SH7216 Group

Interfacing Serial Flash Memory Using the Renesas Serial Peripheral Interface

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Summary

This application note describes how to connect serial flash memory using the SH7216 Microcomputers (MCUs) Renesas Serial Peripheral Interface (RSPI).

Target Device

SH7216 MCU

Contents

1. Introduction

1.1 Specifications

- Use the serial flash memory of 1 Mbit (256 Kbit × 4 sectors) to connect with the SH7216 MCU

1.2 Modules Used

- Renesas Serial Peripheral Interface (RSPI)
- General-purpose I/O ports

1.3 Applicable Conditions

MCU	SH7216
Operating Frequency	Internal clock: 200 MHz Bus clock: 50 MHz Peripheral clock: 50 MHz
Integrated Development Environment	Renesas Electronics High-performance Embedded Workshop Ver.4.07.00
C Compiler	Renesas Electronics SuperH RISC engine Family C/C++ compiler package Ver.9.03 Release 00
Compiler Options	Default setting in the High-performance Embedded Workshop (-cpu=sh2afpu -fpu=single -debug -gbr=auto -global_volatile=0 -opt_range=all -infinite_loop=0 -del_vacant_loop=0 -struct_alloc=1)

1.4 Related Application Note

For more information, refer to the following application note:

- SH7216 Group Example of Initialization

2. Applications

Connect the SH7216 MCU (Master) with the SPI-compatible serial flash memory (Slave) for read/write access using the Renesas Serial Peripheral Interface (RSPI). This chapter describes the pin connection example and flow charts of the sample program.

2.1 RSPI Operation

SH7216 RSPI allows full-duplex, synchronous, serial communications with peripheral devices in SPI operation using MOSI (Master Out Slave In), MISO (Master In Slave Out), SSL (Slave Select), and RSPCK (SPI Clock) pins.

The RSPI has the following features to support SPI-compliant devices:

- Master/slave modes
- Serial transfer clock with programmable polarity and phase (change SPI modes)
- Transfer bit length selectable (8- to 16-bit, 20-, 24-, and 32-bit)

2.2 Serial Flash Memory Pin Connection

The following table lists the specifications of the SPI-compliant serial flash memory (M25P10, STMicroelectronics) used in this application.

Table 1 Serial Flash Memory Specifications

Item	Description
SPI modes	Supports SPI modes 0 and 3
Clock frequency	20 MHz (at maximum)
Capacity	1 Mbit
Sector size	256 Kbit
Page size	128 byte
Erase architecture	Sector Erase (256 Kbit), Bulk Erase (1 Mbit)
Programming options	Page Program (1 to 128 bytes)
Protect area size	None, Upper quarter (sector 3), Upper half (sectors 3 and 2), Whole memory (all sectors)

The figure below shows an example of serial flash memory circuit. Set the SH7216 pin functions as shown in Table 2.

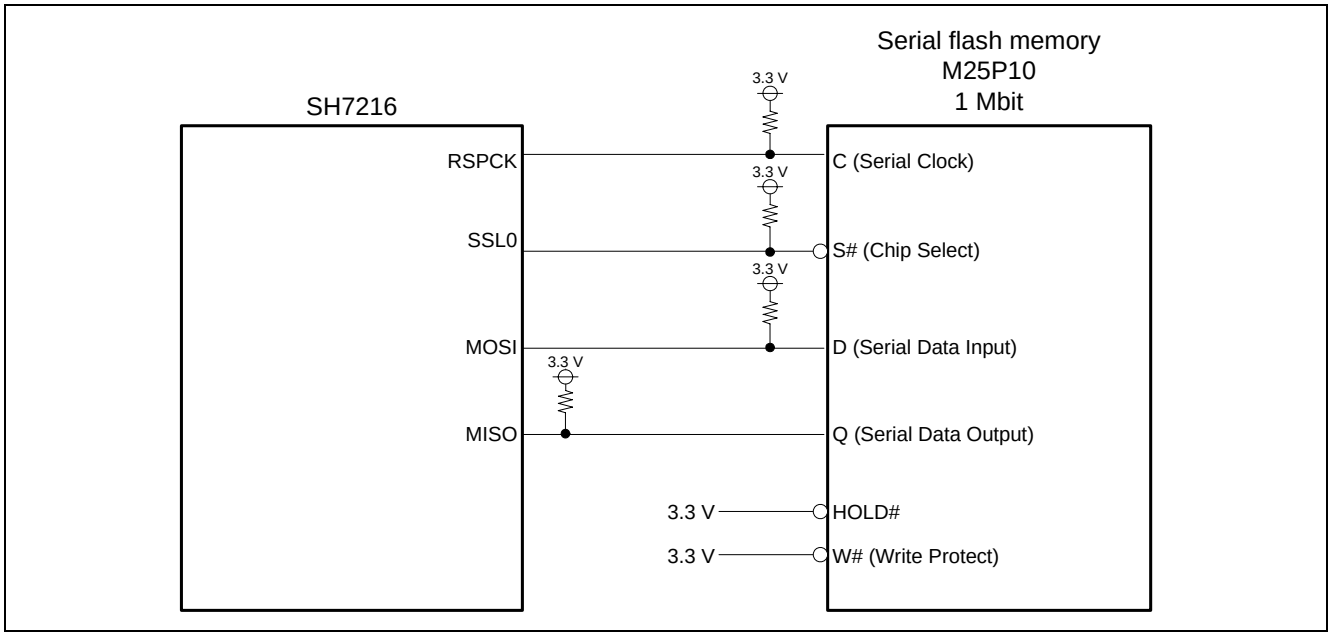

Figure 1 Serial Flash Memory Circuit

Note: Pull up or pull down the control signal pins using the external resistors
To pull up or pull down the control signal pins, determine the signal line level not to cause the external device malfunction when the MCU pin status is high-impedance. SSL0 pin is pulled up by an external resistor to high level. Pull up or down the RSPCK and MOSI pins. As the MISO pin is configured as input, pull-up or pull-down is recommended to avoid floating to the midpoint voltage.

Table 2 Multiplexed Output

Peripheral Functions	Pin Name	SH7216 Port Control Register		SH7216 Multiplexed Pin Name
		Register Name	MD bit Setting	
RSPI	RSPCK	PACRL2	PA6MD[2:0] = B'101	PA6/CS6#/IRQ6/TCLKA/RSPCK/TX_ER
	MOSI	PACRL2	PA7MD[2:0] = B'101	PA7/CS5#/IRQ5/TCLKB/MOSI/TXD1/MII_TXD3
	MISO	PACRL3	PA8MD[2:0] = B'101	PA8/CS4#/IRQ4/TCLKC/MISO/RXD1/MII_TXD2
	SSL0	PACRL3	PA9MD[2:0] = B'101	PA9/CS3#/IRQ3/TCLKD/SSL0/SCK0/MII_TXD1

Note: SH7216 Multiplexed pins
RSPCK, MOSI, MISO, and SSL0 pins are multiplexed, and set to general-purpose I/O ports by default. Before accessing serial flash memory, use the general-purpose I/O port control register to set the multiplexed pins to RSPI pins.

2.3 Interface Timing Example

This section describes an example of the interface timing between the SH7216 and serial flash memory. Initialize the RSPI and the clock frequency according to the serial flash memory, which is used as a slave device.

Figure 2 shows an example of the data transfer timing. As the serial flash memory used in this application latches data at the rising edge of the clock, and outputs data at the falling edge of the clock, specify 1 to the CPOL and CPHA bits in the RSPI command register (SPCMD). By this setting, RSPCK is specified to 1 when it is idling, and the timing to vary the data in the RSPI can be set to the odd edge (falling edge). Initialize the RSPI to satisfy the timing conditions listed in Table 3 and Table 4.

The bit rate is set to 8.3 Mbps, the access width of the RSPI data register (SPDR) is set to 2-bit in this application. Optimizing these settings allows for accessing serial flash memory in high-speed. The setup time may not be enough with the transfer setting shown in Figure 2. Extend the cycle between data output and data latch to one cycle when the setup time is not enough.

