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APPLICATION NOTE

SuperH RISC engine C/C++ Compiler Package

APPLICATION NOTE: [IDE User's Guide] Simulator Usage Guide

This document explains useful simulator functionality.

Table of contents

1. Preface

This document explains the High-performance Embedded Workshop (herein as *Renesas IDE*) simulator functionality shown in Table 1-1.

Table 1-1 List of functionality explained in this document

Functionality	Chapter with explanation
Simulated I/O	Chapter 2
Image display	Chapter 3
Profiler	Chapter 4
Performance analysis	Chapter 4
Pseudo-interrupts	Chapter 5
Timer simulation	Chapter 6
Eventpoints	Chapter 7
Virtual I/O panels	Chapter 8

Each type of functionality comes with sample projects, which are provided from the download site with this document. SH-2A and SH-4 sample projects are provided for pseudo-interrupts. For functionality other than pseudo-interrupts, only SH-2A sample projects are provided. Table 1-2 shows the project name for each sample project. Make sure that you place the sample project workspace in `C:\WorkSpace\sample`.

Table 1-2 Sample projects explained in this document

Contents	Project name
Simulated I/O	`sample_file_io`
Image display	`sample_img`
Profiler / performance analysis	`sample_profile`
Pseudo-interrupts (for SH-2A)	`sample_trigger_sh2a`
Pseudo-interrupts (for SH-4)	`sample_trigger_sh4`
Timer simulation	`sample_timer`
Eventpoints	`sample_ep`
Virtual I/O panel	`sample_panel`

For details about the sample projects, see the sample program explanations given in each chapter. Make sure that sample projects are created on the following environment, as sample projects cannot be opened on earlier environments. Note that these sample projects are for simulator use. Sample programs for simulated I/O will not run on an emulator.

- Renesas SuperH Family C/C++ Compiler Package … V.9.01 Release 01
- High-performance Embedded Workshop … V.4.03.00
- Toolchain … V.9.1.1.0
- Simulator … V.9.0.7

2. Simulated I/O

2.1 Overview

The simulator comes with simulated I/O functionality to virtually check files and standard I/O in the simulator. This chapter gives an overview of simulated I/O functionality, and explains sample programs that use this functionality to check files and standard I/O.

(1) Low-level Interface Routine

When C/C++ is used to develop programs, the standard I/O library (`fopen()`, `printf()`, `scanf()`, and other functions) is often used to perform file and standard I/O. In such cases, the standard I/O library calls the user-implemented functions actually performing I/O to perform file and standard I/O. The functions that actually perform I/O are called *Low-level Interface Routines*. These Low-level Interface Routines are needed because embedded applications have a variety of I/O destinations for standard I/O, including LCDs, hard disks, printers, CD-R/RW drives, DIP switches, keyboards, mice, mobile phone buttons, and touch panels, and each of these requires its own I/O processing applied to the user system. As such, the standard I/O library is comprised of a group of user-defined functions called *low-level interface routines*.

Low-level interface routines are implemented according to the specification in *SuperH™ RISC engine C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual 9.2.2 Execution Environment Settings (6) Low-level interface routines*. This chapter introduces sample programs for the low-level interface routines for virtually performing file and standard I/O in a simulator. These sample programs correspond to standard input (`stdin`), standard output (`stdout`), standard error output (`stderr`), and file I/O.

(2) Simulated I/O functionality

Functionality to virtually perform file and standard I/O in a simulator is called *simulated I/O functionality*. Simulated I/O functionality is executed using branch instructions to a specific address (simulated I/O address) set in the simulator. Branch instructions to simulated I/O addresses are only called by simulated I/O functionality, as branching itself is not performed. Parameters for simulated I/O functionality are passed using the R0 register and R1 register. The simulated I/O functionality used (function code) is set in the R0 register. The simulator performs file I/O and string output to the simulator windows according to the function code set in the R0 register. The start address of the memory area (parameter block) in which file names, output characters, and other parameters specific to simulated I/O functionality are set is set in the R1 register. For details about how to set simulated I/O function codes and parameter blocks, see *2.2 Functionality*.

When simulated I/O functionality is called (a branch instruction is executed) as shown above, parameters need to be set in R0 and R1. As such, the parts of simulated I/O functionality called (simulated I/O functions) need to be coded in assembly language. The sample programs call simulated I/O function from low-level interface routines, so that file and standard I/O can be performed in the simulator.

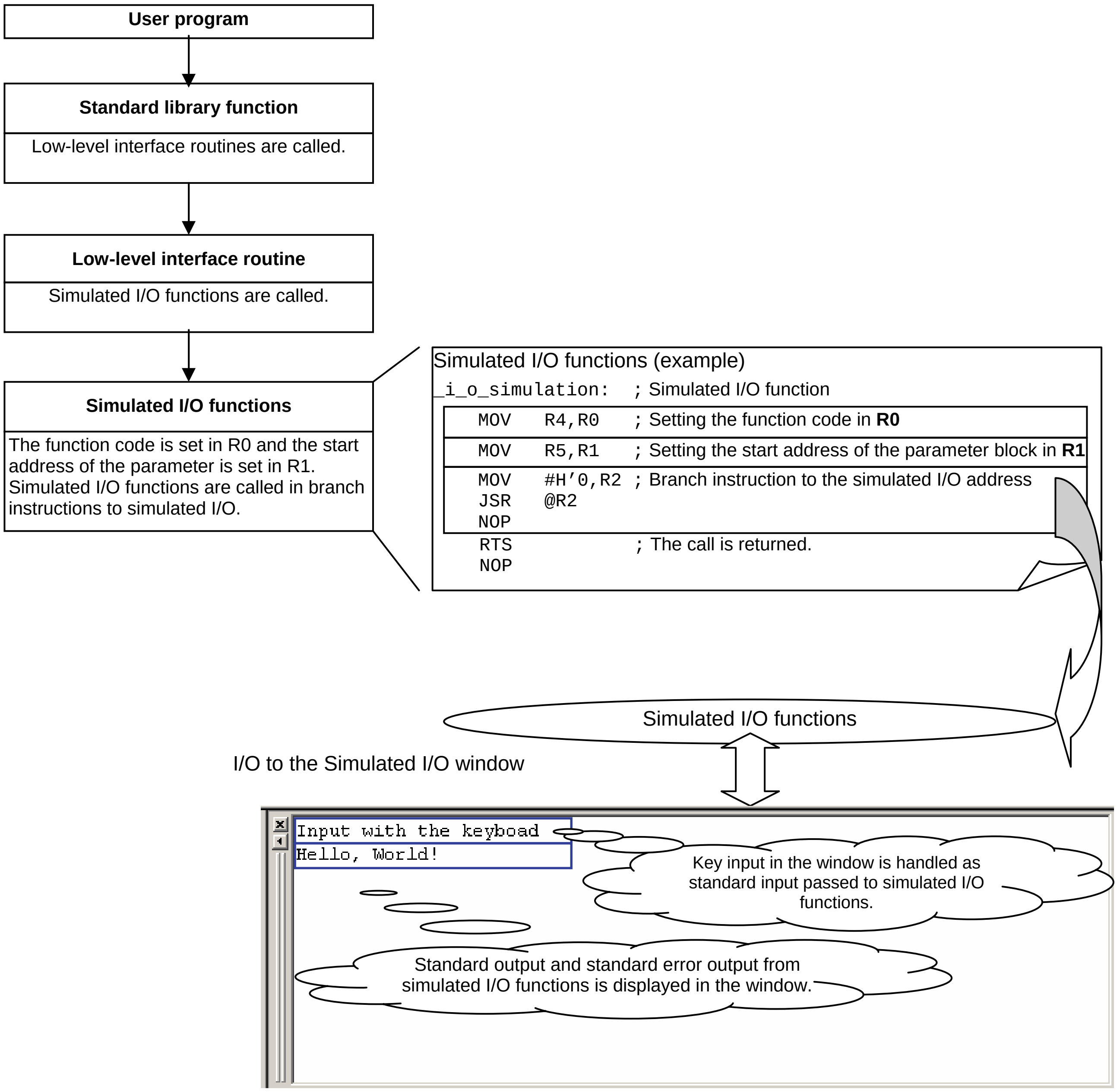

User program
Standard library function
Low-level interface routines are called.
Low-level interface routine
Simulated I/O functions are called.
Simulated I/O functions
The function code is set in R0 and the start address of the parameter is set in R1. Simulated I/O functions are called in branch instructions to simulated I/O.
Simulated I/O functions (example)
_i_o_simulation: ; Simulated I/O function
MOV R4,R0 ; Setting the function code in R0
MOV R5,R1 ; Setting the start address of the parameter block in R1
MOV #H'0,R2 ; Branch instruction to the simulated I/O address
JSR @R2
NOP
RTS ; The call is returned.
NOP
Simulated I/O functions
I/O to the Simulated I/O window
Input with the keyboad
Hello, World!
Key input in the window is handled as standard input passed to simulated I/O functions.
Standard output and standard error output from simulated I/O functions is displayed in the window.

Figure 2-1

2.2 Functionality

The function code needs to be set in the R0 register, and the parameter block start address needs to be set in the R1 register, before simulated I/O functionality is called. Figure 2-2 shows the contents set in the R0 register and R1 register. When I/O processing is finished, simulation is restarted from the next instruction of the branch instructions to the simulated I/O address.

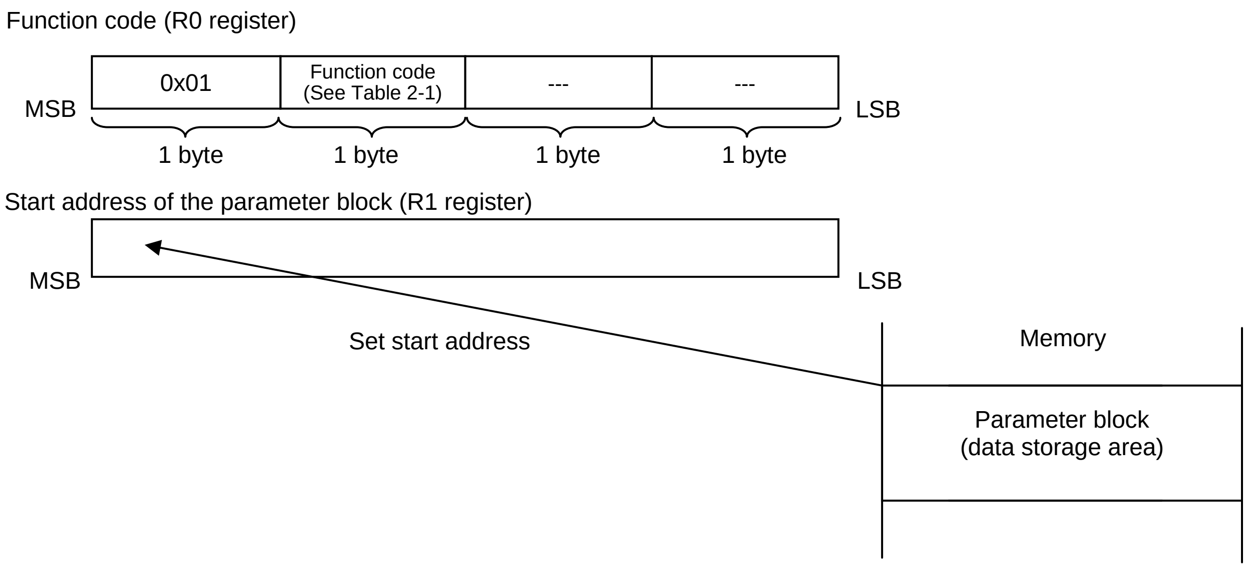


Figure 2-2

Table 2-1 shows the functionality supported by simulated I/O.

Table 2-1 List functionality

No.	Function Code	Function Name	Description
1	H'21	GETC	Inputs one byte from the standard input device
2	H'22	PUTC	Outputs one byte to the standard output device
3	H'23	GETS	Inputs one line from the standard input device
4	H'24	PUTS	Outputs one line to the standard output device
5	H'25	FOPEN	Opens a file
6	H'06	FCLOSE	Closes a file
7	H'27	FGETC	Inputs one byte from a file
8	H'28	FPUTC	Outputs one byte to a file
9	H'29	FGETS	Inputs one line from a file
10	H'2A	FPUTS	Outputs one line to a file
11	H'0B	FEOF	Checks for end of the file
12	H'0C	FSEEK	Moves the file pointer
13	H'0D	FTELL	Returns the current position of the file pointer

The following explains each kind of I/O functionality.

<table>
<tr><td rowspan="2">(1) Number shown in Table 2-1</td><td>(2) Function Name</td><td rowspan="2">(4) I/O overview</td></tr>
<tr><td>(3) Function Code</td></tr>
<tr><td colspan="2">(5) I/O parameter block</td><td>(6) I/O parameters</td></tr>
</table>

GETC: Inputs one byte from the standard input device

1	GETC H'21	Inputs one byte from the standard input device
	1 byte 1 byte +0 +2 Input buffer start address	• Input buffer start address (input) Start address of the buffer in which the output data is stored.

PUTC: Outputs one byte to the standard output device

2	PUTC H'22	Outputs one byte to the standard output device
	1 byte 1 byte +0 +2 Output buffer start address	• Output buffer start address (input) Start address of the buffer in which the output data is stored.

GETS: Inputs one line from the standard input device

3	GETS H'23	Inputs one line from the standard input device
	1 byte 1 byte +0 +2 Input buffer start address	• Input buffer start address (input) Start address of the buffer in which the output data is stored.

PUTS: Outputs one line to the standard output device

4	PUTS H'24	Outputs one line to the standard output device
	1 byte 1 byte +0 +2 Output buffer start address	• Output buffer start address (input) Start address of the buffer in which the output data is stored.

FOPEN: Opens a file

<table>
<tr><td rowspan="2">5</td><td>FOPEN</td><td rowspan="2">Opens a file</td></tr>
<tr><td>H’25</td></tr>
<tr><td colspan="2">The [FOPEN] opens a file and returns the file number. After this processing, the returned file number must be used to input, output, or close files. A maximum of 256 files can be open at the same time.

<table>
<tr><td></td><td>1 byte</td><td>1 byte</td></tr>
<tr><td>+0</td><td>Return value</td><td>File number</td></tr>
<tr><td>+2</td><td>Open mode</td><td>Unused</td></tr>
<tr><td>+4
+6</td><td colspan="2">Start address of file name</td></tr>
</table>
</td><td>

Return value (output)
0 Normal completion
-1 Error
File number (output)
The number to be used in all file accesses after opening.
Open mode (input)
H'00 "r"
H'01 "w"
H'02 "a"
H'03 "r+"
H'04 "w+"
H'05 "a+"
H'10 "rb"
H'11 "wb"
H'12 "ab"
H'13 "r+b"
H'14 "w+b"
H'15 "a+b"
These modes are interpreted as follows.
"r" Open for reading.
"w" Open an empty file for writing.
"a" Open for appending (write starting at the end of the file).
"r+" Open for reading and writing.
"w+" Open an empty file for reading and writing.
"a+" Open for reading and appending.
"b" Open in binary mode.
Start address of file name (input)
The start address of the area for storing the file name.

</td></tr>
</table>

FCLOSE: Closes a file

<table>
<tr><td rowspan="2">6</td><td>FCLOSE</td><td rowspan="2">Closes a file</td></tr>
<tr><td>H’06</td></tr>
<tr><td colspan="2">
<table>
<tr><td></td><td>1 byte</td><td>1 byte</td></tr>
<tr><td>+0</td><td>Return value</td><td>File number</td></tr>
</table>
</td><td>

Return value (output)
0 Normal completion
-1 Error
File number (input)
The number returned when the file was opened.

</td></tr>
</table>

FGETC: Inputs one byte from a file

7	FGETC H'27	Inputs one byte from a file

	1 byte	1 byte
+0	Return value	File number
+2	Unused	
+4 +6	Input buffer start address	

- Return value (output)
  0 Normal completion
  -1 Error
- File number (input)
  The number returned when the file was opened.
- Input buffer start address (input)
  Start address of the buffer in which the output data is stored.

FPUTC: Outputs one byte to a file

8	FPUTC H'28	Outputs one byte to a file

	1 byte	1 byte
+0	Return value	File number
+2	Unused	
+4 +6	Output buffer start address	

- Return value (output)
  0 Normal completion
  -1 Error
- File number (input)
  The number returned when the file was opened.
- Output buffer start address (input)
  Start address of the buffer in which the output data is stored.

FGETS: Inputs one line from a file

9	FGETS H'29	Inputs one line from a file

Reads character string data from a file. Data is read until either a new line code or a NULL code is read, or until the buffer is full.

	1 byte	1 byte
+0	Return value	File number
+2	Buffer size	
+4 +6	Input buffer start address	

- Return value (output)
  0 Normal completion
  -1 Error
- File number (input)
  The number returned when the file was opened.
- Buffer size (input)
  The size of the area for storing the read data.
  A maximum of 256 bytes can be stored.
- Input buffer start address (input)
  Start address of the buffer in which the output data is stored.

FPUTS: Outputs one line to a file

10	FPUTS	Outputs one line to a file
	H'2A	

Writes character string data to a file. The NULL code that terminates the character string is not written to the file.

