R8C/L3AM Group

Power Control Using Power-Off 1 Mode

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Abstract

This document describes the setting to perform power control and data controlling methods in power-off mode using the R8C/L3AM Group power-off 1 mode.

Product

R8C/L3AM Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

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1. Specifications

The MCU enters power-off 1 mode from standard operating mode by a program. When a low-level pulse is input to the $\overline{\text{WKUP0}}$ pin or 1 minute passes, the MCU exits power-off 1 mode and a reset operation is performed. Count the number of resets caused by exiting power-off 1 mode and write the count data to the data flash.

Table 1.1 lists the Peripheral Functions and Their Applications. Figure 1.1 shows an Operation Example.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
Timer RE	Exit source from power-off 1 mode
Data flash	Write the number of resets

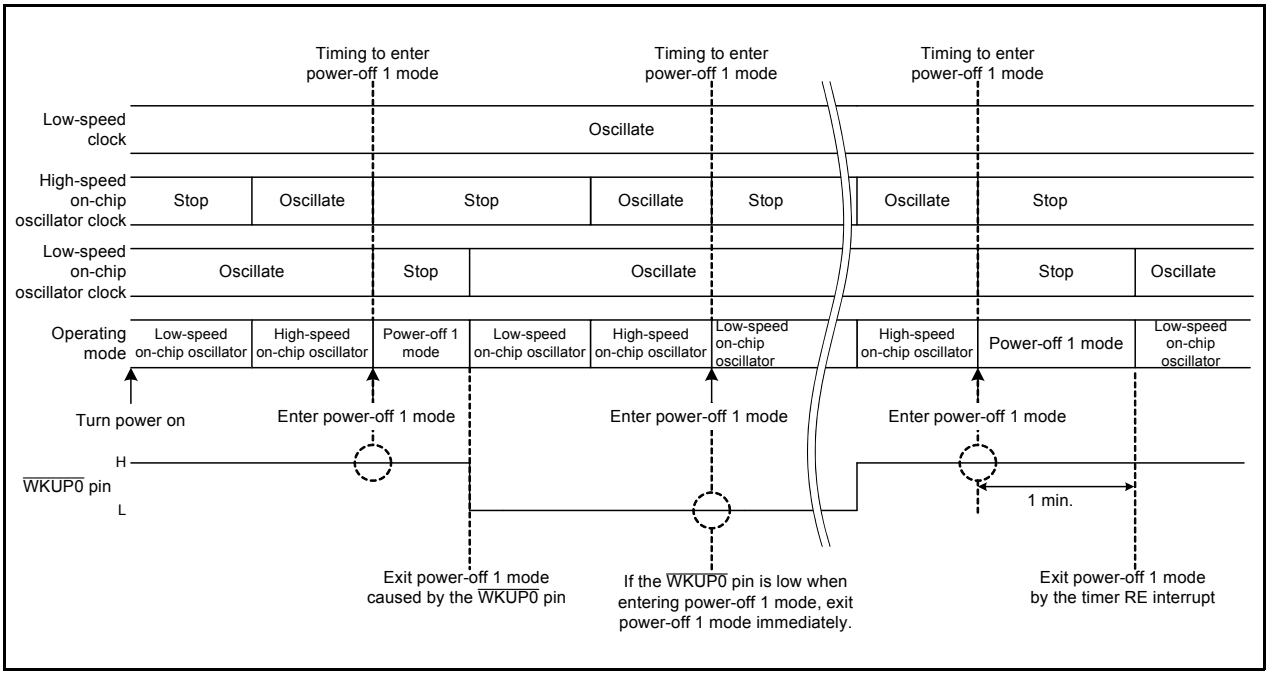


Figure 1.1 Operation Example

2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

Table 2.1 Operation Confirmation Conditions

Item	Contents
MCU used	R8C/L3AM Group
Operating frequencies	• High-speed on-chip oscillator clock: 40 MHz (typical) • XCIN clock: 32.768 kHz • System clock: 20 MHz • CPU clock: 20 MHz
Operating voltage	5.0 V (2.7 to 5.5 V)
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.07
C compiler	Renesas Electronics Corporation M16C Series, R8C Family C Compiler V.5.45 Release 01
	Compile options -D__UART0__ -c -finfo -dir "$(CONFIGDIR)" -R8C (Default setting is used in the integrated development environment.)

3. Hardware

3.1 Pin Used

Table 3.1 lists the Pin Used and Its Function.

Table 3.1 Pin Used and Its Function

Pin Name	I/O	Function
$\overline{\text{WKUP0}}$	Input	Power-off mode exit input

4. Software

4.1 Operation Overview

The MCU enters power-off 1 mode from standard operating mode by a program. The MCU exits power-off 1 mode by inputting a low-level pulse to the $\overline{\text{WKUP0}}$ pin or by a timer RE interrupt. A timer RE interrupt request is generated when the periodic interrupt triggered every minute is generated. Count the number of resets caused by exiting power-off 1 mode and write the count data to the data flash.

Settings

- Use fC4 for the count source of timer RE.
- Select 24-hour mode.
- Use the timer RE interrupt (periodic interrupt triggered every minute).
- Use power-off 1 mode.

(1) Reset source determination
Reset sources to be determined are as follows:
- Cold start-up hardware reset
- Voltage monitor 0 reset
- Software reset
- Watchdog timer reset
- Warm start-up hardware reset
- Exit power-off 1 mode

(2) Search empty records/obtain written count data
When the reset source is a cold start-up hardware reset, voltage monitor 0 reset, or power-off 1 mode exit:
Search empty records from the data flash area, and set an address of an empty record to the write address and the block number of the empty record to select the block used. Also, obtain the value of the written count data based on the search results: (When blocks are all blank (FFh), the count data becomes 0xFFFFFFFF.)
When the reset source is a software reset, watchdog timer reset, or warm start-up hardware reset:
Do not search empty records or obtain the written count data.

(3) Write to the data flash
When the reset source is power-off 1 mode exit:
Update the count data and write the count data to the write address.
When the reset source is a cold start-up hardware reset, voltage monitor 0 reset, software reset, watchdog timer reset, or warm start-up hardware reset:
Do not write to the data flash.

(4) Enter power-off 1 mode
Enter power-off 1 mode. (If the $\overline{\text{WKUP0}}$ pin is low when entering power-off 1 mode, exit power-off 1 mode immediately after entering power-off 1 mode.)

(5) Exit power-off 1 mode
Exit power-off 1 mode by inputting a low-level pulse to the $\overline{\text{WKUP0}}$ pin or by generating a timer RE interrupt when the periodic interrupt triggered every minute.

(6) Repeat steps (1) to (5).

4.2 Write Address Search for Data Flash Area

In this application note, the data flash area has a total of 512 4-byte records. These records are divided into two blocks of 256 records each (block A and block B). Figure 4.1 shows the Relationship between Data Flash and Records.

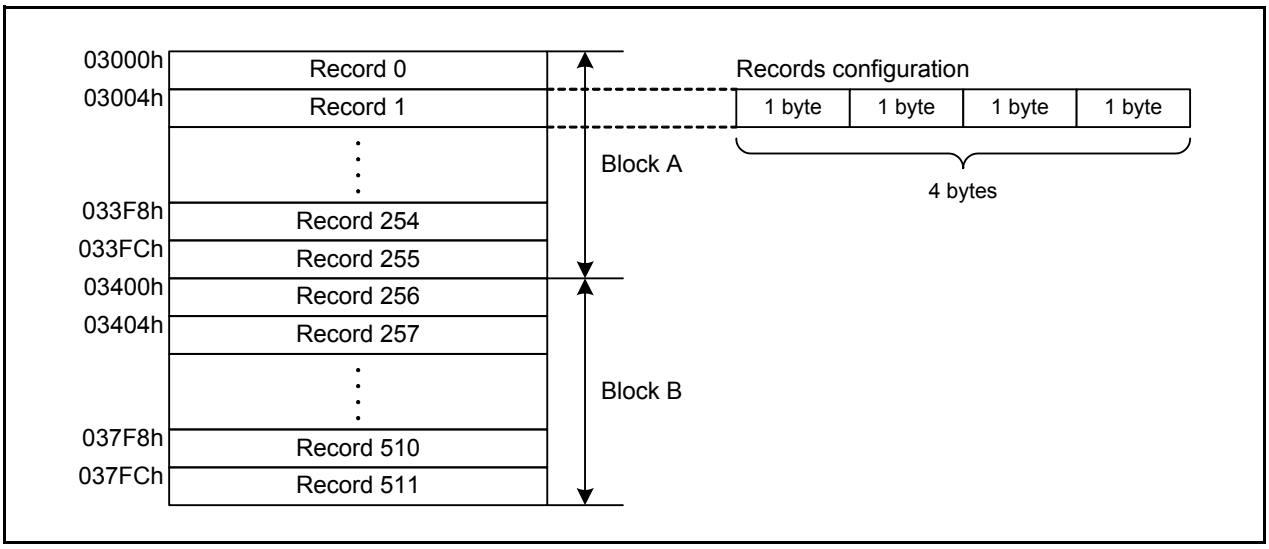


Figure 4.1 Relationship between Data Flash and Records

4.2.1 Empty Record Search (Data FFh Search)

Data written to the data flash is retained even after the power is turned off. After a reset start, a search for records that have all FFh data (empty records) is performed. The method of searching for empty records is described below.

(1) Set the search pointer to the starting address in record 0.

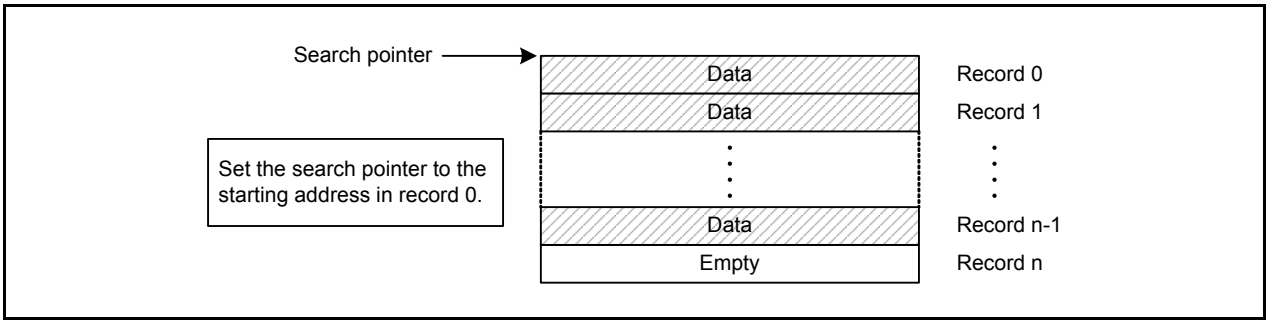


Figure 4.2 Set the Search Pointer

(2) Confirm that the record the search pointer indicates is an empty record (all bytes are FFh).

(3) When a record is not empty, set the search pointer to the starting address in the next record.