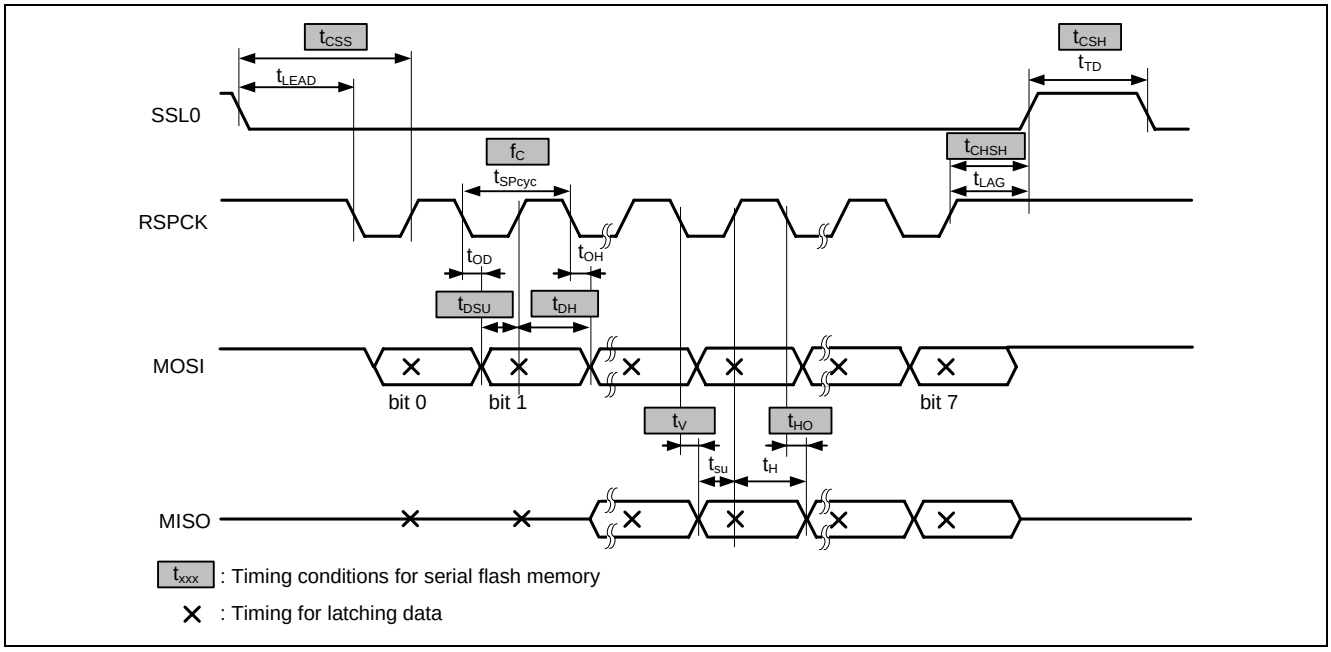

Figure 2 Data Transfer Timing Example (CPOL = 1, CPHA = 1)

Table 3 Timing Conditions for Serial Flash Memory when Transferring Data

Symbol	Item	Description	Related registers
t_{CSS}	Chip Select Low Setup Time	Time required for the slave device to latch data from asserting SSL to the RSPCK rising. The following formula must be fulfilled: t_{LEAD} (= RSPCK delay) + 1/2 × t_{SPcyc} ≥ t_{CSS} (min.)	SPCKD register SPCMD register SPBR register
t_{CSH}	Chip Select High Time	Time required for SSL negation. The following formula must be fulfilled: t_{TD} (= next access delay) ≥ t_{CSH} (min)	SPND register SPCMD register
f_C	Serial Clock Frequency	The maximum operating frequency supported by the slave device. The following formula must be fulfilled: f_C (max) ≥ 1/t_{SPcyc}	SPBR register SPCMD register
t_{CHSH}	Chip select Low Hold Time	Hold time required from the last RSPCK rising to the SSL negation. The following formula must be fulfilled: t_{LAG} (= SSL negation delay) ≥ t_{CHSH} (min.)	SSLND register SPCMD register
t_{DSU}	Data Input Setup Time	Time required for the master device from outputting data to latching data. The following formula must be fulfilled: 1/2 × t_{SPcyc} − t_{OD}(max.) ≥ t_{DSU} (min.)	SPBR register SPCMD register
t_{DH}	Data Input Hold Time	Time required for the master device to remain the data output. The following formula must be fulfilled: t_{OH} (min.) + 1/2 × t_{SPcyc} ≥ t_{DH} (min.)	SPBR register SPCMD register

Table 4 Timing Conditions for the SH7216 MCU when Transferring Data

Symbol	Item	Description	Related registers
t_{SU}	Data Input Setup Time	Time required for the slave device from outputting data to latching data. The following formula must be fulfilled: 1/2 × t_{SPcyc} − t_V (max.) ≥ t_{SU} (min.)	SPBR register SPCMD register
t_H	Data Input Hold Time	Time required for the slave device from latching data to stop the data output. The following formula must be fulfilled: t_{HO} (min.) + 1/2 × t_{SPcyc} ≥ t_H(min.)	SPBR register SPCMD register

2.4 Sample Program Operation

2.4.1 RSPI Initialization Example

Figure 3 and Figure 4 show flow charts of initializing the RSPI in the sample program. This setting enables the SPI operation in master mode.

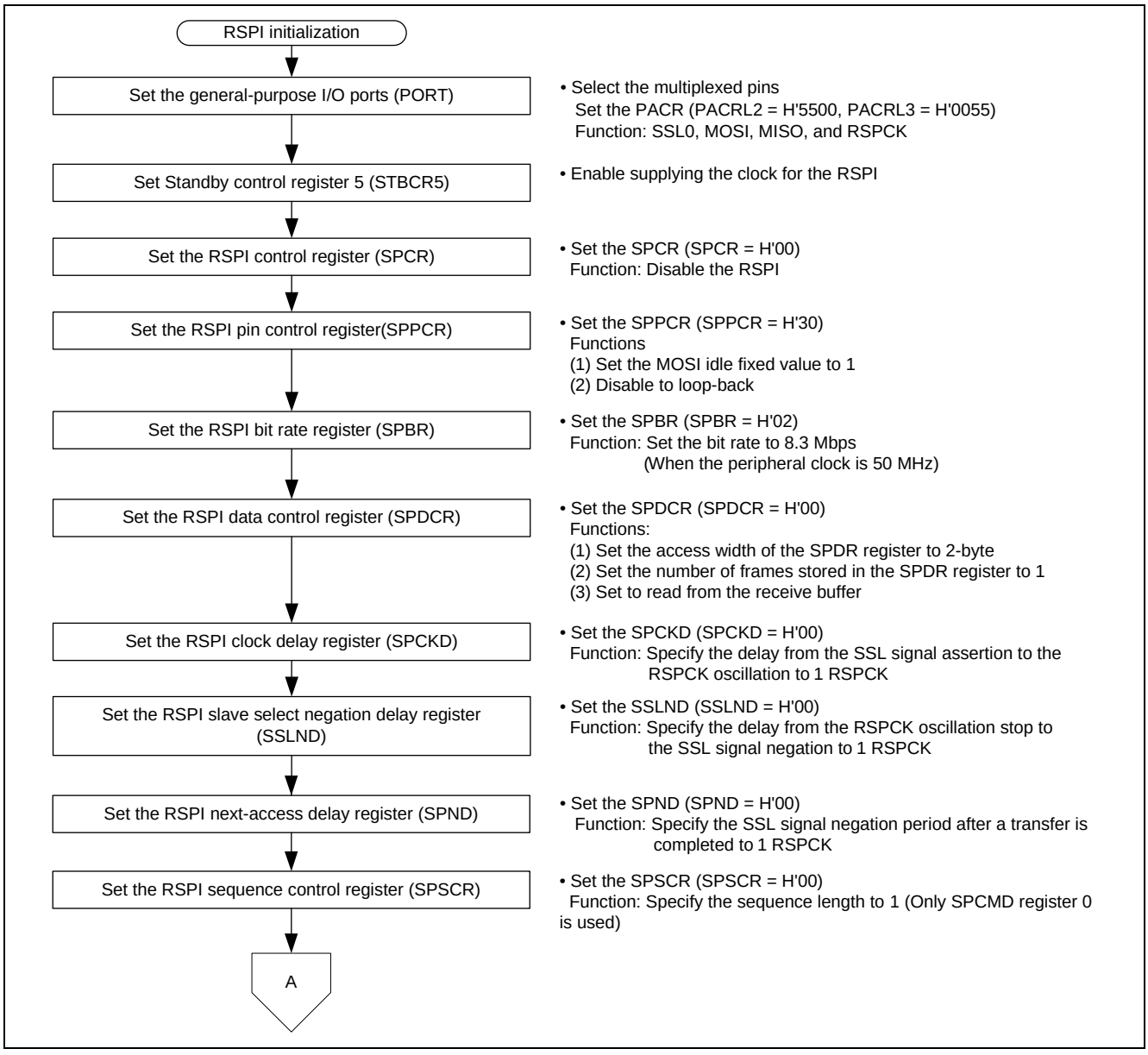

Figure 3 Flow Chart for Initializing the RSPI (1/2)