	1 byte	1 byte
+0	Return value	File number
+2	Unused	
+4 +6	Output buffer start address	

- Return value (output)
  - 0 Normal completion
  - -1 Error
- File number (input)
  The number returned when the file was opened.
- Output buffer start address (input)
  Start address of the buffer in which the output data is stored.

FEOF: Checks for end of the file

11	FEOF	Checks for end of the file
	H'0B	

	1 byte	1 byte
+0	Return value	File number

- Return value (output)
  - 0 File pointer is not at EOF
  - -1 EOF detected
- File number (input)
  The number returned when the file was opened.

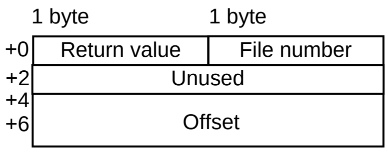
FSEEK: Moves the file pointer

12	FSEEK	Moves the file pointer
	H'0C	

	1 byte	1 byte
+0	Return value	File number
+2	Direction	Unused
+4 +6	Offset	

- Return value (output)
  - 0 Normal completion
  - -1 Error
- File number (input)
  The number returned when the file was opened.
- Direction (input)
  - 0 The offset specifies the position as a byte count from the start of the file.
  - 1 The offset specifies the position as a byte count from the current file pointer.
  - 2 The offset specifies the position as a byte count from the end of the file.
- Offset (input)
  The byte count from the location specified by the direction parameter.

FTELL: Returns the current position of the file pointer

<table>
<tr><td rowspan="2">13</td><td>FTELL</td><td rowspan="2">Returns the current position of the file pointer</td></tr>
<tr><td>H’0D</td></tr>
<tr><td colspan="2">
</td><td>• Return value (output)
0 Normal completion
-1 Error
• File number (input)
The number returned when the file was opened.
• Offset (output)
The current position of the file pointer, as a byte count from the start of the file.</td></tr>
</table>

2.3 Usage

To use simulated I/O, first enable simulated I/O functionality. Note that the Simulated I/O window needs to be displayed to check standard I/O.

(1) Enabling simulated I/O

To enable simulated I/O, from **Simulator** in the **Setup** menu, choose **System** to display the Simulator System dialog box. In the Simulator System dialog box, select the **Enable** checkbox and set the simulated I/O address.

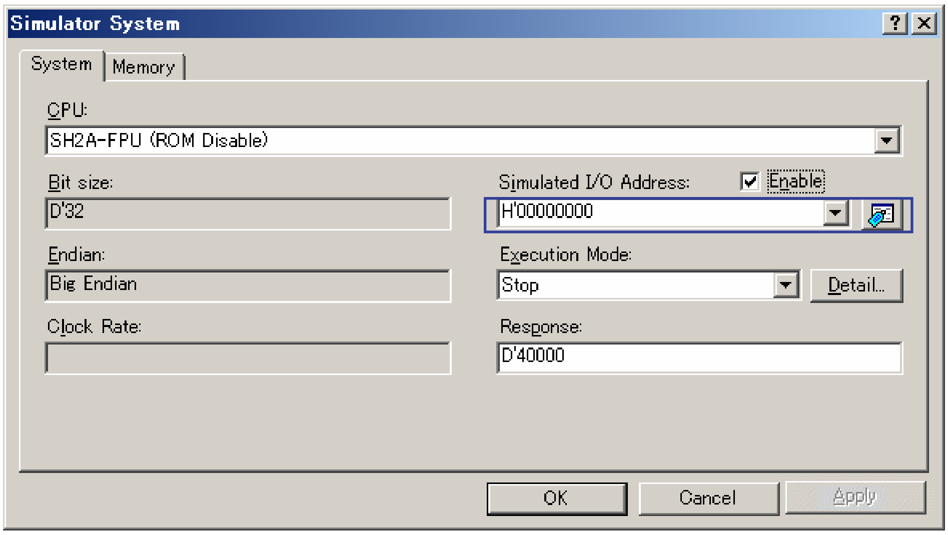


Figure 2-3

Simulated I/O functionality will not operate if **Simulated I/O Address** in the Simulator System dialog box and the simulated I/O address in the program do not match. For example, assume the simulated I/O address in the attached sample program is H'00000000. For an SH-4/SH-4A CPU, the simulated I/O address is H'00000004 by default. This means that if the sample program is used with SH-4/SH-4A, **Simulated I/O Address** needs to be changed in the Simulator System dialog box, or the simulated I/O address must be changed in the program.

(2) Displaying the simulated I/O window

To use simulated I/O, the Simulated I/O window must also be displayed. From **CPU** in the **View** menu, choose **Simulated I/O** to display simulated I/O. Note that the Simulated I/O window must also be displayed when file I/O is used.

Figure 2-4

(3) Using the Simulated I/O window

When a low-level interface routine is implemented using simulated I/O, standard output from the application program is output to this window. Likewise, key input in this window is the standard input to the application program.

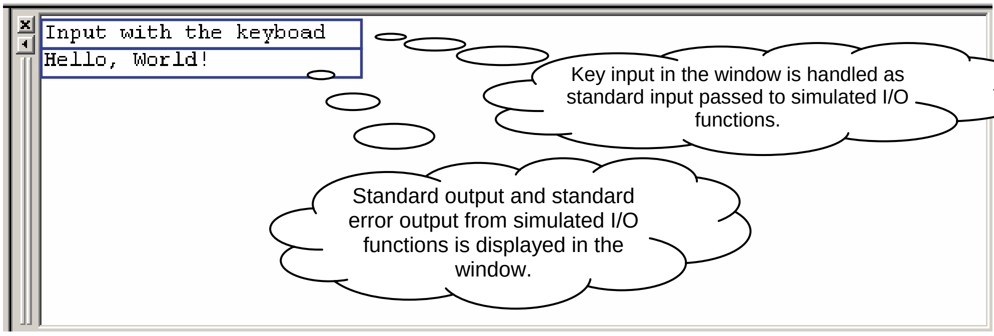


Figure 2-5

2.4 Sample program

`lowsrc.src` and `lowsrc.c` are implemented in the sample program so that file and standard I/O can be checked in simulated I/O. `lowsrc.c` implements the low-level interface routines used by the standard library functions: `open()`, `close()`, `read()`, `write()`, and `lseek()`. Note that with `lowsrc.src`, simulated I/O functions are implemented as called from low-level interface routines.

2.4.1 Source files

(1) `lowsrc.src`

Simulated I/O functions need to be coded in the assembler. The simulated I/O function `i_o_simulation` is defined in `lowsrc.src`. This simulated I/O function is used by the low-level interface routines `open()`, `close()`, `read()`, `write()`, and `lseek()` to call simulated I/O functionality.

The following processing is performed before `i_o_simulation` calls simulated I/O functionality:

- The function code specified in the first argument is set in R0.
- The parameter block address specified in the second argument is set in R1.

(2) `lowsrc.c`

The low-level interface routines `open()`, `close()`, `read()`, `write()`, and `lseek()`, as well as the standard library initialization programs `_INIT_IOLIB()` and `_CLOSEALL()` are implemented in `lowsrc.c`.

Table 2-2 Functions defined in lowsrc.src

Function name	Functionality	Processing
`open`	Opening files	This calls the `i_o_simulation` function with the `FOPEN` function code specified. If `stdin` is specified, the specified open mode is ignored, and the file is opened as read-only. If anything other than `stdin` is specified, the file is opened according to the open mode.
`close`	Closing files	This calls the `i_o_simulation` function with the `FCLOSE` function code specified, and closes the file.
`read`	Inputting data	If `stdin` is specified, this calls the `i_o_simulation` function with the `GETC` function code specified, and loads input from the standard input. If anything other than `stdin` is specified, the `i_o_simulation` function is called with the `FGETC` function code specified, and the string is read from the specified file.
`write`	Outputting data	When `stdout/stderr` is specified, the `i_o_simulation` function is called with the `PUTC` function code specified, and the specified string is output to the standard output. If anything other than `stdout/stderr` is specified, the `i_o_simulation` function is specified with the `FPUTC` function code specified, and the string is output to the specified file.
`lseek`	Moving a file pointer to the specified location	This calls the `i_o_simulation` function with the `FSEEK` function code specified, and moves the file pointer to the specified location. It then calls the `i_o_simulation` function with the `FTELL` function code specified, to obtain the current offset value.
`_INIT_IOLIB`	Performing initial standard I/O settings	This opens `stdin/stdout/stderr`.
`_CLOSEALL`	Closing all files	This closes all open files (including `stdin/stdout/stderr`).

Note In the sample program, the `_CLOSEALL()` function is called when `main()` terminates, and processing is performed to close all files. During program execution, when execution is performed after reset but before close processing is called, since the `_CLOSEALL()` function has not been called, operation may not be performed as expected. When using the `_INIT_IOLIB()` and `open()` functions, execute them after calling the `_CLOSEALL()` function, and after reset. To reset the debugger without executing the `_CLOSEALL()` function, from the **File** menu, choose **Refresh Session**.

2.4.2 Main processing

The `main` function of the sample program uses the `scanf()` function to load the string input to the standard input, and then uses the `printf()` function to output the loaded string to the standard output. It then uses the `fopen()` function, to open the `C:\WorkSpace\sample\file.txt` file, and uses the `fscanf()` function to load the string from the file, and uses the `printf()` function to output the loaded string to the standard output.

```
#include <stdio.h>

unsigned char buf[100];

void main (void)
{
    FILE* fp;

    scanf ("%s", buf);
    printf ("Input=%s\n", buf);

    fp = fopen ("C:\\WorkSpace\\sample\\file.txt", "r");
    if ( fp != NULL ) {
        fscanf (fp, "%s", buf);
        printf ("File=%s\n", buf);
        fclose (fp);
    }
}
```

The `scanf()`, `printf()`, `fopen()`, `fscanf()`, and `fclose()` functions in the standard library call each of the following low-level interface routines:

- `scanf()`: Calls the `read()` function for the standard input (`stdin`).
- `printf()`: Calls the `write()` function for the standard output (`stdout`).
- `fopen()`: Calls the `open()` function for the specified file for `fopen()`.
- `fscanf()`: Calls the `read()` function for the specified file for `fscanf()`.
- `fclose()`: Calls the `close()` function for the specified file pointer for `fclose()`.

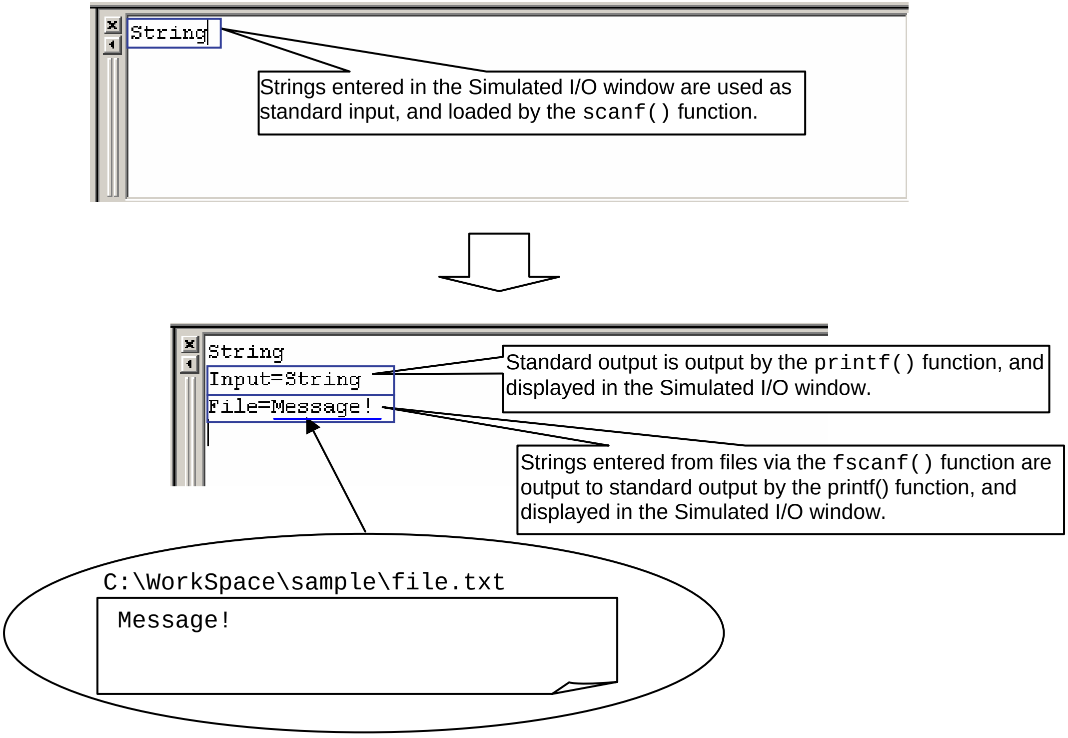


Figure 2-6

Note When checking file I/O for simulated I/O, use an absolute path to specify the file name specified for file open (`fopen()`). Make sure that `\\`, not `\`, is specified as the separator in the absolute path.

3. Image display

3.1 Overview

Image display functionality can be used to visually confirm the contents of image data during program execution. From **Graphic** in the **View** menu, choose **Image** to display the Image Properties dialog box.

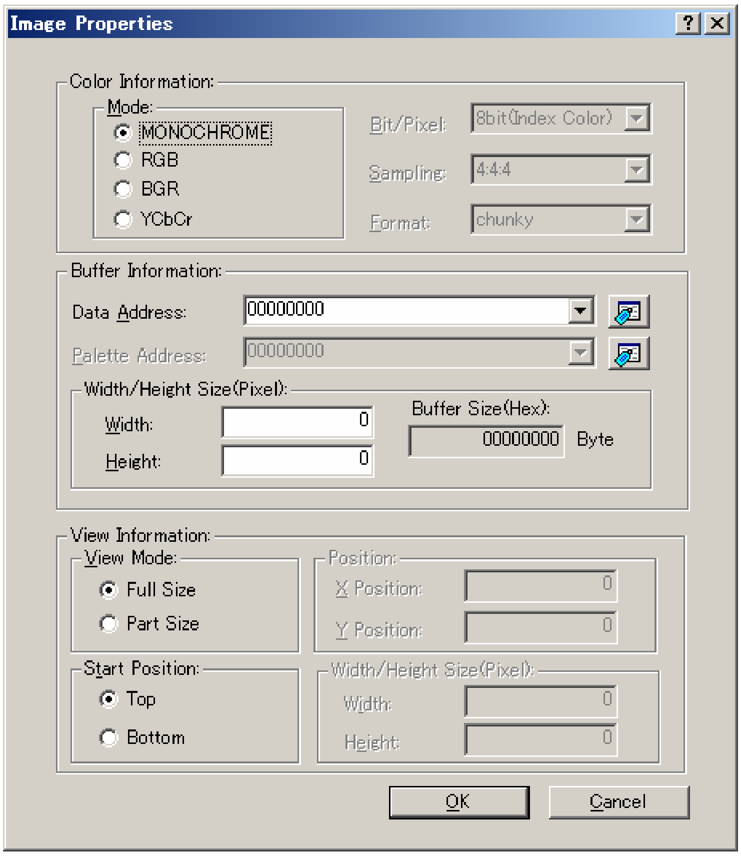


Figure 3-1

In the Image Properties dialog box, when the buffer address and size are specified in **Buffer Information**, and the format of image data in the buffer is specified in **Color Information**, image data is displayed in the Image window during program execution. The following chapter explains the image formats that can be displayed.

Figure 3-2

To update the images during program execution in real-time, right-click the Image window to display the pop-up menu, and then from **Auto Refresh**, choose **Real time**.

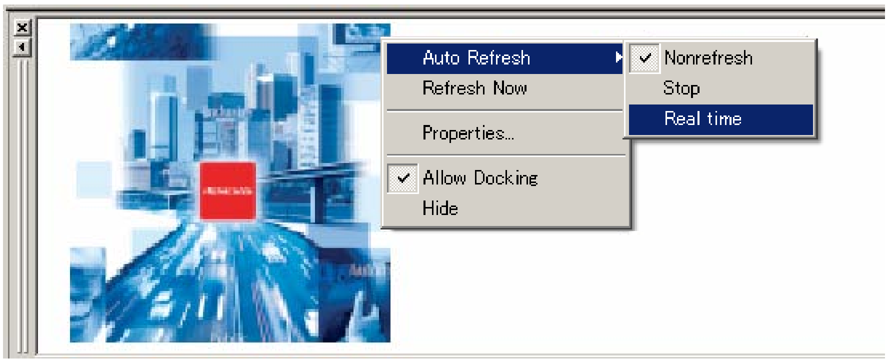

Auto Refresh
Refresh Now
Properties...
Allow Docking
Hide
Nonrefresh
Stop
Real time

Figure 3-3

3.2 Supported image formats

The following image formats can be selected from the Image Properties.

