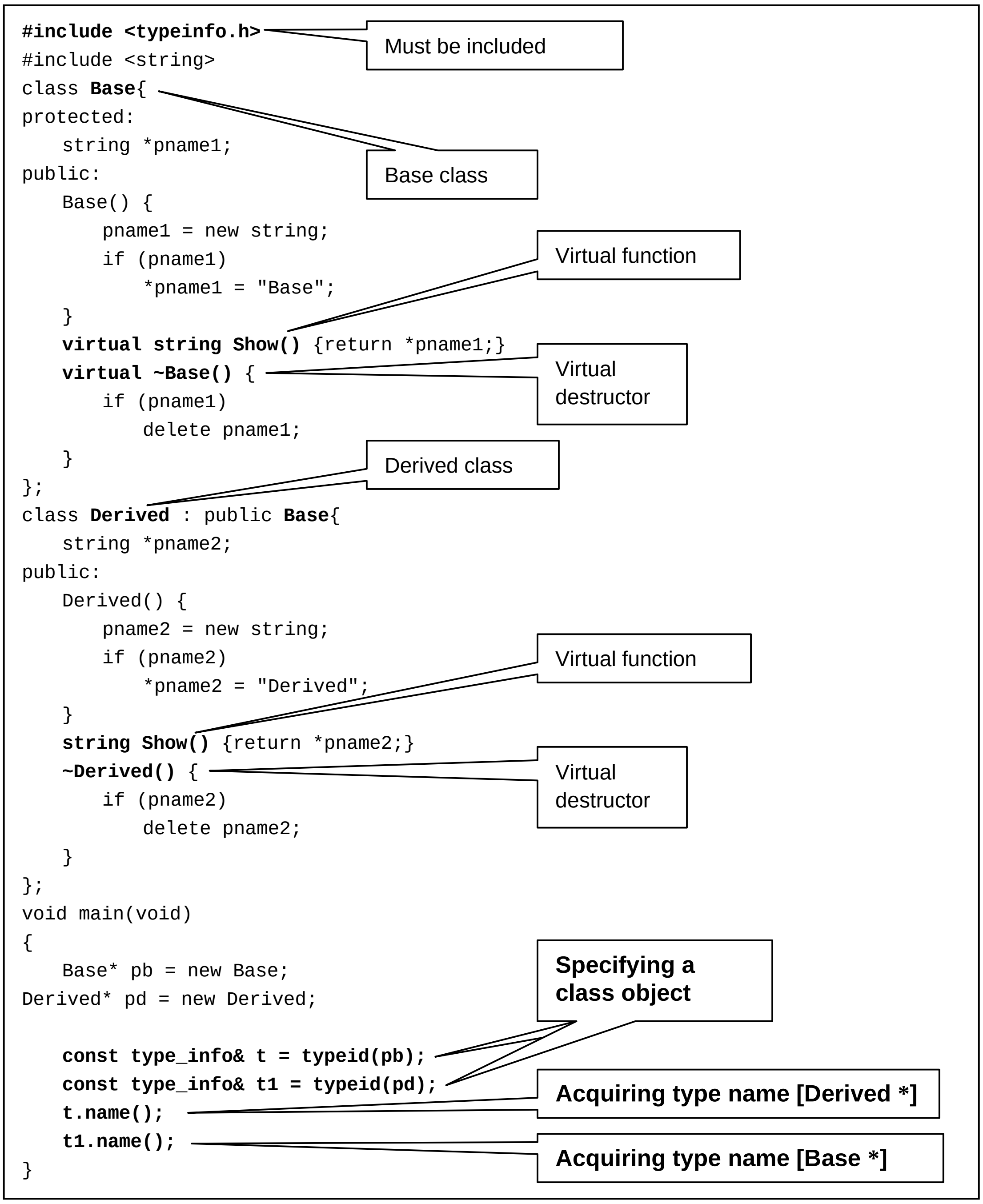
Command line: *Do not specify noprelink (default).*

• Example of Use of *type_info* Class and *typeid* Operator:

The *type_info* class is intended to identify the run-time type of an object.

Use the *type_info* class to compare types at program execution or acquire a class type.

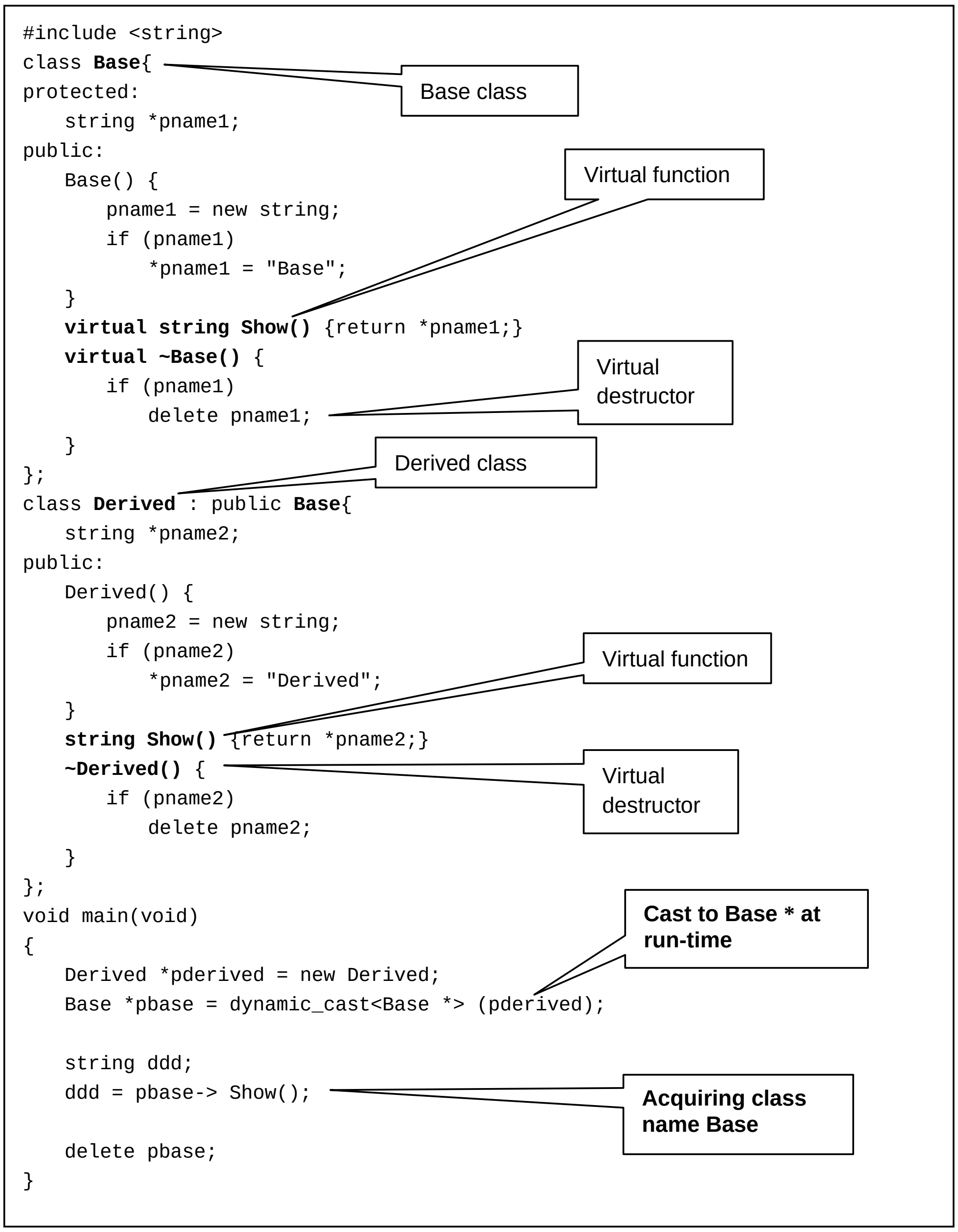
To use the *type_info* class, specify a class object with a virtual function using the typeid operator.



```
#include <typeinfo.h>
#include <string>
class Base{
protected:
    string *pname1;
public:
    Base() {
        pname1 = new string;
        if (pname1)
            *pname1 = "Base";
    }
    virtual string Show() {return *pname1;}
    virtual ~Base() {
        if (pname1)
            delete pname1;
    }
};
class Derived : public Base{
    string *pname2;
public:
    Derived() {
        pname2 = new string;
        if (pname2)
            *pname2 = "Derived";
    }
    string Show() {return *pname2;}
    ~Derived() {
        if (pname2)
            delete pname2;
    }
};
void main(void)
{
    Base* pb = new Base;
Derived* pd = new Derived;

    const type_info& t = typeid(pb);
    const type_info& t1 = typeid(pd);
    t.name();
    t1.name();
}
```

• Example of Use of *dynamic_cast* Operator:

Use the *dynamic_cast* operator, for example, to cast at run-time a pointer or reference of the derived-class type to a pointer or reference of the base-class type between a class including a virtual function and its derived class.



```
#include <string>
class Base{
protected:
    string *pname1;
public:
    Base() {
        pname1 = new string;
        if (pname1)
            *pname1 = "Base";
    }
    virtual string Show() {return *pname1;}
    virtual ~Base() {
        if (pname1)
            delete pname1;
    }
};
class Derived : public Base{
    string *pname2;
public:
    Derived() {
        pname2 = new string;
        if (pname2)
            *pname2 = "Derived";
    }
    string Show() {return *pname2;}
    ~Derived() {
        if (pname2)
            delete pname2;
    }
};
void main(void)
{
    Derived *pderived = new Derived;
    Base *pbase = dynamic_cast<Base *> (pderived);

    string ddd;
    ddd = pbase-> Show();

    delete pbase;
}
```

8.3.3 Exception Handling Function

• Description:

Unlike C, C++ has a mechanism for handling an error called an exception.

An exception is a means for connecting an error location in a program with an error handling code.

Use the exception mechanism to put together error handling codes in one location.

For the Compiler, specify the following option to use the exception mechanism.

• Specification method:

Dialog menu: CPU tab, Use try, throw and catch of C++

Command line: *exception*

• Example of Use:

If opening of file "INPUT.DAT" fails, initiate the exception handling and display an error in the standard error output.

(C++ program example for exception handling)

```
void main(void)
{
    try
    {
        if ((fopen("INPUT.DAT","r"))==NULL){
            char * cp = "cannot open input file\n";
            throw cp;
        }
    }
    catch(char *pstrError)
    {
        fprintf(stderr,pstrError);
        abort();
    }
    return;
}
```

• Important Information:

The coding performance may deteriorate.

8.3.4 Disabling Startup of Prelinker

• Description:

Starting up the Prelinker will reduce the link speed. The Prelinker need not be running unless the template function or run-time type conversion of C++ is used.

To use the Linker from a command line, specify the following *noprelink* option.

If Hew is used and the *Prelinker control* list box is set to Auto, the output of the *noprelink* option will be automatically controlled.

• Specification method:

Dialog menu: Link/Library tab, Category: Input tab, Prelinker control

Command line: *noprelink*

8.4 Advantages and Disadvantages of C++ Coding

The Compiler, when compiling a C++ program, internally converts the C++ program to a C program to create an object.

This chapter compares a C++ program and a C program after conversion and describes the influences on coding efficiency of each function.

No.	Function	Development and maintenance	Size Reduction	Speed	Section
1	Constructor (1)	◎	Δ	Δ	8.4.1
2	Constructor (2)	◎	Δ	Δ	8.4.2
3	Default parameter	◎	O	O	8.4.3
4	Inline expansion	O	Δ	O	8.4.4
5	Class member function	◎	Δ	Δ	8.4.5
6	*operator* Operator	◎	Δ	Δ	8.4.6
7	Function overloading	◎	O	O	8.4.7
8	Reference type	◎	O	O	8.4.8
9	Static function	◎	O	O	8.4.9
10	Static member variable	◎	O	O	8.4.10
11	Anonymous *union*	◎	O	O	8.4.11
12	Virtual function	◎	Δ	Δ	8.4.12

◎ :	Same as C
O :	Requiring caution in use
Δ :	Performance decrease

8.4.1 Constructor (1)

Development and maintenance	◎	Size Reduction	Δ	Speed	Δ

• Important Points:

Use a constructor to automatically initialize a class object. However, use it with caution because it will influence the object size and processing speed as follows:

• Example of Use:

Create a class-A constructor and destructor and compile them.The size and processing speed will be influenced because the constructor and destructor will be called in the class declaration and decisions will be made in the constructor and destructor codes.

```
(C++ program)

class A
{
private:
    int a;
public:
    A(void);
    ~A(void);
    int getValue(void){ return a; }
};

void main(void)
{
    A a;
    b = a.getValue();
}

A::A(void)
{
    a = 1234;
}

A::~A(void)
{
}
```

(C program after conversion)

```
struct A {
    int a;
};

void *_nw__FUl(unsigned long);
void __dl__FPv(void *);
void main(void);
struct A *__ct__A(struct A *);
void __dt__A(struct A *const, int);

void main(void)
{
    struct A a;
    __ct__A(&a);
    _ b = ((a.a));
    __dt__A(&a, 2);
}
```

Constructor call

Destructor call

```
struct A * __ct__A( struct A *this)
{
    if( this != (struct A *)0
      || (this = (struct A
*)_nw__FUl(4) ) != (struct A *)0 )
    {
        (this->a) = 1234;
    }
    return this;
}
```

Constructor code

```
void __dt__A( struct A *const this,
int flag)
{
    if (this != (struct A *)0){
        if (flag & 1) {
            dl__FPv((void *)this);
        }
    }
    return;
}
```

Destructor code

8.4.2 Constructor (2)

Development and maintenance	◎	Size Reduction	Δ	Speed	Δ

• Important Points:

To declare a class in an **array**, use a constructor to automatically initialize a class object. However, use it with caution because it will influence the object size and processing speed as follows:

• Example of Use:

Create a class-A constructor and destructor and compile them.The memory needs to be dynamically allocated and deallocated because the constructor and destructor are called in the class declaration but are declared in the array.

Use *new* and *delete* to dynamically allocate and deallocate the memory.

This requires implementation of a low-level function. (For details on the implementation method, refer to 9.2.2 Execution Environment Settings, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual)

The size and processing speed will be influenced because decisions and the low-level function processing are added in the constructor and destructor codes.

(C++ program)

```
class A
{
private:
    int a;
public:
    A(void);
    ~A(void);
    int getValue(void){ return a; }
};

void main(void)
{
    A a[5];
    b = a[0].getValue();
}

A::A(void)
{
    a = 1234;
}

A::~A(void)
{
}
```

(C program after conversion)

```
struct A {
    int a;
};

void *__nw__FUl(unsigned long);
void __dl__FPv(void *);
void main(void);
void *__vec_new();
void __vec_delete();
struct A *__ct__A(struct A *);
void __dt__A(struct A *const, int);

void main(void)
{
    struct A a[5];
    __vec_new( (struct A *)a, 5, 4,
__ct__A);
    _ b = ((__34_4_a.a));
    __vec_delete( &a, 5, 4, __dt__A,
0, 0);
}
```

Constructor call

Destructor call

```
struct A *__ct__A( struct A *this)
{
    if((this != (struct A *)0)
     || ( (this = (struct A
*)__nw__FUl(4)) != (struct A *)0) )
    {
        (this->a) = 1234;
    }
    return this;
}
```

Constructor code

```
void __dt__A( struct A *const this,
int flag)
{
    if (this != (struct A *)0){
        if (flag & 1){
            __dl__FPv((void *)this);
        }
    }
    return;
}
```

Destructor code

8.4.3 Default Parameter

Development and maintenance	◎	Size Reduction	O	Speed	O

• Important Points:

In C++, a default parameter can be used to set a default used when calling a function.

To use a default parameter, specify a default value for parameters of a function when declaring the function.

This will eliminate the need of specifying a parameter in many of the function calls and enable the use of a default parameter instead, thus improving the development efficiency.

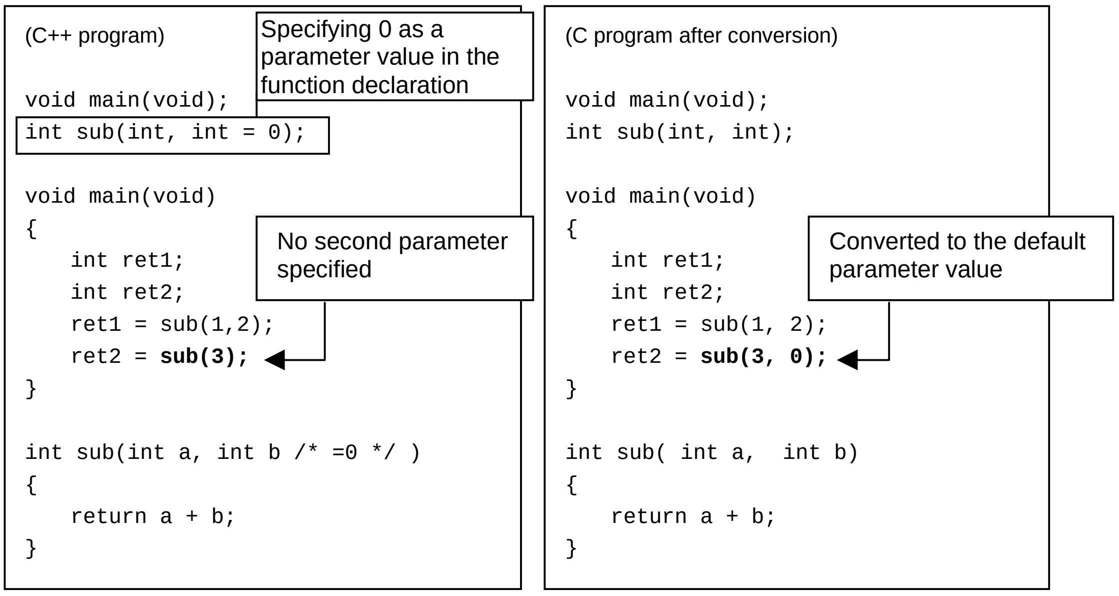
A parameter value can be changed if a parameter is specified.

• Example of Use:

The following shows an example of calling function *sub* when 0 is specified as a default parameter value in the declaration of function *sub*.

As shown below, no parameter needs to be specified if the default parameter value is acceptable when calling function *sub*.Moreover, the efficiency of a program is not deteriorated even when it is converted into C.

In sum, a default parameter ensures superior development and maintenance efficiency and has no disadvantage compared with C.


Specifying 0 as a parameter value in the function declaration
No second parameter specified
Converted to the default parameter value

(C++ program)

```
void main(void);
int sub(int, int = 0);

void main(void)
{
    int ret1;
    int ret2;
    ret1 = sub(1,2);
    ret2 = sub(3);
}

int sub(int a, int b /* =0 */ )
{
    return a + b;
}
```

(C program after conversion)

```
void main(void);
int sub(int, int);

void main(void)
{
    int ret1;
    int ret2;
    ret1 = sub(1, 2);
    ret2 = sub(3, 0);
}

int sub( int a,  int b)
{
    return a + b;
}
```

8.4.4 Inline Expansion

Development and maintenance	O	Size Reduction	Δ	Speed	O

• Important Points:

When coding the definition of a function, specify *inline* in the beginning to cause inline expansion of the function. This will eliminate the overhead of a function call and improve the processing speed.

• Example of Use:

Specify function *sub* as an inline function and inline-expand it in the main function.Then, remove the function *sub* code.

However, function *sub* cannot be reference from other files.

Use inline expansion with caution because, although the processing speed is certain to improve, the program size will become too large unless only small functions are used.

(C++ program)

```
int a;

inline int sub(int x, int y)
{
    return (x+y);
}

void main(void)
{
    a = sub(1,2);
}
```

(C program after conversion)

```
int a;
void main(void)
{
    a = 3;
    return;
}
```

Expanding the content of function *sub* (1+2=3)

8.4.5 Class Member Function

Development and maintenance	◎	Size Reduction	Δ	Speed	Δ

• Important Points:

Defining a class will enable information hidingand improve the development and maintenance efficiency.

However, use this technique with caution because it will influence the size and processing speed.

• Example of Use:

In the following example, class member functions *set* and *add* are used to access *private* class member variables *a*, *b*, and *c*.

When calling a class member function, the parameter specification in a C++ program either has only a value or no parameter.

As shown in the C program after conversion, however, the address of class A (struct A) is also passed as a parameter.

Additionally, *private* class member variables *a*, *b*, and *c* are accessed in the class member function code.

However, the *this* pointer is used to access them.

In sum, use a class member function with caution because it will influence the size and processing speed.

(C++ program)

```
class A
{
private:
    int a;
    int b;
    int c;
public:
    void set(int, int, int);
    int add();
};

int main(void)
{
    A a;
    int ret;

    a.set(1,2,3);
    ret = a.add();

    return ret;
}
void A::set(int x, int y, int z)
{
    a = x;
    b = y;
    c = z;
}
int A::add()
{
    return (a += b + c);
}
```

(C program after conversion)

```
struct A {
    int a;
    int b;
    int c;
};
void set__A_int_int(struct A *const, int, int, int);
int add__A(struct A *const);

int main(void)
{
    struct A a;
    int ret;

    set__A_int_int(&a, 1, 2, 3);
    ret = add__A(&a);

    return ret;
}
void set__A_int_int(struct A *const this, int x, int y, int z)
{
    this->a = x;
    this->b = y;
    this->c = z;
    return;
}
int add__A(struct A *const this)
{
    return (this->a += this->b + this->c);
}
```

8.4.6 *operator* Operator

Development and maintenance	O	Size Reduction	Δ	Speed	Δ

• Important Points:

In C++, use the keyword, *operator* to overload an operator.

This will enable simple coding of the user's operations such as matrix operations and vector calculations.

However, use *operator* with caution because it will influence the size and processing speed.

• Example of Use:

In the following example, unary operator "+" is overloaded using the *operator* keyword.

If the *Vector* class is declared as shown below, unary operator "+" can be changed to the user's operation.

However, the size and processing speed will be influenced because, as shown in the C program after conversion, reference using the *this* pointer is made.

(C++ program)

```
class Vector
{
private:
    int x;
    int y;
    int z;
public:
    Vector & operator+ (Vector &);
};

void main(void)
{
    Vector a,b,c;

    a = b + c;
}

Vector & Vector::operator+ (Vector & vec)
{
    static Vector ret;

    ret.x = x + vec.x;
    ret.y = y + vec.y;      <---  User's operation (addition)
    ret.z = z + vec.z;

    return ret;
}
```

(C program after conversion)

```
struct Vector {
    int x;
    int y;
    int z;
};

void main(void);
struct Vector *__plus__Vector_Vector(struct Vector *const, struct Vector *);

void main(void)
{
    struct Vector a;
    struct Vector b;
    struct Vector c;

    a = __plus__Vector_Vector(&b, &c);
    return;
}

struct Vector *__plus__Vector_Vector( struct Vector *const this,  struct
Vector *vec)
{
    static struct Vector ret;

    ret.x = this->x + vec->x;
    ret.y = this->y + vec->y;
    ret.z = this->z + vec->z;

    return &ret;
}
```

Reference using the this pointer

8.4.7 Overloading of Functions

Development and maintenance	◎	Size Reduction	O	Speed	O

• Important Points:

In C++, you can "overload" functions, i.e., give the same name to different functions.

Specifically, this feature is effective when you use functions with the same processing but with different types of arguments.

Be careful not to give the same name to functions with no commonality because it is sure to cause malfunctions.

The use of this function will not influence the size or processing speed.

• Example of Use:

In the following example, the first and second parameters are added and the resultant value is used as a return value.

All the functions have the same name, *add* but different parameter and return value types..

As shown in the C program after conversion, the call of the add functions or the code of the add functions do not increase the code size.

Thus, the use of this feature will not influence the size and processing speed.

```
(C++ program)

void main(void);
int add(int,int);
float add(float,float);
double add(double,double);

void main(void)
{
    int    ret_i = add(1, 2);
    float  ret_f = add(1.0f, 2.0f);
    double ret_d = add(1.0, 2.0);
}

int add(int x,int y)
{
    return x+y;
}

float add(float x,float y)
{
    return x+y;
}

double add(double x,double y)
{
    return x+y;
}
```

(C program after conversion)

```
void main(void);
int add__int_int(int, int);
float add__float_float(float, float);
double add__double_double(double, double);

void main(void)
{
   auto int ret_i;
   auto float ret_f;
   auto double ret_d;

   ret_i = add__int_int(1, 2);
   ret_f = add__float_float(1.0f, 2.0f);
   ret_d = add__double_double(1.0, 2.0);
}

int add__int_int( int x,  int y)
{
   return x + y;
}

float add__float_float( float x,  float y)
{
   return x + y;
}

double add__double_double( double x,  double y)
{
   return x + y;
}
```

8.4.8 Reference Type

Development and maintenance	◎	Size Reduction	O	Speed	O

• Important Points:

The use of a reference-type parameter will enable simple coding of a program and improve the development and maintenance efficiency.

Additionally, the use of the reference type will not influence the size or processing speed.

• Example of Use:

As shown below, reference-type passing instead of pointer passing will enable simple coding..

In a reference type, not the values but the addresses of *a* and *b* are passed.

The use of a reference type, as shown in the C program after conversion, will not influence the size and processing speed.

(C++ program)

```
void main(void);
void swap(int&, int&);

void main(void)
{
    int a=100;
    int b=256;

    swap(a,b);
}

void swap(int &x, int &y)
{
    int tmp;
    tmp = x;
    x = y;
    y = tmp;
}
```

(C program after conversion)

```
void main(void);
void swap(int *, int *);

void main(void)
{
    int a=100;
    int b=256;

    swap(&a, &b);
}

void swap(int *x,  int *y)
{
    int tmp;
    tmp = *x;
    *x = *y;
    *y = tmp;
}
```

8.4.9 Static Function

Development and maintenance	◎	Size Reduction	O	Speed	O

• Important Points:

If the class configuration becomes complex due to derived classes, etc., it will be increasingly more difficult to access *static* class member variables with the *private* attribute until they need to be changed to the *public* attribute.

To access a *static* class member variable without changing the *private* attribute in such a case, create a member function to be used as an interface and specify the *static* variable in the function.

A *static* function is thus used to access only static class member variables.

• Example of Use:

As shown on the next page, use a static function to access a static member variable.

Although the use of a class will influence the code efficiency, the use of a static function itself will not influence the size and processing speed.

• Note:

For details on a static member variable, refer to section 8.2.3, Static Member Variable.

(C++ program)

```
class A
{
private:
    static int num;                  ← Static member variable
public:
    static int getNum(void);         ← Static function
    A(void);
    ~A(void);
};

int A::num = 0;

void main(void)
{
    int num;

    num = A::getNum();

    A a1;
    num = a1.getNum();

    A a2;
    num = a2.getNum();
}

A::A(void)
{
    ++num;
}

A::~A(void)
{
    --num;
}

int A::getNum(void)
{
    return num;                      ← Accessing the static member variable
}
```

(C program after conversion)

```
struct A
{
    char __dummy;
};
void *__nw__FUl(unsigned long);
void __dl__FPv(void *);
int getNum__A(void);                  Static member variable
struct A *__ct__A(struct A *);
void __dt__A(struct A *const, int);
int num__1A = 0;                      Static function
void main(void)
{
    int num;
    struct A a1;
    struct A a2;

    num = getNum__A();

    __ct__A(&a1);
    num = getNum__A();

    __ct__A(&a2);
    num = getNum__A();

    __dt__A(&a2, 2);
    __dt__A(&a1, 2);
}
int getNum__A(void)
{
    return num__1A;                   Accessing the static member variable
}
struct A *__ct__A( struct A *this)
{
    if ( (this != (struct A *)0)
    || ( (this = (struct A *)__nw__FUl(1)) != (struct A *)0) ){
        ++num__1A;
    }
    return this;
}
void __dt__A( struct A *const this,  int flag)
{
    if (this != (struct A *)0){
        --num__1A;
        if(flag & 1){
            __dl__FPv((void *)this);
        }
    }
    return;
}
```

8.4.10 Static Member Variable

Development and maintenance	◎	Size Reduction	O	Speed	O

• Important Points:

In C++, a class member variable with the static attribute can be shared among multiple objects of a class type.

Thus, a static member variable comes in handy because it can be used, for example, as a common flag among multiple objects of the same class type.

• Example of Use:

Create five class-A objects within the *main* function.

Static member variable *num* has an initial value of 0. This value will be incremented by the constructor every time an object is created.

Static member variable num, shared among objects, will have a value of 5 at the maximum.

Additionally, the use of a class will influence the code efficiency.

However, the use of a static member variable itself will not influence the size and processing speed because the Compiler internally handles member variable *num* as if it is an ordinary global variable.

• Note:

For details on a *static* member variable, refer to section 8.2.3, Static Member Variable.

(C++ program)

```
class A
{
private:
    static int num;
public:
    A(void);
    ~A(void);
};

int A::num = 0;

void main(void)
{
    A a1;
    A a2;
    A a3;
    A a4;
    A a5;
}

A::A(void)
{
    ++num;
}

A::~A(void)
{
    --num;
}
```

Creating a class A-type class object

Incrementing a *static* member variable

(C program after conversion)

```
struct A
{
    char __dummy;
};
void *__nw__FUl(unsigned long);
void __dl__FPv(void *);
struct A *__ct__A(struct A *);
void __dt__A(struct A *const, int);
int num__1A = 0;
void main(void)
{
    struct A a1;
    struct A a2;
    struct A a3;
    struct A a4;
    struct A a5;
    __ct__A(&a1);
    __ct__A(&a2);
    __ct__A(&a3);
    __ct__A(&a4);
    __ct__A(&a5);
    __dt__A(&a5, 2);
    __dt__A(&a4, 2);
    __dt__A(&a3, 2);
    __dt__A(&a2, 2);
    __dt__A(&a1, 2);
}
struct A *__ct__A( struct A *this)
{
    if( (this != (struct A *)0)
    || ( (this = (struct A *)__nw__FUl(1)) != (struct A *)0) ){
        ++num__1A;
    }
    return this;
}
void __dt__A( struct A *const this,  int flag)
{
    if(this != (struct A *)0){
        --num__1A;
        if (flag & 1){
            __dl__FPv((void *)this);
        }
    }
    return;
}
```

Handled by the Compiler as if it is an ordinary global variable

Creating class A-type class objects

Calling constructors

Calling destructors

Incrementing a static member variable

8.4.11 Anonymous *union*

Development and maintenance	◎	Size Reduction	O	Speed	O

• Important Points:

In C++, use an anonymous *union* to directly access a member without, like in C, having to specify the member name.

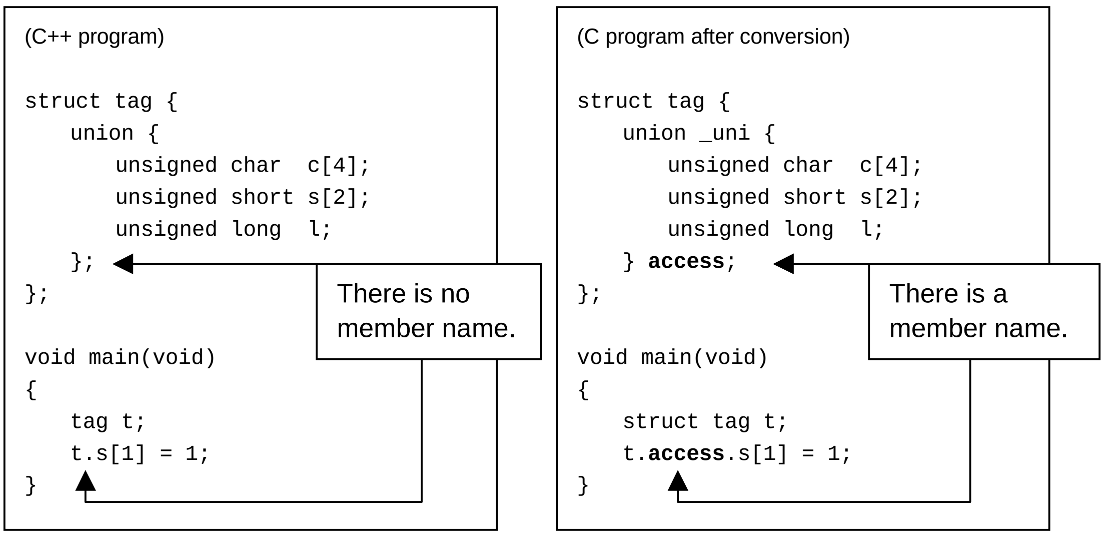
This will improve the development efficiency.Additionally, it will not influence the size and processing speed.

• Example of Use:

In the following example, function main is used to access *union* member variable *s*.

In the C++ program, member variable *s* is directly accessed. In the C program after conversion, it is accessed using a member name that the Compiler has automatically created.

The use of this simple code enables access to a member variable without influencing the object efficiency.



(C++ program)

```
struct tag {
    union {
        unsigned char  c[4];
        unsigned short s[2];
        unsigned long  l;
    };
};

void main(void)
{
    tag t;
    t.s[1] = 1;
}
```

(C program after conversion)

```
struct tag {
    union _uni {
        unsigned char  c[4];
        unsigned short s[2];
        unsigned long  l;
    } access;
};

void main(void)
{
    struct tag t;
    t.access.s[1] = 1;
}
```

8.4.12 Virtual Function

Development and maintenance	◎	Size Reduction	Δ	Speed	Δ

• Important Points:

A virtual function must be used if, as shown in the following program, there is a function with the same name in each of a base class and a derived class. Otherwise, the function call cannot be properly made as intended.

If a virtual function is declared, these calls can be properly made as intended.

Use a virtual function to improve the development efficiency. However, use it with caution because it will influence the size and processing speed.

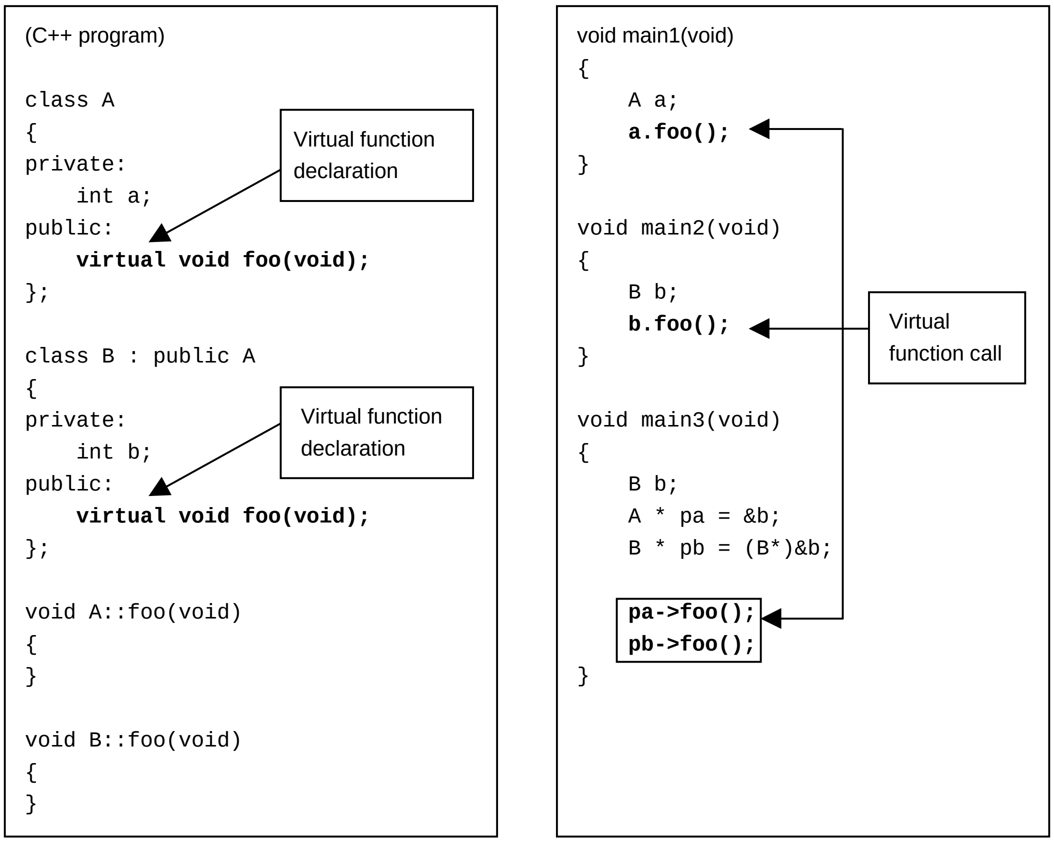
• Example of Use:

In the *main3* function call, two pointers store class-B addresses.

If *virtual* is declared, the class-B *foo* function is properly called.

If *virtual* is not declared, one of the pointers calls the class-A *foo* function.

The use of a virtual function, resulting in creation of a table, etc. as shown on the next page, will influence the size and speed.



(C++ program)

```
class A
{
private:
    int a;
public:
    virtual void foo(void);
};

class B : public A
{
private:
    int b;
public:
    virtual void foo(void);
};

void A::foo(void)
{
}

void B::foo(void)
{
}
```

```
void main1(void)
{
    A a;
    a.foo();
}

void main2(void)
{
    B b;
    b.foo();
}

void main3(void)
{
    B b;
    A * pa = &b;
    B * pb = (B*)&b;

    pa->foo();
    pb->foo();
}
```

• C program after conversion (tables, etc. for virtual functions):

```
struct __T5585724;
struct __type_info;
struct __T5584740;
struct __T5579436;
struct A;
struct B;
extern void main1__Fv(void);
extern void main2__Fv(void);
extern void main3__Fv(void);
extern void foo__1AFv(struct A *const);
extern void foo__1BFv(struct B *const);
struct __T5585724
{
    struct __T5584740 *tinfo;
    long offset;
    unsigned char flags;
};
struct __type_info
{
    struct __T5579436 *__vptr;
};
struct __T5584740
{
    struct __type_info tinfo;
    const char *name;
    char *id;
    struct __T5585724 *bc;
};
struct __T5579436
{
    long d;                             // this pointer offset
    long i;                             // Unassigned
    void (*f)();                        // For virtual function call
};
struct A {                              // Class-A declaration
    int a;
    struct __T5579436 *__vptr;          // Pointer to a virtual function table
};
struct B {                              // Class-B declaration
    struct A __b_A;
    int b;
};
static struct __T5585724 __T5591360[1];
#pragma section $VTBL
extern const struct __T5579436 __vtbl__1A[2];
extern const struct __T5579436 __vtbl__1B[2];
extern const struct __T5579436 __vtbl__Q2_3std9type_info[];
#pragma section
extern struct __T5584740 __T_1A;
extern struct __T5584740 __T_1B;
```

```
static char __TID_1A;                      // Unassigned
static char __TID_1B;                      // Unassigned
static struct __T5585724 __T5591360[1] =   // Unassigned
{
    {
        &__T_1A,
        0L,
        ((unsigned char)22U)
    }
};
#pragma section $VTBL
const struct __T5579436 __vtbl__1A[2] =     // Virtual function table for class-A
{
    {
        0L,                                 // Unassigned area
        0L,                                 // Unassigned area
        ((void (*)())&__T_1A)               // Unassigned area
    },
    {
        0L,                                 // this pointer offset
        0L,                                 // Unassigned area
        ((void (*)())foo__1AFv)             // ((void (*)())foo__1AFv) // Pointer to A::foo()
    }
};
const struct __T5579436 __vtbl__1B[2] =     // Virtual function table for class-B
{
    {
        0L,                                 // Unassigned area
        0L,                                 // Unassigned area
        ((void (*)())&__T_1B)               // Unassigned area
    },
    {
        0L,                                 // this pointer offset
        0L,                                 // Unassigned area
        ((void (*)())foo__1BFv)             // ((void (*)())foo__1BFv) // Pointer to B::foo()
    }
};
#pragma section
struct __T5584740 __T_1A =                  // Type information for class-A (unassigned)
{
    {
        (struct __T5579436 *)__vtbl__Q2_3std9type_info
    },
    (const char *)"A",
    &__TID_1A,
    (struct __T5585724 *)0
};
```

```
struct __T5584740 __T_1B =                        // Type information for class-B  (unassigned)
{
    {
        (struct __T5579436 *)__vtbl__Q2_3std9type_info
    },
    (const char *)"B",
    &__TID_1B,
    __T5591360
};
```

• C program after conversion (virtual function calls):

```
void main1__Fv(void)
{
    struct A _a;
    _a.__vptr = __vtbl__1A;
    foo__1AFv( &_a );                              // foo__1AFv( &_a ); // Call of A::foo()
    return;
}
void main2__Fv(void)
{
    struct B _b;
    _b.__b_A.__vptr = __vtbl__1A;
    _b.__b_A.__vptr = __vtbl__1B;
    foo__1BFv( &_b );                              // foo__1BFv( &_b ); // Call to B::foo()
    return;
}
void main3__Fv(void)
{
    struct __T5579436 *_tmp;
    struct B _a;
    struct A *_pa;
    struct B *_pb;

    (*((struct A*)(&_b))).__vptr = __vtbl__1A;
    (*((struct A*)(&_b))).__vptr = __vtbl__1B;

    _pa = (struct A *)&_b;
    _pb = &_b;

    _tmp = _pa->__vptr + 1;
    (  (void (*)(struct A *const))  _tmp->f  )  (  (struct A *)_pa + tmp->b);
    // Call to B::foo()

    _tmp = _pb->__b_A.__vptr + 1;
    (  (void (*)(struct B *const))  _tmp->f  )  (  (struct B *)_pb + tmp->b);
    // Call to B::foo()

    return;
}
```

Section 9 Optimizing Linkage Editor

This chapter describes the use of effective options at linkage, and the Inter-Module Optimization at linkage.

The following table shows a list of the items relating to the use of Optimizing Linkage Editor.