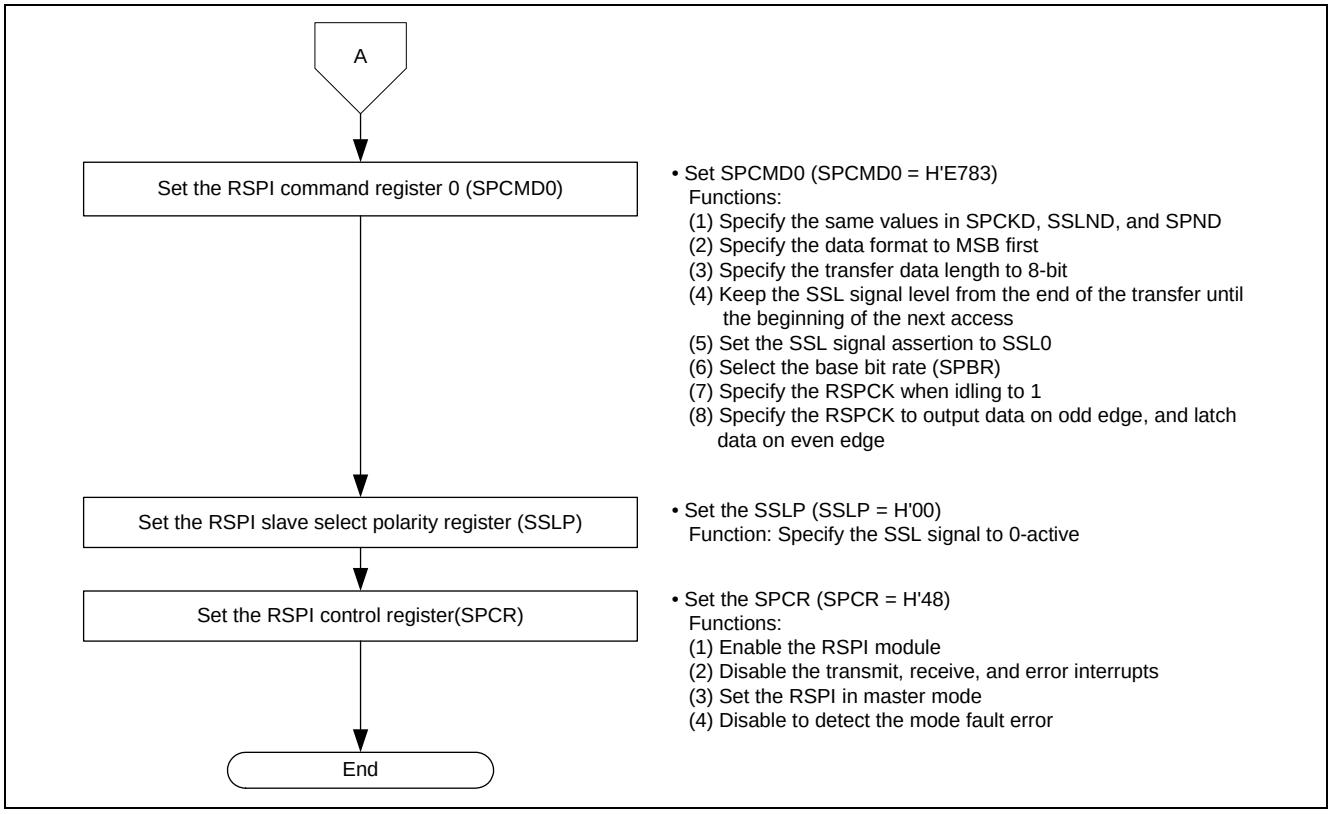

Figure 4 Flow Chart for Initializing the RSPI (2/2)

2.4.2 Command Transfer Example

Use commands to access serial flash memory. This section describes the major commands and command sequence example, and shows flow charts in the sample program.

This application refers to the commands of the STMicroelectronics M25P10. For details on commands, refer to the datasheet provided by the serial flash memory manufacturer.

A. Major Commands

The following table lists the major commands for the M25P10.

Table 5 M25P10 Commands

Command Name	Opcode	Address Bytes	Data Bytes	Function
Write Enable (WREN)	H'06	0	0	Enables the program/erase command
Write Disable (WRDI)	H'04	0	0	Disables the program/erase command
Read Status Register (RDSR)	H'05	0	1 or more	Reads the status
Write Status Register (WRSR)	H'01	0	1	Writes the status
Read Data Bytes (READ)	H'03	3	1 or more (1)	Reads the data
Page Program (PP)	H'02	3	1 to 128 (2)	Writes the data
Sector Erase (SE)	H'D8	3	0	Erases data in sectors (256 Kbit)
Bulk Erase (BE)	H'C7	0	0	Erases the entire memory array

Notes 1. Reads the address incremented from the specified address (When the last byte of the memory array has been read, the device will continue reading back at the beginning of the array).
2. Writes the data in the incremented in the same page (When the device goes beyond the end of the page, it will wrap around back to the beginning of the same page).

B. Command Sequence Example

Figure 5 shows the sequence example of the Read Data Bytes (READ) command.

When issuing the Read Data Bytes (READ) command, the master device transfers the opcode (H'03) and three address bytes after the SSL signal is asserted. Then, the slave device transfers the read data in every falling edge of the RSPCK.

Although commands can be sequentially issued by repeating to transfer the data in the specified access width, pay special attention to the SSL signal level. Do not negate the SSL signal between the assertion of the SSL signal at the beginning of the command and the transfer end of the last byte of the command. The sample program sets the SSLKP bit in the SPCMD register to 1 to keep the SSL signal. SSL signal is negated by clearing the SPE bit in the SPCR register to 0 after all data transfer is completed.

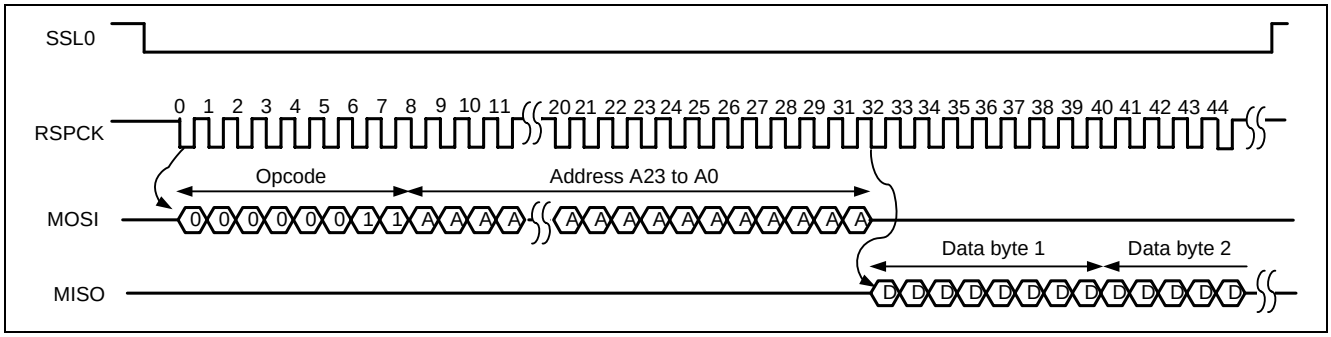

Figure 5 Read Command Sequence (Opcode: H'03)

C. Command Transfer Example in the Sample Program

The Read command that uses both master output and slave output, and the Write command that uses the master output are supported by the sample program. Figure 6 shows the flow chart of the read/write commands transfer. Figure 7 shows the flow chart of the data transfer.