Table 3-1 List of image formats - Monochrome/RGB/BGR

Color information		Data	Data image
Mode	Bits/pixel		
Monochrome	–	One bit per pixel Bit data - 1: white, 0: black	Bit data: B'10100000
RGB/BGR	8 bits (Index Color)	A 256-color (RGB/BGR represented in 32 bits) palette is used, in which image data is stored as numbers (0 to 255) referencing the palette table. The pixel data from the palette table is represented in Blue: 8 Green: 8 Red: 8 alpha: 8-bit. Image display functionality ignores the value of alpha for transparency information.	Pixel data: H'05 This references the sixth color from the palette table. The sixth pixel data from the palette table is H'E7 H'C3 H'81 H'00 BGR: Blue: 231 Green: 195 Red: 129 Alpha: 0 231 195 129 ---
	16 bits (5:5:5)	RGB: Red: 5 Green: 5 Blue: 5 BGR: Blue: 5 Green: 5 Red: 5 The highest bit is padding.	Pixel data H'4677 (=B'0100011001110111) RGB: Red: 17 Green: 19 Blue: 23 17 19 23 BGR: Blue: 17 Green: 19 Red: 23 17 19 23
	16 bits (5:6:5)	RGB: Red: 5 Green: 6 Blue: 5-bit BGR: Blue: 5 Green: 6 Red: 5-bit The highest bit for green is padding.	Pixel data H'8A77 (=B'1000101001110111) RGB: Red: 17 Green: 19 Blue: 23 17 19 23 BGR: Blue: 17 Green: 19 Red: 23 17 19 23
	24 bits	RGB: Red: 8 Green: 8 Blue: 8-bit BGR: Blue: 8 Green: 8 Red: 8-bit	Pixel data H'81 H'C3 H'E7 RGB: Red: 129 Green: 195 Blue: 231 129 195 231 BGR: Blue: 129 Green: 195 Red: 231 129 195 231
	32 bits	RGB: Alpha: 8 Red: 8 Green: 8 Blue: 8-bit BGR: Alpha: 8 Blue: 8 Green: 8 Red: 8-bit Image display functionality ignores the value of alpha for transparency information.	Pixel data H'00 H'81 H'C3 H'E7 RGB: Alpha: 0 Red: 129 Green: 195 Blue: 231 --- 129 195 231 BGR: Alpha: 0 Blue: 129 Green: 195 Red: 231 --- 129 195 231

Table 3-2 List of image formats (2) - YCbCr

Color information		Data		Data image
Mode	Sampling ratio	Source data	Sampling data	
YCbCr	4:4:4	11,12,13,14 21,22,23,24 31,32,33,34 41,42,43,44	11,12,13,14 21,22,23,24 31,32,33,34 41,42,43,44	chunky $Y_{11},Cb_{11},Cr_{11},Y_{12},Cb_{12},Cr_{12},Y_{13},Cb_{13},Cr_{13},$ $...,Y_{nm},Cb_{nm},Cr_{rnm}$ planar $Y_{11},Y_{12},Y_{13},...,Y_{nm},Cb_{11},Cb_{12},Cb_{13},...,Cb_{nm},$ $Cr_{11},Cr_{12},Cr_{13},...,Cr_{nm}$ planar2 $Y_{11},Y_{12},Y_{13},...,Y_{nm},$ $Cb_{11},Cr_{11},Cb_{12},Cr_{12},Cb_{13},Cr_{13},...,Cb_{nm},Cr_{nm}$
	4:2:2	11,12,13,14 21,22,23,24 31,32,33,34 41,42,43,44	11,11,13,13 21,21,23,23 31,31,33,33 41,41,43,43	chunky $Y_{11},Y_{12},Cb_{11},Cr_{11},Y_{13},Y_{14},Cb_{13},Cr_{13},$ $...,Y_{n\ (m-1)},Y_{nm},Cb_{n\ (m-1)},Cr_{n\ (m-1)}$ planar $Y_{11},Y_{12},Y_{13},...,Y_{nm},Cb_{11},Cb_{13},Cb_{15},...,Cb_{n\ (m-1)},$ $Cr_{11},Cr_{13},Cr_{15},...,Cr_{n\ (m-1)}$ planar2 $Y_{11},Y_{12},Y_{13},...,Y_{nm},$ $Cb_{11},Cr_{11},Cb_{13},Cr_{13},Cb_{15},Cr_{15},...,Cb_{n\ (m-1)},Cr_{n\ (m-1)}$
	4:1:1	11,12,13,14 21,22,23,24 31,32,33,34 41,42,43,44	11,11,11,11 21,21,21,21 31,31,31,31 41,41,41,41	chunky $Y_{11},Y_{12},Y_{13},Y_{14},Cb_{11},Cr_{11},$ $Y_{21},Y_{22},Y_{23},Y_{24},Cb_{23},Cr_{21},$ $...,Y_{n\ (m-3)},Y_{n\ (m-2)},Y_{n\ (m-1)},Y_{nm},Cb_{n\ (m-3)},Cr_{n\ (m-3)}$ planar $Y_{11},Y_{12},Y_{13},...,Y_{nm},Cb_{11},Cb_{13},Cb_{15},...,Cb_{n\ (m-1)},$ $Cr_{11},Cr_{13},Cr_{15},...,Cr_{n\ (m-1)}$ planar2 $Y_{11},Y_{12},Y_{13},...,Y_{nm},$ $Cb_{11},Cr_{11},Cb_{13},Cr_{13},Cb_{15},Cr_{15},...,Cb_{n\ (m-1)},Cr_{n\ (m-1)}$
	4:2:0	11,12,13,14 21,22,23,24 31,32,33,34 41,42,43,44	11,11,13,13 11,11,13,13 31,31,33,33 31,31,33,33	planar $Y_{11},Y_{12},Y_{13},...., Y_{nm},$ $Cb_{11},Cb_{13},Cb_{15},...,Cb_{n\ (m-1)},$ $Cr_{11},Cr_{13},Cr_{15},...,Cr_{n\ (m-1)}$ planar2 $Y_{11},Y_{12},Y_{13}, ,...,Y_{nm},$ $Cb_{11},Cr_{11},Cb_{13},Cr_{13},Cb_{15},Cr_{15},...,Cb_{n\ (m-1)},Cr_{n\ (m-1)}$

3.3 Sample program

In the sample program, the two pieces of image data, `data0` and `data1`, are alternately copied to the buffer `buf`. The image data used is in a 200x200-pixel, 24-bit RGB format.

```
#define SIZE (120000)

extern const unsigned char data0[SIZE]; /* Image Data0 */
extern const unsigned char data1[SIZE]; /* Image Data1 */
unsigned char buf[SIZE]; /* Buffer */

void main (void)
{
    int i;

    for (;;)
    {
        for (i=0; i < SIZE; i++ ) {
            buf[i] = data0[i]; /* Image Data0 */
        }
        for (i=0; i < SIZE; i++ ) {
            buf[i] = data1[i]; /* Image Data1 */
        }
    }
}
```

From **Graphic** in the **View** menu, choose **Image** to display the Image Properties dialog box, and perform the following settings:

- Color Information
  - For **Mode**, choose **RGB**
  - From the **Bit/Pixel** drop-down list, choose **24 bits**
- Buffer Information
  - Click the button to the right of the **Data Address** field to display the Select Label dialog box, and then select **_buf**
  - For **Width/ Height Size (Pixel)**, enter `200` in decimal for both **Width** and **Height**

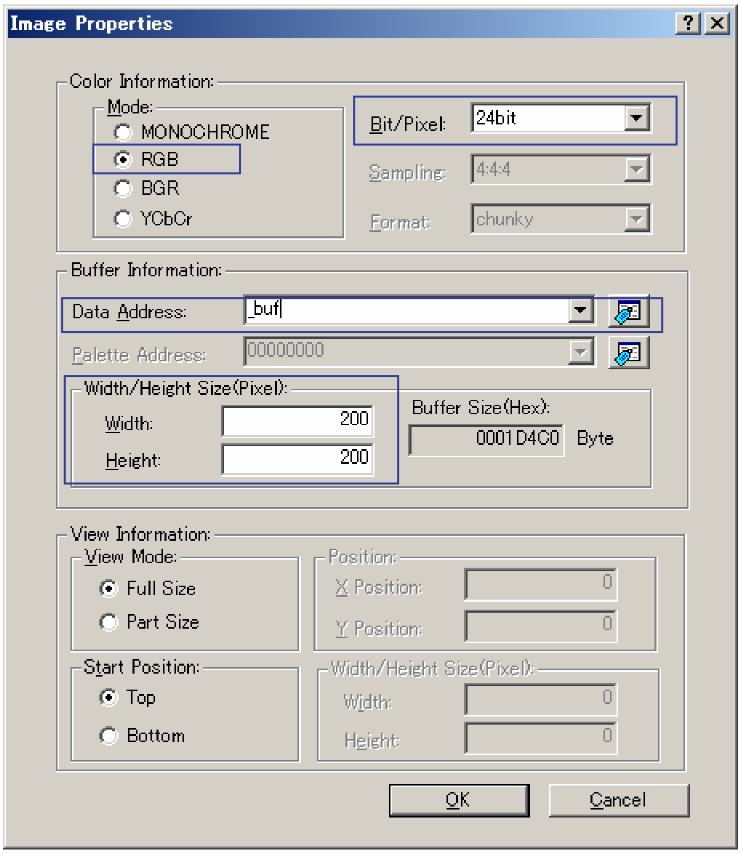


Figure 3-4

The image is displayed in the Image window. To have the image update in real-time, right-click the Image window to display the pop-up menu, and in **Auto Refresh**, choose **Real time**. Swapping between the two image data can be seen.

Figure 3-5

4. Profiler

4.1 Overview

The simulator comes with profiler functionality and performance analysis functionality to measure the execution performance of application programs. The following lists characteristics of profiler functionality and performance analysis functionality.

Table 4-1 Characteristics of profiler functionality and performance analysis functionality

Item	Performance analysis functionality	Profiler functionality
Measurement coverage	Specific functions	All functions
Obtainable execution performance items	Few	Many
Child function measurement	Not possible	Possible
Simulation speed	Fast	Slow

(1) Performance analysis functionality

Performance analysis functionality measures the following items for specific functions in an application program:

- Execution cycle count
- Call count
- Ratio of execution cycle count for the corresponding function as a ratio of program-wide execution cycle count
- Histogram of above ratio

Since only specific functions are measured, faster simulations are possible compared to profiling. Use this when measuring large-scale applications that require significant time to simulate.

Note that measurement is not performed for child functions. To measure a child function, include the child function as part of the measurement target for performance analysis.

(2) Profiler functionality

Profiler functionality measures various execution performance items for all functions in an application program. It can be used for detailed analysis of area and causes of performance degradation with an application program, as well as displaying execution results, including those for child functions.

For details about the execution performance items that can be obtained, see *SuperH™ RISC engine Simulator/Debugger User's Manual 3.6.10 Types and Purposes of Displayed Data*.

4.2 Usage

The following explains how to use performance analysis functionality and profiler functionality.

(1) Performance analysis functionality

From **Performance** in the **View** menu, choose **Performance Analysis** to display the Performance Analysis window. In the Performance Analysis window, right-click to display the pop-up menu, and then choose **Add Range** to display the Performance Option dialog box. In the Performance Option dialog box, specify the name of the function to be measured. Then, from the same pop-up menu, choose **Enable Analysis** (a check mark will be displayed in the pop-up menu).

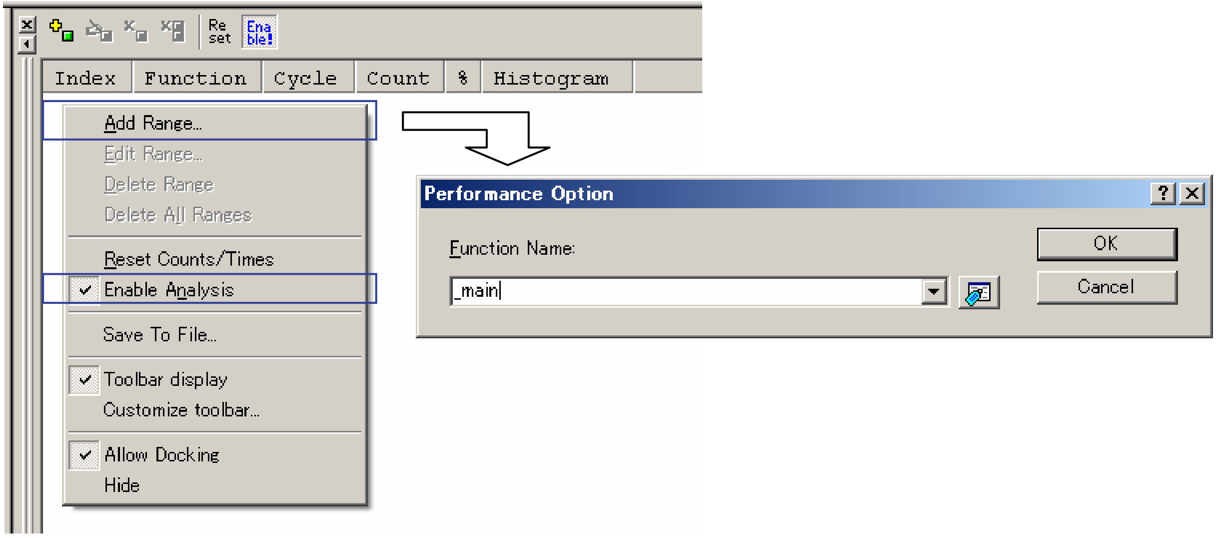


Figure 4-1

When the program is executed, the specified function is measured. The following figure shows the measurement results.

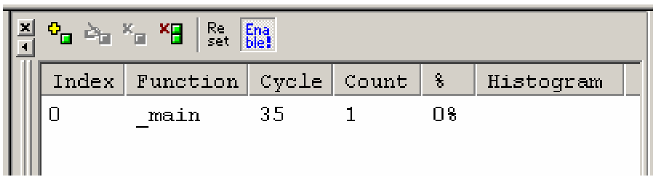


Figure 4-2

The items displayed are as follows:

Index Index number of the set condition

Function Name (or start address) of the measured function

Cycle Cumulative execution cycle count for the corresponding function

Count Cumulative call count for the corresponding function

% Execution cycle count for the corresponding function, as a ratio of the program-wide execution cycle count

Histogram Histogram display of the above ratio

(2) Profiler functionality

From **Performance** in the **View** menu, choose **Profile** to display the Profiling window. Right-click in the Profiling window to display the pop-up menu, and choose **Enable Profiler** (a check mark will be displayed in the pop-up menu).

To include child functions in the displayed execution results, from **Setting** in the pop-up menu, choose **Include Data of Child Functions** (a check mark will be displayed in the pop-up menu).

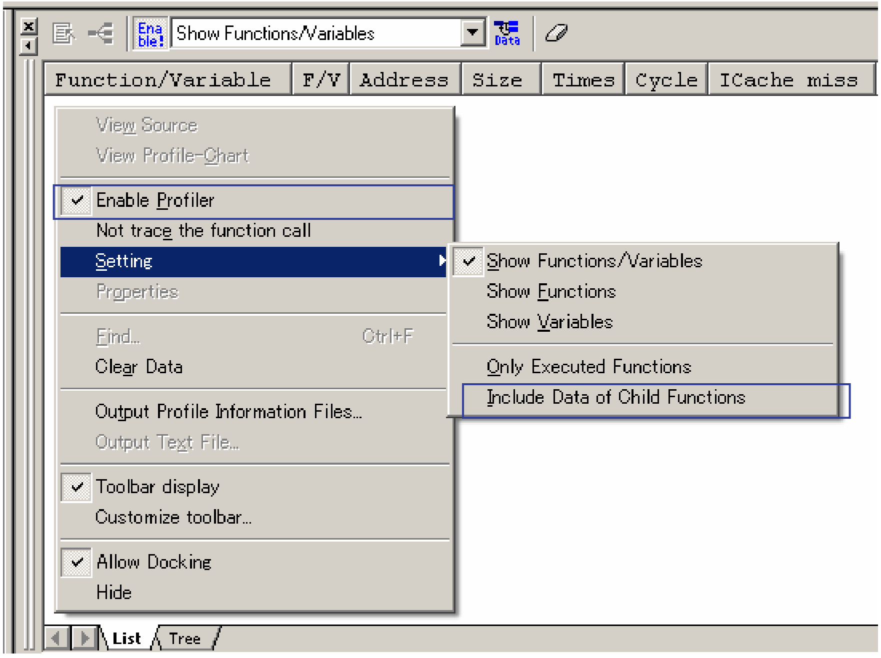


Figure 4-3

The program is executed, and the function and variable information is obtained. The function execution count or variable access count is displayed for **Times**, and the execution cycle count is displayed for **Cycle**. For details about other items displayed, see *SuperH™ RISC engine Simulator/Debugger User's Manual 3.6.10 Types and Purposes of Displayed Data*.

The Profiling window contains a **List** sheet and a **Tree** sheet, as shown in the following figure.

- List
  — The measurement results are displayed in a list.

