RL78/G23

Self-programming using boot swap with I2C communication

Introduction

This application note describes the overview of self-programming using I2C communication.

It uses the Flash Self Programming Library (Renesas Flash Driver RL78 Type01) to rewrite the flash memory and perform boot swap.

Target Device

RL78/G23

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Reference

Documents related to this application note are listed below, refer to the following documents as well.

- RL78 Family Renesas Flash Driver RL78 Type01 User's Manual (R20UT4830)
- RL78 Family Renesas Flash Driver RL78 Type01 SC version (Code Flash) (R20AN0653)
- RL78 Family Renesas Flash Driver RL78 Type01 SC version (Data Flash) (R20AN0654)
- RL78 Family Renesas Flash Driver RL78 Type 01 SC version (Extra Area) (R20AN0655)
- RL78 Family Renesas Flash Driver RL78 Type 01 SC version (Common) (R20AN0656)
- RL78/G23-128p Fast Prototyping Board User's Manual (R20UT4870)

Contents

1. Overview

This application note describes a sample code to rewrite the flash memory of RL78/G23 with I2C communication and perform boot swap by self-programming.

1.1 Configuration

Two RL78/G23 board (RL78/G23-128p Fast Prototyping Board) are used, each assigned as a host MCU and a target MCU.

The PC is connected to the host MCU with a USB-UART conversion cable, and the host MCU is connected to the target MCU with I2C.

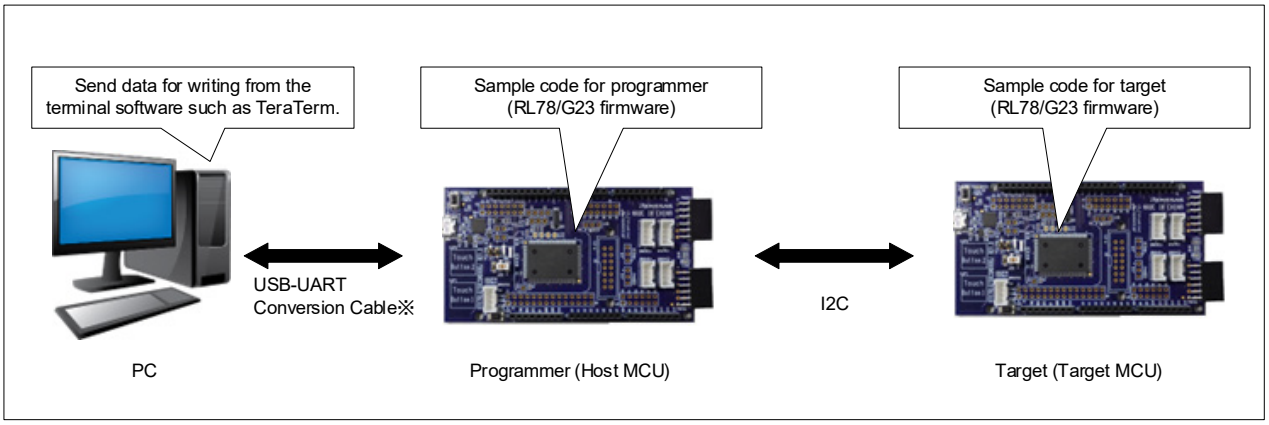
- Host MCU (Programmer)
  Data for writing the target MCU (Motorola S-format) sent by the terminal software from PC is received by UART and the data is sent to the target MCU by I2C.

  It also sends the rewrite result to PC in UART.
- Target MCU (Target)
  Data for writing is received from host PC by I2C and the data is used to rewrite the flash memory by self-programming.

  The system supports rewriting the code flash memory other than boot cluster 0 and the data flash memory. If the boot cluster 1 is rewritten, boot swap will be performed.

Sample codes are provided for both the host MCU and the target MCU.

Figure 1-1 System Configuration



Note. The USB connector of RL78/G23-128p Fast Prototyping Board includes the host MCU is used as RL78 COM port debug tool. In this sample code, it is connected to the PC using a USB-UART conversion cable.

1.2 Project Configuration

In this application note, the sample codes are provided for the programmer and the target.

The sample code for target consists of two projects: a boot program and a user program.

The boot program is a program that rewrites the flash memory by self-programming and is allocated to boot cluster 0 (0x00000 - 0x03FFF).

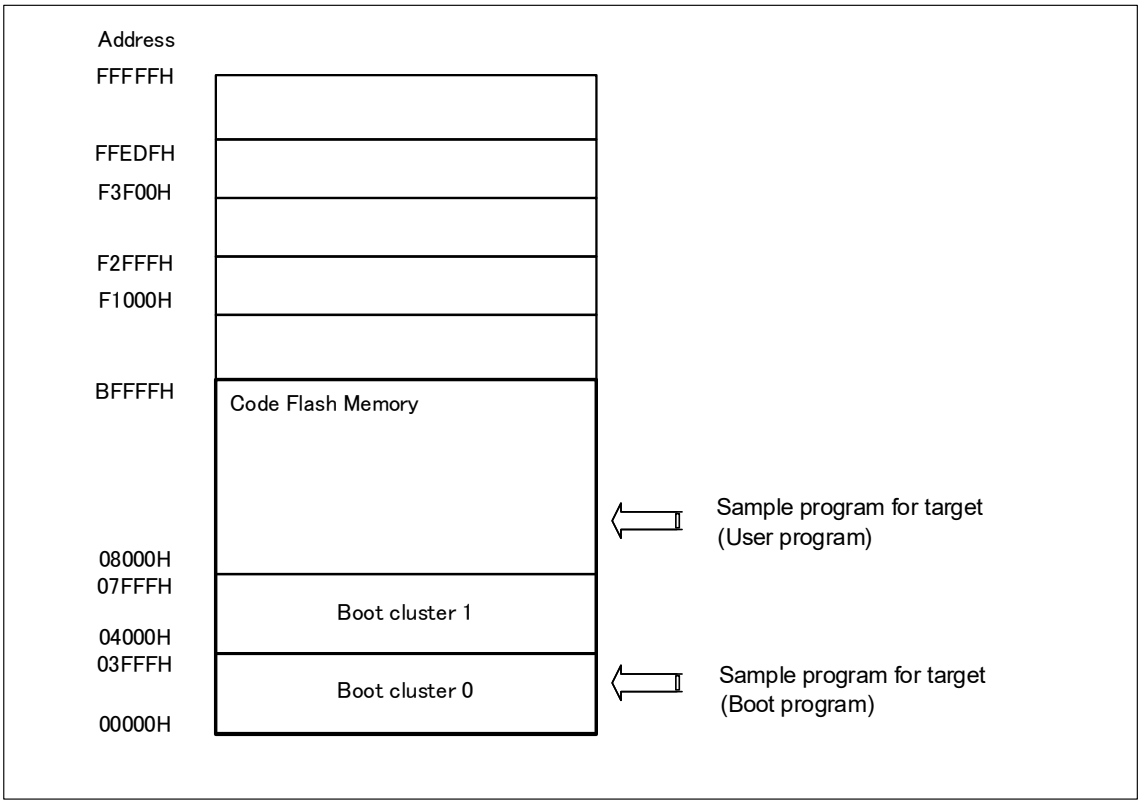
The user program is a program that implements user process and is allocated starting from address 0x08000.

Table 1-1 shows the project configuration.

Table 1-1 Project Configuration

Folder name	Description
rl78g23_UART_To_I2C	Sample program for programmer
rl78g23_RFD_with_I2C	Sample program for target (Boot program)
rl78g23_FlashWriter_UserProgramSample	Sample program for target (User program)

Figure 1-2 Program allocation (Target)



2. Development Environments

The operation of the sample program provided with this application note has been tested under the following conditions.