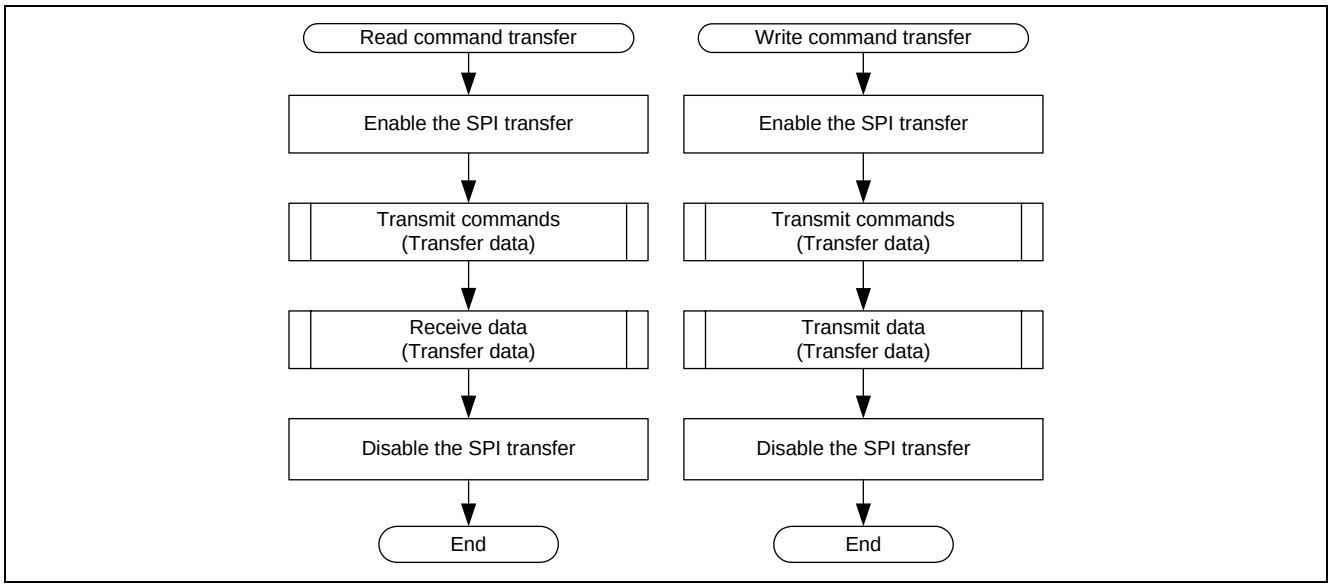

Figure 6 Flow Chart of Read/Write Commands Transfer

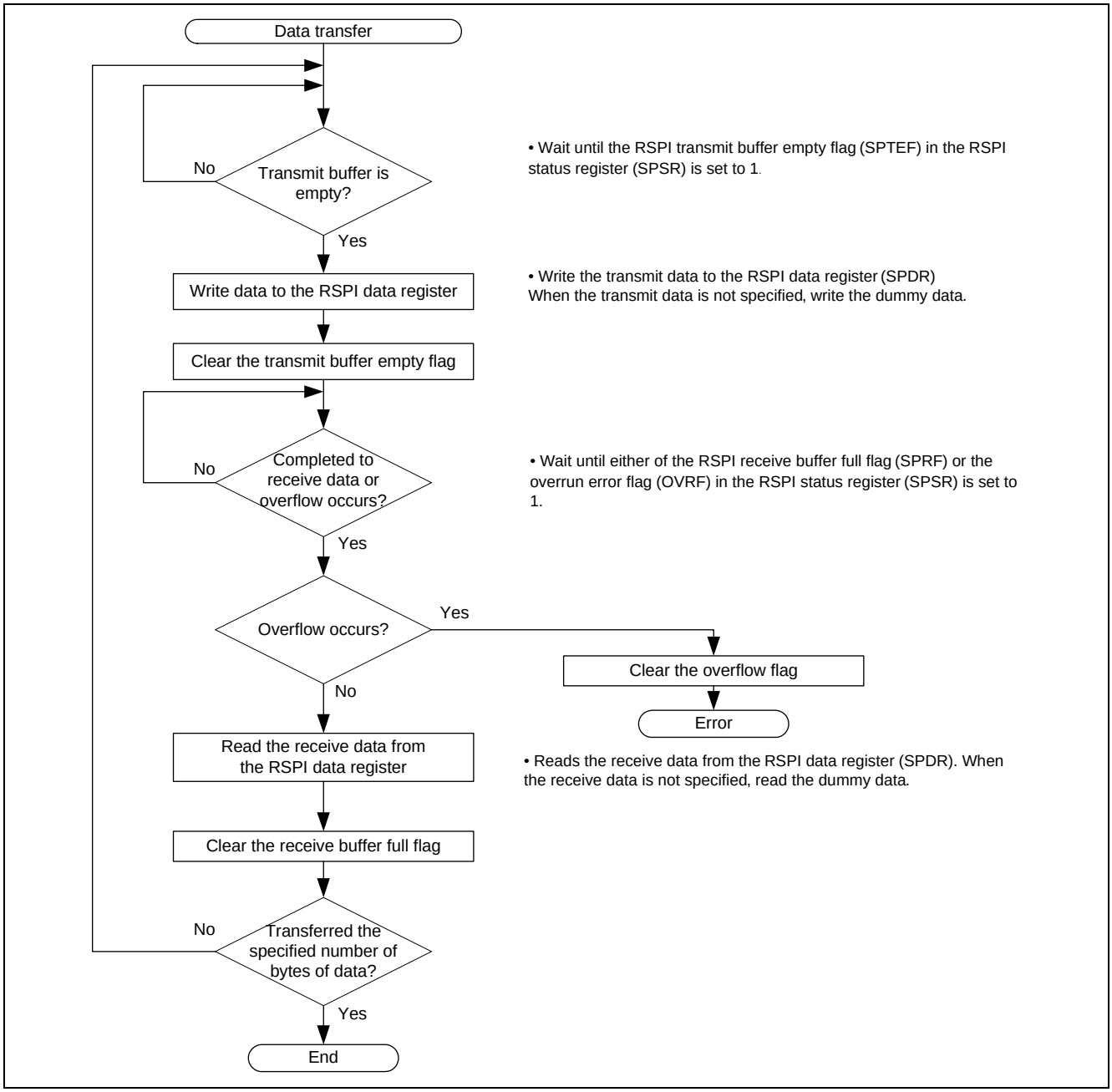

Figure 7 Flow Chart of the Data Transfer

2.4.3 Main Function

Figure 8 shows the flow chart of the main function in the sample program. The sample program writes data in the entire memory array, and compares the written value to the read value.