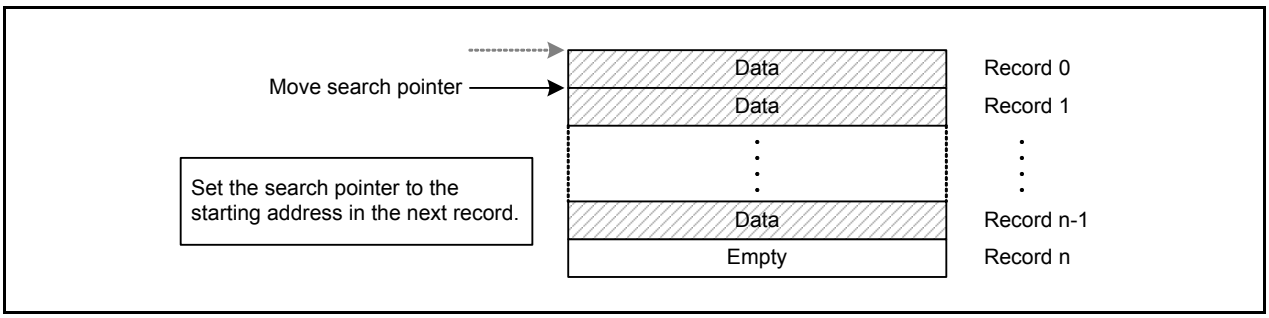


Figure 4.3 Moving the Search Pointer

(4) Repeat steps (2) and (3) until an empty record is found or all records of block A are checked.

(5) Execute steps (1) to (4) for block B (from record 256).

(6) Set the block used and write address based on the searched results to block A and block B. Table 4.1 lists the Search Results and Block Used/Write Address.

Table 4.1 Search Results and Block Used/Write Address

Search Results		Referenced Figure	Block Used	Write Address	Erase Executed Block
Block A	Block B				
All records empty	All records empty	—	Block A	Block A starting address	Not executed
Written records found	All records empty	Figure 4.4	Block A	Block A search results	Not executed
All records written (no empty records)	All records empty	—	Block B	Block B starting address	Not executed
All records empty	Written records found	Figure 4.5	Block B	Block B search results	Not executed
All records empty	All records written (no empty records)	—	Block A	Block A starting address	Not executed
All records written (no empty records)	Written records found	Figure 4.6	Block B	Block B search results	Block A
Written records found	All records written (no empty records)	Figure 4.7	Block A	Block A search results	Block B
All records written (no empty records)	All records written (no empty records)	Figure 4.8	Block A	Block A starting address	Block A Block B
Written records found	Written records found	Figure 4.9	Block A	Block A starting address	Block A Block B