No.	Category	Item		Section
1	Input/Output Options	Input Options		9.1.1
		Output Options		9.1.2
2	List Options	Symbol information		9.2.1
3		Number of references		9.2.2
4		Cross-Reference Information		9.2.3
5	Effective Options	Output to unused area		9.3.1
6		End code of S type file		9.3.2
7		Debug information compression		9.3.3
8		Link time reduction		9.3.4
9		Notification of Unreferenced Symbol		9.3.5
10		Reduce empty areas of boundary alignment		9.3.6
11	Optimize Options	Optimization at linkage		9.4.1
12		Sub options of Optimize Option		
13			Unifies constants/strings	9.4.2
14			Eliminates unreferenced variables/functions	9.4.3
15			Uses short absolute addressing mode	9.4.4
16			Optimizes register save/restore codes	9.4.5
17			Unifies common codes	9.4.6
18			Uses indirect addressing mode	9.4.7
19			Optimizes branch instructions	9.4.8
20			Shortens the addressing mode	9.4.9
21		Optimization partially disabled		9.4.10
22		Confirm Optimization Results		9.4.11

9.1 Input/Output Options

9.1.1 Input Options

• Description

The optimizing linkage editor can input the following four files according to user usage.

This is one of the convenient features.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Input] Show entries for :**

Command line: *Input <suboption>:<file name>*
Library<file name>
Binary<suboption>:<file name>

• Available Input Files

Kind of Files	Command line
Object Files	input
Relocatable Files	input
Library Files	library
Binary Files	binary

(1) Object Files

Ordinary files output from the compiler or the assembler.

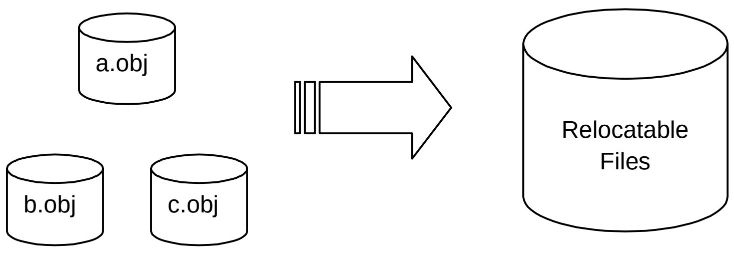
(2) Relocatable Files

Relocatable (Address Unresolved) Files.

This file consists of one or more object files, and is generated from the optimizing linkage editor with output options.

Symbols in relocatable files **are linked**, even if other files **don't refer** to them.

So in case of using the relocatable files, be careful about the above not to increase ROM size by linking unnecessary files.

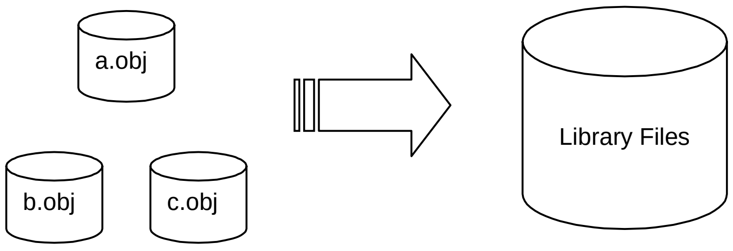


(3) Library Files

Relocatable (Address Unresolved) Files.

This file consists of one or more object files, and is generated from the optimizing linkage editor with output options.

Symbols in relocatable files **are not linked**, if other files **don't refer** to them.



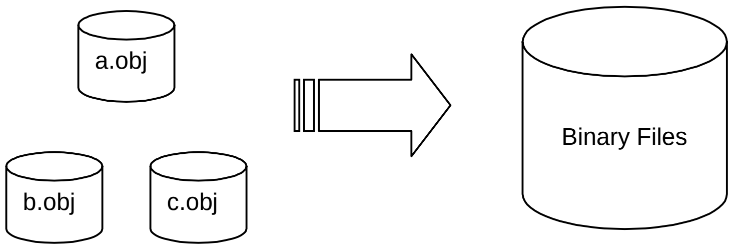
(4) Binary Files

Binary Files are available to input.

This file consists of one or more object files, and is generated from the optimizing linkage editor with output options.

When input binary files, section name should be specified. This section name is located with the **start** option.

As binary files have no debug information, C/C++ source level debugger can't be used.

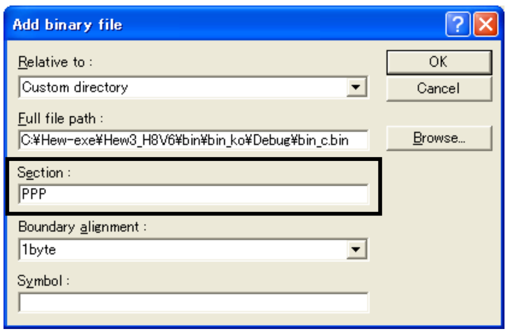


[Specification Method 1]

Section name should be specified.

Dialog menu: **Link/Library Tab Category: [Input] Show entries for : Binary files**

Command line: ***binary=bin_c.bin(PPP)***



Relative to : Custom directory

Full file path : C:¥Hew-exe¥Hew3_H8V6¥bin¥bin_ko¥Debug¥bin_c.bin

Section : PPP

Boundary alignment : 1byte

Symbol :

[Specification Method 2]

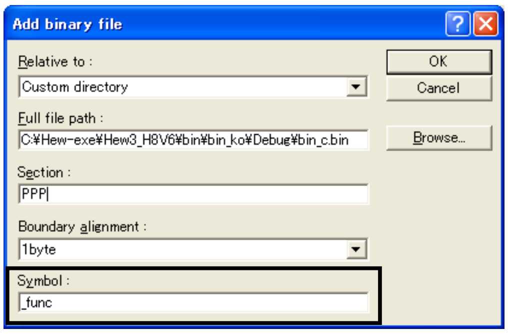
Symbol can be defined at the head of the binary files.

Specify symbol name with section name, to do this.

For a variable name referred by a C/C++ program, add an underscore (_) at the head of the symbol name.

Dialog menu: **Link/Library Tab Category: [Input] Show entries for : Binary files**

Command line: ***binary=bin_c.bin(PPP,_func)***



Add binary file

Relative to : Custom directory

Full file path : C:¥Hew-exe¥Hew3_H8V6¥bin¥bin_ko¥Debug¥bin_c.bin

Section : PPP

Boundary alignment : 1byte

Symbol : _func

[Specification Method 3]

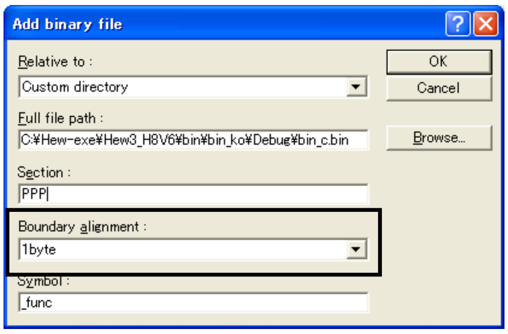
When input binary files, boundary alignment value can be specified.

When the boundary alignment specification is omitted, 1 is used as the default for the compatibility with earlier versions. This boundary alignment specification is valid in the Optimizing Linkage Editor Ver.9.0 or later.

Dialog menu: **Link/Library Tab Category: [Input] Show entries for : Binary files**

Command line: ***binary=bin_c.bin(PPP:<boundary alignment>,_func)***

<boundary alignment>: 1 | 2 | 4 | 8 | 16 | 32 (default: 1)



Add binary file

Relative to : Custom directory

Full file path : C:¥Hew-exe¥Hew3_H8V6¥bin¥bin_ko¥Debug¥bin_c.bin

Section : PPP

Boundary alignment : 1byte

Symbol : _func

9.1.2 Output Options

• Description

Some type of ROM writer can input only HEX files or only S-type files.

The optimizing linkage editor can output the following eight files according to user usage.

User can change the kind of output file, if necessary.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Output] Type of output file :**

Command line: *orm{ absolute* | *relocate* | *object* | *library=s* | *library=u* | *hexadecimal* | *stype* | *binary }*

• Available Output Files

No.	Kind of Files	Command line
1	Absolute Files	form absolute
2	Relocatable Files	form relocate
3	Object Files	form object
4	User Library Files	form library=s
5	System Library Files	form library=u
6	HEX Files	form hexadecimal
7	S-type Files	form stype
8	Binary Files	form binary

(1) Absolute Files

Address resolved Files by the optimizing linkage editor.

As this file has debug information, C/C++ source level debugger can be used.

When writing to ROM, this file should be transformed to either S-type format, HEX, or Binary.

(2) Relocatable Files

Relocatable (Address Unresolved) Files.

As this file has debug information, C/C++ source level debugger can be used.

To execute this file, this file should be transformed to absolute file by linking again.

(3) Object Files

This file is used when a module (object) is extracted as an object file from a library with the extract option.

When specifying by command line, a needed object file can be extracted from the library file specified by this option.

When using HEW, specify the following options at **Link/Library Tab Category: [Other] User defined options :**

[Extract Options]

form=object
extract=<module name>

(4) User Library/System Library

Output Library Files.

(5) HEX Files

Output HEX Files.

As this files have no debug information, C/C++ source level debugger can’t be used.

For details of HEX file, please refer to section 19.1.2, HEX File Format, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

(6) S-type Files

Output S-type Files.

As this files have no debug information, C/C++ source level debugger can’t be used.

For details of S-type file, please refer to section 19.1.1, S-Type File Format, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

(7) Binary Files

Output Binary Files.

As binary files have no debug information, C/C++ source level debugger can’t be used.

9.2 List Options

9.2.1 Symbol Information List

• Description

The optimizing linkage editor can output symbol address, size and optimization information in addition to linkage map information, by specifying additional sub-options.

(1) symbol address -**ADDR**

(2) size **-SIZE**

(3) optimization **-OPT** (**ch-** changed, **cr-** created, **mv-** moved)

• Specification Method

Dialog menu: **Link/Library Tab Category: [List] Contents : Show symbol**

Command line: *list [=<file name>]*
show symbol

<*.map file>

```
*** Options ***
      :
*** Error information ***
      :
*** Mapping List ***
      :
*** Symbol List ***


SECTION=
FILE=                                         START       END     SIZE
 SYMBOL                                   (1) ADDR    (2) SIZE  INFO  COUNTS    (3) OPT

SECTION=P
FILE=C:\Hew-exe\Hew3_SHV9\bin\bin\Debug\bin.obj

                                           00000800  00000821        22
    _main
                                           00000800       6    func ,g    *   ch
    _abort
                                           00000806       4    func ,g    *   ch
    _com_opt1
                                           0000080a      18    func ,g    *   cr ch
*** Delete Symbols ***
       :
*** Variable Accessible with Abs8 ***
       :
*** Variable Accessible with Abs16 ***
       :
*** Function Call ***
       :
```

9.2.2 Symbol Reference Count

• Description

The optimizing linkage editor can output static symbol reference count in addition to linkage map information, by specifying additional sub-options.

(1) symbol reference count -COUNTS

• Specification Method

Dialog menu: **Link/Library Tab Category: [List] Contents : Show reference**

Command line: *list [=<file name>]*
Show reference

```
<*.map file>
*** Options ***
       :
*** Error information ***
       :
*** Mapping List ***
       :
*** Symbol List ***


SECTION=
FILE=                                          START      END       SIZE
 SYMBOL                                    ADDR       SIZE  INFO       (1) COUNTS  OPT

SECTION=P
FILE=C:\Hew-exe\Hew3_SHV9\bin\bin\Debug\bin.obj

                                               00000800  00000821      22
     _main
                                           00000800         6   func ,g     1   ch
     _abort
                                           00000806         4   func ,g     0   ch
     _com_opt1
                                           0000080a        18   func ,g     2   cr ch
*** Delete Symbols ***
       :
*** Variable Accessible with Abs8 ***
       :
*** Variable Accessible with Abs16 ***
       :
*** Function Call ***
```

9.2.3 Cross-Reference Information

• Description

The optimizing linkage editor can output cross-reference information in addition to linkage map information, by specifying additional sub-options. Cross-reference information makes it possible to search where a global symbol is referenced.

Local symbols and static symbols are not output.

• Specification Method

Dialog menu: **Link/Library Tab Category: [List] Contents : Show cross reference**

Command line: *list [=<file name>]*
Show xreference

```
<*.map file>
*** Cross Reference List ***

No   Unit Name   Global.Symbol   Location  External Information
(1)      (2)           (3)           (4)             (5)
---- ----------- --------------- -------- ---------------------
0001 test1
     SECTION=P
                 _main
                                 00000100
     SECTION=B
                 _sl1
                                 00007000 0001(0000011a:P)
                 _sl2
                                 00007004 0001(0000010e:P)
                 _ret
                                 00007008 0001(00000128:P)
     SECTION=D
0002 test2
     SECTION=P
                 _func1
                                 0000015c 0001(00000124:P)
                 _func2
                                 00000164 0001(0000013c:P)
                 _func3
                                 00000170 0001(00000150:P)
```

• Description of Each Item

(1) Unit number, which is an identification number in object units, displayed in External Information (5).
(2) Object name, which specifies the input order at linkage.
(3) Symbol name output in ascending order for every section.
(4) Symbol allocation address, which is a relative value from the beginning of the section when relocatable format is specified for output file format (form=relocate).
(5) Address from which an external symbol is referenced.
Output format: <Unit number> (<address or offset in section>:<section name>)

• Remarks

This option is valid for the Optimizing Linkage Editor Ver.9.0 or later.

9.3 Effective Options

9.3.1 Output to Unused Area

• Description

The optimizing linkage editor can output any data to unused area.

This is useful for ROM transfer, and this is useful to detect an abnormal interrupt by executing unused area with no data, when program hangs.

A 1-, 2-, or 4-byte value is valid for output data size. If an odd number of digits are specified, the upper digits are extended with 0 to use it as an even number of digits.

The maximum size of output data is 4-byte. If a value over 4-byte is specified, the lower 4-byte is used.

This option is available only when output file is S-type file, Binary or HEX.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Output] Show entries for :**
Specify value filled in unused area

Command line: *space [=<numerical value>]*

• Examples

(1) Divide file and specify the range to fill unused area with data by

Link/Library Tab Category: [Output] Show entries for : Divided output files
-output="C:\bin\Debug\a.bin"=00-0FFFF

(2) Specify the filling data by

Link/Library Tab Category: [Output] Show entries for : Specify value filled in unused area
-space=FF

The example of the following page <Specify value filled in unused area [H'FF]> shows how unused area is filled with data.

• **Examples of S-type Files**

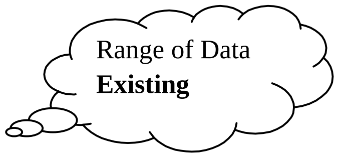
As the following examples, 0xFF records are added to the unused areas in the range of data existing.

If this option is not specified, the records in the range of data not existing are not output.

If this option is specified, 0xFF records are added to the area in the range of data not existing, according to the output range specification in the output option **Divided output files**.

<NOT Specify value filled in unused area>

```
S00E000062696E20202020206D6F74C8
S107000000000400F4
S10700140000041AC6
S107001C0000041CBC
S10700200000041EB6
S107002400000420B0
S107002800000422AA
S107002C00000424A4
S1070040000004268E
S10700440000042888
S10700480000042A82
S107004C0000042C7C
S10700500000042E76
S10700540000043070
```

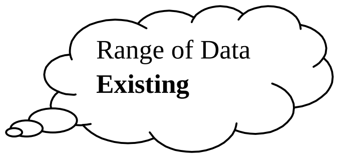


…

```
S11308901F9045EC7A00000008C67A01000008D2D7
S11308A0401801006D0401006D0501006D0640064D
S11308B06C4A68EA0B061FD445F61F9045E40120F4
S10908C06D766D725470A8
S10F08C6000008DA000008DE00FFE42A4D
S10B08D200FFE00000FFE42A2E
S10708DA00FFE00A2D
S10F08DE7900000A6BA00000200C54708C
S9030400F8
```

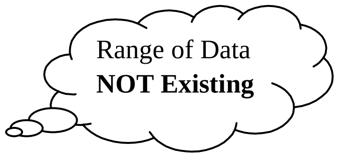
<Specify value filled in unused area [H'FF]>

```
S00E000062696E20202020206D6F74C8
S107000000000400F4
S1130004FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF8
S10700140000041AC6
S1070018FFFFFFFFE4
S107001C0000041CBC
S10700200000041EB6
S107002400000420B0
S107002800000422AA
S107002C00000424A4
S1130030FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFCC
S1070040000004268E
S10700440000042888
S10700480000042A82
```



…

```
S113FF8AFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF73
S113FF9AFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF63
S113FFAAFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF53
S113FFBAFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF43
S113FFCAFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF33
S113FFDAFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF23
S113FFEAFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF13
S109FFFAFFFFFFFFFFFF03
S9030400F8
```



• Examples of Binary Files

As the following examples, the unused areas in the range of data existing are changed from 0x00 to 0xFF.

If this option is not specified, the records in the range of data not existing are not output.

If this option is specified, 0xFF records are added to the area in the range of data not existing, according to the output range specification in the output option **Divided output files**.

<NOT Specify value filled in unused area>

```
000100  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000110  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000120  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000130  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000140  00 00 04 6E 00 00 04 70  00 00 04 72 00 00 04 74  ...n...p...r...t
000150  00 00 04 76 00 00 04 78  00 00 04 7A 00 00 04 7C  ...v...x...z...|
000160  00 00 04 7E 00 00 04 80  00 00 04 82 00 00 04 84  ...~............
000170  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000180  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
000190  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
0001a0  00 00 04 86 00 00 04 88  00 00 04 8A 00 00 04 8C  ................
0001b0  00 00 04 8E 00 00 04 90  00 00 04 92 00 00 00 00  ................
0001c0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
0001d0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
0001e0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
```

Range of Data
Existing

…

```
0008a0  40 18 01 00 6D 04 01 00  6D 05 01 00 6D 06 40 06  @...m...m...m.@.
0008b0  6C 4A 68 EA 0B 06 1F D4  45 F6 1F 90 45 E4 01 20  lJh.....E...E..
0008c0  6D 76 6D 72 54 70 00 00  08 DA 00 00 08 DE 00 FF  mvmrTp..........
0008d0  E4 2A 00 FF E0 00 00 FF  E4 2A 00 FF E0 0A 79 00  .*.......*....y.
0008e0  00 0A 6B A0 00 00 20 0C  54 70                    ..k... .Tp
```

<Specify value filled in unused area [H'FF]>

```
000100  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
000110  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
000120  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
000130  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
000140  00 00 04 6E 00 00 04 70  00 00 04 72 00 00 04 74  ...n...p...r...t
000150  00 00 04 76 00 00 04 78  00 00 04 7A 00 00 04 7C  ...v...x...z...|
000160  00 00 04 7E 00 00 04 80  00 00 04 82 00 00 04 84  ...~............
000170  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
000180  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
000190  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
0001a0  00 00 04 86 00 00 04 88  00 00 04 8A 00 00 04 8C  ................
0001b0  00 00 04 8E 00 00 04 90  00 00 04 92 FF FF FF FF  ................
0001c0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
0001d0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
0001e0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
```

Range of Data
Existing

…

```
00ffc0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
00ffd0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
00ffe0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
00fff0  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF  ................
010000
```

Range of Data
NOT Existing

• Examples of HEX Files

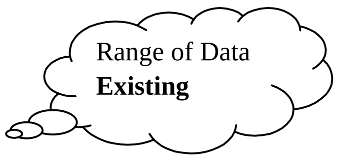
As the following examples, 0xFF records are added to the unused areas in the range of data existing.

If this option is not specified, the records in the range of data not existing are not output.

If this option is specified, 0xFF records are added to the area in the range of data not existing, according to the output range specification in the output option **Divided output files**.

<NOT Specify value filled in unused area>

```
:0400000000000400F8
:04001400000000041ACA
:04001C000000041CC0
:04002000000000041EBA
:040024000000000420B4
:040028000000000422AE
:04002C000000000424A8
:04004000000000042692
:0400440000000004288C
:04004800000000042A86
:04004C000000042C80
```



…

```
:0C08C600000008DA000008DE00FFE42A51
:0808D20000FFE00000FFE42A32
:0408DA0000FFE00A31
:0C08DE007900000A6BA00000200C547090
:00000001FF
:0400000300000400F5
```

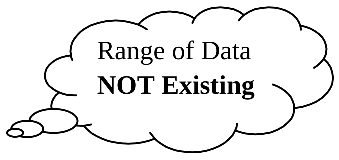
<Specify value filled in unused area [H'FF]>

```
:0400000000000400F8
:10000400FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFC
:04001400000000041ACA
:04001800FFFFFFFFE8
:04001C000000041CC0
:04002000000000041EBA
:040024000000000420B4
:040028000000000422AE
:04002C000000000424A8
:10003000FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFD0
:04004000000000042692
```

Range of Data
Existing

…

```
:FFFCF500FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFI
:FFFDF400FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFI
:FFFEF300FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFI
:0EFFF200FFFFFFFFFFFFFFFFFFFFFFFFFFFF0F
:00000001FF
:0400000300000400F5
```



• **Remarks**

This option is valid for the optimizing linkage editor Ver.8 or later.

9.3.2 End Code of S Type File

• Description

By specifying this option, the end code can be always S9.
In some type of ROM writer, run time error may occur during input to ROM writer, when the end code of S-type file is not S9 record.
This is because end code is S7 or S8, if the entry address exceeds 0x10000.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Other] Miscellaneous options :**
Always output S9 record at the end

Command line: *s9*

• Remarks

For details of S-type file, please refer to section 19.1.1, S-Type File Format, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

9.3.3 Debug Information Compression

• Description

By specifying this option, the loading time is reduced when loading files to debugger.

But on the contrary, the link time is increased.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Other] Miscellaneous options :**
Compress debug information

Command line: *compress*
uncompress

• Remarks

This option is valid only when output file is absolute file.

9.3.4 Link Time Reduction

• Description

When this option is specified, the linkage editor loads the necessary information at linkage in smaller units to reduce the memory occupancy.

As a result, the link time may be reduced.

Try this option when processing is slow because a large project is linked and the memory size occupied by the linkage editor exceeds the available memory in the machine used.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Other] Miscellaneous options :**
Low memory use during linkage

Command line: *memory={high | low}*

• Examples

The following example is the comparison of the link time when this option is specified or not.

At the following case, the link time is reduced by 34 %.

<Measurement Conditions>

- 1,000 files
- 100 symbols per each file
- 1,000 function symbols
- Specifies the same options, except this option

<memory=high>

111 seconds

<memory=low>

73 seconds

• Remarks

This option is valid for the optimizing linkage editor Ver.8 or later.

9.3.5 Notification of Unreferenced Symbol

• Description

When project is large, it is difficult to find the externally defined symbol which is defined but not referenced.

When this option is specified, the external symbol which is not referenced can be notified through an output message at linkage.

To output a notification message, the message option* must also be specified.

Note: * Link/Library Tab Category: [Output] [Show entries for :] [Output messages] Repressed information level messages :

• Specification Method

Dialog menu: **Link/Library Tab Category: [Output] [Show entries for :] [Output messages] Notify unused symbol**

Command line: *msg_unused*

• Output Message

L0400 (I) Unused symbol "file"-"symbol"

The symbol named **symbol** in **file** is not used.

• Remarks

(1) This option is valid for the optimizing linkage editor Ver.9 or later.

(2) In any of the following cases, references are not correctly analyzed so that information shown by output messages will be incorrect.

- **–goptimize** is not specified at assembly and there are branches to the same section within the same file.
- There are references to constant symbols within the same file.
- There are branches to immediate subordinate functions when optimization is specified at compilation.
- Optimization is specified at linkage and constants are unified.

9.3.6 Reduce Empty Areas of Boundary Alignment

• Description

When this option is specified, the empty areas, which are generated as the boundary alignment of sections for each object file, are filled at linkage.

As a result, the unnecessary empty areas generated by boundary alignment are filled, reducing the size of the data sections as a whole.

This option affects constant area (C section), initialized data area (D section), and uninitialized data area (B section).

• Specification Method

Dialog menu: **Link/Library Tab Category: [Output] [Show entries for :] Reduce empty areas of boundary alignment**

Command line: *data_stuff*

• **Examples**

The following example shows how empty areas of boundary alignment are reduced.

```
(file1.c)
short s1;
char c1;
```

```
(file2.c)
char c2;
```

<When **data_stuff** is not specified>

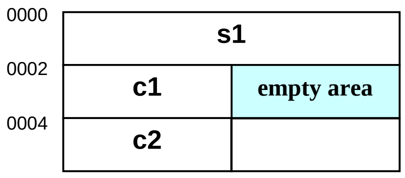
When **data_stuff** is not specified, one byte empty area of boundary alignment is generated between **file1.c** and **file2.c**, because boundary alignment value is 2 for H8 CPU specification.

In this example, if the size of the top data which is linked next is one byte, there is no need of this boundary alignment.

But the top data of the next file is 2 bytes or more, boundary alignment at the end of this file (**file1.c**) should be performed.

As a result, data alignment and data size are

s1(2 bytes) + c1(1 byte) + empty area(1 byte) + c2(1 byte) = 5 bytes



<When **data_stuff** is specified>

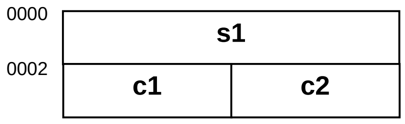
When **data_stuff** is specified, empty area of boundary alignment is not generated, if the size of the top data which is linked next is one byte as this example.

As a result, data alignment and data size are

s1(2 bytes) + c1(1 byte) + c2(1 byte) = 4 bytes

Here, the data size is reduced to 4 bytes.

As this program example, empty areas generated as the boundary alignment of sections are filled at linkage. However, the order of data allocation is not changed.



• **Remarks**

(1) This option is valid for the optimizing linkage editor Ver.8.00.06 or later.
(2) The function of this option is not applicable to object files generated by the assembler.
(3) Specification of this option is invalid in any of the following cases:

- **library** or **object** is specified as output format of the optimizing linkage editor
- **absolute** is specified as input format of the optimizing linkage editor
- **memory=low** is specified
- optimization at linkage (**optimize**) is specified

(4) Optimization will not be applied in the linkage of a relocatable file that was generated with this option specified.

9.4 Optimize Options

9.4.1 Optimization at Linkage

• **Description**

Compiler outputs the supplement information to each module when generating object files.

According to this supplement information, the optimizing linkage editor performs the inter-module optimization which is impossible at compile and links.

As a result, both ROM size and execution speed are improved.

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items**

Command line: *optimize=<suboption>*
<suboption> is described in sections 9.4.2 to 9.4.9.

The following specification for supplement information is necessary at compile/assemble, even if optimization at linkage is specified. Without the following specification, optimization at linkage is not available.

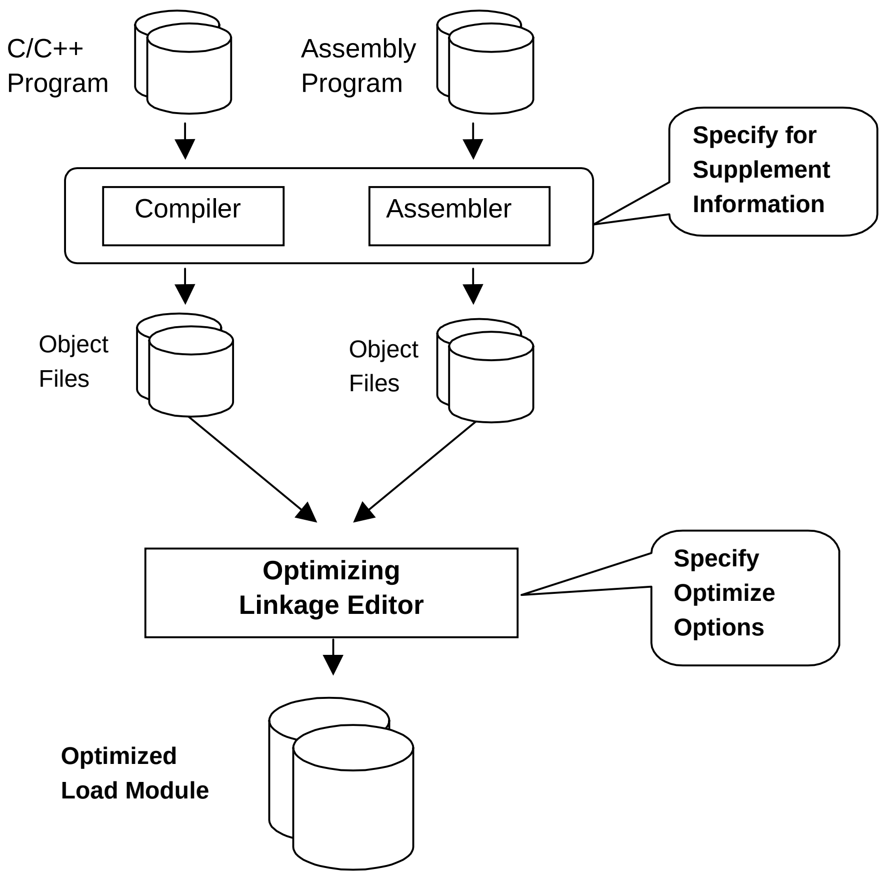
• **Specification Method for Supplement Information**

Dialog menu: **C/C++ Tab Category: [Optimize] Generate file for inter-module optimization**

Dialog menu: **Assembly Tab Category: [Object] Generate file for inter-module optimization**

Command line: *goptimize*

• Inter-Module Optimization Flow



9.4.2 Unifies Constants/Strings

Size	O	Speed	-

• Description

The same value constants and the same strings having the const attribute are unified across the modules.

This option deletes const section to improve Size.

Speed is not changed.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items Unify strings**

Command line: *optimize=string_unify*

• Examples of the sane value constants

The const long variables "**cl1, cl2**" which have the same constant value are unified to one constant.

This reduces ROM size by 4 bytes.

```
(file1.c)
#include <machine.h>
const long cl1=100;
void main(void);
void func01(long);
long g_max;
void main(void)
{
        func01(cl1+1);
        func02(cl1+2);
        func03(cl1+3);
}
void func01(long c_litr)
{
        g_max = c_litr++;
}
```

```
(file2.c)
#include <machine.h>
const long cl2=100;
void main(void);
void func02(long);
void func03(long);
extern long g_max;

void func02(long c_litr)
{
        func03(cl2+c_litr);
        nop();
}
void func03(long c_litr)
{
        g_max = c_litr;
}
```

Deleted

• Remarks

This option is valid only for object files generated by C/C++ Compiler. Object files generated by Assembler are not optimized.

9.4.3 Eliminates Unreferenced Variables/Functions

Size	O	Speed	-

• Description

Variables/functions which are never referred are deleted. When specifying this optimization, an entry function should be specified. Without an entry function specification, this optimization is not performed.

This is because CPU jumps from vector table to entry function, and the optimization of entry functions or the functions whose address is before entry functions changes the jump address.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items Eliminate dead code**

Command line: *optimize=symbol_delete*

• Specification Method for Entry Functions

Dialog menu: **Link/Library Tab Category: [Input] Use entry point**

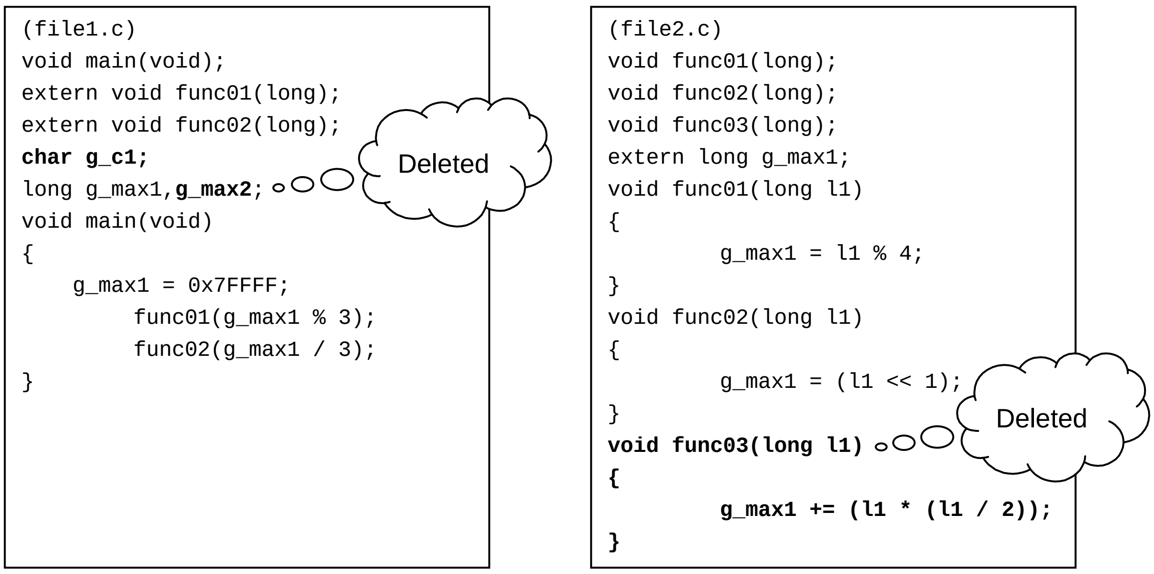
Command line: *entry=<symbol name>* | *<address>*

When specify symbol name, add an underscore (_) at the head of the name.

Example: main -> _main

• Examples of eliminates unreferenced variables/functions

Variable **g_max2** and function **func03** which are never referred are deleted.



```
(file1.c)
void main(void);
extern void func01(long);
extern void func02(long);
char g_c1;
long g_max1,g_max2;
void main(void)
{
    g_max1 = 0x7FFFF;
         func01(g_max1 % 3);
         func02(g_max1 / 3);
}
```

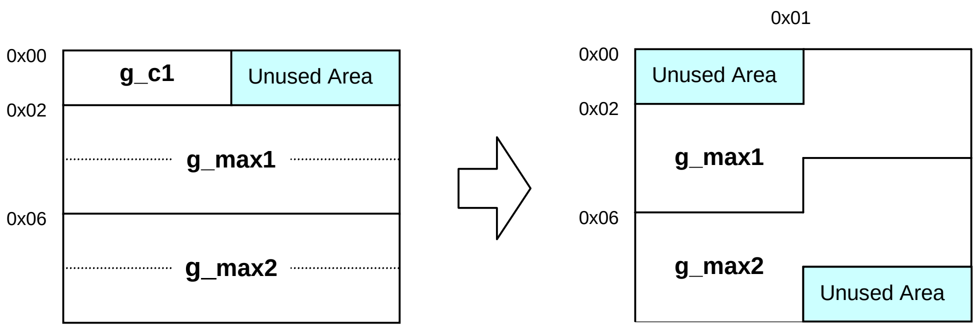
```
(file2.c)
void func01(long);
void func02(long);
void func03(long);
extern long g_max1;
void func01(long l1)
{
         g_max1 = l1 % 4;
}
void func02(long l1)
{
         g_max1 = (l1 << 1);
}
void func03(long l1)
{
         g_max1 += (l1 * (l1 / 2));
}
```

The **char** type variable **g_c1** is never referred, but is not deleted.

This is because H8 is 2-byte boundary alignment, and if **g_c1** is deleted, the address of next variable is not multiples of two.

The access for the odd address symbol occurs an address error because of the CPU specification (except H8SX).

[If 1-byte variable is deleted]



If optimization is performed, 4-byte variable **g_max1** is accessed by address 0x01.

• Remarks

This option is valid only for object files generated by C/C++ Compiler. Object files generated by Assembler are not optimized.

9.4.4 Uses Short Absolute Addressing Mode

Size	O	Speed	O

• Description

If an area accessible in the 8- or 16-bit absolute addressing mode has space, frequently accessed variables are allocated, and the access codes of the variable are optimized by this specification.

The optimizing linkage editor automatically allocates these variables to the section which is automatically generated.

Compiler has similar function, but the optimizing linkage editor can automatically allocate the section.

As the short absolute addressing area differs depending on CPU types, the address of ROM or RAM should be specified by cpu option.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items**
Use short addressing

Command line: *optimize=variable_access*

• Specification Method for cpu option

Dialog menu: **Link/Library Tab Category: [Verify]**

Command line: *cpu=<memory type>=<address range> or*
: *cpu=<cpu information file name>*
: *<memory type> : {ROm | RAm | XROm | XRAm | YROm | YRAm }*
: *<address range>:<start address>-<end address>*

• Examples of this Optimization

char type variable **g_c1** is allocated to **ABS8B_OPT1** section, and **short** type variable **g_s1**,**g_s2** are allocated to **ABS16B_OPT1** section.

So both size efficiency and execution speed of the access codes to these variables are improved.

```
#include <machine.h>
void init(void);
void main(void);
short func01(short);
char g_c1;
short g_s1,g_s2;

void init(void)
{
        main();
        sleep();
}
```

```
void main(void)
{
    g_s1 = 7;
    g_s2 = 8;
    g_c1 = 10;
g_s1 =
func01(g_s1+g_s2+g_c1);
nop();
}
short func01(short p_s1)
{
short wk = ++p_s1;
return wk;
}
```

• **Examples of Optimized Access Codes**

In the following example, which is in H8S/2600 advanced mode,

ROM Size: 40 bytes to 30 bytes

Execution Speed: 41 cycles to 36 cycles

(Option NOT Specified)
```
_main:
MOV.W       #7,R0
MOV.W       R0,@_g_s1:32
MOV.B       #8,R0L
MOV.W       R0,@_g_s2:32
MOV.B       #10,R0L
MOV.B       R0L,@_g_c1:32
MOV.B       #25,R0L
BSR         _func01:8
MOV.W       R0,@_g_s1:32
NOP
RTS
```

(Option Specified)
```
_main:
MOV.W       #7,R0
MOV.W       R0,@_g_s1:16
MOV.B       #8,R0L
MOV.W       R0,@_g_s2:16
MOV.B       #10,R0L
MOV.B       R0L,@_g_c1:8
MOV.B       #25,R0L
BSR         _func01:8
MOV.W       R0,@_g_s1:16
NOP
RTS
```

• **Remarks**

(1) For more details of short absolute addressing area, please refer to section 5.4.11, Using 8-Bit Absolute Address Area and, section 5.4.12, Using 16-Bit Absolute Address Area.

(2) This option is valid for object files generated by C/C++ Compiler or Assembler.

9.4.5 Optimizes Register Save/Restore Codes

Size	O	Speed	O

• **Description**

The relationships between function calls are analyzed and redundant register save/restore codes are deleted with this specification. In addition, depending on the register state before and after the function call, the register numbers to be used are modified.

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items Reallocate registers**

Command line: *optimize=register*

- **Examples of Optimizes register save/restore codes**

Function **main** calls function **func01**, and **func01** calls **func02**.

```
(file1.c)
void main();
extern void func01(long *,long *,long *,long *);
long g_l1,g_l2,g_l3,g_l4;
void main()
{
         g_l1 = 1;
         g_l2 = 2;
         g_l3 = 3;
         g_l4 = 4;
    func01(&g_l1,&g_l2,&g_l3,&g_l4);
}
```

```
(file2.c)
extern long g_l1,g_l2,g_l3,g_l4;
extern void func02(long *,long *,long *,long *);
void func01(long *l_p1,long *l_p2,long *l_p3,long *l_p4)
{
    g_l2 = 2;
         g_l2 += *l_p1;
    func02(&g_l1,&g_l2,&g_l3,&g_l4);
}
```

```
(file3.c)
extern long g_l1,g_l2,g_l3,g_l4;
void func02(long *l_p1,long *l_p2,long *l_p3,long *l_p4)
{
    g_l1++;
         *l_p1 = g_l1;
}
```

- **Examples of Codes by Optimizes register save/restore codes**

Examples of codes before and after this optimization are as follows.

Due to the addition of register save/restore codes in the parent function, register save/restore codes in the child function are reduced.

In the following example, which is in H8S/2600 advanced mode,

ROM Size: 202 bytes to 198 bytes

Execution Speed: 172 cycles to 166 cycles

(Before Optimization)
save/restore ER2-ER3 (**2 registers**)

```
_main:
        STM.L       (ER2-ER3),@-SP
        SUB.L       ER0,ER0
        MOV.B       #1,R0L
        MOV.L       ER0,@_g_l1:32
        SUB.L       ER1,ER1
           :
        MOV.L       #_g_l3,ER2
        PUSH.L      ER2
        MOV.L       #_g_l2,ER1
        MOV.L       #_g_l1,ER0
        JSR         @_func01:24
        ADDS.L      #4,SP
        ADDS.L      #4,SP
        LDM.L       @SP+,(ER2-ER3)
        RTS
```

(After Optimization)
save/restore ER2-ER4 (**3 registers**)

```
_main:
        STM     (ER2-ER3),@-SP
        PUSH.L  ER4
        SUB.L   ER0,ER0
        MOV.B   #1:8,R0L
        MOV.L   ER0,@_g_l1:32
        SUB.L   ER1,ER1
           :
        MOV.L   #h'00f00004:32,ER1
        MOV.L   #h'00f00000:32,ER0
        BSR     _func01:8
        ADDS    #4,SP
        ADDS    #4,SP
        POP.L   ER4
        LDM     @SP+,(ER2-ER3)
        RTS
```

save/restore ER2-ER3 (**2 registers**)

```
_func01:
        STM.L       (ER2-ER3),@-SP
        MOV.L       #_g_l2,ER1
           :
        MOV.L       #_g_l1,ER0
        JSR         @_func02:24
        ADDS.L      #4,SP
        ADDS.L      #4,SP
        LDM.L       @SP+,(ER2-ER3)
        RTS
```

save/restore ER2 (**1 register**)

```
_func01:
        PUSH.L  ER2
        MOV.L   #_g_l2,ER1
           :
        MOV.L   #_g_l1,ER0
        BSR     _func02:8
        ADDS    #4,SP
        ADDS    #4,SP
        POP.L   ER2
        RTS
```

save/restore ER2 (**1 register**)

```
_func02:
        PUSH.L      ER2
        MOV.L       #_g_l1,ER1
        MOV.L       @ER1,ER2
        INC.L       #1,ER2
        MOV.L       ER2,@ER1
        MOV.L       ER2,@ER0
        POP.L       ER2
        RTS
```

NO save/restore (**0 register**)

```
_func02:
        MOV.L   #_g_l1,ER1
        MOV.L   @ER1,ER2
        INC.L   #1,ER2
        MOV.L   ER2,@ER1
        MOV.L   ER2,@ER0
        RTS
```

• **Remarks**

This option is valid only for object files generated by C/C++ Compiler. Object files generated by Assembler are not optimized.

9.4.6 Unifies Common Codes

Size	O	Speed	-

• Description

Multiple strings representing the same instruction are unified into a subroutine and the code size is reduced with this specification.

This optimization increases the overhead of function call and decreases execution speed, so should be careful.

The minimum code size for the optimization with the same-code unification can be specified.