Table 2-1 Operation Confirmation Condition

Development tools		Descriptions
MCU (Common to programmer and target)		Part No.: R7F100GSN2DFB (Internal memory: Code Flash 768KB, RAM 48KB, Data Flash 8KB)
Evaluation board (Common to programmer and target)		RL78/G23-128p Fast Prototyping Board Part No.: RTK7RLG230CSN000BJ Note: Set VDD to 1.8 V or higher because this sample program runs in HS mode (high-speed on-chip oscillator frequency: 32 MHz).
Debug tool		RL78 COM port debug tool of RL78/G23-128p Fast Prototyping Board is required to debug the sample program. When using E2 or E2 Lite, please refer to the RL78/G23-128p Fast Prototyping Board User's Manual and set jumpers, etc.
CS+	Integrated development environment	Renesas Electronics Corp. CS+ for CC V8.14.00
	C compiler	Renesas Electronics Corp. CC-RL V1.15.01
e2studio	Integrated development environment	Renesas Electronics Corp. e^{2}studio 2025-07 (25.07.0)
	C compiler	Renesas Electronics Corp. CC-RL V1.15.01
IAR	Integrated development environment	IAR Systems Corp. IAR Embedded Workbench for Renesas RL78 V5.20
	C compiler	IAR Systems Corp. IAR C/C++ Compiler for Renesas RL78 V 5.20.1
Self-programming library		Renesas Flash Driver RL78 Type01

2.1 Renesas Flash Driver RL78 Type01

Renesas Flash Driver RL78 Type 01 (hereafter called RFD RL78 Type 01) is software for reprogramming the flash memory in the RL78/G2x. For details, refer to Renesas Flash Driver RL78 Type01 Use's manual (R20UT4830). Renesas Flash Driver RL78 Type01 (RFD) can be downloaded from the following URL.

https://www.renesas.com/ja/software-tool/code-flash-libraries-flash-self-programming-libraries

https://www.renesas.com/ja/software-tool/data-flash-libraries

3. External Specification

3.1 Host Communication Specifications

This section describes the specifications for communication between the host PC and the programmer (RL78/G23-128p Fast Prototyping Board).

Connect P02/TXD1 of the programmer (RL78/G23-128p Fast Prototyping Board) to P03/RXD2 and GND to the host PC by using USB-UART conversion cable.

This sample program works based on the following settings for communication between the host PC and the programmer (RL78/G23-128p Fast Prototyping Board).

Table 3-1 Host Communication Settings

Item	Setting
Data length [bit]	8
Data transfer direction	LSB first
Parity bit	No parity
Communication speed [bps]	115,200
Stop bit [bit]	1
Flow control	Software (Xon/Xoff)

3.2 Sample Program Execution Procedure

3.2.1 Operation Environment Setup

The following steps describe how to set up the operation environment.

① Connect PC to the programmer and the target, referring to “4.2 How to Connect”.

② Build the sample programs in “1.2 Project Configuration” and use Renesas Flash Programmer to write the firmware to the hosted MCU and destination MCU.

3.2.2 Sample Program Execution and Flash Memory Rewriting

The following steps describe how to rewrite the flash memory of the target MCU(RL78/G23).

① Start the terminal software from PC and configure the communication settings according to “3.1 Host Communication Specifications”.

② Turn on the programmer and target power (VDD) while holding down the user switch (SW) on the target (RL78/G23-128p Fast Prototyping Board). By starting the target while holding down SW, the mode is changed to the rewriting mode, and the process on the boot program side is enabled.

If SW is not pressed, the user program is executed. For more details on the rewriting mode, please refer to “6.1 Mode Selection”.

③ After the target MCU starts, start (reset) the host MCU.

④ If the connection between the programmer and the target is successful,” Send an S-Record file:” is displayed on the terminal software.
If it fails,” Target Not Found.” is displayed in the terminal software.

⑤ Use the terminal software to transmit data (in Motorola S format) for writing user or boot programs. For more details about the file to be used, please refer to “6.5.1 Creating Program Files for Target”.

⑥ If the writing is successful, "Target Processes Ended." is displayed in the terminal software.

For other message specifications, please refer to “3.4 Message Specifications”.

3.3 LED Display Specifications

Table 3-2 and Table 3-3 show the relationship between the programmer and target operating status and LED display.

Table 3-2 LED Display of Programmer

Operating status	LED1	LED2
In operation	Lighting-on	Lighting-on
Abnormal end	Lighting-off	Lighting-off
Normal end	Lighting-off	Lighting-on

Table 3-3 LED Display of Target

Operating status	LED1	LED2
In operation (Boot program)	Lighting-on	Lighting-on
In operation (User program)	Blinking	Lighting-off
Abnormal end	Lighting-off	Lighting-off
Normal end	Lighting-off	Lighting-on

3.4 Message Specifications

The programmer sends the message to the PC.

Table 3-4 shows the descriptions of messages.

Table 3-4 Descriptions of Message

Message	Description
Target Processes Ended.	Write success Message when writing is successful.
S Record Error.	Invalid Motorola S-format data It occurs when the Motorola S format to be sent is invalid. This error also occurs when the data record in Motorola S format is not in ascending address order.
I2C Error.	Programmer error It occurs when the programmer encounters an I²C communication error.
Target Not Found.	Target communication error It occurs when the host MCU was unable to verify connectivity with the target MCU.
Target Occurred an Error.	Target write error It occurs when there is an error in the target writing process.