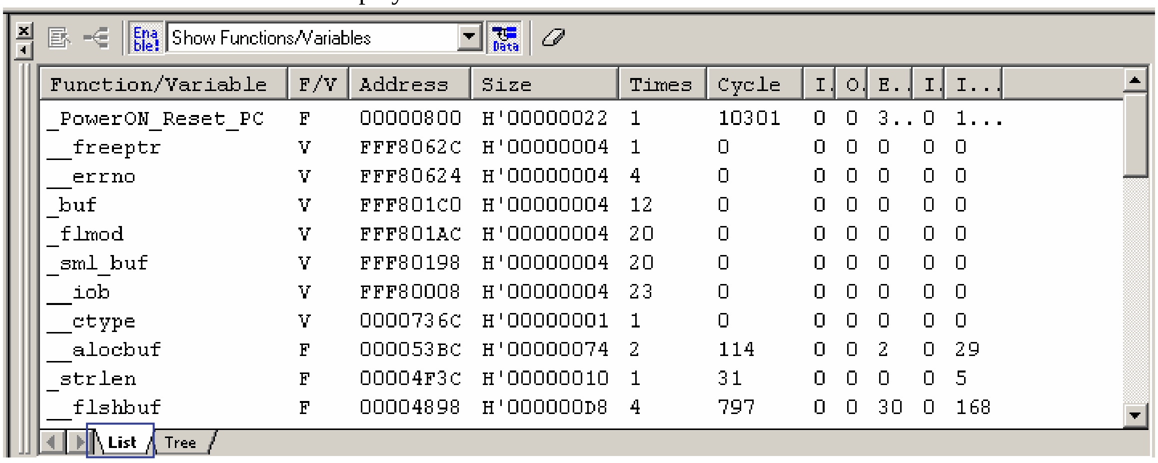
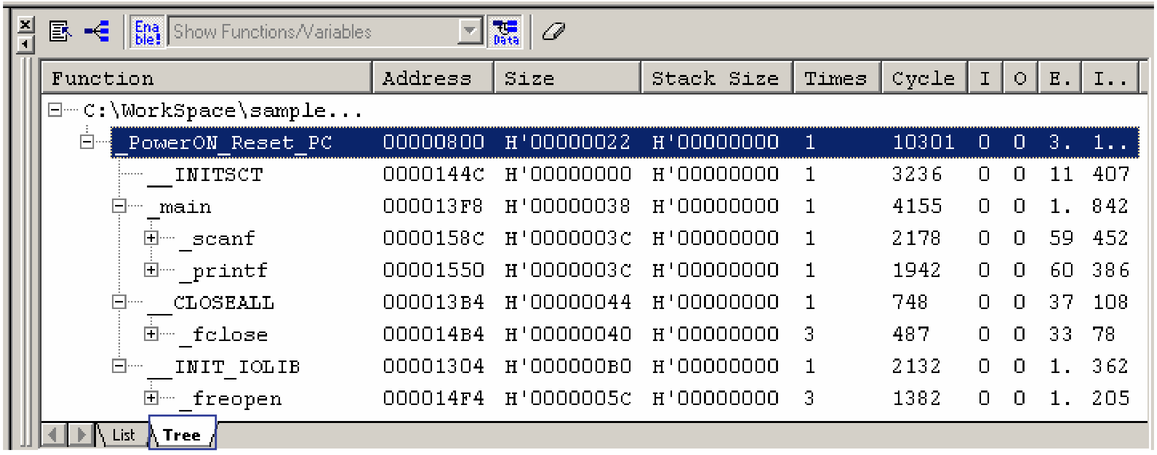


Figure 4-4

- Tree
  — The **Function** column displays the measurement results in tree format.
  Double-click the **Function** column to expand or hide the tree structure.



Function	Address	Size	Stack Size	Times	Cycle	I	O	E.	I..
C:\WorkSpace\sample...									
_PowerON_Reset_PC	00000800	H'00000022	H'00000000	1	10301	0	0	3.	1..
__INITSCT	0000144C	H'00000000	H'00000000	1	3236	0	0	11	407
_main	000013F8	H'00000038	H'00000000	1	4155	0	0	1.	842
_scanf	0000158C	H'0000003C	H'00000000	1	2178	0	0	59	452
_printf	00001550	H'0000003C	H'00000000	1	1942	0	0	60	386
__CLOSEALL	000013B4	H'00000044	H'00000000	1	748	0	0	37	108
_fclose	000014B4	H'00000040	H'00000000	3	487	0	0	33	78
__INIT_IOLIB	00001304	H'000000B0	H'00000000	1	2132	0	0	1.	362
_freopen	000014F4	H'0000005C	H'00000000	3	1382	0	0	1.	205

Figure 4-5

The measurement results in the Profiling window can be used to display the call relationship for functions according to a specific function.

Select a function as shown in Figure 4-4 or Figure 4-5, and right-click it to display a pop-up menu. From the pop-up menu, choose **View Profile-Chart** to display the Profile-Chart window.

The chosen function is displayed in the center of the Profile-Chart window, with the function from which it was called on the right, and the functions it called on the left. Note that the number of times each function is called is also displayed.

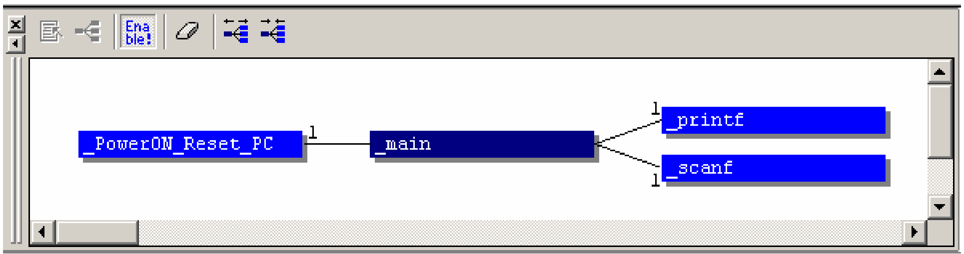


Figure 4-6

4.3 Sample program

The following shows examples of performance measurement using performance analysis functionality and profiler functionality, which in turn uses the three types of sort programs provided as sample programs (quicksort: `quicksort()`, heapsort: `heapsort()`, and bubblesort: `bubblesort()`).

Note that the order of unbiased efficiency for sorted data is: quicksort > heapsort > bubblesort.

- Main processing

```
#include <string.h>

extern void quicksort (int n, int a[]);
extern void bubblesort (int n, int a[]);
extern void heapsort (int n, int a[]);

#define N (80)
const int array[N] = {
    0, 690, 505, 591, 554, 378, 257, 207, 626, 340,
  843,  68, 409, 879, 319, 980,  85, 907, 102, 921,
  507, 872, 333, 692, 556, 361,  31, 858,  98, 877,
  449, 432, 606, 927, 664, 395, 438, 652, 928, 949,
  307, 596, 783, 338, 805, 942,  66, 857, 977, 889,
  545, 864, 457, 800, 873, 821, 185,  86, 638, 233,
  462,   7, 635, 421, 953, 210, 970, 261, 857, 581,
  707, 285, 318, 643, 858, 668, 443,  55, 777, 594,
};

void main (void)
{
    int dist1[N];
    int dist2[N];
    int dist3[N];

    memcpy (dist1, array, sizeof (int) * N);
    quicksort (N, dist1);

    memcpy (dist2, array, sizeof (int) * N);
    bubblesort (N, dist2);

    memcpy (dist3, array, sizeof (int) * N);
    heapsort (N, dist3);
}
```

- Quicksort: `quicksort()`

```
/* Quick Sort */
void qsort (int a[], int first, int last);

void quicksort (int n, int a[])
{
    qsort (a, 0, n-1);
}

void qsort (int a[], int first, int last)
{
    int i, j;
    int pivot;
    int tmp;

    pivot = a[ (first + last) / 2];
    i = first;  j = last;
    for (;;) {
        while (a[i] < pivot) i++;
        while (pivot < a[j]) j--;
        if (i >= j) break;
        tmp = a[i]; a[i] = a[j]; a[j] = tmp;
        i++;  j--;
    }
    if (first < i - 1) qsort (a, first , i - 1);
    if (j + 1 < last) qsort (a, j + 1, last);
}
```

- Heapsort: `heapsort()`

```
/* Heap Sort */
void heapsort (int n, int a[])
{
    int i, j, k;
    int x;

    for (k=n/2; k >= 1; k--) {
        i = k;  x = a[i];
        while ( (j=2*i) <= n) {
            if (j < n && a[j] < a[j + 1]) j++;
            if (x >= a[j]) break;
            a[i] = a[j];  i = j;
        }
        a[i] = x;
    }
    while (n > 1) {
        x = a[n];  a[n] = a[1];  n--;
        i = 1;
        while ( (j=2*i) <= n) {
            if (j < n && a[j] < a[j + 1]) j++;
            if (x >= a[j]) break;
            a[i] = a[j];  i = j;
        }
        a[i] = x;
    }
}
```

- Bubblesort: `bubblesort()`

```
/* Bubble Sort */
void bubblesort (int n, int a[])
{
    int i, j, k;
    int tmp;

    k = n - 1;
    while (k >= 0) {
        j = -1;
        for (i=1; i <= k; i++)
            if (a[i - 1] > a[i]) {
                j = i - 1;
                tmp = a[j]; a[j] = a[i]; a[i] = tmp;
            }
        k = j;
    }
}
```

(1) Performance analysis functionality

In the Performance Analysis window, set the function to be measured. The measured functions are quicksort: `quicksort()`, heapsort: `heapsort()`, bubblesort: `bubblesort()`, and `qsort()` as called from `quicksort()`. For details about these settings, in *4.2 Usage*, see *(1) Performance analysis functionality*.

When the program is executed, the measurement results are output to the Performance Analysis window.

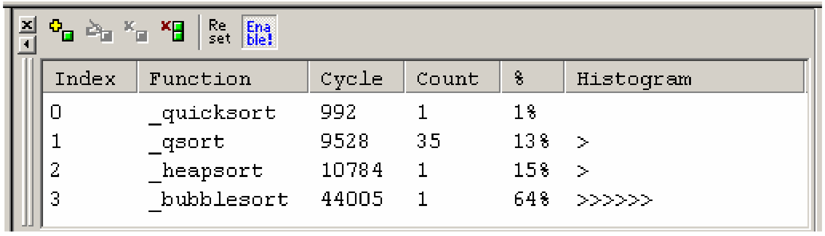


Figure 4-7

Table 4-2 lists the cycle count for each sort from Figure 4-7.

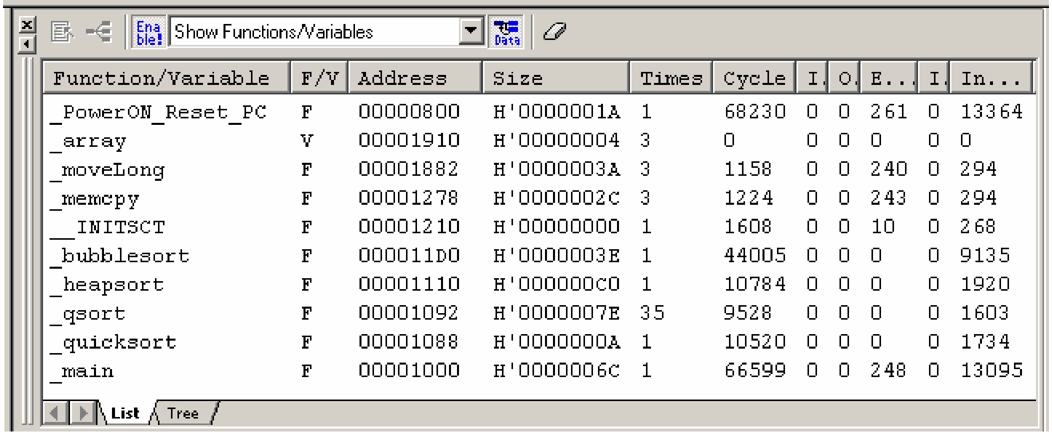
Table 4-2 Measurement results for performance analysis functionality

Sort name	Functions	Cycle count
quicksort	`quicksort()` + `qsort()`	10520
heapsort	`heapsort()`	10784
bubblesort	`bubblesort()`	44005

(2) Profiler functionality

In the Profiling window, enable **Include Data of Child Functions**. For details about this setting, in *4.2 Usage*, see *(2) Profiler functionality*.

When the program is executed, the measurement results are output to the Profiling window.



Function/Variable	F/V	Address	Size	Times	Cycle	I.	O.	E...	I.	In...
_PowerON_Reset_PC	F	00000800	H'0000001A	1	68230	0	0	261	0	13364
_array	V	00001910	H'00000004	3	0	0	0	0	0	0
_moveLong	F	00001882	H'0000003A	3	1158	0	0	240	0	294
_memcpy	F	00001278	H'0000002C	3	1224	0	0	243	0	294
__INITSCT	F	00001210	H'00000000	1	1608	0	0	10	0	268
_bubblesort	F	000011D0	H'0000003E	1	44005	0	0	0	0	9135
_heapsort	F	00001110	H'000000C0	1	10784	0	0	0	0	1920
_qsort	F	00001092	H'0000007E	35	9528	0	0	0	0	1603
_quicksort	F	00001088	H'0000000A	1	10520	0	0	0	0	1734
_main	F	00001000	H'0000006C	1	66599	0	0	248	0	13095

Figure 4-8

Table 4-3 lists the cycle count for each sort from Figure 4-8.

Table 4-3 Profiler functionality measurement results

Sort name	Function	Cycle count
quicksort	`quicksort()`	10520
heapsort	`heapsort()`	10784
bubblesort	`bubblesort()`	44005

5. Pseudo-interrupts

The simulator window can be used manually to make an interrupt occur virtually. This allows interrupts that cannot be made to occur, such as those from external devices, to be simulated as well. This chapter explains how to use pseudo-interrupts.

5.1 Usage

To use a pseudo-interrupt, use the trigger button placed in the Trigger window. The following explains how to use the trigger button to make a pseudo-interrupt occur. First, from **CPU** in the **View** menu, choose **Trigger** to display the Trigger window. In the Trigger window, right-click to display the pop-up menu, and choose **Setting** from this menu to display the Trigger Setting dialog box and set the trigger button.

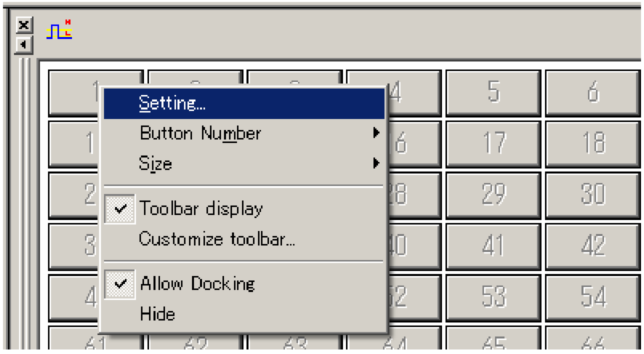


Figure 5-1

In the Trigger Setting dialog box, set the contents of the interrupt to occur when the trigger button is clicked. Note that as many as 256 settings can be performed for a button.

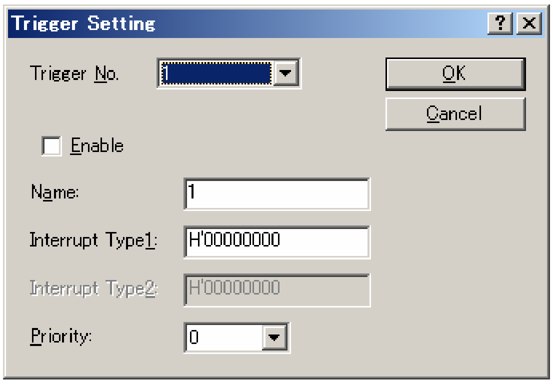


Figure 5-2

The following lists the contents set in the Trigger Setting dialog box:

[Trigger No.]	Selects the trigger button to be specified in detail
[Enable]	Checking this box enables the trigger button.
[Name]	Specifies a name for the selected trigger button; the name will be displayed in the [Trigger] window
[Interrupt Type1]	Sets the following values for each CPU • SH-1, SH-2, SH2-DSP, and SH2A-FPU series Interrupt vector number • SH-3, SH-4 and SH3-DSP series INTEVT (H'0 to H'FFF) • SH-4A series INTEVT (H'0 to H'3FFF)
[Interrupt Type2]	Only selectable for the SH3-DSP series: INTEVT2 (H'0 to H'FFF)
[Priority]	Interrupt priority (0 to 17) When 16 is specified, the interrupt is always accepted regardless of the value of the I bit value in SR, but is masked by the BL bit in SR. When 17 is specified, the interrupt is always accepted regardless of the I and BL bit values in SR.

The Simulator System dialog box can be used to set whether the simulation stops or continues to be executed when an interrupt occurs. From **Simulator** in the **Setup** menu, choose **System** to display the Simulator System dialog box. To continue execution of the simulation, choose **Continue** from the **Execution Mode** drop-down list. To stop the simulation, choose **Stop** from the **Execution Mode** drop-down list, and click the **Detail** button to display the Stoppage Setting dialog box. In this dialog box, select the **Interrupt Exception** checkbox for **Break cause**.