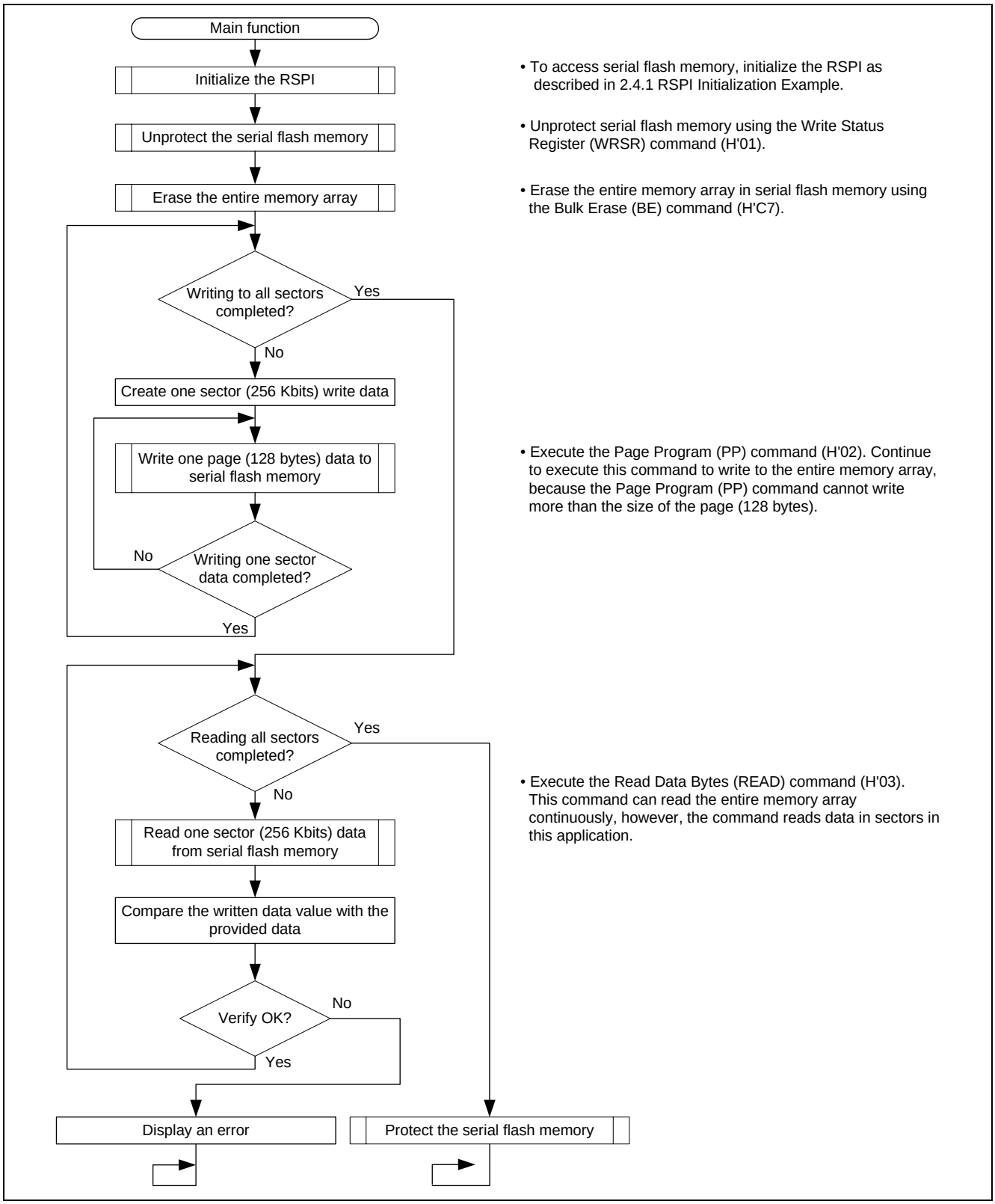

Figure 8 Main Function Flow Chart

3. Sample Program Listing

3.1 Sample Program Listing "main.c" (1/3)

```
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*********************************************************************************
*   Copyright (C) 2010 Renesas Electronics Corporation. All Rights Reserved.
*""FILE COMMENT""*********** Technical reference data *************************
*   System Name : SH7216 Sample Program
*   File Name   : main.c
*   Abstract    : Interfacing Serial Flash Memory Using the Renesas Serial
*               : Peripheral Interface
*   Version     : 1.00.00
*   Device      : SH7216
*   Tool-Chain  : High-performance Embedded Workshop (Ver.4.07.00).
*               : C/C++ compiler package for the SuperH RISC engine family
*               :                               (Ver.9.03 Release00).
*   OS          : None
*   H/W Platform: R0K572167 (CPU board)
*   Description : Connects the serial flash memory with the MCU using the Renesas
*               : Serial Peripheral Interface.
*********************************************************************************
*   History     : Aug.17,2010 Ver.1.00.00
*""FILE COMMENT END""*********************************************************/
#include <stdio.h>
#include "serial_flash.h"
```

3.2 Sample Program Listing "main.c" (2/3)

```
48
49  /* ==== Macro definition ==== */
50  #define TOP_ADDRESS    0              /* Start address of serial flash memory */
51
52  /* ==== Function prototype declaration ==== */
53  void main(void);
54
55  /* ==== Variable definition ==== */
56  #pragma section DEBUG_BUFFER
57  static unsigned char data[SF_SECTOR_SIZE];
58  static unsigned char rbuf[SF_SECTOR_SIZE];
59  #pragma section
60
61  /*""FUNC COMMENT""*****************************************************************
62   * ID           :
63   * Outline      : Accessing serial flash memory main
64   *-----------------------------------------------------------------------------
65   * Include      :
66   *-----------------------------------------------------------------------------
67   * Declaration  : void main(void);
68   *-----------------------------------------------------------------------------
69   * Description  : Erases, programs, and reads serial flash memory.
70   *              : After initializing RSPI channel 0, erases the entire memory
71   *              : array, and writes data from the start address. Reads the written
72   *              : data to compare to the provided data.
73   *-----------------------------------------------------------------------------
74   * Argument     : void
75   *-----------------------------------------------------------------------------
76   * Return Value : void
77   *-----------------------------------------------------------------------------
78   * Note         : None
79   *""FUNC COMMENT END""*************************************************************/
80  void main(void)
81  {
82    int i, j;
83    static unsigned long addr;
84
85    /* ==== Initializes the RSPI ==== */
86    sf_init_serial_flash();
87
88    /* ==== Unprotects serial flash memory ==== */
89    sf_protect_ctrl( SF_REQ_UNPROTECT );
90
91    /* ==== Chip erase (1 Mbits) ==== */
92    sf_chip_erase();
93
```

3.3 Sample Program Listing "main.c" (3/3)

```
94      /* ==== Writes data (1 Mbits) ==== */
95      addr = TOP_ADDRESS;
96      for(i = 0; i < SF_NUM_OF_SECTOR; i++){
97        /* ---- Initializes the data (32 KB) ---- */
98        for(j = 0; j < SF_SECTOR_SIZE; j++){
99            data[j] = (i + j) % 100;
100       }
101       /* ---- Writes one sector (32 KB) data  ---- */
102       for(j = 0; j < ( SF_SECTOR_SIZE / SF_PAGE_SIZE ); j++){
103           /* ---- Writes one page (128 bytes) data ---- */
104           sf_byte_program( addr, data+(j*SF_PAGE_SIZE), SF_PAGE_SIZE );
105           addr += SF_PAGE_SIZE;             /* Updates the destination address to write */
106       }
107     }
108     /* ==== Reads data (1 Mbits) ==== */
109     addr = TOP_ADDRESS;
110     for(i = 0; i < SF_NUM_OF_SECTOR; i++){
111       /* ---- Reads one sector (32 KB) data ---- */
112       sf_byte_read( addr, rbuf, SF_SECTOR_SIZE );
113       addr += SF_SECTOR_SIZE;                  /* Updates the destination address to read */
114
115       /* ---- Verifies data ---- */
116       for(j = 0; j < SF_SECTOR_SIZE; j++){
117           data[j] = (i + j) % 100;          /* Outputs the written data */
118           if( data[j] != rbuf[j] ){
119               puts("Error: verify error\n");
120               fflush(stdout);
121               while(1);
122           }
123       }
124     }
125     /* ==== Protects serial flash memory ==== */
126     sf_protect_ctrl( SF_REQ_PROTECT );
127
128     while(1){
129           /* loop */
130       }
131   }
132
133   /* End of File */
```

3.4 Sample Program Listing "serial_flash.c" (1/13)

```
1   /***********************************************************************
2   *   DISCLAIMER
3   *
4   *   This software is supplied by Renesas Electronics Corp. and is only
5   *   intended for use with Renesas products.  No other uses are authorized.
6   *
7   *   This software is owned by Renesas Electronics Corp. and is protected under
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26  *   http://www.renesas.com/disclaimer
27  ***********************************************************************
28  *   Copyright (C) 2010 Renesas Electronics Corporation. All Rights Reserved.
29  *""FILE COMMENT""*********** Technical reference data *************************
30  *   System Name : SH7216 Sample Program
31  *   File Name   : serial_flash.c
32  *   Abstract    : Interfacing Serial Flash Memory Using the Renesas Serial
33  *               : Peripheral Interface
34  *   Version     : 1.00.00
35  *   Device      : SH7216
36  *   Tool-Chain  : High-performance Embedded Workshop (Ver.4.07.00).
37  *               : C/C++ compiler package for the SuperH RISC engine family
38  *               :                             (Ver.9.03 Release00).
39  *   OS          : None
40  *   H/W Platform: R0K572167 (CPU board)
41  *   Description : Connects the serial flash memory with the MCU using the Renesas
42  *               : Serial Peripheral Interface.
43  ***********************************************************************
44  *   History     : Aug.17,2010 Ver.1.00.00
45  *""FILE COMMENT END""*****************************************************/
46  #include <stdio.h>
47  #include <machine.h>
48  #include "iodefine.h"
49  #include "serial_flash.h"
50
```

