RX Family

Flash ROM Correction

Summary

With large-capacity flash memory or when performing low-speed serial programming on a user system, it can take considerable time to rewrite all of the flash memory. This application note describes a method of flash ROM correction in which patches are applied to the user program in a manner that rewrites the smallest area possible.

Unless otherwise specified, the descriptions in this application note apply to the RX113.

Target Device

RX113 Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to match the specifications of the alternative MCU.

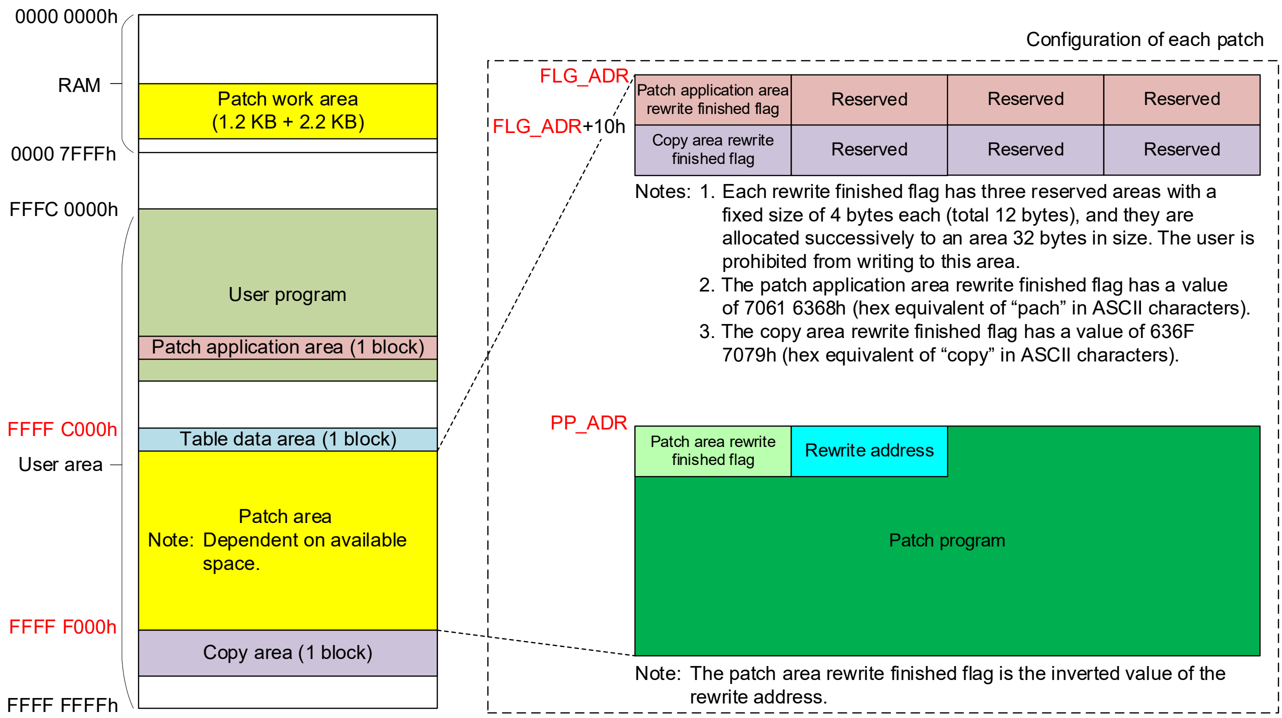
Contents

1. Specifications

This application note describes a method of updating a user program (referred to below as "ROM correction") in which a patch program and table data created by the user are written beforehand to the patch area shown in Figure 1.1 and to the table data area shown in Figure 1.2, respectively.

The sample code is executed before the user program runs. When a location corresponding to a patch is reached while the user program is running, the patch program runs, and after execution of the patch program has finished, execution returns to the user program. Figure 1.3 shows an example of the operation of the sample code described in this application note.

Even if writing of the patch program or table data area created by the user fails due to a momentary voltage drop or the like, it is still possible to run the pre-update version of the program. In addition, if writing fails due to a momentary voltage drop or the like while the patch program is being applied, the sample code will retry the process and apply the updated program when the system is restarted.



Addresses in red may be changed. Note that FLG_ADR and PP_ADR are addresses inside the patch area.

Figure 1.1 Patch Area

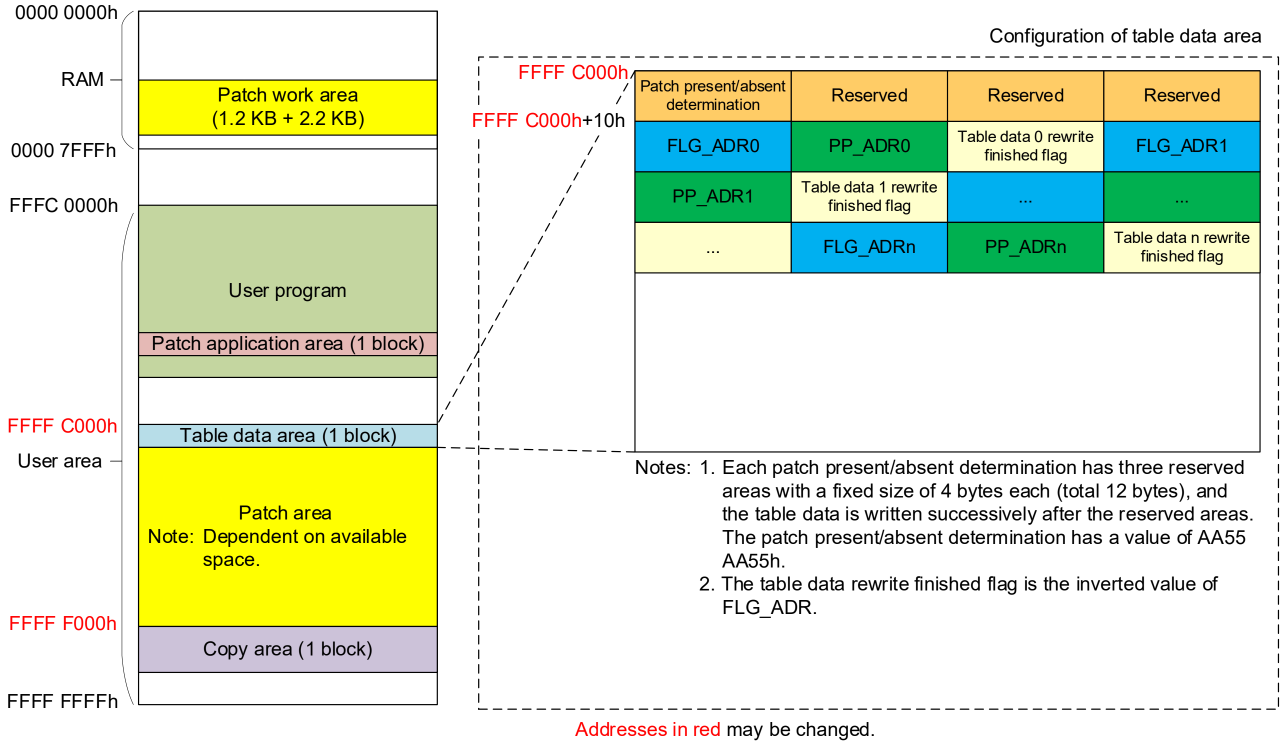


Figure 1.2 Table Data Area

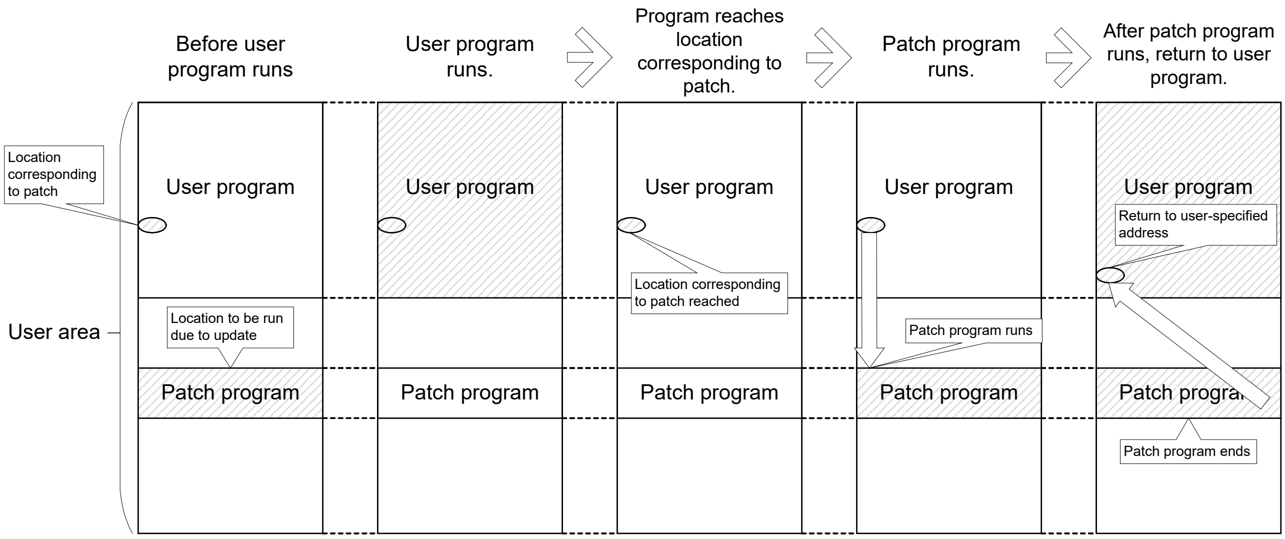


Figure 1.3 Application Note Operation Example

2. Operation Confirmation Conditions

Table 2.1 lists the conditions under which the operation of the sample code referenced in this application note has been confirmed.

Table 2.1 Operation Confirmation Conditions

Item	Description
MCU used	R5F51138AFP (RX113 Group)
Operating frequencies	Main clock: 16 MHz Subclock stopped PLL: 32 MHz (main clock: × 1/4 × 8) HOCO stopped System clock (ICLK): 32 MHz (PLL × 1/1) FlashIF clock (FCLK): 32 MHz (PLL × 1/1)
Operating voltage	3.3 V
Integrated development environment	Renesas Electronics e^2 studio Version 7.7.0
C compiler	Renesas Electronics C/C++ Compiler Package for RX Family V3.02.00
	Compiler option Default settings of integrated development environment
iodefine.h version	Ver. 1.1
Endian order	Little endian or big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Board used	Renesas Starter Kit for RX113 (product number: R0K505113C010BR)

3. Related Application Notes

Application notes related to this application note are listed below. Refer to them in conjunction with this application note.

- RX Family Board Support Package Module Using Firmware Integration Technology (R01AN1685)
- RX Family Flash Module Using Firmware Integration Technology (R01AN2184)

Sample code from the above application notes is incorporated into the sample code accompanying this application note. If a newer version is available, use it instead. Visit the Renesas Electronics Corporation website to check for and download the latest version.

4. Software

4.1 Operation Overview

To use ROM correction, create a table data area and patch area to match your specifications. Note that the sample code imposes an upper limit of four on the number of times the patch present/absent determination, patch application area rewrite finished flag, and copy area rewrite finished flag may be written.

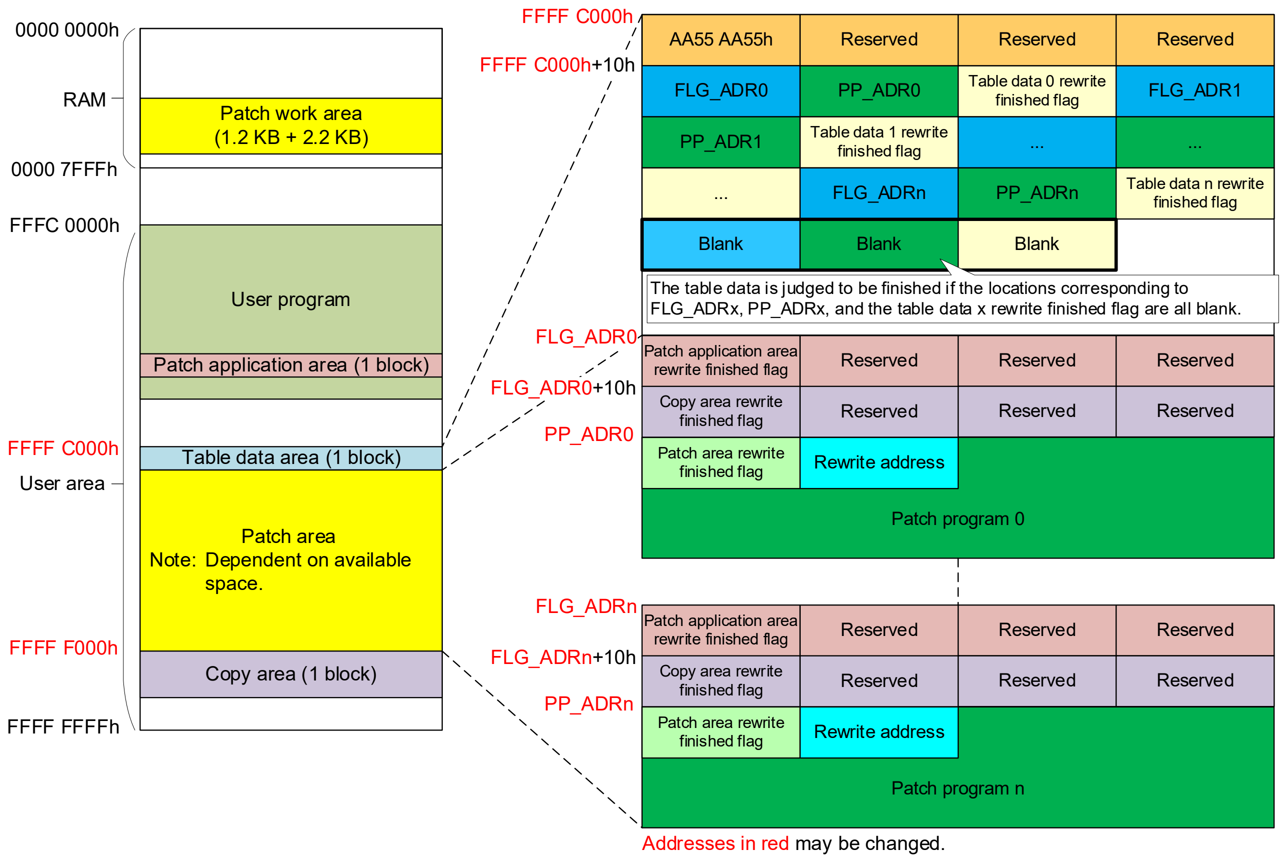


Figure 4.1 Table Data Area for ROM Correction

Execute the sample code before running the user program. After the processing corresponding to the patch area and table data area created by the user completes, the user program is run. Figure 4.2 is a flowchart of operation when the sample code is used.