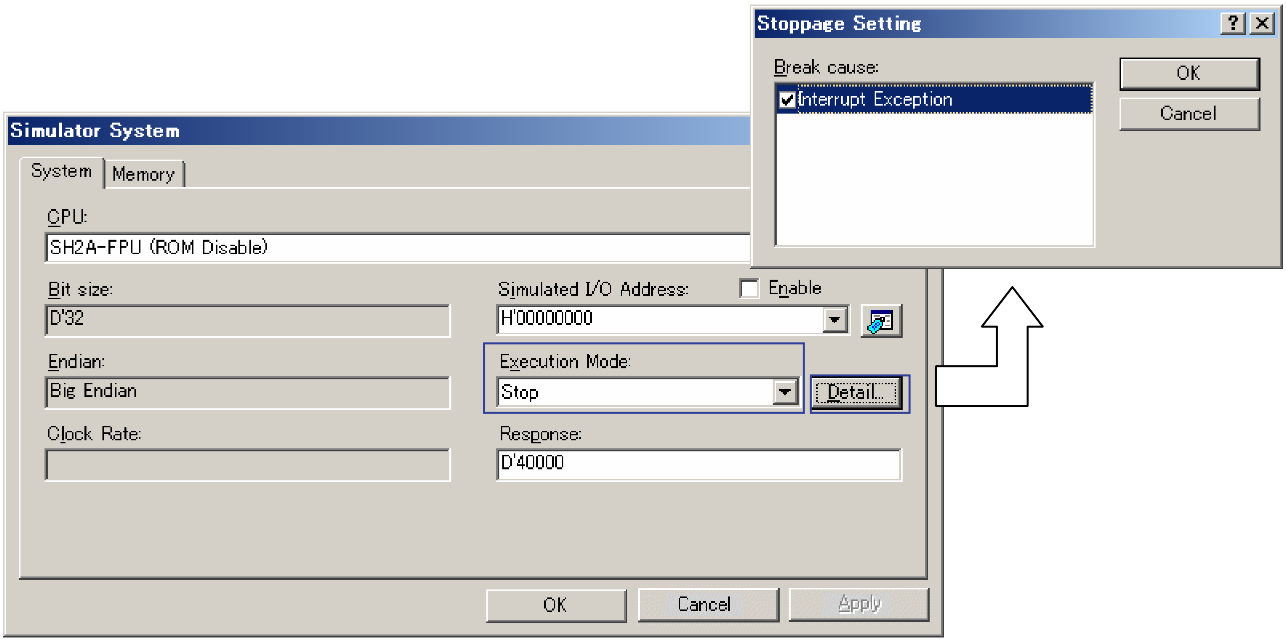


Figure 5-3

5.2 Sample program

The interrupt specification differs between the SH-1, SH-2, and SH-2A series, and the SH-3, SH-4, and SH-4A series, as do the settings in the Trigger Setting dialog box. The following explains how to use pseudo-interrupts using the sample programs for SH-2A and SH-4.

5.2.1 SH-2A

The following explains how to use a pseudo-interrupt in the SH-2A simulator. To receive interrupts in the sample program, use `set_imask()` in the `main` function to set the interrupt mask to `0`. This means that interrupts with a priority level of 1 or higher are accepted. Then, once the interrupt mask is set, processing is only performed for infinite loops. When an interrupt occurs, the function corresponding to the vector number registered in the interrupt vector table is called.

```
#include <machine.h>

void main (void)
{
    set_imask (0);

    for (;;) {
        nop();
    }
}
```

For **Interrupt Type1** in the Trigger Setting dialog box, specify the vector number in the interrupt vector table. In Figure 5-4, `H'00000040` is specified as the vector number, with `5` specified as the interrupt priority. In the sample program, the function corresponding to vector number `H'00000040` is `INT_IRQ0()`.

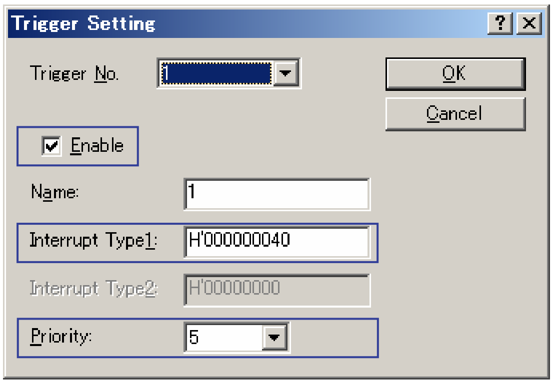
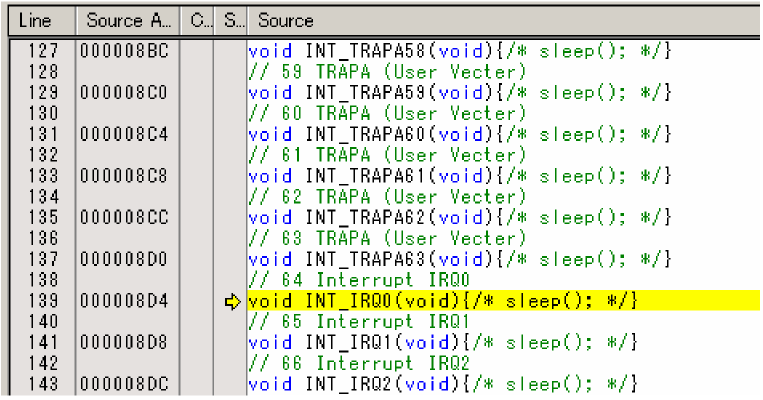


Figure 5-4

Use the Simulator System dialog box to set the simulation to stop when an interrupt occurs. For details about this setting, see *5.1 Usage*. Once the program is executed, click the trigger button set in the Trigger window.

Figure 5-5

When the trigger button is clicked, a virtual interrupt occurs, and `INT_IRQ0()`, the function corresponding to vector number `H'00000040`, is called.



Line	Source A...	C...	S...	Source
127	000008BC			void INT_TRAPA58(void){/* sleep(); */}
128				// 59 TRAPA (User Vecter)
129	000008C0			void INT_TRAPA59(void){/* sleep(); */}
130				// 60 TRAPA (User Vecter)
131	000008C4			void INT_TRAPA60(void){/* sleep(); */}
132				// 61 TRAPA (User Vecter)
133	000008C8			void INT_TRAPA61(void){/* sleep(); */}
134				// 62 TRAPA (User Vecter)
135	000008CC			void INT_TRAPA62(void){/* sleep(); */}
136				// 63 TRAPA (User Vecter)
137	000008D0			void INT_TRAPA63(void){/* sleep(); */}
138				// 64 Interrupt IRQ0
139	000008D4			void INT_IRQ0(void){/* sleep(); */}
140				// 65 Interrupt IRQ1
141	000008D8			void INT_IRQ1(void){/* sleep(); */}
142				// 66 Interrupt IRQ2
143	000008DC			void INT_IRQ2(void){/* sleep(); */}

Figure 5-6

5.2.2 SH-4

The following explains how to use pseudo-interrupts for the SH-4 simulator. To have the sample program receive interrupts, use `set_cr()` in the power-on reset function `PowerON_Reset()` to set the interrupt mask to `0`. This means that interrupts with a priority level of 1 or higher are accepted. Then, once the interrupt mask is set, processing is only performed for infinite loops. When an interrupt occurs, the exception processing handler `_IRQHandler` is called, and the interrupt processing function corresponding to the `INTEVT` value in `_IRQHandler` is called.

```
#include    <machine.h>
        .
        .
        .
#define SR_Init     0x00000000
        .
        .
        .
void PowerON_Reset (void)
{
        .
        .
        .
    set_cr (SR_Init);

    for (;;) {
        nop();
    }
        .
        .
        .
```

For **Interrupt Type1** in the Trigger Setting dialog box, specify the value of `INTEVT`. In Figure 5-7, `H'00000200` is specified as the value of `INTEVT`, and **4** is specified as the interrupt priority. In the sample program, when the value of `INTEVT` is `H'00000200`, an attempt is made to call the interrupt processing function `INT_Extern_0000()` in `_IRQHandler`.

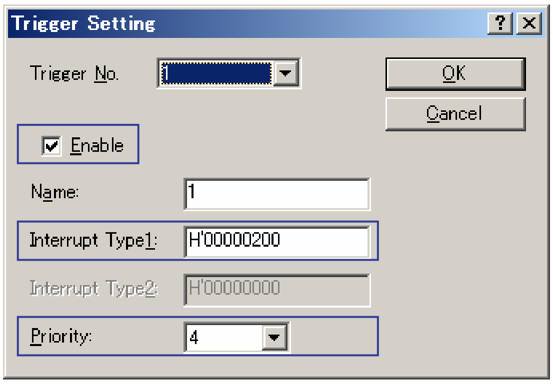


Figure 5-7

Use the Simulator System dialog box to set the simulation to stop when an interrupt occurs. For details about this setting, see *5.1 Usage*. Once the program is executed, click the trigger button set in the Trigger window.

Figure 5-8

When the trigger button is clicked, an interrupt occurs, and the simulation stops during an infinite loop. Here, step-in (F11) can be performed to see that the exception processing handler `_IRQHandler` is called. Step-in can be repeated to see that the value of `INTEVT` is `H'00000200`, and the corresponding interrupt processing function of `INT_Extern_0000()` is called.

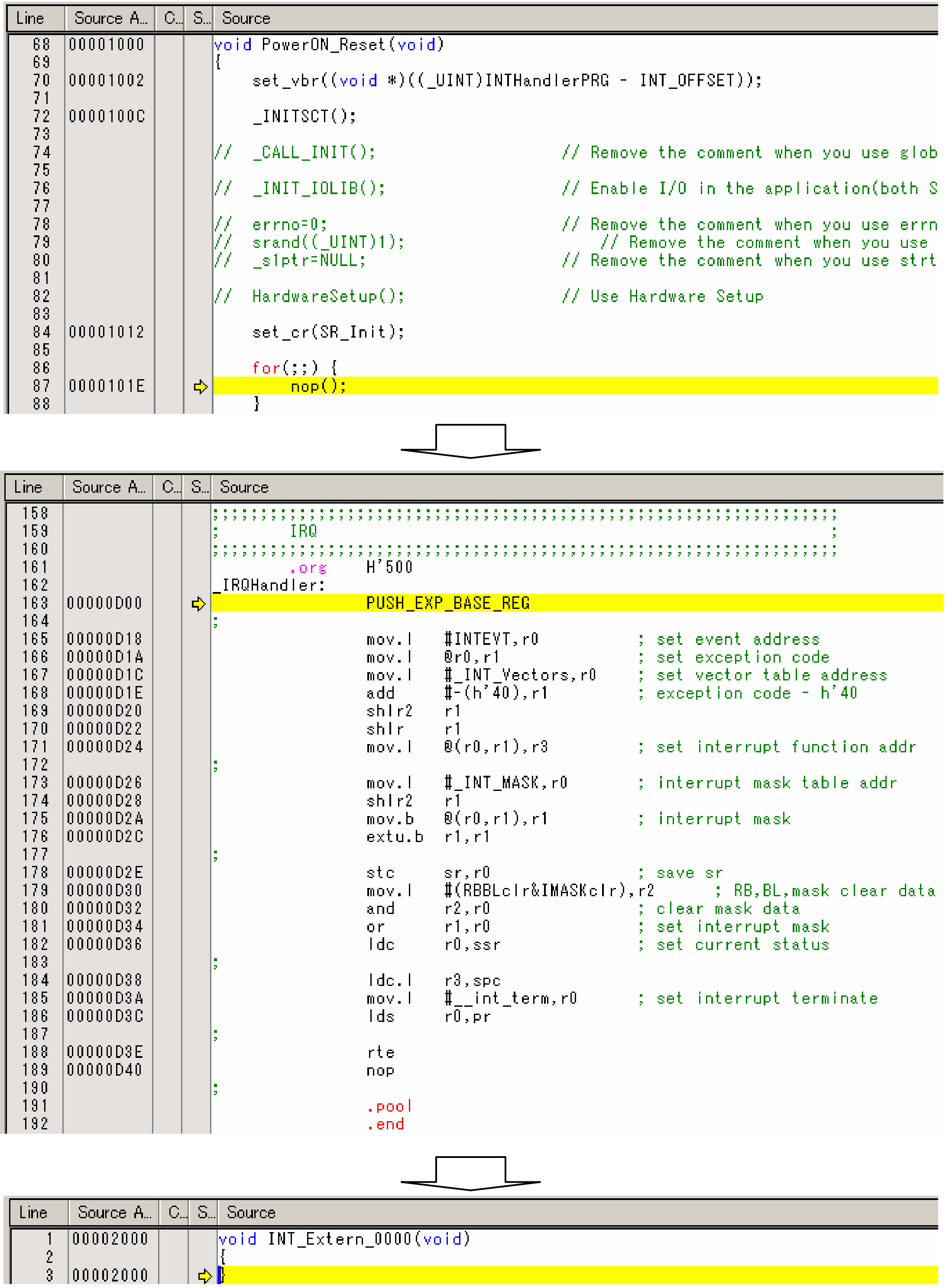

Line Source A... C... S... Source
68 00001000 void PowerON_Reset(void)
69 {
70 00001002 set_vbr((void *)((_UINT)INTHandlerPRG - INT_OFFSET));
71
72 0000100C _INITSCT();
73
74 // _CALL_INIT(); // Remove the comment when you use glob
75
76 // _INIT_IOLIB(); // Enable I/O in the application(both S
77
78 // errno=0; // Remove the comment when you use errn
79 // srand((_UINT)1); // Remove the comment when you use
80 // _s1ptr=NULL; // Remove the comment when you use strt
81
82 // HardwareSetup(); // Use Hardware Setup
83
84 00001012 set_cr(SR_Init);
85
86 for(;;) {
87 0000101E nop();
88 }
Line Source A... C... S... Source
158 ;;;
159 ; IRQ ;
160 ;;;
161 .org H'500
162 _IRQHandler:
163 00000D00 PUSH_EXP_BASE_REG
164 ;
165 00000D18 mov.l #INTEVT,r0 ; set event address
166 00000D1A mov.l @r0,r1 ; set exception code
167 00000D1C mov.l #_INT_Vectors,r0 ; set vector table address
168 00000D1E add #-(h'40),r1 ; exception code - h'40
169 00000D20 shlr2 r1
170 00000D22 shlr r1
171 00000D24 mov.l @(r0,r1),r3 ; set interrupt function addr
172 ;
173 00000D26 mov.l #_INT_MASK,r0 ; interrupt mask table addr
174 00000D28 shlr2 r1
175 00000D2A mov.b @(r0,r1),r1 ; interrupt mask
176 00000D2C extu.b r1,r1
177 ;
178 00000D2E stc sr,r0 ; save sr
179 00000D30 mov.l #(RBBLclr&IMASKclr),r2 ; RB,BL,mask clear data
180 00000D32 and r2,r0 ; clear mask data
181 00000D34 or r1,r0 ; set interrupt mask
182 00000D36 ldc r0,ssr ; set current status
183 ;
184 00000D38 ldc.l r3,spc
185 00000D3A mov.l #__int_term,r0 ; set interrupt terminate
186 00000D3C lds r0,pr
187 ;
188 00000D3E rte
189 00000D40 nop
190 ;
191 .pool
192 .end
Line Source A... C... S... Source
1 00002000 void INT_Extern_0000(void)
2 {
3 00002000 }

Figure 5-9

6. Timer simulation

Timer control is used in many embedded applications. The simulator allows timer functionality to be partially simulated, allowing timer-based application debugging.

Note that the timers supported by the simulator differ depending on the CPU used. For details about the timers supported by the simulator, see *SuperH™ RISC engine Simulator/Debugger User's Manual 2.9.2 Control Registers*. For simulation of functionality for which terminal I/O such as input capture is used, use a pseudo-interrupt (see *5. Pseudo-interrupts*). Note that the type and usage of device timers differ depending on the device used. For details about timers, see the hardware documentation for the device used.

6.1 Usage

To simulate timer control in the simulator, the peripheral function simulation module for the timer used must be registered. Note that if the register address of the device used differs from the default simulator settings, the register address for the peripheral function simulation module needs to be changed. The following explains how to register the peripheral function simulation module, and change the register address of the peripheral function simulation module.

(1) Registering the peripheral function simulation module

The peripheral function simulation module can be registered from the Set Peripheral Function Simulation dialog box displayed when the simulator starts up. From the Set Peripheral Function Simulation dialog box, select the checkbox of the timer to be used, from the **Peripheral Functions** list.

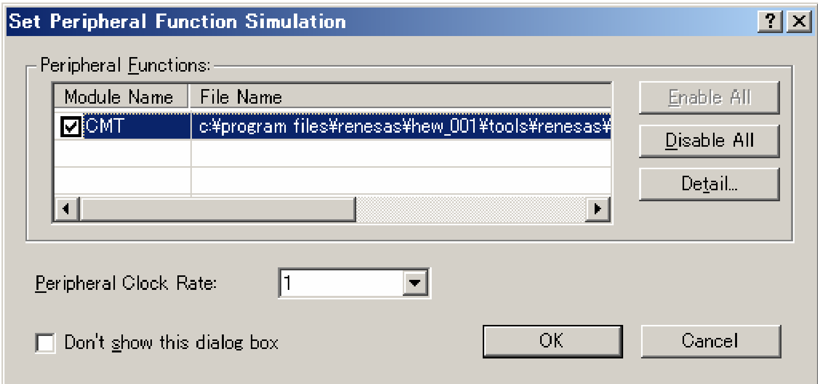


Figure 6-1

The following explains the contents set in each item in the Set Peripheral Function Simulation dialog box.

[Peripheral Function] Shows information on the peripheral function simulation modules.
[Module Name] Names of peripheral functions to be simulated
[File Name] Names of files holding peripheral function simulation modules
Check the checkbox under [Module Name] to register the corresponding peripheral function simulation module and make it available.
[Enable All] Enables all peripheral functions.
[Disable All] Disables all peripheral functions.
[Detail…] Opens the [Peripheral Module Configuration] dialog box, allowing you to view information on the corresponding peripheral function, and change the address where it starts and the interrupt-source information.
[Peripheral Clock Rate] The ratio between the peripheral clock and the internal clock (the number of cycles of the internal clock corresponding to one cycle of the peripheral clock) is specified here. The clock rate setting can be selected as 1, 2, 3, 4, 6, 8, 12, 16, 24, or 32.