3.5 Sample Program Listing "serial_flash.c" (2/13)

```
51  /* ==== Macro definition ==== */
52  #define SFLASHCMD_CHIP_ERASE  0xc7
53  #define SFLASHCMD_SECTOR_ERASE0xd8
54  #define SFLASHCMD_BYTE_PROGRAM0x02
55  #define SFLASHCMD_BYTE_READ       0x0B
56  #define SFLASHCMD_BYTE_READ_LOW   0x03
57  #define SFLASHCMD_WRITE_ENABLE0x06
58  #define SFLASHCMD_WRITE_DISABLE   0x04
59  #define SFLASHCMD_READ_STATUS 0x05
60  #define SFLASHCMD_WRITE_STATUS0x01
61  #define UNPROTECT_WR_STATUS       0x00
62  #define PROTECT_WR_STATUS     0x3C
63
64  /* ==== Function prototype declaration ==== */
65  /*** Local function ***/
66  static void write_enable(void);
67  static void write_disable(void);
68  static void busy_wait(void);
69  static unsigned char read_status(void);
70  static void write_status(unsigned char status);
71  static void io_init_rspi(void);
72  static void io_cmd_exe(unsigned char *ope, int ope_sz, unsigned char *data, int data_sz);
73  static void io_cmd_exe_rdmode(unsigned char *ope, int ope_sz, unsigned char *rd, int rd_sz);
74  static int io_rspi_transfer(unsigned char *write_data, unsigned char *read_data, int data_sz);
75
76  /* ==== Variable definition ==== */
77
78  /*""FUNC COMMENT""****************************************************************
79   * ID           :
80   * Outline      : Serial flash memory initialization
81   *-------------------------------------------------------------------------------
82   * Include      :
83   *-------------------------------------------------------------------------------
84   * Declaration  : void sf_init_serial_flash(void);
85   *-------------------------------------------------------------------------------
86   * Description  : Initializes serial flash memory for being accessed.
87   *              : Initializes the Renesas Serial Peripheral Interface (RSPI).
88   *-------------------------------------------------------------------------------
89   * Argument     : void
90   *-------------------------------------------------------------------------------
91   * Return Value : void
92   *-------------------------------------------------------------------------------
93   * Note         : None
94   *""FUNC COMMENT END""************************************************************/
95  void sf_init_serial_flash(void)
96  {
97    /* ==== Initializes the RSPI ==== */
98    io_init_rspi();
99  }
```

3.6 Sample Program Listing "serial_flash.c" (3/13)

```
100  /*""FUNC COMMENT""*****************************************************************
101   * ID           :
102   * Outline      : Protect/unprotect operation
103   *-------------------------------------------------------------------------------
104   * Include      :
105   *-------------------------------------------------------------------------------
106   * Declaration  : void sf_protect_ctrl(enum sf_req req);
107   *-------------------------------------------------------------------------------
108   * Description  : Protects or unprotects serial flash memory.
109   *              : Use the argument req to specify. Default setting and unprotecting
110   *              : method depends on the specifications of the serial flash memory.
111   *-------------------------------------------------------------------------------
112   * Argument     : enum sf_req req ; I : SF_REQ_UNPROTECT -> Write-enable all sectors
113   *              :                       SF_REQ_PROTECT   -> Write-protect all sectors
114   *-------------------------------------------------------------------------------
115   * Return Value : void
116   *-------------------------------------------------------------------------------
117   * Note         : None
118   *""FUNC COMMENT END""*************************************************************/
119  void sf_protect_ctrl(enum sf_req req)
120  {
121    if( req == SF_REQ_UNPROTECT ){
122      write_status( UNPROTECT_WR_STATUS);      /* Unprotects the entire memory area */
123    }
124    else{
125      write_status( PROTECT_WR_STATUS );    /* Protects the entire memory area */
126    }
127  }
128  /*""FUNC COMMENT""*****************************************************************
129   * ID           :
130   * Outline      : Chip erase
131   *-------------------------------------------------------------------------------
132   * Include      :
133   *-------------------------------------------------------------------------------
134   * Declaration  : void sf_chip_erase(void);
135   *-------------------------------------------------------------------------------
136   * Description  : Erases all bits in serial flash memory.
137   *              : Before erasing or programming, issue the Write Enable command.
138   *              : After erasing or programming, make sure to check the status of
139   *              : serial flash memory if it is not busy.
140   *-------------------------------------------------------------------------------
141   * Argument     : void
142   *-------------------------------------------------------------------------------
143   * Return Value : void
144   *-------------------------------------------------------------------------------
145   * Note         : None
146   *""FUNC COMMENT END""*************************************************************/
147  void sf_chip_erase(void)
148  {
```

3.7 Sample Program Listing "serial_flash.c" (4/13)

```
149     unsigned char cmd[1];
150     cmd[0] = SFLASHCMD_CHIP_ERASE;
151
152     write_enable();
153     io_cmd_exe(cmd, 1, NULL, 0);
154     busy_wait();
155   }
156   /*""FUNC COMMENT""*****************************************************************
157    * ID           :
158    * Outline      : Sector erase
159    *-------------------------------------------------------------------------------
160    * Include      :
161    *-------------------------------------------------------------------------------
162    * Declaration  : void sf_sector_erase(int sector_no);
163    *-------------------------------------------------------------------------------
164    * Description  : Erases the specified sector in serial flash memory.
165    *              : Before erasing or programming, issue the Write Enable command.
166    *              : After erasing or programming, make sure to check the status of
167    *              : serial flash memory if it is not busy.
168    *-------------------------------------------------------------------------------
169    * Argument     : int sector_no ; I : Sector number
170    *-------------------------------------------------------------------------------
171    * Return Value : void
172    *-------------------------------------------------------------------------------
173    * Note         : None
174    *""FUNC COMMENT END""*************************************************************/
175   void sf_sector_erase(int sector_no)
176   {
177     unsigned char cmd[4];
178     unsigned long addr = sector_no * SF_SECTOR_SIZE;
179
180     cmd[0] = SFLASHCMD_SECTOR_ERASE;
181     cmd[1] = (addr >> 16) & 0xff;
182     cmd[2] = (addr >>  8) & 0xff;
183     cmd[3] =  addr        & 0xff;
184
185     write_enable();
186     io_cmd_exe(cmd, 4, NULL, 0);
187     busy_wait();
188   }
```

3.8 Sample Program Listing "serial_flash.c" (5/13)

```
189  /*""FUNC COMMENT""*****************************************************************
190   * ID           :
191   * Outline      : Program data
192   *-------------------------------------------------------------------------------
193   * Include      :
194   *-------------------------------------------------------------------------------
195   * Declaration  : void sf_byte_program(unsigned long addr, unsigned char *buf, int size);
196   *-------------------------------------------------------------------------------
197   * Description  : Programs the specified data in serial flash memory.
198   *              : Before erasing or programming, issue the Write Enable command.
199   *              : After erasing or programming, make sure to check the status of
200   *              : serial flash memory if it is not busy.
201   *              : The maximum write data size depends on the type of the device.
202   *-------------------------------------------------------------------------------
203   * Argument     : unsigned long addr ; I : Address in serial flash memory to write
204   *              : unsigned char *buf ; I : Buffer address to store the write data
205   *              : int size           ; I : Number of bytes to write
206   *-------------------------------------------------------------------------------
207   * Return Value : void
208   *-------------------------------------------------------------------------------
209   * Note         : None
210   *""FUNC COMMENT END""*************************************************************/
211  void sf_byte_program(unsigned long addr, unsigned char *buf, int size)
212  {
213    unsigned char cmd[4];
214
215    cmd[0] = SFLASHCMD_BYTE_PROGRAM;
216    cmd[1] = (unsigned char)((addr >> 16) & 0xff);
217    cmd[2] = (unsigned char)((addr >>  8) & 0xff);
218    cmd[3] = (unsigned char)( addr        & 0xff);
219    write_enable();
220    io_cmd_exe(cmd, 4, buf, size);
221    busy_wait();
222  }
```