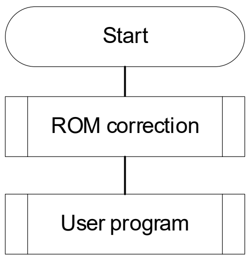


Figure 4.2 Flowchart of Operation Using Sample Code

4.1.1 Table Data Area and Patch Area Checking

When performing ROM correction, the sample code performs the steps shown in Figure 4.3 to check the table data area and patch area.

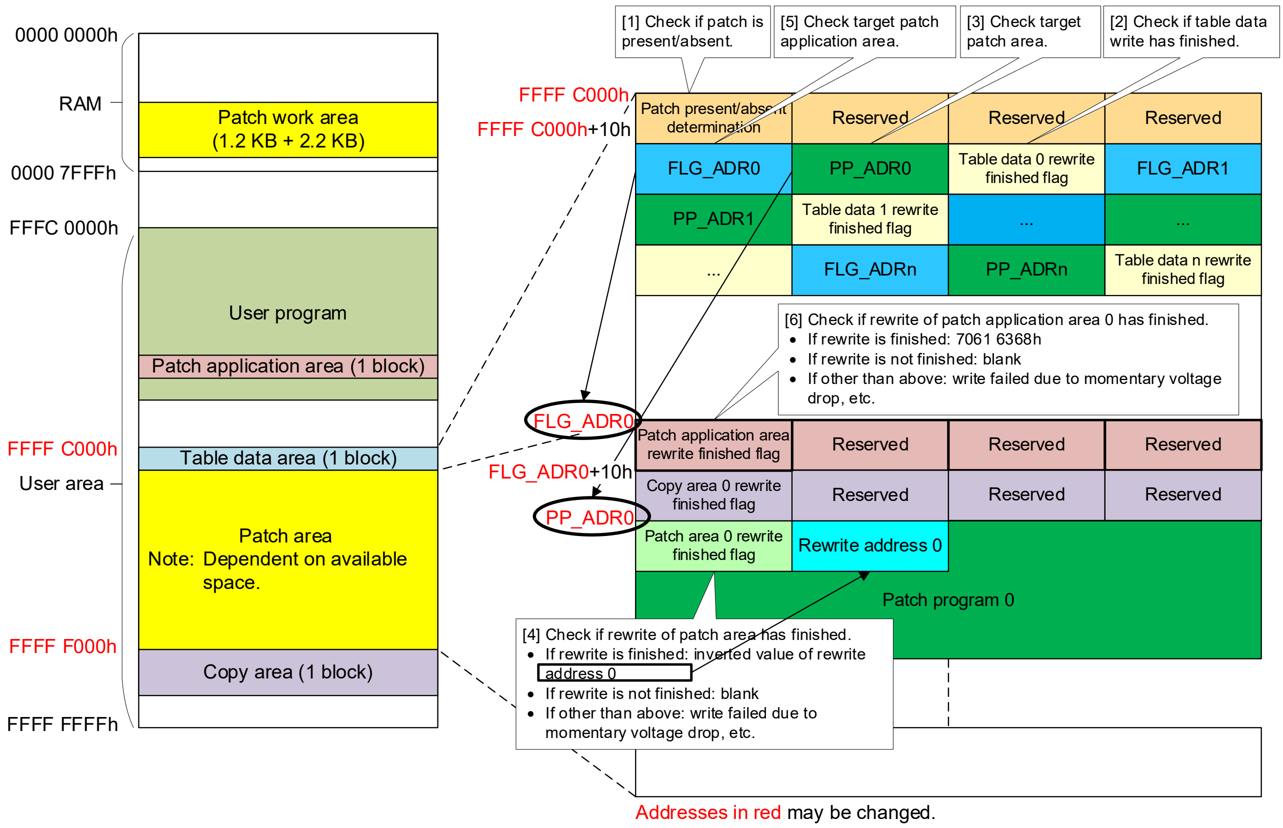


Figure 4.3 Table Data Area and Patch Area Checking

4.1.2 ROM Correction Flowchart

Figure 4.4 is a flowchart of ROM correction.

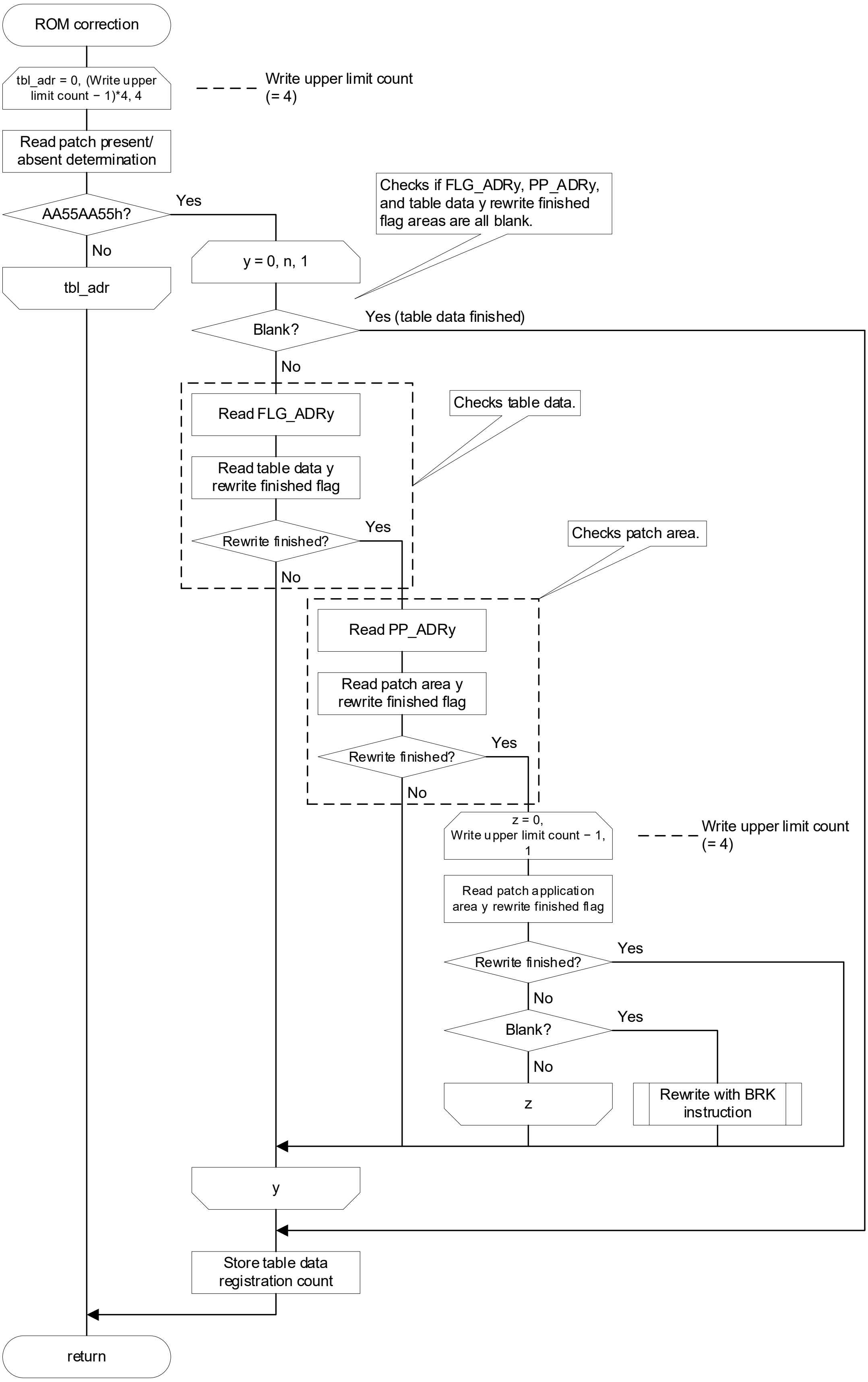


Figure 4.4 ROM Correction Flowchart

4.1.3 Rewrite with BRK Instruction Flowchart

The sample code uses the BRK exception handler, which is called when an address that has been rewritten by ROM correction with the value 00h is executed, as the trigger for running the patch program. Figure 4.5 is a flowchart of the rewrite with BRK instruction processing.

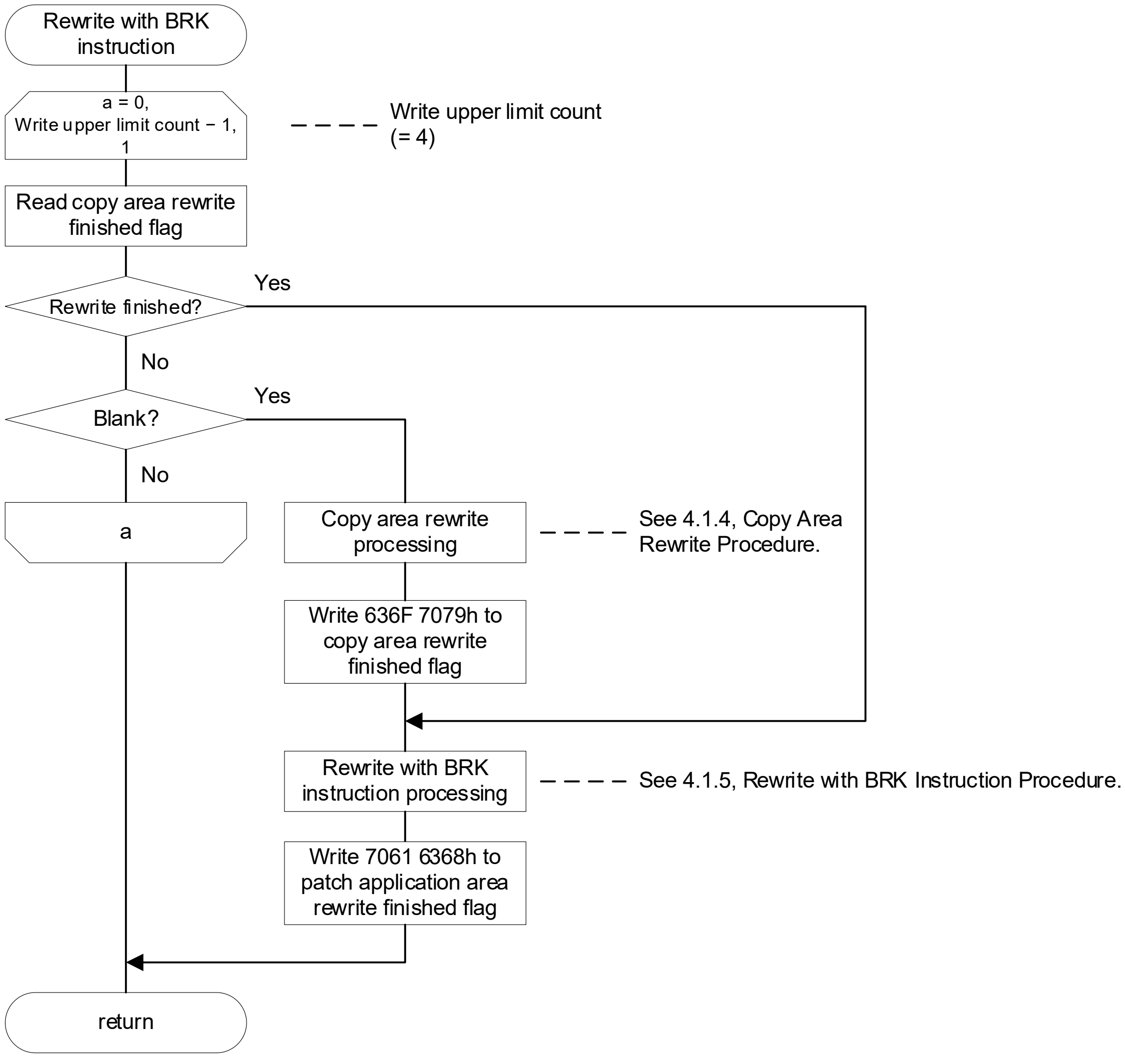


Figure 4.5 Rewrite with BRK Instruction Flowchart

4.1.4 Copy Area Rewrite Procedure

Considering the possibility of write failure due to a momentary voltage drop or the like while the patch application area is being rewritten, the sample code stores to the copy area the contents of the patch application area before it is rewritten. Figure 4.6 shows the copy area rewrite procedure.

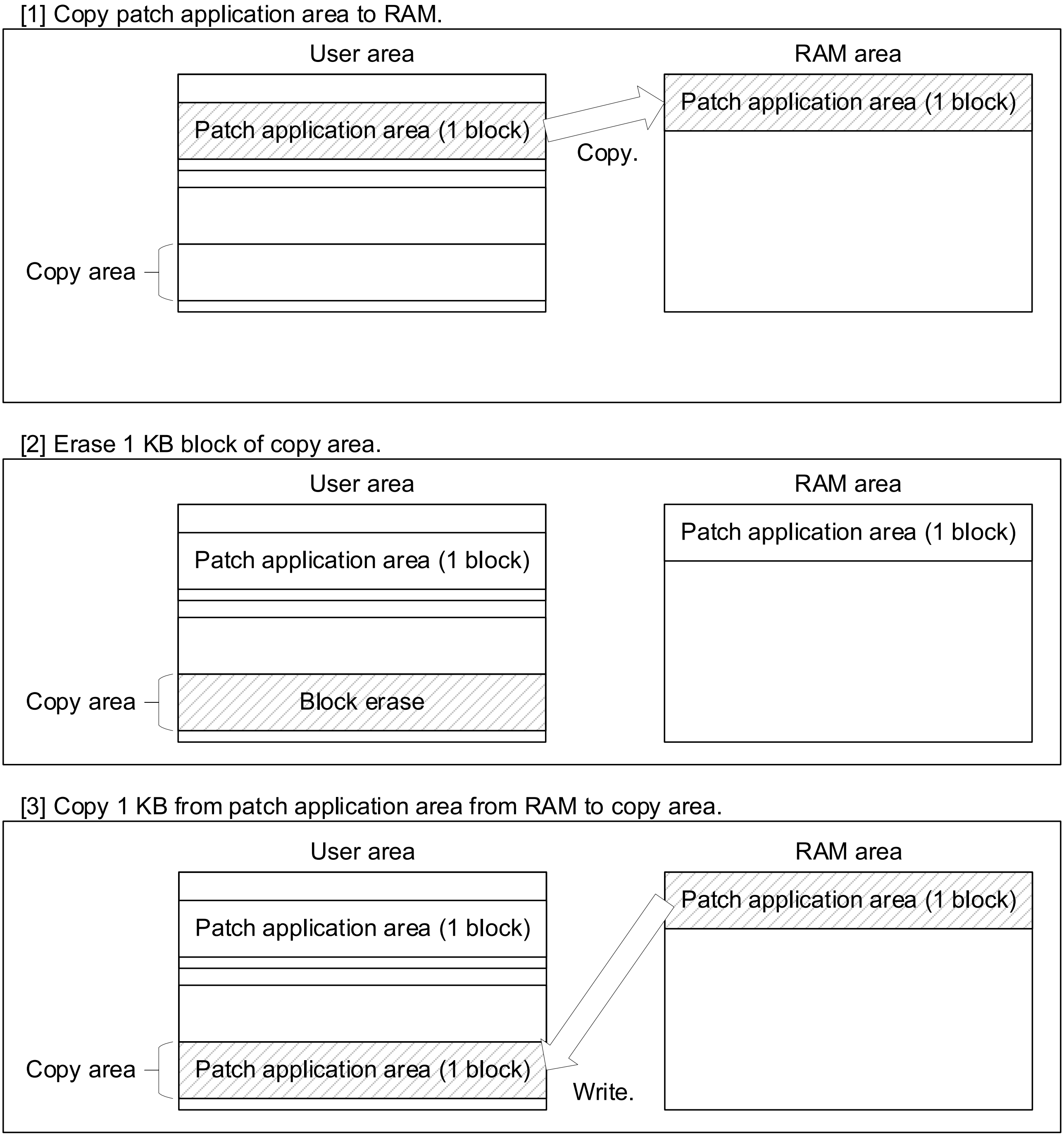


Figure 4.6 Copy Area Rewrite Procedure

4.1.5 Rewrite with BRK Instruction Procedure

Figure 4.7 shows the rewrite with BRK instruction procedure.