When the **Don't show this dialog box** checkbox is selected in the Set Peripheral Function Simulation dialog box, the Set Peripheral Function Simulation dialog box is no longer displayed when the simulator starts up. To have it displayed again, from the **Setup** menu, choose **Options** to display the Options dialog box, and then select the **Confirmation** tab. When the **Display Set Peripheral Function Simulation dialog box at start up** checkbox is selected in the **Display confirmation**

dialogs for list in the **Confirmation** tab, the Set Peripheral Function Simulation dialog box is displayed when the simulator starts up.

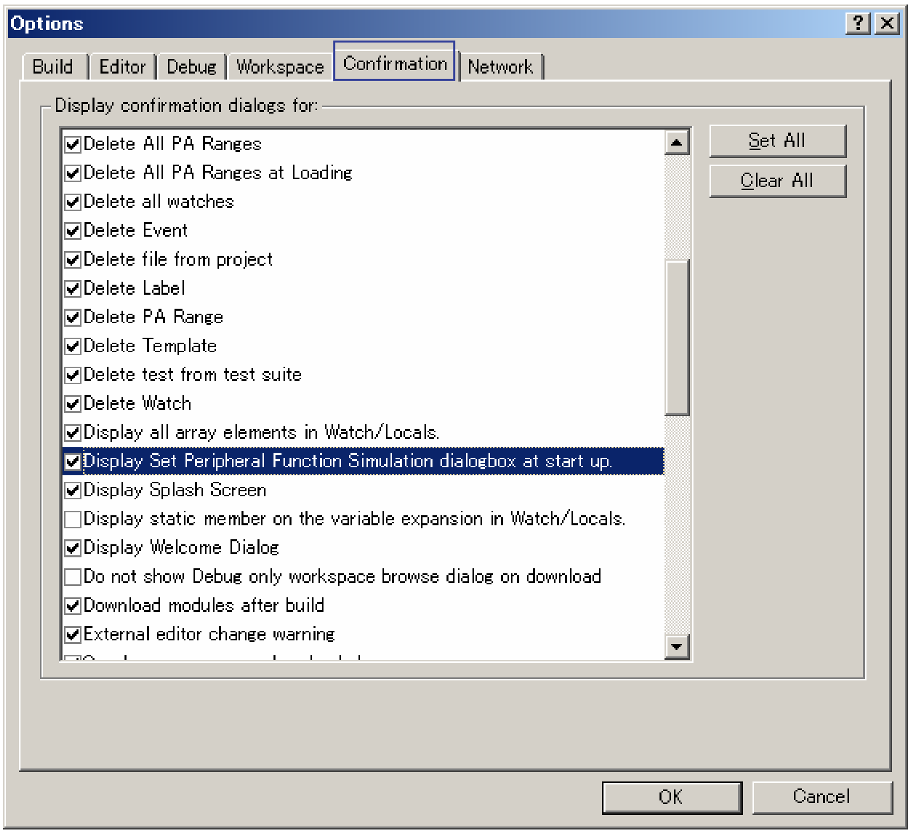


Figure 6-2

(2) Changing the address of the peripheral function simulation module

The register address of the peripheral function simulation module can be changed from the Peripheral Module Configuration dialog box. In the **Peripheral Function** field in the Set Peripheral Function Simulation dialog box, select the peripheral function for which the register address is to be changed, and then click the **Detail** button to display the Peripheral Module Configuration dialog box. In the Peripheral Module Configuration dialog box, set the register address of the device used in **Begin Address (Register)**.

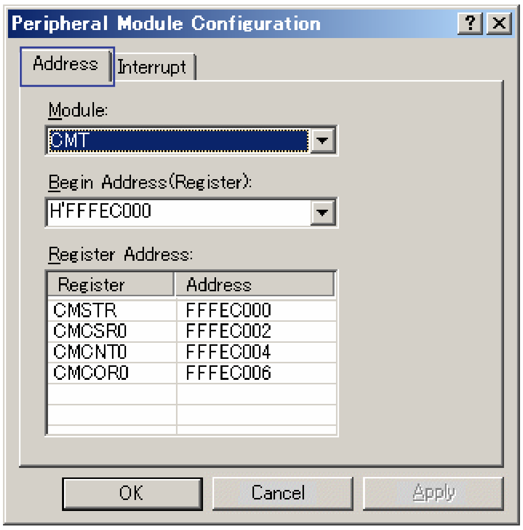
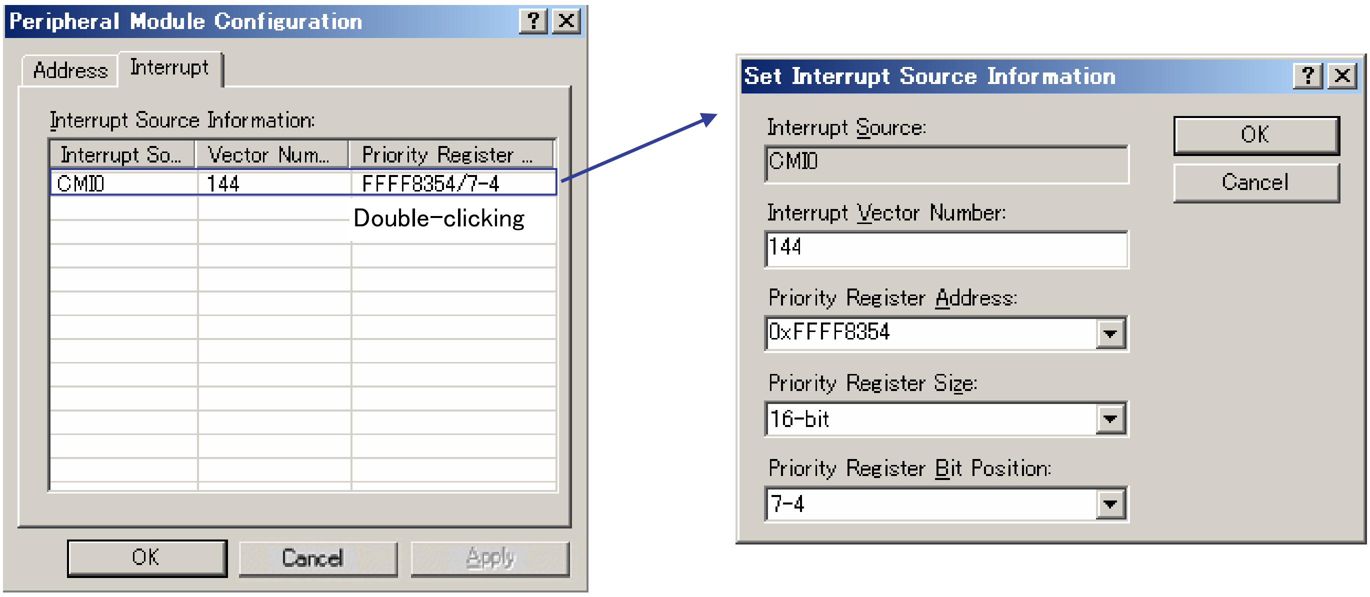


Figure 6-3

The following items are displayed and set in the **Address** tab of the Peripheral Module Configuration dialog box.

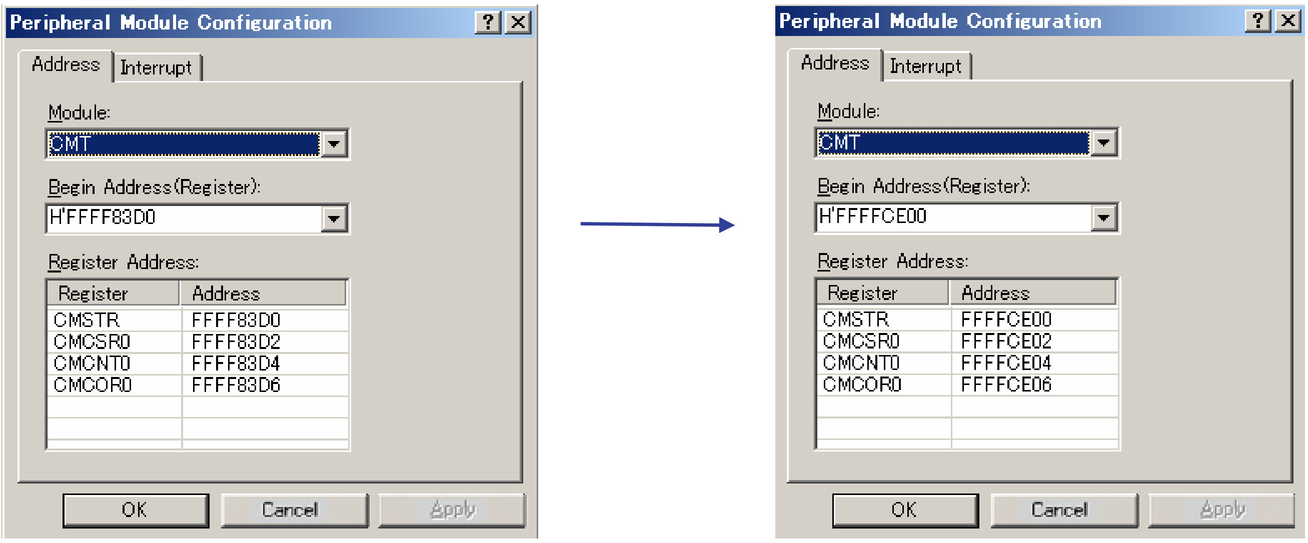
[Module]	Name of the peripheral function supported by the selected peripheral function simulation module
[Begin Address(Register)]	Start address of the peripheral function selected in [Module]
[Register Address]	Names and addresses of registers of the peripheral function selected in [Module]. It is not possible to change the register addresses.

Note that interrupt cause information for peripheral functions can be viewed and changed in the **Interrupt** tab of the Peripheral Module Configuration dialog box.

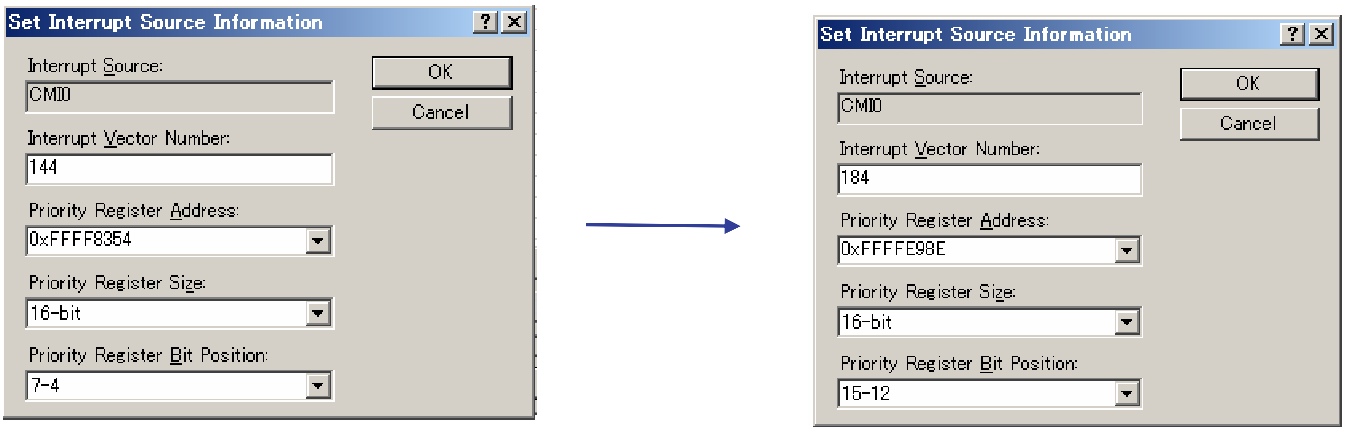


[Interrupt Vector Number]	Number of Interrupt Vector
[Priority Register Address]	Address of Priority Register
[Priority Register Size]	Size of Priority Register
[Priority Register Bit Position]	Bit Position of Priority Register

[Example of setting SH7085]



Begin Address (Register) : H'FFFFCE00



Interrupt Vector Number : 184

Priority Register Address : 0xFFFFE98E

Priority Register Bit Position : 15 - 12

6.2 Sample program

The following explains how to use the sample program for timer simulation. In the sample program, interrupts based on a compare match timer (CMT) are used to increment a variable at a fixed interval. The CMT is a timer for which an interrupt occurs when the timer count and compare match value match.

The following gives a detailed explanation of the sample program. Note that the structure corresponding the register for the interrupt controller (INTC) and CMT peripheral function module is defined in `iodefine.h`.

- `main` function
  (1) The `count` variable for counting is initialized.
  (2) `set_imask()` is used to set the interrupt mask to `0` so that interrupts can be received.
  (3) The CMT interrupt priority is set.
  (4) The CMT compare match value is set.
  (5) CMT interrupt occurrence is permitted.
  (6) The CMT timer count is started.
  (7) An infinite loop occurs, and the CMT interrupt continues to be received.

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

unsigned int count;

void main (void)
{
    count = 0;                /* (1) */

    set_imask (0);            /* (2) */
    INTC.IPR08.WORD = 0xF000; /* (3) */
    CMT0.CMCOR      = 0x0FFF; /* (4) */
    CMT0.CMCSR.WORD = 0x0040; /* (5) */
    CMT.CMSTR.WORD  = 0x01;   /* (6) */

    for (;;) {                 /* (7) */
        nop();
    }
}
```

- Timer interrupt function
  (1) The `count` variable for counting is incremented.
  (2) Interrupt is permitted again, since timer interrupt occurrence is prohibited when the CMT timer count matches the compare match value. Note that the CMT timer count returns to `0` when it matches the compare match value, and that incrementing is restarted.

```
// 140 CMT CMI0
#include "iodefine.h"

extern unsigned int count;

void INT_CMT_CMI0 (void){
    count++;                  /* (1) */
    CMT0.CMCSR.WORD = 0x0040; /* (2) */
}
```

When starting the simulator, register the peripheral function simulation module in the Set Peripheral Function Simulation dialog box. For details about registration, see *6.1 Usage*.

Check the Watch window for the value of the `count` variable during program execution. From **Symbol** in the **View** menu, choose **Watch** to display the Watch window. In the Watch window, register the symbol for the `count` variable, and then enable auto-update for the registered `count` symbol. When the sample program is executed, the `count` variable is incremented in the Watch window (Figure 6-4). This reflects the fact that timer interrupts are occurring regularly.

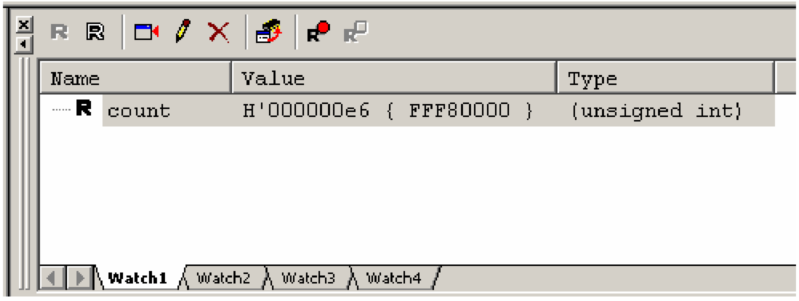


Figure 6-4

7. Eventpoints

Breakpoints (software breakpoints) set from the editor window stop execution of user programs immediately before the instruction at the set address is executed. In contrast, eventpoints can be set to provide more advanced program stop conditions than software breakpoints. For example, breakpoints can be set to stop a program when conditions such as the following are satisfied:

(1) The value of a certain register or piece of data reaches a specified value
(2) The specified data area is accessed
(3) The execution cycle count reaches the specified cycle count

Note that for an eventpoint, instead of stopping the program when a set condition is satisfied, data can be written from a file to memory or from memory to a file, and an interrupt can occur.

7.1 Usage

Eventpoints can be set by choosing **Eventpoints** from **Code** in the **View** menu, to display the Eventpoints window. Right-click in the Eventpoints window to display a pop-up menu, and then choose **Add** to display the Select Break Type dialog box. In the Select Break Type dialog box, set the conditions for stopping user programs, and the operations performed when conditions are satisfied. When settings are completed, if **Stop** is specified for **Action type**, the contents of the set eventpoint are displayed in the **Software Break** tab of the Eventpoints window. If anything other than **Stop** is specified, the contents of the set eventpoint are displayed in the **Software Event** tab of the Eventpoints window. For details about the items that can be set for eventpoints, see *SuperH™ RISC engine Simulator/Debugger User's Manual - 3.4 Using the Simulator/Debugger Breakpoints*.

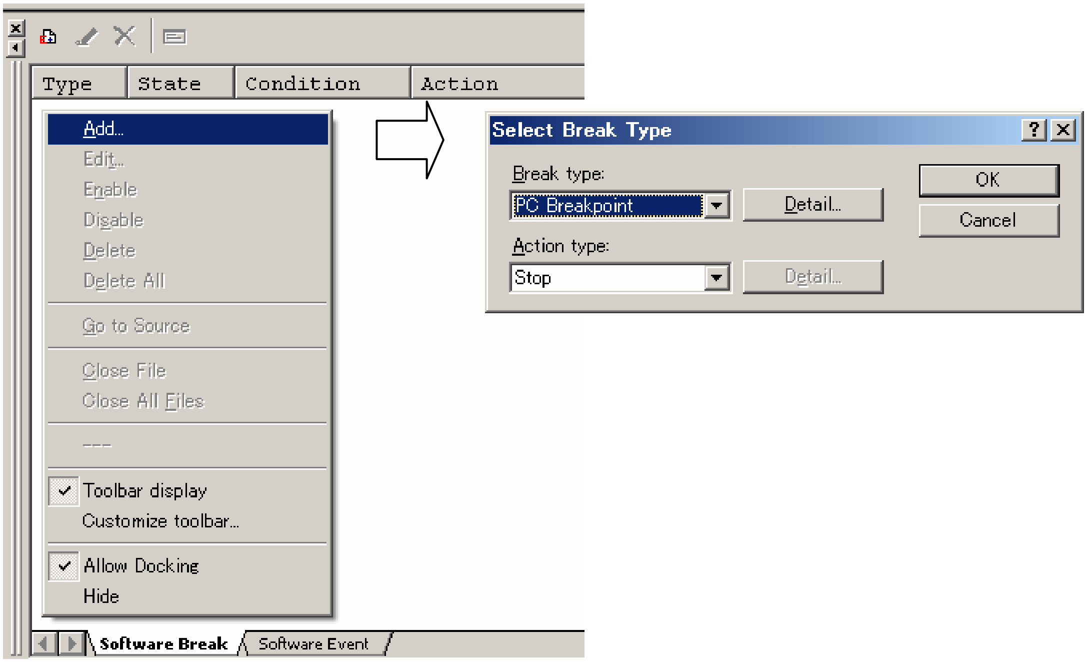


Figure 7-1

The following lists the information displayed in the Eventpoints window:

[Type] Break types

- [BP]: PC break
- [BA]: Access break
- [BD]: Data break
- [BR]: Register break (register name)
- [BS]: Sequential break
- [BCY]: Number-of cycles break

[State] Whether the breakpoint is enabled or disabled.

- [Enable]: Valid
- [Disable]: Invalid

[Condition] Condition that causes a break. The contents to be displayed depend on the type of the break. When the type of the break is BR, the register name is displayed, and when the type of the break is BCY, the number of cycles is displayed.

- BP: PC = Program counter (Corresponding file name, line, and symbol name)
- BA: Address=Address (Symbol name)
- BD: Address=Address (Symbol name)
- BR: Register=Register name
- BS: PC = Program counter (Corresponding file name, line, and symbol name)
- BCY: Cycle = Number of cycles (displayed in hexadecimal)

[Action] Operation of the simulator/debugger when a break condition is satisfied.

- [Stop]: Execution halts
- [File Input]: (file name) [File state]: Memory data is read from file
- [File Output]: (file name) [File state]: Memory data is written to file
- [Interrupt]: (Interrupt type/priority): Interrupt processing.
  Only for the SH3-DSP, (Interrupt type 1, interrupt type 2/priority) is displayed.

7.2 Sample program

The following explains how to use the sample program for using eventpoint break data. In the sample program, the global variable `x` is incremented in a loop. This program is used as an example in which the program is stopped when the global variable `x` reaches a specific value.

The sample program is as follows:

```
volatile long x;

void main (void)
{
    int i;

    x = 0;
    for (i=0; i < 10000; i++ ) {
        x++;
    }
}
```

The following explains how to stop a program when the value of the global variable `x` reaches 5000. First, from the Select Break Type dialog box, choose **break data** for **Break type**, and then click the **Detail** button to display the Set Data Break Condition dialog box. Then, set the items in the Set Data Break Condition dialog box as follows:

- **Address**: `_x`
- **Option**: **Equal**
- **Data**: `D'5000`
- **Data mask**: Cleared
- **Size**: `Long word`

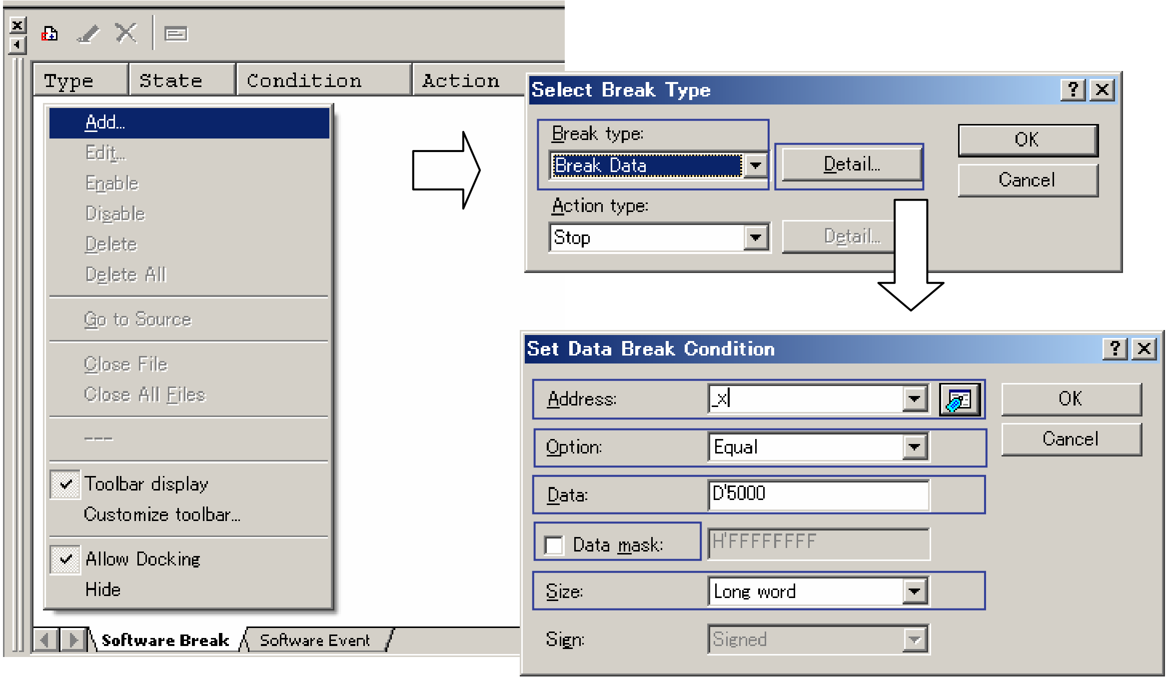


Figure 7-2

The set eventpoint is displayed in the Eventpoints window.

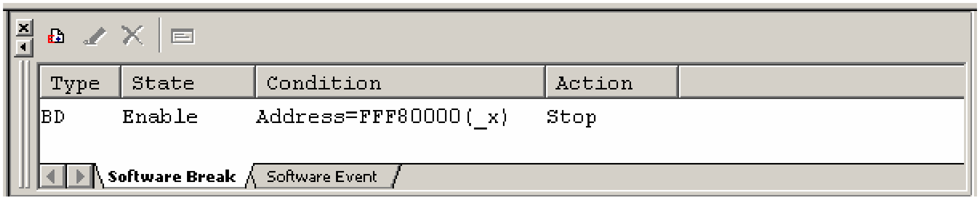


Figure 7-3

When the sample program is executed, it is stopped immediately after the value of the variable x reaches 5000.

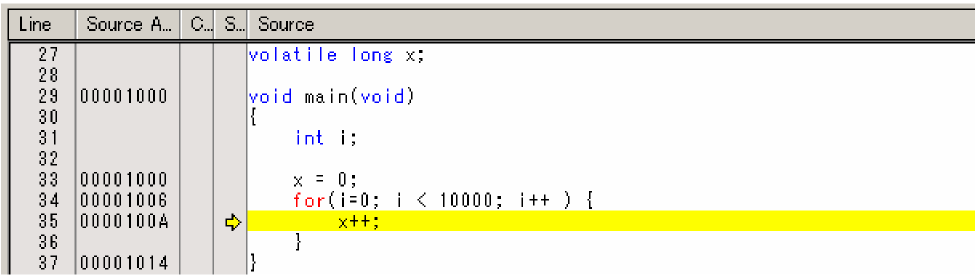


Figure 7-4

8. Virtual I/O panels

Virtual I/O panels can be used to check data visually, by placing virtual buttons and LEDs on the simulator window. Virtual I/O panels can use the following GUI components:

- Buttons
  Buttons can be clicked to input data to the specified address, or make a virtual interrupt occur.
- Labels
  Specific strings can be displayed and removed when specified values are written to a specified address or bit.
- LEDs
  Specified colors can be displayed (in place of an LED light) when specified values are written to a specified address or bit.
- Text
  Specified strings are always displayed.

8.1 Usage

Virtualized output panels are used by being placed in the GUI I/O window. The following explains how to set up a panel.

From **Graphic** in the **View** menu, choose **GUI I/O** to display the GUI I/O window. To place the panel, right-click in the GUI I/O window to display a pop-up menu, and then choose the item for the panel to be created. The mouse cursor will change to a plus sign (+), at which point the panel to be created can be dragged between from the upper left to the lower right to create an output frame. As output frames are selected once they are created, the created output frame can be double-clicked to display a dialog box for setting the panel display contents.

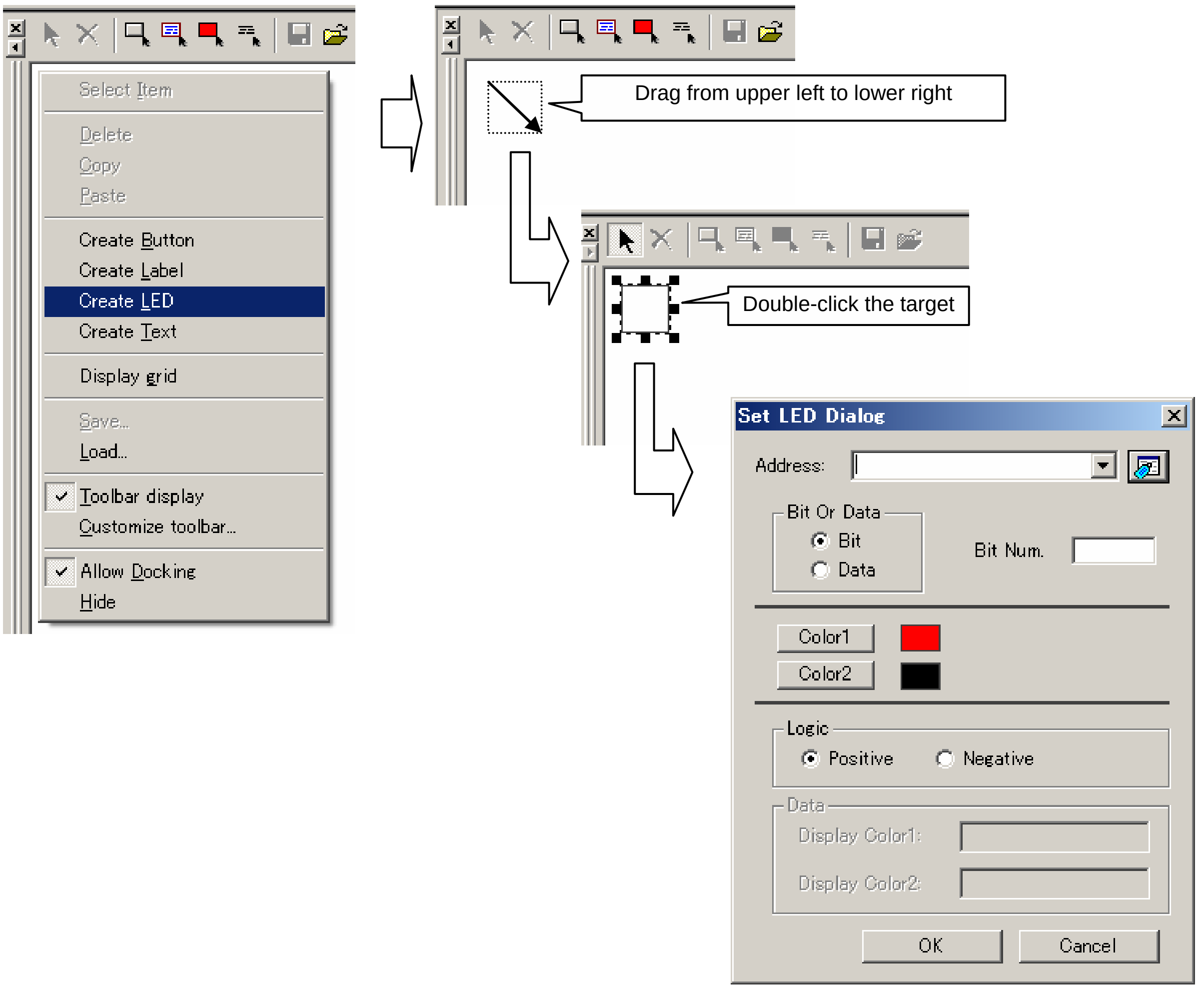


Figure 8-1

The panel settings for the GUI I/O window are saved independently of the workspace, which means that they need to be saved to a file separate from the workspace and project. To save panel settings, from the pop-up menu, choose **Save** to display the Save GUI I/O Panel File dialog box. In the Save GUI I/O Panel File dialog box, specify the save destination file name, whose extension is `.pnl` by default. To load a file to which panel settings have been saved, from the pop-up menu in the GUI I/O window, choose **Load**, and then select the saved file.

8.1.1 Button display

To create a button panel, from the pop-up menu, choose **Create** Button. Once the button output frame is created, select the output frame, and double-click to display the Set Button Dialog dialog box.

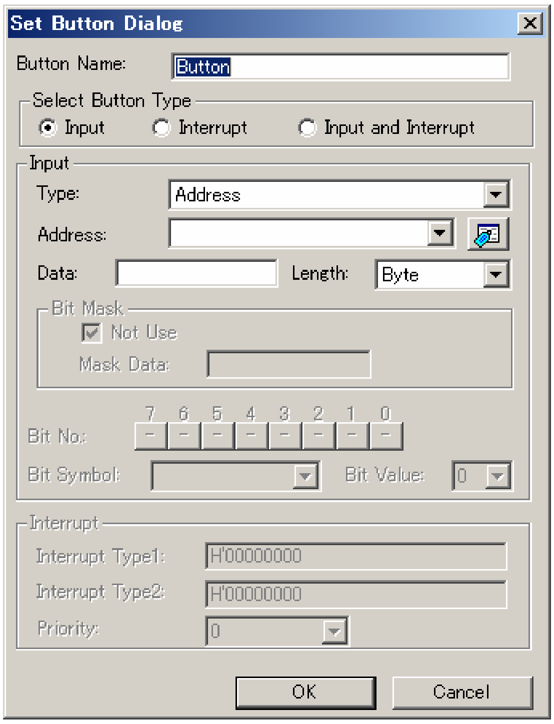


Figure 8-2

Perform the following settings in the Set Button Dialog dialog box.

Button Name Specify the name displayed in the button panel.

Select Button Type Select **Input**, **Interrupt**, or **Input and Interrupt**.

Input: specify the following when **Input** or **Input and Interrupt** is selected for **Select Button Type**:

Type Select **Address** to change the specified address to a specific value, or **Address & Bit No.** to specify a bit position and change the value of the specified address, when the button panel is clicked.

Address Specify the address for changing the value when the button panel is clicked.

Data Specify the value to replace the specified address when the button panel is clicked. Specify this if **Address** is selected for **Type**, or **Address & Bit No.** is selected and a bitwise mask is used.

Length Specify the size of the data.

Bit Mask Set the following when **Address & Bit No.** is set for **Type**:
When not using a bitwise mask, clear the **Not use** checkbox, and set **Bit No**. To use a bitwise mask, set **Mask Data**.

Mask Data Change the value of the specified address to the bits of the value specified for the data, only where the bit for the specified mask value is `1`.

Bit No For bits 7 to 0, specify `0`, `1`, or `-`.
Specify `0` for bits whose value is to be set to `0`.
Specify `1` for bits whose value is to be set to `1`.
Specify `-` for bits whose value is to be unchanged.

Bit Symbol and **Bit Value** cannot be input for SH microcomputer simulators.

Interrupt Specify this when **Interrupt** or **Input and Interrupt** is selected for **Select Button Type**.

[Interrupt Type1] Sets the following values for each CPU
- SH-1, SH-2, SH2-DSP, and SH2A-FPU series
  Interrupt vector number
- SH-3, SH-4 and SH3-DSP series
  INTEVT (H'0 to H'FFF)
- SH-4A series
  INTEVT (H'0 to H'3FFF)

[Interrupt Type2] Only selectable for the SH3-DSP series: INTEVT2 (H'0 to H'FFF)

[Priority] Interrupt priority (0 to 17)
When 16 is specified, the interrupt is always accepted regardless of the value of the I bit value in SR, but is masked by the BL bit in SR. When 17 is specified, the interrupt is always accepted regardless of the I and BL bit values in SR.

8.1.2 Label display

To create a label panel, from the pop-up menu, choose **Create Label**. Once the label output frame is created, select the output frame, and double-click to display the Set Label Dialog dialog box.

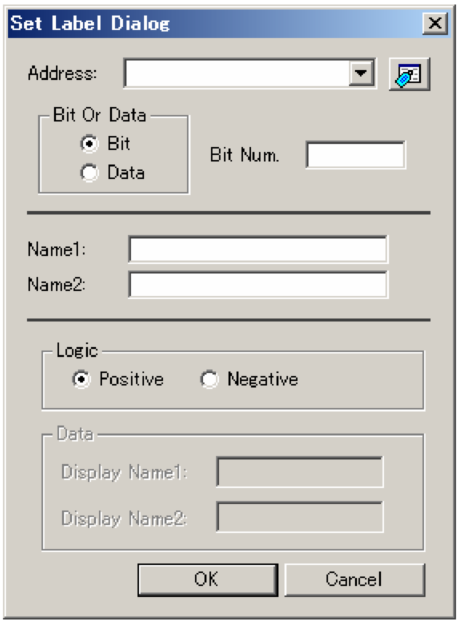


Figure 8-3

Perform the following settings in the Set Label Dialog dialog box:

(1) When the **Bit** radio button is selected for **Bit Or Data**:

Address Set the start address for byte data.
Bit Num Set the bit position (0 to 7) from the LSB in the byte data.
Name1 Set the string to be displayed.
Name2 Set the string to be displayed.
Logic The label panel is displayed as follows:
If the **Positive** radio button is selected, **Name1** is displayed when the set bit is `1`, and **Name2** is displayed when the set bit is `0`.
If the **Negative** radio button is selected, **Name2** is displayed when the set bit is `1`, and **Name1** is displayed when the set bit is `0`.

(2) When the **Data** radio button is selected for **Bit Or Data**:

Address Set the start address for byte data.
Name1 Set the string to be displayed.
Name2 Set the string to be displayed.
Data The label panel is displayed as follows:
Name1 is displayed if the data specified in **Address** is the value set for **Display Name1**, and **Name2** is displayed if the data specified in **Address** is the value set for **Display Name2**. Note that no string is displayed for values other than those set for **Display Name1** and **Display Name2**.

8.1.3 LED display

To create an LED panel, from the pop-up menu, select **Create LED**. Once the LED output frame is created, select the output frame and double-click to display the Set LED Dialog dialog box.

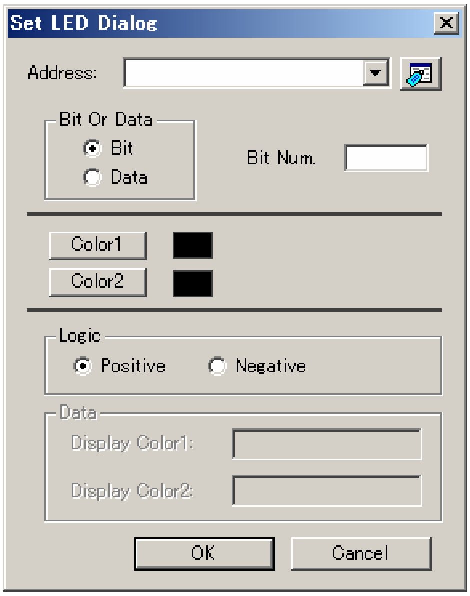


Figure 8-4

Perform the following settings in the Set LED Dialog dialog box:

(1) When the **Bit** radio button is selected for **Bit Or Data**:

Address Set the start address for byte data.
Bit Num Set the bit position (0 to 7) from the LSB in the byte data.
Color1 Select the color to be displayed.
Color2 Select the color to be displayed.
Logic The label panel is displayed as follows:
If the **Positive** radio button is selected, **Color1** is displayed when the set bit is `1`, and **Color2** is displayed when the set bit is `0`.
If the **Negative** radio button is selected, **Color2** is displayed when the set bit is `1`, and **Color1** is displayed when the set bit is `0`.

(2) When the **Data** radio button is selected for **Bit Or Data**:

Address Set the start address for byte data.
Color1 Select the color to be displayed.
Color2 Select the color to be displayed.
Data The label panel is displayed as follows:
Color1 is displayed if the data specified in **Address** is the value set for **Display Color1**, and **Color2** is displayed if the data specified in **Address** is the value set for **Display Color2**. Note that nothing is displayed for values other than those set for **Display Color1** and **Display Color2**.

8.1.4 Text display

To create a text panel, from the pop-up menu, choose **Create Text**. Once the text output frame is created, select the output frame, and then double-click to display the Set Text Dialog dialog box.

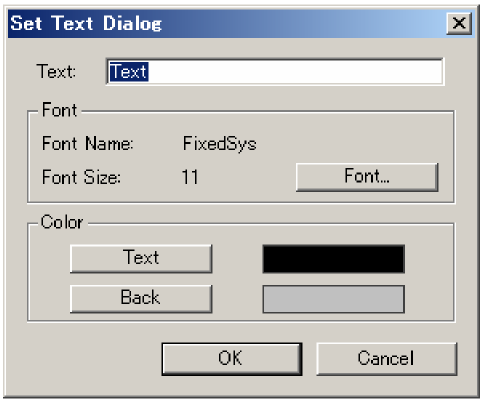


Figure 8-5

Perform the following settings in the Set Text Dialog dialog box:

Text	Set the string to be displayed in the text panel.
Font	Click the **Font** button to set the font and font size of the string displayed.
Color	Click the **Text** button to set the color of the string displayed. Click the **Back** button to set the background color of the text panel.

8.2 Sample program

The following uses a sample program to explain how to use virtual I/O panels.

The virtual I/O panel for the sample program contains an LED panel that is lit based on the value of a given variable, and a button panel to change the value of the variable. The sample program shows an example in which the value of a variable is changed by the button panel, and the results are indicated by a lit LED panel. Note that in the sample program, using flashing LEDs for variable access implies I/O port access. On actual hardware, I/O port initialization processing is required when displaying LEDs or performing input from buttons.

The sample program is as follows. The `main` function performs only an infinite loop.