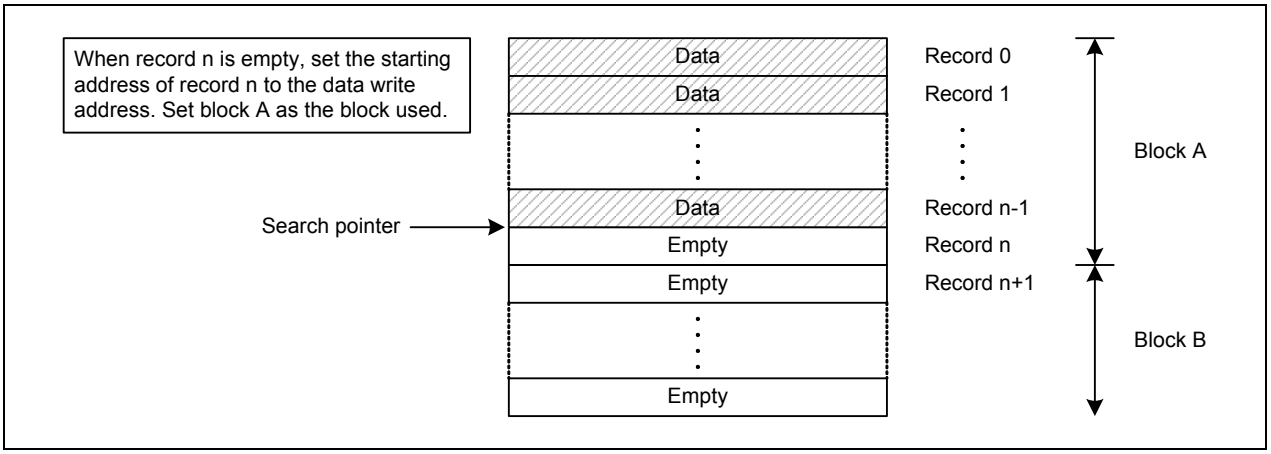


Figure 4.4 Block A: Written Records Found; Block B: All Records Empty

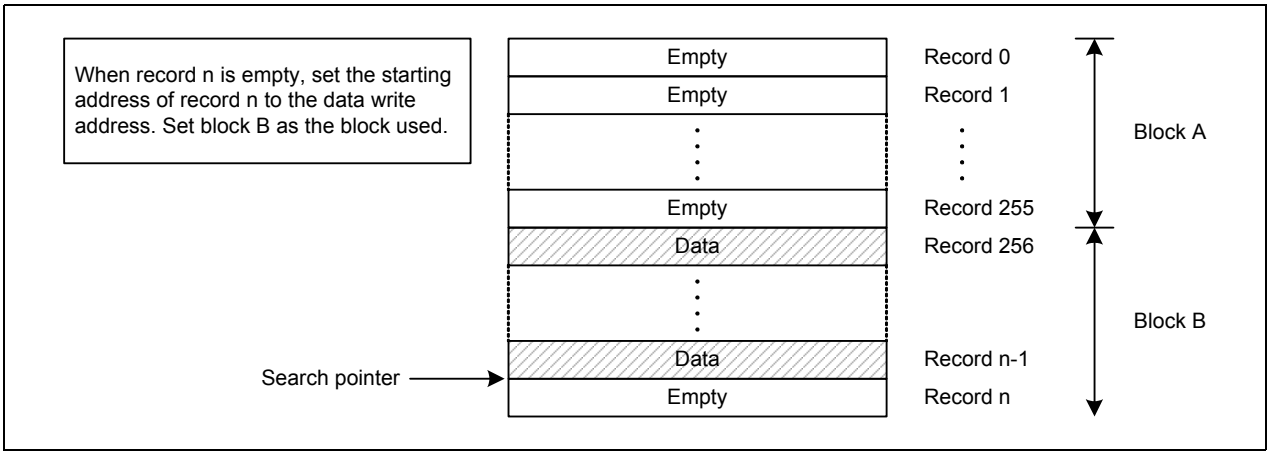


Figure 4.5 Block A: All Records Empty; Block B: Written Records Found

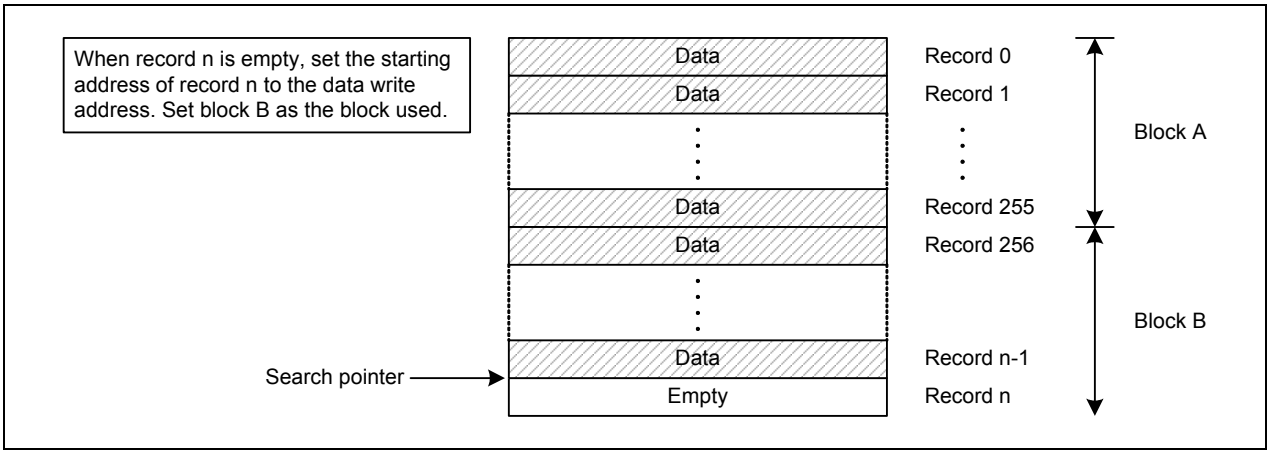


Figure 4.6 Block A: All Records Written; Block B: Written Records Found

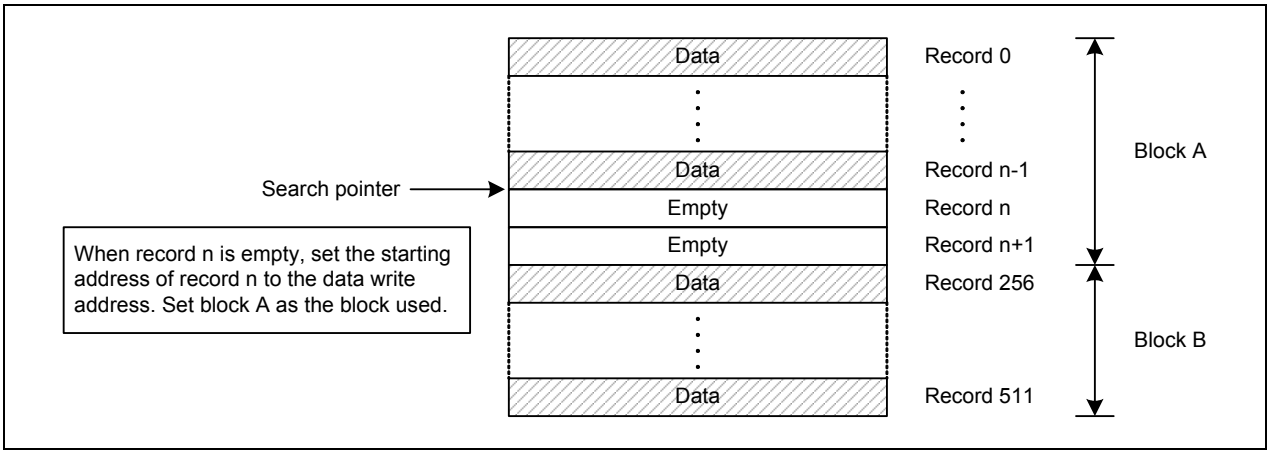


Figure 4.7 Block A: Written Records Found; Block B: All Records Written

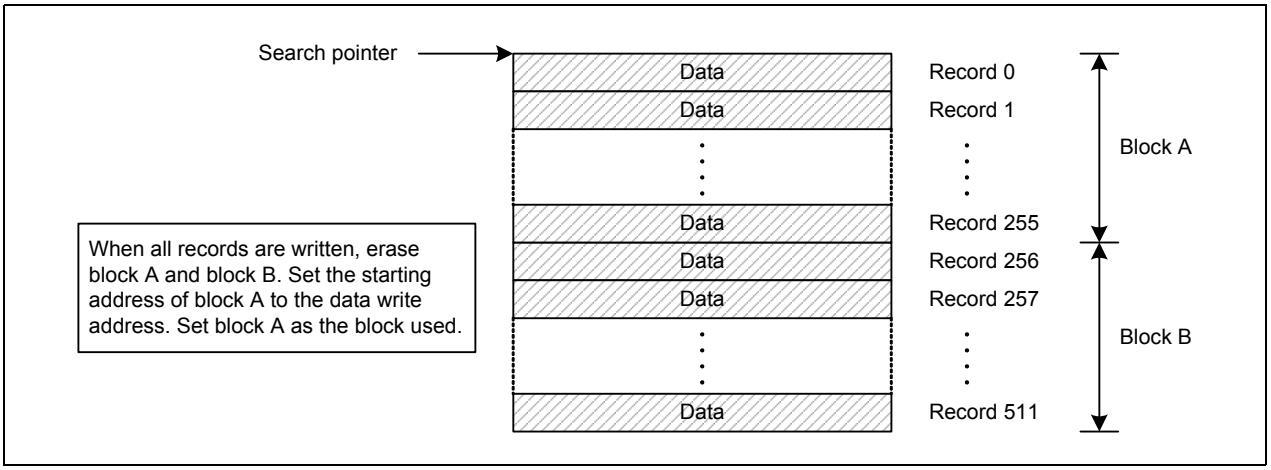


Figure 4.8 Block A: All Records Written; Block B: All Records Written

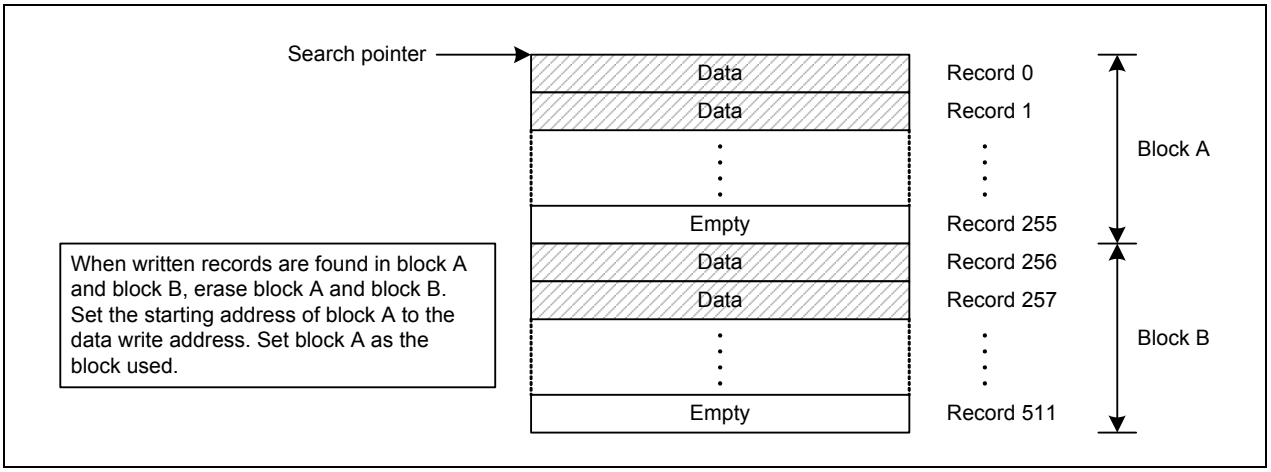


Figure 4.9 Block A: Written Records Found; Block B: Written Records Found

4.3 Required Memory Size

Table 4.2 lists the Required Memory Size.

Table 4.2 Required Memory Size

Memory Used	Size	Remarks
ROM	1179 bytes	In the r01an0366_src.c module
RAM	14 bytes	In the r01an0366_src.c module
Maximum user stack usage	33 bytes	
Maximum interrupt stack usage	18 bytes	

The required memory size varies depending on the C compiler version and compile options.

4.4 Constants

Table 4.3 lists the Constants Used in the Sample Code.

Table 4.3 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
COLD_HARDWARE_RST	0	Hardware reset (cold start-up)
LVD_RST	1	Voltage monitor 0 reset
SOFTWARE_RST	2	Software reset
WDT_RST	3	Watchdog timer reset
WARM_HARDWARE_RST	4	Hardware reset (warm start-up)
POWER_OFF_MODE	5	Exit power-off 1 mode
BLOCK_A	(unsigned char *) 0x03000	Starting address of block A
BLOCK_A_END	(unsigned char *) 0x033FF	Last address of block A
BLOCK_B	(unsigned char *) 0x03400	Starting address of block B
BLOCK_B_END	(unsigned char *) 0x037FF	Last address of block B
RECORD_SIZE	4	Size of one record
BLOCK_A_SELECT	0	Block A is the block used
BLOCK_B_SELECT	1	Block B is the block used
NORMAL	0x00	Completed normally
CMD_SEQ_ERROR	0x01	Command sequence error
ERS_BLK_CHK_ERROR	0x02	Erase/blank check error
PROGRAM_ERROR	0x03	Program error
ALL_FF_BLOCK_A	0x00	All records empty in block A
WRITE_BLOCK_A	0x01	Written records found in block A
ALL_XX_BLOCK_A	0x02	All records written in block A
ALL_FF_BLOCK_B	0x00	All records empty in block B
WRITE_BLOCK_B	0x10	Written records found in block B
ALL_XX_BLOCK_B	0x20	All records written in block B

4.5 Structure/Union List

Figure 4.10 shows the Structure/Union Used in the Sample Code.

```
typedef union{
    unsigned long all;
    struct{
        unsigned char lower;                /* Low-order data */
        unsigned char middle_lower;         /* Lower bytes of the middle-order data */
        unsigned char middle_upper;         /* Higher bytes of the middle-order data */
        unsigned char upper;                /* High-order data */
    }byte;
}byte_dt;
```

Figure 4.10 Structure/Union Used in the Sample Code

4.6 Variables

Table 4.4 lists the Global Variables.

Table 4.4 Global Variables

Type	Variable Name	Contents	Function Used
byte_dt	DataStr	Count data	user_program, write_address_init, set_data
unsigned char	block_select	Select the block used	write_address_init, data_write
unsigned char	*read_addr	Read address	write_address_init
unsigned char	*write_addr	Write address	write_address_init, data_write
unsigned char	record_data [RECORD_SIZE]	Write record	write_control
unsigned char	write_req	Write request 1: Write request 0: No write request	main, user_program

4.7 Functions

Table 4.5 lists the Functions.

Table 4.5 Functions

Function Name	Outline
reset_check	Reset source determination
mcu_init	System clock setting
user_program	User program processing
timer_re_init	Initial setting of timer RE
power_control	Power control processing
write_address_init	Initial setting of record write address
write_control	Data write control
set_data	Write data setting
block_erase	Block erase processing
data_write	Program command processing
full_sts_chk	Full status check

4.8 Function Specifications

The following tables list the sample code function specifications.

reset_check	
Outline	Reset source determination
Header	None
Declaration	unsigned char reset_check(void)
Description	Determine the reset source and return the result.
Argument	None
Returned value	• Cold start-up hardware reset: COLD_HARDWARE_RST(0) • Voltage monitor 0 reset: LVD_RST(1) • Software reset: SOFTWARE_RST(2) • Watchdog timer reset: WDT_RST(3) • Warm start-up hardware reset: WARM_HARDWARE_RST(4) • Exit power-off 1 mode: POWER_OFF_MODE(5)
Remark	—

mcu_init	
Outline	System clock setting
Header	None
Declaration	void mcu_init(void)
Description	Set the system clock.
Argument	None
Returned value	None
Remark	—

user_program	
Outline	User program processing
Header	None
Declaration	void user_program(unsigned char reset_result)
Description	Perform user program processing. Add processing based on the user system. In this application note, count the number of resets occurred by exiting power-off 1 mode and set the data flash write request (write_req) to 1.
Argument	First argument: reset_result — Reset source determination result
Returned value	None
Remark	—

timer_re_init	
Outline	Initial setting of timer RE
Header	None
Declaration	void timer_re_init(void)
Description	Perform initial setting to use timer RE in real-time clock mode.
Argument	None
Returned value	None
Remark	—

power_control	
Outline	Power control processing
Header	None
Declaration	void power_control(void)
Description	Enter power-off 1 mode.
Argument	None
Returned value	None
Remark	—

write_address_init	
Outline	Initial setting of record write address
Header	None
Declaration	void write_address_init(void)
Description	Search for empty records in each block, select the block used depending on block use, and set the starting address in the empty record to the write address (write_addr). Read the last write record and set the data as the count data.
Argument	None
Returned value	None
Remark	—

write_control	
Outline	Data write control
Header	None
Declaration	unsigned char write_control(void)
Description	Write the count data set in write data setting.
Argument	None
Returned value	• Completed normally: NORMAL(0x00) • Command sequence error: CMD_SEQ_ERROR(0x01) • Erase/blank check error: ERS_BLK_CHK_ERROR(0x02) • Program error: PROGRAM_ERROR(0x03)
Remark	—

set_data	
Outline	Write data setting
Header	None
Declaration	void set_data(unsigned char *data)
Description	Set the count data to the argument address.
Argument	First argument: data — Starting address of write data
Returned value	None
Remark	—

block_erase	
Outline	Block erase processing
Header	None
Declaration	unsigned char block_erase(unsigned char block_no)
Description	Erase the specified block in CPU rewrite mode (EW1 mode). Perform full status check and return the result after erasing is completed.
Argument	First argument: block_no — Block number to erase
Returned value	• Completed normally: NORMAL(0x00) • Command sequence error: CMD_SEQ_ERROR(0x01) • Erase/blank check error: ERS_BLK_CHK_ERROR(0x02) • Program error: PROGRAM_ERROR(0x03)
Remark	—

data_write	
Outline	Program command processing
Header	None
Declaration	unsigned char data_write(unsigned char *data)
Description	Write one record data from the write address (write_addr) in CPU rewrite mode (EW1 mode). Perform a full status check each time 1 byte is written and return the result.
Argument	First argument: data — Starting address of write data
Returned value	• Completed normally: NORMAL(0x00) • Command sequence error: CMD_SEQ_ERROR(0x01) • Erase/blank check error: ERS_BLK_CHK_ERROR(0x02) • Program error: PROGRAM_ERROR(0x03)
Remark	—

full_sts_chk	
Outline	Full status check
Header	None
Declaration	unsigned char full_sts_chk(unsigned char *chk_adr)
Description	Perform a full status check and return the result.
Argument	First argument: chk_adr — Address where erase command or program command is written
Returned value	• Completed normally: NORMAL(0x00) • Command sequence error: CMD_SEQ_ERROR(0x01) • Erase/blank check error: ERS_BLK_CHK_ERROR(0x02) • Program error: PROGRAM_ERROR(0x03)
Remark	—

4.9 Flowcharts

4.9.1 Main Processing

Figure 4.11 shows the Main Processing.