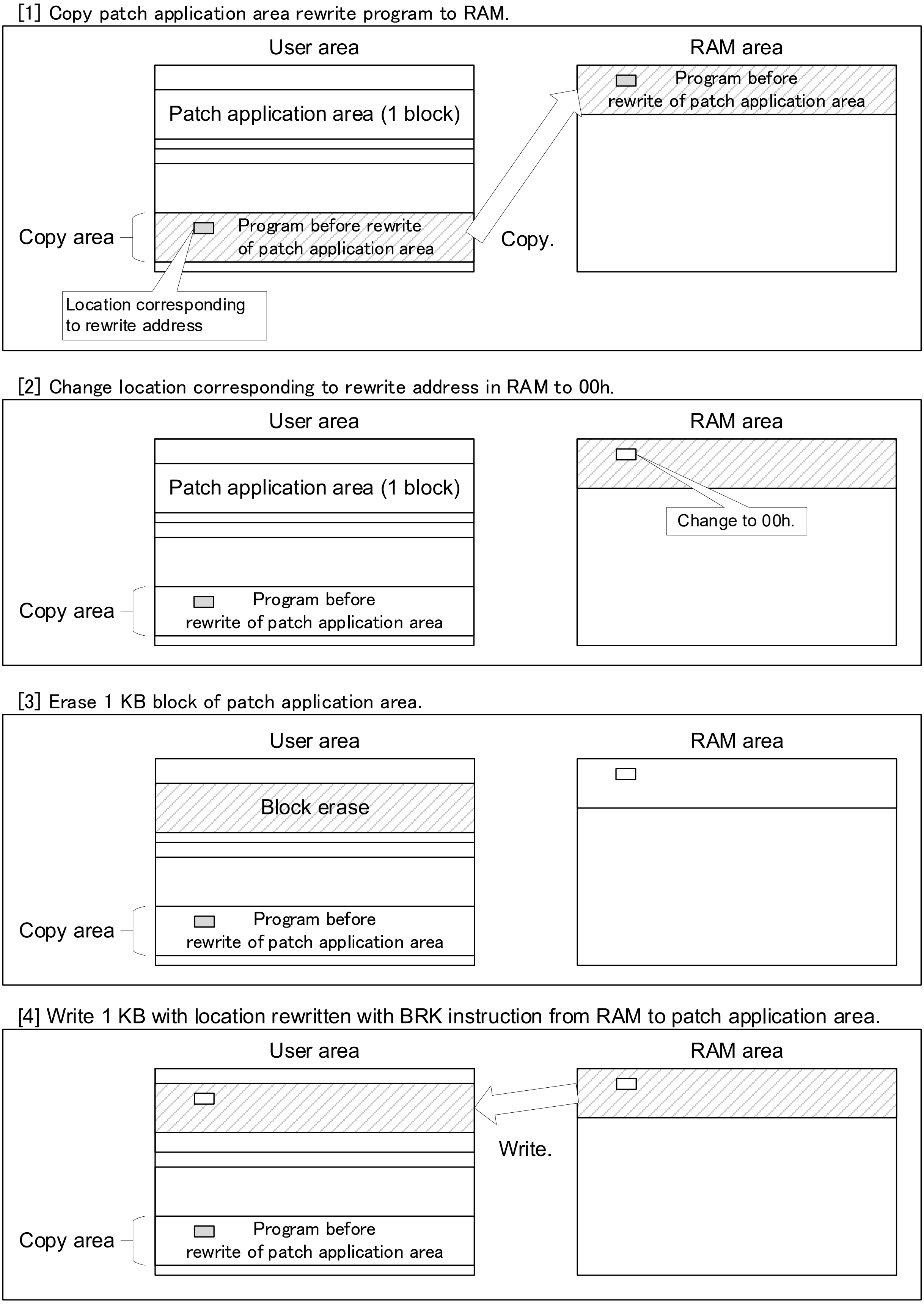


Figure 4.7 Rewrite with BRK Instruction Procedure

4.1.6 Write Procedure for Flags with Allocated Reserved Areas

The processing to write the patch application area rewrite finished flag, copy area rewrite finished flag, and patch present/absent determination, each of which have reserved areas allocated to them, proceeds as follows: If the target area is blank, the item is written to it. If the target area is not blank, a write failure is judged to have occurred due to a momentary voltage drop or the like, the area located at the address 4h ahead of the previous target area becomes the target, and the check to determine if it is blank is repeated.

Figure 4.8 shows the write procedure using the patch application area rewrite finished flag as an example.

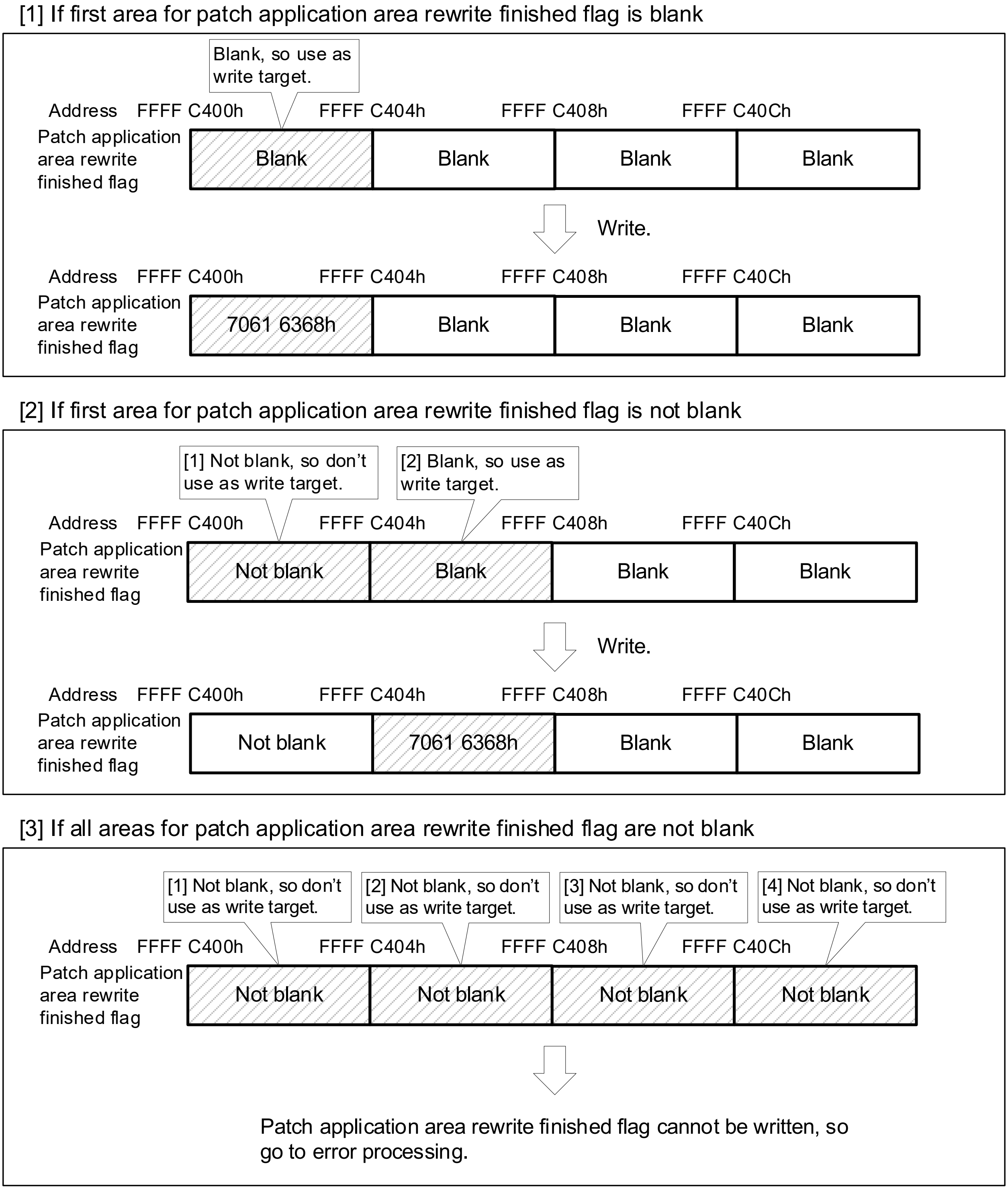
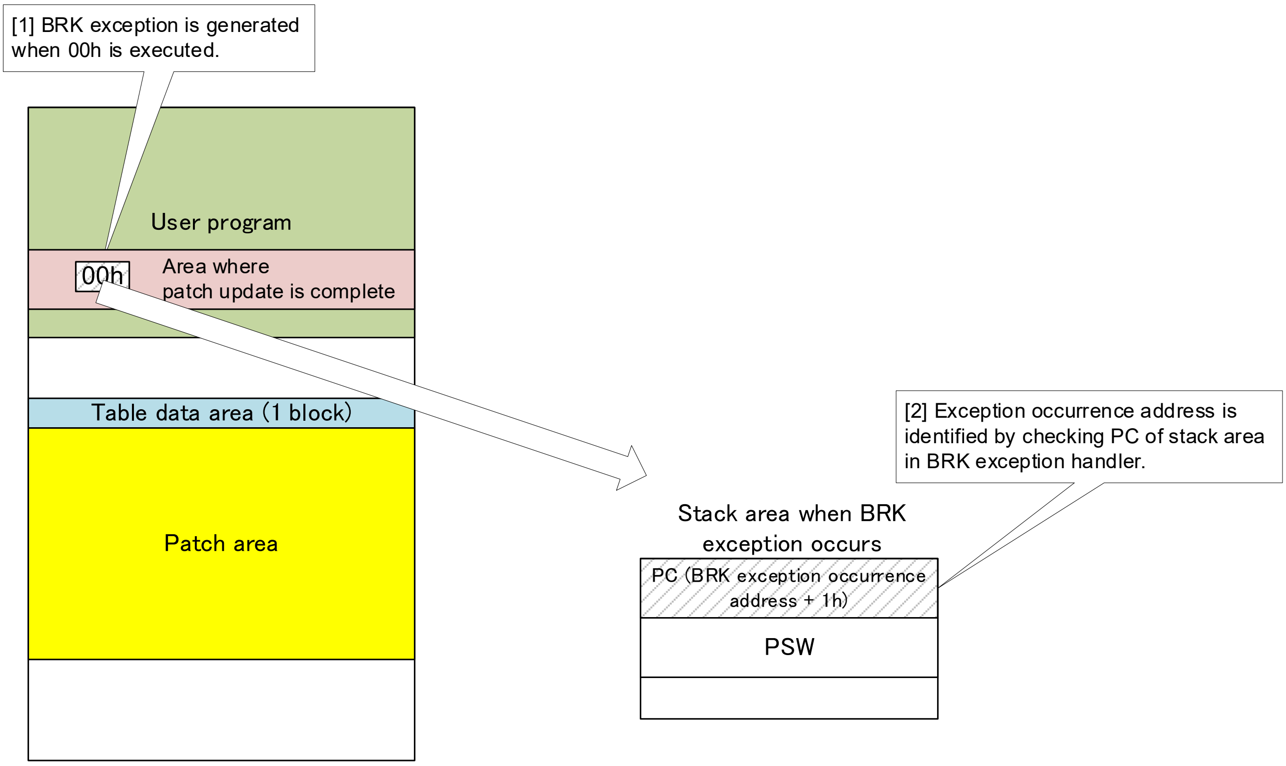


Figure 4.8 Write Procedure with Patch Application Area Rewrite Finished Flag as Example

4.1.7 Identifying BRK Exception (Unconditional Trap) Occurrence Address

The sample code uses the BRK exception, which occurs when an address that has been rewritten by ROM correction with the value 00h is executed, as the trigger for running the patch program.

When execution of the user program reaches an address to which 00h has been written, that is the rewrite address target location, a BRK exception is generated. The address where the BRK exception occurred is identified by checking the program counter (PC) of the stack area in the BRK exception handler. Figure 4.9 illustrates operation when a BRK exception occurs.