3.5 Flowchart of Programmer

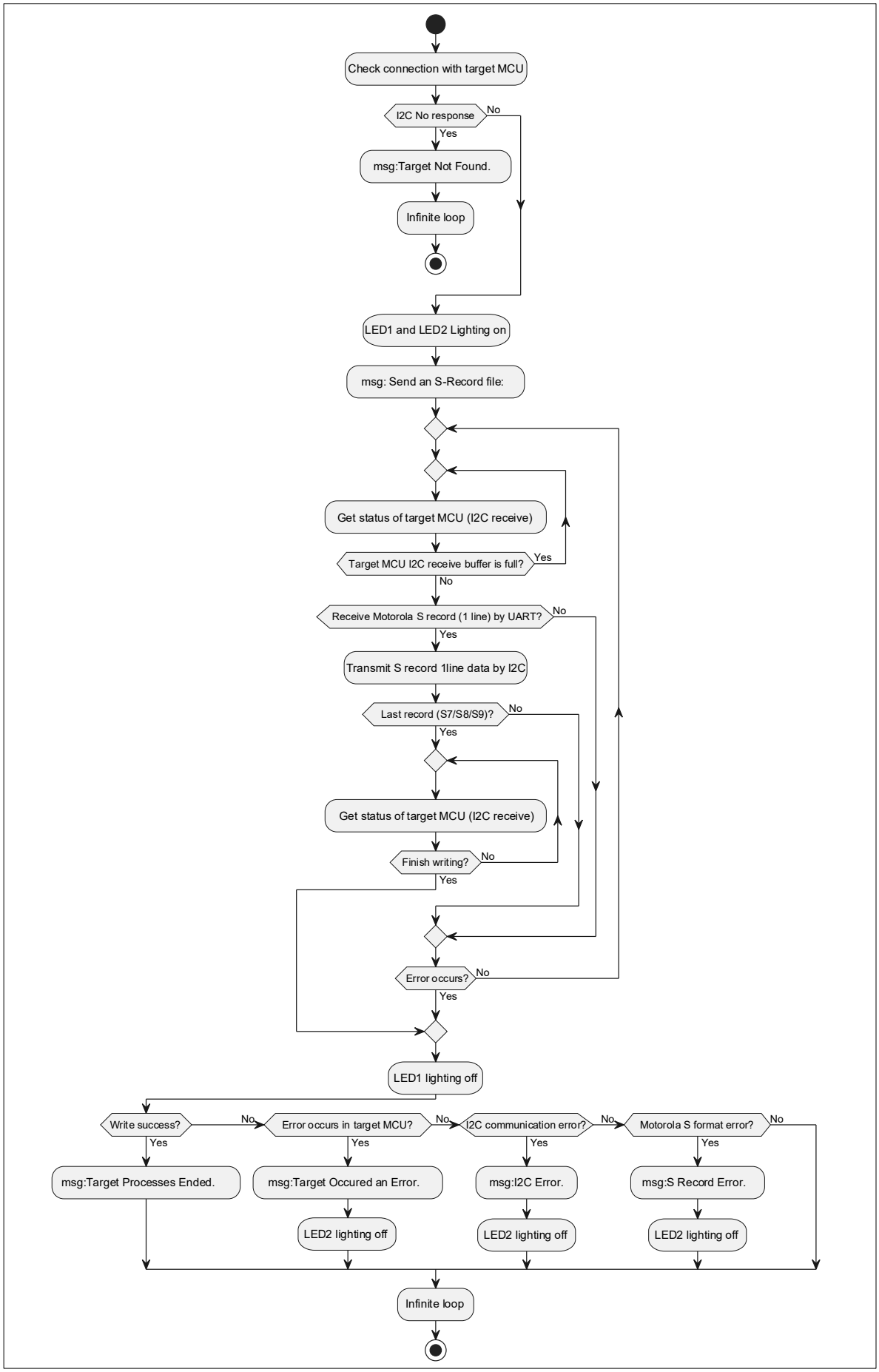
3.5.1 Main Process of Programmer

Figure 3-1 shows the main processing operation of the programmer.

Motorola S-format file is received by UART from the PC and sends the S-record data by I2C to the target line by line. The status of the target is acquired by I2C communication and processed while synchronized with the target.

Although not described in the flowchart, communication with PC is performed by software flow control (Xon/Xoff) for UART communication, and transmission from PC is stopped when the receive buffer of the programmer becomes full. When the receive buffers become free, UART communication resumes.

Figure 3-1 Main Process of Programmer



3.6 Flowchart of Target

3.6.1 Main Process of Target

Figure 3-2 shows the main processing operation of the target (boot program).

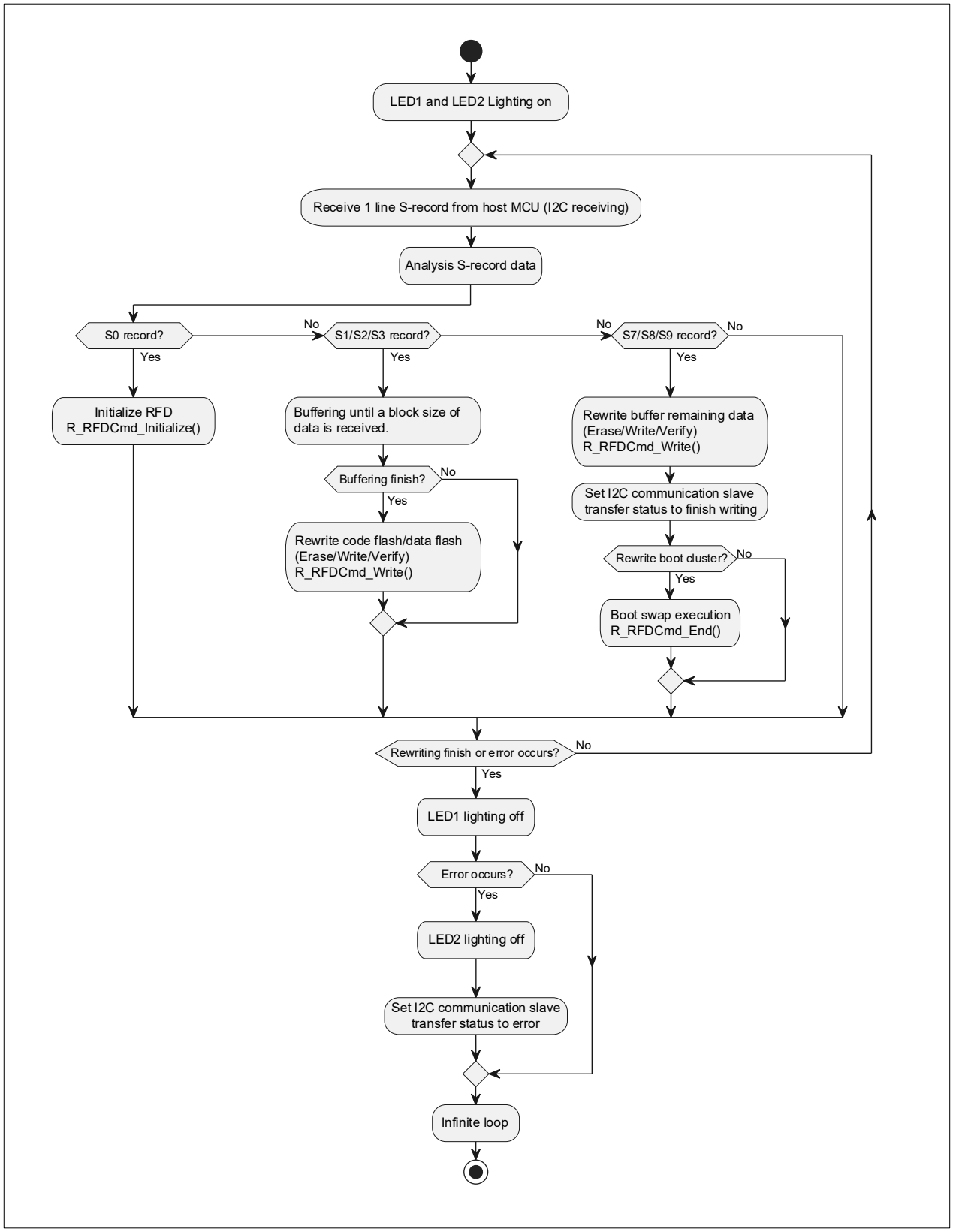
S-record data is received by I2C from the programmer and initialization, rewriting, and boot swapping (when boot cluster 1 is rewritten) are executed according to the record type.

The write target areas of the S-record file are code flash and data flash except boot cluster 1(0x04000 - 0x07FFF).

The address range of the S-record file to be written to Boot Cluster 1 should be from 0x00000 to 0x03FFF.(Set the option bytes to 0x000C0 to 0x000C3 and the on-chip debug security IDs to 0x000C4 to 0x000CD) The boot program writes to Boot Cluster 1 by adding an offset of 0x04000 to the address.

When boot cluster 1 is rewritten, boot cluster 1 and boot cluster 0 are swapped because boot swap is executed last.

Figure 3-2 Main Process of Target



4. Hardware Descriptions

4.1 Example of Hardware Configuration

Figure 4-1 and Figure 4-2 show an example of the hardware configuration of the programmer and target used in the application note.