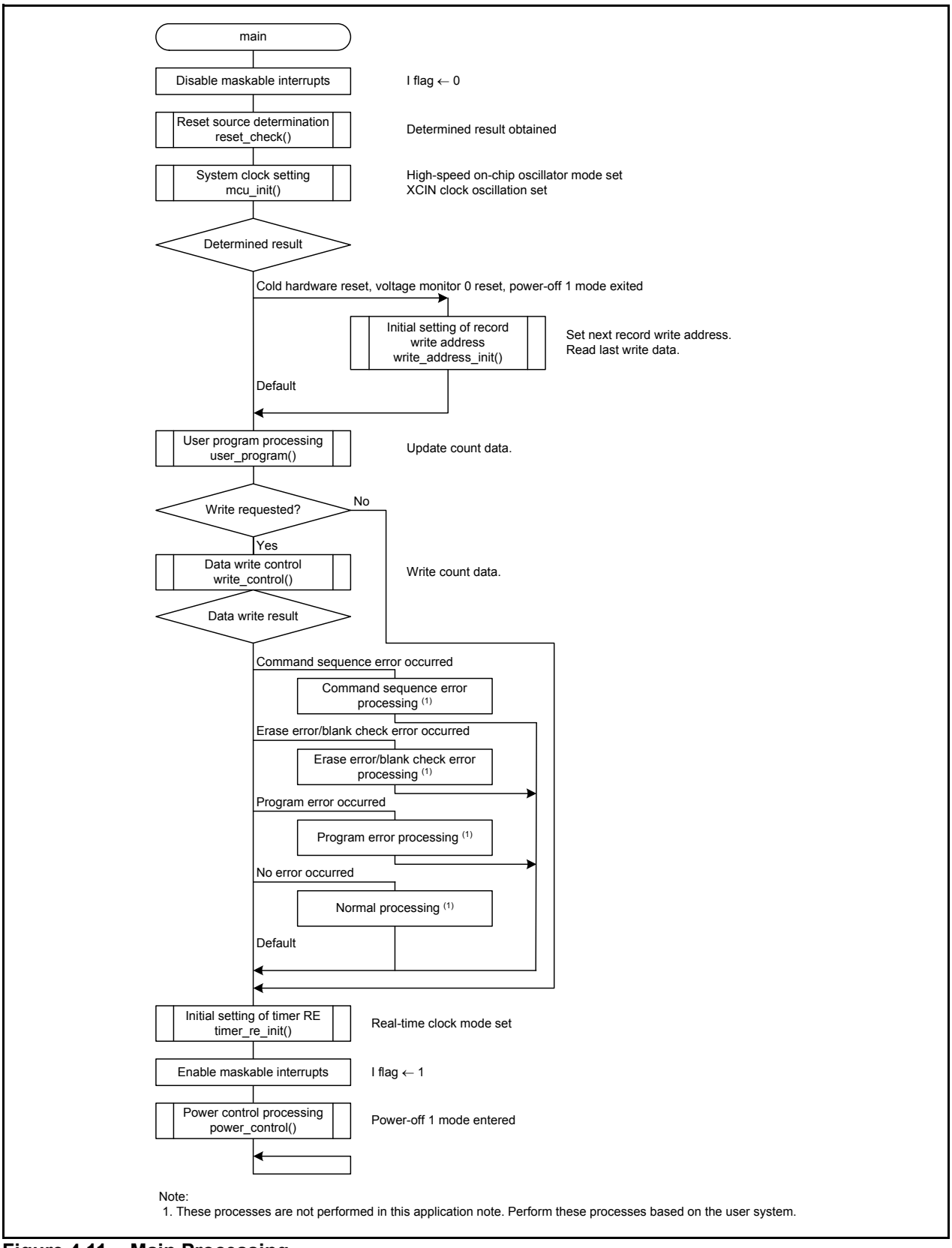


Figure 4.11 Main Processing

4.9.2 Reset Source Determination

Figure 4.12 shows the Reset Source Determination.

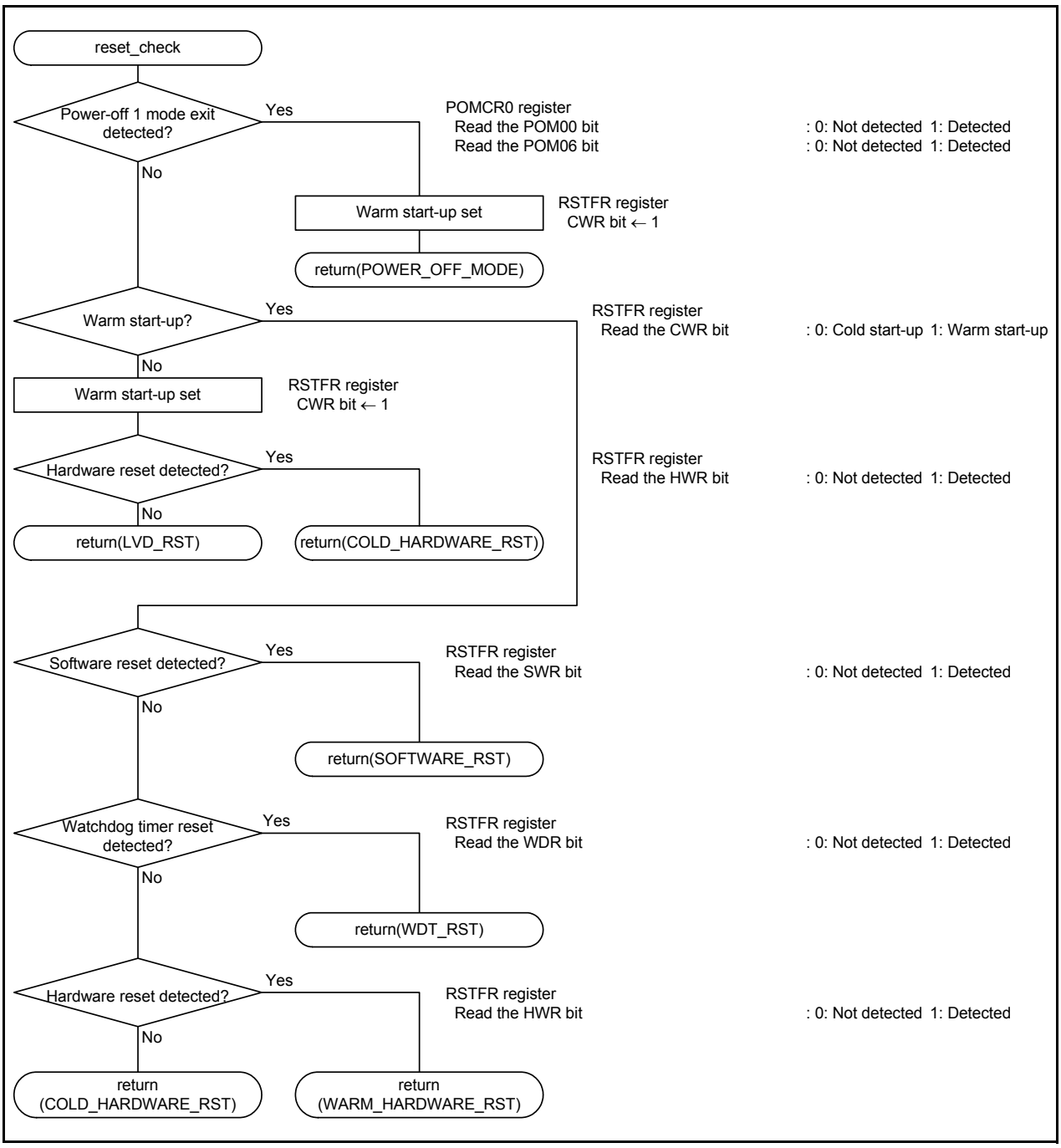


Figure 4.12 Reset Source Determination

4.9.3 System Clock Setting

Figure 4.13 shows the System Clock Setting.

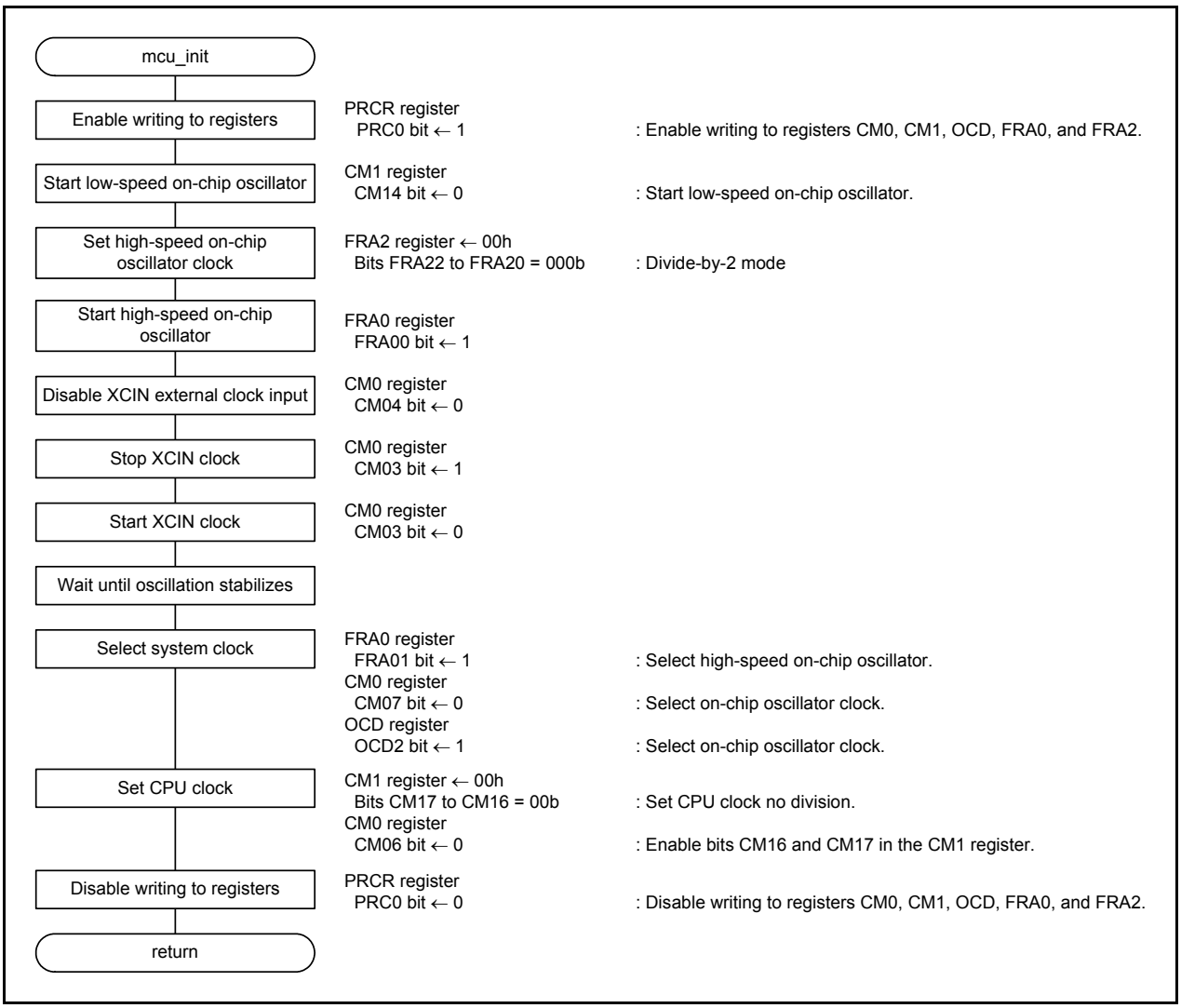


Figure 4.13 System Clock Setting

4.9.4 User Program Processing

Figure 4.14 shows the User Program Processing.