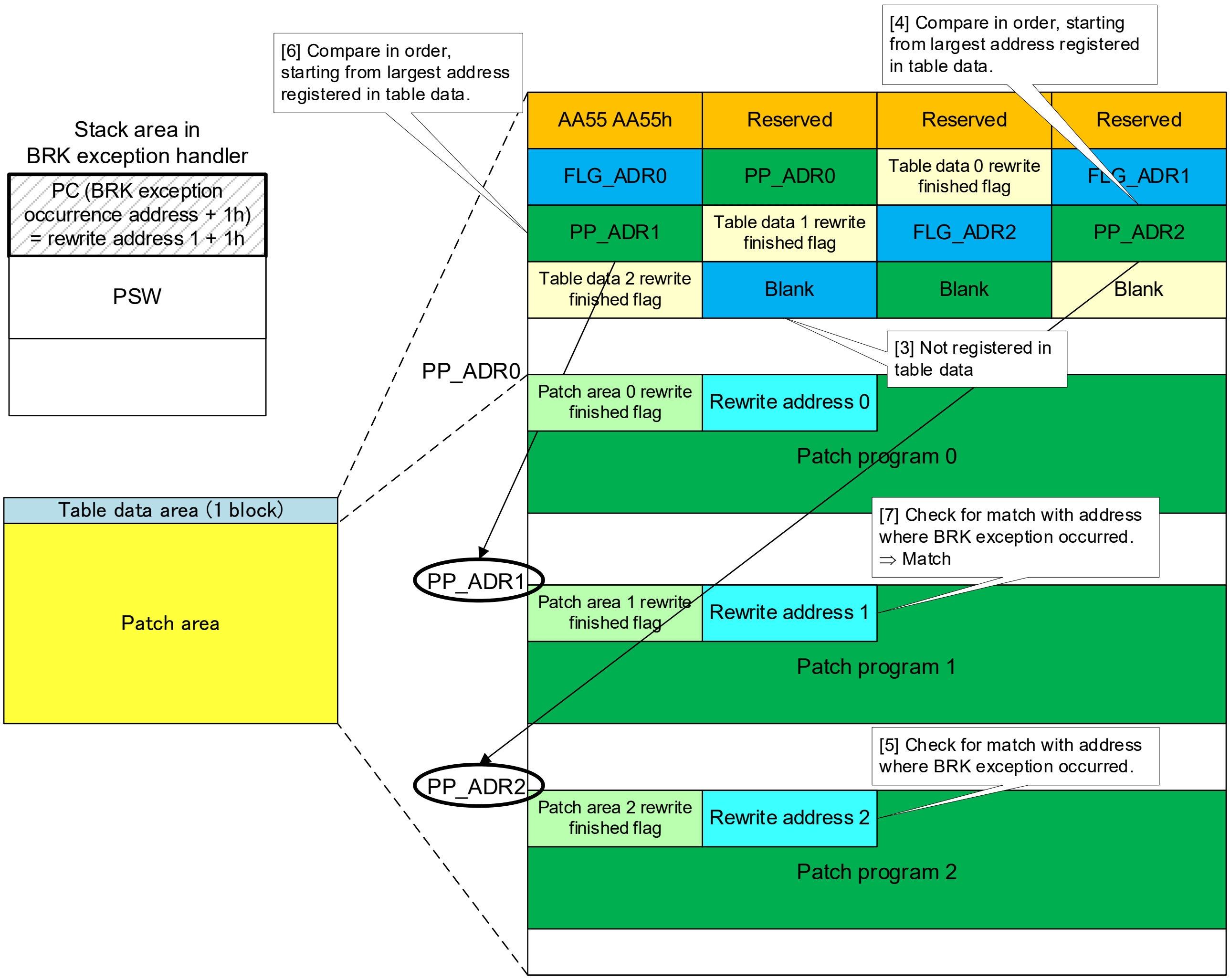


Note: Continues in Figure 4.10.

Figure 4.9 Operation when BRK Exception Occurs

4.1.8 Determination of Patch Processing to Be Run from Address where BRK Exception Occurred

The BRK exception handler compares, via the table data area, the address where the BRK exception occurred with the rewrite addresses in the patch area. It is assumed that addresses are registered in the table data in ascending order, and the comparison proceeds in order, starting from the largest address. Using this method ensures that the latest patch program will applied even if multiple patches have been applied to the same address. Figure 4.10 illustrates the operation whereby the patch processing to be executed is determined from the address at which the BRK exception occurred.



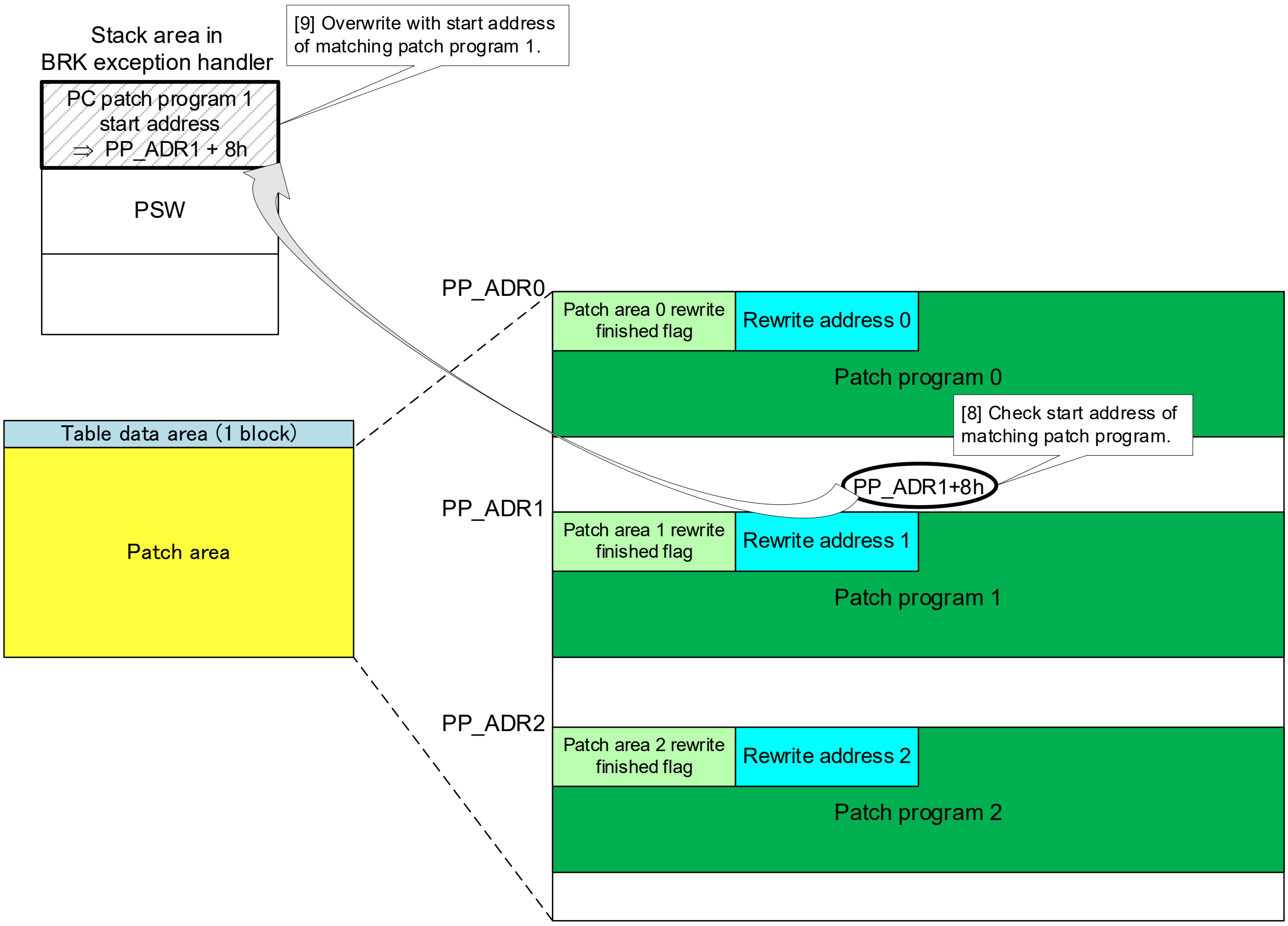
Note: Even of rewrite address 0 and rewrite address 1 are the same address, the above processing will not apply patch program 0 (the old patch).

Continues in Figure 4.11.

Figure 4.10 Determination of Patch Processing to Be Run from Address where BRK Exception Occurred

4.1.9 Return Setting from BRK Exception Handler

After the patch processing to be executed is determined, the start address of the patch program to be run is set in the program counter (PC) of the stack area in the BRK exception handler, causing execution to return to the patch program after the BRK exception handler. Figure 4.11 illustrates return setting from the BRK exception handler.



Note: Continues in Figure 4.12.

Figure 4.11 Return Setting from BRK Exception Handler

4.1.10 Patch Program Execution and Return to User Program

After the BRK exception handler finishes, execution returns to the patch program to be run, and the patch program is executed. After the patch program runs, execution returns to the user program by means of an instruction specified by the user beforehand. Figure 4.12 illustrates the return from the patch program to the user program.

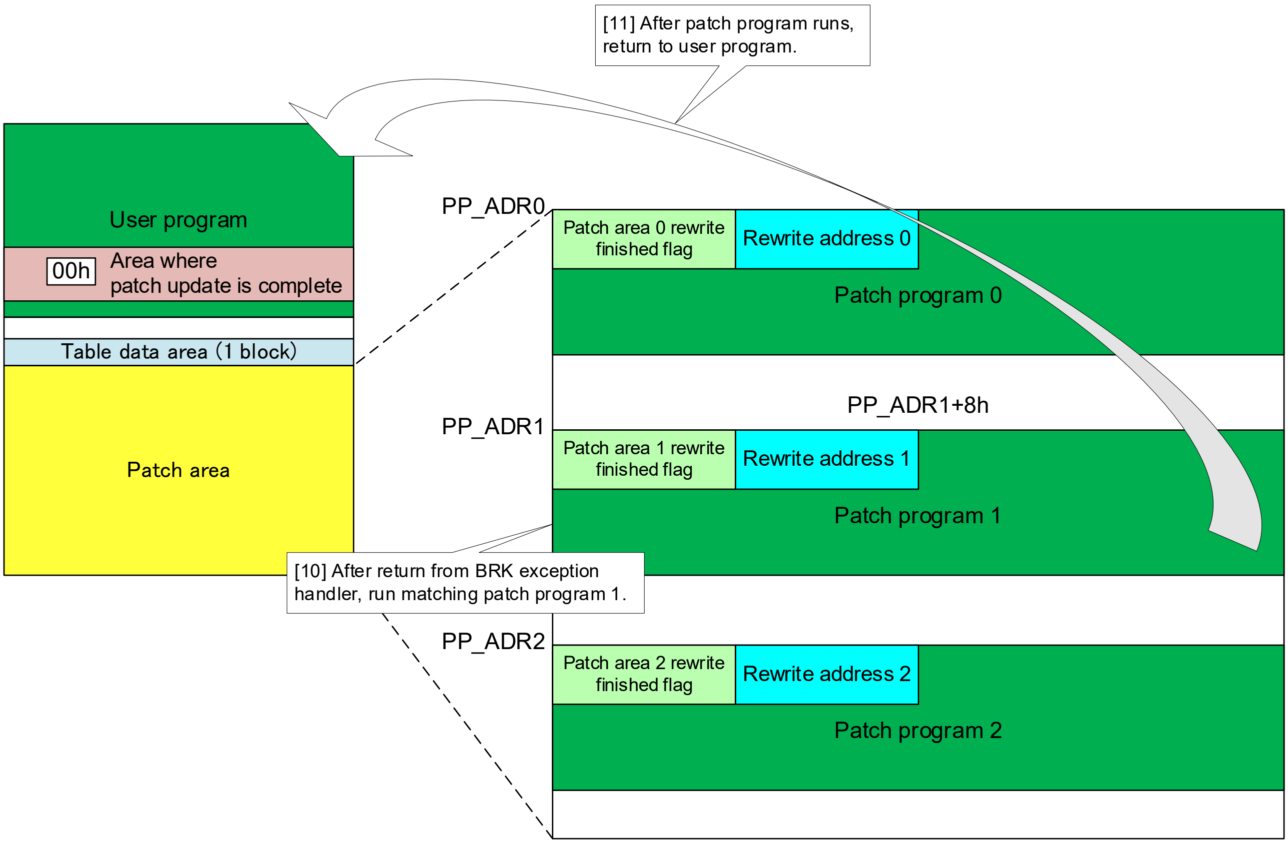


Figure 4.12 Patch Program Execution

4.2 Required Memory Sizes

Table 4.1 lists the required memory sizes.

Table 4.1 Required Memory Sizes

Memory Used	Size	Remarks
ROM	1,028 bytes	In r_rom_correct.c module
RAM	20 bytes	In r_rom_correct.c module
Patch work area	1,300 bytes	In r_rom_correct.c module Size depends on capacity of patch application area to be copied.
	2,531 bytes	Capacity used in r_flash_rx module

Note: The required memory sizes differ depending on the version of the C compiler and the compile options used. Refer to the applicable application notes for the sizes of r_bsp and r_flash_rx.

4.3 File and Folder Structure

Figure 4.13 shows the source file and folder structure of the sample code. Note that files generated automatically by the integrated development environment are omitted.

```
＋HardwareDebug                                              [Executable files, etc.]
＋src
    ＋－ smc_gen
    |      ＋－－ r_bsp                                       [Renesas Board Support Package]
    |      |        ＋－－ board                              BSP settings for each RSK
    |      |                ＋－－ rskrx113                    RX113 RSK
    |      |                ＋－－ user                        For user settings
    |      |        ＋－－ doc                                BSP application note
    |      |                ＋－－ en                          English version
    |      |                ＋－－ jp                          Japanese version
    |      |        ＋－－ mcu                                BSP information for each MCU
    |      |                ＋－－ all                         Common to all MCUs
    |      |                ＋－－ rx113                       For RX113
    |      |                        ＋－－ register_access     RX113 register access
    |      ＋－－ r_config                                    [API settings file]
    |      ＋－－ r_flash_rx                                  [Simple flash API]
    |               ＋－－ doc                                Simple flash API application note
    |               ＋－－ ref                                Flash API driver settings file
    |               ＋－－ src                                Flash API driver
    |                       ＋－－ flash_type_1                For flash type 1
    |                       ＋－－ flash_type_2                For flash type 2
    |                       ＋－－ flash_type_3                For flash type 3
    |                       ＋－－ targets                     ROM information for each MCU
    |                               ＋－－rx113                Flash definitions for RX113
    ＋－－－r_rom_correct                                      [ROM correction]
```

Figure 4.13 ROM Correction Folder Structure

The sample code uses the following packages:

- r_bsp (Renesas board support package)
- r_flash_rx (RX Family simple flash module)

4.3.1 src Folder

This folder contains a sample source file and header file used by the ROM correction program.

Table 4.2 Sample Files Used

File Name	Description	Notes
main.c	Source file of main routine	
main.h	Header file of main routine	

4.3.2 src\r_bsp Folder

This folder contains the source files and header files of the Renesas Board Support Package module. For details, refer to the RX Family Board Support Package Module application note.

4.3.3 src\r_config Folder

Table 4.3 lists the files in the folder containing the setting files for the target MCU.

Table 4.3 Header Files

File Name	Description	Notes
r_bsp_config.h	BSP settings header file	For RSK RX113
r_flash_rx_config.h	Flash write settings file	

4.3.4 src\r_flash_rx Folder

This folder contains the source files and header files of the flash FIT module. For details, refer to the Flash Module Firmware Integration Technology application note.

4.3.5 src\r_rom_correct Folder

This folder contains the source file and header file of the ROM correction program.