Figure 4-1 Hardware Configuration (Programmer)

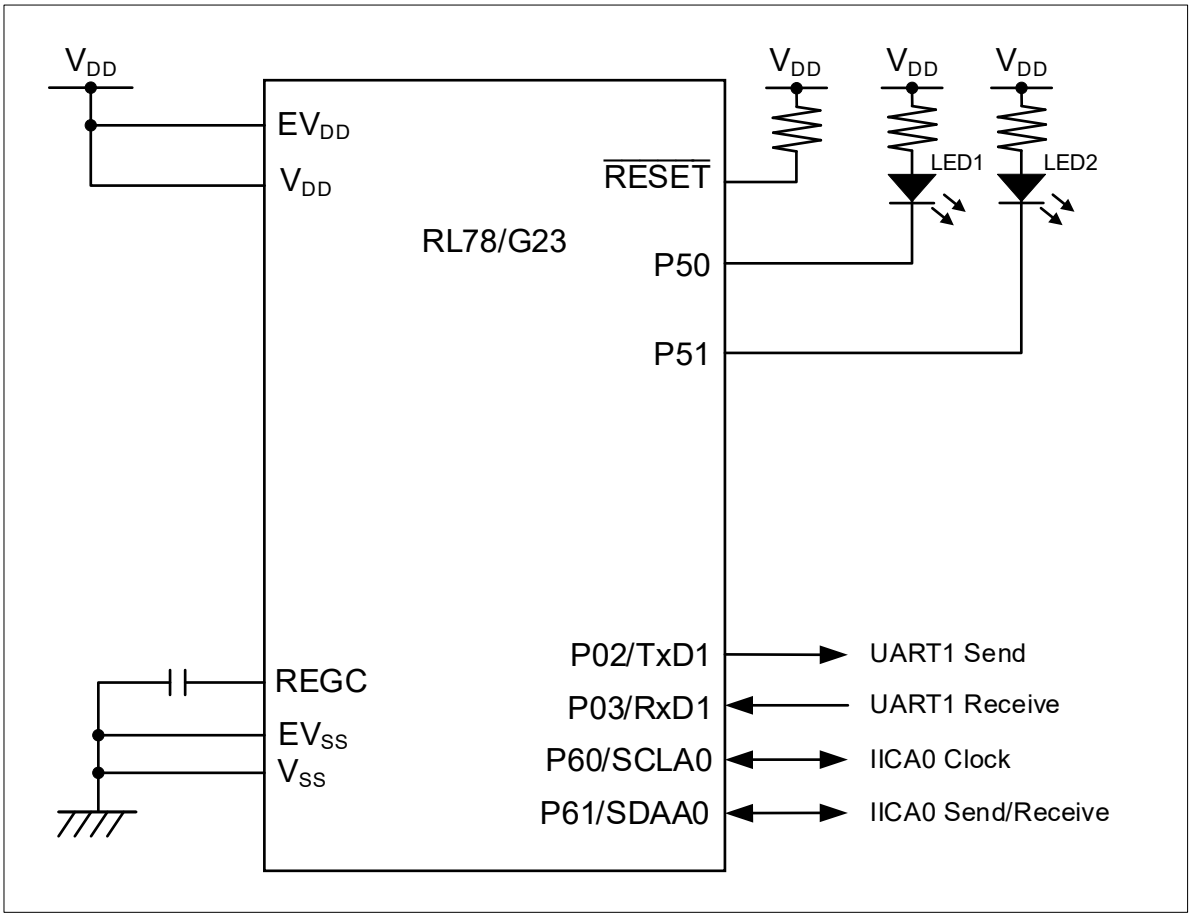
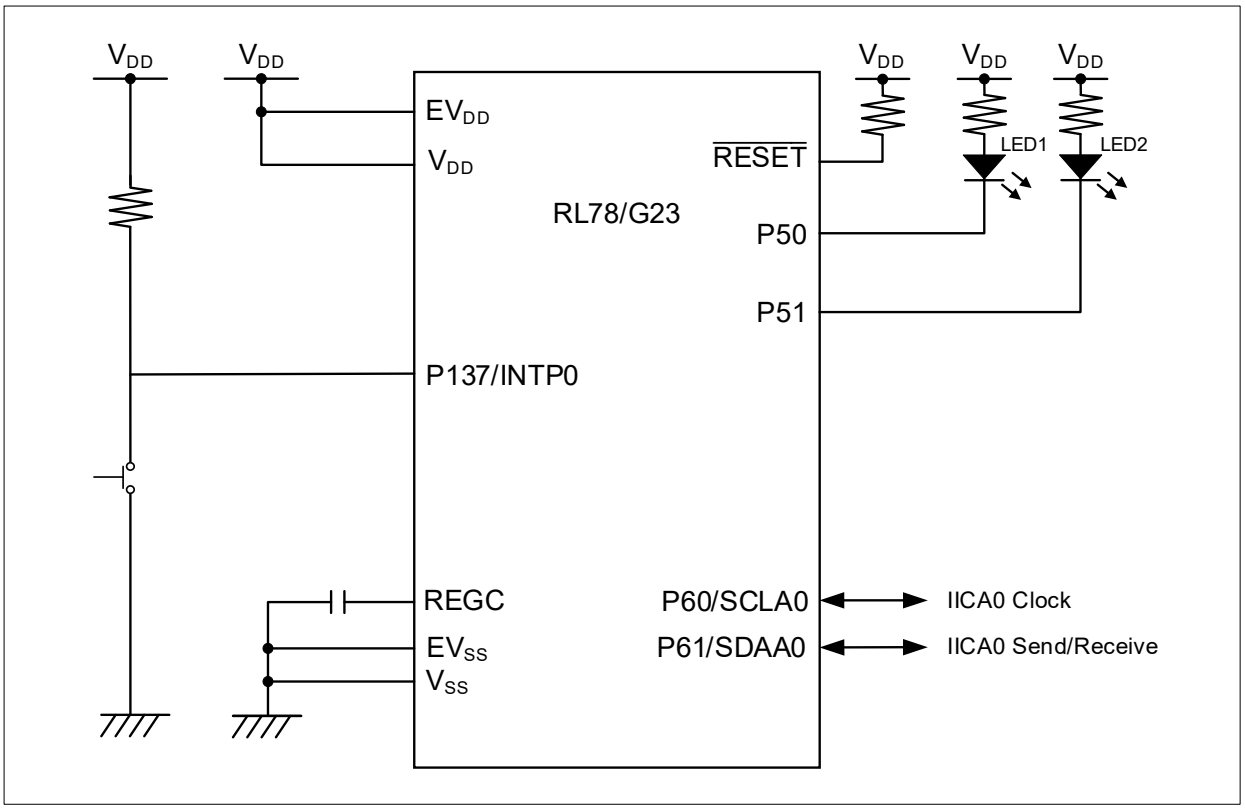


Figure 4-2 Hardware Configuration (Target)



Caution 1. This simplified circuit diagram was created to show an overview of connections only. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements. (Connect each input-only port to V_{DD} or V_{SS} through a resistor.)