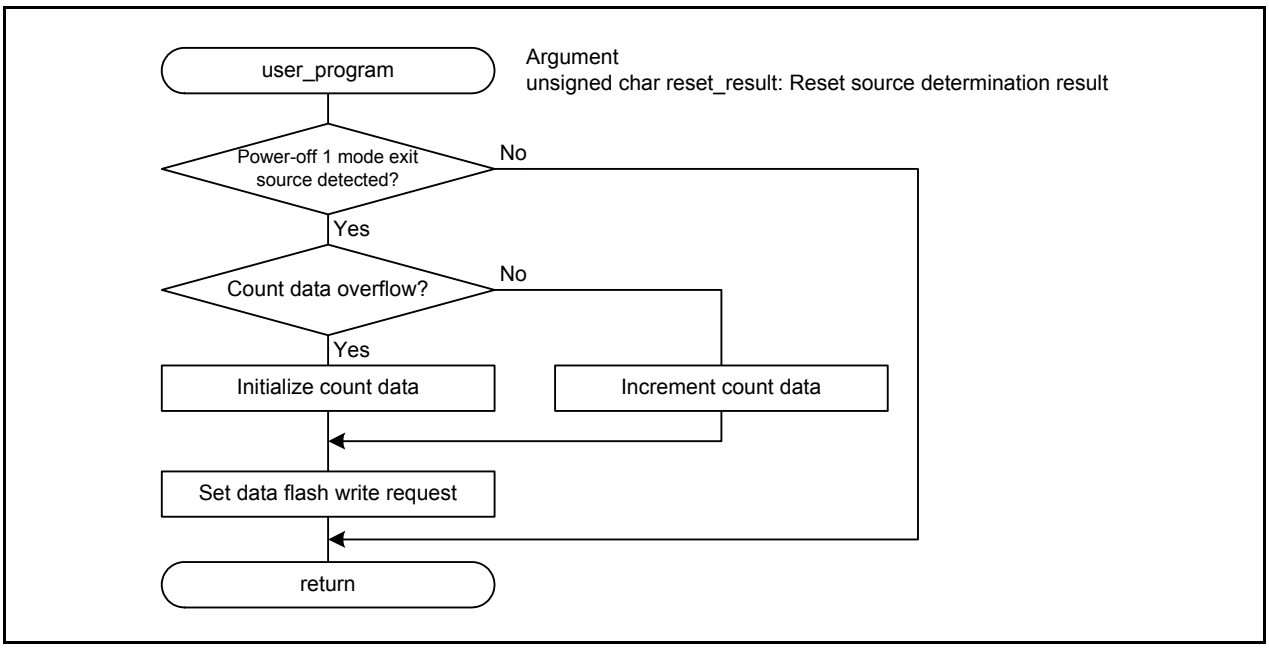
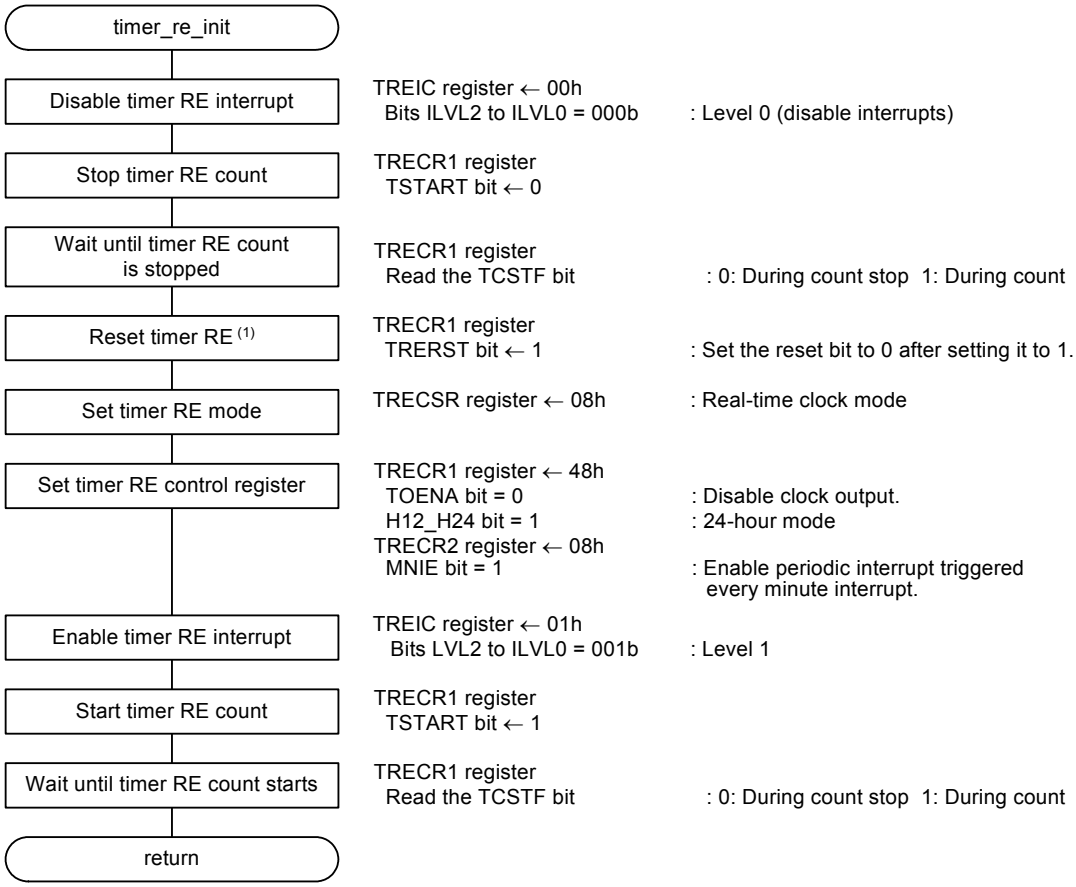


Figure 4.14 User Program Processing

4.9.5 Initial Setting of Timer RE

Figure 4.15 shows the Initial Setting of Timer RE.



Note:
1. When setting this bit to 0 after setting it to 1, the following will occur:
   - Registers TRESEC, TREMIN, TREHR, TREWK, and TRECR2 are set to 00h.
   - Bits TCSTF, INT, PM, H12_H24, and TSTART in the TRECR1 register are set to 0.
   - The 8-bit counter is set to 00h and the 4-bit counter is set to 0h.

Figure 4.15 Initial Setting of Timer RE

4.9.6 Power Control Processing

Figure 4.16 shows the Power Control Processing.

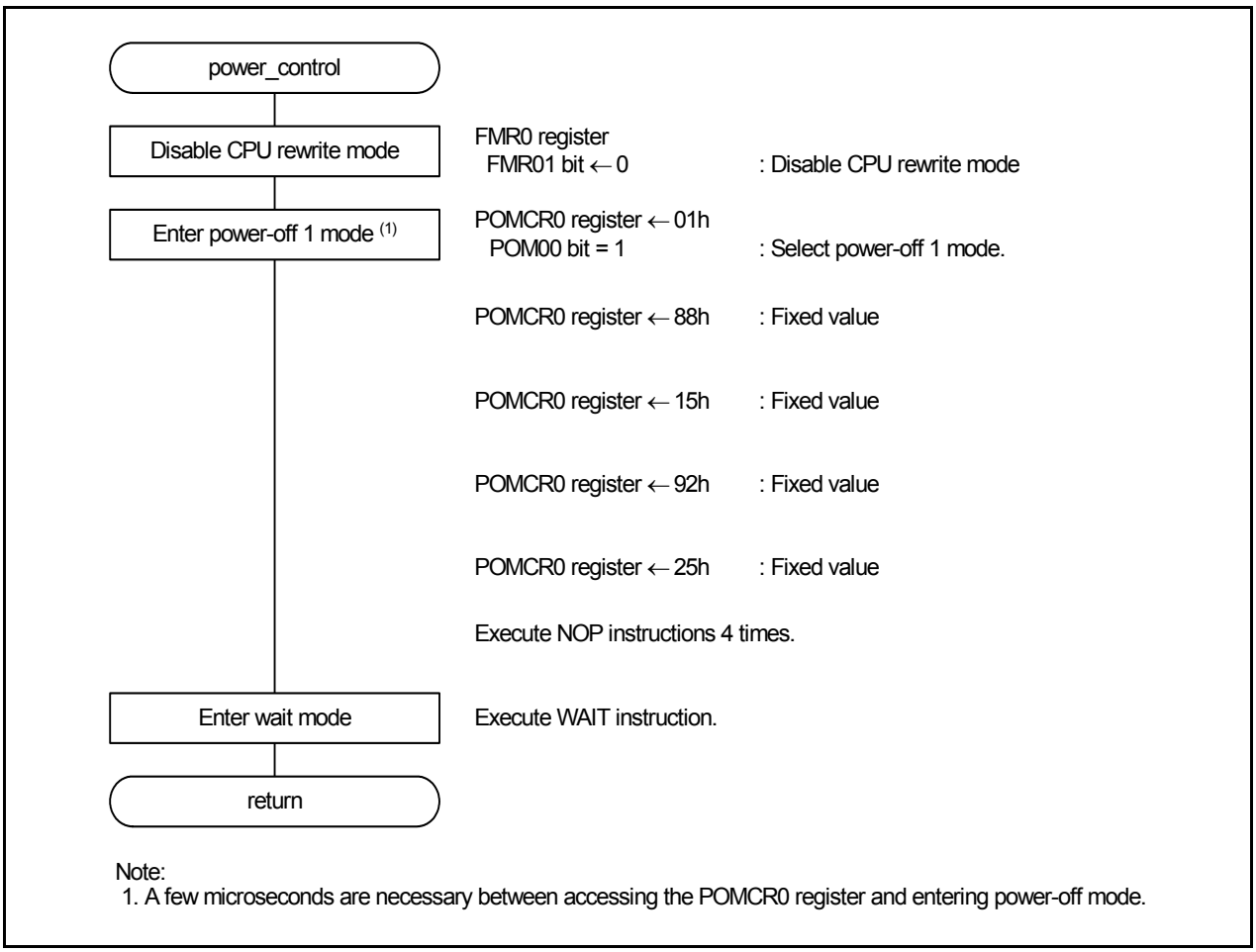


Figure 4.16 Power Control Processing

4.9.7 Initial Setting of Record Write Address

Figure 4.17 to Figure 4.19 show the Initial Settings of Record Write Address.