Table 4.4 ROM Correction

File Name	Description	Notes
r_rom_correct.c	ROM correction source file	
r_rom_correct.h	ROM correction header file	

4.4 Option-Setting Memory

Table 4.5 lists the option-setting memory settings used in the sample code. Modify the setting values as necessary to match your system.

Table 4.5 Option-Setting Memory Settings in Sample Code

Symbol	Address	Setting Value	Description
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	• IWDT stopped after a reset • Timeout duration: 2,048 cycles • IWDT clock division ratio: 1/128 • Window start position/end position: Not specified • Resets enabled • Count stop in sleep mode enabled
OFS1	FFFF FF88h to FFFF FF8Bh	FFFF FFFFh	• Voltage monitor reset disabled at startup • HOCO oscillation disabled after a reset
MDE	FFFF FF80h to FFFF FF83h	FFFF FFFFh	Little endian

4.5 Constants

Table 4.6 lists the constants used in the sample code.

Table 4.6 Constants Used in Sample Code

Constant Name	Setting Value	Description
APPLY_PATCH	AA55 AA55h	Data indicating patch present in patch present/absent determination
PATCH_TARGET_REWRITE	7061 6368h	Data indicating rewrite finished in patch application area rewrite finished flag
COPY_AREA_REWRITE	636F 7079h	Data indicating rewrite finished in copy area rewrite finished flag
LMT_WRITE_TIMES	4	Write count upper limit value of patch application area rewrite finished flag, copy area rewrite finished flag, and patch present/absent determination
REWRITE_FLG_AREA_SIZE	LMT_WRITE_TIMES * 4	Area size of patch application area rewrite finished flag, copy area rewrite finished flag, and patch present/absent determination
BRK_CODE	00h	Code indicating BRK instruction
FLASH_RETRY_TIMES	3	Retry count when flash-related error occurs*[1]
FLASH_BLOCK_TOP_MASK	FFFF FC00h	Mask for acquiring start address of flash block
TABLE_DATA_AREA_TOP_ADR	FFFF C000h	Start address of table data area
APPLY_PATCH_ADR	TABLE_DATA_AREA_TOP_ADR	Start address of patch present/absent determination
TABLE_DATA_TOP_ADR	TABLE_DATA_AREA_TOP_ADR + REWRITE_FLG_AREA_SIZE	Table data start address (excluding patch present/absent determination)
PATCH_AREA_TOP_ADR	TABLE_DATA_AREA_TOP_ADR + FLASH_CF_BLOCK_SIZE	Start address of patch area
COPY_AREA_TOP_ADR	FFFF F000h	Start address of copy area
TABLE_DATA_NUM_MAX	(COPY_AREA_TOP_ADR-TABLE_DATA_TOP_ADR)/(sizeof(table_data_t)	Maximum table data count

Note: 1. In the sample code, when a flash-related error occurs, an error is reported when the error continues up to the retry count specified by this setting.

4.6 Structure Listing

Figure 4.14 lists the structures used in the sample code.

```
typedef struct
{
        uint32_t flg_adr;             /* FLG_ADR */
        uint32_t pp_adr;              /* PP_ADR */
        unit32_t table_rewrite_flg;   /* Table data rewrite finished flag */
} table_data_t;

typedef struct
{
        uint32_t patch_rewrite_flg;   /* Patch area rewrite finished flag */
        uint32_t rewrite_adr;         /* Rewrite address */
        uint8_t * ppatch_prg;         /* Pointer to start address of patch program */
} patch_data_t;
```

Figure 4.14 Structures Used in Sample Code

4.7 Enumeration Listing

Figure 4.15 lists the enumerated types used in the sample code. Also included is flash_err_t, a structure for the RX Family simple flash module used by the sample code, so refer to it as well.

```
typedef enum
{
        ROM_CORRECT_SUCCESS = 0,
        ROM_CORRECT_ERR_BUSY,
        ROM_CORRECT_ERR_ACCESSW,
        ROM_CORRECT_ERR_FAILURE,
        ROM_CORRECT_ERR_CMD_LOCKED,
        ROM_CORRECT_ERR_LOCKBIT_SET,
        ROM_CORRECT_FREQUENCY,
        ROM_CORRECT_ALIGNED,
        ROM_CORRECT_BOUNDARY,
        ROM_CORRECT_OVERFLOW,
        ROM_CORRECT_ERR_BYTES,
        ROM_CORRECT_ERR_ADDRESS,
        ROM_CORRECT_ERR_BLOCKS,
        ROM_CORRECT_ERR_PARAM,
        ROM_CORRECT_ERR_NULL_PTR,
        ROM_CORRECT_TIMEOUT,
        ROM_CORRECT_ERR_TABLE,               /* Table data area error */
        ROM_CORRECT_ERR_PATCH,               /* Patch area error */
        ROM_CORRECT_ERR_COPY_AREA_FLG,       /* Copy area rewrite finished flag write error */
        ROM_CORRECT_ERR_PATCH_AREA_FLG,      /* Patch application area rewrite finished flag write error */
        ROM_CORRECT_NOT_APPLY                /* No valid data in patch present/absent determination */
} rom_correct_err_t;
```

Figure 4.15 Enumerated Types Used in Sample Code

4.8 Variables

Table 4.7 lists the variables used in the sample code.

Table 4.7 static Type Variables

Type	Variable Name	Description	Used by Function
static uint8_t	table_data_num	Table data registration count	• R_ROM_Correct • setting_patch

4.9 Functions

Table 4.8 lists the functions used in the sample code.

Table 4.8 Functions

Function Name	Description
R_ROM_Correct	ROM correction processing
R_ROM_MakePatch	Go to applicable patch program (BRK exception handler)
get_brk_address	Get BRK exception occurrence address
set_return_adr	Set return address to corresponding patch program
chk_apply_patch	Patch present/absent determination processing
setting_patch	Set patch to register
chk_patch	Check patch to register
chk_table_data	Check table data
chk_patch_area	Check patch area
chk_rewrite_patch_target_area	Check patch application area rewrite
rewrite_patch_target_area	Patch application area rewrite processing
chk_rewrite_copy_area	Check copy area rewrite
rewrite_copy_area	Copy area rewrite processing
rewrite_brk_code	Rewrite patch application area with BRK instruction
call_R_FLASH_Open	Flash FIT module initialization, including retry in case of error
call_R_FLASH_Erase	Erase flash, including retry in case of error
call_R_FLASH_BlankCheck	Flash blank check, including retry in case of error
call_R_FLASH_Write	Write to flash, including retry in case of error

4.10 Function Specifications

The following tables list the sample code function specifications.

R_ROM_Correct		
Outline	ROM correction function	
Header	r_rom_correct.h	
Declaration	rom_correct_err_t R_ROM_Correct (void)	
Description	ROM correction processing	
Arguments	None	
Return Value	ROM correction setting result	
	ROM_CORRECT_SUCCESS:	Success
	ROM_CORRECT_ERR_BUSY:	Software command running, or flash FIT module not initialized
	ROM_CORRECT_ERR_FAILURE:	Flash blank check, erase, or write failure
	ROM_CORRECT_ERR_BYTES:	Flash write or blank check size error
	ROM_CORRECT_ERR_ADDRESS:	Invalid address setting
	ROM_CORRECT_ERR_BLOCKS:	Invalid flash block number
	ROM_CORRECT_ERR_TABLE:	Table data area setting error
	ROM_CORRECT_ERR_PATCH:	Patch area setting error
	ROM_CORRECT_ERR_WR_COPY_FLAG:	Copy area rewrite finished flag write error
	ROM_CORRECT_ERR_WR_PATCH_FLAG:	Patch application area rewrite finished flag write error
	ROM_CORRECT_NOT_APPLY:	No valid data in patch present/absent determination
Remarks	Except for ROM_CORRECT_NOT_APPLY, the last registered table data setting result is sent as the return value. If setting result information is needed for each table data item, register each table data item and patch area individually.	

R_ROM_MakePatch	
Outline	Go to applicable patch program (BRK exception handler)
Header	r_rom_correction.h
Declaration	void R_ROM_MakePatch (void)
Description	Determines the applicable patch program from the address at which the BRK exception occurred and transitions to it.
Arguments	None
Return Value	None
Remarks	This function is a BRK exception handler.

get_brk_address	
Outline	Get BRK exception occurrence address
Header	r_rom_correction.h
Declaration	uint32_t get_brk_address (void)
Description	Gets the address at which the BRK exception occurred.
Arguments	None
Return Value	Address where BRK exception occurred + 1
Remarks	This function is declared in #pragma inline_asm. If the R_ROM_MakePatch function is altered to change the capacity of the stack where the data is saved, this function should be modified to match.

Set_return_adr	
Outline	Set return address to corresponding patch program
Header	r_rom_correction.h
Declaration	uint32_t set_return_adr (uint32_t return_adr)
Description	Sets the address to return to from the BRK exception handler.
Arguments	uint32_t return_adr: State address of applicable patch program
Return Value	None
Remarks	This function is declared in #pragma inline_asm. If the R_ROM_MakePatch function is altered to change the capacity of the stack where the data is saved, this function should be modified to match.

chk_apply_patch	
Outline	Patch present/absent determination processing
Header	r_rom_correction.h
Declaration	static rom_correct_err_t chk_apply_patch (void)
Description	Checks the patch present/absent determination.
Arguments	None
Return Value	Patch present/absent checking result ROM_CORRECT_SUCCESS: Patch present ROM_CORRECT_NOT_APPLY: No valid data in patch present/absent determination
Remarks	

setting_patch	
Outline	Set patch to register
Header	r_rom_correction.h
Declaration	static rom_correct_err_t setting_patch (void)
Description	Registers the patch set in the table data area and patch area, and stores the table data count.
Arguments	None
Return Value	Execution result ROM_CORRECT_SUCCESS: Success ROM_CORRECT_ERR_BUSY: Software command running, or flash FIT module not initialized ROM_CORRECT_ERR_FAILURE: Flash blank check, erase, or write failure ROM_CORRECT_ERR_BYTES: Flash write or blank check size error ROM_CORRECT_ERR_ADDRESS: Invalid address setting ROM_CORRECT_ERR_BLOCKS: Invalid flash block number ROM_CORRECT_ERR_TABLE: Table data area setting error ROM_CORRECT_ERR_PATCH: Patch area setting error ROM_CORRECT_ERR_WR_COPY_FLAG: Copy area rewrite finished flag write error ROM_CORRECT_ERR_WR_PATCH_FLAG: Patch application area rewrite finished flag write error
Remarks	

chk_patch	
Outline	Check patch to register
Header	r_rom_correction.h
Declaration	rom_correct_err_t chk_patch (const table_data_t table_data)
Description	Checks the patch set in the table data area and patch area.
Arguments	const table_data_t table_data: Target table data
Return Value	Execution result ROM_CORRECT_SUCCESS: Success ROM_CORRECT_ERR_BUSY: Software command running, or flash FIT module not initialized ROM_CORRECT_ERR_FAILURE: Flash blank check, erase, or write failure ROM_CORRECT_ERR_BYTES: Flash write or blank check size error ROM_CORRECT_ERR_ADDRESS: Invalid address setting ROM_CORRECT_ERR_BLOCKS: Invalid flash block number ROM_CORRECT_ERR_TABLE: Table data area setting error ROM_CORRECT_ERR_PATCH: Patch area setting error ROM_CORRECT_ERR_WR_COPY_FLAG: Copy area rewrite finished flag write error ROM_CORRECT_ERR_WR_PATCH_FLAG: Patch application area rewrite finished flag write error
Remarks	

chk_table_data	
Outline	Check table data
Header	r_rom_correction.h
Declaration	rom_correct_err_t chk_table_data (const table_data_t table_data)
Description	Checks whether the target table data is set correctly.
Arguments	const table_data_t table_data: Target table data
Return Value	Target table data checking result ROM_CORRECT_SUCCESS: Target table data correct ROM_CORRECT_ERR_TABLE: Target table data not correct
Remarks	

chk_patch_area	
Outline	Check patch area
Header	r_rom_correction.h
Declaration	rom_correct_err_t chk_patch_area (const uint32_t pp_adr)
Description	Checks whether the target patch area is set correctly.
Arguments	const uint32_t pp_adr: PP_ADR of target table data
Return Value	Target patch area checking result ROM_CORRECT_SUCCESS: Target patch area correct ROM_CORRECT_ERR_PATCH: Target patch area not correct
Remarks	

chk_rewrite_patch_target_area	
Outline	Check patch application area rewrite
Header	r_rom_correction.h
Declaration	rom_correct_err_t chk_rewrite_patch_target_area (const table_data_t table_data)
Description	Checks rewriting of the patch application area.
Arguments	const table_data_t table_data: Target table data
Return Value	Execution result ROM_CORRECT_SUCCESS: Success ROM_CORRECT_ERR_BUSY: Software command running, or flash FIT module not initialized ROM_CORRECT_ERR_FAILURE: Flash blank check, erase, or write failure ROM_CORRECT_ERR_BYTES: Flash write or blank check size error ROM_CORRECT_ERR_ADDRESS: Invalid address setting ROM_CORRECT_ERR_BLOCKS: Invalid flash block number ROM_CORRECT_ERR_WR_COPY_FLAG: Copy area rewrite finished flag write error ROM_CORRECT_ERR_WR_PATCH_FLAG: Patch application area rewrite finished flag write error
Remarks	

rewrite_patch_target_area		
Outline	Patch application area rewrite processing	
Header	r_rom_correction.h	
Declaration	rom_correct_err_t rewrite_patch_target_area (const table_data_t_t table_data)	
Description	Rewrites the patch application area.	
Arguments	const table_data_t table_data: Target table data	
Return Value	Execution result	
	ROM_CORRECT_SUCCESS:	Success
	ROM_CORRECT_ERR_BUSY:	Software command running, or flash FIT module not initialized
	ROM_CORRECT_ERR_FAILURE:	Flash blank check, erase, or write failure
	ROM_CORRECT_ERR_BYTES:	Flash write or blank check size error
	ROM_CORRECT_ERR_ADDRESS:	Invalid address setting
	ROM_CORRECT_ERR_BLOCKS:	Invalid flash block number
	ROM_CORRECT_ERR_WR_COPY_FLAG:	Copy area rewrite finished flag write error
	ROM_CORRECT_ERR_WR_PATCH_FLAG:	Patch application area rewrite finished flag write error
Remarks		

chk_rewrite_copy_area		
Outline	Check copy area rewrite	
Header	r_rom_correction.h	
Declaration	rom_correct_err_t chk_rewrite_copy_area (const table_data_t table_data)	
Description	Checks rewriting of the copy area.	
Arguments	const table_data_t table_data: Target table data	
Return Value	Execution result	
	ROM_CORRECT_SUCCESS:	Success
	ROM_CORRECT_ERR_BUSY:	Software command running, or flash FIT module not initialized
	ROM_CORRECT_ERR_FAILURE:	Flash blank check, erase, or write failure
	ROM_CORRECT_ERR_BYTES:	Flash write or blank check size error
	ROM_CORRECT_ERR_ADDRESS:	Invalid address setting
	ROM_CORRECT_ERR_BLOCKS:	Invalid flash block number
	ROM_CORRECT_ERR_WR_COPY_FLAG:	Copy area rewrite finished flag write error
Remarks		