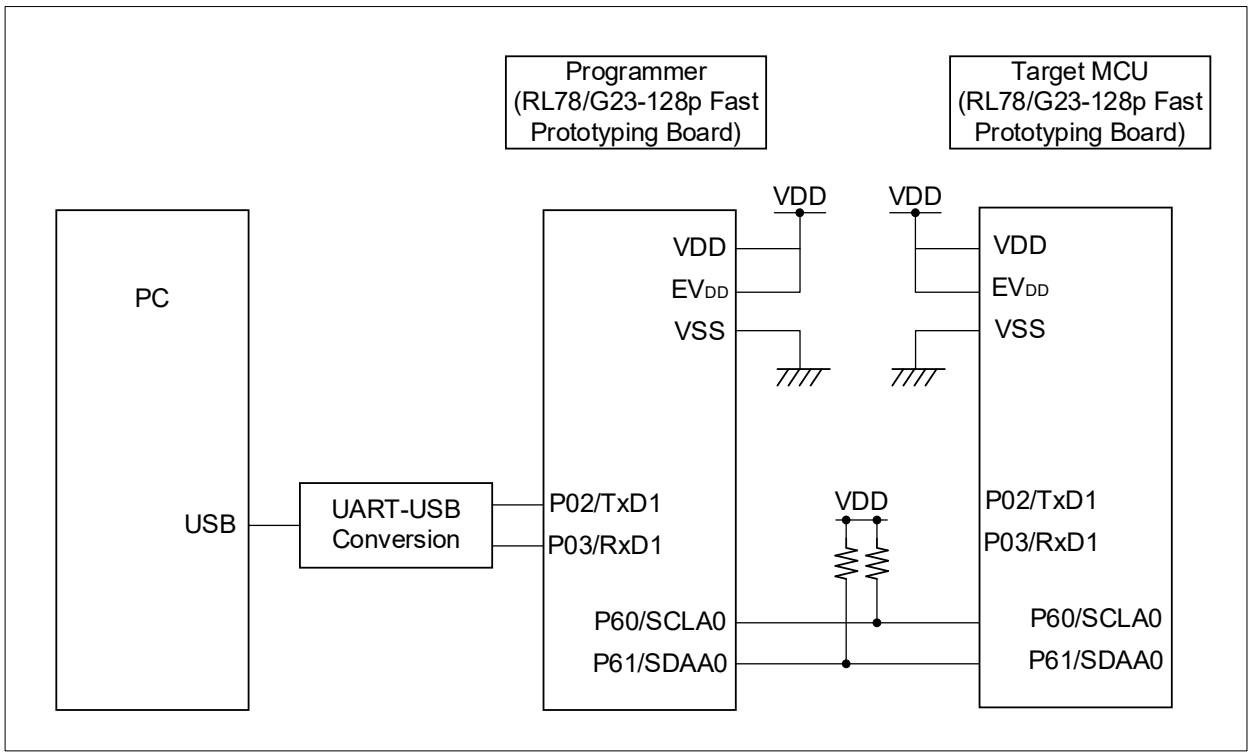
Caution 2. Connect the EV_{SS} pin to V_{SS} and the EV_{DD} pin to V_{DD}.

Caution 3. V_{DD} must be held at not lower than the reset release voltage (V_{LVD0}) that is specified as LVD.

4.2 How to Connect

The following figure shows how to connect the PC to the programmer and the target.

Figure 4-3 Connection Diagram



4.3 List of Used Pins

Table 4-1 and Table 4-2 show the pins to be used and functions in the sample code of programmer and target.

Table 4-1 List of Used Pins (Programmer)

Pin name	I/O	Function
P02/TxD1	Output	Host PC communication transmission pin (UART1)
P03/RxD1	Input	Host PC communication receiving pin (UART1)
P60/SCLA0	Output	Target interface communication clock pin (IICA0)
P61/SDAA0	Output	Target interface communication transmission and receiving pin (IICA0)
P50, P51	Output	Output (to LED1 and LED2) pins

Table 4-2 List of Used Pins (Target)

Pin name	Input/Output	Function
P60/SCLA0	Input	Target interface communication clock pin (IICA0)
P61/SDAA0	Input	Target interface communication transmission and receiving pin (IICA0)
P50, P51	Output	Output (to LED1 and LED2) pins
P137	Input	Mode selection (Rewriting mode/User mode)

Caution. In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

4.4 Setting of RL78/G23-128p Fast Prototyping Board

When using the E2 emulator Lite or the E2 emulator for debugging, make the following settings for the RL78/G23-128p Fast Prototyping Board.

- Cut the cut-patterns "TOOL0_USB", "RESET", and "T_RESET".
- Short-circuit (between 2 and 3 pins) pin headers "J15", "J16", and "J19".

Set the operating voltages of VDD and EVDD with "J20".

For details, refer to RL78/G23-128p Fast Prototyping Board User's Manual (R20UT4870).

5. Programmer Internal Specification

5.1 Option Byte Settings (Programmer)

Table 5-1 shows the option byte settings of the programmer.

Table 5-1 Option Byte Settings (Programmer)

Address	Setting value	Contents
000C0H/040C0H	11101111B	Disables the watchdog timer
000C1H/040C1H	00111010B	LVD0 OFF
000C2H/040C2H	11101000B	HS mode, High-speed on-chip oscillator clock: 32MHz
000C3H/040C3H	10000100B	Enables on-chip debugging

RL78/G23's option bytes consist of user option bytes (000C0H to 000C2H) and on-chip debug option byte (000C3H).

5.2 Section Settings (Programmer)

The section settings use default settings (automatic placement).

5.3 Smart Configurator Settings (Programmer)

The settings of the programmer by Smart Configurator are shown below.

(1) Initialize the I/O port.

- Set P50 and P51 to an output port.

(2) Initialize the Interval Timer (16-bit Counter mode).

- Set the Operation clock to CK10, set the Clock source to fCLK/2^4.
- Set the Interval value (higher 16 bits) to 20ms.
- Set the Count end interrupt priority (INTTM10) to Level3.

(3) Initialize the Serial Array Unit.

- Use UART1. (P02 is used as TXD1, P03 is used as RXD1)
- Set the Operation clock to CK00, set the Clock source to fCLK/2.
- Set the Transfer mode to Single transfer mode.
- Set the Data length to 8 bits.
- Set the Transfer direction to LSB.
- Set the Parity to None.
- Set the Stop bit length to 1 bit.
- Set the Transfer data level to Non-reverse.
- Set the Transfer rate to 115200bps.
- Set the Transmit end interrupt priority (INTST1) to Level 1.
- Set the Reception end interrupt priority (INTSR1) to Level 3.
- Set the Reception error interrupt priority (INTSRE1) to Level 3.
- Select the Transmission end, Reception end and Reception error of the Callback function setting.

(4) Initialize the I2C (Master mode).

- Use IICA0. (P60 is used as SCLA0, P61 is used as SDAA0)
- Set the Operation clock to fCLK/2.
- Set the Address of the Local address setting to 16.
- Set the Operation mode to Standard, set the Transfer clock to 100000bps.
- Set the Communication end interrupt priority (INTIICA0) to Level 3.
- Select the Master transmission end, Master reception end and Master error of the Callback function setting.
- Select the Callback function enhanced feature setting.

5.4 Defined Value (Programmer)

SRECORD_TYPE is an enumeration and defines the S record type of the Motorola S-format.

Table 5-2 shows the specifications of SRECORD_TYPE.

Table 5-2 SRECORD_TYPE

Defined Value	Description
SRECORD_0	S0 record
SRECORD_1	S1 record
SRECORD_2	S2 record
SRECORD_3	S3 record
SRECORD_4	S4 record
SRECORD_5	S5 record
SRECORD_6	S6 record
SRECORD_7	S7 record
SRECORD_8	S8 record
SRECORD_9	S9 record
SRECORD_ERR	Invalid S record data

5.5 Specification of Functions (Programmer)

5.5.1 List of Functions

Table 5-3 shows the major functions used in the sample code of programmer.

Table 5-3 List of Functions

Function name	Outline
R_Get_SRecordType	Acquires S record type.
R_Config_UART1_SendMessage	Send the message to the PC.
r_SendSRecord_I2C	Send the data to the target MCU.
r_Receive1Byte_I2C	Receives the 1-byte data from the target MCU.
r_Receive1Byte_I2C_Sparse	Receives the 1-byte data from the target MCU. (with 20ms wait)

5.5.2 Function Specifications

The function specifications of the sample code (programmer) are shown below.

R_Get_SRecordType	
Outline	Acquires S record type.
Declaration	SRECORD_TYPE R_Get_SRecordType(uint8_t * srecord_str)
Arguments	srecord_str: S record character string (1 line)
Return value	Record type
Description	Analyzes 1 line of the S record data and acquires the record type.