When inline expansion of functions is specified at compile, this optimization is not performed, as execution speed is decreased.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items Eliminate same code**

Command line: *optimize=same_code*

• Specification Method for Unification Size

Dialog menu: **Link/Library Tab Category: [Optimize] Eliminated size**

Command line: *samesize=<size>*

• Examples: C Source Programs

Function **func00** and **func01** have the same lines of expressions.

```
(file1.c)
void main(void);
void func00(void);
long g_l1,g_l2,g_l3,g_l4,g_l5;
void main(void)
{
         func00();
         func01();
}
void func00(void)
{
         g_l1 = 1;
         g_l2 = 3;
         g_l3 = 5;
         g_l4 = 7;
         g_l5 = 9;
}
```

```
(file2.c)
void func01(void);
extern long g_l1,g_l2,g_l3,g_l4,g_l5;
void func01(void)
{
        g_l1 = 1;
        g_l2 = 3;
        g_l3 = 5;
        g_l4 = 7;
        g_l5 = 9;
}
```

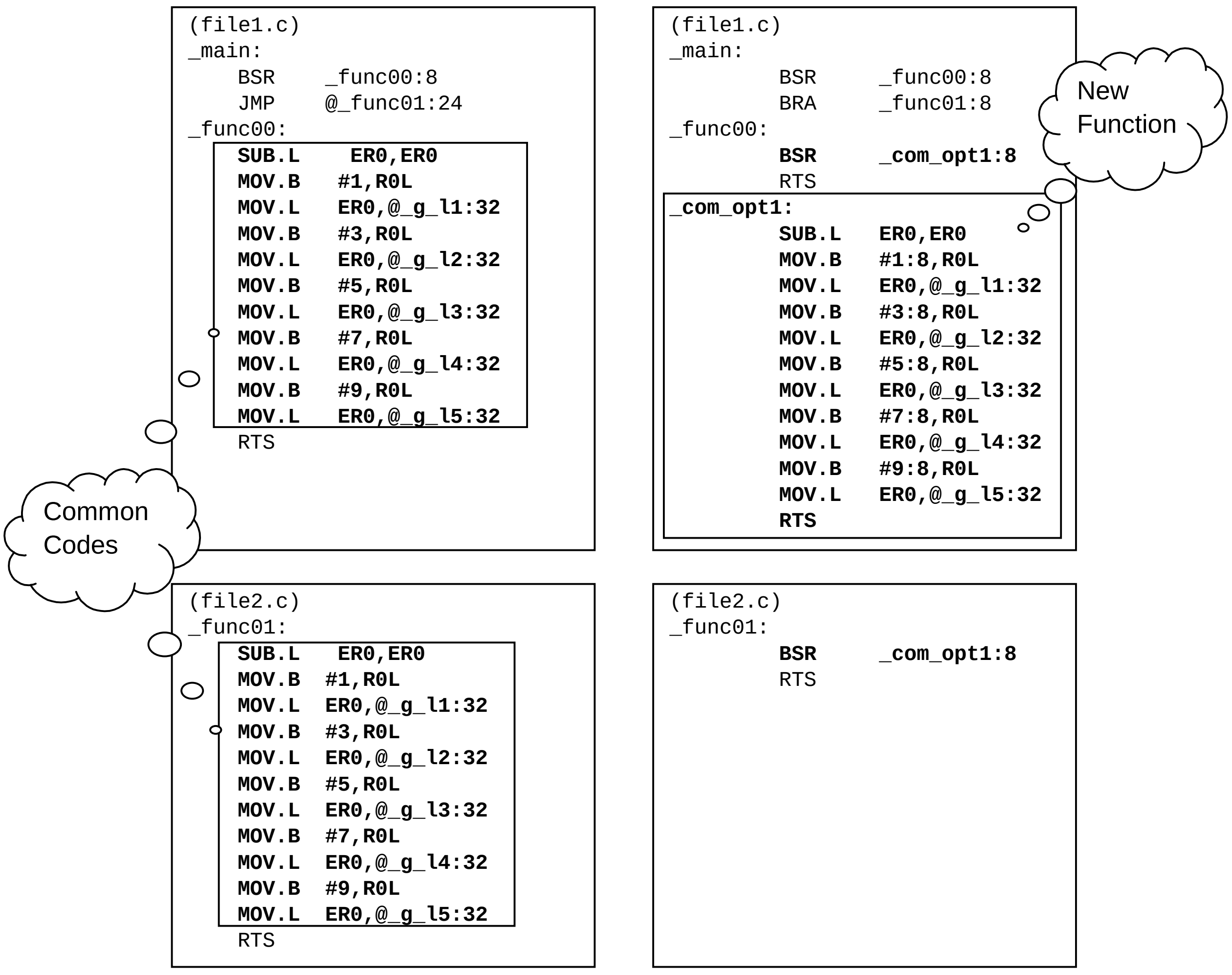
• **Examples: Codes**

Examples of codes before and after this optimization are as follows.

Common codes are unified into a new function **_com_opt1**, which is called from the original positions.

In the following example, which is in H8S/2600 advanced mode,

ROM Size: 114 bytes to 66 bytes
Execution Speed: 91 cycles to 108 cycles



(Before Optimization)

```
(file1.c)
_main:
    BSR    _func00:8
    JMP    @_func01:24
_func00:
    SUB.L    ER0,ER0
    MOV.B   #1,R0L
    MOV.L   ER0,@_g_l1:32
    MOV.B   #3,R0L
    MOV.L   ER0,@_g_l2:32
    MOV.B   #5,R0L
    MOV.L   ER0,@_g_l3:32
    MOV.B   #7,R0L
    MOV.L   ER0,@_g_l4:32
    MOV.B   #9,R0L
    MOV.L   ER0,@_g_l5:32
    RTS
```

```
(file2.c)
_func01:
    SUB.L   ER0,ER0
    MOV.B  #1,R0L
    MOV.L  ER0,@_g_l1:32
    MOV.B  #3,R0L
    MOV.L  ER0,@_g_l2:32
    MOV.B  #5,R0L
    MOV.L  ER0,@_g_l3:32
    MOV.B  #7,R0L
    MOV.L  ER0,@_g_l4:32
    MOV.B  #9,R0L
    MOV.L  ER0,@_g_l5:32
    RTS
```

(After Optimization)

```
(file1.c)
_main:
         BSR     _func00:8
         BRA     _func01:8
_func00:
         BSR     _com_opt1:8
         RTS
_com_opt1:
         SUB.L   ER0,ER0
         MOV.B   #1:8,R0L
         MOV.L   ER0,@_g_l1:32
         MOV.B   #3:8,R0L
         MOV.L   ER0,@_g_l2:32
         MOV.B   #5:8,R0L
         MOV.L   ER0,@_g_l3:32
         MOV.B   #7:8,R0L
         MOV.L   ER0,@_g_l4:32
         MOV.B   #9:8,R0L
         MOV.L   ER0,@_g_l5:32
         RTS
```

```
(file2.c)
_func01:
         BSR     _com_opt1:8
         RTS
```

• Remarks

This option is valid only for object files generated by C/C++ Compiler. Object files generated by Assembler are not optimized.

9.4.7 Uses Indirect Addressing Mode

Size	O	Speed	-

• Description

If the indirect memory access space has space area, the addresses of functions frequently accessed are assigned to **INDIRECT_OPT** section, which is automatically allocated to the indirect memory access space.

As the functions are accessed in the indirect memory format, size efficiency is improved.

Because this area is also used by the vector table, should be careful.

ROM address should be specified by **cpu** option.

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items**
Use indirect call/jump

Command line: *optimize=function_call*

• Specification Method for cpu option

Dialog menu: **Link/Library Tab Category: [Verify]**

Command line: *cpu=<memory type>=<address range> or*
: *cpu=<cpu information file name>*
: *<memory type> : {ROm | RAm | XROm | XRAm | YROm | YRAm }*
: *<address range>:<start address>-<end address>*

• **Examples: C Source Programs**

Function **main** calls function **func01**, **func02**, **func03**. Here the function **func01** is frequently called.

```
(file1.c)
extern long func01(void);
extern long func02(void);
extern long func03(void);
void main(void);
long g_l1,g_l2,g_l3,g_l4,g_l5;
void main(void)
{
        g_l1 = 100;
        g_l1 = func01();
        g_l2 = 1000;
        g_l2 = func02();
        g_l3 = func03();
        g_l1 = func01();
        g_l1 = func01();
}
```

```
(file2.c)
long func01(void);
long func02(void);
long func03(void);
extern long g_l1,g_l2,g_l3,g_l4,g_l5;
long func01(void)
{
        return g_l1 *= 100;
}
long func02(void)
{
        return g_l2 /= 100;
}
long func03(void)
{
        return g_l2 %= 4;
}
```

• **Examples: Codes**

Examples of codes before and after this optimization are as follows.

Function func01 frequently called is accessed in the indirect memory format.

In the following example, which is in H8S/2600 advanced mode,

ROM Size: 288 bytes to 274 bytes

Execution Speed: 491 cycles to 485 cycles

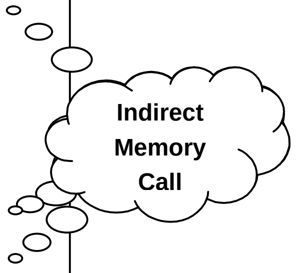
(Before Optimization)

```
_main
        PUSH.L      ER6
        MOV.L       #_g_l1,ER6
        SUB.L       ER0,ER0
        MOV.B       #100,R0L
        MOV.L       ER0,@ER6
        JSR         @_func01:24
        MOV.L       ER0,@ER6
        MOV.L       #1000,ER0
        MOV.L       ER0,@_g_l2:32
        JSR         @_func02:24
        MOV.L       ER0,@_g_l2:32
        JSR         @_func03:24
        MOV.L       ER0,@_g_l3:32
        JSR         @_func01:24
        MOV.L       ER0,@ER6
        JSR         @_func01:24
        MOV.L       ER0,@ER6
        POP.L       ER6
        RTS
```

```
_func01:
        MOV.L       @_g_l1:32,ER0
        SUB.L       ER1,ER1
        MOV.B       #100,R1L
        JSR         @$MULL$3:24
        MOV.L       ER0,@_g_l1:32
        RTS
_func02:
        MOV.L       @_g_l2:32,ER0
        SUB.L       ER1,ER1
        MOV.B       #100,R1L
        JSR         @$DIVL$3:24
        MOV.L       ER0,@_g_l2:32
        RTS
_func03:
        MOV.L       @_g_l2:32,ER0
        SUB.L       ER1,ER1
        MOV.B       #4,R1L
        JSR         @$DIVL$3:24
        MOV.L       ER1,@_g_l2:32
        MOV.L       ER1,ER0
        RTS
```

(After Optimization)

```
_main:
        PUSH.L  ER6
        MOV.L   #_g_l1,ER6
        SUB.L   ER0,ER0
        MOV.B   #100,R0L
        MOV.L   ER0,@ER6
        JSR     @@_$ind_opt1:8
        MOV.L   ER0,@ER6
        MOV.L   #1000,ER0
        MOV.L   ER0,@_g_l2:32
        BSR     _func02:8
        MOV.L   ER0,@_g_l2:32
        BSR     _func03:8
        MOV.L   ER0,@_g_l3:32
        JSR     @@_$ind_opt1:8
        MOV.L   ER0,@ER6
        JSR     @@_$ind_opt1:8
        MOV.L   ER0,@ER6
        POP.L   ER6
        RTS
```



```
_func01:
        MOV.L   @_g_l1:32,ER0
        SUB.L   ER1,ER1
        MOV.B   #100:8,R1L
        BSR     $MULL$3:8
        MOV.L   ER0,@_g_l1:32
        RTS
_func02:
        MOV.L   @_g_l2:32,ER0
        SUB.L   ER1,ER1
        MOV.B   #100,R1L
        BSR     $DIVL$3:8
        MOV.L   ER0,@_g_l2:32
        RTS
_func03:
        MOV.L   @_g_l2:32,ER0
        SUB.L   ER1,ER1
        MOV.B   #4,R1L
        BSR     $DIVL$3:8
        MOV.L   ER1,@_g_l2:32
        MOV.L   ER1,ER0
        RTS
```

• **Remarks**

(1) For more details of indirect memory access space, please refer to section 5.4.13, Using Indirect Memory Format, and section 5.4.14, Using Extended Indirect Memory Format.

(2) This option is valid for object files generated by C/C++ Compiler or Assembler.

9.4.8 Optimizes Branch Instructions

Size	O	Speed	O

• Description

C/C++ Compiler calls functions by the absolute addressing mode (JSR), when access functions in other files, and when access over the address range* which can be accessed by the PC relative addressing mode (BSR).

As the optimizing linkage editor performs optimization at linkage, it can recalculate the branch range of which the branch destination is in other file.

The branch instruction can be changed to the PC relative addressing mode (BSR), if possible.

Though the original branch range exceeds the address range which can be accessed by the PC relative addressing mode, the branch instruction can be also changed to BSR, if the branch range is reduced by other optimization.

If any other optimization item is executed, this optimization is always performed regardless of whether it is specified or not.

Note: * The address range which can be accessed by the PC relative addressing mode: –126 to 128 bytes

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items**
Optimize branches

Command line: *optimize=branch*

• Examples: C Source Programs

Function **main** calls function **func01** in other file.

```
(file1.c)
#include <machine.h>
extern long func01(long,long);
void main(void);
long g_l1,g_l2;
void main(void)
{
    g_l1 = 100;
    g_l2 = 200;
    g_l1 = func01(g_l1,g_l2);
}
```

```
(file2.c)
long func01(long,long);
long func01(long l1,long l2)
{
         return l1 + l2;
}
```

• **Examples: Codes**

Examples of codes before and after this optimization are as follows.

Function **func01** in other file is called by **BSR**.

In the following example, which is in H8S/2600 advanced mode,

ROM Size: 52 bytes to 50 bytes

Execution Speed: 46 cycles to 45 cycles

(Before Optimization)

```
_main:
        PUSH.L  ER6
        MOV.L   #_g_l1,ER6
        SUB.L   ER0,ER0
        MOV.B   #100,R0L
        MOV.L  ER0,@ER6
        MOV.B   #-56,R0L
        MOV.L   ER0,@_g_l2:32
        MOV.L   ER0,ER1
        MOV.L   @ER6,ER0
        JSR  @_func01:24
        MOV.L   ER0,@ER6
        POP.L    ER6
        RTS
```

```
_func01
        ADD.L   ER1,ER0
        RTS
```

(After Optimization)

```
_main:
        PUSH.L  ER6
        MOV.L   #_g_l1,ER6
        SUB.L   ER0,ER0
        MOV.B   #100:8,R0L
        MOV.L   ER0,@ER6
        MOV.B   #56,R0L
        MOV.L   ER0,@_g_l2:32
        MOV.L   ER0,ER1
        MOV.L   @ER6,ER0
        BSR  _func01:8
        MOV.L   ER0,@ER6
        POP.l   ER6
        RTS
```

```
_func01:
        ADD.L   ER1,ER0
        RTS
```

• **Remarks**

This option is valid for object files generated by C/C++ Compiler or Assembler.

9.4.9 Shortens the Addressing Mode

Size	O	Speed	-

• **Description**

The optimizing linkage editor replaces an instruction with a smaller-size instruction, when the code size of the displacement or immediate value can be reduced.

As compile is performed for each file, the distance between the address of the instruction which refers a variable and the address of the variable define is unknown.

As the address of instruction and variable is determined at linkage, the distance between them can be calculated, and this optimization can be performed.

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Optimize items**
Use short disp/imm

Command line: *optimize=short_format*

• **Examples: C Source Programs**

The following example shows substitution for array, and the address of variables is stored to variables.

```
(file1.c)
short str1[4];
short str2[4];
void main(void);
void func01(short);
void func02(void);
char g_c1;
unsigned long g_l1;
void main(void)
{
int i;
for (i = 0;i < 4;i++)
    {
         str1[i] = i + 1;
         str2[i] = i * 2;
    }
func01(i - 1);
func02();
}
void func01(short s1)
{
    str1[s1] = s1;
    str2[s1] = s1+4;
}
void func02(void)
{
    g_l1 = (unsigned long)&g_c1;
}
```

• **Examples: Codes**

Examples of codes before and after this optimization are as follows.

32-bit accesses are changed to 16-/8-bit access respectively.

In the following example, which is in H8SX advanced mode,

ROM Size: 80 bytes to 68 bytes

Execution Speed: 96 cycles to 96 cycles

(Before Optimization)

```
_main:
        SUB.W   R1,R1
L36:
        MOV.W   R1,R0
        INC.W    #1,R0
        MOV.W   R0,@(_str1:32,R1.W)
        MOV.W   R1,R0
        SHLL.W  R0
        MOV.W   R0,@(_str2:32,R1.W)
        INC.W   #1,R1
        CMP.    #4:3,R1
        BLT     L36:8
        DEC.W   #1,R1
        MOV.W   R1,R0
        BSR     _func01:8
        BSR     _func02:8
        RTS
_func01:
        MOV.W    R0,@(_str1:32,R0.W)
        MOV.W    R0,E0
        ADD.W    #4:3,E0
        MOV.W   E0,@(_str2:32,R0.W)
        RTS
_func02:
        MOV.L  #_g_c1:32,@_g_l1:32
        RTS
```

(After Optimization)

```
_main:
        SUB.W   R1,R1
L36:
        MOV.W   R1,R0
        INC.W   #1,R0
        MOV.W   R0,@(h'0044:16,R1.W)
        MOV.W   R1,R0
        SHLL.W  R0
        MOV.W   R0,@(h'004c:16,R1.W)
        INC.W   #1,R1
        CMP.W   #4:3,R1
        BLT     L36
        DEC.W   #1,R1
        MOV.W   R1,R0
        BSR     _func01:8
        BSR     _func02:8
        RTS
_func01:
        MOV.W   R0,@(_str1:16,R0.W)
        MOV.W   R0,E0
        ADD.W   #4:3,E0
        MOV.W   E0,@(_str2:16,R0.W)
        RTS
_func02:
        MOV.L   #_g_c1:8,@_g_l1:32
        RTS
```

• Remarks

(1) This option is valid only when CPU is H8SXN, H8SXM, H8SXA or H8SXX.
(2) This option is valid for object files generated by C/C++ Compiler or Assembler.

9.4.10 Optimization Partially Disabled

• Description

When don't want to optimize some variables or functions by the optimizing linkage editor, that variables or functions can be specified as follows.

Disablements by the symbol name and by the address range are available.

• Disables elimination of unreferenced symbols

• Specification Method

Dialog menu: **Link/Library Tab Category: [Optimize] Forbid item**
Elimination of dead code

Command line: *symbol_forbid=<symbol name>*

• Disables unification of common codes

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Forbid item**
Elimination of same code

Command line: *samecode_forbid=<function name>*

• **Disables allocation of short absolute address areas**

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Forbid item**
Use of short addressing to

Command line: *variable_forbid=<symbol name>*

• **Disables indirect address calls**

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Forbid item**
Use of indirect call/jump to

Command line: *function_forbid=<function name>*

• **Address Range where optimization is disabled**

• **Specification Method**

Dialog menu: **Link/Library Tab Category: [Optimize] Forbid item**
Memory allocation in

Command line: *absolute_forbid=<address>[+size]*

9.4.11 Confirm Optimization Results

• **Description**

Optimization results by the optimizing linkage editor can be confirmed as follows.

• **Confirmation by message**

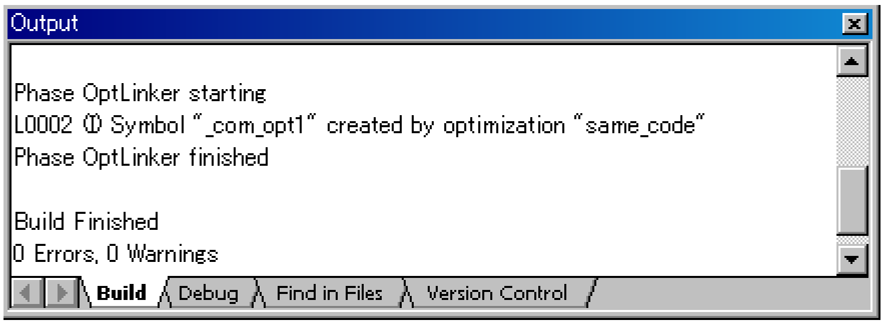
When using HEW, optimization results are output by not checking in the following dialog.

Dialog menu: **Link/Library Tab Category: [Output] Show entries for:**
Repressed information level messages

Command line: *message[=<error number>]>*
: *nomessage*

• Example of message output

The following example shows that a new function has been created by the unification of common codes.



```
Phase OptLinker starting
L0002 (I) Symbol "_com_opt1" created by optimization "same_code"
Phase OptLinker finished

Build Finished
0 Errors, 0 Warnings
```

• Confirmation by list

Optimization results are confirmed by specifying the following options.

For more details, please refer to section 9.2.1, Symbol Information List.

Dialog menu: **Link/Library Tab Category: [List] Contents : Symbol**

Command line: *list [=<file name>]*
show symbol

Section 10 MISRA C

10.1 MISRA C

10.1.1 What Is MISRA C?

MISRA C refers to the usage guidelines for the C language that were issued by the Motor Industry Software Reliability Association (MISRA) in 1998, as well as the C coding rules standardized by those guidelines. The C language itself is very useful, but suffers from some particular problems. The MISRA C guideline divides these problems into five types: programmer errors, misconceptions about the language, unintended compiler operations, errors at execution, and errors in the compiler itself. The purpose of MISRA C is to overcome these problems, while promoting safe usage of the C language. MISRA C contains 127 rules of two types: *required* and *advisory*. Code development should aim to conform to all of these rules, but as this is sometimes difficult to accomplish, there is also a process to confirm and document times when the rule conformance is not followed. Compliance to various issues is also required separate from these rules, such as when software metrics need to be measured.

10.1.2 Rule Examples

This subsection introduces some actual MISRA C rules. Figure 10.1 shows Rule 62, that all switch statements shall contain a final default clause. This is categorized as a programmer error. In a `switch` statement, if the "default" label is misspelled as "defalt", the compiler will not treat this as an error. If the programmer does not notice this error, the expected default operation will never be executed. This problem can be avoided through the application of Rule 62.

```
Example:
 switch(x) {
     :
 defalt:   ←  Misspelled
     err = 1;
     break;
 }
```

Figure 10.1 Rule 62

Figure 10.2 shows Rule 46, that the value of an expression shall be the same under any order of evaluation that the standard permits. This is categorized as a misconception about the language. Namely, if ++i is evaluated first, the expression becomes 2+2, but if i is evaluated first, the expression becomes 2+1. Likewise, since no provision exists for the evaluation order of function arguments, if ++j is evaluated first, the expression becomes f(2,2), but if j is evaluated first, the expression becomes f(1,2). This problem can be avoided through the application of Rule 46.

```
Example:
  i = 1;
  x = ++i + i;       x = 2 + 2? x = 2 + 1?

  j = 1;
  func(j, ++j);      func(1, 2)? func(2, 2)?
```

Figure 10.2 Rule 46

Figure 10.3 shows Rule 38, that the right hand operand of a shift operator shall lie between zero and one less than the width in bits of the left hand operand. This is categorized as an unintended compiler operation. In ANSI, if the shift number of the bit-shift operator is a negative number or larger than the size of the object to be shifted, the calculation results are undefined. In figure 10.3, if the shift number when us is shifted is not between 0 and 15, the results are undefined and the value will differ depending on the compiler. This problem can be avoided through the application of Rule 38.

```
Example:
 unsigned short us;

  us << 16;  ←   Undefined action
  us >> -1   ←   Undefined action
```

Figure 10.3 Rule 38

Figure 10.4 shows Rule 51, that the evaluation of constant unsigned integer expressions should not lead to wrap-around. This is categorized as an error at execution. When the result of an unsigned integer calculation is theoretically negative, it is unclear whether a theoretically negative value is expected, or a result based on a calculation without the sign will suffice. This situation could lead to a malfunction. Also, the results of an addition calculation may cause an overflow, resulting in a very small value. This problem can be avoided through the application of Rule 51.

```
Example:
   if( 1UL - 2UL )  ←  What is intended: -1 or 0xFFFFFFFF?

   *(char*)(0xfffffffeUL + 2); ←  Results in a 0 address.
```

Figure 10.4 Rule 51

10.1.3 Compliance Matrix

With MISRA C, source code is checked for compliance with all 127 rules. In addition, a table as the one shown in Table 10.1 needs to be made, showing whether or not each rule is upheld. This is called a *compliance matrix*. Given the difficulty of visually checking all rules, we recommend that you use a static check tool. The MISRA C guideline also indicates such, stating that the use of a tool to adhere to rules is of utmost importance. As not every rule can be checked using such a tool, you will need to perform a visual review to check such rules visually.

Table 10.1 Compliance Matrix

Rule number	Compiler	Tool 1	Tool 2	Review (visual)
1	Warning 347			
2		Violation 38		
3			Warning 97	
4				Pass
...	...	...	...	...

10.1.4 Rule Violations

Rule violations can consist of those that are known to be safe, and those that may have more effects. Rule violations such as the former should be accepted, but some degree of safety is lost when rule violations are accepted too easily. This is why MISRA C states a special procedure for accepting rule violations. Such violations require a valid reason, as well as verification that the violation is safe. As such, locations and valid reasons for all accepted rules are documented. So that violations are not accepted too easily, the signature of an individual with appropriate authority within the organization is added to such documentation after consultation with an expert. This means that when a rule that is the same as one already accepted is violated, it is deemed as an "accepted rule violation", and can be treated as accepted, without performing the above procedures again. Of course, such violations need to be reviewed regularly.

10.1.5 MISRA C Compliance

To encourage MISRA C compliance, code needs to be developed in compliance with the rules, and rule violation problems need to be resolved. To show whether code complies with the rules, documentation for the compliance matrix and accepted rule violations is needed, along with signatures for each rule violation. To prevent future problems, you should train programmers to make the most of the C language and tools used, implement policies regarding coding style, choose adequate tools, and measure software metrics of various kinds. Such efforts should be officially standardized, along with the appropriate documentation. MISRA C compliance requires more than just development of individual products according to the guidelines, but rather of the organization itself.

10.2 SQMlint

10.2.1 What Is SQMlint?

SQMlint is a package that provides the Renesas C compiler with the additional function for checking whether it conforms to the MISRA C rules. SQMlint statically checks the C source code, and reports the areas that violate the rules. SQMlint runs as part of the C compiler in the Renesas product development environment. SQMlint can be started simply by adding an option at compile-time, as shown in figure 10.5. It in no way affects the code generated by the compiler.

Table 10.2 lists the rules supported by SQMlint.

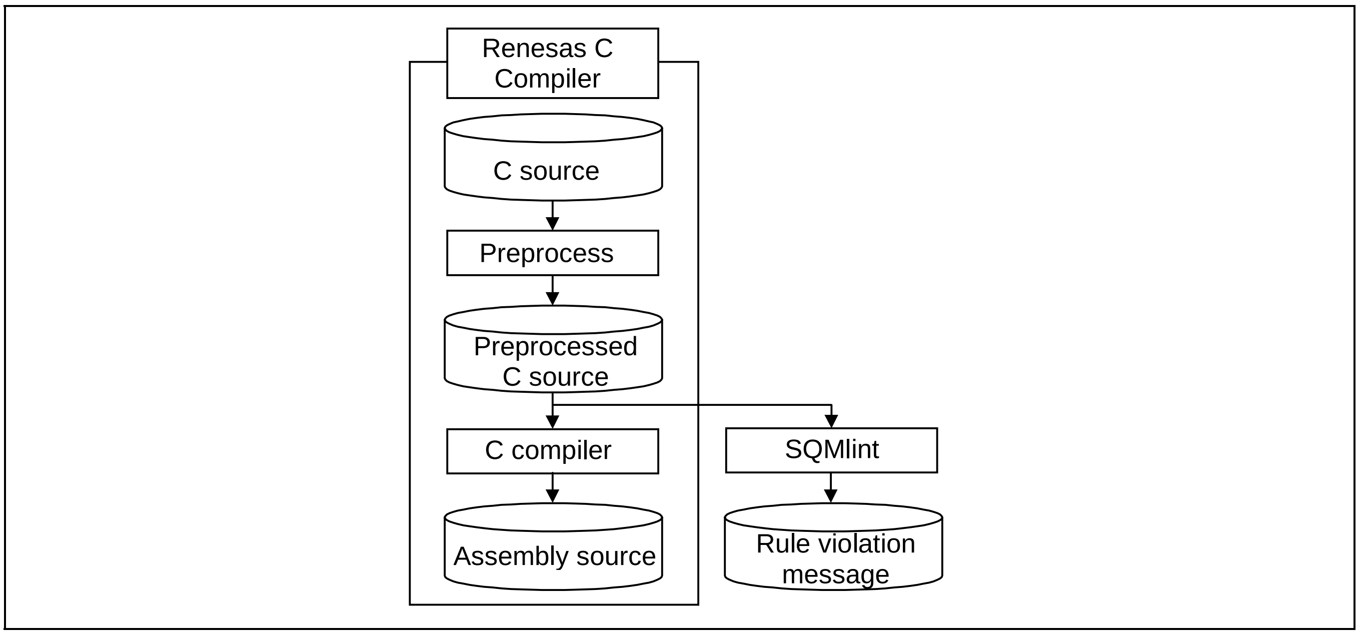


Figure 10.5 SQMlint Positioning

Table 10.2 Rules Supported by SQMlint

Rule	Test	Rule	Test	Rule	Test	Rule	Test	Rule	Test	Rule	Test
1	O	26	X	51	O*	76	O	101	O	126	O
2	X	27	X	52	X	77	O	102	O	127	O
3	X	28	O	53	O	78	O	103	O		
4	X	29	O	54	O*	79	O	104	O		
5	O	30	X	55	O	80	O	105	O		
6	X	31	O	56	O	81	X	106	O*		
7	X	32	O	57	O	82	O	107	X		
8	O	33	O	58	O	83	O	108	O		
9	X	34	O	59	O	84	O	109	X		
10	X	35	O	60	O	85	O	110	O		
11	X	36	O	61	O	86	X	111	O		
12	O	37	O	62	O	87	X	112	O		
13	O	38	O	63	O	88	X	113	O		
14	O	39	O	64	O	89	X	114	X		
15	X	40	O	65	O	90	X	115	O		
16	X	41	X	66	X	91	X	116	X		
17	O*	42	O	67	X	92	X	117	X		
18	O	43	O	68	O	93	X	118	O		
19	O	44	O	69	O	94	X	119	O		
20	O	45	O	70	O*	95	X	120	X		
21	O*	46	O*	71	O	96	X	121	O		
22	O*	47	X	72	O*	97	X	122	O		
23	X	48	O	73	O	98	X	123	O		
24	O	49	O	74	O	99	O	124	O		
25	X	50	O	75	O	100	X	125	O*		

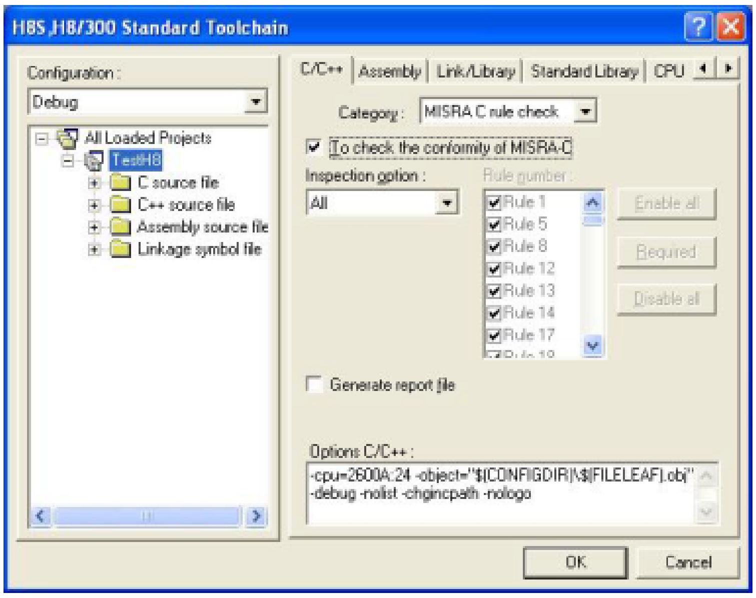
O: Testable X: Not testable *: Testable with limitations

Table 10.3 Number of Rules Supported by SQMlint

Rule category	Number of testable rules (Supported by SQMlint / Total)
Required	67/93
Advisory	19/34
Total	86/127

10.2.2 Using SQMlint

SQMlint start options can be set easily from the window for setting the HEW Compile Options. Figure 10.6 shows the dialog box for specifying HEW options, in which [MISRA C rule check] should be selected from [Category].



Configuration : Debug

Category : MISRA C rule check

☑ To check the conformity of MISRA-C

Inspection option : All

☑ Rule 1
☑ Rule 5
☑ Rule 8
☑ Rule 12
☑ Rule 13
☑ Rule 14
☑ Rule 17

☐ Generate report file

Options C/C++ :

```
-cpu=2600A:24 -object="$(CONFIGDIR)\$(FILELEAF).obj"
-debug -nolist -chgincpath -nologo
```

Figure 10.6 HEW Options Window

Thus, SQMlint will start at compile-time. The meaning of [Inspection Option] in this dialog is:

- [All]: Performs testing for all rules.
- [Required]: Performs testing only for rules necessary according to the MISRA C rule.
- [Custom]: Performs testing for the rules specified by the user. Please select the rules by using the check box and the buttons of the right-side.

10.2.3 Viewing Test Results

Test results can be output in the following three ways:

(a) Standard error output

Messages are output the same as HEW compile errors. A tag jump can be performed by double-clicking the message, or right-clicking the message and choosing [Jump]. The source code can be easily corrected by the same operation as the compile error.

Note that an explanation is displayed by right-clicking the message and choosing [Help].

(b) CSV file

A file format that can be read by spreadsheet software, allowing reviews to be performed more easily.

(c) SQMmerger

SQMmerger is a tool for merging a C source file with CSV-formatted report file generated by SQMlint into a file that contains C source lines and their associated report messages.

To execute SQMmerger, use the following command entry format:

```
sqmmerger -src <c-source-file-name> -r <report-file-name> -o <output-file-name>
```

Displays both the source file and test results, as shown in figure 10.7.

```
1 : void func(void);
2 : void func(void){
4 : LABEL:
    [MISRA(55) Complain] label ('LABEL') should not be used
5 :
6 : goto LABEL;
    [MISRA(56) Complain] the 'goto' statement shall not be used
7 : }
```

Figure 10.7   SQMmerger

10.2.4 Development Procedures

Figure 10.8 shows how to perform development using SQMlint.

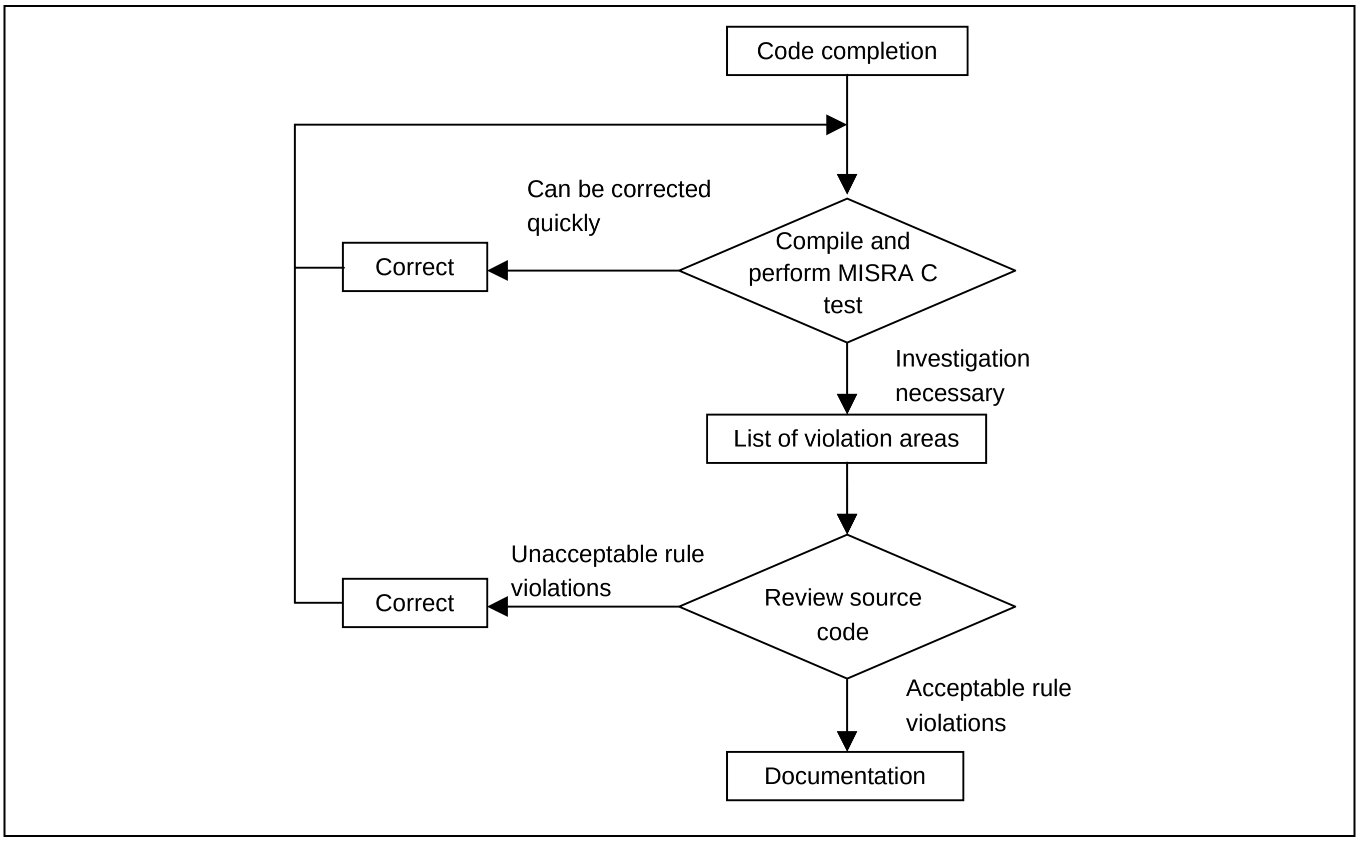


Figure 10.8   Development Procedure Using SQMlint

- Collect all compile errors. SQMlint assumes that the C source code is valid.
- Find errors detected by SQMlint.
- Correct the errors that can be easily corrected.
- Create a list of the locations of rule violations that require investigation, and perform a review.
- Perform corrections for rules deemed unacceptable upon review.
- Document rules deemed acceptable upon review, to leave a record.

10.2.5 Supported Compilers

The following compilers are supported by SQMlint:

- H8C/C++ Compiler Package V.6.01 Release00 and later

Section 11 Q & A

This section presents answers to questions frequently asked by users.

No.	Tool Name	Description	Referenced Section
1	C/C++ Compiler	How to change character string assignment destinations	11.1.1
2		Failure to identify 1-bit data	11.1.2
3		Startup from the DOS screen	11.1.3
4		Runtime routine specifications and execution speed	11.1.4
5		H8 family object compatibility	11.1.5
6		Questions on host machine and OSes	11.1.6
7		Failure in C source-level debugging	11.1.7
8		Warning message displayed at inline expansion	11.1.8
9		Output of “function not optimized”	11.1.9
10		How to specify include files	11.1.10
11		Program coding using Japanese fonts	11.1.11
12		Output of “illegal value in operand” from the cross assembler	11.1.12
13		Deletion of large amount of codes by optimization	11.1.13
14		How to view values of local variables during debugging	11.1.14
15		Regarding optimization options	11.1.15
16		Failure to pass function parameters	11.1.16
17		Failure at bit operation in a write-only register	11.1.17
18		Notes on linking with assembly language programs	11.1.18
19		How to check coding which may cause incorrect operation	11.1.19
20		Comment coding	11.1.20
21		How to specify options for each file	11.1.21
22		How to build programs when the assembler is embedded	11.1.22
23		Output of syntax errors at linkage	11.1.23
24		C++ language specifications	11.1.24
25		How to view source programs after pre-processor expansion	11.1.25
26		How to output save/restore codes of MACH or MACL registers	11.1.26
27		The program runs correctly on the ICE but fails when installed on a real chip	11.1.27
28		How to use C language programs developed for SH microcomputers	11.1.28
29		How to modify global options	11.1.29
30		Optimizations that cause infinite loops	11.1.30
31		Read/write instructions for bit fields	11.1.31
32		Common invalid instruction exceptions that occur when programs are run for an extended period of time	11.1.32
33		Failure at integer multiplication	11.1.33

No.	Tool Name	Description	Referenced Section
34	Optimizing Linkage Editor	Output of “undefined external symbol”	11.2.1
35		Output of “relocation size overflow”	11.2.2
36		How to run programs in RAM	11.2.3
37		Fixing symbol addresses in certain memory areas for linking	11.2.4
38		How to implement an overlay	11.2.5
39		How to specify output of undefined symbol error	11.2.6
40		Unify output forms S type file	11.2.7
41		Dividing an output file	11.2.8
42		Output file format of optimizing linkage editor	11.2.9
43		How to calculate program size (ROM, RAM)	11.2.10
44		Output of "section alignment mismatch "	11.2.11
45	Library Generator	Reentrant and standard libraries	11.3.1
46		I would like to use reentrant library function in standard library file	11.3.2
47		There is no standard library file (H8C V4 or later)	11.3.3
48		Warning message on building standard library	11.3.4
49		Size of memory used as heap	11.3.5
50		How to reduce ROM size for I/O libraries	11.3.6
51		How to edit library file	11.3.7
52	HEW	Failure to display dialog menu	11.4.1
53		Linkage order of object files	11.4.2
54		Excluding a project file	11.4.3
55		Specifying the default options for project files	11.4.4
56		Changing memory map	11.4.5
57		How to use HEW on network	11.4.6
58		Limitations on file and directory names created with HEW	11.4.7
59		Failure of Japanese font display with HEW editor of HDI	11.4.8
60		How to convert programs from HIM to HEW	11.4.9
61		I want to use an old compiler (tool chain) in the latest HEW	11.4.10

11.1 C/C++ Compiler

11.1.1 How to Change Character String Assignment Destinations

Question

How can I modify attributes of the section to which character strings and data are assigned?