rewrite_copy_area		
Outline	Copy area rewrite processing	
Header	r_rom_correction.h	
Declaration	static flash_err_t rewrite_copy_area (const uint32_t pp_adr)	
Description	Rewrites the copy area with data from the patch application area. The data is saved to the copy area before rewriting with the BRK instruction in case a momentary voltage drop or the like while writing to the patch application area causes the write to fail.	
Arguments	const uint32_t pp_adr: PP_ADR of target table data	
Return Value	Execution result	
	FLASH_SUCCESS:	Success
	FLASH_ERR_BUSY:	Software command running, or flash FIT module not initialized
	FLASH_ERR_FAILURE:	Flash erase or write failure
	FLASH_ERR_BYTES:	Flash write size error
	FLASH_ERR_ADDRESS:	Invalid address setting
	FLASH_ERR_BLOCKS:	Invalid flash block number
Remarks		

rewrite_brk_code		
Outline	Rewrite patch application area with BRK instruction	
Header	r_rom_correction.h	
Declaration	static flash_err_t rewrite_brk_code (const uint32_t pp_adr)	
Description	Rewrites the rewrite address in the patch application area with the BRK instruction. The data is saved to the copy area before rewriting with the BRK instruction in case a momentary voltage drop or the like while writing to the patch application area causes the write to fail.	
Arguments	const uint32_t pp_adr: PP_ADR of target table data	
Return Value	FLASH_SUCCESS:	Success
	FLASH_ERR_BUSY:	Software command running, or flash FIT module not initialized
	FLASH_ERR_FAILURE:	Flash erase or write failure
	FLASH_ERR_BYTES:	Flash write size error
	FLASH_ERR_ADDRESS:	Invalid address setting
	FLASH_ERR_BLOCKS:	Invalid flash block number
Remarks		

call_R_FLASH_Open		
Outline	Flash FIT module initialization, including retry in case of error	
Header	r_rom_correction.h	
Declaration	static flash_err_t call_R_FLASH_Open (void)	
Description	Initializes the flash FIT module. Includes retry in case of error.	
Arguments	None	
Return Value	FLASH_SUCCESS:	Success
	FLASH_ERR_BUSY:	Software command running, or flash FIT module not initialized
Remarks		

call_R_FLASH_Erase		
Outline	Erase flash, including retry in case of error	
Header	r_rom_correction.h	
Declaration	static flash_err_t call_R_FLASH_Erase (uint32_t block_start_address, uint32_t num_blocks)	
Description	Erased the flash memory. (Includes retry in case of error.)	
Arguments	uint32_t block_start_address:	Start address of erase target block
	uint32_t num_blocks:	Number of target blocks to be erased
Return Value	FLASH_SUCCESS:	Success
	FLASH_ERR_BUSY:	Software command running, or flash FIT module not initialized
	FLASH_ERR_FAILURE:	Flash erase failure
	FLASH_ERR_ADDRESS:	Invalid address setting
	FLASH_ERR_BLOCKS:	Invalid flash block number
Remarks		

call_R_FLASH_BlankCheck		
Outline	Flash blank check, including retry in case of error	
Header	r_rom_correction.h	
Declaration	static flash_err_t call_R_FLASH_BlankCheck (uint32_t address, uint32_t num_bytes, flash_res_t *result)	
Description	Performs a blank check on the flash memory. (Includes retry in case of error.)	
Arguments	uint32_t address:	Blank check start address
	uint32_t num_bytes:	Blank check byte count
	flash_res_t *result:	Pointer to blank check result
Return Value	FLASH_SUCCESS:	Success
	FLASH_ERR_BUSY:	Software command running, or flash FIT module not initialized
	FLASH_ERR_FAILURE:	Blank check of flash memory failure
	FLASH_ERR_BYTES:	Flash memory blank check size error
	FLASH_ERR_ADDRESS:	Invalid address setting
Remarks		

call_R_FLASH_Write		
Outline	Write to flash, including retry in case of error	
Header	r_rom_correction.h	
Declaration	static flash_err_t call_R_FLASH_Write (uint32_t src_address, uint32_t dest_address, uint32_t num_bytes)	
Description	Writes to the flash memory. (Includes retry in case of error.)	
Arguments	uint32_t src_address:	Start address where write data is stored
	uint32_t dest_address:	Start address of write destination
	uint32_t num_bytes:	Write byte count
Return Value	FLASH_SUCCESS:	Success
	FLASH_ERR_BUSY:	Software command running, or flash FIT module not initialized
	FLASH_ERR_FAILURE:	Write to flash memory failure
	FLASH_ERR_BYTES:	Flash memory write size error
	FLASH_ERR_ADDRESS:	Invalid address setting
Remarks		

5. Precautions

5.1 Precautions When Using This Application Note

- The user should write data to the table data area and patch area beforehand using self-rewrite in P/E mode, or the like. Note that when using a serial programmer it is not possible to use a boot program to write the data.
- When writing data to the table data area and patch area, do not write FFh to the reserved areas and empty areas.
- The user's R_ROM_Correct function sends the last setting result registered in the table data as its return value. If setting result information is needed for each table data item, register each table data item and patch area individually.

5.2 Table Data Area and Patch Area Write Procedure Examples

Examples of the procedures for writing to the table data area and patch area implemented by the user are described below. Figure 5.1 shows a table data area write procedure example. Figure 5.2 shows a write procedure example where the write failed due to a momentary voltage drop or the like. Note that the user should make sure to run a blank check before writing data.

1. Only when applying a patch for the first time, write AA55 AA55h to the patch present/absent determination in the table data area. It is not necessary to write AA55 AA55h to the patch present/absent determination when applying a patch the second or subsequent times.

2. Write data to the table data area and to the patch area, in that order.
   - 2-1. After writing to the table data area, write the table data rewrite finished flag (inverted value of FLG_ADR).
   - 2-2. After writing to the patch area, write the patch area rewrite finished flag (inverted value of rewrite address).
   - 2-3. Repeat steps 2-1 and 2-2 to write additional patch data. If the write fails due to a momentary voltage drop or the like, retry the write in the next empty area. Note that the table data consists of 12-byte sets comprising FLG_ADR, PP_ADR, and the table data rewrite finished flag. For FLG_ADR(m), add 0Ch to the FLG_ADR(m − 1) write address.

Note: Since PP_ADR changes when a write to the patch area fails, you will need to redo the procedure from step 2-1. Also, do not perform an erase if a write fails; write the data to the next area.

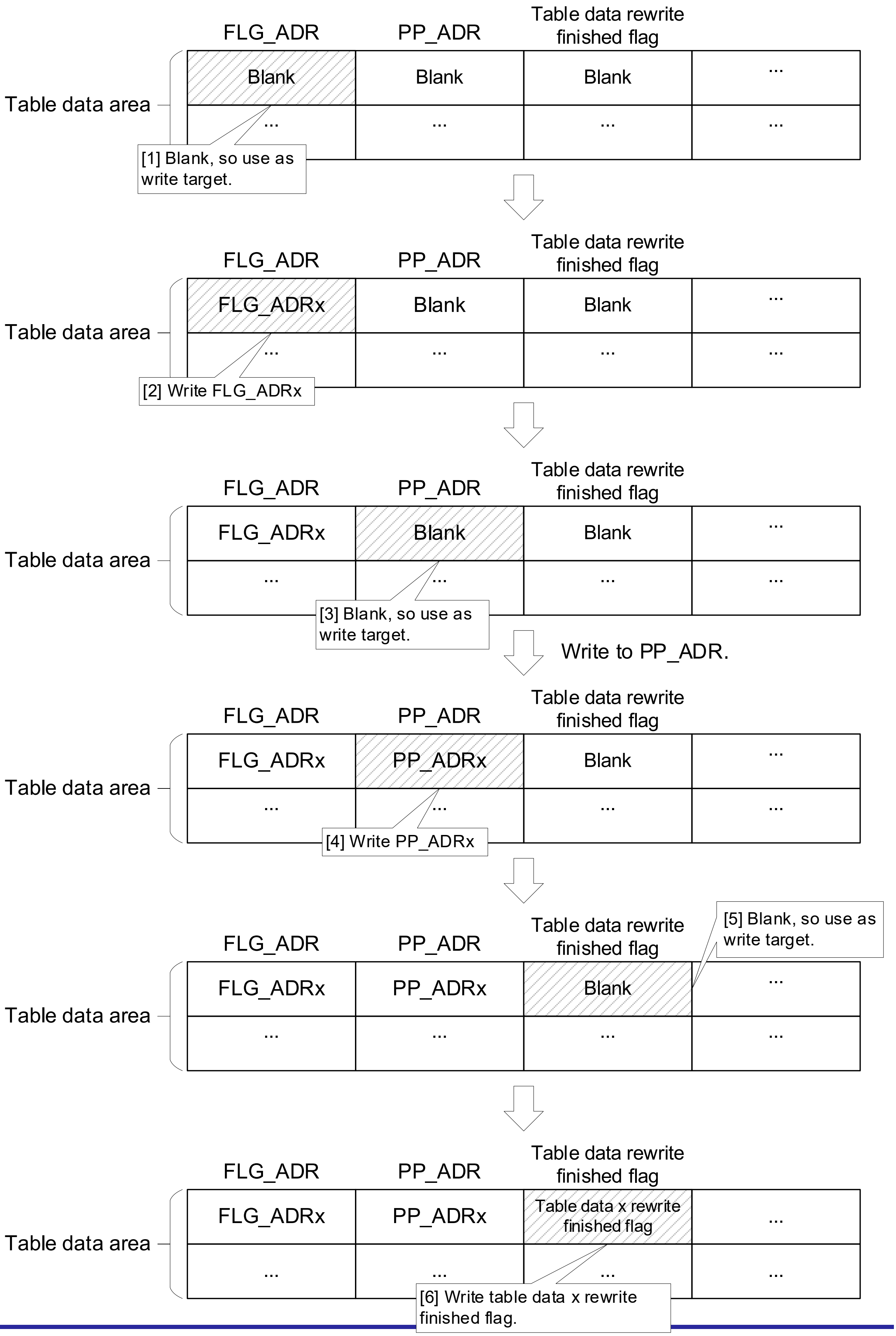

FLG_ADR
PP_ADR
Table data rewrite finished flag
Table data area
Blank
Blank
Blank
...
[1] Blank, so use as write target.
FLG_ADRx
[2] Write FLG_ADRx
[3] Blank, so use as write target.
Write to PP_ADR.
PP_ADRx
[4] Write PP_ADRx
[5] Blank, so use as write target.
Table data x rewrite finished flag
[6] Write table data x rewrite finished flag.

Figure 5.1 Table Data Area Write Procedure Example

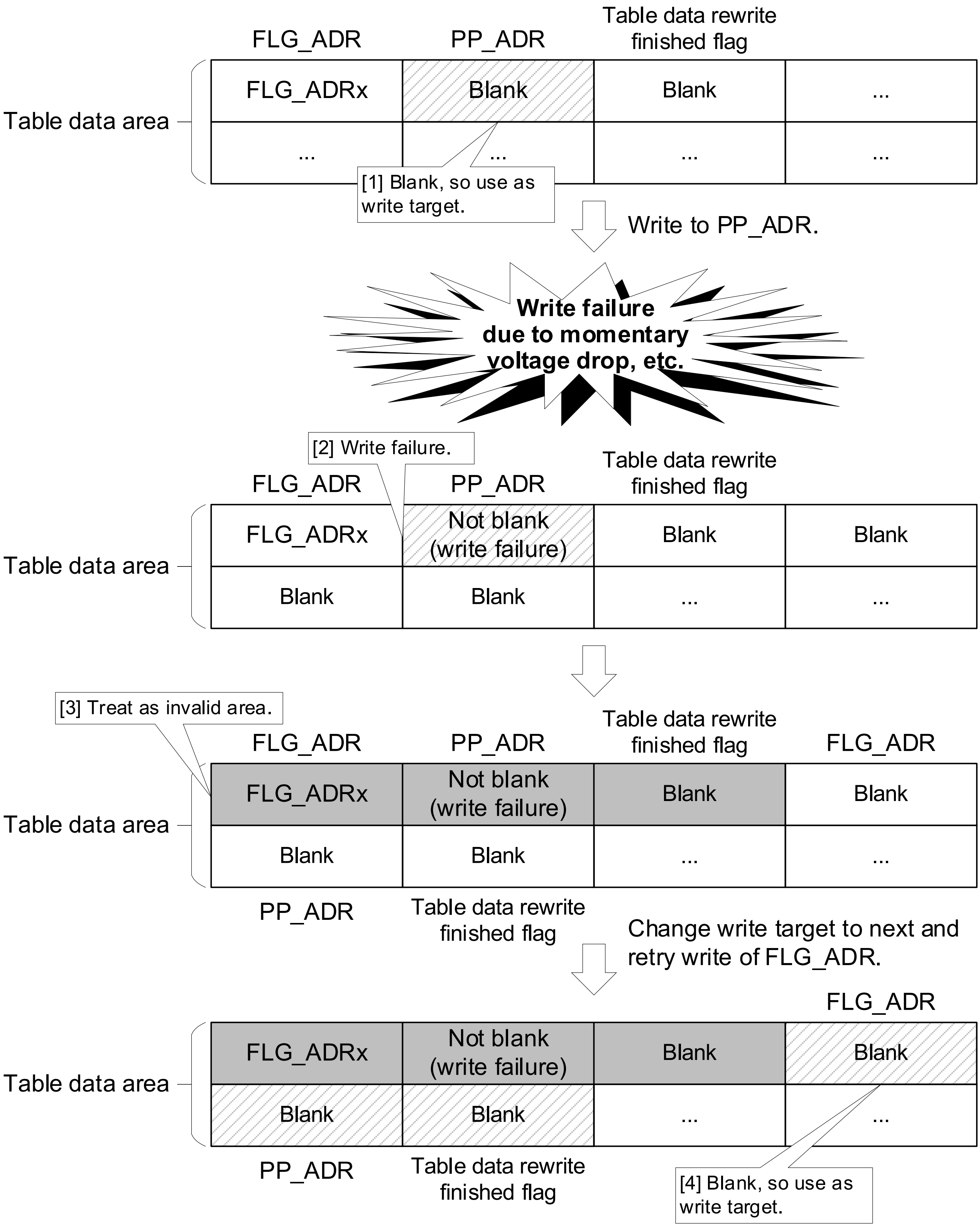
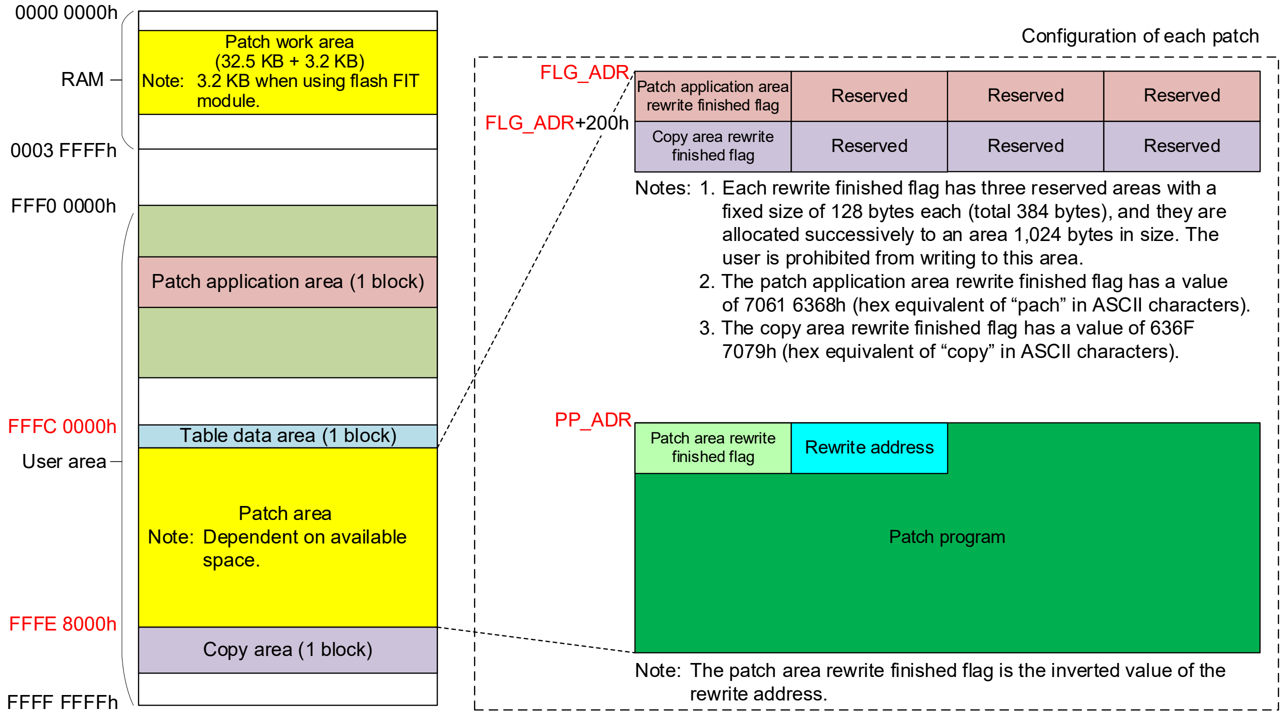