R_Config_UART1_SendMessage	
Outline	Send the message to the PC
Declaration	MD_STATUS R_Config_UART1_SendMessage(const char * p_msg, uint8_t len, uint8_t is_waiting)
Arguments	p_msg: Pointer for the display message string len: Length of the display message is_waiting: Whether to wait for transmission completion
Return value	MD_OK: Success MD_ERROR: Failure
Description	Send a message to PC using UART1.

r_SendSRecord_I2C	
Outline	Send data to the target
Declaration	MD_STATUS r_SendSRecord_I2C(uint8_t * p_buff, uint16_t length)
Arguments	p_buff: Buffer pointer to store the transmission data length: Size of the transmission data
Return value	MD_OK: Success MD_ERROR: Failure
Description	Send data to the target (slave) using IICA0.

r_Receive1Byte_I2C	
Outline	Receive 1-byte data from the target
Declaration	MD_STATUS r_Receive1Byte_I2C(uint8_t * p_buff)
Arguments	p_buff: Buffer pointer to store the receiving data
Return value	MD_OK: Success MD_ERROR: Failure
Description	Receive 1-byte data from the target (slave) using IICA0.

r_Receive1Byte_I2C_Sparse	
Outline	Receive 1-byte data from the target (20ms wait)
Declaration	MD_STATUS r_Receive1Byte_I2C_Sparse(uint8_t * p_buff)
Arguments	p_buff: Buffer pointer to store the receiving data
Return value	MD_OK: Success MD_ERROR: Failure
Description	Receive 1-byte data from the target (slave) using IICA0. To reduce unwanted I2C communication while there is no status of target change, insert 20ms weight prior to the receiving process.

6. Target Internal Specification

6.1 Mode Selection

The target MCU checks the status of RL78/G23-128p Fast Prototyping Board user switch (SW) in the start-up routine of the boot program, and if SW is pressed (P137=Low) moves to the rewriting mode (boot program processing), and if SW is not pressed (P137=High) moves to the user mode (user program processing).

6.2 Option Byte Settings (Target MCU)

Table 6-1 shows the option byte settings used in the sample program of the target.

Set by the boot program.

Table 6-1 Option Byte Settings (Target MCU)

Address	Setting Value	Contents
000C0H/040C0H	01101110B	Disables the watchdog timer
000C1H/040C1H	11111110B	LVD0 detection voltage: Reset mode At rising edge TYP. 1.90 V (1.84 V ~ 1.95 V) At falling edge TYP. 1.86 V (1.80 V ~ 1.91 V)
000C2H/040C2H	11101000B	HS mode, High-speed on-chip oscillator clock: 32MHz
000C3H/040C3H	10000100B	Enables on-chip debugging

RL78/G23's option bytes consist of user option bytes (000C0H to 000C2H) and on-chip debug option byte (000C3H).

6.3 Sharing Interrupt Vector

Since the boot program and the user program are separate projects, and the interrupt vectors cannot be shared as is, a mechanism is provided for executing user program interrupt handler functions from the boot program.

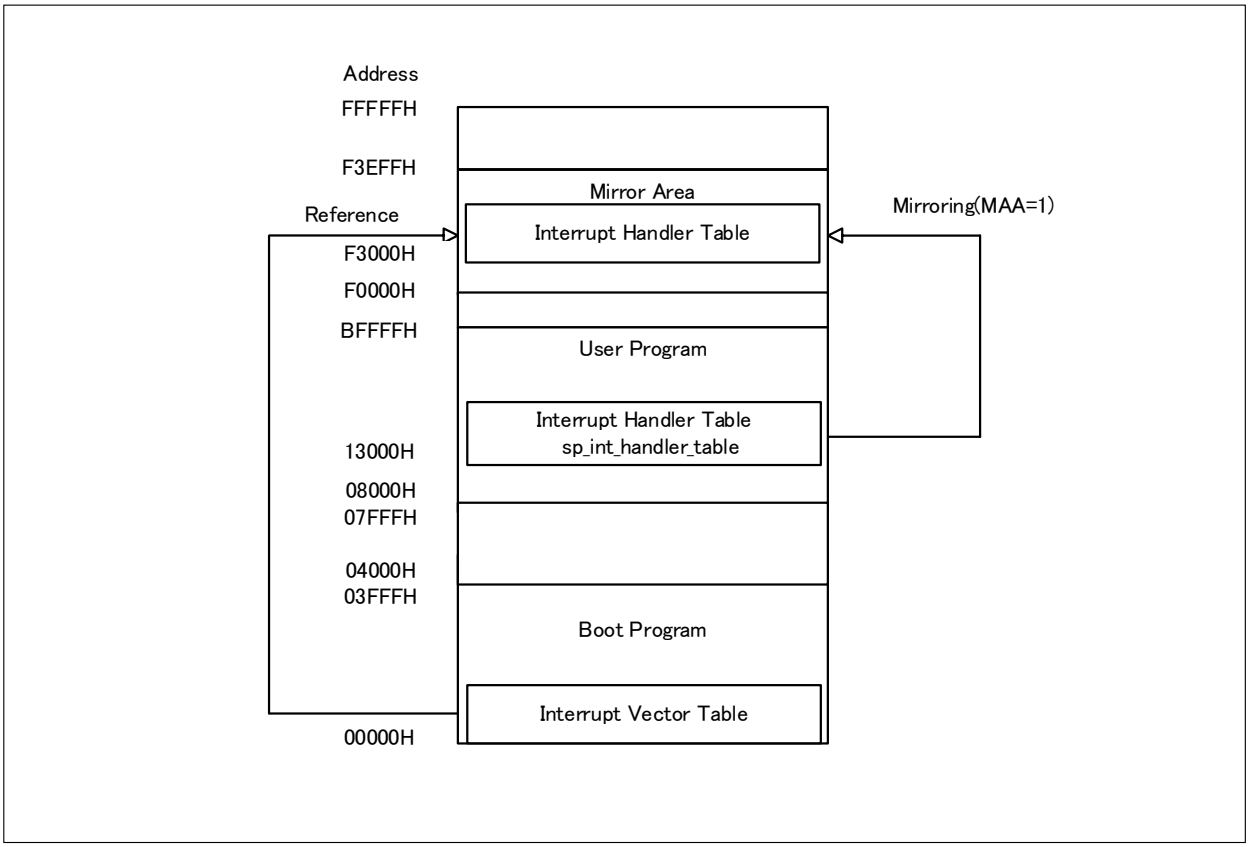
The user program allocates the interrupt handler table for registering the interrupt handler used by the user program at a fixed address (0x13000).

In addition, the user-program startup routines set MAA in PMC register to 1 so that the interrupt handler table is mirrored at 0xF3000 address.

The boot program implements the process of jumping to the corresponding vector address by referencing the interrupt handler table of the user program at 0xF3000 address in the interrupt handler of the boot program.

Because the boot program uses IICA0 interrupts (INTIICA0), IICA0 interrupt handler for the boot program executes IICA0 interrupt process for the boot program when MAA=0, and the user program's interrupt handler table is referenced when MAA=1 to jump to the vector address of the user program's IICA0.

Figure 6-1 Sharing the Interrupt Vector



6.3.1 Registering Interrupt Handler of User Program

The interrupt handler table for the user program is defined in int_handlers.c in the project of the user program.

Add the interrupt handler used by the user program to sp_int_handler_table.

For sp_int_handler_table[0], specify the user program start address.

In the sample program, INTTM01 is used in LED blinking process.