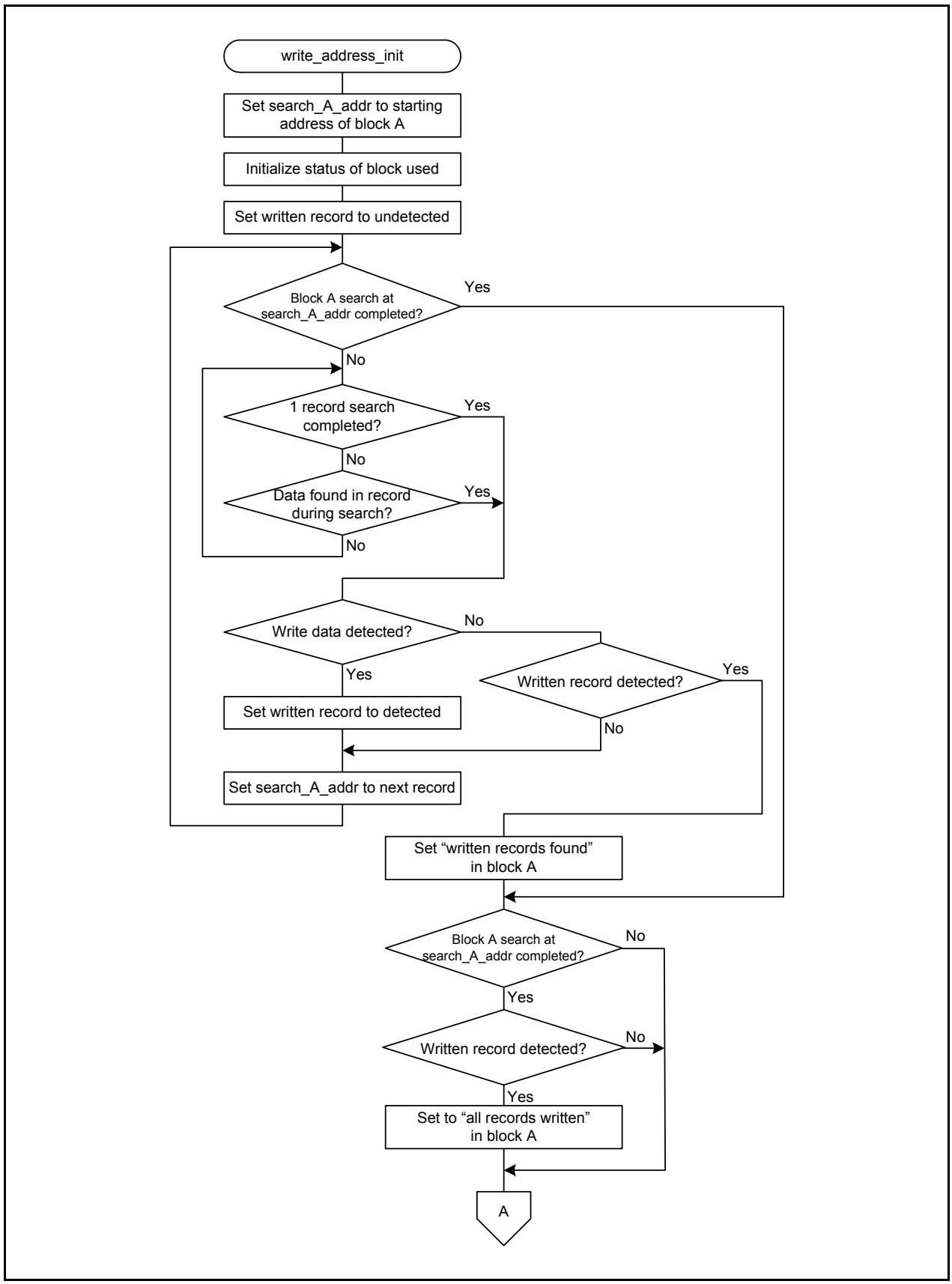


Figure 4.17 Initial Setting of Record Write Address (1/3)

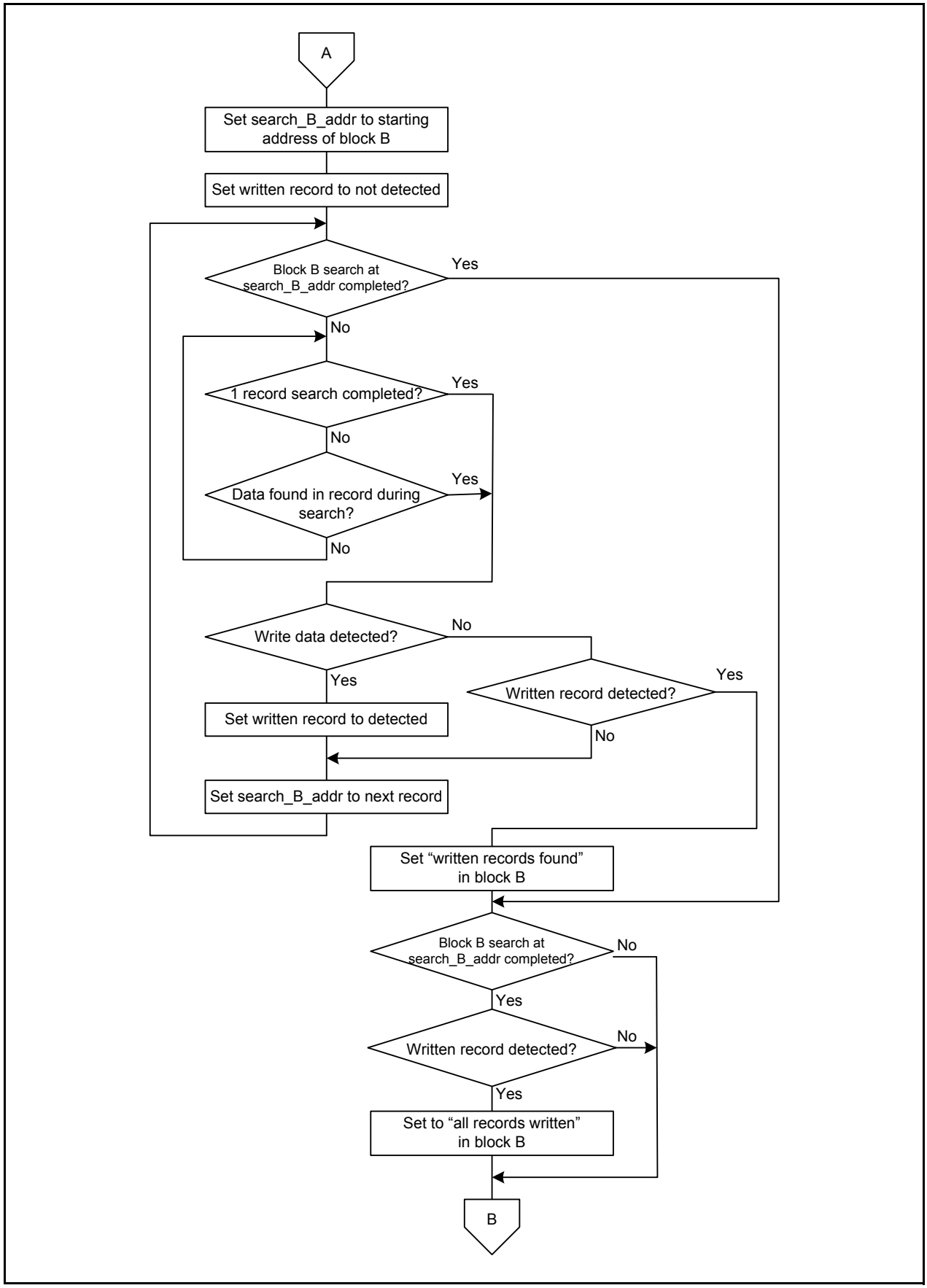


Figure 4.18 Initial Setting of Record Write Address (2/3)

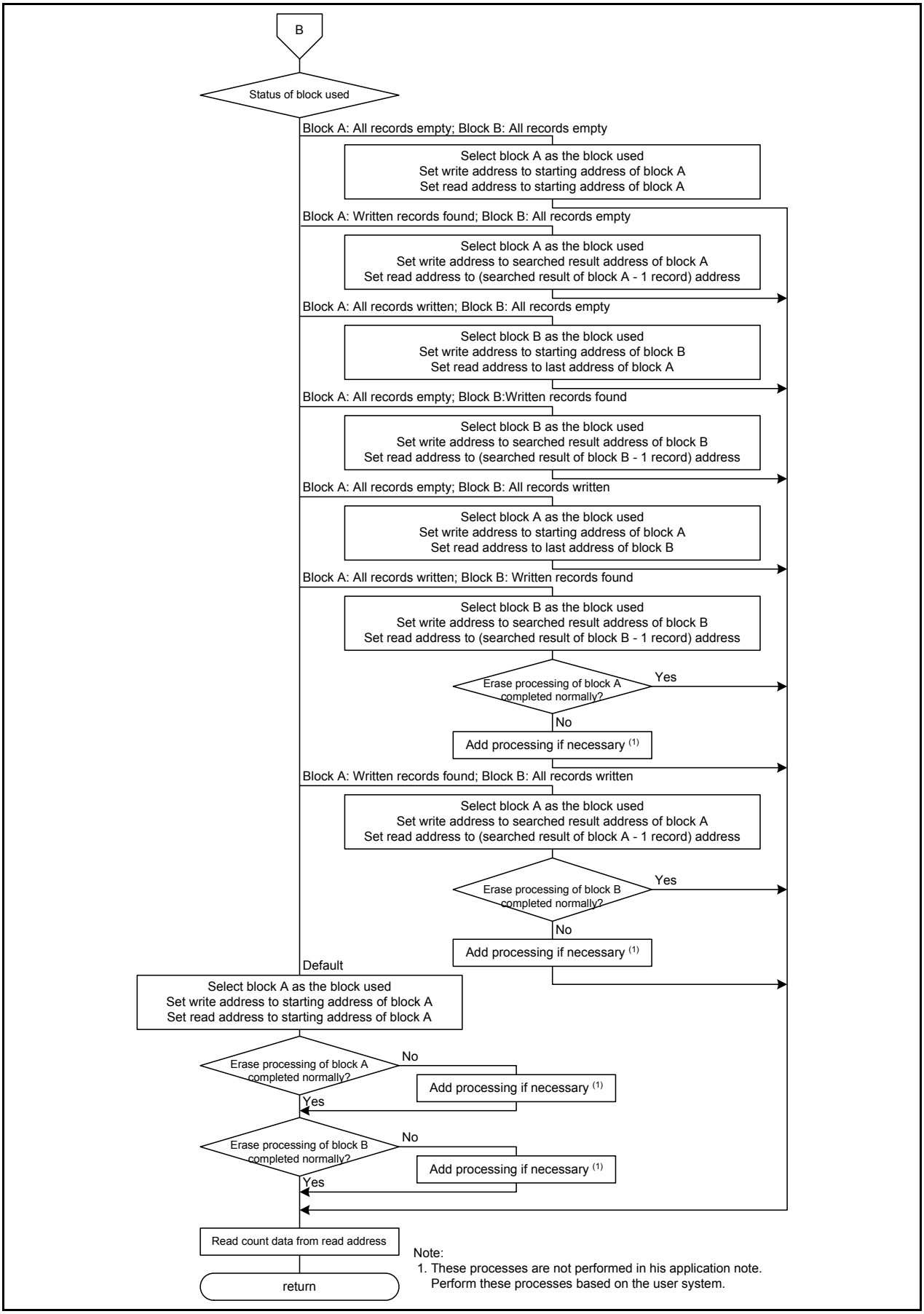


Figure 4.19 Initial Setting of Record Write Address (3/3)

4.9.8 Data Write Control

Figure 4.20 shows the Data Write Control.