3.9 Sample Program Listing "serial_flash.c" (6/13)

```
/*""FUNC COMMENT""*****************************************************************
 * ID           :
 * Outline      : Read data
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : void sf_byte_read(unsigned long addr, unsigned char *buf, int size);
 *-----------------------------------------------------------------------------
 * Description  : Reads the specified number of bytes from serial flash memory.
 *-----------------------------------------------------------------------------
 * Argument     : unsigned long addr ; I : Address in serial flash memory to read
 *              : unsigned char *buf ; I : Buffer address to store the read data
 *              : int size           ; I : Number of bytes to read
 *-----------------------------------------------------------------------------
 * Return Value : void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
void sf_byte_read(unsigned long addr, unsigned char *buf, int size)
{
  unsigned char cmd[4];

  cmd[0] = SFLASHCMD_BYTE_READ_LOW;
  cmd[1] = (unsigned char)((addr >> 16) & 0xff);
  cmd[2] = (unsigned char)((addr >>  8) & 0xff);
  cmd[3] = (unsigned char)( addr        & 0xff);
  io_cmd_exe_rdmode(cmd, 4, buf, size);
}
/*""FUNC COMMENT""*****************************************************************
 * ID           :
 * Outline      : Write enable
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : static void write_enable(void);
 *-----------------------------------------------------------------------------
 * Description  : Issues the Write Enable command to enable erasing or programming
 *              : serial flash memory.
 *-----------------------------------------------------------------------------
 * Argument     : void
 *-----------------------------------------------------------------------------
 * Return Value : void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
static void write_enable(void)
{
  unsigned char cmd[1];
  cmd[0] = SFLASHCMD_WRITE_ENABLE;
  io_cmd_exe(cmd, 1, NULL, 0);
}
```

3.10 Sample Program Listing "serial_flash.c" (7/13)

```
/*""FUNC COMMENT""*************************************************************
 * ID           :
 * Outline      : Write disable
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : static void write_disable(void);
 *-----------------------------------------------------------------------------
 * Description  : Issues the Write Disable command to disable erasing or programming
 *              : serial flash memory.
 *-----------------------------------------------------------------------------
 * Argument     : void
 *-----------------------------------------------------------------------------
 * Return Value : void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*********************************************************/
static void write_disable(void)
{
  unsigned char cmd[1];
  cmd[0] = SFLASHCMD_WRITE_DISABLE;
  io_cmd_exe(cmd, 1, NULL, 0);
}
/*""FUNC COMMENT""*************************************************************
 * ID           :
 * Outline      : Busy waiting
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : static void busy_wait(void);
 *-----------------------------------------------------------------------------
 * Description  : Loops internally when the serial flash memory is busy.
 *-----------------------------------------------------------------------------
 * Argument     : void
 *-----------------------------------------------------------------------------
 * Return Value : void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*********************************************************/
static void busy_wait(void)
{
  while ((read_status() & 0x01) != 0) {
    /* serial flash is busy */
  }
}
```

3.11 Sample Program Listing "serial_flash.c" (8/13)

```
/*""FUNC COMMENT""*****************************************************************
 * ID           :
 * Outline      : Read status
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : static unsigned char read_status(void);
 *-----------------------------------------------------------------------------
 * Description  : Reads the status of serial flash memory.
 *-----------------------------------------------------------------------------
 * Argument     : void
 *-----------------------------------------------------------------------------
 * Return Value : Status register value
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
static unsigned char read_status(void)
{
  unsigned char buf;
  unsigned char cmd[1];

  cmd[0] = SFLASHCMD_READ_STATUS;
  io_cmd_exe_rdmode(cmd, 1, &buf, 1);
  return buf;
}
/*""FUNC COMMENT""*****************************************************************
 * ID           :
 * Outline      : Write status
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration : static void write_status(unsigned char status);
 *-----------------------------------------------------------------------------
 * Description : Writes the status of serial flash memory.
 *-----------------------------------------------------------------------------
 * Argument    : unsigned char status ; I : status register value
 *-----------------------------------------------------------------------------
 * Return Value: void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
static void write_status(unsigned char status)
{
  unsigned char cmd[2];

  cmd[0] = SFLASHCMD_WRITE_STATUS;
  cmd[1] = status;

  write_enable();
  io_cmd_exe(cmd, 2, NULL, 0);
  busy_wait();
}
```

3.12 Sample Program Listing "serial_flash.c" (9/13)

```
/*""FUNC COMMENT""*****************************************************************
 * ID          :
 * Outline     : RSPI initialization
 *-----------------------------------------------------------------------------
 * Include     :
 *-----------------------------------------------------------------------------
 * Declaration : static void io_init_rspi(void);
 *-----------------------------------------------------------------------------
 * Description : Initializes the RSPI.
 *             : Sets the RSPI in master mode to set parameters required to transfer
 *             : according to the specifications of serial flash memory.
 *-----------------------------------------------------------------------------
 * Argument    : void
 *-----------------------------------------------------------------------------
 * Return Value: void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
static void io_init_rspi(void)
{
  /* ==== PFC ==== */
  PFC.PACRL3.BIT.PA9MD = 5;   /* SSL0 */
  PFC.PACRL3.BIT.PA8MD = 5;   /* MISO */
  PFC.PACRL2.BIT.PA7MD = 5;   /* MOSI */
  PFC.PACRL2.BIT.PA6MD = 5;   /* RSPCK */

  /* ==== CPG ==== */
  STB.CR5.BIT._RSPI = 0;  /* RSPI active */

  /* ==== RSPI ==== */
  RSPI.SPCR.BYTE   =  0x00;   /* Disables the RSPI */
  RSPI.SPPCR.BYTE  =  0x30;   /* MOSI idle fixed value = 1 */
  RSPI.SPBR.BYTE   = 0x02;/* Specifies the base bit rate as 8.3 MHz
                          /* (P clock = 50 MHz) */
  RSPI.SPDCR.BYTE  =  0x00;   /* Access width of the SPDR register: 16-bit */
  RSPI.SPCKD.BYTE  =  0x00;   /* RSPCK delay: 1 RSPCK */
  RSPI.SSLND.BYTE  =  0x00;   /* SSL negation delay: 1 RSPCK */
  RSPI.SPND.BYTE   =  0x00;   /* Next access delay: 1 RSPCK */
  RSPI.SPSCR.BYTE  =  0x00;   /* Sequence length: 1 (Only SPCMD0 is used) */
  RSPI.SPCMD0.WORD = 0xE783;  /* MSB first */
                          /* Data length: 8-bit */
                          /* Keeps the SSL signal level after a transfer */
                          /* is completed */
                          /* Bit rate: Base bit rate is not divided */
                          /* RSPCK when idling is 1 */
                          /* Outputs data on odd edge, latches data on even edge */
  RSPI.SSLP.BYTE   =  0x00;   /* SSLP = b'0 SSL signal 0-active */
  RSPI.SPCR.BYTE   =  0x48;   /* Master mode */
                          /* Disables interrupts */
                          /* Enables the RSPI */
}
```

3.13 Sample Program Listing "serial_flash.c" (10/13)

```
/*""FUNC COMMENT""*****************************************************************
 * ID           :
 * Outline      : Execute command (No read data).
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : static int io_cmd_exe(unsigned char *ope, int ope_sz,
 *              :                       unsigned char *data,int data_sz)
 *-----------------------------------------------------------------------------
 * Description  : Executes the specified command.
 *              : Transmits the argument ope, and then transmits the argument
 *              : data. Discards the received data.
 *              : Set one of the values between 0 and 8 to the ope_sz.
 *              : Set one of the values between 0 and 256 to the data_sz.
 *-----------------------------------------------------------------------------
 * Argument     : unsigned char *ope ; I : Start address of the opcode block and
 *              :                       : address block to transmit
 *              : int ope_sz         ; I : Number of bytes in the opcode block and
 *              :                       : address block
 *              : unsigned char *data; I : Start address of the data block to transmit
 *              : int data_sz        ; I : Number of bytes in the data block
 *-----------------------------------------------------------------------------
 * Return Value : void
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
static void io_cmd_exe(unsigned char *ope, int ope_sz, unsigned char *data, int data_sz)
{
  /* ---- Enables the SPI transfer ---- */
  RSPI.SPCR.BIT.SPE = 1;

  /* ---- MOSI ---- */
  io_rspi_transfer(ope, NULL, ope_sz);
  io_rspi_transfer(data, NULL, data_sz);

  /* ---- SPI transfer is completed (SSL negation) ---- */
  RSPI.SPCR.BIT.SPE = 0;
}
```