Figure 6-2 Interrupt Handler Table

```
/***********************************************************************************************************************
Macro definitions
***********************************************************************************************************************/
#define USER_PROGRAM_START                  (0x8000)


/***********************************************************************************************************************
Static variables and functions
***********************************************************************************************************************/
#pragma section const USER_INT_HANDLERS
const int_handler_t sp_int_handler_table[64] =
{
    (int_handler_t)(USER_PROGRAM_START),    /* RST (Note: This must be a start point of your program.) */
    NULL,                                   /* INTDBG(do't set a handler here!) */
    NULL,                                   /* INTWDTI */
    NULL,                                   /* INTLVI */
    NULL,                                   /* INTP0  */
    NULL,                                   /* INTP1  */
    NULL,                                   /* INTP2  */
    NULL,                                   /* INTP3  */
(Omitted.)
    R_Config_TAU0_1_interrupt,              /* INTTM01 */
    NULL,                                   /* INTTM14  */
    NULL,                                   /* INTTM15  */
    NULL,                                   /* INTTM16  */
    NULL,                                   /* INTTM17  */
    NULL,                                   /* No Use  */
    NULL,                                   /* No Use  */
    NULL,                                   /* BRK_I */
};
#pragma section
```

6.3.2 Boot Program Interrupt Handler

Each interrupt handler in the boot program refers to the interrupt handler table of the user program and implements the processing to jump to the corresponding vector address.

It is defined by int_handlers.c and int_handlers_tmpl.h in the project of the boot program.

Figure 6-3 Boot Program Interrupt Handler (int_handlers.c)

```
#define INT_VECT     INTWDTI
#define R_HANDLER    r_handler_INTWDTI_vect
#include "int_handlers_tmpl.h"

#define INT_VECT     INTLVI
#define R_HANDLER    r_handler_INTLVI_vect
#include "int_handlers_tmpl.h"

#define INT_VECT     INTP0
#define R_HANDLER    r_handler_INTP0_vect
#include "int_handlers_tmpl.h"

#define INT_VECT     INTP1
#define R_HANDLER    r_handler_INTP1_vect
#include "int_handlers_tmpl.h"

#define INT_VECT     INTP2
#define R_HANDLER    r_handler_INT2_vect
#include "int_handlers_tmpl.h"

(Omitted.)

#define INT_VECT     INTTM16
#define R_HANDLER    r_handler_INTTM16_vect
#include "int_handlers_tmpl.h"

#define INT_VECT     INTTM17
#define R_HANDLER    r_handler_INTTM17_vect
#include "int_handlers_tmpl.h"

/* software break handler */
#define INT_VECT     0x7E
#define R_HANDLER    r_handler_BRK_vect
#include "int_handlers_tmpl.h"
```

Figure 6-4 Boot Program Interrupt Handler (int_handlers_tmpl.h)

```
#ifdef R_HANDLER
#if INT_VECT == 0x7E
#pragma interrupt_brk R_HANDLER
#else
#pragma interrupt R_HANDLER(vect=INT_VECT)
#endif

static void __near R_HANDLER(void)
{
    int_handler_t __far * int_handler_table= INT_HANDLER_ADDRESS;

    if (int_handler_table[INT_VECT>>1])
    {
        int_handler_table[INT_VECT>>1]();
    }
}

#undef R_HANDLER
#undef INT_VECT

#endif
```

6.4 Smart Configurator Settings (Boot Program)

The settings of the boot program by Smart Configurator are shown below.

(1) Initialize the I/O port.

- Set P50 and P51 to an output port.

(2) Initialize the I2C (Slave mode).

- Use IICA0. (P60 is used as SCLA0, P61 is used as SDAA0)
- Set the Operation clock to fCLK/2.
- Set the Address of the Local address setting to 160.
- Set the Operation mode to Standard.
- Set the Wakeup function setting to Off.
- Set the Communication end interrupt priority (INTIICA0) to Level 3.
- Select the Slave transmission end, Slave reception end and Slave error of the Callback function setting.

(3) Initialize the Voltage detector.

- Select the Reset mode.
- Set the Reset generation level (VLVD0) to 1.86V.

6.5 Section Settings (Target)

Table 6-2 and Table 6-3 show the CC-RL section settings for the boot program and the user program.

- Sections beginning with "." are reserved by the compiler.
- Sections beginning with "RFD_" or "SMP_" are defined by the specifications of the Renesas Flash Driver RL78 Type01(RFD) and its sample program.
- Though reserved section names of IAR vary, IAR has a similar section configuration.

Table 6-2 List of Boot Program Section

Section Name	Address	Description
.text	0x000D8	Section for code (allocated to the near area)
.RLIB	(Automatic allocation)	Section for code of runtime libraries
.SLIB	(Automatic allocation)	Section for code of standard libraries
.textf	(Automatic allocation)	Section for code (allocated to the far area)
.constf	(Automatic allocation)	ROM data (allocated to the far area)
RFD_DATA_n	(Automatic allocation)	Section for RFD: Data section for initialized global variables
RFD_CMN_f	(Automatic allocation)	Section for RFD: Program section of API functions used in common for flash memory control
RFD_CF_f	(Automatic allocation)	Section for RFD: Program section of API functions for code flash memory control
RFD_DF_f	(Automatic allocation)	Section for RFD: Program section of API functions for data flash memory control
RFD_EX_f	(Automatic allocation)	Section for RFD: Program section of API functions for data flash memory control
SMP_CMN_f	(Automatic allocation)	Section for RFD sample: Program section of sample functions used in common for flash memory control
SMP_CF_f	(Automatic allocation)	Section for RFD sample: Program section of sample functions for code flash memory control
SMP_CMN_n	(Automatic allocation)	Section for SMP: Program section of sample functions used in common for flash memory control
SMP_DF_f	(Automatic allocation)	Section for RFD sample: Program section of sample functions for data flash memory control
.data	(Automatic allocation)	Section for near initialized data (with initial value)
.sdata	(Automatic allocation)	Section for initialized data (with initial value, variable allocated to saddr)
.dataR	0xF3F00	Section for near initialized data (with initial value) (Data copied from ROM area)
.bss	(Automatic allocation)	Section for data area (without initial value, allocated to the near area)
RFD_DATA_nR	(Automatic allocation)	Section for RFD: Data section for initialized global variables (Data copied from ROM area)
RFD_CMN_fR	(Automatic allocation)	Section for RFD: Program section of API functions used in common for flash memory control (Program copied from ROM area)
RFD_CF_fR	(Automatic allocation)	Section for RFD: Program section of API functions for code flash memory control (Program copied from ROM area)
RFD_EX_fR	(Automatic allocation)	Program section of API functions for extra area control (Program copied from ROM area)
SMP_CMN_fR	(Automatic allocation)	Section for RFD sample: Program section of sample functions used in common for flash memory control (Program copied from ROM area)
SMP_CF_fR	(Automatic allocation)	Section for RFD sample: Program section of sample functions for code flash memory control (Program copied from ROM area)
.sdataR	0xFFE20	Section for initialized data (with initial value, variable allocated to saddr) (Data copied from ROM area)
.sbss	(Automatic allocation)	Section for data area (without initial value, variable allocated to saddr)

Table 6-3 List of User Program Section

Section Name	Address	Description
.text	0x08000	Section for code (allocated to the near area)
.RLIB	(Automatic allocation)	Section for code of runtime libraries
.SLIB	(Automatic allocation)	Section for code of standard libraries
.textf	(Automatic allocation)	Section for code (allocated to the far area)
.constf	(Automatic allocation)	ROM data (allocated to the far area)
.data	(Automatic allocation)	Section for near initialized data (with initial value)
.sdata	(Automatic allocation)	Section for initialized data (with initial value, variable allocated to saddr)
USER_INT_HANDLERS_n	0x13000	Section for interrupt handler table of user program
.const	(Automatic allocation)	ROM data (allocated to the near area) (mirror area)
.dataR	0xF3F00	Section for near initialized data (with initial value) (Data copied from RAM area)
.bss	(Automatic allocation)	Section for data area (without initial value, allocated to the near area)
.sdataR	0xFFE20	Section for initialized data (with initial value, variable allocated to saddr) (Data copied from RAM area)
.sbss	(Automatic allocation)	Section for data area (without initial value, variable allocated to saddr)

6.5.1 Creating Program Files for Target

In this sample program, the boot program is assigned to the address 0x00000~0x03FFF and the user program is assigned to the address 0x08000~0xBFFFF to support the boot swap.