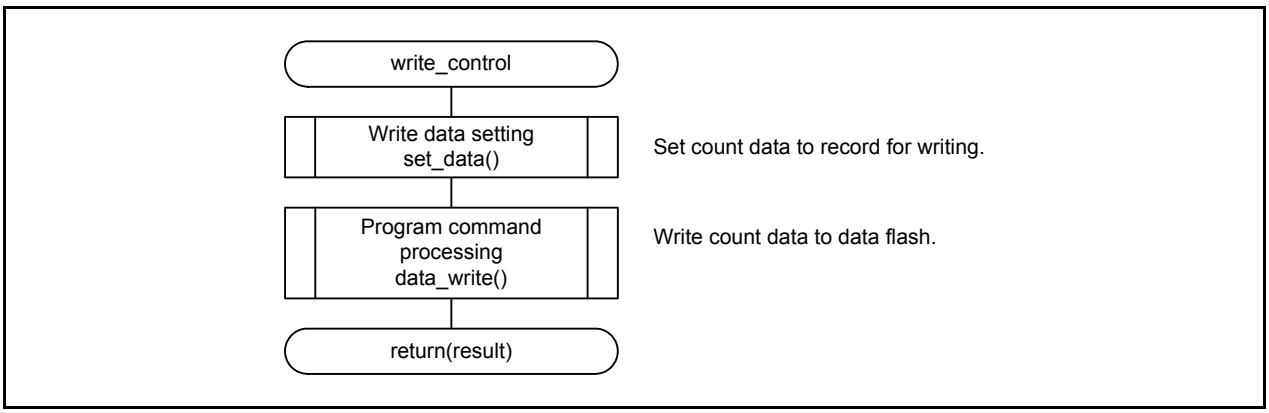


Figure 4.20 Data Write Control

4.9.9 Write Data Setting

Figure 4.21 shows the Write Data Setting.

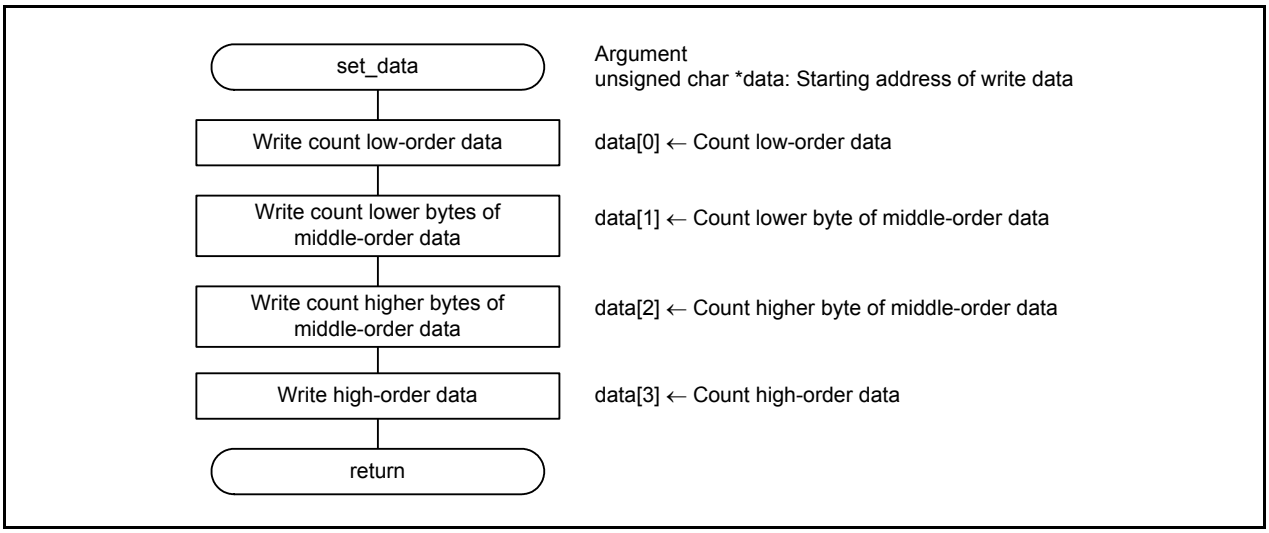


Figure 4.21 Write Data Setting

4.9.10 Block Erase Processing

Figure 4.22 shows the Block Erase Processing.

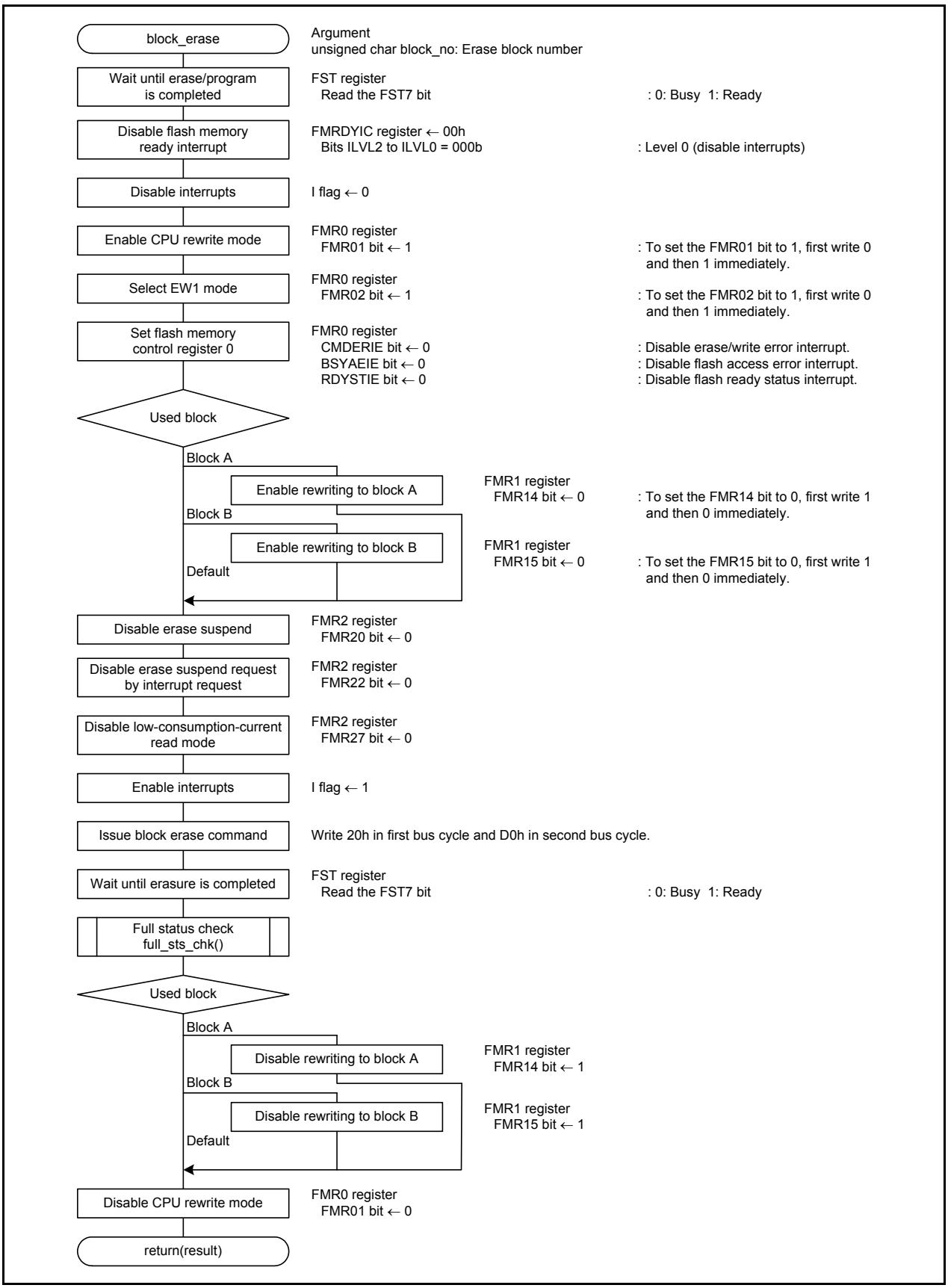


Figure 4.22 Block Erase Processing

4.9.11 Program Command Processing

Figure 4.23 and Figure 4.24 show the Program Command Processing.