```
#include <machine.h>

volatile unsigned char port;

void main (void)
{
    Port = 0;
    for (;;) {
        nop();
    }
}
```

Place the output frame of the virtual I/O panel as follows in the GUI I/O window. Place an LED panel and label panel for which the display changes according to the second bit in the variable `port`. Also place a button panel that changes the second bit of the variable `port` to `0`, and a button panel that changes the second bit of the variable `port` to `1`.

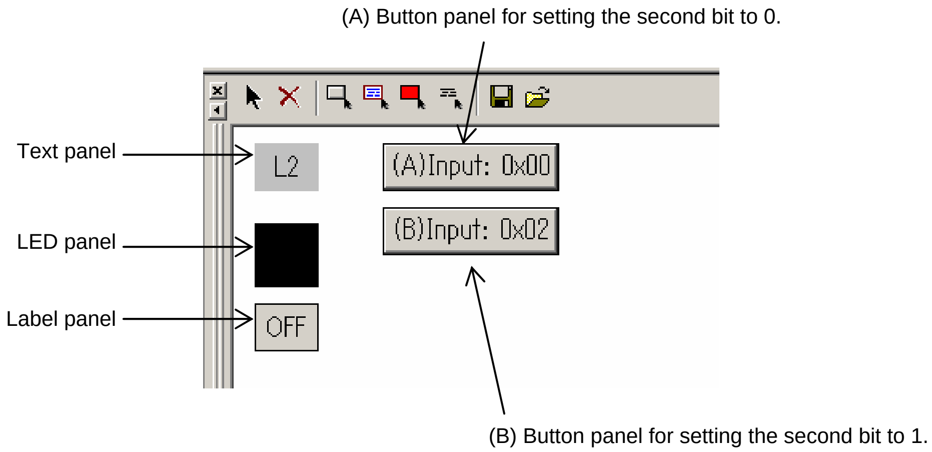


Figure 8-6

Set the contents of each panel as follows.

- Text panel
  Create a text panel to display the string L2.

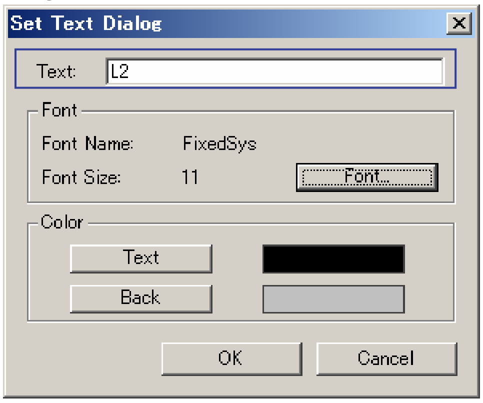


Figure 8-7

- LED panel
  Create an LED panel that changes color based on the value of the second bit of the variable `port`. Specify `1` for **Bit Num**, and set positive logic for **Logic**.

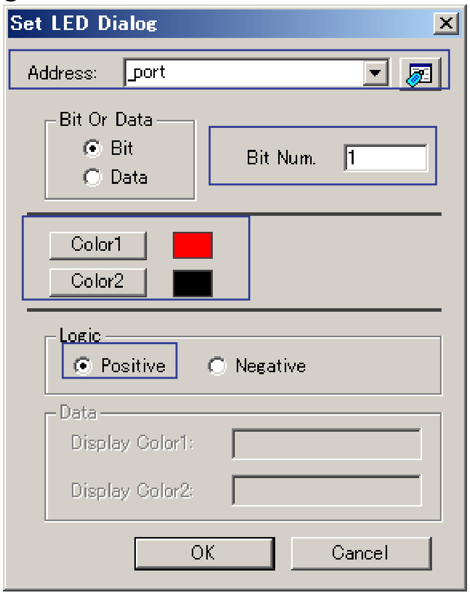


Figure 8-8

- Label panel
  Create a label panel that changes its displayed string based on the value of the second bit in the variable `port`. Specify `1` for **Bit Num**, and set positive logic for **Logic**.

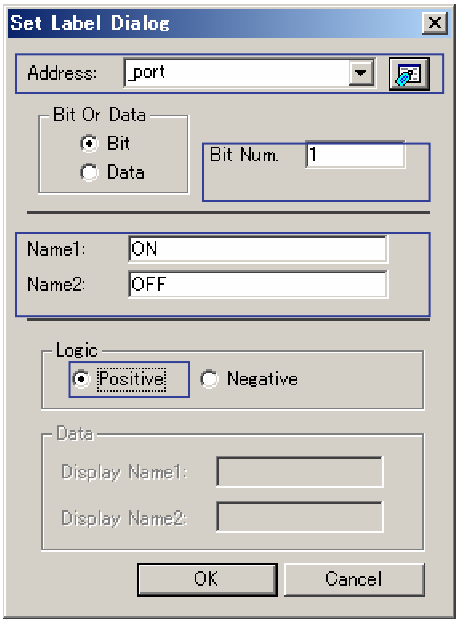


Figure 8-9

- Button panel

  Create the following button panels for setting the data in the variable `port`:
  - (A) A button panel that sets the second bit of the variable `port` to `0`.
  - (B) A button panel that sets the second bit of the variable `port` to `1`.

(A) (B)

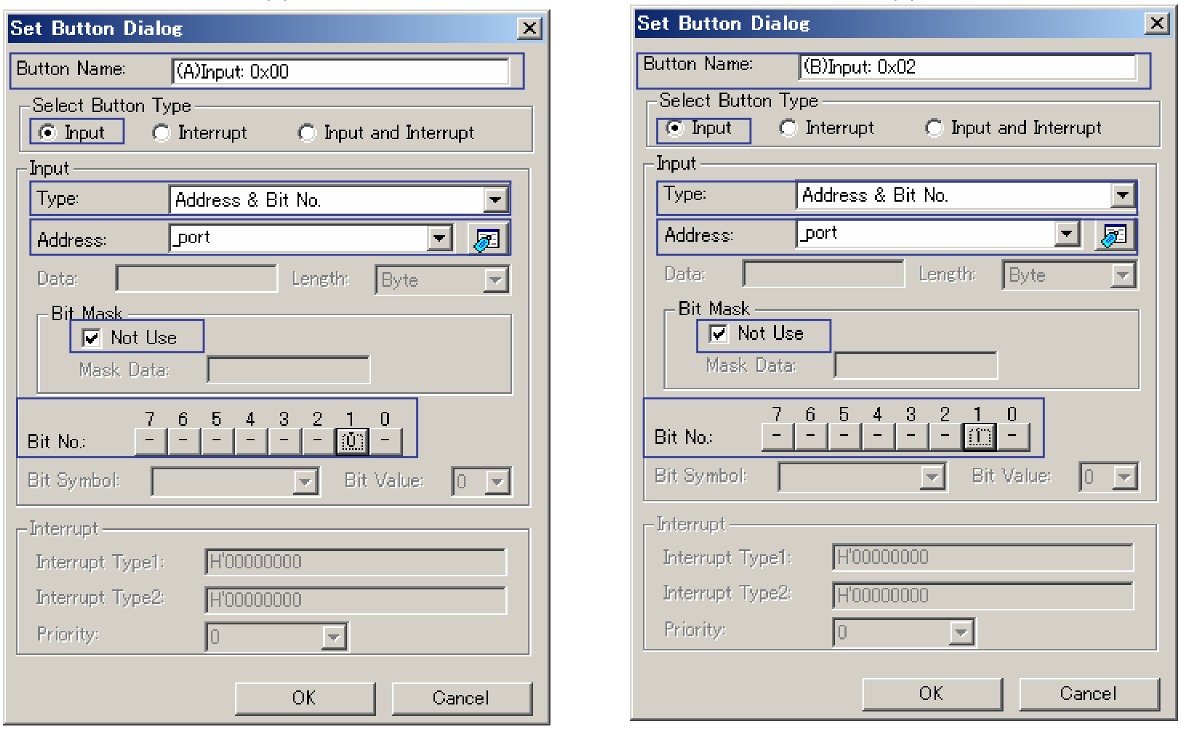


Figure 8-10

To prevent the GUI I/O window from updating during program execution, execute `cache off` in the Command window (Figure 8-11). To display the Command window, choose **Command Line** from the **View** menu.

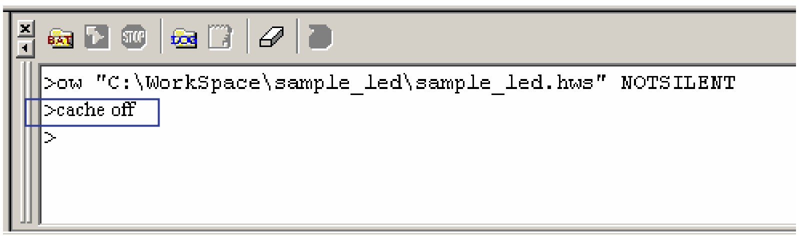


Figure 8-11

Click the (B) button panel during program execution to set the second bit of the variable `port` to `1`. This will cause the color of the LED panel to change from black to red. Likewise, the string in the label panel will change from `OFF` to `ON`.

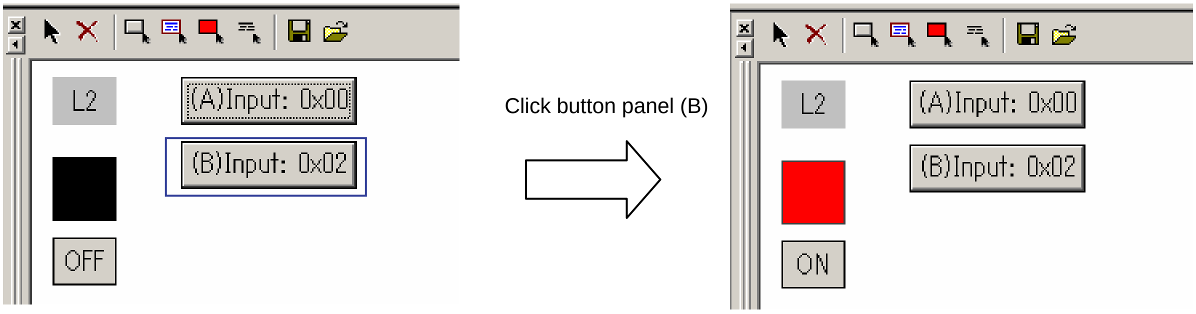


Figure 8-12

Click the (A) button panel during program execution to set the second bit of the variable `port` to `0`. This will cause the color of the LED panel to change from red to black. Likewise, the string in the label panel will change from `ON` to `OFF`.

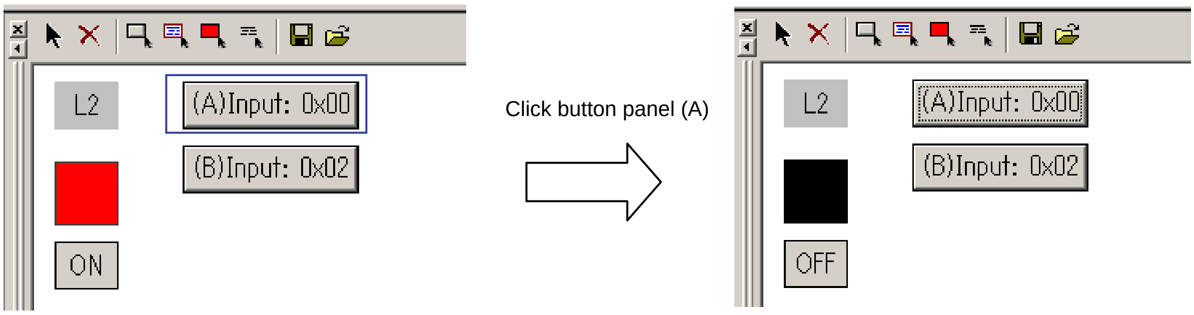


Figure 8-13

Website and Support <website and support,ws>

Renesas Technology Website

http://japan.renesas.com/

Inquiries

http://japan.renesas.com/inquiry

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Revision Record <revision history,rh>

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		Page	Summary
1.00	Apr.01.08	--	First edition issued