Answer

Although character strings are normally assigned to the constants area, they can be assigned to the initialization area by the following operation:

(1) Modifies with an option

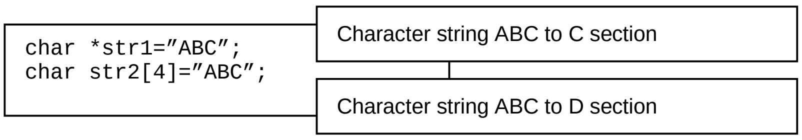
A character string can be assigned to the D section with the following option.

[Specification method]

Dialog menu: **C/C++**Tab **Category: [Object]**, change **Store string data in: to Data section**

Command line: *string=data*

(2) Restricts the storage area for the character string as follows:



```
char *str1=”ABC”;
char str2[4]=”ABC”;
```

Character string ABC to C section
Character string ABC to D section

The results are as follows:

```
      .SECTION    D,DATA,ALIGN=2
_str1:
      .DATA.L     L2
_str2:
      .SDATAZ     "ABC"
      .SECTION    C,DATA,ALIGN=2
L2:
      .SDATAZ     "ABC"
```

(3) Data assigned to the constants area are assigned to the initialization area with the volatile specification.

Example:

```
const int a=1;
```

The volatile option is specified.

(Not specified)

```
    .SECTION    C,DATA,ALIGN=2
_a:
    .DATA.W     H'0001
```

(Specified)

```
    .SECTION    D,DATA,ALIGN=2
_a:
    .DATA.W     H'0001
```

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Other]**,
Avoid optimizing external symbols treating them as volatile

Command line: *volatile*

11.1.2 Failure to Identify 1-bit Data

Question

When a 1-bit data is compared with “1”, a branch operation sometimes fails, why is this?

Answer

Make sure that the data is not declared as a signed variable (int, short, char).

If 1-bit data is declared in a bit field as a signed variable, the 1-bit data itself is interpreted as the sign.

Therefore, only the values “0” and “-1” can be represented.

To represent “0” and “1” , the data should be declared as unsigned.

(Example that always gives false results)

```
struct {
  char p7:1;
  char p6:1;
  char p5:1;
  char p4:1;
  char p3:1;
  char p2:1;
  char p1:1;
  char p0:1;
}s1;

if(s1.p0==1){
  s1.p1=0;
}
```

(Example that gives correct results)

```
struct {
  unsigned char p7:1;
  unsigned char p6:1;
  unsigned char p5:1;
  unsigned char p4:1;
  unsigned char p3:1;
  unsigned char p2:1;
  unsigned char p1:1;
  unsigned char p0:1;
}s1;

if(s1.p0==1){
  s1.p1=0;
}
```

11.1.3 Startup from DOS Screen

Question

How can I start the H8S, H8/300C/C++ compiler system in the PC version from the DOS screen using a command?

Answer

To start the compiler from the DOS window, set the following environment:

(1) Setting the PATH

Set the PATH option to the place where the tool to be used is located.

Example: If the tool to be used is C:\Hew2\Tools\Hitachi\H8\5_0_1\bin

```
c:\> PATH=%PATH%;C:\Hew2\Tools\Hitachi\H8\5_0_1\bin (RET)
```

This should be added to an existing PATH.

(2) Setting CH38

This indicates the location of the system include file used by the compiler.

Example: If the system include file is located in C:\Hew2\Tools\Hitachi\H8\5_0_1\include

```
c:\> set CH38=C:\Hew2E\Tools\Hitachi\H8\5_0_1\include (RET)
```

(3) Setting CH38TMP

Set the intermediate file directory for files generated by the compiler.

Example: If the intermediate file directory is C:\temp,

c:\> set CH38TMP=C:\temp

If this is not specified, intermediate files are created in the current directory. Usually, this specification is not required; however, sometimes it is necessary such as when the disk space in the current directory is insufficient.

(4) Setting H38CPU

Specify the CPU/operation mode.

Example: To specify a CPU/operation mode 2600a:24,

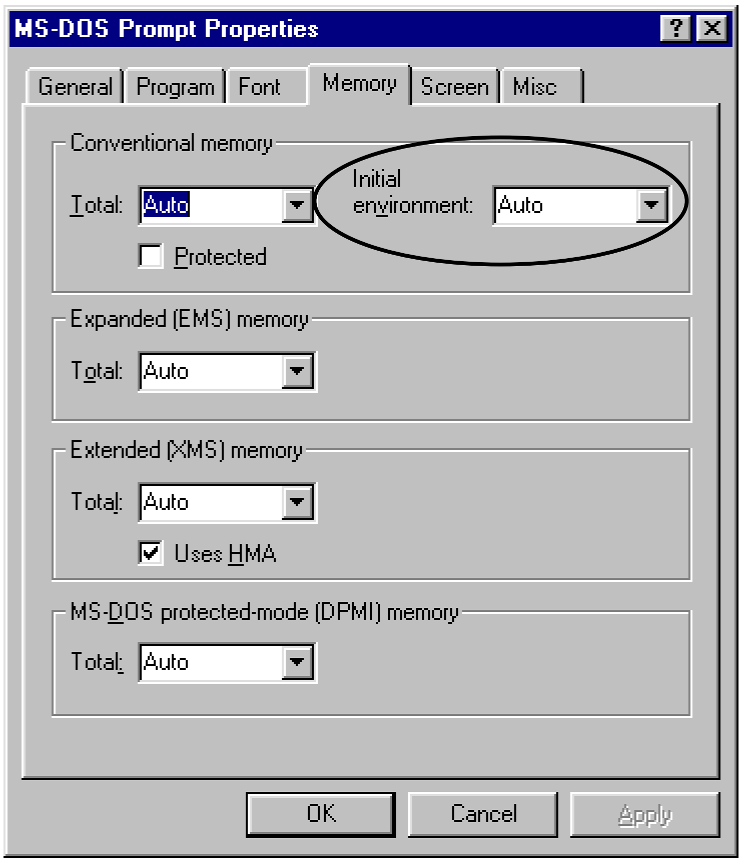
```
c:\> set H38CPU=2600a:24
```

This designation can also be specified in a compiler option. If this specification differs from a compiler option, the compiler option takes priority.

Remarks

If the message "insufficient area for environment variables" is displayed at the compiler startup with this environmental specification, modify the settings as follows:

Open "DOS Prompt Properties".



Conventional memory
Total: Auto
Initial environment: Auto
[ ] Protected

Expanded (EMS) memory
Total: Auto

Extended (XMS) memory
Total: Auto
[✓] Uses HMA

MS-DOS protected-mode (DPMI) memory
Total: Auto

Increase the initial allocation size for the [Conventional memory] environment variable. A value of 1024 or greater is recommended.

After making this change, re-open the DOS prompt.

11.1.4 Runtime Routine Specifications and Execution Speed

Question

Tell me about the speed of the runtime routines provided by the compiler.

Answer

The following is a list of runtime routine speeds speeds when using internal ROM and RAM. The options for creating a library are default specifications:

List of Runtime Routine Speeds (1)

No.	Type	Function Name	300	300HN	300HA	2000N	2000A	H8sxn	H8sxa	H8sxx
1	Add	$ADDD$3	1002	746	480	206	208	175	175	175
2		$ADDF$3	426	216	174	102	104	87	87	87
3		$ADDL$3	76	-	-	-	-	-	-	-
4	Subtract	$SUBD$3	1212	618	626	268	272	240	226	226
5		$SUBF$3	448	224	228	106	108	91	91	91
6		$SUBL$3	76	-	-	-	-	-	-	-
7	Multiply	$MULD$3	1886	984	992	606	610	539	539	539
8		$MULF$3	702	388	392	220	222	192	192	192
9		$MULI$3	102	-	-	-	-	-	-	-
10		$MULL$3	304	130	134	95	88	-	-	-
11		$MULXSB$3	60	-	-	-	-	-	-	-
12		$MULXSW$3	168	-	-	-	-	-	-	-
13		$MULXUW$3	148	-	-	-	-	-	-	-
14		$CMLI$3	142	-	-	-	-	-	-	-
15	Divide	$DIVC$3	82	-	-	-	-	-	-	-
16		$DIVD$3	7304	2544	356	1236	1238	1248	1248	1248
17		$DIVF$3	1688	1176	1180	551	553	649	649	649
18		$DIVI$3	262	-	-	-	-	-	-	-
19		$DIVL$3	1068	154	162	95	99	91	91	91
20		$DIVUI$3	208	-	-	-	-	-	-	-
21		$DIVUL$3	1038	100	108	68	70	91	91	91
22		$DIVUX$3	936	-	-	-	-	-	-	-
23		$DIVXSB$3	80	-	-	-	-	-	-	-
24		$DIVXSW$3	188	-	-	-	-	-	-	-
25		$DIVXUW$3	158	-	-	-	-	-	-	-
26		$CDVC$3	132	-	-	-	-	-	-	-
27		$CDVI$3	310	-	-	-	-	-	-	-
28		$CDVUI$3	258	-	-	-	-	-	-	-
29	Remainder	$MODL$3	254	-	-	-	-	-	-	-
30		$MODUL$3	224	-	-	-	-	-	-	-
31		$CMDC$3	132	-	-	-	-	-	-	-
32		$CMDI$3	310	-	-	-	-	-	-	-
33		$CMDUI$3	256	-	-	-	-	-	-	-
34	Post Increment	$POID$3	1164	624	542	278	283	-	-	-
35		$POIF$3	476	-	-	-	-	-	-	-
36		$POIL$3	102	-	-	-	-	-	-	-

List of Runtime Routine Speeds (2)

No.	Type	Function Name	300	300HN	300HA	2000N	2000A	H8sxn	H8sxa	H8sxx
37	Post	$PODD$3	1114	604	618	268	273	-	-	-
38	Decrement	$PODF$3	490	-	-	-	-	-	-	-
39		$PODL$3	98	-	-	-	-	-	-	-
40	Pre	$PRID$3	1112	572	498	254	267	229	228	228
41	Increment	$PRIF$3	448	314	292	123	127	101	99	99
42		$PRIL$3	56	-	-	-	-	-	-	-
43	Pre	$PRDD$3	1066	556	578	246	259	216	212	212
44	Decrement	$PRDF$3	466	326	342	131	135	108	106	106
45		$PRDL$3	56	-	-	-	-	-	-	-
46	Logic operations	$ANDL$3	78	-	-	-	-	-	-	-
47		$NEGD$3	74	76	80	38	40	20	20	20
48		$NEGF$3	50	-	-	-	-	-	-	-
49		$NEGL$3	76	-	-	-	-	-	-	-
50		$ORL$3	78	-	-	-	-	-	-	-
51		$XORL$3	78	-	-	-	-	-	-	-
52	Block	$MV4$3	48	-	-	-	-	-	-	-
53	Transfer	$MV8$3	72	72	76	36	38	17	17	17
54		$MVN$3	170	296	328	138	146	64	71	71
55		$mv3mm $	-	-	-	30	32	-	-	-
56		$mv3mr$	-	-	-	28	30	-	-	-
57		$mv3rm$	-	-	-	17	19	-	-	-
58		$mv4mm$	-	-	-	36	38	-	-	-
59		$mv4mr$	-	-	-	31	33	-	-	-
60		$mv4rm$	-	-	-	20	22	-	-	-
61	Set bit field	$BFINC$3	102	96	100	47	49	-	-	-
62		$BFINCR$3	94	88	92	43	45	-	-	-
63		$BFINI$3	256	180	184	71	73	35	35	35
64		$BFINIR$3	248	156	160	67	69	31	31	31
65		$BFINL$3	820	346	350	135	137	45	45	45
66		$BFINLR$3	-	330	334	127	129	39	39	39
67	Reference bit field	$BFSC$3	78	78	82	38	40	-	-	-
68		$BFSI$3	196	168	172	67	69	34	34	34
69		$BFSL$3	578	270	270	122	124	37	37	37
70		$BFUC$3	68	68	72	33	35	-	-	-
71		$BFUI$3	168	144	148	55	57	-	-	-
72		$BFUL$3	546	236	240	105	107	-	-	-
73	Compare	$CMPD$3	230	226	218	101	97	66	62	62
74		$CMPF$3	178	90	94	45	47	36	36	36
75		$CMPL$3	94	-	-	-	-	-	-	-
76		$EQD$3	254	250	246	113	111	87	73	73

List of Runtime Routine Speeds (3)

No.	Type	Function Name	300	300HN	300HA	2000N	2000A	H8sxn	H8sxa	H8sxx
77	Compare	$EQF$3	202	114	122	57	61	49	47	47
78		$GED$3	264	250	256	118	116	91	77	77
79		$GEF$3	202	114	122	57	61	49	47	47
80		$GTD$3	262	250	254	117	115	90	76	76
81		$GTF$3	202	114	122	57	61	49	47	47
82		$LED$3	264	250	266	123	121	93	79	79
83		$LEF$3	212	114	122	57	61	49	47	47
84		$LTD$3	264	250	266	123	121	93	79	79
85		$LTF$3	212	115	122	57	61	49	47	47
86		$NED$3	250	252	248	114	112	78	75	75
87		$NEF$3	204	116	124	58	62	47	47	47
88	Convert	$CTOL$3	60	-	-	-	-	-	-	-
89		$DTOF$3	316	238	242	110	112	87	87	87
90		$DTOI$3	508	-	-	-	-	-	-	-
91		$DTOL$3	464	290	294	100	102	105	105	105
92		$FTOD$3	178	144	148	62	64	56	56	56
93		$FTOI$3	608	-	-	-	-	-	-	-
94		$FTOL$3	564	338	342	150	152	188	188	188
95		$ITOD$3	176	152	156	74	76	82	84	84
96		$ITOF$3	164	124	128	62	64	80	80	80
97		$ITOL$3	44	-	-	-	-	-	-	-
98		$LTOD$3	366	244	256	126	128	150	150	150
99		$LTOF$3	334	224	236	116	118	151	151	151
100		$ULTOD$3	180	84	124	54	56	55	51	51
101		$ULTOF$3	150	22	104	50	52	47	47	47
102		$UTOD$3	114	62	94	43	45	38	36	36
103		$UTOF$3	80	22	52	21	23	25	25	25
104	Left-shift	$DSLC$3	70	70	84	31	37	-	-	-
105		$DSLI$3	82	78	92	35	41	-	-	-
106		$DSLL$3	-	98	112	45	51	-	-	-
107		$SLC$3	-	-	-	23	25	-	-	-
108		$SLI$3	62	-	-	26	28	-	-	-
109		$SLL$3	118	-	-	29	31	-	-	-
110	Right-shift	$DSRC$3	70	70	84	31	37	-	-	-
111		$DSRI$3	88	78	92	35	41	-	-	-
112		$DSRL$3	-	98	112	45	51	-	-	-
113		$DSRUC$3	70	70	84	31	37	-	-	-
114		$DSRUI$3	88	78	92	35	39	-	-	-
115		$DSRUL$3	-	98	112	45	51	-	-	-
116		$SRC$3	-	-	-	18	25	23	18	19

List of Runtime Routine Speeds (4)

No.	Type	Function Name	300	300HN	300HA	2000N	2000A	H8sxn	H8sxa	H8sxx
117	Right-shift	$SRI$3	68	-	-	28	28	17	17	17
118		$SRL$3	110	-	-	29	31	18	18	18
119		$SRUC$3	-	-	-	23	25	-	-	-
120		$SRUI$3	68	-	-	26	28	-	-	-
121		$SRUL$3	110	-	-	29	31	-	-	-
122	Register save/restore	fp_regld3	52	70	80	-	-	-	-	-
123		$fp_rgld3$3	46	60	70	-	-	-	-	-
124		fp_regsv3	52	70	80	-	-	-	-	-
125		$fp_rgsv3$3	46	60	70	-	-	-	-	-
126		sp_regld3	58	80	90	-	-	-	-	-
127		$sp_rgld3$3	52	70	90	-	-	-	-	-
128		sp_regsv3	58	80	90	-	-	-	-	-
129		$sp_rgsv3$3	52	70	90	-	-	-	-	-
130		$spregld2$3	50	66	70	-	-	-	-	-
131		$sprgld23$3	40	56	60	-	-	-	-	-
132	Other	$SWI$3	124	-	-	-	-	-	-	-

Remarks

Measurements are from entry into the runtime routine until exit.

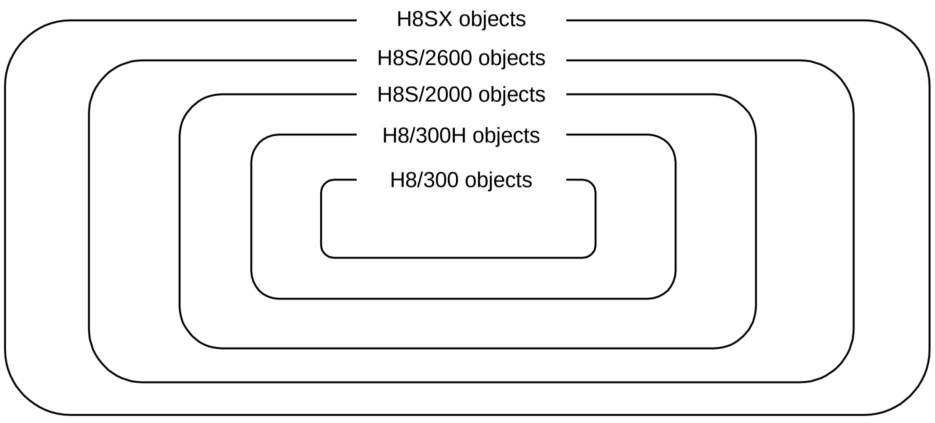
11.1.5 H8 Family Object Compatibility

Question

Are there any problems with linking an object compiled with the compile options "-cpu=300" (or 300h, 2000, 2600, h8sx)?

Answer

In essence the H8 CPUs are upward-compatible, so that an H8/300 object and an H8S/2000 object can be linked and then executed on the H8S/2000. This means that previous resources can continue to be used without modification.



Object Compatibility

11.1.6 Questions on Host Machines and OSes

Question

How can I identify the version of host machine and the OS where the compiler is operated?

Answer

The operating environment is shown below:

H8S,H8/300 C/C++ compiler Package

Host Machine	OS	Disk Space
IBM-PC/AT Series	Windows98/Me/2000/XP/NT 4.0	Approx. 120 MB
HP9000	HP-UX 10.2	Approx. 30 MB
Sun SPARC	Japanese Solaris2.5 or higher	Approx. 30 MB

Online manuals are also supplied.

The operating environment for the online manuals are as follows:

- A personal computer installing a Pentium® processor
- Microsoft Windows®98, Windows®/ME, or Microsoft WindowsNT®4.0, Microsoft Windows®2000, Windows®XP
- A CD-ROM drive with double speed or faster
- Available disk space: approximately 15MB

Online manuals can be referenced under Windows®98, Windows®ME, Windows NT®4.0, Windows®2000, or Windows® XP.

Pentium® is a registered trademark of (U.S.) Intel Corporation.
Windows® and Microsoft® are registered trademarks of Microsoft Corporation in the U.S. and other countries.

11.1.7 Failure in C Source-Level Debugging

Question

The output of debugging information is specified at compilation, debugging at the C source level cannot be performed. Why is this?

Answer

Check the following items:

(1) Is the debugging information specified to be output at compiling for each inter-module optimization step?

The object-output formats and ways to output debugging information differ depending on debuggers. The following table lists examples of available debuggers and the relationship between output objects and debugging information:

Available Debugger	Object Format	Debug Information Output	Debug Information Output Format
3rd party ELF/DWARF 2 support debugger	ELF/DWARF2	debug	In load module
3rd party ELF/DWARF support debugger	ELF	debug	In load module
Hitachi Integration Manager (Ver.4 or higher) +E7000	SYSROFPLUS	sdebug	Debug information file
Hitachi Integration Manager (Ver.3 or higher) +E7000	SYSROF	debug	Debug information file
Hitachi Debugging Interface (Ver.2 or higher) +E6000	SYSROF	debug	In load module
Hitachi Debugging Interface (Ver.3 or higher) +E6000	ELF	sdebug	Debug information file

Note: If a program is written in the C++ language, the object should be output in the ELF format.

(2) Has the directory containing the source program for compiling been specified to be changed?

Debugging information is stored with the information of the directory location of the source program. Therefore, if the directory in which the source program for compiling is located is changed, the source program cannot be modified. Some debuggers support a feature that allows the user to specify the source program directory.

When relocating a directory, be sure to also move the dwfinf directory.

The dwfinf directory may be required at debugging because it contains inter-module optimization add-on information files.

(3) Are you debugging a file to which the C source file is output in assembly language?

If this is the case, specify the output of debugging information both at compilation and assembly.

Then, step execution and external variable reference can be performed at the C source level.

Answer 2

When -code=asm is specified, debugging cannot be performed at the C source level.

If you use an inline assembler, specify -code=asm.

To perform debugging at the C source level for a project using an inline assembler, specify -code=asm only for files for which the inline assembler is used.

Remarks

For detailed information on debugging at the C source level, refer to the H8S, H8/300 Series Simulator/Debugger User's Manual.

11.1.8 Warning Message Displayed at Inline Expansion

Question

At the inline expansion of a function, the warning message ”Function <“function name”> in #pragma inline is not expanded” is displayed. Why is this?

Answer

This warning message does not affect the program execution.

In the following cases, however, the inline expansion is not performed:

- A function is defined before the #pragma inline specification.
- The function has variable parameters.
- Parameter addresses are referenced in the function.
- A function call is made through the address of the function to be expanded.
- For the second or after condition/logical operators.

```
#pragma inline (A,B)
int A(int a)
{
    if (a>10) return 1;
    else      return 0;
}
int B(int a)
{
    if (a<25) return 1;
    else      return 0;
}
void main()
{
    int a;
    if (A(a)==1 && B(a)==1)    ←A() is inline-expanded, but not B().
    {

    }
}
```

The function specified in #pragma inline and the function specified in the function specifier inline (C++ language) are inline-expanded to the location where they are called.

11.1.9 Output of "Function not optimized"

Question

The warning message “Function not optimized” is displayed. Previously, the same program was compiled without any problem using the same compile options and under the same system environment. Why is it?

Answer

This warning message does not affect the program execution.

The message may be output by any of the following reasons:

(1) Compiler limitations were exceeded.

Because the compiler generates new internal variables at optimization processing, the limitation may be exceeded. In this case, divide the function in question.

(2) Insufficient memory

When memory is insufficient during optimization processing, the H8S, H8/300 C/C++ compiler stops optimization in the expression unit or greater and outputs this warning message while continuing to compile. In this case, the optimization level achieved is no different from that without the optimization option. To prevent this warning message, rewrite large functions in the C/C++ program to be divided. Additionally, increase the amount of memory available to the compiler.

11.1.10 How to Specify Include Files

Question

(1) How can I specify an include file in another directory?

(2) How can I provide include specification to an existent file?

Answer

These can be specified with the compiler functions.

The following gives the description:

(1) The compiler option to specify the include file in the specified directory has been prepared
[Specification method]
Dialog menu: **C/C++ Tab Category: [Source] Show entries for:, Include file directories**
Command line: *include*

(2) This option specifies a file as an include file even if the file is not included in the source file.
[Specification method]
Dialog menu: **C/C++ Tab Category: [Source]Show entries for:, Preinclude files**
Command line: *preinclude*

11.1.11 Program Coding Using Japanese Fonts

Question

Is it possible to code character strings and comments in a program in Japanese?

Answer

Yes, you can code in Japanese. However, the Japanese environment differs according to the host machine. The Japanese environment for each host machine is listed below

Host Machine	Japanese Code
PC	Shift JIS code
HP9000	Shift JIS code
SPARC	EUC code

For example, when a file created on a SPARC machine is compiled on a PC, the way the compiler recognizes Japanese should be modified using an option.

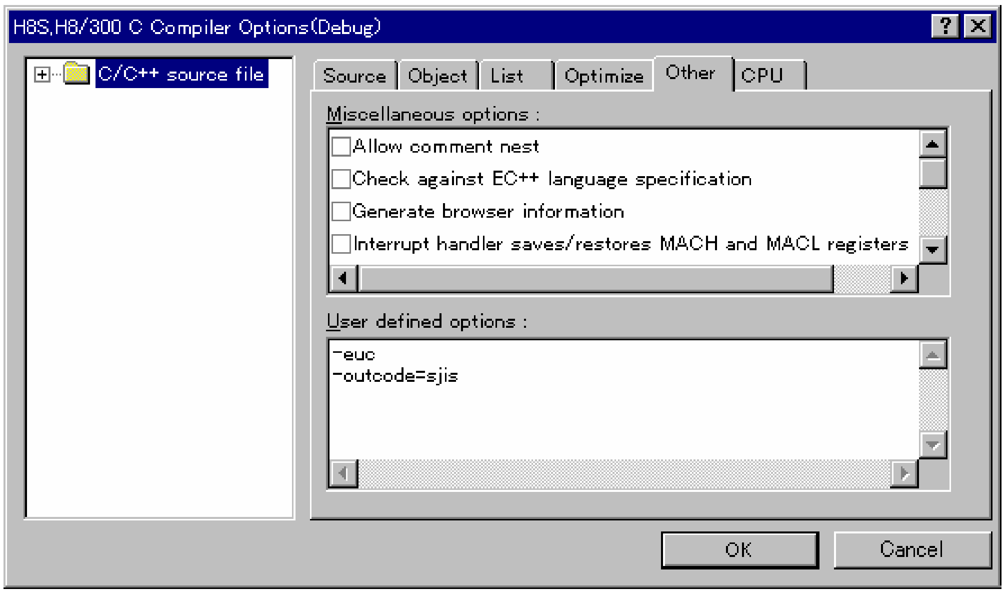
The following command options are available:

Command Option	Description
sjis	Selects shift JIS codes.
euc	Selects EUC codes.
latin1	Selects Latin 1 codes.

In the outcode option, you can specify the Japanese code to be output to the object program. The outcode=sjis option outputs the Japanese codes in the shift-JIS code. Similarly, the outcode=euc option outputs the Japanese codes in the EUC codes.

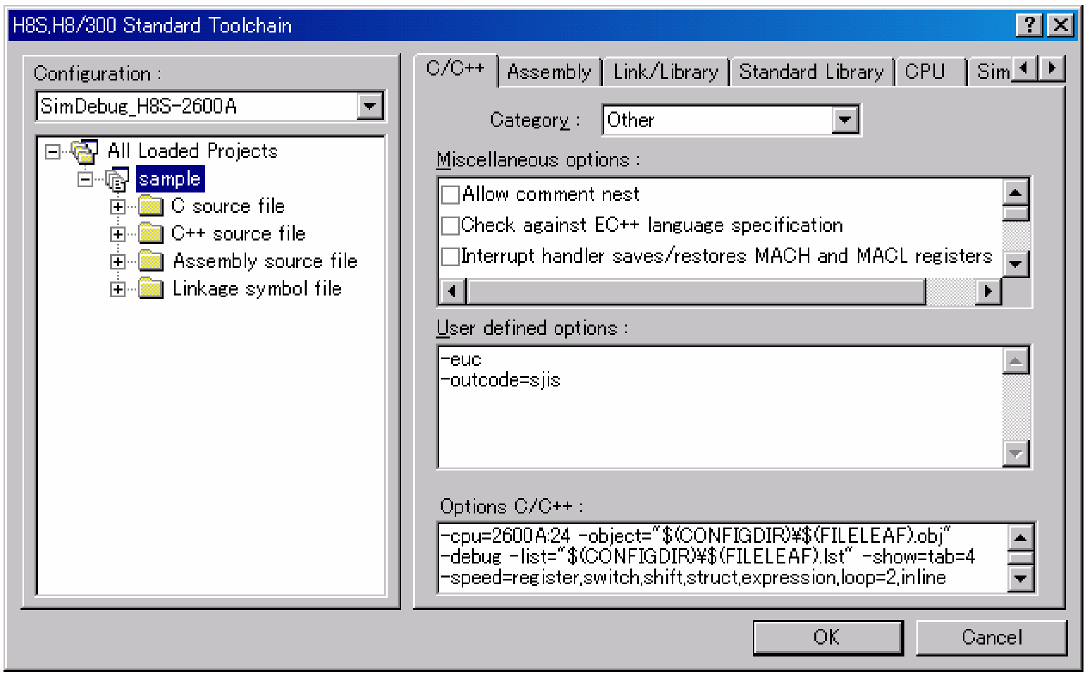
On the HEW, code in the “User defined options” on the “Other” tab when specifying the object program output codes for the Japanese environment. You can specify these options in the same way as you would specify in a command line.

<HEW1.2>


H8S,H8/300 C Compiler Options(Debug)
C/C++ source file
Source
Object
List
Optimize
Other
CPU
Miscellaneous options :
Allow comment nest
Check against EC++ language specification
Generate browser information
Interrupt handler saves/restores MACH and MACL registers
User defined options :
OK
Cancel

```
-euc
-outcode=sjis
```

<HEW2.0 or later>



```
-euc
-outcode=sjis
```

```
-cpu=2600A:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -list="$(CONFIGDIR)¥$(FILELEAF).lst" -show=tab=4
-speed=register,switch,shift,struct,expression,loop=2,inline
```

11.1.12 Output of "Illegal Value in Operand" from the Cross Assembler

Question

When a file output with the assembly source by the compiler is assembled by the Cross Assembler, the message ”Illegal value in operand” is displayed. Why is it?

Answer

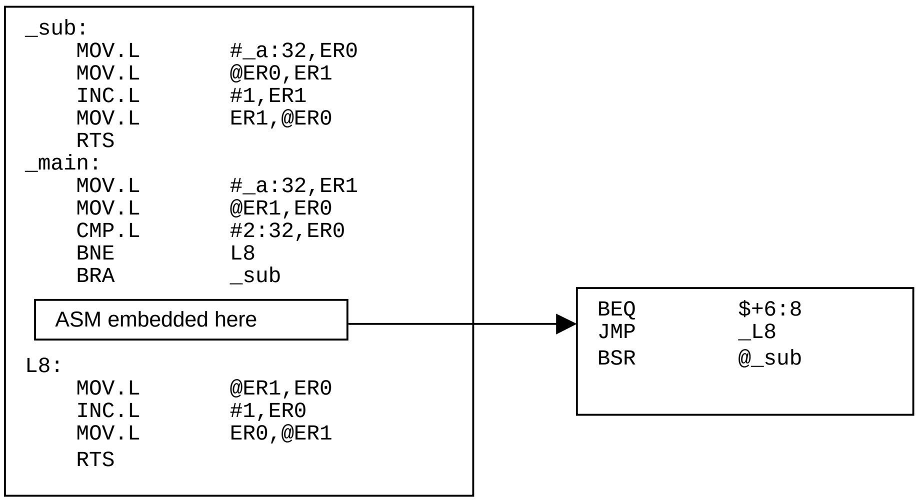
Be sure that the Assembly embedding is not performed with the #pragma asm and #pragma endasm or #pragma inline_asm.

In this case, the branch width containing assembler-intrinsic code is output in a 16-bit displacement, and this message is output because the actual branch width exceeds that range. To solve the problem, modify the assembly language program output by the compiler using the JMP instruction to reach the branch range.

Example

To modify the program as follows:

<Results of Assembly expansion>



```
_sub:
    MOV.L       #_a:32,ER0
    MOV.L       @ER0,ER1
    INC.L       #1,ER1
    MOV.L       ER1,@ER0
    RTS
_main:
    MOV.L       #_a:32,ER1
    MOV.L       @ER1,ER0
    CMP.L       #2:32,ER0
    BNE         L8
    BRA         _sub
  ASM embedded here
L8:
    MOV.L       @ER1,ER0
    INC.L       #1,ER0
    MOV.L       ER0,@ER1
    RTS
```

```
BEQ         $+6:8
JMP         _L8
BSR         @_sub
```

11.1.13 Deletion of Large Amount of Codes by Optimization

Question

Large amount of codes are deleted after the compilation. Why is it?

Answer

There are the following possibilities to cause this problem:

(1) Deleting a substitution to a local variable

If a value is substituted to a local variable but is not referenced, the substitution operation itself is deleted by the optimization.

```
   void func(void)
_func:
           PUSH.L      ER6
    {
        int res1,res2,res3;
        res1=data1*data2;
           MOV.W       @_data1:32,R0
           MOV.W       @_data2:32,E0
           MULXU.W     E0,ER0
           MOV.W       R0,R6
        res2=data2*data3;
        res3=data3*data1;
           MOV.W       @_data1:32,R1
           MOV.W       @_data3:32,E1
           MULXU.W     E1,ER1
        sub(res1,res1,res3);
           MOV.W       R0,E0
           JSR         @_sub:24
    }
           POP.L       ER6
           RTS
```

← Because res2 is not referenced hereafter, the expression itself is deleted.

← Coding error in the second parameter. Code res1 -> res2 to avoid deletion.

Because a local variable is effective as far as the end of the function, normally, unreference of a local variable does not occur when the value is substituted in the function. Therefore, this problem is caused by a coding error as shown in the above example.

(2) Optimizing substitution to external variables

The following types of substitution expressions to external variables are optimized, and only the last arithmetic expression results are reflected:

```
   int glb;
   void main()
 _main:
   {
       glb=0;
       glb=1;
          MOV.W   #1:16,R0
          MOV.W   R0,@_glb:32
   }
          RTS
```

← Code glb=0 is not generated

If volatile is specified at a declaration of an external valuable type, the code glb=0 is generated. By specifying the volatile option with the compiler, the volatile specification is applied to external valuables in the entire file.

11.1.14 How to View Values of Local Variables at Debugging

Question

Local variable values cannot be viewed.

I attempted to reference a local variable with the Debugger, but the value cannot be referenced or an incorrect value is returned. Why is it?

Answer

There are the following possibilities to cause this problem:

(1) Constant operation at compiling

A variable whose value is determined at compiling is operated at compiling not at the run time, and then the variable itself may disappear.

```
int x;
void func(void)
{
    int a;
    a=3;
    x=x+a;
}
```

In this case, x=x+3 is set to “a” at compiling. If the variable “a” is not used elsewhere, it is not necessary to treat “a” as a variable. Therefore, it is deleted as debug information.

```
void func(int a,int b)
{
    int tmp;
    int len;

    tmp=a*a+b*b;
    len=sq(tmp);
}
```

len=sq(a*a+b*b) is set and the variable tmp is deleted.

The problem may be due to these cases, however, the actual program execution is not influenced.

(2) Deletion of unreferenced variables

```
int data1,data2,data3;
void func(void)
{
    int res1,res2,res3;

    res1=data1*data2;
    res2=data2*data3;
    res3=data3*data1;
    sub(res1,res1,res3);
}
```

Because a local variable is effective as far as the end of the function, normally, unreference of a local variable does not occur when the value is substituted in the function. Therefore, this problem is caused by a coding error as shown in the above example.

11.1.15 Regarding Optimization Options

Question

What will be changed by optimization option (speed, size)?

Answer

Generated codes are changed by specified optimization option. (Do not change Algorithm of User program by optimization.) By optimization, optimize codes like inline expansion of a function and loop unrolling, so the number of times of run-time cycles is changed. Thereby, the timing of operation is also changed. First of all, please verify enough about timing of operation. Moreover, optimization of variable access is also considered as concern matters other than the above. The case that an instruction of data can be realized between registers without memories, and it is corresponded to optimization of variable access, it may be said [Timing verification]. If you want [Do not want to optimize] variable, please confirm including a necessity of an addition of volatile declaration.

11.1.16 Failure to Pass Function Parameters

Question

Parameters of functions are not passed correctly. Why is this?

Answer

When the parameter type is not declared as a prototype, specify the same type to the calling function and the called function in order to pass parameters correctly.

```
(Specification where results are not
guaranteed)

void f(x)
char x;
{
    x+=10;
}
void main(void)
{
    char x;
    f(x);
}
```

```
(Correct specification)

void f(char x)
{
    x+=10;
}
void main(void)
{
    char x;
    f(x);
}
```

This problem can be checked by using the **Display information level message (message option)** on **C/C++**tab **Category:[Source] Message**s at compilation. The output of each information message can be selected with this specification. Whether a function is declared as a prototype or not can be checked with the (I)0200 No prototype function.

Remarks

In the above “Specification where results are not guaranteed” example, a prototype declaration of the function f parameters is not included. In this case, the parameter x is converted to the int type when it is called from the main function. When no type declaration is provided by a prototype declaration of parameters, the following type conversions occur:

- The char-type and unsigned-char types parameters are converted into int-type.
- The float-type parameters are converted into double type.
- No other types are converted.

11.1.17 Failure at Bit Operation in Write-Only Register

Question

The bit operation of a write-only register does not produce the intended result. What can be done about it?

Answer

The compiler generates bit operation instructions for BSET, BCLR, BNOT, BST, and BIST. These instructions read data in byte units and after performing a bit operation, write them back in byte units. On the other hand, when a write-only register is read, the CPU fetches undefined data regardless of the register contents. As a result, a bit operation instruction in a write-only register may change values of bits other than the operated bit.

Countermeasure

Avoid performing a bit operation directly in a write-only register.

Perform any operation after substituting a value to a 1-byte data. The following shows an example:

```
(Include file (300x.h))

struct  S_p4ddr {
  unsigned char p7:1;
  unsigned char p6:1;
  unsigned char p5:1;
  unsigned char p4:1;
  unsigned char p3:1;
  unsigned char p2:1;
  unsigned char p1:1;
  unsigned char p0:1;
};
union SS {
  unsigned char Schar;
  struct S_p4ddr Sstr;
};
#define P4DDR (*(union SS
*)0xffffc5)
#define P0 0x1
```

```
(C language program)

#include "300x.h"
unsigned char DDR;
//Specify data to back up
//write-only register
void sub(void)
{

  DDR &=~P0;
  P4DDR.Schar=DDR;
}
```

Remarks

There are various kinds of write-only registers, such as I/O port registers or peripheral device registers. When developing a program, confirm that the appropriate write-only registers are operated by referring to the hardware manuals supplied with each product.

11.1.18 Notes on Linking with Assembly Language Programs

Questions

(1) When an assembly language program subroutine is called from a C language program, what should I do on the assembly language program?

(2) When a C language program subroutine is called from an assembly language program, what should I do on the assembly language program?

Answer

(1) When can assembly language program subroutine is called from a C language program and the following listed registers are used, save/restore registers at the entry/exit points of the function:

CPU Series	Number of Parameter-Passing Registers: 2	Number of Parameter-Passing Registers: 3
H8SX, H8S/2600, H8S/2000 H8/300H	Optimization specified: ER2 to ER6	Optimization specified: ER3 to ER6
	Optimization not specified: ER2 to ER5	Optimization not specified: ER3 to ER5
H8/300	Optimization specified: R2 to R6	Optimization specified: R3 to R6
	Optimization not specified: R2 to R5	Optimization not specified: R3 to R5

(2) When a C language program subroutine is called from an assembly language program, the following register values are not guaranteed on the C language program before and after the subroutine is called. If the register is used in the assembly language program, save it before the C language program is called:

CPU Series	Number of Parameter-Passing Registers: 2	Number of Parameter-Passing Registers: 3
H8SX,H8S/2600, H8S/2000 H8/300H	ER0, ER1	ER0, ER1, ER2
H8/300	R0,R1	R0, R1, R2

Remarks

For a detailed description of linkage with an assembly language program, refer to section 9.3, Linking C/C++ Programs and Assembly Programs, in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

11.1.19 How to Check Coding Which May Cause Incorrect Operation

Question

Is there any function to check for potential problem code, such as a missing prototype declaration for a function?

Answer

When coding a program, note that there are some kinds of codes which are not errors in language

specifications but may produce incorrect operation results. These codes can be checked by outputting information messages using an option.

The MISRA-C check tool can be used with version 6.1 or later.

```
Example)
  ch38 Δ -message Δ test.c (RET)

(C language program)

/*  /* COMMENT */      →0001 : String “/*” in a comment
int ;                  →0002 : A declaration without a declarator
int tmp;
void func(int);
void main(void)
{
  long a;
  tmp=a;               →0011 : Reference to an undefined local variable
  func(a+1);           →0006 : Function parameter expression is converted
into the parameter type specified in prototype
declaration
  sub();               →0200 : No prototype declaration for called function
}
```

Specification method

Dialog menu: **C/C++**tab **Category: [Source] Messages, Display information level message**

Command line: *message*

Remarks

In the dialog menu, removing the left-side checkmark from a message disables the output of the message. In the command line, specifying an error number in a sub-option of the nomessage option disables the output of the message. This option is valid for an error number from 0001 to 0307. For details on error numbers, refer to section 12, Compiler Error Messages, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

After generating information messages, the compiler performs an error recovery and generates an object program. Check that the error recovery performed by the compiler conforms with the aims of the program.

11.1.20 Comment Coding

Question

(1) How can I nest comments?

(2) How can I code C++ comments in a C language program?

Answer

(1) There is an option that allows you to nest comments without generating an error. In this case, note that these comments are interpreted as described below. While the nesting levels for comments in the compiler Ver.4.0 are unlimited, up to 255 nesting levels can be used for comments in the compiler Ver.3.0.

[Specification method]

Dialog menu: **C/C++** tab **Category: [Other] Miscellaneous options: Allow comment nest**

Command line: *comment*

C/C++ Source Code	Nested Comments Not Allowed	Nested Comments Allowed
`/* comment */`	Recognized as a comment statement	Recognized as a comment statement
`/* /* comment */ */`	Coding error	Recognized as a comment statement
`/* /* /* comment */`	Recognized as a comment statement	Coding error

(2) The C++ comment code "//" can be used. There is the following relationship between the "//" and the C comment code (/* */). The parts that can be recognized as comments are underlined:

```
void func()
{
    abc=0;        //  /* comment  */

    def=1;        /* comment
    ghi=2;        // comment        */
}
```

←Code after // is recognized as a comment

←Code enclosed in /* */ is recognized as a comment

11.1.21 How to Specify Options for Each File

Question

How can I modify options for each file in a project on the HEW system?