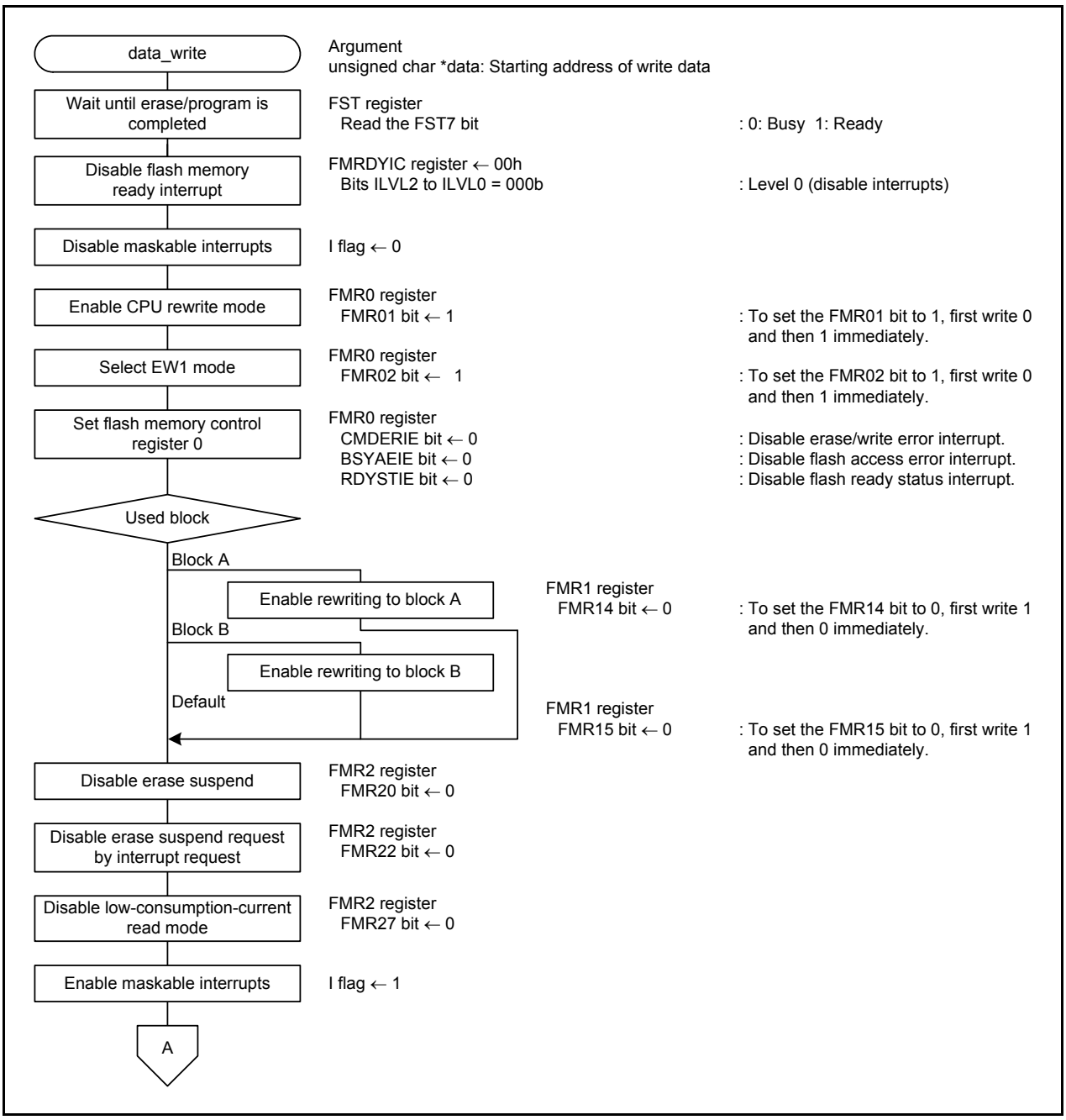


Figure 4.23 Program Command Processing (1/2)

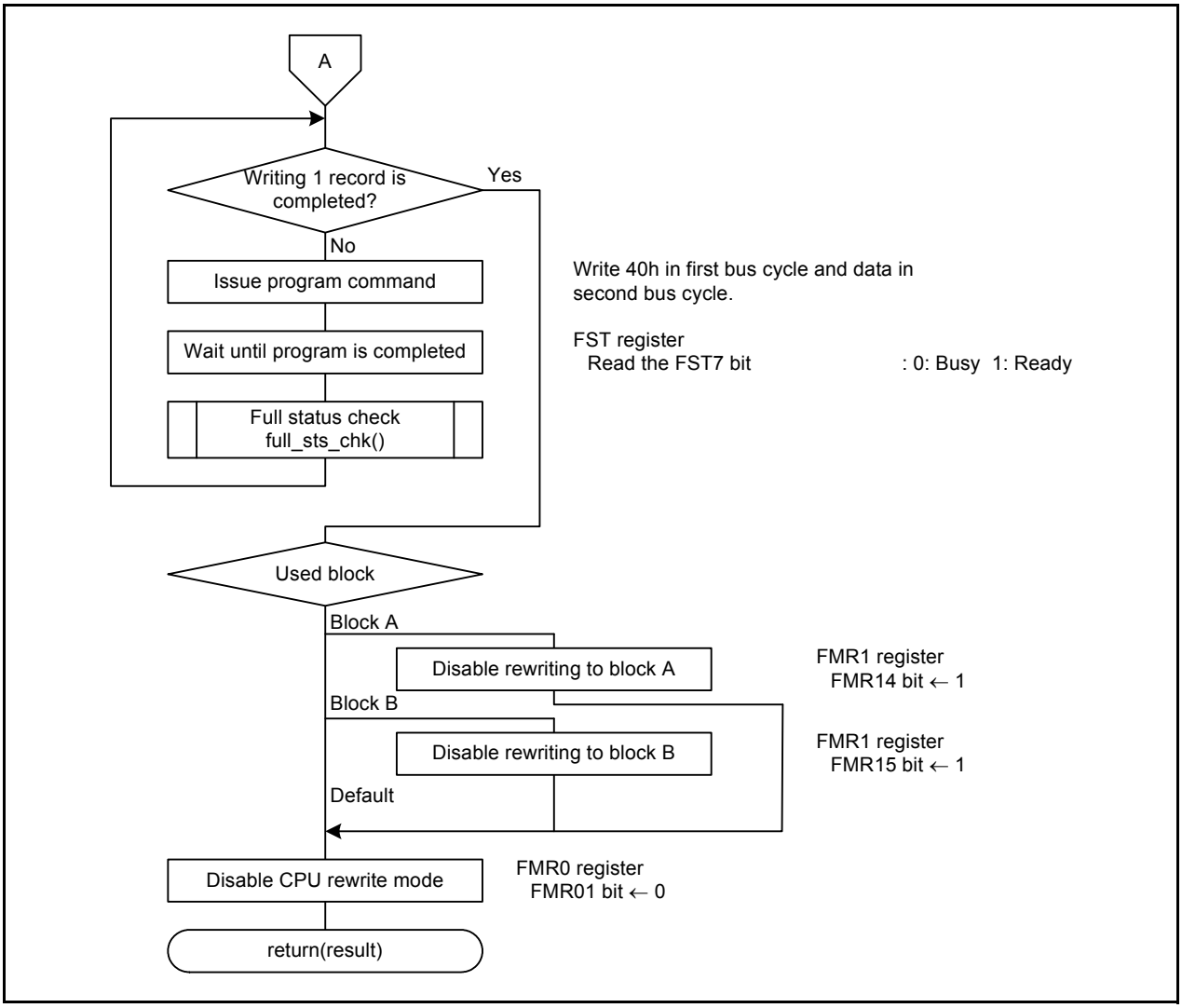


Figure 4.24 Program Command Processing (2/2)

4.9.12 Full Status Check

Figure 4.25 shows the Full Status Check.

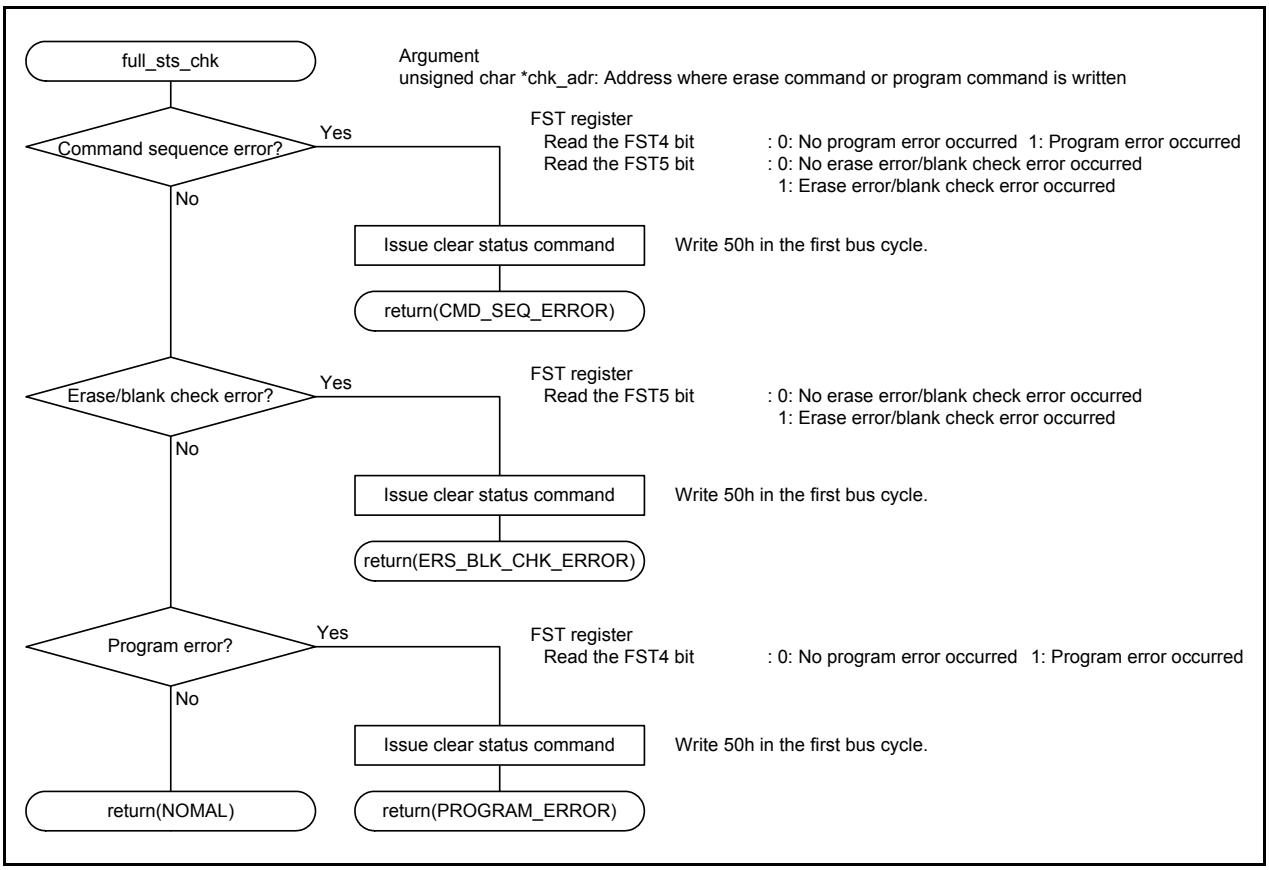


Figure 4.25 Full Status Check

5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

R8C/L3AM Group User's Manual: Hardware Rev.1.00
The latest version can be downloaded from the Renesas Electronics website.

Technical Update/Technical News
The latest information can be downloaded from the Renesas Electronics website.

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Revision History	R8C/L3AM Group Power Control Using Power-Off 1 Mode

Rev.	Date	Description	
		Page	Summary
1.01	Jan. 6, 2012	—	First edition issued

General Precautions in the Handling of MPU/MCU Products

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 part number, confirm that the change will not lead to problems.

   — The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.

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