Figure 5.2 Table Data Area Write Procedure Example where Write Failed Due to Momentary Voltage Drop, Etc.

5.3 Adapting Specifications to Other Products

When adapting the source code accompanying this application note to other products, it may be necessary to increase the size of the user stack in some cases. Figure 5.3 and Figure 5.4 show examples of using a 32 KB patch application area on the RX65N.

Also, when using the flash FIT module, change the setting of FLASH_CFG_CODE_FLASH_ENABLE to 1, and refer to 2.15, Programming Code Flash from RAM, in RX Family Flash Module Using Firmware Integration Technology (R01AN2184) when adding sections.



Addresses in red may be changed. Note that FLG_ADR and PP_ADR are addresses inside the patch area.

Figure 5.3 Conceptualization of Patch Area when Using 32 KB Patch Application Area on RX65N

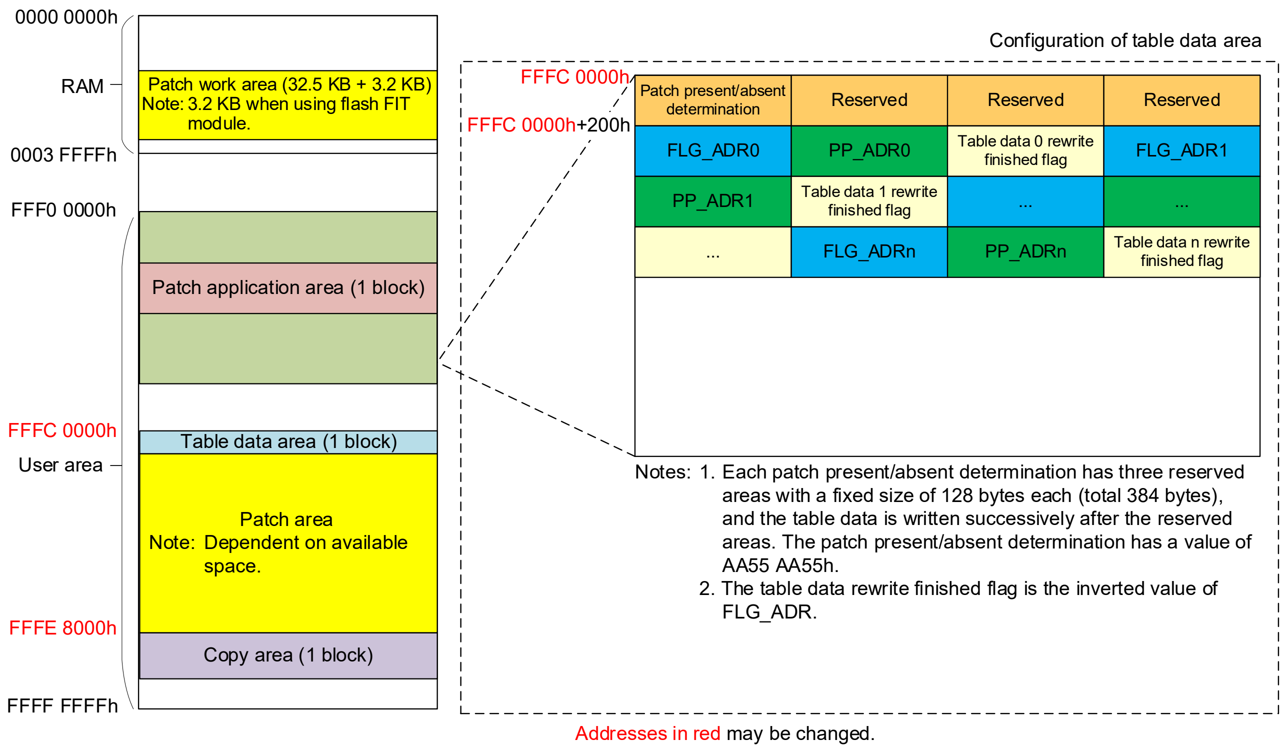


Figure 5.4 Conceptualization of Patch Area when Using 32 KB Table Data Area on RX65N

6. Creating Data for Table Data Area and Patch Area

The method of creating data for the table data area and patch area set by the user is described below, using the patch area as an example.

6.1 Patch Area Data Creation Example

Figure 6.1 shows an example of settings for patch area 0.

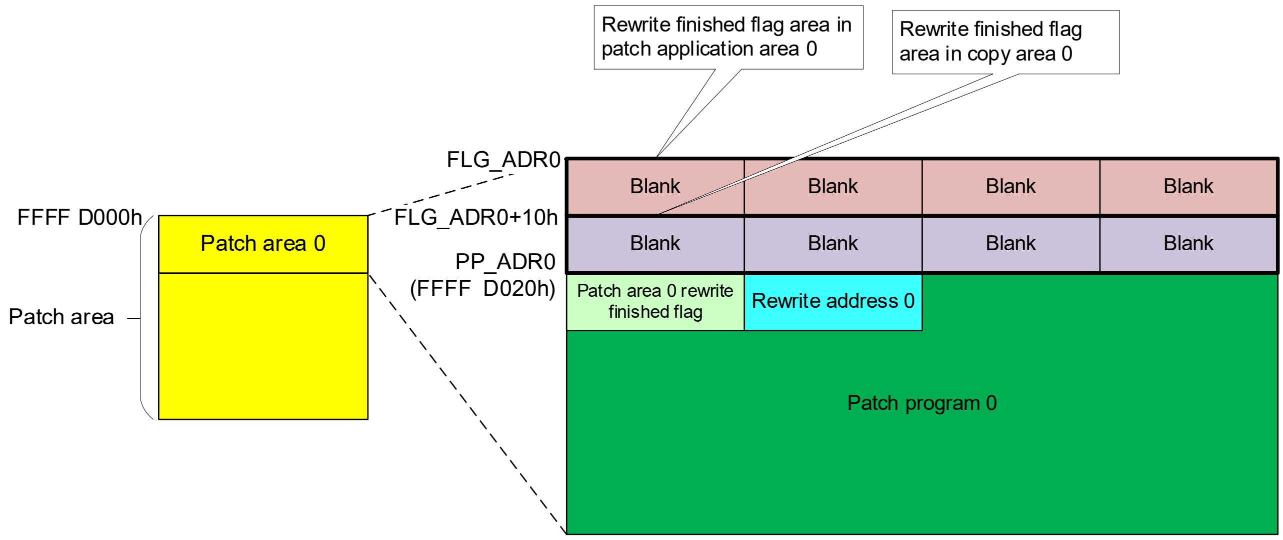


Figure 6.1 Example Patch Area Settings

The patch area PP_ADR0 is set using #pragma section and, after specifying the patch area rewrite finished flag and rewrite address with const declarations, the patch program code follows. For information on the write procedure, refer to 5.2, Table Data Area and Patch Area Write Procedure Examples.

```
#pragma section PP_ADR0

/* Patch area rewrite finished flag */
const uint32_t g_rewrite_flg0  = XXXXXXXX;
/* Rewrite address */
const uint32_t g_rewrite_adr0 = YYYYYYYY;

void patch_prg0( void )
{
        Applicable patch program processing;
        .
        .
        .
        Processing for jump to specified user program;
}

#pragma section             /* End of section */
```

Figure 6.2 Patch Area Code Example

In the section above the address is set in e² studio. In the menu bar, click **Project** → **C/C++ Project Settings**.

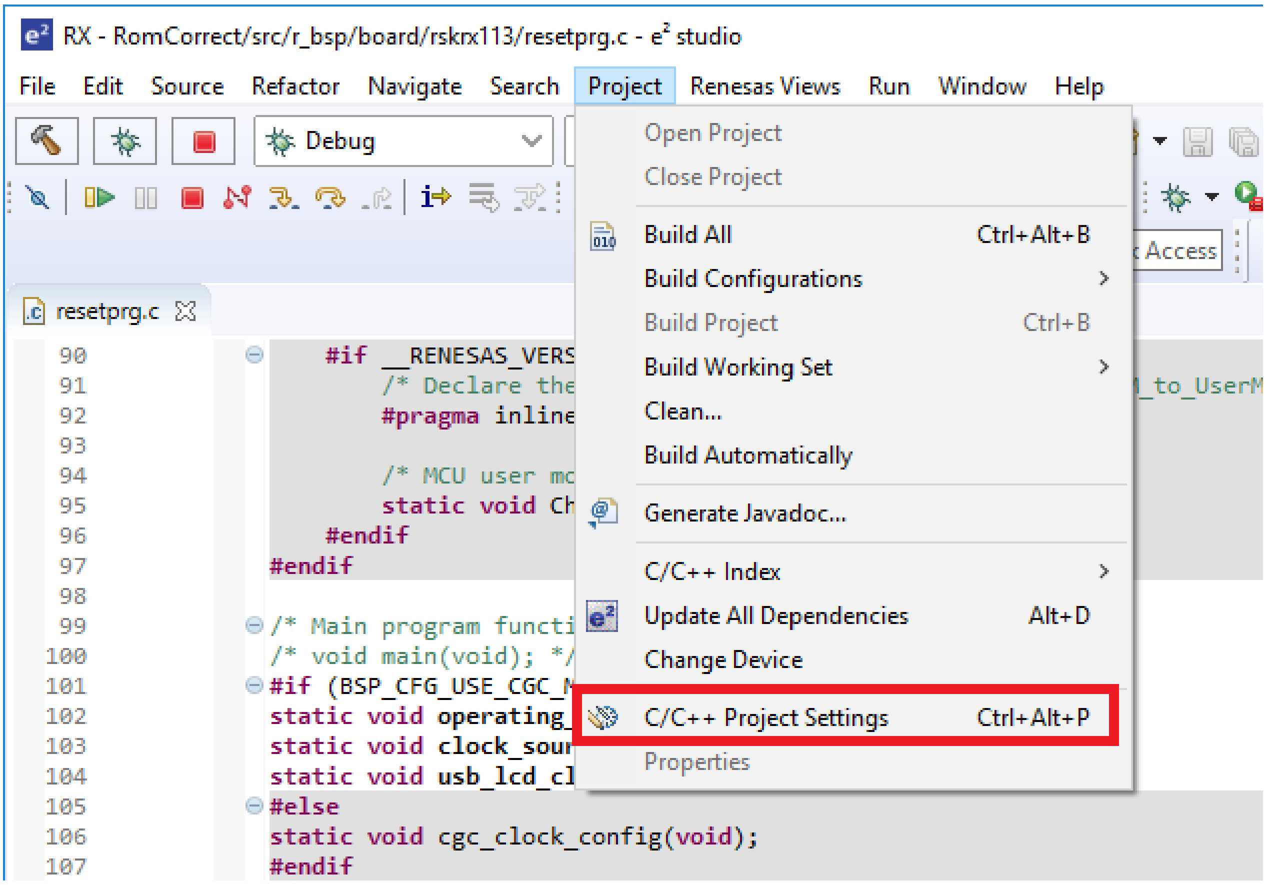


Figure 6.3 Example Section Settings (1/2)

The Properties for RomCorrect window appears, as shown in Figure 6.4. In **C/C++ Build** → **Settings** → **Linker** → **Section Viewer**, add sections **CPP_ADR0** and **PPP_ADR0**, set the corresponding address, and click the **OK** button.

When you build this project after this, an executable file will be generated with the section data allocated to the specified addresses.