Answer

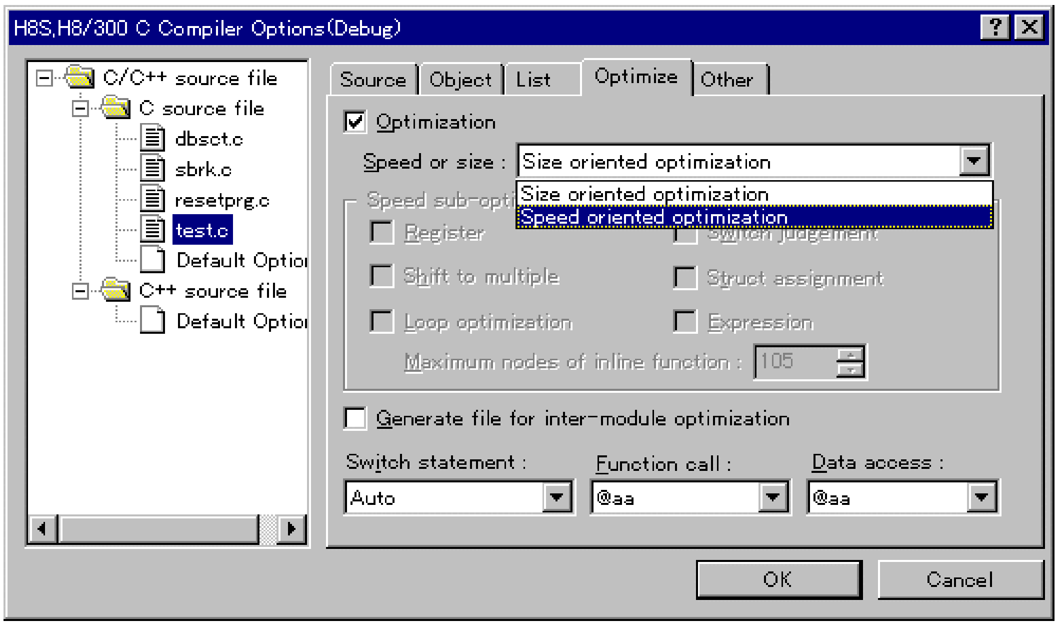
The HEW system supports functions to modify and specify options individually on each file with the compiler or the Assembler.

When specifying with a compiler option, expand the directory of the C/C++ source file on the left side of the option screen. Then, click on a specific file to set the desired options.

If an options is specified in the folder unit, it is effective on all the files in the specified directory.

In the following example, the speed efficiency option is specified only to the file test.c in a project:

<HEW1.2>


H8S,H8/300 C Compiler Options(Debug)

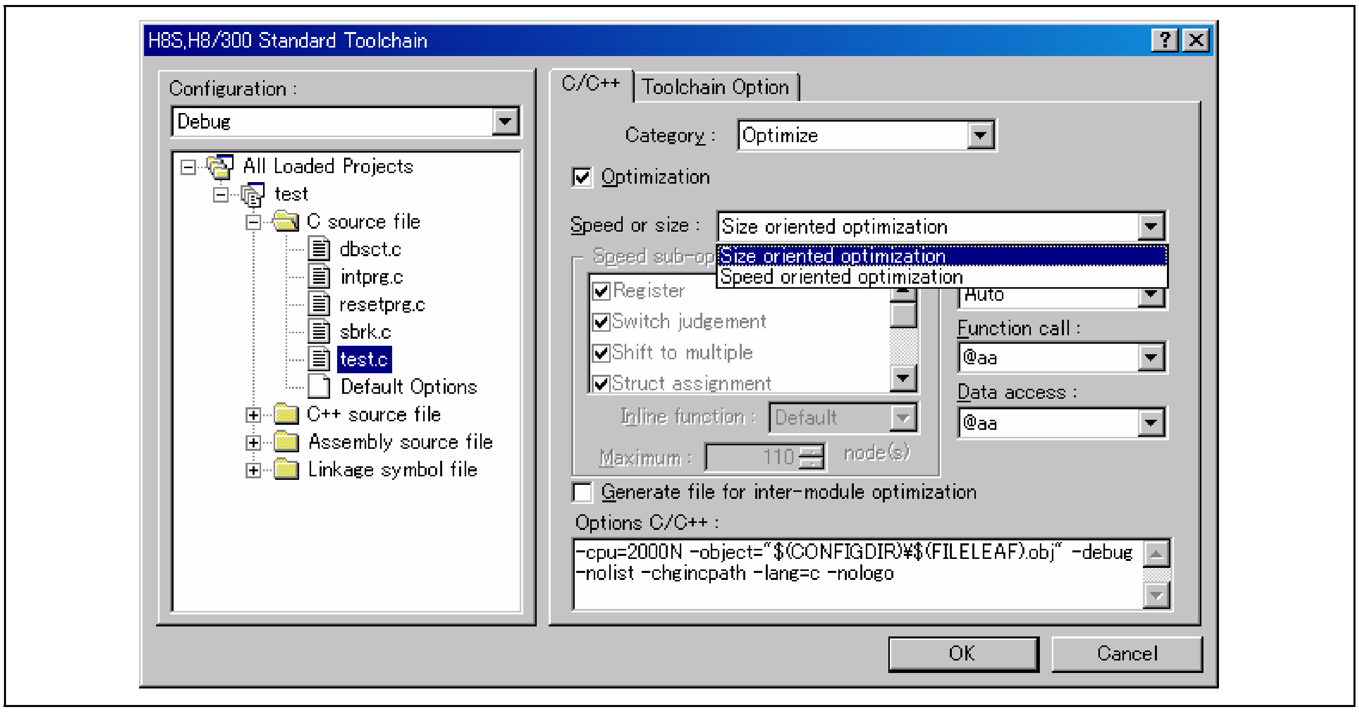
C/C++ source file
C source file
dbsct.c
sbrk.c
resetprg.c
test.c
Default Optio
C++ source file
Default Optio

Source | Object | List | Optimize | Other

[✓] Optimization
Speed or size : Size oriented optimization
Size oriented optimization
Speed oriented optimization
Speed sub-opti
[ ] Register [ ] Switch judgement
[ ] Shift to multiple [ ] Struct assignment
[ ] Loop optimization [ ] Expression
Maximum nodes of inline function : 105
[ ] Generate file for inter-module optimization
Switch statement : Auto
Function call : @aa
Data access : @aa

Select test.c from the left side of the screen and select Speed oriented optimization from Speed or size: on the Optimize tab.

<HEW2.0 or later>



```
-cpu=2000N -object="$(CONFIGDIR)¥$(FILELEAF).obj" -debug
-nolist -chgincpath -lang=c -nologo
```

Select test.c from the left side of the screen and select **Speed oriented optimization** from **C/C++** Tab **Category: [Optimize] Speed or size:**.

11.1.22 How to Build Programs When the Assembler is Embedded

Question

A warning message is output at compiling when the assembler intrinsic is performed using #pragma asm and #pragma endasm or #pragma inline_asm.

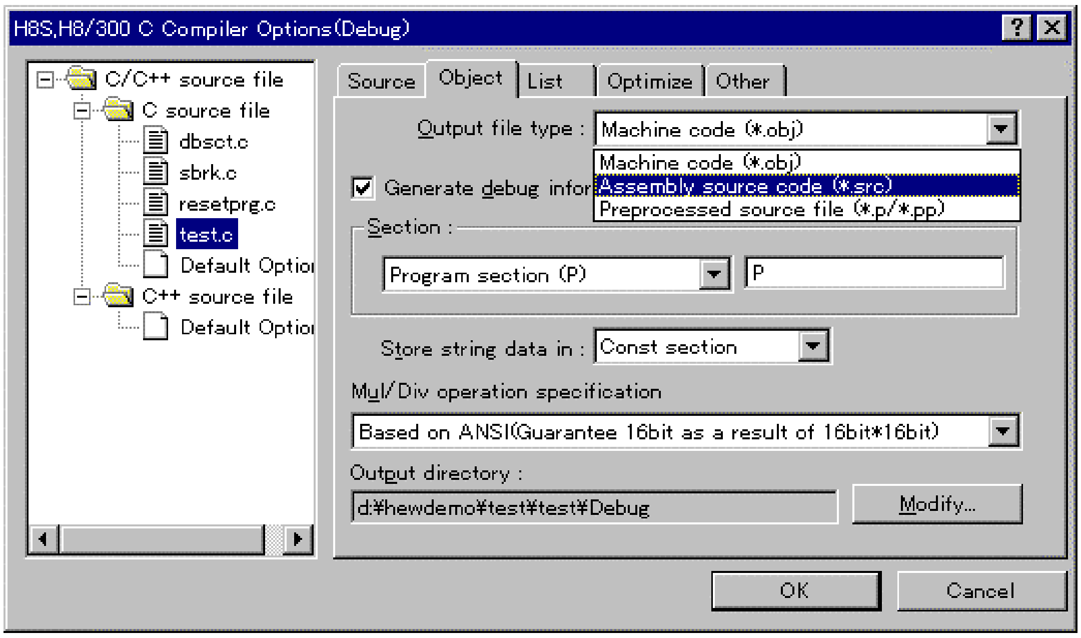
Answer

Assembler embedded files should be output in the Assembly language and then be assembled.

To build a file on the HEW, specify the file containing the Assembler embedding to the Assembly output referring to the procedure described in section 11.1.21, How to Specify Options for Each File. When built in this manner, the file that has been Assembly output will automatically be assembled.

In the following example, the file test.c containing an Assembly embedding is specified:

<HEW1.2>

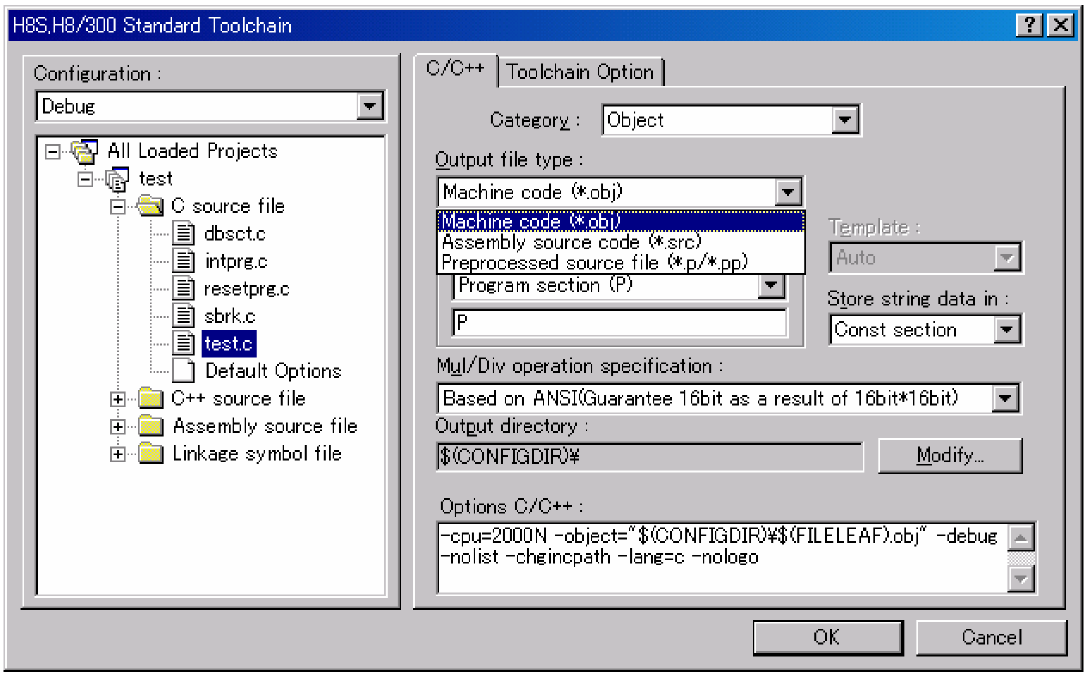


Output file type : Machine code (*.obj)
Machine code (*.obj)
Assembly source code (*.src)
Preprocessed source file (*.p/*.pp)
Generate debug infor
Section :
Program section (P) P
Store string data in : Const section
Mul/Div operation specification
Based on ANSI(Guarantee 16bit as a result of 16bit*16bit)
Output directory :
d:¥hewdemo¥test¥test¥Debug

Select Assembly source code (*.src) from Output file type: on the Object tab.

Files are built normally with this specification. Note that this specification disables C source debugging.

<HEW2.0 or later>



Configuration : Debug
Category : Object
Output file type : Machine code (*.obj)
Machine code (*.obj)
Assembly source code (*.src)
Preprocessed source file (*.p/*.pp)
Program section (P)
P
Store string data in : Const section
Mul/Div operation specification :
Based on ANSI(Guarantee 16bit as a result of 16bit*16bit)
Output directory :
$(CONFIGDIR)¥
Options C/C++ :

```
-cpu=2000N -object="$(CONFIGDIR)¥$(FILELEAF).obj" -debug
-nolist -chgincpath -lang=c -nologo
```

Select **Assembly source code (*.src)** from **C/C++** Tab **Category: [Object] Output file type:** .

Files are built normally with this specification.

11.1.23 Output of Syntax Errors at Linkage

Question

The error message 202 SYNTAX ERROR is displayed with the inter-module optimizer for HEW1.2. Why is it?

Answer

Does the file name or the project name contain Japanese characters, minus symbols, or space characters?

With the compiler, the Assembler, the inter-module optimizer, the Librarian or the S-Type Converter, Japanese characters, minus symbols, or space characters cannot be specified for a file name. For example, if a project name contains Japanese characters, a syntax error occurs when the output destination is specified with an inter-module optimizer option.

Remarks

In HEW2.0 or later, programs can successfully be built without the error message displayed even if a file name or a project name contains Japanese characters, minus symbols or space characters. However, Japanese characters, minus symbols or space characters should not be used if possible.

11.1.24 C++ Language Specifications

Question

Are there any function supporting the development of programs in the C++ language?

Answer

The H8S,H8/300 C/C++ compiler supports the following functions to support program development in C++:

(1) Support of EC++ class libraries

As EC++ class libraries are supported, the intrinsic C++ class libraries can be used from a C++ program without any specification.

The following four-type libraries are supported:

- Stream I/O class library
- Memory manipulation library
- Complex number calculation class library
- Character string manipulation class library

For details, refer to section 10.3.2, C++ Class Libraries, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User’s Manual.

(2) EC++ language specification syntax check function

Syntaxes are checked on C++ programs, based upon the EC++ language specifications, using a compiler option.

[Specification method]

Dialog menu: **C/C++** Tab **Category: [Other] Miscellaneous options: Check against EC++ language specification**

Command line *ecpp*

(3) Other functions

The following functions are supported for efficient coding of C++ programs:

<Better C functions>

- Inline expansion of functions
- Customization of operators such as +, -,<<
- Simplification of names through the use of multiple definition functions
- Simple coding of comments

<Object-oriented functions>

- Classes
- Constructors
- Virtual functions

For a description of how to set the execution environment at using library functions in a C++ program, refer to section 9.2.2(5), C/C++ library function initial settings(_INILIB), in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

11.1.25 How to View Source Programs after Pre-Processor Expansion

Question

How can I review a program after macros are expanded?

Answer

The output of the source program expanded by the Pre-Processor is specified with the compiler option.

If the source program before expansion was a C language program, it is output with the extension <filename>.p. For a C++ program, the extension is <filename>.pp.

In this case, no object program is created. Therefore, any optimization option specifications are not available.

Specification method

Dialog menu: **C/C++** Tab **Category: [Object] Output file type: Preprocessed source file (*.p/*.pp)**

Command line: *preprocessor*

11.1.26 How to Output Save/Restore Codes for MACH or MACL Register

Question

How can I output the MAC register save/restore code?

Answer

The Output of save/restore codes for the MAC register is specified with a compiler option.

Values of the MAC register are always guaranteed with this specification when the MAC register is used in an interrupt function (by using the built-in function mac or macl) or when a function call is made within an interrupt function.

Even if this option is not specified, the MAC register save/restore codes are output whenever the MAC register is used in an interrupt function.

Specification method

Dialog menu: **C/C++** Tab **Category: [Other] Miscellaneous options: Interrupt handler saves/resotres MACH and MACL registers if used**

Command line: *macsave*

Example

To call the function sub from an interrupt function:

(CC++ program)

```
extern void sub(void);
#pragma interrupt func
void func(void)
{
    sub();
}
```

(Compiled Assembly expansion code)

Without option

```
_func:
      STM.L   (ER0-ER1),@-SP



      JSR     @_sub:24



      LDM.L   @SP+,(ER0-ER1)
      RTE
```

With option

```
_func:
      STM.L   (ER0-ER1),@-SP
      STMAC.L MACL,ER1
      PUSH.L  ER1
      STMAC.L MACH,ER1
      PUSH.L  ER1
      JSR     @_sub:24
      POP.L   ER1
      LDMAC.L ER1,MACH
      POP.L   ER1
      LDMAC.L ER1,MACL
      LDM.L   @SP+,(ER0-ER1)
      RTE
```

11.1.27 The Program Runs Correctly on the ICE but Fails When Installed on a Real Chip

Question

The program runs correctly at debugging on the ICE but fails when operated on a real chip.

Answer

If a program contains the initialization data area (D section), it uses emulation memory on the ICE. Therefore, read/write operation can be performed on the ICE, however, only read operation can be performed on a real chip because memory on a real chip is ROM. This causes the malfunction of the program execution whenever a write operation is attempted.

The initialization data area should be copied from the ROM area to the RAM area at the power-on reset.

Secure an area for each of ROM and RAM using the ROM implementation support option of the HEW2.0 or later optimizing linkage editor and the HEW1.2 inter-module optimizer.

For a description of how to copy data from a ROM area to a RAM area, refer to section 3.3, Section Address Operators.

11.1.28 How to Use C language programs Developed for SH Microcomputers

Question

What points should I confirm when using a C language program developed for an SH microcomputer on an H8S,H8/300 microcomputer?

Answer

Be careful on the following points for the program:

(1) int-type data are treated as 2-byte data.

On the SH, int type data are treated as 4-byte data, however, on the H8S,H8/300 Series, they are treated as 2-byte data. Confirm that there is not any problem on the range of values.

(2) Some expanded functions cannot be used.

Functions on the SH series C/C++ compiler and the H8S and H8/300 series C/C++ compiler are compatible by using the #pragma statement, for example, however there are some differences between them in the expanded functions and specifications.
Note that built-in functions are CPU-specific.

(3) Notes on assembler embedding

Because of differences in architecture, the H8S,H8/300 Series cannot handle any code in which an SH series assembly source is embedded.

Remarks

If you wish to use C source files created in the M16C development environment in the H8 development environment, Translation Helper is available.

This is a support tool to translate smoothly the all C source files created in the M16C development environment to the H8 development environment.

Translation Helper can be free downloaded from Renesas Development Environment site.

11.1.29 How to Modify Global Options

Question

When the number of parameter-passing registers is changed, the inter-module optimizer generates an error. What causes this problem?

Answer

The compiler option to specify the number of parameter-passing registers is a global option, which must be the same specification through the project.

Therefore, if the compiler option only is modified, an error may occur.

There are two global options, that specifying the number of parameter-passing registers and that specifying the CPU type.

A global option can be modified as follows:

Example: To change the number of parameter-passing registers:

(1) Modify the compiler option

[Specification method]

Dialog menu: **CPU** tab, **Change number of parameter from 2 (default) to 3**

Command line: *regparam=3*

This changes the option specification for all applicable C/C++ files.

(2) Modify the Assembler file

The registers used changes during the linkage of a C/C++ program and an Assembler file.

This requires a modification of the Assembler file.

When the number of parameter-passing registers is set to three, used registers are changed as follows:

For an H8/300 CPU: R0, R1 → R0, R1, R2
Other CPUs: ER0, ER1 → ER0, ER1, ER2

For details of the interface, refer to section 9.3.2(3), Rules concernig registers, in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

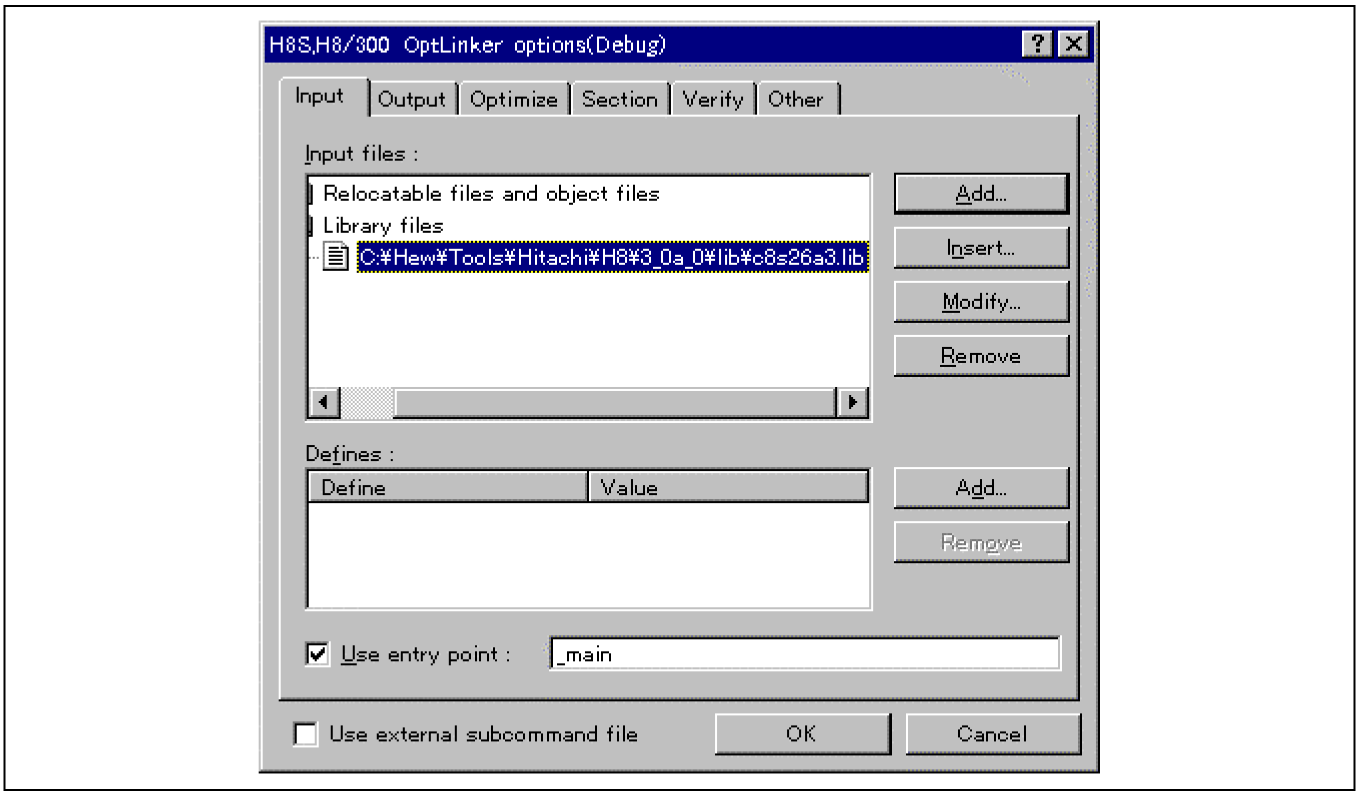
The described interface is also applicable to assembly language codes that is embedded in a C/C++ program.

(3) Change the standard library/EC++ class library to be linked

Use the inter-module optimizer to change the library to be linked.

Modification on the HEW1.2 is shown below:

If the previously linked library is c8s26a.lib, change it into c8s26a3.lib:



For a detailed information for global options and the related libraries, refer to table 1.1, The Relationship between Standard Libraries and Compile Options, in the H8S, H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

In HEW2.0 or later, global options are set in common for the compiler, Assembler and Library Generation Tool and they should not necessarily be set with the optimizing linkage editor.

(If the library in the older version is set on **Link/Library** Tab **Category: [Input] Library files**, the modification as shown above is necessary.)

11.1.30 Optimizations That Cause Infinite Loops

Question

Why do infinite loops occur when I upgrade the compiler, or turn optimization on?

Answer

Infinite loops may occur due to compiler optimization, such as in the following common source, in which substitution for a is read from the register instead of from memory, preventing the value of *d from being reflected when changed via interrupt. This optimization is part of the compiler specification, and can be prevented by using the volatile-type specifier.

Example

C source

```
int i1;
void f( int *d)
{
int a;
    do
    {
       a=*d;
    }while(a!=0);
    i1 = a;
}
```

Assembler source with optimization

```
_f:                                     ; function: f
          .STACK      _f=4
          MOV.W       @ER0,R1
L25:
          MOV.W       R1,R1        ; not read from memory
          BNE         L25:8
          MOV.W       R1,@_i1:32
          RTS
```

Modified C source

```
int i1;
void f( volatile int *d)
{
int a;
    do
    {
       a=*d;
    }while(a!=0);
    i1 = a;
}
```

Modified assembler source with optimization

```
_f:                                     ; function: f
          .STACK      _f=4
          MOV.L       ER0,ER1
L25:
          MOV.W       @ER1,R0••••; read from memory
          BNE         L25:8
          MOV.W       R0,@_i1:32
          RTS
```

11.1.31 Read/write Instructions for Bit Fields

Question

```
struct bit{
 unsigned short int b0 : 1;
 unsigned short int b1 : 1;
 unsigned short int b2 : 1;
 unsigned short int b3 : 1;
 unsigned short int b4 : 1;
 unsigned short int b5 : 1;
 unsigned short int b6 : 1;
 unsigned short int b7 : 1;
 unsigned short int b8 : 1;
 unsigned short int b9 : 1;
 unsigned short int b10 : 1;
 unsigned short int b11 : 1;
 unsigned short int b12 : 1;
 unsigned short int b13 : 1;
 unsigned short int b14 : 1;
 unsigned short int b15 : 1;
}  ;
```

In the above code, I'd like to define a bit field, and access the bits of a specific register for a 16 bit width, but I end up performing access by byte and bit operation instruction. For registers that can only be accessed for 16 bits, when a byte access or bit operation instruction is generated, I can't properly read the register value. What should I do?

Answer

As long as there are no particular specifications in the program, bit field members are accessed by compiler-optimized instructions. As a result, access may be performed by unintended instructions. Specify __evenaccess to perform access using the type set for the member variable.

To prevent changes to access methods and multiple accesses by the compiler, specify __evenaccess explicitly for variables for which you would like to prevent such changes.

C source without __evenaccess

```
struct bit reg;

void main()
{
    reg.b6=1;
}
```

Assembler source without __evenaccess

```
_main:                                 ; function: main
          .STACK      _main=4
          BSET.B      #1,@_reg:32
          RTS
```

C source with __evenaccess

```
__evenaccess struct bit reg;

void main()
{
    reg.b6=1;
}
```

Assembler source with __evenaccess

```
_main:                                   ; function: main
          .STACK      _main=4
          MOV.W       @_reg:32,R0
          BSET.B      #1,R0H
          MOV.W       R0,@_reg:32
          RTS
```

Remarks

For details on **__evenaccess** keyword, refer to section 3.5.3, Even Byte Access Specification Features.

11.1.32 Common Invalid Instruction Exceptions That Occur When Programs Are Run for an Extended Period of Time

Question

Once the device has been running for 10 minutes to 2 hours, a common invalid instruction exception occurs, and a reset is necessary. Is there some way to analyze from where the problem is occurring?

Answer

Ultimately, this means that a common invalid instruction is occurring, but the system may lose control and cause a common invalid instruction exception due to the following reasons. If the system loses control after an extended period of operation, (2) is very likely.

(1) An unintended interrupt is being performed.
(2) A stack overflow is corrupting valid RAM data.
(3) A problem exists with the board environment (such as a data conflict or memory software error).

To find the cause of the problem, perform the following and operate the device:

- Enable instruction tracing.
- Set breakpoints for the interrupt function jumped to during the common invalid instruction exception.

Once the device is operating and the common invalid instruction exception occurs, processing will stop at the breakpoint set for the interrupt function. When this occurs, analyze the status of the instruction trace, and determine the cause of the problem.

Use the following analysis method when a stack overflow is causing the problem:

- Set read/write break access for the address immediately before the address of the start of the stack area.

Once the device is operating and an access occurs that overflows the stack, processing will stop at the breakpoint set above. When this occurs, if the access instruction is a stack access instruction, the cause of the problem is most likely a stack overflow.

11.1.33 Failure at Integer Multiplication

Question

When the result of integer multiplication is assigned to the global variable of type **long**, the result is not the intended value.

The result of [20 * 2000] is this example. But [15 * 2000] produces the correct result. The integer multiplication, which exceeds the range of **short**, does not produce the correct result, even though the result is assigned to the variable of type **long**. Why is this?

<Example>

```
long l_max;
      :
   l_max = 20 * 2000;
```

Answer

The compiler recognizes the integer described in constant expression as type **int** (2 bytes), even though the result is assigned to the variable of type **long**.

Therefore, [20 * 2000] is 0x9C40 after multiplication, and is assigned to the variable of type **long** as 0xFFFF9C40 because of sign extension.

[15 * 2000] is 0x7530, and assigned as 0x00007530 because the sign extension does not occur, which is the intended value.

To get the intended result of multiplication, the constant expression should be postfixed by “L”, so that the compiler can recognize the constant as type **long**.

<Example>

```
long l_max;
      :
   l_max = 20L * 2000L;    // constant with “L” postfixed, one postfixed is OK at least
```

11.2 Optimizing Linkage Editor

11.2.1 Output of "Undefined External Symbol"

Question

The inter-module optimizer outputs the message ”Undefined external symbol(XXX)” when the symbol XXX is not used. Why is this?

Answer

(1) Is a compiler-supplied standard library or an EC++ class library linked?

A standard library includes both C library functions and runtime routines (operation routines that are necessary for the execution of C language programs).

Even when the user program does not include C library functions, the compiler-generated object program sometimes may require functions that are provided in a standard library. In such a case, the library option of the inter-module optimizer should be used to specify a standard library.

For HEW1.2, the standard library/EC++ class library to be specified must be selected according to the type of CPU used, the optimization method employed, and the number of registers to which parameters are passed as indicated in the following table

CPU/ Operation Mode	No. of Parameter -Passing Registers	Std. C Library		EC++ Class Library	
		Size Priority	**Speed Priority**	**Size Priority**	**Speed Priority**
H8/300	2	c38reg.lib	c38regs.lib	ec2reg.lib	ec2regs.lib
	3	c38reg3.lib	c38regs3.lib	ec2reg3.lib	ec2regs3.lib
H8/300H NRM	2	c38hn.lib	c38hns.lib	ec2hn.lib	ec2hns.lib
	3	c38hn3.lib	c38hns3.lib	ec2hn3.lib	ec2hns3.lib
H8/300H ADV	2	c38ha.lib	c38has.lib	ec2ha.lib	ec2has.lib
	3	c38ha3.lib	c38has3.lib	ec2ha3.lib	ec2has3.lib
H8S NRM	2	c8s26n.lib	c8s26ns.lib	ec226n.lib	ec226ns.lib
	3	c8s26n3.lib	c8s26ns3.lib	ec226n3.lib	ec226ns3.lib
H8S ADV	2	c8s26a.lib	c8s26as.lib	ec226a.lib	ec226as.lib
	3	c8s26a3.lib	c8s26as3.lib	ec226a3.lib	ec226as3.lib

Legend:
NRM: normal mode; ADV: advanced mode

Size efficiency and speed efficiency can be specified regardless of the compiler option. However, the CPU type and the number of parameter-passing registers should conform to the compiler option specification.

For HEW2.0 or later, check that a standard library is created by selecting Standard Library tag Category: on [Mode], Build a library file(Option Changed).

(2) The problem may occur because an I/O or memory management library is specified. In order to specify a function declared in the C library function stdio.h or stdlib.h, a low-level interface routine is necessary.

When creating a low-level interface routine, refer to section 9.2.2, Execution Environment Settings, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Also refer to the example of a low-level interface routine included in the sample program.

The following low-level interface routines are available:

Name	Function
open	Opens a file.
close	Closes a file.
read	Reads from a file.
write	Writes to a file.
lseek	Sets a file read/write position.
sbrk	Allocates a memory area.

11.2.2 Output of "Relocation Size Overflow"

Question

The message ”Relocation size overflow” is displayed during linking with the HEW2.0 or later optimizing linkage editor and the HEW1.2 inter-module optimizer. What should I do?

Answer

First, check the linkage map.

- Are the $ABS8 and $ABS16 sections included within the range accessible with 8-bit absolute addresses and 16-bit absolute addresses of the CPU?
- Is the $INDIRECT section included within the range from 0 to FF of the CPU?

This warning message is displayed if data specified to be assigned to an 8-bit absolute address, a 16-bit absolute address, or an indirect memory address with an option or #pragma operator is not assigned to the correct address.

For details on the ranges, refer to each programming manual. Check the range, and if a section is assigned out of the range, it should be adjusted appropriately.

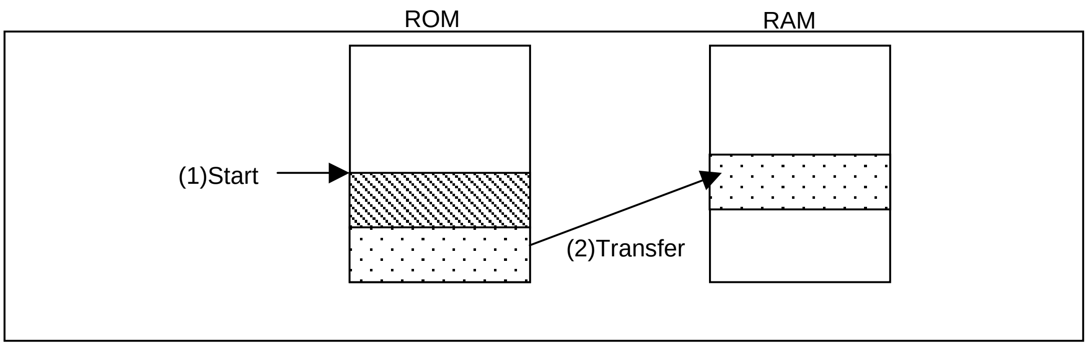
Confirm that assembly coding is correctly provided in those program locations where assembly code is to be embedded.

This message is sometimes displayed when a branch width is not appropriate when an attempt is made to embed assembly code in a C/C++ program.

11.2.3 How to Run Programs in RAM

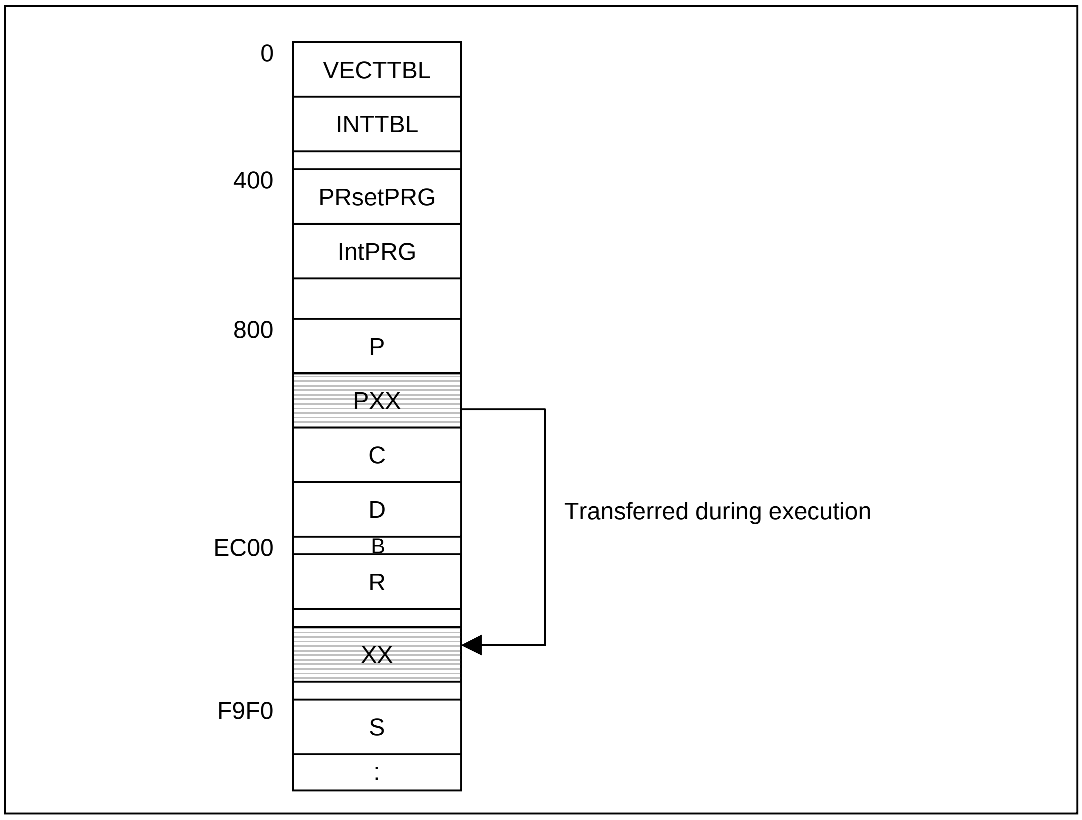
Question

How can I allocate a program in fast RAM?



Answer

You can use the ROM support functions of the HEW2.0 or later optimizing linkage editor and the HEW1.2 inter-module optimizer to copy a part of the program to be executed to the fixed addresses (determined at linking) during runtime to execute the program in RAM.



This program can be installed in the project that was created in section 2 as follows:

First, specify the address of the program section to be transferred to be executed in RAM at startup. This processing is added to an existing file.

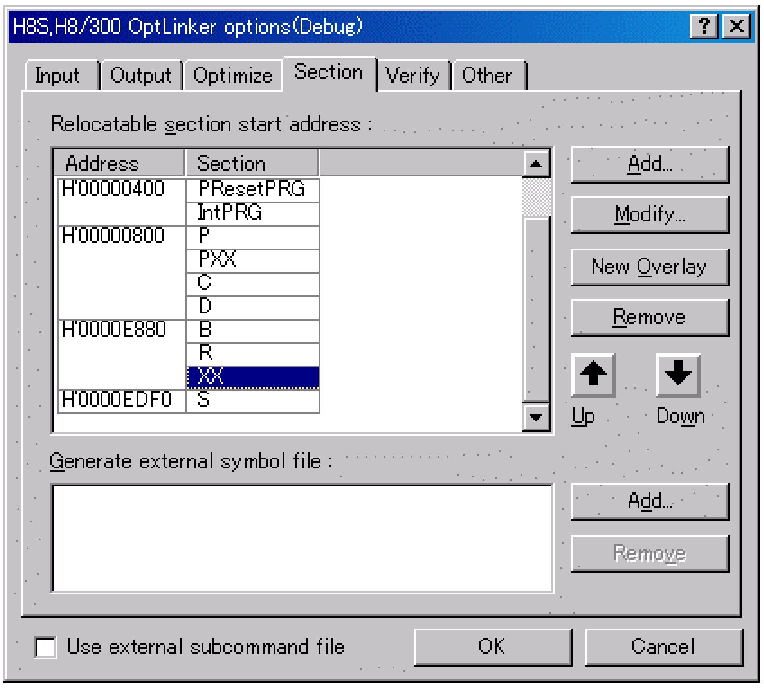
```
#pragma section $DSEC
static const struct {
   char *rom_s;       /* Start address of the initialized data section in ROM */
   char *rom_e;       /* End address of the initialized data section in ROM   */
   char *ram_s;       /* Start address of the initialized data section in RAM */
}DTBL[]= {
   {__sectop("D"), __secend("D"), __sectop("R")},
// {__sectop("$ABS8D"), __secend("$ABS8D"), __sectop("$ABS8R")},
// {__sectop("$ABS16D") , __secend("$ABS16D") , __sectop("$ABS16R") },
   {__sectop("PXX"),__secend("PXX"),__sectop("XX")}
};
                                      ↑ Set the addresses of PXX and XX sections.
#pragma section $BSEC
static const struct {
   char *b_s;         /* Start address of non-initialized data section */
   char *b_e;         /* End address of non-initialized data section */
}BTBL[]= {
   {__sectop("B"), __secend("B")},
// {__sectop("$ABS8B"), __secend("$ABS8B")},
// {__sectop("$ABS16B"), __secend("$ABS16B")}
};
```

With this specifications, the PXX section is copied to the XX section at startup.

Next, specify the start address of the destination section XX with the optimizing linkage editor and the

inter-module optimization tool.