3.14 Sample Program Listing "serial_flash.c" (11/13)

```
460  /*""FUNC COMMENT""*****************************************************************
461   * ID           :
462   * Outline      : Execute command (With read data).
463   *-------------------------------------------------------------------------------
464   * Include      :
465   *-------------------------------------------------------------------------------
466   * Declaration  : static void io_cmd_exe_rdmode(unsigned char *ope, int ope_sz,
467   *              :                               unsigned char *rd,  int rd_sz)
468   *-------------------------------------------------------------------------------
469   * Description  : Executes the specified command.
470   *              : Transmits the argument ope, and then receives data in the
471   *              : argument rd. Set one of the values between 0 and 8 in the ope_sz.
472   *              : More than 0 can be set in the rd_sz.
473   *-------------------------------------------------------------------------------
474   * Argument     : unsigned char *ope ; I : Start address of the opcode block and
475   *                                       : address block to transmit
476   *              : int ope_sz         ; I : Number of bytes in the opcode block and
477   *                                       : address block
478   *              : unsigned char *rd  ; I : Buffer address to store the received data
479   *              : int rd_sz          ; I : Number of bytes in the data block
480   *-------------------------------------------------------------------------------
481   * Return Value : void
482   *-------------------------------------------------------------------------------
483   * Note         : None
484   *""FUNC COMMENT END""*************************************************************/
485  static void io_cmd_exe_rdmode(unsigned char *ope, int ope_sz, unsigned char *rd, int rd_sz)
486  {
487    /* ---- Enables the SPI transfer ---- */
488    RSPI.SPCR.BIT.SPE = 1;
489
490    /* ---- MISO ---- */
491    io_rspi_transfer(ope, NULL, ope_sz);
492    io_rspi_transfer(NULL, rd, rd_sz);
493
494    /* ---- SPI transfer is completed (SSL negation) ---- */
495    RSPI.SPCR.BIT.SPE = 0;
496  }
```

3.15 Sample Program Listing "serial_flash.c" (12/13)

```
/*""FUNC COMMENT""*****************************************************************
 * ID           :
 * Outline      : RSPI data transfer
 *-----------------------------------------------------------------------------
 * Include      :
 *-----------------------------------------------------------------------------
 * Declaration  : int io_rspi_transfer(unsigned char *write_data,
 *              :           unsigned char *read_data, int data_sz);
 *-----------------------------------------------------------------------------
 * Description  : Transfers commands and data in bytes. Transmits the opcode or
 *              : data from the argument write_data, and receives the data in the
 *              : argument read_data.
 *              : When the argument write_data is NULL, this function transmits
 *              : the dummy data (0xff). When the argument read_data is NULL,
 *              : this function does not receive the data.
 *-----------------------------------------------------------------------------
* Argument     : unsigned char *write_data : I : Start address of the transmit data
 *              : unsinged char *read_data : O : Buffer address to store the
 *              :                              : received data
 *              : int data_sz : I : Number of bytes of the transmit and received data
 *-----------------------------------------------------------------------------
 * Return Value : 0 : Succeeded to transfer data
 *              : -1: Overrun error occurs
 *-----------------------------------------------------------------------------
 * Note         : None
 *""FUNC COMMENT END""*************************************************************/
static int io_rspi_transfer(unsigned char *write_data, unsigned char *read_data, int data_sz)
{
  unsigned short tmp;

  while(data_sz--){
    while(RSPI.SPSR.BIT.SPTEF == 0){
        /* wait */
    }
    /* Writes the transmit data to the data register */
    if(write_data != (unsigned char *)0){
        tmp = (unsigned short)*write_data++;
    }
    else{
        tmp = 0x00ff;  /* Dummy write data */

    }

    RSPI.SPDR.WORD = 0x00ff & tmp;

    RSPI.SPSR.BIT.SPTEF = 0;   /* Clears the bit to 0 to transmit data */

```

3.16 Sample Program Listing "serial_flash.c" (13/13)

```
544       /* Waits until the reception is completed */
545       while((RSPI.SPSR.BYTE & 0x81) == 0x00){
546           /* Waits until the receive buffer is full or an overrun error occurs */
547       }
548
549       /* Overrrun error occurs? */
550       if(RSPI.SPSR.BIT.OVRF == 1){
551           RSPI.SPSR.BIT.OVRF = 0;
552           return -1;  /* Overrun error occurred */
553       }
554
555       /* Reads the received data */
556       tmp = RSPI.SPDR.WORD;
557       if(read_data != (unsigned char *)0){
558           *read_data++ = (unsigned char)tmp;
559       }
560       RSPI.SPSR.BIT.SPRF = 0;
561     }
562
563     return 0;
564   }
565
566   /* End of File */
```

3.17 Sample Program Listing "serial_flash.h" (1/2)

```
1   /***********************************************************************
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3   *
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26  *   http://www.renesas.com/disclaimer
27  ***********************************************************************
28  *   Copyright (C) 2010 Renesas Electronics Corporation. All Rights Reserved.
29  *""FILE COMMENT""*********** Technical reference data *************************
30  *   System Name : SH7216 Sample Program
31  *   File Name   : serial_flash.h
32  *   Abstract    : Interfacing Serial Flash Memory Using the Renesas Serial
33  *               : Peripheral Interface
34  *   Version     : 1.00.00
35  *   Device      : SH7216
36  *   Tool-Chain  : High-performance Embedded Workshop (Ver.4.07.00).
37  *               : C/C++ compiler package for the SuperH RISC engine family
38  *               :                             (Ver.9.03 Release00).
39  *   OS          : None
40  *   H/W Platform: R0K572167 (CPU board)
41  *   Description : Connects the serial flash memory with the MCU using the Renesas
42  *               : Serial Peripheral Interface.
43  ***********************************************************************
44  *   History     : Aug.17,2010 Ver.1.00.00
45  *""FILE COMMENT END""*****************************************************/
46  #ifndef _SERIAL_FLASH_H_
47  #define _SERIAL_FLASH_H_
48
```

3.18 Sample Program Listing "serial_flash.h" (2/2)

```
49    /* ==== Macro definition ==== */
50    #define SF_PAGE_SIZE       128         /* Page size of serial flash memory */
51    #define SF_SECTOR_SIZE     0x8000      /* Sector size = 32 KB   */
52    #define SF_NUM_OF_SECTOR   4           /* Number of sectors: 4   */
53    enum sf_req{
54      SF_REQ_PROTECT = 0,              /* Requests to protect */
55      SF_REQ_UNPROTECT                 /* Requests to unprotect */
56    };
57    /* ==== Function prototype declaration ==== */
58    void sf_init_serial_flash(void);
59    void sf_protect_ctrl(enum sf_req req);
60    void sf_chip_erase(void);
61    void sf_sector_erase(int sector_no);
62    void sf_byte_program(unsigned long addr, unsigned char *buf, int size);
63    void sf_byte_read(unsigned long addr, unsigned char *buf, int size);
64
65    #endif /* _SERIAL_FLASH_H_ */
66    /* End of File */
```

4. References

- Software Manual
  SH-2A/SH2A-FPU Software Manual Rev.3.00
  The latest version of the software manual can be downloaded from the Renesas Electronics website.

- Hardware Manual
  SH7214 Group, SH7216 Group Hardware User's Manual Rev.2.00
- The latest version of the hardware user's manual can be downloaded from the Renesas Electronics website.

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Sep.30.10	—	First edition issued

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The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.
   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on
   The state of the product is undefined at the moment when power is supplied.
   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.
   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.
5. Differences between Products
   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
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