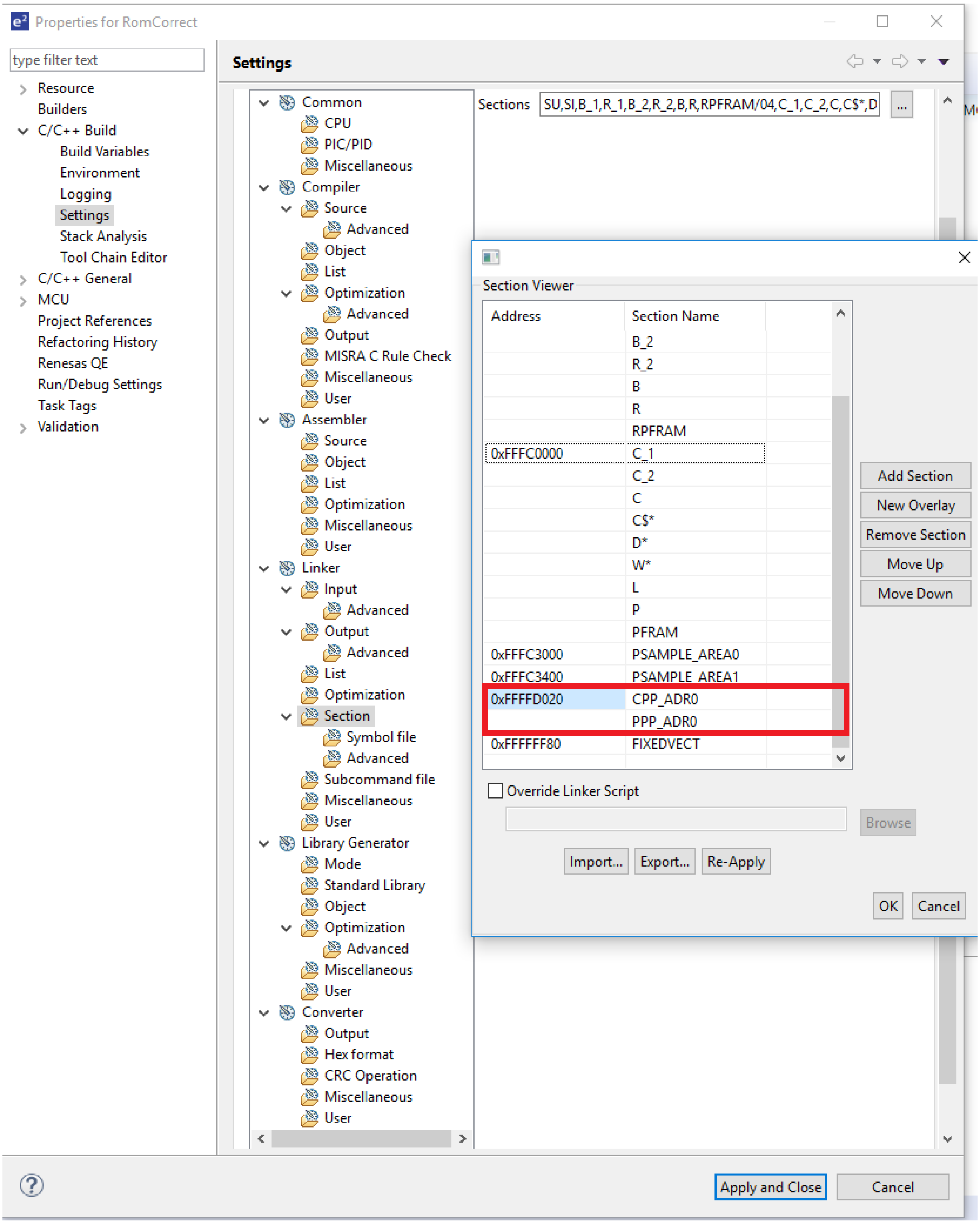


Figure 6.4 Example Section Settings (2/2)

6.2 Example of Procedure for Exporting Data from Patch Area

The procedure for exporting data from a specified memory area is described below.

Connect e[2] studio to the user system, download the program, and then in the menu bar click **Window** → **Show View** → **Memory** to display the **Memory** window (see Figure 6.5).

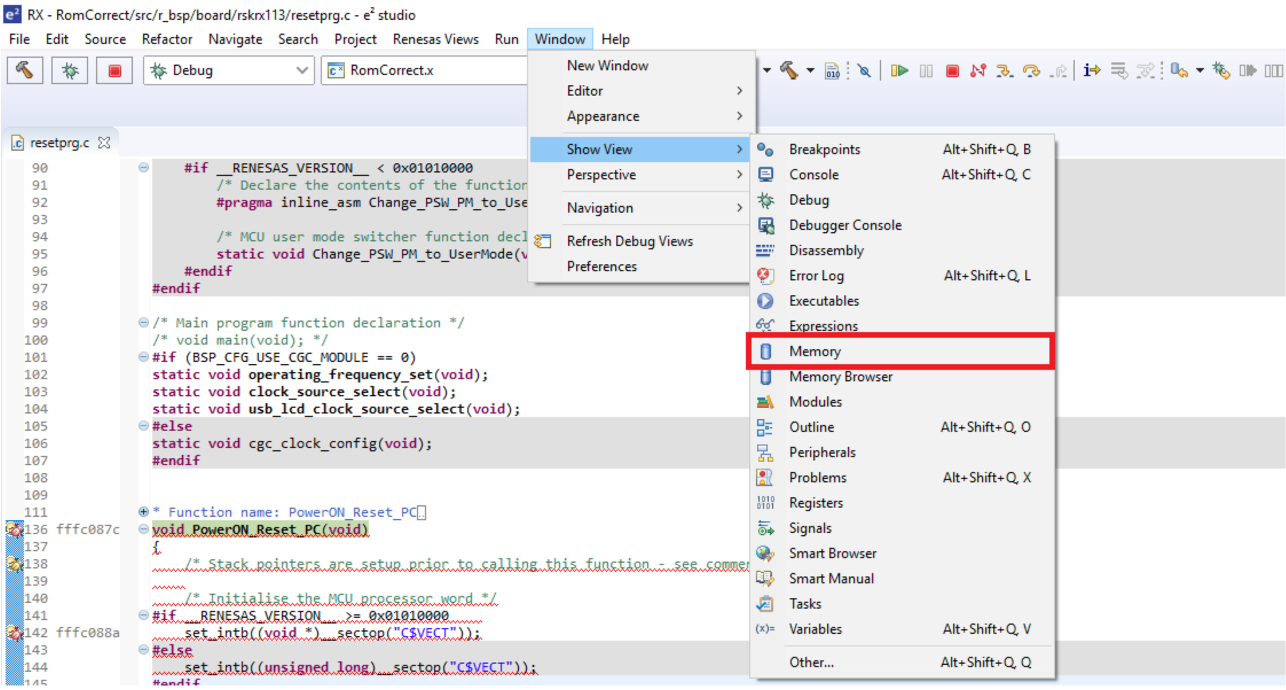


Figure 6.5 Displaying Memory Window

The **Memory** window appears, as shown in Figure 6.6. In the **Memory** window, click the **Add Memory Monitor** button.

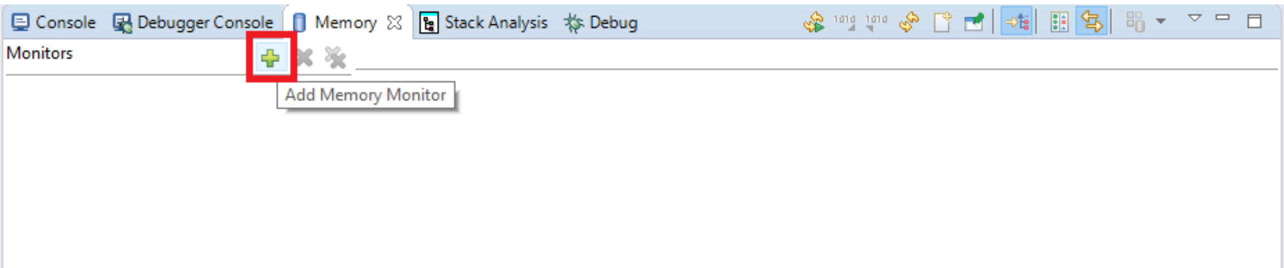


Figure 6.6 Memory Window

The **Monitor Memory** window appears, as shown in Figure 6.7. Enter the address of the memory area you wish to view, then click the **OK** button.

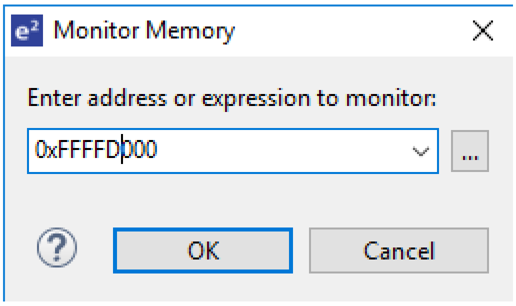


Figure 6.7 Monitor Memory Window

The memory area at the specified address is displayed as shown in Figure 6.8.

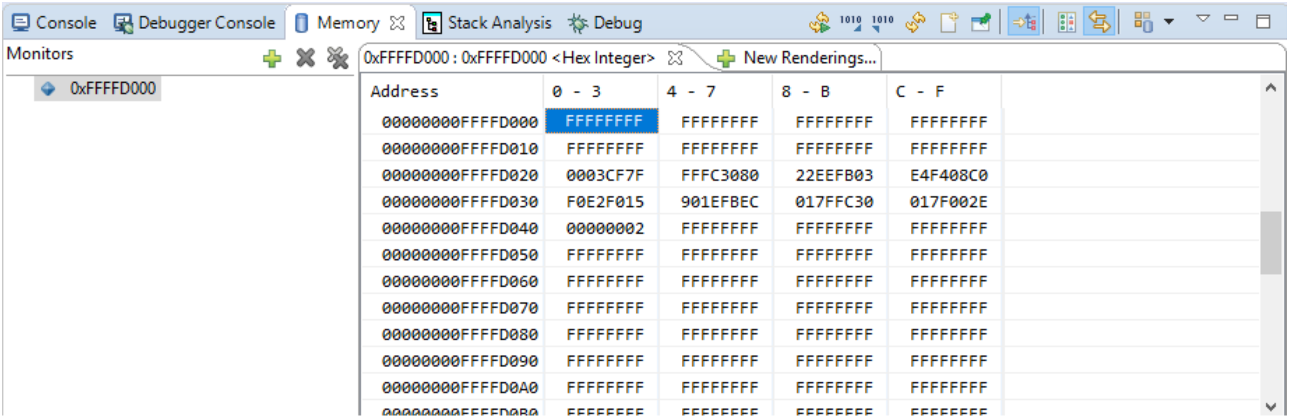


Figure 6.8 Memory Area Display

The method of exporting data from the specified memory area is as follows. Click the **Export** button in the **Memory** window (see Figure 6.9).

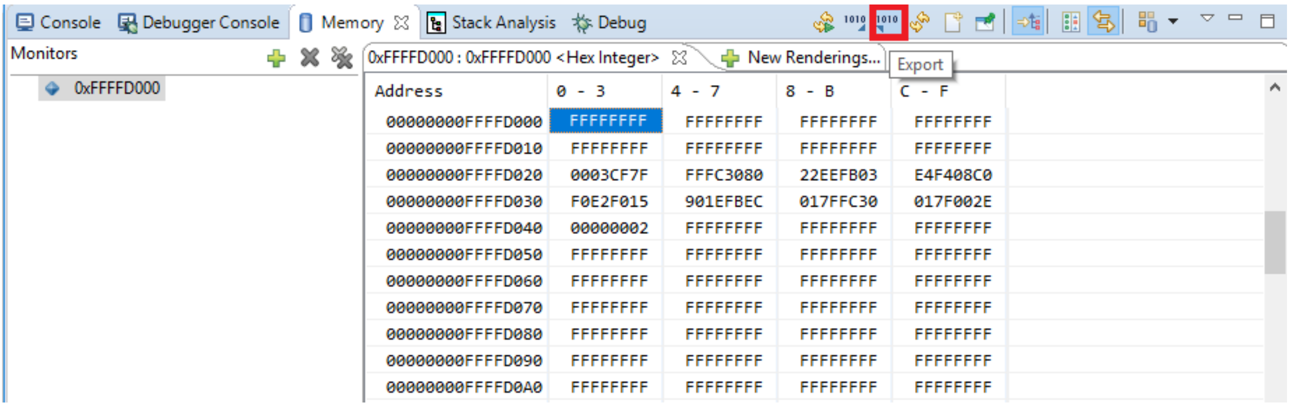


Figure 6.9 Exporting Data from a Memory Area

The **Export Memory** window appears, as shown in Figure 6.10. For **Format:** select the file format in which to save the data. The memory area to be exported is **Length:** (bytes), beginning at **Start address:** and ending immediately before **End address:**. For **File name:** specify the name of the file to be saved, then click the **OK** button.

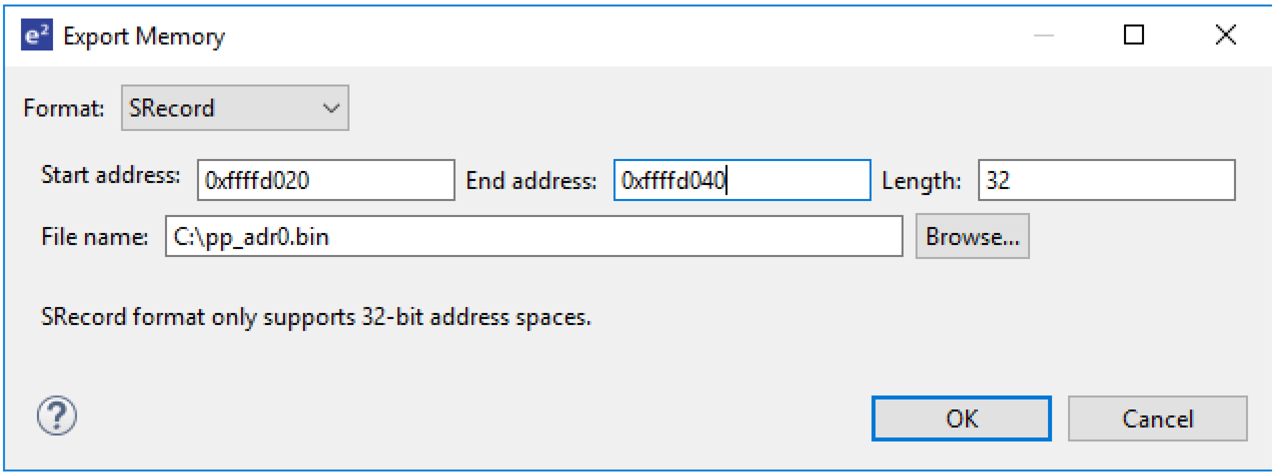


Figure 6.10 Export Memory Window

7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

8. Reference Documents

User's Manual: Hardware

RX113 Group User's Manual: Hardware (R01UH0448)
(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.)

User's Manual: Development Tools

RX Family CC-RX Compiler User's Manual (R20UT3248)
(The latest version can be downloaded from the Renesas Electronics website.)

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar. 10, 2020	—	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance 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 the 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.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit: www.renesas.com/contact/.

© 2020 Renesas Electronics Corporation. All rights reserved.