<HEW1.2>



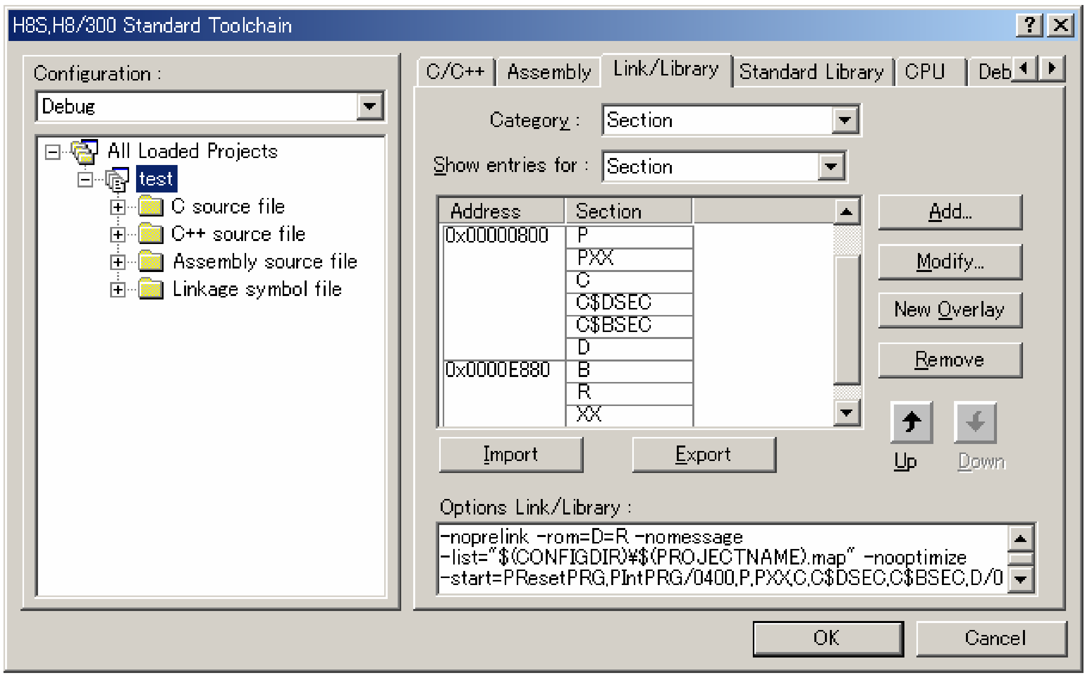
Relocatable section start address :

Address	Section
H'00000400	PResetPRG
	IntPRG
H'00000800	P
	PXX
	C
	D
H'0000E880	B
	R
	XX
H'0000EDF0	S

Generate external symbol file :

☐ Use external subcommand file

<HEW2.0 or later>



Category : Section

Show entries for : Section

Address	Section
0x00000800	P
	PXX
	C
	C$DSEC
	C$BSEC
	D
0x0000E880	B
	R
	XX

Options Link/Library :

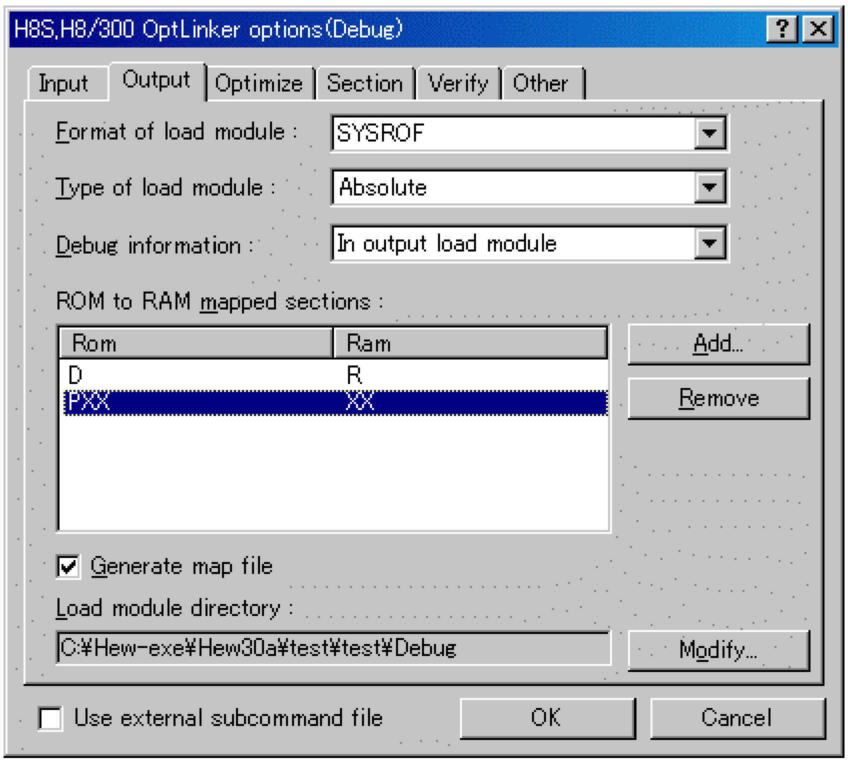
```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,PXX,C,C$DSEC,C$BSEC,D/0
```

After that, allocate the same area as the area occupied by the source section PXX in the RAM with the ROM implementation support option. When ROM is specified, the size of this area is equal to that of the PXX section.

This operation of the optimizing linkage editor and the inter-module optimizer can be coded in a subcommand as follows:

```
           :
start VECTTBL,INTTBL(0),PRsetPRG,IntPRG(0400),P,C,D(0800),B,R,XX(0EC00),S…
           :
```

<HEW1.2>


H8S,H8/300 OptLinker options(Debug)

Format of load module : SYSROF

Type of load module : Absolute

Debug information : In output load module

ROM to RAM mapped sections :

Rom	Ram
D	R
PXX	XX

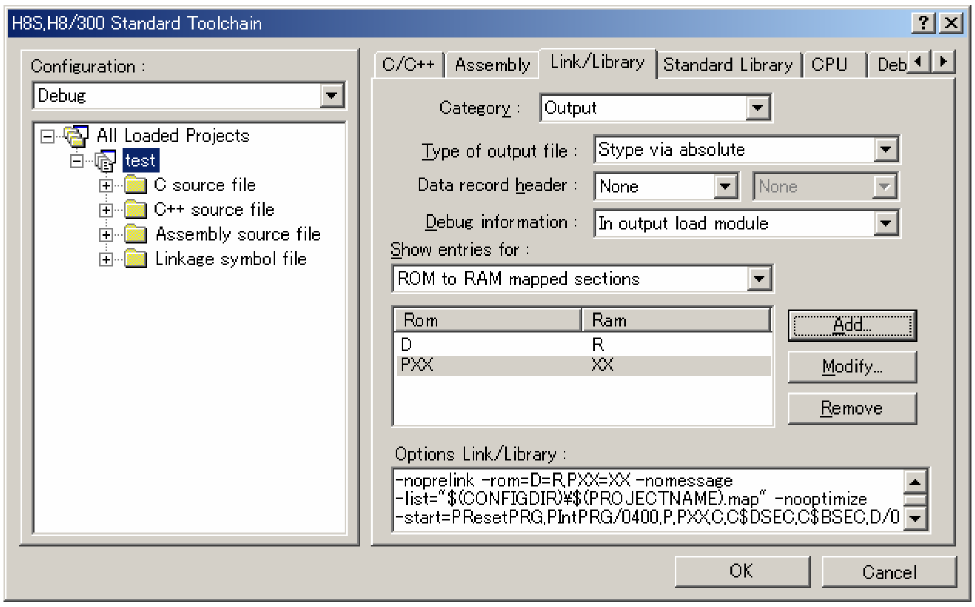
☑ Generate map file

Load module directory :

C:¥Hew-exe¥Hew30a¥test¥test¥Debug

☐ Use external subcommand file

<HEW2.0 or later>


H8S,H8/300 Standard Toolchain

Configuration : Debug

Category : Output

Type of output file : Stype via absolute

Data record header : None None

Debug information : In output load module

Show entries for : ROM to RAM mapped sections

Rom	Ram
D	R
PXX	XX

Options Link/Library :

```
-noprelink -rom=D=R,PXX=XX -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,PXX,C,C$DSEC,C$BSEC,D/0
```

In the subcommand, specify as follows using rom:

```
          :
rom(D,R)
rom(PXX,XX)
          :
```

Use the subcommand file including this code to start the optimizing linkage editor and the inter-module optimizer:

<HEW1.2>

% optlnk38 –sub=test.sub(RET) (the inter-module optimizer)

<HEW2.0 or later>

% optlnk –sub=test.sub(RET) (the optimizing linkage editor)

Remarks and notes

When the above processing is performed, the warning message (1300 SECTION ATTRIBUTE MISMATCH IN ROM OPTION/SUBCOMMAND(XX)) may be displayed by the HEW1.2 inter-module optimizer.

This message is displayed because a program section was specified with the __sectop and __secend operators. In this case, this can be ignored.

Improvements with HEW2.0 or later no longer cause the message to be displayed, normally. But when in the following case, the warning message (L1323 (W) Section attribute mismatch : “FXX“) may be displayed like by the HEW1.2. In this case, this can be also ignored.

(1) the program section (P) is changed to other name by the section option of the C/C++ Compiler
(2) the section of (1) is specified as the source section

11.2.4 Fixing Symbol Addresses in Certain Memory Areas for Linking

Question

After fixing a program in internal ROM, I want to develop the program for external memory, and in future want to update only the external memory program.

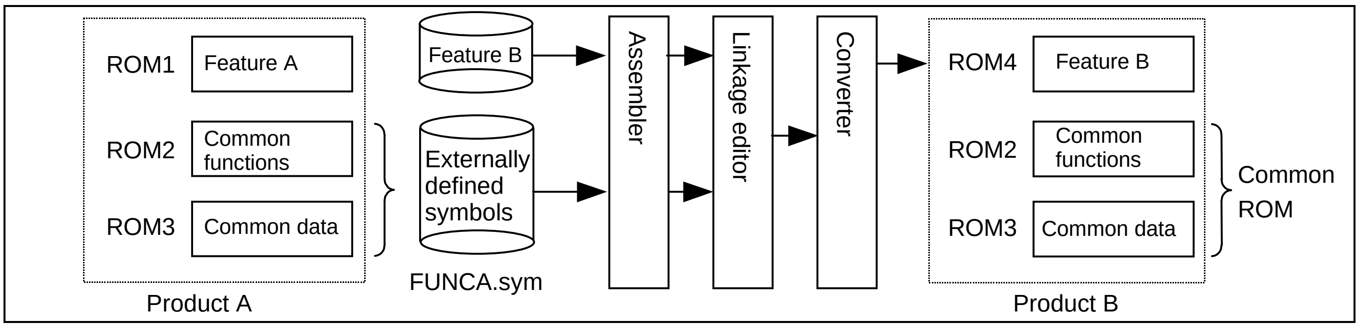
Answer

When fixing a program in internal ROM, the link command fsymbol can be used to output a definition file of externally defined labels for the internal ROM.

A definition file is created by the assembler EQU statement, and so when creating an external memory program, this file can be assembled and input to reference a fixed address in ROM.

Example of Use:

Illustrates an example in which the feature A of a product A is modified to the feature B, to develop the product B. Using this, by resolving the addresses of symbols in shared ROM, the common ROM can be used.



Example of Use of the Feature for Output of Symbol Addresses

Example of specification of externally defined symbol file output

optlnkΔROM1,ROM2,ROM3Δ-output=FUNCAΔ-fsymbol=sct2,sct3

The externally defined symbols sct2 and sct3 are output to a file.

Example of file output (FUNCA.sym)

```
;H SERIES LINKAGE EDITOR GENERATED FILE   1997.10.10
;fsymbol = sct2, sct3

;SECTION NAME = sct1
.export sym1
sym1:  .equ     h'00FF0080
.export sym2
sym2:  .equ     h'00FF0100
;SECTION NAME = sct2
.export sym3
sym3:  .equ     h'00FF0180
    .end
```

Example of specification of assembly and relinking

asm38ΔROM4
asm38ΔFUNCA.sym
optlnkΔROM4,FUNCA

The externally referenced symbols in ROM4 can be resolved without linking the object files ROM2, ROM3.

Note: When using this procedure, the symbols within feature A cannot be referenced from common functions.

11.2.5 How to Implement Overlay

Question

How can I assign sections that do not exist simultaneously to the same address?

Answer

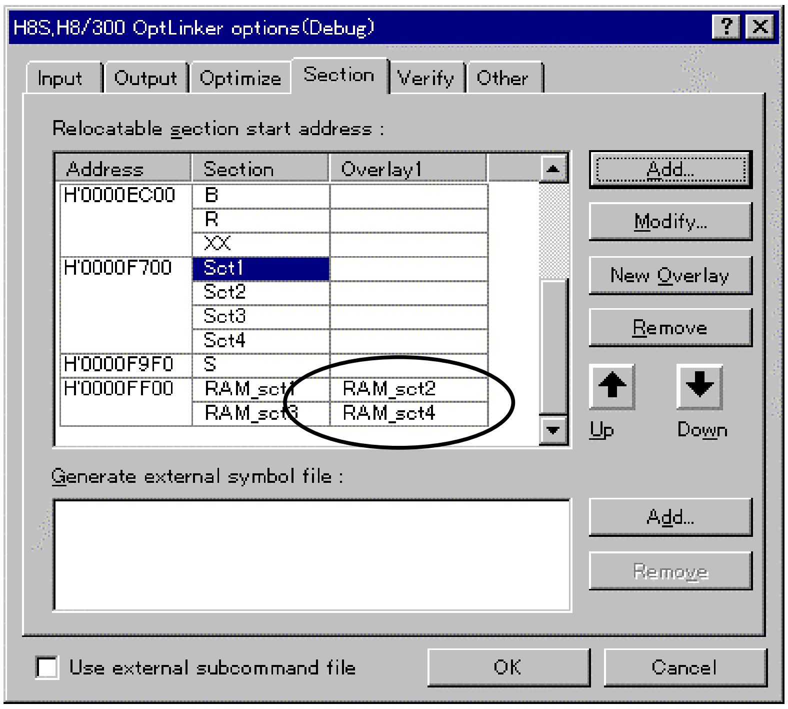
Such an assignment can be specified using an option of the HEW2.0 or later optimizing linkage editor and the HEW1.2 inter-module optimizer.

Specification method

<HEW1.2>

Send the cursor to: **Section** tab, **Relocatable section start address:** target section, to specify the New Overlay option.

The following shows the specification screen:



H8S,H8/300 OptLinker options(Debug)

Relocatable section start address :

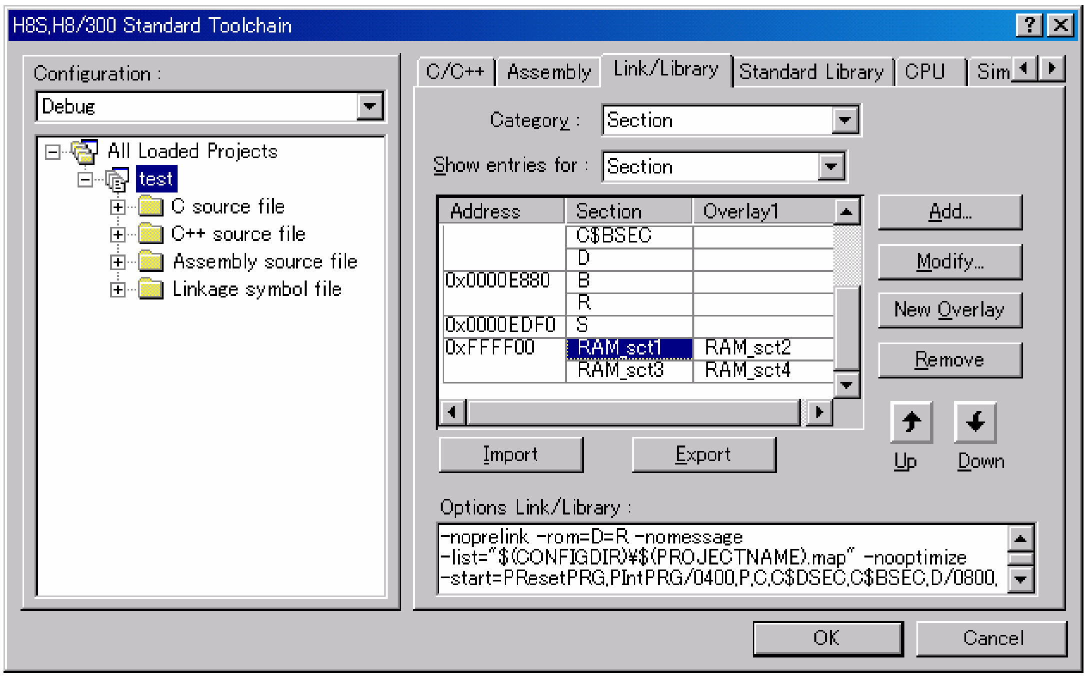
Address	Section	Overlay1
H'0000EC00	B	
	R	
	XX	
H'0000F700	Sct1	
	Sct2	
	Sct3	
	Sct4	
H'0000F9F0	S	
H'0000FF00	RAM_sct1	RAM_sct2
	RAM_sct3	RAM_sct4

Generate external symbol file :

☐ Use external subcommand file

<HEW2.0 or later>

Send the cursor to: **Lik/Library** tab Category:**[Section]** target section**,** to specify the New Overlay option.



Address	Section	Overlay1
	C$BSEC	
	D	
0x0000E880	B	
	R	
0x0000EDF0	S	
0xFFFF00	RAM_sct1	RAM_sct2
	RAM_sct3	RAM_sct4

Options Link/Library :

```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

In the case of subcommands, use the start option:

```
         :
start RAM_Sct1,RAM_Sct3:RAM_Sct2,RAM_Sct4(0FF00)
         :
```

Remarks and notes

If an overlay is going to be specified on a program section, the section needs to be transferred.

Refer to section 11.2.3, How to Run Programs in RAM.

11.2.6 How to Specify Output of Undefined Symbol Error

Question

How can I specify to output an error message and disable output of a load module when an undefined symbol is found at linking?

Answer

Undefined symbols can be checked using an option with the inter-module optimizer for HEW1.2.

When this option is specified, an error message is displayed if an undefined symbol is included, and the output of a load module is disabled.

Without this specification, a warning message is displayed while a load module is generated.

Specification method

Dialog menu: **Link/Library** Tab **Category: [Other] Miscellaneous options: Check for undefined symbols**

Subcommand: *udfcheck*

Remarks

Undefined symbols are always checked with the optimizing linkage editor for HEW2.0 or later and if an undefined symbol is included, an error message is displayed and the output of a load module is disabled.

11.2.7 Unify Output Forms of S Type File

Question

I would like to unify mixed output forms S1, S2, S3 of S type file.

Answer

These can be output by specific data record (S1, S2, S3) irrespective of load address by options.

Example: optlnk test.abs -form=stype -output=test.mot -record=s2 ; All data records are output by S2.

11.2.8 Dividing an Output File

Question

I would like to divide an output file for each ROM devices into some files.

Answer

If specify a start address and termination address in the end of an output file name, an object of specified area can be output. An output file name can be specified more than two.

Example: An area of 0x0-0xFFFF is output into optlnk test.abs -form=stype -output=test1. mot=0-FFFF test2.mot=10000-1FFFF; test1.mot, an area of 0x10000-0x1FFFF is output into test2.mot.

11.2.9 Output File Format of Optimizing Linkage Editor

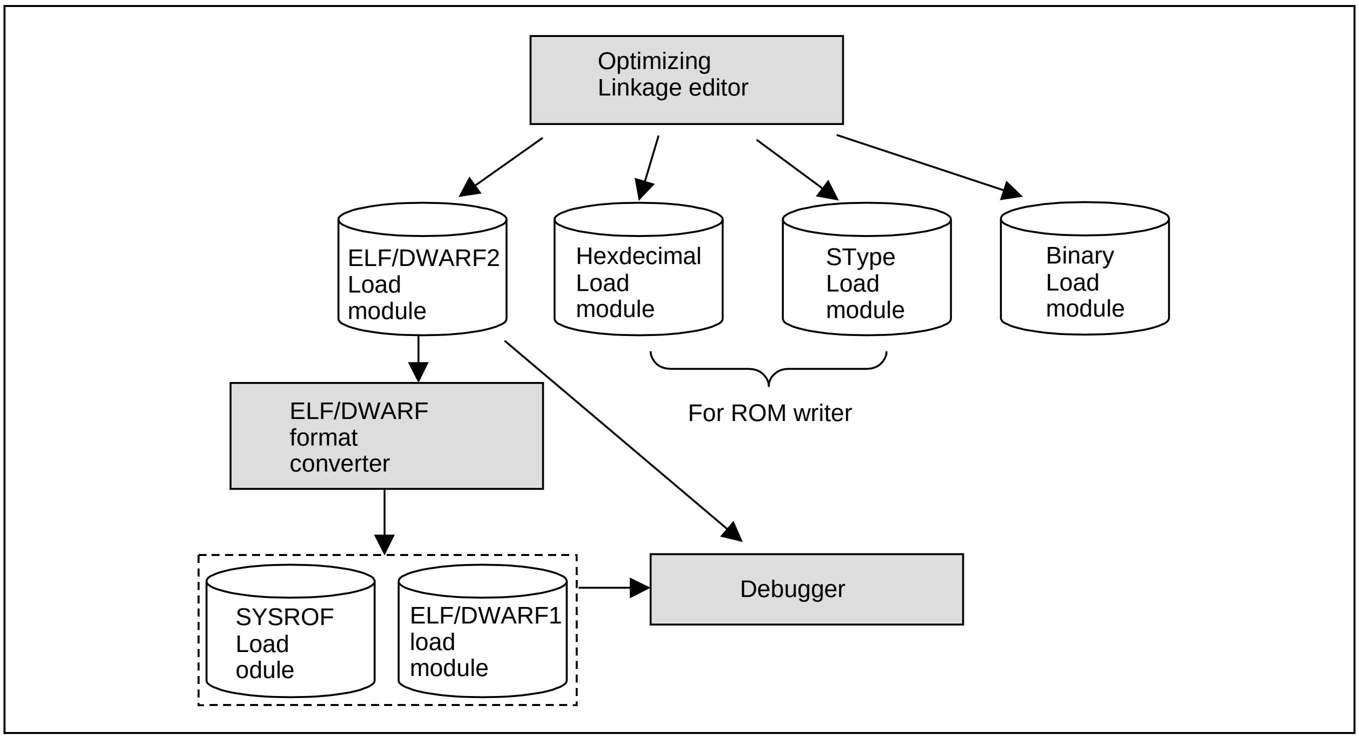
Question

Tell me about the load module file format available to a ROM writer.

Answer

The load modules output by the optimizaton linkage editor are shown below:

- When creating a load module for a ROM writer, output it in the hexdecimal or SType format. In this case, no debugging information is output.
- Optimization linkage editors supporting the C/C++ Compiler V4.0 or later output load modules in the ELF/DWARF2 format at debugging. The load modules created by earlier versions is output in either the SYSROF or ELF/DWARF1 format, and so the format should be changed with the ELF/DWARF format converter to use in the latest version.



Optimizing Linkage Editor Output Load Module

11.2.10 How to Calculate Program Size (ROM, RAM)

Question

How can I calculate the accurate size of ROM, RAM?

Answer

It can be calculated by the list file output from the Optimizing Linkage Editor.

Specification method

Dialog menu: **Link/Library** Tab **Category: [List] Generate list file**

Command line: *list=<file name>*

Calculation method

When this option is specified, the following list file (*.map) can be output.

In this example, code section is PResetPRG, PIntPRG, P, C$DSEC, C$BSEC and D, therefore ROM size is 0x00000146.

RAM size is 0x00000628 by B, R and S.

(Example of list file)

```
*** Mapping List ***

SECTION                START      END              SIZE    ALIGN
PResetPRG
                    00000400  00000415             16         2
PIntPRG
                    00000416  0000048f             7a         2
P
                    00000800  0000089d             9e         2
C$DSEC
                    0000089e  000008a9              c         2
C$BSEC
                    000008aa  000008b1              8         2
D
                    000008b2  000008b5              4         2
B
                    00ffe000  00ffe423            424         2
R
                    00ffe424  00ffe427              4         2
S
                    00ffedc0  00ffefbf            200         2
```

11.2.11 Output of "Section Alignment Mismatch"

Question

The L1322 warning message “Section alignment mismatch” is displayed, when the section name of binary file is referred by the section address operator in binary file input as follows. How can I prevent this?

[Option Specification]
binary=project.bin(BIN_SECTION)

[C/C++ Program]

```
void main(void)
{
    unsigned char *s_ptr;
    s_ptr = __sectop("BIN_SECTION");

    dumy(s_ptr);
}
```

Answer

When the section address operator (__sectop, __second) is specified, the compiler generates the section, of which size is 0 and boundary alignment value is 2, for the specified section in the code generated by compiler as follows.

In this case, because the boundary alignment value of the entity of binary section is 1 in binary section input, the L1322 warning message is displayed due to different boundary alignments with the same name.

This warning message does not affect the program execution.

To prevent this warning message, specify the boundary alignment value in binary file input by the Optimizing Linkage Editor.

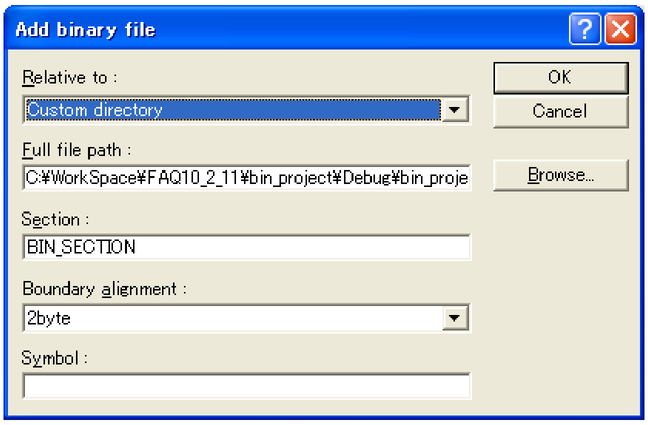
[Code: __sectop used]

```
_main:                          ; function: main
        .STACK      _main=4
        MOV.L       #STARTOF BIN_SECTION,ER0
        BRA         _dumy:8
        .SECTION    BIN_SECTION,DATA,ALIGN=2 ← Section:  size is 0, boundary alignment value is 2
        .END
```

Specification example

Dialog menu: **Link/Library** Tab **Category: [Input] Show entries for : Binary files**

Command line: binary=project.bin(BIN_SECTION:2)


Add binary file

Relative to : Custom directory

Full file path : C:¥WorkSpace¥FAQ10_2_11¥bin_project¥Debug¥bin_proje

Section : BIN_SECTION

Boundary alignment : 2byte

Symbol :

Remarks

This specification of the boundary alignment value in binary file input is valid for the Optimizing Linkage Editor Ver.9.0 or later.

For more details, please refer to section 9.1.1(4), Binary Files.

11.3 Library Generator

11.3.1 Reentrant and Standard Libraries

Question

Is it possible to create a reentrant object program when a standard library is used?

Answer

When a library function that sets or references an external variable is used, the object program is no longer reentrant. The following table lists available reentrant libraries, where the symbol (denotes a function that sets the variable _errno. If these functions do not reference the variable _errno in the program, the reentrant is available.

List of Reentrant Libraries

Reentrant column O: Reentrant X: Non-reentrant Δ: Sets _errno.

No.	Std. Include File	No.	Function	Reentrant	Remarks
1	stddef.h	1	offsetof	O	Macro
2	assert.h	2	assert	×	Macro
3	ctype.h	3	isalnum	O	
		4	isalpha	O	
		5	iscntrl	O	
		6	isdigit	O	
		7	isgraph	O	
		8	islower	O	
		9	isprint	O	
		10	ispunct	O	
		11	isspace	O	
		12	isupper	O	
		13	isxdigit	O	
		14	tolower	O	
		15	toupper	O	
4	math.h	16	acos	Δ	Floating point
		17	asin	Δ	same as above
		18	atan	Δ	same as above
		19	atan2	Δ	same as above
		20	cos	Δ	same as above
		21	sin	Δ	same as above
		22	tan	Δ	same as above
		23	cosh	Δ	same as above
		24	sinh	Δ	same as above
		25	tanh	Δ	same as above
		26	exp	Δ	same as above
		27	frexp	Δ	same as above
		28	ldexp	Δ	same as above
		29	log	Δ	same as above
		30	log10	Δ	same as above
		31	modf	Δ	Floating point
		32	pow	Δ	same as above
		33	sqrt	Δ	same as above
		34	ceil	Δ	same as above
		35	fabs	Δ	same as above
		36	floor	Δ	same as above
		37	fmod	Δ	same as above

No.	Std. Include File	No.	Function	Reentrant	Remarks
5	mathf.h	38	acosf	Δ	Floating-point
		39	asinf	Δ	same as above
		40	atanf	Δ	same as above
		41	atan2f	Δ	same as above
		42	cosf	Δ	same as above
		43	sinf	Δ	same as above
		44	tanf	Δ	same as above
		45	coshf	Δ	same as above
		46	sinhf	Δ	same as above
		47	tanhf	Δ	same as above
		48	expf	Δ	same as above
		49	frexpf	Δ	same as above
		50	ldexpf	Δ	same as above
		51	logf	Δ	same as above
		52	log10f	Δ	same as above
		53	modff	Δ	same as above
		54	powf	Δ	same as above
		55	sqrtf	Δ	same as above
		56	ceilf	Δ	same as above
		57	fabsf	Δ	same as above
		58	floorf	Δ	same as above
		59	fmodf	Δ	same as above
6	setjmp.h	60	setjmp	O	
		61	longjmp	O	
7	stdarg.h	62	va_start	O	Macro
		63	va_arg	O	Macro
		64	va_end	O	Macro
8	stdio.h	65	fclose	×	
		66	fflush	×	
		67	fopen	×	
		68	freopen	×	
		69	setbuf	×	
		70	setvbuf	×	
		71	fprintf	×	
		72	fscanf	×	
		73	printf	×	
		74	scanf	×	
		75	sprintf	Δ	
		76	sscanf	Δ	
		77	vfprintf	×	
		78	vprintf	×	

No.	Std. Include File	No.	Function	Reentrant	Remarks
8	stdio.h	79	vsprintf	Δ	
		80	fgetc	×	
		81	fgets	×	
		82	fputc	×	
		83	fputs	×	
		84	getc	×	
		85	getchar	×	
		86	gets	×	
		87	putc	×	
		88	putchar	×	
		89	puts	×	
		90	ungetc	×	
		91	fread	×	
		92	fwrite	×	
		93	fseek	×	
		94	ftell	×	
		95	rewind	×	
		96	clearerr	×	
		97	feof	×	
		98	ferror	×	
		99	perror	×	
9	stdlib.h	100	atof	Δ	Non-ANSI
		101	atoi	Δ	same as above
		102	atol	Δ	same as above
		103	strtod	Δ	
		104	strtol	Δ	
		105	rand	×	Floating-point
		106	srand	×	
		107	calloc	×	
		108	free	×	
		109	malloc	×	
		110	realloc	×	
		111	bsearch	O	
		112	qsort	O	Recursive function
		113	abs	O	
		114	div	Δ	
		115	labs	O	
		116	ldiv	Δ	
10	string.h	117	memcpy	O	
		118	strcpy	O	
		119	strncpy	O	

No.	Std. Include File	No.	Function	Reentrant	Remarks
10	string.h	120	strcat	O	
		121	strncat	O	
		122	memcmp	O	
		123	strcmp	O	
		124	strncmp	O	
		125	memchr	O	
		126	strchr	O	
		127	strcspn	O	
		128	strpbrx	O	
		129	strrchr	O	
		130	strspn	O	
		131	strstr	O	
		132	strtok	×	
		133	memset	O	
		134	strerror	O	
		135	strlen	O	
		136	memmove	O	

11.3.2 Like to Use Reentrant Library Function in Standard Library File

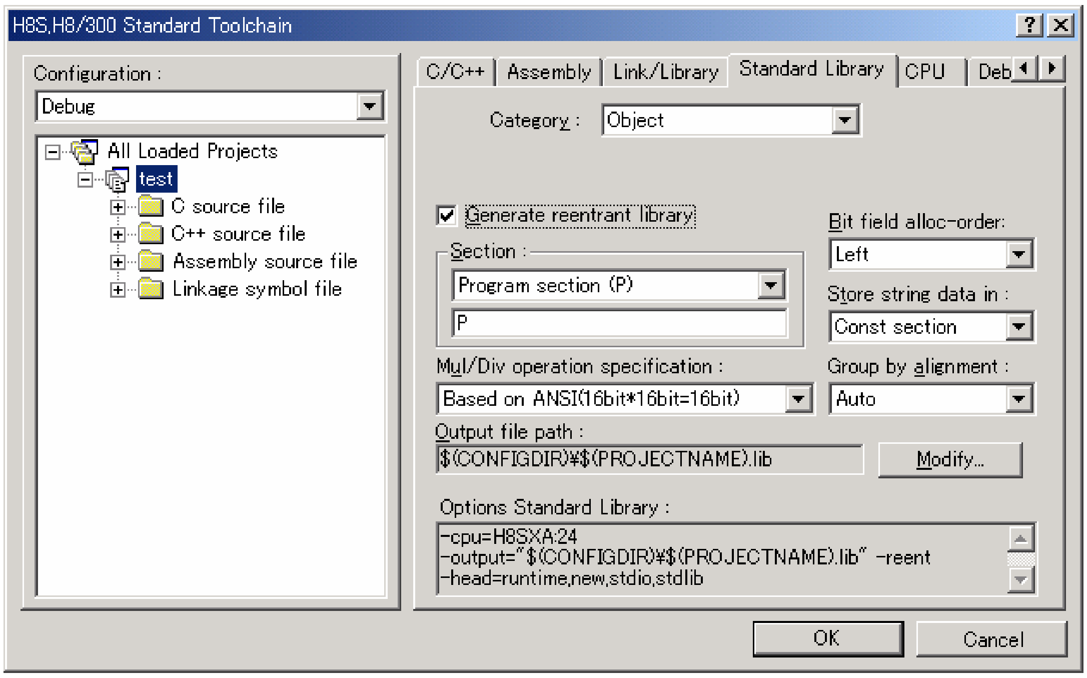
Question

I would like to use reentrant library function in standard library file.

Answer

There are reentrant function lists on [11.3.1 reentrant library]. Reentrant function can be generated by setting of library generator in H8C V6.0 or later.

- On command line, use the lbg38 -reent option.
- The setting in the HEW is shown below.



Configuration : Debug
Category : Object
☑ Generate reentrant library
Section : Program section (P)
P
Bit field alloc-order: Left
Store string data in : Const section
Mul/Div operation specification : Based on ANSI(16bit*16bit=16bit)
Group by alignment : Auto
Output file path : $(CONFIGDIR)¥$(PROJECTNAME).lib
Options Standard Library :

```
-cpu=H8SXA:24
-output="$(CONFIGDIR)¥$(PROJECTNAME).lib" -reent
-head=runtime,new,stdio,stdlib
```

Standard Library Dialog Box

11.3.3 There Is No Standard Library File (H8C V4 or Later)

Question

There are several kinds of standard libraries in H8C V3.

But there is no standard library file in H8C V4 or later.

Answer

Since H8C V4, the specification of the standard library was changed, and the options became to be able to be specified. This enabled the user to have the standard libraries tuned by the options.

Please generate a standard library file by using a library generator since a standard library file has not been attached to a product in H8C V4 or later.

11.3.4 Warning Message On Building Standard Library

Question

[L1200(W) Backed up file "a.lib" into "b.lbk"] may be output when generate a standard library file.

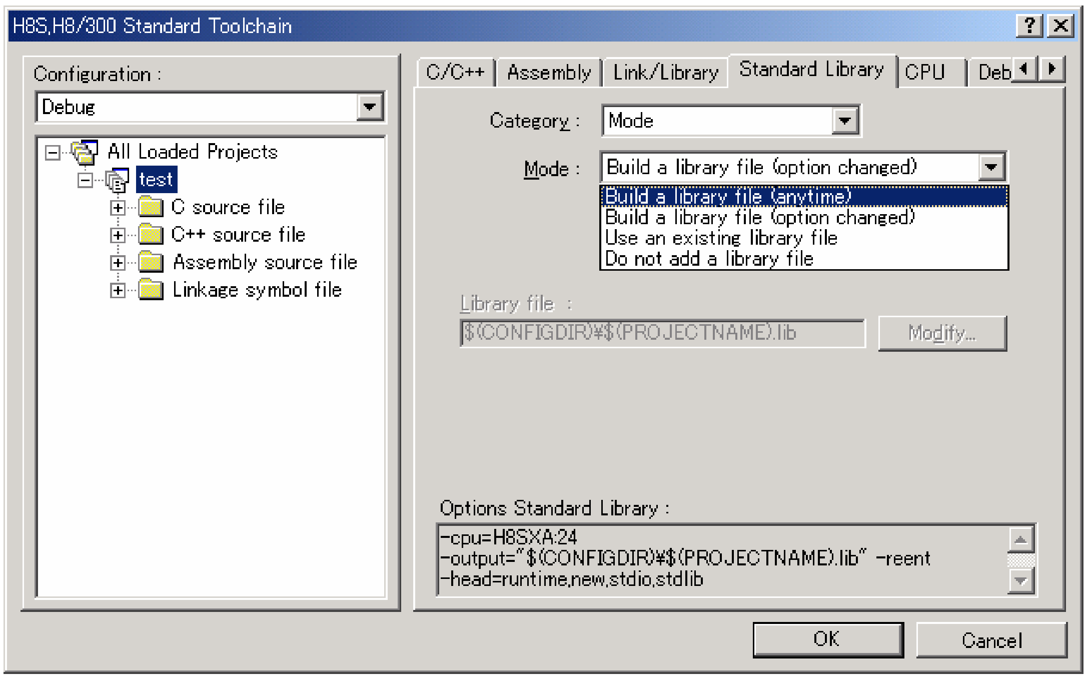
Answer

This is just warning message which HEW will make backup files when it generates new library files.

If you select "Use an existing library file" at [Standard Library] mode: in HEW/[OPTIONS]/[H8S,H8 Standard Toolchain…], the warning will not be issued. When you select "BUILD ALL" in HEW, Linkage editor generates a standard library at first. For the first project you created, it is necessary to build a standard library, and so you must select the “Build a library file” in the [Standard Library] mode of the HEW/[OPTIONS]/[H8S,H8 Standard Toolchain…].

However, a standard library is already created in the file for which BUILD ALL is once specified, and so the automatic generation of a standard library is not necessary for this file. In this case, since a standard library is automatically generated for each BUILD ALL specification, the existing library is backed up.

If you select the “Use an existing library file”, this warning message can be avoided. Also, this can save the time required for automatically generating a standard libray on BUILD ALL.


H8S,H8/300 Standard Toolchain
Configuration :
Debug
All Loaded Projects
test
C source file
C++ source file
Assembly source file
Linkage symbol file
C/C++
Assembly
Link/Library
Standard Library
CPU
Deb
Category :
Mode
Mode :
Build a library file (option changed)
Build a library file (anytime)
Build a library file (option changed)
Use an existing library file
Do not add a library file
Library file :
$(CONFIGDIR)¥$(PROJECTNAME).lib
Modify...
Options Standard Library :
OK
Cancel

```
-cpu=H8SXA:24
-output="$(CONFIGDIR)¥$(PROJECTNAME).lib" -reent
-head=runtime,new,stdio,stdlib
```

Standard Library Dialog Box

11.3.5 Size of Memory Used as Heap

Question

Tell me how to calculate the size of the memory used as heap.

Answer

The size of the memory used as heap is the total of memory areas assigned by the memory management library functions (calloc, malloc, ralloc, new) in a C/C++ program. However, these functions use four bytes as management area each time they are called. Calculate the heap size by adding this size to the size of the actually assigned area.

The compiler manages the heap in 1024 byte unit. Calculate the size of the area allocated as heap (HEAPSIZE) as follows:

HEAPSIZE = 1024 x n (n ≥ 1)

(area size allocated by memory management library) + (Management area size ≤ HEAPSIZE)

The I/O library functions use the memory management library functions in internal processing. The size of the area allocated during I/O is 516 bytes x maximum number of concurrently open files.

Note: The area freed by the memory management library function free or delete is reused by a memory management library function for allocation. Even if the total size of the free area is sufficient, repeating allocations causes the free area to be divided into smaller ones, making the allocation of newly requested large areas impossible. To prevent this situation, use the heap area according to following suggestions.
a. Large sized areas should be allocated immediately after the program starts to run.
b. The size of the data area to be freed and reused should be constant.

11.3.6 How to Reduce ROM Size for I/O Libraries

Question

How can I reduce the ROM size of the I/O library for standard include files?

Answer

When the no_float.h include file is specified, simple I/O functions including no floating-point conversion process can be used.

This specification is available for the following functions:

fprintf, fscanf, printf, scanf, sprintf, sscanf, vfprintf, vprintf, vsprintf

Add the option no_float.h to specify a file as an include file before the standard I/O file stdio.h.

Example:

```
#include <no_float.h>

#include <stdio.h>
void main(void)
{
    printf("HELLO¥n");
}
```

Macro declaration

For a file using an existent standard I/O library, use the preinclude option.

When simple I/O functions are used, the ROM size is reduced when the I/O operations of files are performed.

However, if this option is specified together with a floating-point (%f, %e, %E, %g,%E) specification, the runtime execution is not guaranteed.

11.3.7 How to Edit Library File

Question

How can I edit the library file to reuse existing library files?

Answer

It can be edited by specifying options in the Optimizing Linkage Editor. The usage of the options is shown below.

There is H Series Librarian Interface which can startup the Optimizing Linkage Editor from GUI.

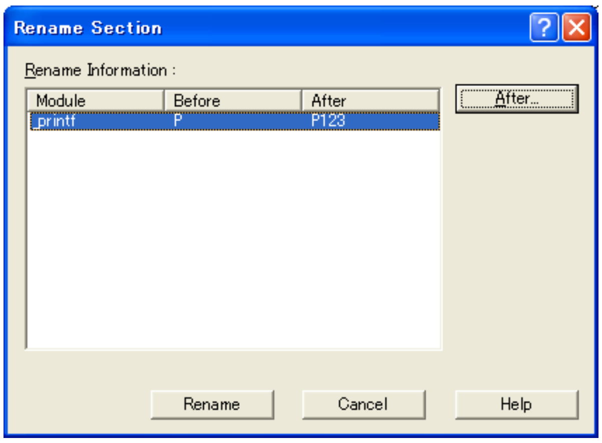
How to startup H Series Librarian Interface

Select [Tools->Hitachi H Series Librarian Interface] in HEW, to startup H Series Librarian Interface.

(A) Modify Section Name of Module in Library

The section name of the specified module in library can be modified, to locate the section into any address.

(1) Open library, and select module to assign into any address.
(2) Display the following dialog by [Action->Rename Section…], and modify section name by **After** button



Module	Before	After
_printf	P	P123

Command line: optlnk –lib=<Library File Name> -rename=<Module Name in Library>(P=P123)

(B) Replace Module in Library/Add Module to Library

The module in library can be replaced. New module can be added to library.

(1) Open library, and select [Action->Add/Replace…].
(2) Open module with same name to replace. Open module with new name to add.

Command line: optlnk –lib=<Library File Name> -replace=<Module Name in Library>

(C) Delete Module in Library

The module in library can be deleted.

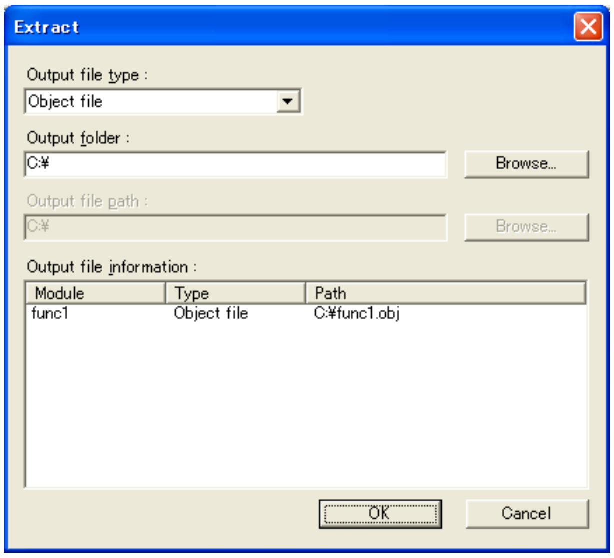
(1) Open library, and select module to delete. (multiple select available)
(2) Display **Delete** dialog by [Action->Delete…], and push **Delete** button.

Command line: optlnk –lib=<Library File Name> -delete=<Module Name in Library>

(D) Extract Module in Library

The module in library can be extracted.

(1) Open library, and select module to extract. (multiple select available)
(2) Display the following dialog by [Action->Extract…], specify **Output folder**, and push OK button.
(3) Then the specified modules are output to the specified **Output folder**. (C: \ in the following example)



Output file type : Object file

Output folder : C:¥

Output file path : C:¥

Output file information :

Module	Type	Path
func1	Object file	C:¥func1.obj

Command line: optlnk –lib=<Library File Name> -extract=<Module Name in Library> -form=<Output File Type>

Here, Output file type is object in this example.

11.4 HEW

11.4.1 Failure to Display Dialog Menu

Question

Tool option dialog boxes are not displayed correctly with the HEW.

Answer

If an old release (such as 400.950a) of Windows®95 is used, an application error occurs when options in the C/C++ compiler, the Assembler, or the IM OptLinker are opened, and the HEW may aborts the operation abnormally or option dialog boxes may not be displayed correctly. This problem is caused when the version of the COMCTL32.DLL file that is located in the System directory of the Windows directory is too old. In this case, upgrade the Windows®95.

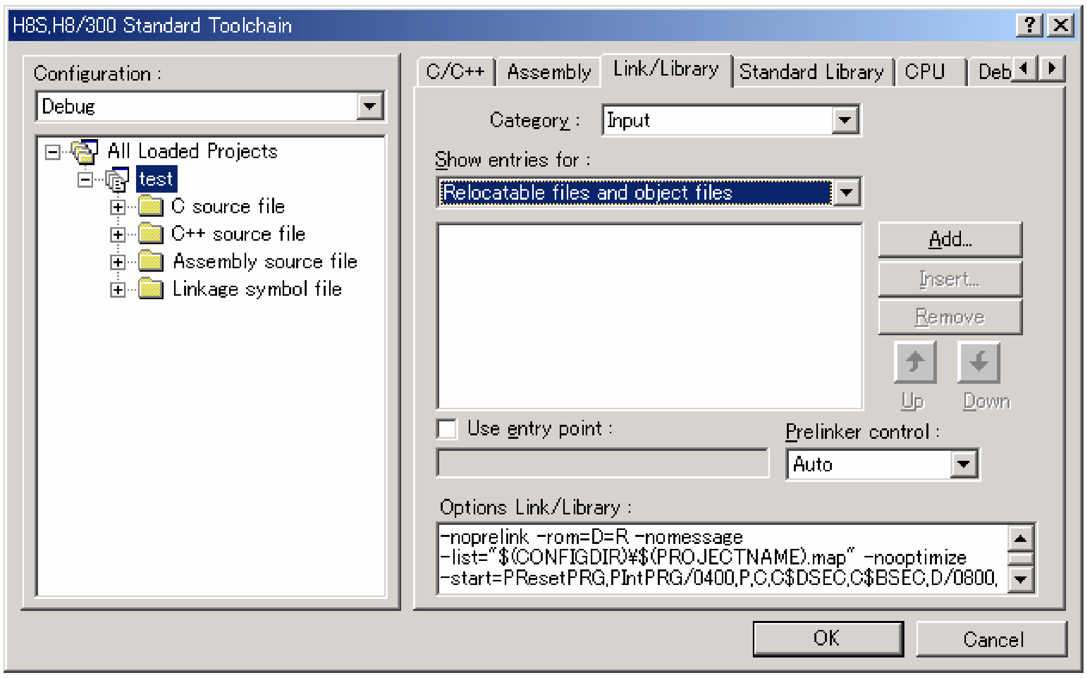
11.4.2 Linkage Order of Object Files

Question

I would like to specify an order of link of an object file on HEW.

Answer

Please add an object file by pushing [Add] and select the Show entry for: [Relocatable files and object files] from the category [Input] in the Link/Library tab of the H8S,H8 Standard Toolchain…. An object is linked in order specified in this time.



Configuration : Debug

All Loaded Projects
test
C source file
C++ source file
Assembly source file
Linkage symbol file

Category : Input

Show entries for : Relocatable files and object files

Use entry point :

Prelinker control : Auto

Options Link/Library :

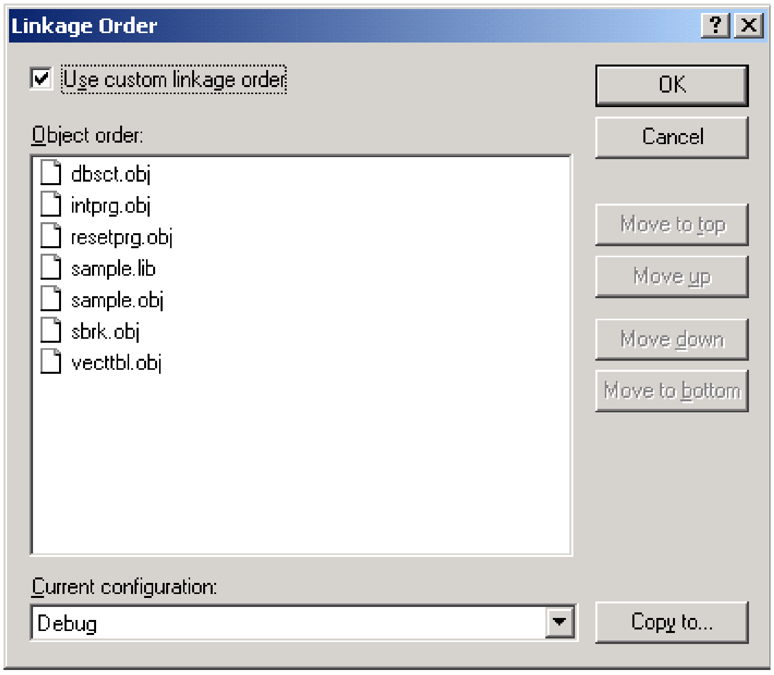
```
-noprelink -rom=D=R -nomessage
-list="$(CONFIGDIR)¥$(PROJECTNAME).map" -nooptimize
-start=PResetPRG,PIntPRG/0400,P,C,C$DSEC,C$BSEC,D/0800,
```

Link/Library Dialog Box

H8C V.6.00Release02 or later eases specifying the link order.

To display the dialog box for customizing the link order, choose [Build], and then [Specify link order].

Here, specify the link order. The items higher on the list are linked first.



Linkage Order

[✓] Use custom linkage order

Object order:

- dbsct.obj
- intprg.obj
- resetprg.obj
- sample.lib
- sample.obj
- sbrk.obj
- vecttbl.obj

Current configuration: Debug

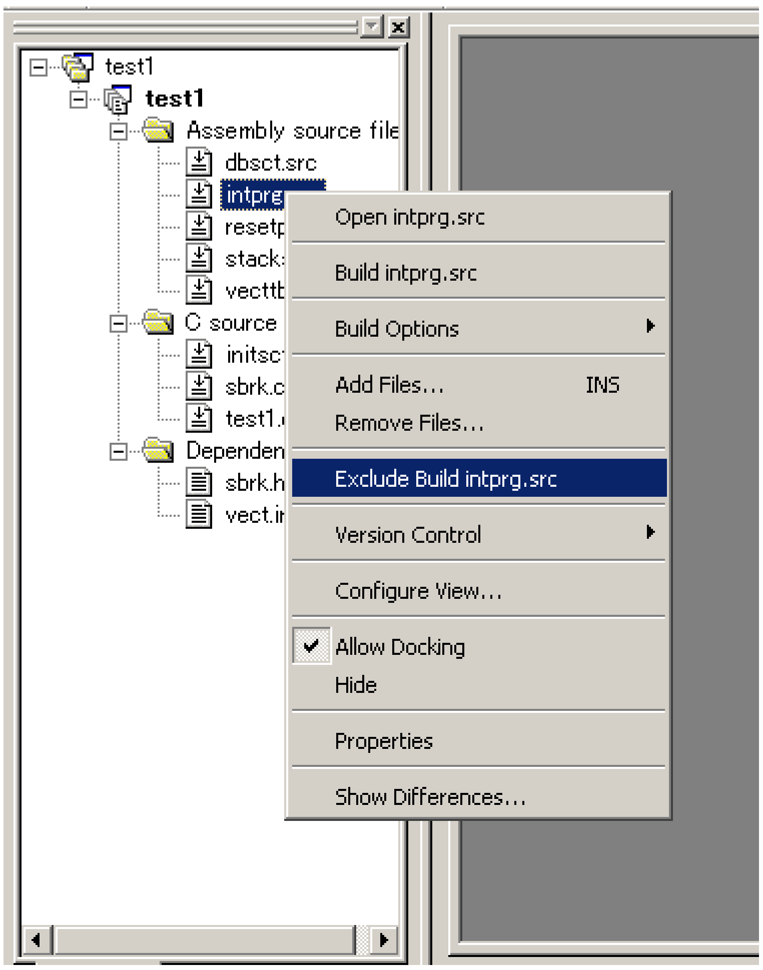
11.4.3 Excluding a Project File

Question

I would like to eliminate a project file from Build temporarily.

Answer

The file is eliminated from Build if choose [Exclude Build <file>] by pressing a right button of mouse onto the file of "Projects" tab on work space window. If sending a file back to Build again, please choose [Include Build <file>] by pressing a right button of mouse on the file of "Projects" tab on work space window.



Exclude Build Menu

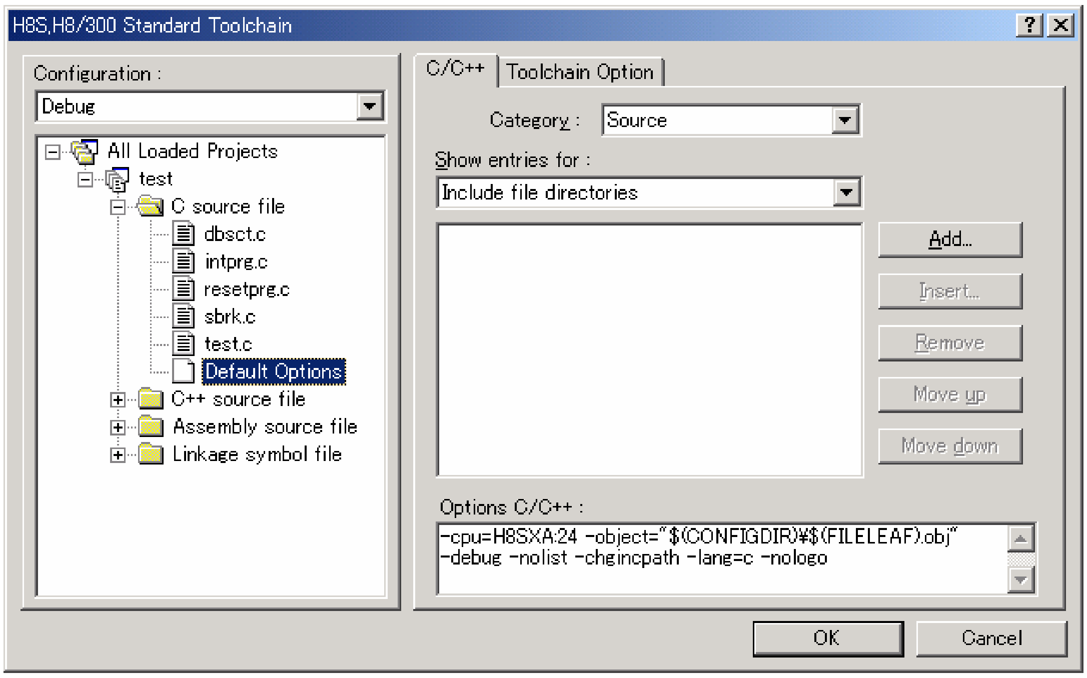
11.4.4 Specifying the Default Options for Project Files

Question

I would like to automatically specify a default option into file when adding a project into file.

Answer

The list of files is displayed on the left of the H8S, H8 Standard Toolchain (see the figure below). Please open the folder in file group in which Default Option is to be specified by the file list. "Default Options" icon is displayed in the folder. Please choose an icon and click "OK" by specifying an option in the right side of an option dialog box. This option can be applied when a file of the file group is first added to the project.



```
-cpu=H8SXA:24 -object="$(CONFIGDIR)¥$(FILELEAF).obj"
-debug -nolist -chgincpath -lang=c -nologo
```

Degault Options

11.4.5 Changing Memory Map

Question

A memory map can not be changed.

Answer

When a memory source of the memory window has been mapped, a memory map can not be changed in the system configuration window. Please change a memory map after mapping of a memory resource was released.

11.4.6 How to Use HEW on Network

Question

(1) Can the HEW be installed on a network?

(2) Can projects and programs be installed on a network?

Answer

(1) The HEW system itself cannot be installed on a network.

(2) No problem. Be careful not to access a single file by plural users.

11.4.7 Limitations on File and Directory Names Created in HEW

Question

The message ”Error has occurred whilst saving file <filename>” is displayed at the HEW system startup. Why is it?

Answer

Files and directories created on the HEW system have limitations.

For the specifications of the following items, only half-width alphanumeric characters and half-width underlines can be used:

- Names of the directories to be installed
- Names of the directories in which projects are to be created
- Project names

11.4.8 Failure of Japanese Font Display with the HEW Editor or HDI

Question

(1) Japanese fonts are not displayed with the HEW editor.

(2) Japanese characters are rotated 90 degrees with the HEW editor.

(3) The inter-module optimizer generates SYNTAX ERROR messages.

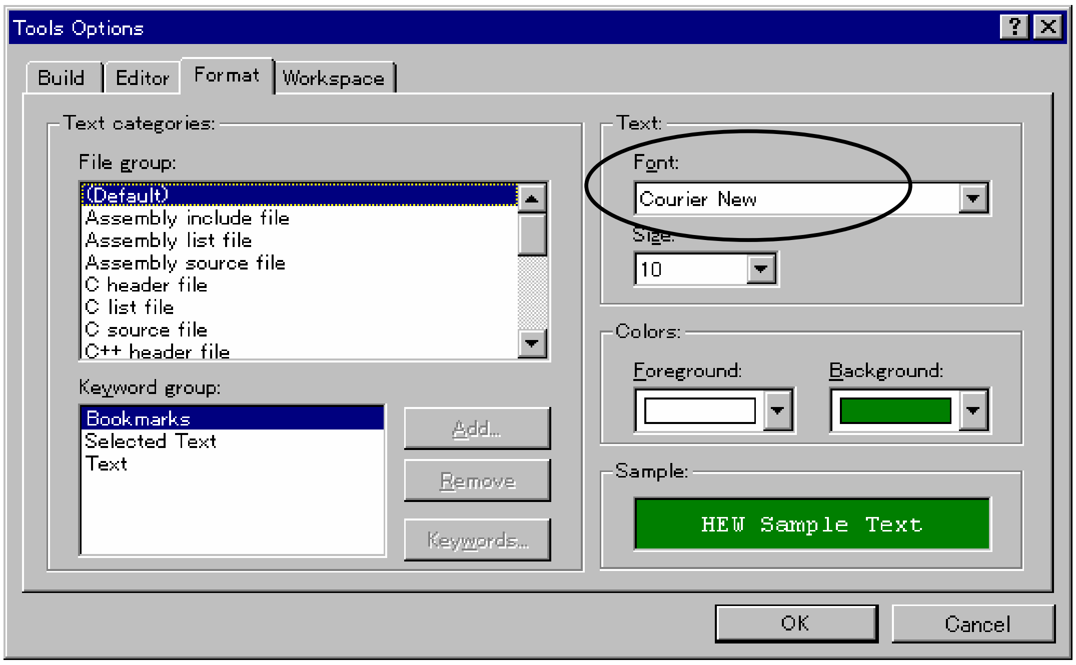
Answer

When coding Japanese with the HEW editor, specify Japanese font as follows:

Use **Font** in the **Text** column of the **Format** tab in Tools->Options:

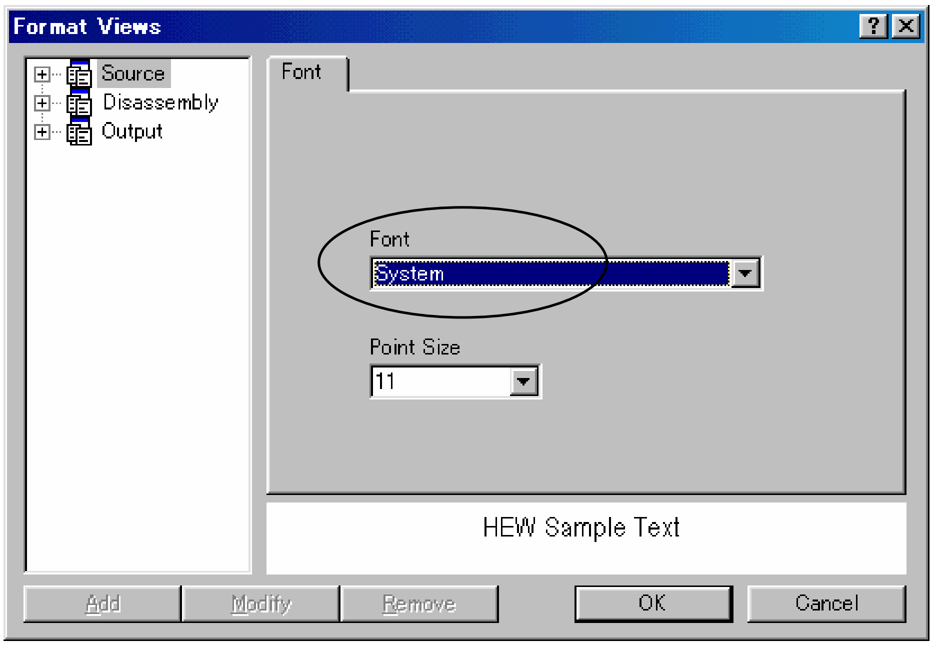
<HEW1.2>

Use Font in the **Text** column of the **Format** tab in Tools->Options:



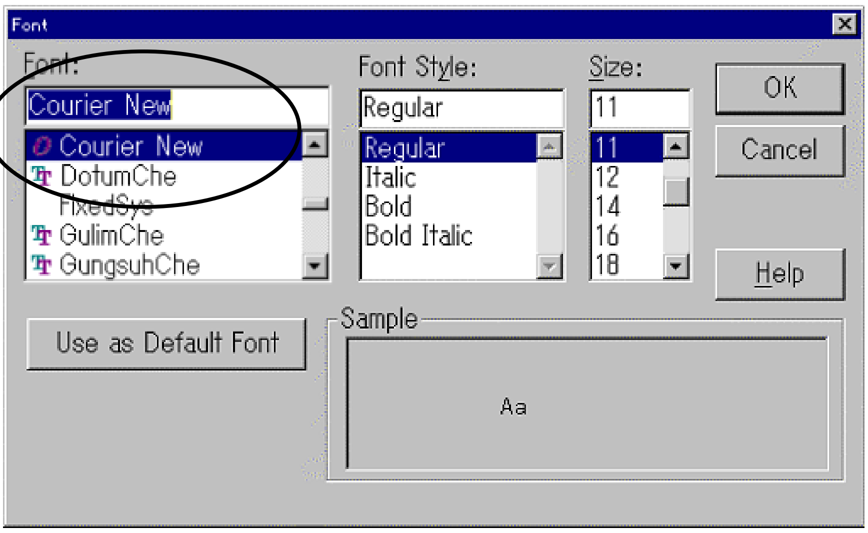
<HEW2.0 or later>

Use **Font** of the **Font** tab in Tools-> Format Views.:



If Japanese fonts are not correctly displayed with the HDI, modify as follows:

[Setup->Customize->Font…]



11.4.9 How to Convert Programs from HIM to HEW

Question

How can I use a project created under HIM (Hitachi Integration Manager) on the HEW?

Answer

Projects can be converted from HIM to HEW using a tool called " HIM To HEW Project Converter” that is supplied with the HEW system.

11.4.10 I Want to Use an Old Compiler (Tool Chain) in the Latest HEW.

Question

I have an old compiler package. When I bought an Emulator, new HEW was bundled.

In order to Build and Debug with new HEW, I want to use an old tool chain in the new HEW.

Can I do that?

Answer

It depends on the version of the compiler package you are using. See below.

[H8C V.3.0]

< Build >

The tool chain cannot be registered in the latest HEW. Therefore, building by new HEW is not available.

(Note)

"HIM to HEW Project Converter" is usable if you have H8C V.3.0A compiler package.

By using this tool, you can convert HIM project into HEW project. You can use H8C V.3.0A with new HEW after conversion.

< Debug >

Absolute file (*.abs) cannot be used. You can only use S-type format file.

Moreover, debugging program at C source level is not available. Only at assembler level is available.

[H8C V.3.0A]

< Build >

The tool chain can be registered in the latest HEW. Therefore, building by new HEW is available.

But you cannot create new project with the latest HEW.

In case of creating new project, you must use HEW V.1 bundled with the older compiler package.

Once you create project by HEW V.1, you can open it with in new HEW.

< Debug >

Absolute file (*.abs) cannot be used. You can only use S-type format file.

Moreover, debugging program at C source level is not available. Only at assembler level is available.

[H8C V.4]

< Build >

The tool chain can be registered in the latest HEW. Therefore, building by new HEW is available.

But you cannot create new project with the latest HEW.

In case of creating new project, you must use HEW V.1 bundled with the older compiler package.

Once you create project by HEW V.1, you can open it in new HEW.

< Debug >

Absolute file (*.abs) can be used.

By registering absolute file, debugging at C source level is available.

[H8C V.5 or later]

<Build & Debug>

There is no limitation. You can use all functions of new HEW.

Appendix A Lists of Floating-Point Arithmetic Operation Performance

A. Floating-Point Operation Performance

A.1 Single-Precision Floating-Point Operation Performance

A.1.1 Single-Precision Floating-Point Operation Performance (H8/300,H8/300H,H8S/2600)

					H8/300H		H8S/2000,H8S/2600	
No.	Function	Parameter 1	Parameter 2	H8/300	NRM	ADV	NRM	ADV
1	acos	0.4	-	30,850	23,316	25,636	8,495	8,852
		1.57075	-	3,830	3,022	3,484	930	999
		0.6	-	30,864	23,226	25,546	8,450	8,806
		-0.4	-	30,918	23,302	25,622	8,496	8,853
2	asin	0.4	-	29,840	22,390	24,576	8,158	8,494
		1.57075	-	2,904	2,194	2,522	642	690
		0.6	-	29,850	22,310	24,496	8,118	8,453
		-0.4	-	29,926	22,402	24,588	8,172	8,508
3	atan	0.11	-	13,166	9,948	11,010	3,581	3,767
		0.27	-	18,122	14,302	15,718	5,269	5,502
		0.547	-	17,964	14,128	15,544	5,179	5,412
		0.777	-	18,890	14,820	16,270	5,436	5,672
		0.975	-	17,924	14,210	15,582	5,277	5,502
		54.45	-	21,834	17,744	19,390	6,659	6,922
		154.233	-	21,952	17,840	19,486	6,707	6,970
		-54.45	-	21,920	17,754	19,400	6,672	6,935
		-0.975	-	18,010	14,220	15,592	5,290	5,515
		-0.777	-	18,976	14,830	16,280	5,449	5,685
4	atan2	0.3	0.7	20,898	16,758	18,494	6,182	6,441
		0.2	0.1	24,736	20,204	22,214	7,523	7,820
		0.1	0.9	16,156	12,648	14,030	4,619	4,831
5	cos	0.523333333	-	11,124	8,148	8,780	3,114	3,262
		1.046666667	-	13,090	9,610	10,506	3,588	3,757
		1.9625	-	12,420	9,024	9,842	3,404	3,562
		2.7475	-	12,074	8,932	9,642	3,398	3,557
		3.5325	-	11,332	8,284	8,916	3,183	3,331
		4.3175	-	13,184	9,748	10,644	3,656	3,825
		5.1025	-	12,462	9,114	9,932	3,448	3,606
		5.8875	-	12,050	8,960	9,670	3,411	3,570
		-0.52333333	-	11,210	8,158	8,790	3,127	3,275
		-1.04666667	-	13,176	9,620	10,516	3,601	3,770

					H8/300H		H8S/2000,H8S/2600	
No.	Function	Parameter 1	Parameter 2	H8/300	NRM	ADV	NRM	ADV
5	cos	-1.9625	-	12,506	9,034	9,852	3,417	3,575
		-2.7475	-	12,160	8,942	9,652	3,411	3,570
		-3.5325	-	11,418	8,294	8,926	3,196	3,344
		-4.3175	-	13,270	9,758	10,654	3,669	3,838
		-5.1025	-	12,548	9,124	9,942	3,461	3,619
		-5.8875	-	12,136	8,970	9,680	3,424	3,583
6	sin	0.523333333	-	12,170	8,838	9,656	3,314	3,472
		1.046666667	-	11,942	8,872	9,582	3,373	3,532
		1.9625	-	11,196	8,202	8,834	3,147	3,295
		2.7475	-	13,240	9,764	10,660	3,671	3,840
		3.5325	-	12,482	9,060	9,878	3,428	3,586
		4.3175	-	12,120	8,954	9,664	3,415	3,574
		5.1025	-	11,382	8,312	8,944	3,203	3,351
		5.8875	-	13,204	9,776	10,672	3,674	3,843
		-0.52333333	-	12,348	8,876	9,694	3,342	3,500
		-1.04666667	-	12,120	8,910	9,620	3,401	3,560
		-1.9625	-	11,374	8,240	8,872	3,175	3,323
		-2.7475	-	13,418	9,802	10,698	3,699	3,868
		-3.5325	-	12,660	9,098	9,916	3,456	3,614
		-4.3175	-	12,298	8,992	9,702	3,443	3,602
		-5.1025	-	11,560	8,350	8,982	3,231	3,379
		-5.8875	-	13,382	9,814	10,710	3,702	3,871
7	tan	0.3925	-	16,682	12,494	13,374	4,768	4,997
		1.1775	-	17,522	13,240	14,198	5,055	5,276
		1.9625	-	16,908	12,634	13,514	4,863	5,074
		2.7475	-	17,696	13,344	14,302	5,111	5,332
8	cosh	0.33	-	44,886	33,624	35,796	13,237	13,735
		0.78	-	46,018	34,462	36,646	13,354	13,864
		-0.33	-	44,904	33,636	35,808	13,243	13,741
		-0.78	-	46,036	34,474	36,658	13,360	13,870
9	sinh	0.33	-	12,538	9,004	9,660	3,375	3,520
		0.98	-	47,040	35,310	37,568	13,689	14,209
		-0.33	-	12,538	9,004	9,660	3,375	3,520
		-0.98	-	47,058	35,322	37,580	13,695	14,215
10	tanh	0.0033+00	-	9,772	7,102	7,710	2,553	2,672
11	exp	0.33	-	21,860	16,184	17,180	6,471	6,713
		0.98	-	22,588	16,740	17,742	6,598	6,846
		-0.33	-	21,980	16,212	17,208	6,485	6,727
		-0.98	-	22,684	16,732	17,734	6,594	6,842

					H8/300H		H8S/2000,H8S/2600	
No.	**Function**	**Parameter 1**	**Parameter 2**	**H8/300**	**NRM**	**ADV**	**NRM**	**ADV**
12	frexp	0.3	-	186	102	118	54	60
		400	-	186	102	118	54	60
13	ldexp	0.3	30	1,382	964	1,068	316	337
		0.1	100	1,382	964	1,068	316	337
14	log	1.2	-	18,766	14,272	15,410	5,353	5,575
		2.5	-	18,882	14,476	15,614	5,455	5,677
		0.999	-	19,376	14,996	16,134	5,715	5,937
		0.3	-	19,016	14,604	15,742	5,519	5,741
15	log10	1.2	-	20,138	15,260	16,532	5,686	5,929
		2.5	-	20,254	15,464	16,736	5,788	6,031
		0.999	-	20,764	16,008	17,280	6,060	6,303
		0.3	-	20,372	15,572	16,844	5,482	6,085
16	modf	256.3	-	3,518	2,890	3,388	914	975
		0.032	-	3,342	2,760	3,252	850	908
		10000.2345	-	3,608	2,962	3,460	950	1,011
17	pow	2.3	4.2	43,236	33,010	35,340	12,577	13,074
		45.2	-5	43,642	33,412	35,742	12,789	13,286
		-4.56	-3	47,134	36,326	39,066	13,678	14,231
		-85.55	476	45,988	35,406	38,064	13,360	13,904
18	sqrt	2	-	4,918	1,878	1,980	829	852
		3	-	4,966	1,910	2,012	845	868
		0.1	-	4,906	1,890	1,992	835	858
19	ceil	0.3	-	2,998	2,452	2,790	749	801
		-0.6	-	1,806	1,314	1,502	393	426
20	fabs	5	-	126	38	40	24	27
		-5	-	126	38	40	24	27
21	floor	0.3	-	1,806	1,314	1,502	393	426
		-0.6	-	2,998	2,446	2,784	746	798
22	fmod	11.1	3.2	1,964	1,498	1,654	533	564
		500.55	0.4	2,436	1,858	2,014	713	744
		1.05E+06	9.54E-07	4,178	3,186	3,342	1,377	1,408

A.1.2 Single-Precision Floating-Point Operation Performance (H8SX)

				H8SX		
No.	**Function**	**Parameter 1**	**Parameter 2**	**NRM**	**ADV**	**MAX**
1	acos	0.4	-	6,108	6,403	6,397
		1.57075	-	495	438	438
		0.6	-	6,079	6,373	6,368
		-0.4	-	6,100	6,396	6,390
2	asin	0.4	-	5,880	6,219	6,220
		1.57075	-	340	309	309
		0.6	-	5,885	6,195	6,196
		-0.4	-	5,884	6,225	6,226
3	atan	0.11	-	2,167	2,550	2,549
		0.27	-	3,542	4,012	4,011
		0.547	-	3,449	3,919	3,918
		0.777	-	3,643	4,122	4,121
		0.975	-	3,595	4,055	4,054
		54.45	-	4,769	5,308	5,307
		154.233	-	4,828	5,368	5,367
		-54.45	-	4,773	5,314	5,313
		-0.975	-	3,599	4,061	4,060
		-0.777	-	3,647	4,128	4,127
4	atan2	0.3	0.7	4,370	4,811	4,806
		0.2	0.1	5,570	6,088	6,085
		0.1	0.9	3,146	3,497	3,493
5	cos	0.523333333	-	2,039	2,347	2,349
		1.046666667	-	2,229	2,658	2,660
		1.9625	-	2,208	2,543	2,547
		2.7475	-	2,222	2,552	2,556
		3.5325	-	2,201	2,408	2,411
		4.3175	-	2,371	2,732	2,737
		5.1025	-	2,256	2,593	2,597
		5.8875	-	2,240	2,572	2,576
		-0.52333333	-	2,045	2,351	2,353
		-1.04666667	-	2,305	2,662	2,664
		-1.9625	-	2,214	2,547	2,551
		-2.7475	-	2,228	2,556	2,560
		-3.5325	-	2,108	2,412	2,415
		-4.3175	-	2,377	2,736	2,741
		-5.1025	-	2,262	2,597	2,601
		-5.8875	-	2,246	2,576	2,580

				H8SX		
No.	**Function**	**Parameter 1**	**Parameter 2**	**NRM**	**ADV**	**MAX**
6	sin	0.523333333	-	2,385	2,459	2,460
		1.046666667	-	2,464	2,537	2,539
		1.9625	-	2,308	2,377	2,380
		2.7475	-	2,650	2,728	2,733
		3.5325	-	2,497	2,571	2,575
		4.3175	-	2,501	2,574	2,578
		5.1025	-	2,361	2,430	2,433
		5.8875	-	2,663	2,741	2,746
		-0.52333333	-	2,397	2,468	2,469
		-1.04666667	-	2,476	2,546	2,548
		-1.9625	-	2,320	2,386	2,389
		-2.7475	-	2,662	2,737	2,742
		-3.5325	-	2,509	2,580	2,584
		-4.3175	-	2,513	2,583	2,587
		-5.1025	-	2,373	2,439	2,442
		-5.8875	-	2,675	2,750	2,755
7	tan	0.3925	-	3,366	3,775	3,771
		1.1775	-	3,566	4,000	3,996
		1.9625	-	3,448	3,854	3,850
		2.7475	-	3,609	4,040	4,036
8	cosh	0.33	-	10,276	9,214	9,214
		0.78	-	10,294	9,237	9,237
		-0.33	-	10,272	9,219	9,219
		-0.78	-	10,299	9,242	9,242
9	sinh	0.33	-	2,413	2,110	2,110
		0.98	-	10,623	9,548	9,548
		-0.33	-	2,413	2,110	2,110
		-0.98	-	10,628	9,553	9,553
10	tanh	0.0033+00	-	1,604	1,553	1,552
11	exp	0.33	-	5,110	4,564	4,556
		0.98	-	5,215	4,667	4,663
		-0.33	-	5,116	4,570	4,562
		-0.98	-	5,221	4,673	4,669
12	frexp	0.3	-	41	42	42
		400	-	41	42	42
13	ldexp	0.3	30	220	196	196
		0.1	100	220	196	196

				H8SX		
No.	**Function**	**Parameter 1**	**Parameter 2**	**NRM**	**ADV**	**MAX**
14	log	1.2	-	3,706	3,573	3,573
		2.5	-	3,770	3,636	3,636
		0.999	-	4,058	3,924	3,924
		0.3	-	3,858	3,724	3,724
15	log10	1.2	-	3,884	3,754	3,755
		2.5	-	3,948	3,818	3,818
		0.999	-	4,245	4,115	4,115
		0.3	-	4,029	3,889	3,899
16	modf	256.3	-	535	514	514
		0.032	-	469	450	450
		10000.2345	-	571	550	550
17	pow	2.3	4.2	9,338	8,626	8,634
		45.2	-5	9,492	8,780	8,795
		-4.56	-3	10,016	9,242	9,254
		-85.55	476	9,783	9,033	9,053
18	sqrt	2	-	885	859	859
		3	-	893	867	867
		0.1	-	889	863	863
19	ceil	0.3	-	446	390	390
		-0.6	-	246	215	215
20	fabs	5	-	21	21	21
		-5	-	21	21	21
21	floor	0.3	-	246	215	215
		-0.6	-	445	393	393
22	fmod	11.1	3.2	367	413	415
		500.55	0.4	581	627	629
		1.05E+06	9.54E-07	1,388	1,434	1,436

A.2 Double-Precision Floating-Point Operation Performance

A.2.1 Double-Precision Floating-Point Operation Performance (H8/300,H8/300H,H8S/2600)

					H8/300H		H8S/2000,H8S/2600	
No.	Function	Parameter 1	Parameter 2	H8/300	NRM	ADV	NRM	ADV
1	acos	0.4	-	88,070	44,762	47,294	20,277	21,016
		1.57075	-	4,646	3,786	4,284	1,814	1,994
		0.6	-	88,396	44,974	47,506	20,383	21,121
		-0.4	-	88,114	44,730	47,262	20,269	21,008
2	asin	0.4	-	86,796	43,666	46,062	19,681	20,369
		1.57075	-	3,542	2,834	3,196	1,290	1,419
		0.6	-	87,104	43,862	46,258	19,779	20,466
		-0.4	-	86,882	43,678	46,074	19,695	20,383
3	atan	0.11	-	29,172	18,570	19,780	7,784	8,156
		0.27	-	41,948	25,560	27,142	11,126	11,590
		0.547	-	41,590	25,512	27,094	11,099	11,563
		0.777	-	43,906	26,862	28,484	11,640	12,114
		0.975	-	41,862	25,714	27,250	11,218	11,669
		54.45	-	53,282	30,720	32,546	13,589	14,113
		154.233	-	53,626	31,070	32,896	13,764	14,288
		-54.45	-	53,368	30,730	32,556	13,602	14,126
		-0.975	-	41,948	25,724	27,260	11,231	11,682
		-0.777	-	43,992	26,872	28,494	11,653	12,127
4	atan2	0.3	0.7	51,604	29,210	31,122	12,919	13,457
		0.2	0.1	62,958	34,532	36,734	15,451	16,062
		0.1	0.9	39,414	22,708	24,248	9,824	10,270
5	cos	0.523333333	-	24,152	15,346	16,078	6,412	6,681
		1.046666667	-	27,734	17,718	18,730	7,411	7,723
		1.9625	-	26,848	17,014	17,944	7,091	7,382
		2.7475	-	25,478	16,430	17,244	6,922	7,212
		3.5325	-	24,488	15,598	16,330	6,538	6,807
		4.3175	-	27,984	17,876	18,888	7,489	7,801
		5.1025	-	26,982	17,064	17,994	7,115	7,406
		5.8875	-	25,488	16,446	17,260	6,930	7,220
		-0.52333333	-	24,238	15,350	16,082	6,422	6,691
		-1.04666667	-	27,796	17,728	18,740	7,424	7,736
		-1.9625	-	26,934	17,024	17,954	7,104	7,395
		-2.7475	-	25,564	16,440	17,254	6,935	7,225
		-3.5325	-	24,574	15,608	16,340	6,551	6,820
		-4.3175	-	28,070	17,886	18,898	7,502	7,814

					H8/300H		H8S/2000,H8S/2600	
No.	**Function**	**Parameter 1**	**Parameter 2**	**H8/300**	**NRM**	**ADV**	**NRM**	**ADV**
5	cos	-5.1025	-	27,068	17,074	18,004	7,128	7,419
		-5.8875	-	25,574	16,456	17,270	6,943	7,233
6	sin	0.523333333	-	26,522	16,820	17,750	7,000	7,289
		1.046666667	-	25,278	16,214	17,028	6,821	7,109
		1.9625	-	24,278	15,556	16,288	6,524	6,791
		2.7475	-	27,926	17,840	18,852	7,480	7,790
		3.5325	-	26,960	17,002	17,932	7,093	7,382
		4.3175	-	25,590	16,472	17,286	6,951	7,239
		5.1025	-	24,636	15,712	16,444	6,603	6,870
		5.8875	-	27,988	17,908	18,920	7,512	7,822
		-0.52333333	-	26,700	16,858	17,788	7,028	7,317
		-1.04666667	-	25,480	16,300	17,114	6,873	7,161
		-1.9625	-	24,456	15,594	16,326	6,552	6,819
		-2.7475	-	28,104	17,878	18,890	7,508	7,818
		-3.5325	-	27,138	17,040	17,970	7,121	7,410
		-4.3175	-	25,768	16,510	17,324	6,979	7,267
		-5.1025	-	24,814	15,750	16,482	6,631	6,898
		-5.8875	-	28,166	17,946	18,958	7,540	7,850
7	tan	0.3925	-	38,230	21,734	22,712	9,149	9,483
		1.1775	-	39,408	22,136	23,196	9,323	9,677
		1.9625	-	38,490	21,456	22,434	9,017	9,357
		2.7475	-	39,672	22,672	23,732	9,595	9,955
8	cosh	0.33	-	99,902	56,136	58,518	23,476	24,258
		0.78	-	101,046	57,590	59,980	24,901	24,693
		-0.33	-	99,920	56,140	58,522	23,478	24,260
		-0.78	-	101,064	57,594	59,984	23,903	24,695
9	sinh	0.33	-	28,064	17,778	18,546	7,269	7,535
		0.98	-	102,482	57,370	59,838	23,765	24,586
		-0.33	-	28,064	17,778	18,546	7,269	7,535
		-0.98	-	102,500	57,374	59,842	23,765	24,588
10	tanh	0.0033+00	-	109,818	63,362	66,024	26,975	27,838
11	exp	0.33	-	49,318	27,448	28,558	11,505	11,886
		0.98	-	50,186	27,746	28,860	11,503	11,889
		-0.33	-	49,428	27,556	28,666	11,559	11,940
		-0.98	-	50,288	27,782	28,896	11,521	11,907
12	frexp	0.3	-	290	246	274	134	147
		400	-	290	246	274	134	147
13	ldexp	0.3	30	1,792	1,436	1,576	659	721
		0.1	100	1,792	1,436	1,576	659	721

					H8/300H		H8S/2000,H8S/2600	
No.	**Function**	**Parameter 1**	**Parameter 2**	**H8/300**	**NRM**	**ADV**	**NRM**	**ADV**
14	log	1.2	-	43,214	25,574	26,854	10,931	11,341
		2.5	-	43,360	26,242	27,522	11,265	11,675
		0.999	-	44,000	25,250	26,530	10,769	11,179
		0.3	-	43,580	25,936	27,216	11,112	11,522
15	log10	1.2	-	45,900	27,160	28,580	11,654	12,117
		2.5	-	46,022	27,808	29,228	11,978	12,441
		0.999	-	46,718	26,858	28,278	11,503	11,966
		0.3	-	46,266	27,516	28,936	11,832	12,295
16	modf	256.3	-	4,458	4,044	4,484	1,795	1,945
		0.032	-	4,148	3,712	4,148	1,632	1,780
		10000.2345	-	4,434	3,898	4,338	1,722	1,872
17	pow	2.3	4.2	96,904	56,372	58,948	23,829	24,677
		45.2	-5	97,438	55,556	58,132	23,432	24,280
		-4.56	-3	101,770	59,090	62,090	24,943	25,891
		-85.55	476	100,174	59,292	62,206	25,111	26,039
18	sqrt	2	-	30,274	9,906	10,040	4,940	5,000
		3	-	30,374	9,922	10,056	4,948	5,008
		0.1	-	29,250	9,780	9,914	4,877	4,937
19	ceil	0.3	-	3,720	3,196	3,572	1,451	1,578
		-0.6	-	2,238	1,816	2,034	827	915
20	fabs	5	-	214	166	188	102	112
		-5	-	214	166	188	102	112
21	floor	0.3	-	2,238	1,816	2,034	827	915
		-0.6	-	3,720	3,190	3,566	1,448	1,575
22	fmod	11.1	3.2	2,716	2,070	2,258	1,047	1,127
		500.55	0.4	3,724	2,524	2,712	1,274	1,354
		1.05E+06	9.54E-07	7,624	3,904	4,092	1,964	2,044

A.2.2 Double-Precision Floating-Point Operation Performance (H8SX)

No.	Function	Parameter 1	Parameter 2	H8SX		
				NRM	**ADV**	**MAX**
1	acos	0.4	-	16,203	16,305	16,306
		1.57075	-	1,097	1,136	1,135
		0.6	-	16,220	16,323	16,324
		-0.4	-	16,185	16,289	16,291
2	asin	0.4	-	15,881	15,903	15,904
		1.57075	-	738	805	804
		0.6	-	14,895	15,916	15,918
		-0.4	-	14,888	15,910	15,911
3	atan	0.11	-	5,081	5,873	5,872
		0.27	-	8,163	9,066	9,065
		0.547	-	8,089	8,992	8,991
		0.777	-	8,512	9,425	9,424
		0.975	-	8,271	9,159	9,158
		54.45	-	10,528	11,515	11,514
		154.233	-	10,693	11,680	11,679
		-54.45	-	10,534	11,522	11,520
		-0.975	-	8,277	9,166	9,164
		-0.777	-	8,518	9,432	9,430
4	atan2	0.3	0.7	9,791	10,739	10,740
		0.2	0.1	12,161	13,208	13,209
		0.1	0.9	6,978	7,815	7,816
5	cos	0.523333333	-	4,653	4,928	4,927
		1.046666667	-	5,340	5,691	5,691
		1.9625	-	5,147	5,443	5,443
		2.7475	-	5,028	5,355	5,355
		3.5325	-	4,788	5,060	5,060
		4.3175	-	5,418	5,771	5,771
		5.1025	-	5,181	5,479	5,479
		5.8875	-	5,039	5,369	5,368
		-0.52333333	-	4,656	4,931	4,931
		-1.04666667	-	5,341	5,692	5,693
		-1.9625	-	5,151	5,447	5,448
		-2.7475	-	5,032	5,359	5,360
		-3.5325	-	4,792	5,064	5,065
		-4.3175	-	5,422	5,775	5,776
		-5.1025	-	5,185	5,483	5,484
		-5.8875	-	5,043	5,373	5,373

				H8SX		
No.	**Function**	**Parameter 1**	**Parameter 2**	**NRM**	**ADV**	**MAX**
6	sin	0.523333333	-	4,665	5,363	5,362
		1.046666667	-	4,601	5,260	5,260
		1.9625	-	4,405	5,040	5,040
		2.7475	-	5,033	5,754	5,754
		3.5325	-	4,764	5,461	5,461
		4.3175	-	4,725	5,384	5,384
		5.1025	-	4,473	5,108	5,108
		5.8875	-	5,061	5,783	5,782
		-0.52333333	-	4,674	5,372	5,372
		-1.04666667	-	4,622	5,281	5,282
		-1.9625	-	4,414	5,049	5,050
		-2.7475	-	5,042	5,763	5,764
		-3.5325	-	4,773	5,470	5,471
		-4.3175	-	4,734	5,393	5,394
		-5.1025	-	4,482	5,117	5,118
		-5.8875	-	5,072	5,792	5,792
7	tan	0.3925	-	7,096	7,418	7,418
		1.1775	-	7,284	7,631	7,631
		1.9625	-	7,050	7,317	7,371
		2.7475	-	7,451	7,797	7,797
8	cosh	0.33	-	16,425	16,725	16,727
		0.78	-	16,918	17,216	17,218
		-0.33	-	16,427	16,727	16,729
		-0.78	-	16,920	17,218	17,220
9	sinh	0.33	-	4,793	4,873	4,873
		0.98	-	16,705	17,003	17,006
		-0.33	-	4,793	4,873	4,873
		-0.98	-	16,707	17,005	17,008
10	tanh	0.0033+00	-	21,563	20,209	20,210
11	exp	0.33	-	8,073	8,249	8,248
		0.98	-	8,113	8,289	8,288
		-0.33	-	8,113	8,289	8,288
		-0.98	-	8,129	8,305	8,304
12	frexp	0.3	-	80	75	75
		400	-	80	75	75
13	ldexp	0.3	30	378	413	413
		0.1	100	378	413	413

				H8SX		
No.	**Function**	**Parameter 1**	**Parameter 2**	**NRM**	**ADV**	**MAX**
14	log	1.2	-	8,345	7,889	7,889
		2.5	-	8,640	8,181	8,181
		0.999	-	8,258	7,799	7,799
		0.3	-	8,538	8,079	8,079
15	log10	1.2	-	8,114	8,313	8,316
		2.5	-	8,400	8,599	8,601
		0.999	-	8,035	8,234	8,236
		0.3	-	8,304	8,503	8,505
16	modf	256.3	-	1,226	1,194	1,194
		0.032	-	1,065	1,035	1,035
		10000.2345	-	1,150	1,118	1,118
17	pow	2.3	4.2	17,485	17,294	17,295
		45.2	-5	17,060	16,868	16,870
		-4.56	-3	17,965	17,820	17,820
		-85.55	476	18,237	18,076	18,078
18	sqrt	2	-	3,882	3,912	3,912
		3	-	3,888	3,918	3,918
		0.1	-	3,837	3,867	3,867
19	ceil	0.3	-	892	908	908
		-0.6	-	482	509	509
20	fabs	5	-	51	55	55
		-5	-	51	55	55
21	floor	0.3	-	482	498	498
		-0.6	-	893	894	894
22	fmod	11.1	3.2	688	750	749
		500.55	0.4	921	983	982
		1.05E+06	9.54E-07	1,712	1,774	1,773

Appendix B Added Features

B.1 Features Added between Ver. 2.0 and Ver. 3.0

B.1.1 Addition of Embedded Extended Functions

1. entry Function

In H8S, H8/300 Series C/C++ compiler version 3.0 (new version) or later, #pragma entry can specify the entry function. The entry function is executed first when the power is turned on or at reset.

The entry function enables the creation of a C/C++ program without the use of the stack pointer (SP) initial value or assembly language embedded in a C/C++ program.

2. Section Address Operator

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, operators (_ _sectop and _ _secend) that refer to the start and end addresses of sections have been added. This enables use of the data initialization library function (_INITSCT) when the section switching function is used.

3. packed Structure

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, pack option and #pragma pack can specify the boundary alignment of the structure member.

B.1.2 Additional and Improved Functions

1. C++ Language Function

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the compiler can compile both C and C++ language programs. The compiler distinguishes the C and C++ language programs by option lang or by their file extensions.

2. Library

H8S, H8/300 Series C/C++ compiler Version 3.0 or later supports mathematical functions (double and float types) in the standard library. Embedded class libraries (ios, istream, ostream, iostream, string, complex, and new) are also supported.

3. Specification of the Number of Register Parameters

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the regparam option can be used to select the number of parameter registers.

4. Expansion of the speed Option

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, subcommand speed=expression has been added for option speed. When speed=expression is specified, inline expansion is performed for most operations instead of calling run-time routines.

5. Support of long Type Bit Field

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the long type data bit field has been added to the supported data type.

6. Extension of Limited Values

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the limitation values of the following items have been extended compared to the old version (version 2.0):

- Symbol size (version 3.0 or later: 250 characters, version 2.0: 31 characters)
- Nesting of compound statements (version 3.0 or later: 256 levels, version 2.0: 32 levels)
- Nesting of repeat statements (while, do, and for statements) (version 3.0 or later: 256 levels, version 2.0: 32 levels)
- Nesting of combinations of select statements (if and switch statements) (version 3.0 or later: 256 levels, version 2.0: 32 levels)
- Nesting of switch statements (version 3.0 or later: 128 levels, version 2.0: 16 levels)
- Nesting of for statements (version 3.0 or later: 128 levels, version 2.0: 16 levels)
- Number of characters in one line (version 3.0 or later: 8192 characters, version 2.0: 4096 characters)
- Memory size allocated by malloc (in advanced mode: version 3.0 or later: size_t, version 2.0: INT_MAX)

7. Output of Optimized List

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, symbol reference count and optimized information list output functions have been added at the execution of the inter-module optimizer.

8. Output of Command Line

The character string specified by a command line is output in a list to a file.

9. Strengthening Option message

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, any information message level message specified by the message option can be excluded from being output to a file.

10. Character Code Conversion

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the Latin1 option enables the Latin1 code to be used in the source code.

B.1.3 Modification of Language Specifications

1. Output of Warning Message for *((int*)p)++

In H8S, H8/300 Series C/C++ compiler version 2.0, an error message is output for *((int*)p)++. In version 3.0 or later, a warning message is output.

2. Checking Prototype

In H8S, H8/300 Series C/C++ compiler version 2.0, if a prototype declaration without a parameter type specification and a prototype declaration with a parameter type specification are specified at the same time, an error message is output. In H8S, H8/300 series C/C++ compiler version 3.0 or later, correct operation is enabled in such a case.

Example of version 2.0:

```
void f();

void f(int);                    -> Error 2118 is output
```

Example of version 3.0:

```
void f();
void f(int);                    <- Correct compilation
```

3. Description of a Bit Field without a Name at the Head of a Structure

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, a bit field without a name can be written at the head of a structure.

Example of version 2.0:

```
struct S {
   int   :1;
   int a:1;                     -> Error 2141 is output
};
```

Example of version 3.0:

```
           struct S {
   int   :1;
   int a:1;                     -> Correct compilation
};
```

4. Inhibiting Errors from Occurring for Structure Initial Values

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the assignment and declaration of structures can be done simultaneously.

Example of version 2.0:

```
struct S {
   int a,b;
}s1;
void test()
{
   struct S s2 = s1;            <- Error 2130 is output
}
```

Example of version 3.0:

```
struct S {
    int a,b;
}s1;
union U {
    int a,b;
}u1;
void test()
{
    struct S s2 = s1;           <- Correct compilation
}
```

5. Changing the Conditions of Undefined Symbol Errors for the static Function

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, no error message is output for unreferenced symbols in a static function that has only a declaration and no definition.

Example of version 2.0:

```
static void func();             <- Error 2143 is output unconditionally since
there is no definition
void test()
{
}
```

Example of version 3.0:

```
static void func();             <- Since there is no reference, no error is output
void test()
{
}
```

6. Enabling the Use of the // Comment in C Programs

In H8S, H8/300 Series C/C++ compiler version 3.0 or later, the // comment can be used in C programs. Therefore, the meaning of a program in version 3.0 may differ from that of version 2.0.

Example of version 2.0:

```
int b = a //* Comment */4;        <- The meaning of the program is “int b = a/4; -a;”
   -a;
```

Example of version 3.0:

```
int b = a //* Comment */4;        <- The meaning of the program is “int b = a -a;”
   -a;
```

B.2 Features Added between Ver. 3.0 and Ver. 4.0

B.2.1 Common Additions and Improvements

1. Loosening Limits on Values

Limitations on source programs and command lines have been greatly loosened:

- Length of file name: 251 bytes -> unlimited
- Length of symbol: 251 bytes -> unlimited
- Number of symbols: 65,535 -> unlimited
- Number of source program lines: C/C++: 32,767, ASM: 65,535 -> unlimited
- Length of C program line: 8,192 characters -> 16,384 characters
- Length of C program string literals: 512 characters -> 16,384 characters
- Length of subcommand file lines: ASM: 300 bytes, optlnk: 512 bytes -> unlimited
- Number of parameters of the optimizing linkage editor rom option: 64 -> unlimited

2. Hyphens for Directory and File Names

A hyphen (-) can be specified for directory and file names.

3. Specification of Copyright Display

Specifying the logo/nologo option can specify whether or not the copyright output is displayed.

4. Prefix to Error Messages

To support the error-help function in Hitachi Embedded Workshop, a prefix has been added to error messages for the compiler and optimizing linkage editor.

B.2.2 Added and Improved Compiler Functions

1. Use of Keyword

Attributes can be specified in declarations and definitions of functions and variables by using keywords (_ _interrupt, _ _indirect, _ _entry, _ _abs8, _ _abs16, _ _regsave, _ _noregsave, _ _inline, or _ _register).

2. Creation of Vector Table

Vector tables of functions can be created automatically when vect is specified by #pragma interrupt, indirect, entry, _ _interrupt, _ _indirect, or _ _entry.

3. Supports _ _evenaccess

Memory access in even on even-numbered byte boundaries is guaranteed for variables that are specified by _ _evenaccess.

4. Expanded Register Parameter Specification

_ _regparam2 and **_ _regparam3** can be used to specify the number of register parameters in a function.

5. Specifies Options in Function Units

Options can be specified in function units by using #pragma options.

6. Allocates Data Close to Each Other

Optimizes address calculation code of arrays or structures by using **_ _near8** or **_ _near16.**

However, the pointer size is not changed.

7. Allocates Stacks Close to Each Other

Optimizes stack address calculation code of stack area by using **stack**.

8. Added Intrinsic Functions

The following intrinsic functions were added.

- Unsigned overflow operation

9. Supports double=float

In the new version, **double**=**float** can be specified so that data declared as double-precision type and floating point constants are both dealt with as floating-point type.

10. Strengthening noregsave Functions

When functions declared with #pragma noregsave or _ _noregsave are called, the contents of the register are guaranteed by the caller.

11. Specifying Multiple Sets of Include Directory by Using Environment Variables

Multiple sets of include directories can be specified by using the environment variable (CH38).

12. Allocate Structure Parameter or Return Value to Register

Option structreg is used to allocate a small structure parameters or return values to registers.

13. Allocate 4-Byte Parameter or Return Value to Register (cpu=300)

Option longreg is used to allocate 4-byte parameters or return values to registers.

14. Conditions for Moving a Non-volatile Variable Outside a Loop

A non-volatile external variable in an iteration condition inhibits external variable optimization from moving out the loop even though there are no function calls or assignment expressions in an iteration condition.

15. Supporting speed=loop=1|2

Option **speed**=**loop**=**1|2** controls optimization of loop expansion.

16. Modifies Data Allocation by the Boundary Alignment

Data can be reallocated for each boundary alignment so that gaps that are generated by the boundary alignment are minimized.

17. Added Implicit Declarations

_ _ HITACHI_ _ and _ _ HITACHI_VERSION_ _, are implicitly declared by #define.

18. static Label Name

The specification of label names as references to static file labels by using #pragma asm and #pragma endasm, and #pragma inline_asm has been changed to _ _$ (name). However, in a linkage list, the name is displayed as _ (name).

19. Extension and Change of Language Specification

- Inhibits errors when initializing unions.

Example:

```
union{

char c[4];

}uu={ {'a','b','c'} };
```

- enum can be applied to bit fields.

Example:

```
struct{

enum E1{a,b,c}m1:2;

enum E1 m2:2;

};
```

- The output of an error message when a comma “,” is written after the last enumeration has been inhibited.

Example:

```
enum E1{a,b,c,}m1;
```

- An union can be assigned and declared in a single statement

Example:

```
union U{

int a,b;

}u1;

void test(){

union U u2 = u1;

}
```

- The level of checking for errors in casting of symbol address expressions has been eased.

Example:

```
int x;

short addr1=(short)&x;
```

- Restrictions on the order of writing declaration of functions and variables, and #pragma declarations in C programs has been eased.

Example:

```
void f(void);

#pragma interrupt f

void f(void){}    // #pragma declaration following a function declaration is

//valid. (In version 3, an error would have occurred.)
```

- The restrictions on the order of writing declarations of functions and variables, and #pragma declarations in C++ programs have been modified.

Example:

```
void f(void){}

#pragma interrupt f

void f(void);    // An error will occur when a #pragma declaration follows a

// function declaration.
```

- Exception processing and template functions are also supported according to the C++ language specification.

B.2.3 Added and Improved Functions for the Assembler

1. External Definition and Reference of BEQU

The .BEQU symbol can be externally defined and referenced by using .BIMPORT and .BEXPORT.

B.2.4 Added and Improved Functions for the Optimizing Linkage Editor

1. Support for Wild Cards

A wild card can be specified with a section name of an input file or for file names in start options.

2. Search Path

An environment variable (HLNK_DIR) can be used to specify the several search paths for input files or library files.

3. Subdividing the Output of Load Modules

The output of an absolute load module file can be subdivided.

4. Changing the Error Level

For informational, warning, and error level messages, the error level or the output can be individually changed.

5. Support for Binary and HEX

Binary files can be input and output.

Intel® HEX-type output can be selected.

6. Output the Stack Amount Information

The stack option can output an information file for the stack analysis tool.

7. Improved Optimization by optimize=variable

Variables allocated in a 16-bit absolute address space can be allocated in an 8-bit address space by applying optimization.

8. Improved Optimization by optimize=register

When option **optimize**=**speed** is not specified, the file is compressed after optimizing the saving and restoring of register contents between functions, and replacing saving and restoring of multiple register contents with function calls.

9. Improved Optimization of Assembly Programs

Sections including .org, .align, or .data directives can be optimized.

10. Debugging Information Deletion

The strip option can be used to delete debugging information from either the load module file or the library file.

B.3 Added and Improved Features in Upgrade from Ver. 4.0 to Ver. 6.0

(Note: Ver. 5.0 does not exist and is a missing number.)

B.3.1 Added and Improved Compiler Functions

a. Support for New CPU

Creation of an object file with a CPU type of H8SX is supported.

b. Support for 2-byte Pointer (only in H8SX)

The **_ _ptr16** keyword or option **ptr16** can be used to specify use of a 2-byte pointer.

They are valid in H8SX advanced mode or H8SX maximum mode.

c. Specifying Bit Field Order

#pragma bit_order or the **bit_order** option can be used to specify the order to store bit field members in a field.

d. Function Call in Extended Memory Indirect Addressing Mode (only in H8SX)

The **_ _indirect_ex** keyword or the **indirect=extended** option can be used to declare functions to be called in extended memory indirect addressing mode. Also, #pragma indirect section can modify the section name of not only $INDIRECT, the function address area for memory indirect addressing mode (@@aa:8), but also $EXINDIRECT, the function address area for extended memory indirect addressing mode (@@aa:7).

e. Assembly Capability (only in H8SX)

The **_ _asm** keyword can be used to allow the assembly language to be used in a C/C++ source program.

f. Disabling #line Output

The **noline** option can be used to disable the **#line** output at preprocessor expansion.

g. Specifying Inline Expansion for Functions memcpy and strcpy (only in H8SX)

The **library** option can be used to specify inline expansion of two library functions, **memcpy** and **strcpy**.

h. Changing Error Level

The **change_message** option can be used to individually change the error level of information-level and warning-level error messages.

i. Specifying 8-bit Absolute Area Address (only in H8SX)

Option **sbr** can be used to specify the address to locate the 8-bit absolute area.

j. Strengthening Optimizing Feature (only in H8SX)

The optimization details can be further specified by the following added options: opt_range, del_vacant_loop, max_unroll, infinite_loop, global_alloc, struct_alloc, const_var_propagate, and volatile_loop

k. Added Intrinsic Functions

The following intrinsic functions are added.

- 64-bit multiplication of H8SX (mulsu and muluu)
- Block transfer instructions of H8SX (movmdb, movmdw, movmdl, and movsd)
- Block transfer instructions (eepmovb, eepmovw, eepmovi)
- Revised instrinsic function for MOVFPE instruction (_movfpe)

l. Support for Wild Cards

An input file can be specified with a wild card.

m. Change in Compiler Limitation

The limitation in the number of **switch** statements is changed from 256 to 2048.

n. Change in specification of information message display

In Ver. 4.0, only the last specification of all the **message** and **nomessage** options was effective in a command line. In Ver. 6.0, the union of all the numbers specified by each **nomessage** option in a command line is suppressed to display the message.

o. Type of enum instance

If the **byteenum** option is specified and if all the numbers in an enum are in the range from 0 to 255, the compiler handles the data as **unsigned char**.

p. Inline expansion

In H8SX, <numeric value> in the **speed=inline=<numeric value>** option means the percentage of increase in program size allowed by inline expansion. In the other CPU, <numeric value> means the maximum number of nodes in a function allowed to perform inline expansion.

q. 1-byte-aligned Data Section and 4-byte-aligned Data Section (only in H8SX)

Specifying the align=4 option places data whose size is odd to 1-byte-aligned data section and ata whose size is a multiple of 4 to 4byte-aligned data section.

r. Section Name

Changing the section name of P, C, B or D into S by the section option causes a warning error. S is the reserved name for the stack area.

s. Added Implicit Declarations

_ _ H8SXN_ _, _ _ H8SXM_ _, _ _ H8SXA_ _, _ _ H8SXX_ _, _ _ HAS_MULTIPLIER_ _, _ _HAS_DIVIDER_ _, _ _INTRINSIC_LIB_ _, _ _ DATA_ADDRESS_SIZE_ _, _ _ H8_ _, _ _RENESAS_VERSION_ _, and _ _ RENESAS_ _ are implicitly declared using #define directive by the compiler.

t. Reentrant library

If the **reent** option is specified to the library generator, a reentrant library is created.

u. Support of Little-endian Space (only in H8SX)

A little-endian space is supported depending on a chip of H8SX A 2 -or 4--byte datum in a little-endian space should be written and read with its own data size. In order to do so, the feature of the **_ _evenaccess** keyword is enhandced.

B.3.2 Notes on Optimizing Features of the Compiler Ver. 6.0

Notes below about optimization apply in a case where an H8SX object program is created with Ver. 6.0 optimization. For the other cases, optimization is similar to that of Ver. 4.0 or earlier.

Adopting the newest compiler optimization technology allows the optimization processing in Ver. 6.0 to analyze aliases for pointers or external variables and analyze data live ranges including the control flow, which were not possible so far (in Ver. 4.0 or lower). This provides a wider range of optimization than Ver. 4.0 within the limits of the language specifications.

However, a program that was previously running because it was not optimized enough may not run because it has become a target of optimization.

Examples of programs that were not optimized so far but will become targets of optimization in Ver. 6.0 are shown below.

a. Access to External Variables or Pointer Variables without volatile Declaration

A volatile declaration guarantees that the volatile-qualified variable is accessed whenever it is used because the variable may be updated outside the program sequence. For example. data values are changed by interrupt processing or hardware processing.

The compiler assumes that variables without a **volatile** declaration are changed only by successive processing of the program sequence or function calls.

In Ver. 4.0 or earlier, external variables without a volatile declaration were optimized as shown in the example below:

Example:

```
int a;

f() {

   int *ptr=&a;

   *ptr=1;  // <- Only this assignment expression is eliminated.

   *ptr=2;

}
```

In Ver. 6.0, optimization is further performed in the cases below.

To disable the optimization, declare the relevant variable with **volatile**.

Example 1:

```
int a;

f() {

   int *ptr=&a;

   *ptr &= ~( (0x0080) ); //<- (1)

   while( !( *ptr & (0x0080) ) ) //<- (2)

   {

      :

   }

}
```

In this example, **while** statement (2) has become an infinite loop as a result of optimization.

. Due to alias analysis of the pointer, *ptr in (1) and *ptr in (2) are handled as the same value.

. Expression (1) is propagated to expression (2). Accordingly, expression (2) is converted as follows:

```
while( !( (*ptr & ~( (0x0080) )) & (0x0080) ) ) //<- (2)

-> while(!(*ptr & 0))

-> while(!(0))

-> while(1)
```

Therefore, the expression in question is judged as true, the judge statement is eliminated, and the above **while** statement becomes an infinite loop.

Example 2:

```
int a,b;

f() {

   a=1; //<- (1)

   if(a); //<- (2)

   {

      b=1; //<- (3)

   }

}
```

In this example, **if** statement (2) has been eliminated and (3) is always executed at all times as a result of optimization.

- Due to alias analysis of external variables, a in (1) and a in (2) are handled as the same value.
- Constant value (1) is propagated to expression (2). Accordingly, expression (2) is converted as follows:

```
+-> if(1)
```

Therefore, the expression in question is judged as true, the conditional statement is eliminated, and the above expression (3) is always executed at all times.

Example 3:

```
int a,b,c;

f() {

    a=1; //<- (1)

    if(c); //<- (2)

    {

        b=1; //<- (3)

    }

    a=2; //<- (4)

}
```

In this example, expression (1) has been eliminated as a result of optimization.

- Obtains the control flow including the conditional of the if statement expression.
- Due to analyzing the control flow analysis and alias analysis of external variables, it is proved that the value set in a in (1) is not used. Therefore, the above expression (1) is a redundant expression that is not referenced, and thus it is eliminated.

Example 4:

```
int a;

int b[10];

f() {

    int i; //<- (1)

    for(i=0; i<10; i++) //<- (2)

    {

        b[i]=a; //<- (3)

    }

}
```

In this example, a in expression (3) is referenced once before the loop and is always handled as a constant value in the loop as a result of optimization.

- Obtains the control flow including the **for** loop control expression.
- Due to analyzing the control flow analysis and alias analysis of external variables, a in (3) is handled as a constant value in the loop.
- (3) which is the reference expression to a is moved outside the **for** loop (2) as follows:

```
temp=a;

for(i=0; i<10; i++) //<- (2)

{

    b[i]=temp; //<- (3)

}
```

Therefore, the variable a in expression (3) is unchanged in the loop.

Example 5:

```
int a;

f() {

    a=0; //<- (1)

    while(1); //<- (2)

}
```

In this example, the statement (1) is assumed as unnecessary and eliminated as a result of optimization.

- Since (2) is an infinite loop, this function is judged to have no exit.
- Since a is not referenced in the infinite loop, specification (1) is assumed as unnecessary coding and is eliminated.

b. volatile_loop Option

If the loop control variable is a non-volatile external variable and also the conditional expression is simple, the **volatile_loop** option regards the loop control variable as **volatile** qualified to prevent an infinite loop from being created. However, if the loop control variable is not loop-invariant, it cannot be treated as **volatile**-qualified.

In Ver. 6.0, declare the relevant variable with **volatile**.

An example program is given below.

Example:

```
struct{
    unsigned char a:1;
} ST;
int a;
extern void f();
void func() {
    while (ST.a) { //<- (1)
        if (a) { //<- (2)
            f(); //<- (3)
        }
    }
}
```

In this example, because ST.a may be updated in f(), ST.a is not assumed as loop-invariant value in the loop. Therefore, ST cannot be treated as **volatile** even though specified so with the **volatile_loop** option.

- If the condition in (2) is satisfied, (3) is executed and the ST.a value may be updated.
  Accordingly, after the function call, ST.a is to be reloaded.
- If the condition in (2) is not satisfied, the ST.a value is not updated so the ST.a value used in the previous conditional at (1) can be directly used.

B.3.3 Compatibility between Ver. 4.0 and Ver. 6.0

To link an object program created by Ver. 4.0 with an object program created by Ver. 6.0, the following conditions need to be satisfied.

(1) C source program

The following options that affect function interface must be specified equally.

- regparam
- longreg/nolongreg
- double=float
- structreg/nostructreg
- stack
- byteenum
- pack/unpack

(2) Assembly program

An assembly program must conform to the rules concerning function call, which are described in section 9.3.2, Function Calling Interface, in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Notes: 1. For information not mentioned in the manual, the compatibility with an upgraded version is not guaranteed. An object program created by Ver. 4.0 cannot be linked with an object program created by Ver. 6.0 if one or both of the object programs contain assembly coding which depends on the compiler output coding, such as the order to save and restore register contents.

2. For details on linkage with an OS, middleware, and so on, contact your sales agency.

B.4. Added and Improved Features in Upgrade from Ver. 6.0 to Ver. 6.1

B.4.1 Added and Improved Compiler Functions

a. Support for AE5

AE5 is supported.

b. Enhanced Conformance with the ANSI Standard

strict_ansi brings the associative rule of floating-point operations into conformance with the ANSI standard.

c. Compatibility of Output Object Code with Object Code Produced by Ver. 4.0

With H8S CPUs, **legacy=v4** supports the output of object code which is compatible with that produced by earlier versions of the compiler (Ver.4.0).

d. Expanded Specifications of **cpuexpand=v6** Specified with **legacy=v4**

When **cpuexpand=v6** is specified with **legacy=v4,** output object code is compatible with object code produced by Ver. 6.00 and the **cpuexpand** option.

e. Preferential Allocation of Register Storage Class Variables

enable_register preferentially allocates the variables with register storage class specification to registers.

f. Division of Optimizing Ranges

scope/noscope can be specified to select whether or not to divide up ranges for optimization within functions.

g. Inter-file Inline Expansion

file_inline is used to specify inline expansion for functions that extend across files and **file_inline_path** is used to specify the path name of a file for inline expansion.

h. Added Intrinsic Function

Intrinsic function **set_vbr** is used to set the VBR.

i. #pragma address

#pragma address can be used to allocate variables to specific absolute addresses.

j. Support for .stack Directive

When **code=asmcode** has been specified, the compiler outputs a .stack directive within the assembly-source program.

k. Added Environment Variable

Environment variable **CH38SBR** can be used to set initial values for the SBR.

l. Added Implicit Declarations

Implicit declaration of _ _AE5_ _ and _ _ABS16_ _ have been added.

B.4.2 Notes on Optimizing Features of the Compiler Ver. 6.01

Notes below about optimization apply in a case where an H8SX and H8S (without the **legacy=v4** option) object program is created with Ver. 6.01 optimization. For the other cases, optimization is similar to that of Ver. 4.0 or earlier.

Adopting the newest compiler optimization technology of H8SX and H8S allows the optimization processing in Ver. 6.01 to analyze aliases for pointers or external variables and analyze data live ranges including the control flow, which were not possible so far (in Ver. 4.0 or ealier). This provides a wider range of optimization than Ver. 4.0 within the limits of the language specifications.

So especially when a development of H8S has been done with H8C Ver.6.0 and the project will be updated to Ver.6.01, the generated code will be for different from that of the old project because of the new optimization technology described above.

However, a program that was previously running because it was not optimized enough may not run because it has become a target of optimization.

Examples of programs that were not optimized so far but will become targets of optimization in Ver. 6.01 are shown below.

a. Access to External Variables or Pointer Variables without volatile Declaration

A **volatile** declaration guarantees that the volatile-qualified variable is accessed whenever it is used because the variable may be updated outside the program sequence. For example, data values are changed by interrupt processing or hardware processing.

The compiler assumes that variables without a **volatile** declaration are changed only by successive processing of the program sequence or function calls.

In Ver. 4.0 or earlier, external variables without a **volatile** declaration were optimized as shown in the example below:

Example:

```
int a;
f() {
        int *ptr=&a;
        *ptr=1; //<- Only this assignment expression is eliminated.
        *ptr=2;
}
```

In Ver. 6.01, optimization is further performed in the cases below.

To disable the optimization, declare the relevant variable with **volatile**.

Example 1:

```
int a;
f() {
        int *ptr=&a;
        *ptr &= ~( (0x0080) ); //<- (1)
        while( !( *ptr & (0x0080) ) ) //<- (2)
        }
                  :
        }
}
```

In this example, **while** statement (2) has become an infinite loop as a result of optimization.

- Due to alias analysis of the pointer, *ptr in (1) and *ptr in (2) are handled as the same value.
- Expression (1) is propagated to expression (2). Accordingly, expression (2) is converted as follows:
  while(!((*ptr & ~((0x0080))) & (0x0080))) //<- (2)
  -> while(!(*ptr & 0))
  -> while(!(0))
  -> while(1)

Therefore, the expression in question is judged as true, the judge statement is eliminated, and the above **while** statement becomes an infinite loop.

Example 2:

```
int a,b;
f() {
        a=1; //<- (1)
        if(a); //<- (2)
        {
               b=1; //<- (3)
        }
}
```

In this example, **if** statement (2) has been eliminated and (3) is always executed at all times as a result of optimization.

- Due to alias analysis of external variables, a in (1) and a in (2) are handled as the same value.
- Constant value (1) is propagated to expression (2). Accordingly, expression (2) is converted as follows:
  -> if(1)

Therefore, the expression in question is judged as true, the conditional statement is eliminated, and the above expression (3) is always executed at all times.

Example 3:

```
int a,b,c;
f() {
        a=1; //<- (1)
        if(c); //<- (2)
        {
               b=1; //<- (3)
        }
        a=2; //<- (4)
}
```

In this example, expression (1) has been eliminated as a result of optimization.

- Obtains the control flow including the conditional of the if statement expression.
- Due to analyzing the control flow analysis and alias analysis of external variables, it is proved that the value set in a in (1) is not used. Therefore, the above expression (1) is a redundant expression that is not referenced, and thus it is eliminated.

Example 4:

```
int a;
int b[10];
f() {
        int i; //<- (1)
        for(i=0; i<10; i++) //<- (2)
        {
               b[i]=a; //<- (3)
        }
}
```

In this example, a in expression (3) is referenced once before the loop and is always handled as a constant value in the loop as a result of optimization.

- Obtains the control flow including the **for** loop control expression.
- Due to analyzing the control flow analysis and alias analysis of external variables, a in (3) is handled as a constant value in the loop.
- (3) which is the reference expression to a is moved outside the **for** loop (2) as follows:

```
        temp=a;
        for(i=0; i<10; i++) //<- (2)
        {
               b[i]=temp; //<- (3)
        }
```

Therefore, the variable a in expression (3) is unchanged in the loop.

Example 5:

```
int a;
f() {
        a=0; //<- (1)
        while(1); //<- (2)
}
```

In this example, the statement (1) is assumed as unnecessary and eliminated as a result of optimization.

- Since (2) is an infinite loop, this function is judged to have no exit.
- Since a is not referenced in the infinite loop, specification (1) is assumed as unnecessary coding and is eliminated.

b. volatile_loop Option

If the loop control variable is a non-volatile external variable and also the conditional expression is simple, the **volatile_loop** option regards the loop control variable as **volatile**qualified to prevent an infinite loop from being created. However, if the loop control variable is not loop-invariant, it cannot be treated as **volatile**-qualified.

In Ver.6.01, declare the relevant variable with **volatile**.

An example program is given below.

Example:

```
struct{
    unsigned char a:1;
} ST;
int a;
extern void f();
void func() {
    while (ST.a) { //<- (1)
        if (a) { //<- (2)
            f(); //<- (3)
        }
    }
}
```

In this example, because ST.a may be updated in f(), ST.a is not assumed as loop-invariant value in the loop. Therefore, ST cannot be treated as **volatile** even though specified so with the **volatile_loop** option.

- If the condition in (2) is satisfied, (3) is executed and the ST.a value may be updated. Accordingly, after the function call, ST.a is to be reloaded.
- If the condition in (2) is not satisfied, the ST.a value is not updated so the ST.a value used in the previous conditional at (1) can be directly used.

B.4.3 Compatibility between Ver. 4.0 and Ver. 6.01

To link an object program created by Ver. 4.0 with an object program created by Ver. 6.01, the following conditions need to be satisfied.

(1) C source program

The following options that affect function interface must be specified equally.

- regparam
- longreg/nolongreg
- double=float
- structreg/nostructreg
- stack
- byteenum
- pack/unpack

(2) Assembly program

An assembly program must conform to the rules concerning function call, which are described in section 9.3.2, Function Calling Interface in the H8S,H8/300 Series C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual.

Notes: 1. For information not mentioned in the manual, the compatibility with an upgraded version is not guaranteed. An object program created by Ver. 4.0 cannot be linked with an object program created by Ver. 6.01 if one or both of the object programs contain assembly coding which depends on the compiler output coding, such as the order to save and restore register contents.

2. For details on linkage with an OS, middleware, and so on, contact your sales agency.

Appendix C   Notes on Version Upgrade

This section describes notes when the version is upgraded from the earlier version (H8S, H8/300 Series C/C++ Compiler Package Ver. 4.x or lower).

C.1 Guaranteed Program Operation

When the version is upgraded and program is developed, operation of the program may change.

When the program is created, note the followings and sufficiently test your program.

(1) Programs Depending on Execution Time or Timing

C/C++ language specifications do not specify the program execution time. Therefore, a version difference in the compiler may cause operation changes due to timing lag with the program execution time and peripherals such as the I/O, or processing time differences in asynchronous processing, such as in interrupts.

(2) Programs Including an Expression with Two or More Side Effects

Operations may change depending on the version when two or more side effects are included in one expression.

Example

```
a[i++]=b[i++];          /* i increment order is undefined.                    */
f(i++,i++) ;            /* Parameter value changes according to increment order. */
                        /* This results in f(3, 4) or f(4, 3) when the value of i is 3. */
```

(3) Programs with Overflow Results or an Illegal Operation

The value of the result is not guaranteed when an overflow occurs or an illegal operation is performed. Operations may change depending on the version.

Example

```
int a, b;
x=(a*b)/10;  /* This may cause an overflow depending on the value range of a and b. */
```

(4) No Initialization of Variables or Type Inequality

When a variable is not initialized or the parameter or return value types do not match between the calling and called functions, an incorrect value is accessed. Operations may change depending on the version.

File 1:

```
int f(double d)
{
     :
}
```

File 2:

```
int g(void)
{
     f(1);
}
```

The parameter of the caller function is the int type, but the parameter of the callee function is the double type. Therefore, a value cannot be correctly referenced.correctly referenced.

The information provided here does not include all cases that may occur. Please use this compiler prudently, and sufficiently test your programs keeping the differences between the versions in mind.

C.2 Compatibility with Earlier Version

The following notes cover situations in which the compiler (Ver. 3.x or lower) is used to generate a file that is to be linked with files generated by the earlier version or with object files or library files that have been output by the assembler (Ver. 2.x or lower) or linkage editor (Ver. 6.x or lower). The notes also covers remarks on using the existing debugger supplied with the earlier version of the compiler.

(1) Object Format

The standard object file format has been changed from SYSROF to ELF. The standard format for debugging information has also been changed to DWARF2. When object files (SYSROF) output by the earlier version of the compiler (Ver. 3.x or lower) or assembler (Ver. 2.x or lower) are to be input to the optimizing linkage editor, use a file converter to convert it to the ELF format. However, relocatable files output by the linkage editor (extension: rel) and library files that include one or more relocatable files cannot be converted.

(2) Point of Origin for Include Files

When an include file specified with a relative directory format was searched for, in the earlier version, the search would start from the compiler’s directory. In the new version, the search starts from the directory that contains the source file.

(3) C++ Program

Since the encoding rule and execution method were changed, C++ object files created by the earlier version of the compiler cannot be linked. Be sure to recompile such files. The name of the library function for initial/post processing of the global class object, which is used to set the execution environment, has also been changed. Refer to section 9.2.2, Execution Environment Settings, and modify the name.

(4) Abolition of Common Section (Assembly Program)

With the change of the object format, support for a common section has been abolished.

(5) Specification of Entry via .END (Assembly Program)

Only an externally defined symbol can be specified with.END.

(6) Inter-module Optimization

Object files output by the earlier version of the compiler (Ver. 3.x or lower) or the assembler (Ver. 2.x or lower) are not targeted for inter-module optimization. Be sure to recompile and reassemble such files so that they are targeted for inter-module optimization.

Appendix D List of Limitations

The H8S and H8/300 C/C++ compiler version6.01 has the following limitations:

No	Category	Item	Limitation
1	Compiler startup	Number of source programs that can be compiled in a single operation	No limitation *[1]
2		Total number of macro names that can be specified in define option	No limitation
3		File name length	No limitation(depends on the OS)
4	Number of source program lines	Length of a line	32768 characters (H8SX/H8S) 16384 characters (300H,300)
5		Number of source program lines per file	No limitation
6		Number of compilable source program lines	No limitation
7	Preprocessor	Depth of file nesting levels created by #include statement	No limitation
8		Total number of macro names defined by the #define statement	No limitation
9		Number of parameters specifiable in macro definitions and macro calls	No limitation
10		Number of macro name replacements	No limitation
11		Depth of nesting levels for the #if, #ifdef, #indef, #else, and #elif statements	No limitation
12		Total number of operators and operands specifiable in the #if or #elif statements	No limitation
13	Declarations	Number of function definitions	No limitation
14		Number of externally linked identifiers (external names)	No limitation
15		Number of identifiers (internal names) that can be used in a function	No limitation
16		Total number of declarations in the pointer type, the array type and the function type which qualify the base type	16 declarations
17		Number of array dimensions	6 dimensions
18		Size of arrays or structures *[2]	
		H8SX normal mode, H8S/2600 normal mode, H8S/2000 normal mode, H8/300H normal mode, H8/300	65535 bytes
		H8SX middle mode, H8SX advanced mode(with ptr16 option), H8SX maximum mode(with ptr16 option)	32767 bytes
		H8/300H advanced mode	16777215 bytes
		H8SX advanced mode(without ptr16 option), H8SX maximum mode(without ptr16 option), H8S/2600 advanced mode, H8S/2000 advanced mode	2147483647 bytes 4294967295 (if legacy=v4 is specified)bytes

No	Category	Item	Limitation
19	Statements	Depth of compound statement nesting levels	No limitation
20		Depth of nesting levels when iterative statements (while, do, and for statements) and select statements (if and switch statements) are combined	4096 levels (H8SX/H8S) 256 levels (300H/300)
21		Number of goto labels specifiable in a function	2147483646 labels (H8SX/H8S) 511 labels(300H/300)
22		Number of switch statements	2048 statements
23		Depth of nesting levels for switch statements	2048 levels (H8SX/H8S) 128 levels (300H/300)
24		Number of case labels	2147483646 labels (H8SX/H8S) 511 labels(300H/300)
25		Depth of nesting levels for the for statements	2048 levels (H8SX/H8S) 128 levels (300H/300)
26	Expressions	Length of a character string	32766 characters
27		Number of parameters specifiable in function definitions or function calls	2147483646 parameters (H8SX/H8S) 63 parameters (300H/300) *[3]
28		Total number of operators and operands specifiable in an expression	Approx. 500
29	Standard includes	Number of files that can be opened at once using the open function	Variable *[4]

Notes: 1. For PC, up to 127 characters can be input due to the command line limitation.

2. In the advanced mode, if a bit width for the address space is specified, the size of the address space corresponding to the specified bit width takes precedence.

3. In the case of a non-static function member, the maximum number is 62.

4. The number of files that can be opened at once using the *open* function can be specified.

Appendix E ASCII Code Table

Table E.1 ASCII Code Table

	Upper four bits							
Lower four bits	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	NULL	DLE	SP	0	@	P	`	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETX	DC3	#	3	C	S	c	s
4	EOT	DC4	$	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	{
C	FF	FS	,	<	L	\	l	|
D	CR	GS	-	=	M	]	m	}
E	SO	RS	.	>	N	^	n	~
F	SI	US	/	?	O	_	o	DEL

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