For the boot program, only 0x00000~0x03FFF data should be used because the build settings add data for OCD monitoring to the final area of the code flash memory.

For the user program, the data (interrupt vector table, optional bytes, security ID and OCD monitoring) is automatically generated below 0x08000 regardless of the section setting, so they are deleted.

In CS+ and e2studio, the split output file function of CC-RL enables the setting to output only the required data.

Please use rl78g23_RFD_with_I2C_boot.mot for the boot program and rl78g23_FlashWriter_UserProgramSample_program.mot for the user program.

Figure 6-5 Split Output File Settings of Boot Program (CS+)

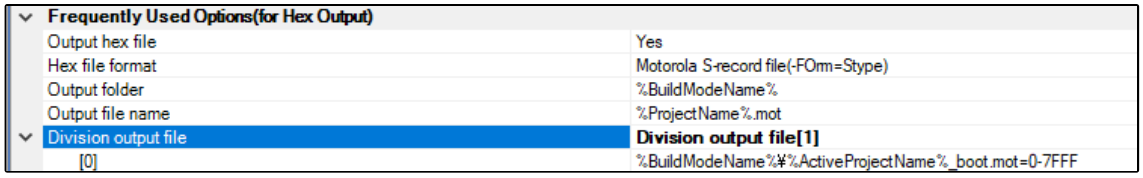
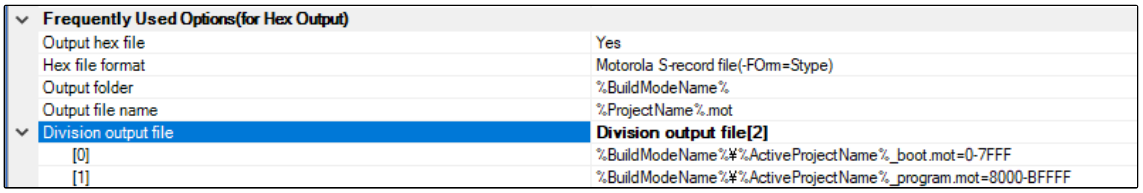


Figure 6-6 Split Output File Settings of User Program (CS+)



For IAR, SRecordSplitter.bat is used because there is no split output file function.

(Located in rl78g23_FlashWriter_UserProgramSample¥Workspace¥IAREW¥)

At the command prompt, run the following to extract only the records after 0x08000.

Table 6-4 How to use SRecordSplitter.bat

> ./SRecordSplitter.bat <original S-Record file> <new S-Record file>

6.6 Defined Value (Target)

SRECORD_DATA structure is used to temporarily store Motorola S format S record analysis data.

Table 6-5 shows the specifications of SRECORD_DATA structure.

Table 6-5 SRECORD_DATA Structure

Member	Description
SRECORD_TYPE type	Motorola S record type
uint32_t address	Motorola S record address
uint16_t size	Motorola S record size
uint8_t data[SRECORD_DATA_SIZE]	Motorola S record data (SRECORD_DATA_SIZE=128)

6.7 Specification of Functions (Boot Program)

6.7.1 List of Functions

Table 6-6 shows the major functions used in the sample code (boot program).

Table 6-6 List of Functions (Boot Program)

Function Name	Outline
R_Decode_SRecord	Analyzes S record.
R_RFDCmd_Initialize	Initializes RFD.
R_RFDCmd_Write	Rewrites the flash memory.
R_RFDCmd_End	Executes boot swap.

6.7.2 Function Specifications

The function specifications of the sample code (boot program) are shown below.

R_Decode_SRecord	
Outline	Analyzes S record.
Declaration	void R_Decode_SRecord(uint8_t * srecord_str, uint16_t len, SRECORD_DATA * srecord_data)
Argument	srecord_str: S record string (1 line) len: Length of srecord_str srecord_data: Analysis data of S record
Return Value	None
Description	Analyzes S record and sets the analysis results in the SRECORD_DATA structure.

R_RFDCmd_Initialize	
Outline	Initializes RFD.
Declaration	e_rfd_ret_t R_RFDCmd_Initialize(void)
Argument	None
Return Value	R_RFD_ENUM_RET_STS_OK: Success Other: Failure
Description	Executes R_RFD_Init() and initializes RFD.

R_RFDCmd_Write	
Outline	Rewrites the flash memory.
Declaration	R_RFDCmd_Write(uint32_t start_addr, uint16_t length, uint8_t __near * p_data)
Argument	start_addr: Write start address length: Data size p_data: Data for writing
Return Value	R_RFD_ENUM_RET_STS_OK: Success Other: Failure
Description	The following process is used to rewrite the flash memory data. 1. Set interrupt vectors in RAM. 2. Set flash memory control mode to code flash programming mode or data flash programming mode. 3. Perform a blank check. 4. Perform a block erase (if non-blank). 5. Performs a writing operation. 6. Set flash memory control mode to non-write mode. 7. Perform Verify (compare write data with read data). 8. Return interrupt vector to ROM.

R_RFDCmd_End	
Outline	Executes boot swap.
Declaration	e_rfd_ret_t R_RFDCmd_End(void)
Argument	None
Return Value	R_RFD_ENUM_RET_STS_OK: Success Other: Failure
Description	After executing boot swap, executes software reset.

6.7.3 Note (Boot Program)

If this sample program is re-generated after the Board support package (bsp) version has been changed, an error may occur. Please add the following description to cstart.asm in the newly generated file.

Figure 6-7 cstart.asm of the Boot Program

```
(Omitted.)
;-------------------------------------------------------------------------------
;   startup
;-------------------------------------------------------------------------------
.SECTION .text, TEXT
_start:
;===============================================================================
; Jump to a user-program if SW is off(P137 == 1)
PORT13              .EQU  0xFFF0D
USER_INT_HANDLERS   .EQU  0x13000
        BF PORT13.7, $_jump_user_program_end
        MOV  ES, #HIGHW(USER_INT_HANDLERS)
        MOVW HL, #LOWW(USER_INT_HANDLERS)
        MOVW AX, ES:[HL+0]
        BR AX
_jump_user_program_end:
;===============================================================================

    ;-------------------------------------------------
    ; setting register bank
    ;-------------------------------------------------
$IFDEF BSP_CFG_ASM_RAM_GUARD_START_ADDRESS
    MOV !RAMSAR, #BSP_CFG_ASM_RAM_GUARD_START_ADDRESS
$ENDIF
(Omitted.)
```

6.8 Specification of Functions (User Program)

6.8.1 List of Functions

Table 6-7 shows the major functions used in the sample code (user program).

Table 6-7 List of Functions (User Program)

Function Name	Outline
main	Main processing

6.8.2 Function Specifications

The function specifications of the sample code (user program) are shown below.

main	
Outline	Main processing
Declaration	void main(void)
Argument	None
Return Value	None
Description	Performs LED blinking using interval timer (INTTM01).

6.8.3 Note (User Program)

If this sample program is re-generated after the Board support package (bsp) version has been changed, an error may occur. Please change the mirror area setting in cstart.asm in the newly generated file as follows.

Figure 6-8 cstart.asm of the User Program

```
(Omitted.)


    ;---------------------------------------------------
    ; setting mirror area
    ;---------------------------------------------------
   ONEB    !PMC        ; mirror area = 10000-1FFFFH


    ;---------------------------------------------------
    ; setting the stack pointer
    ;---------------------------------------------------


(Omitted.)
```

7. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896)

RL78 Family Renesas Flash Driver RL78 Type 01 User's Manual (R20UT4830)

RL78 Family Renesas Flash Driver RL78 Type 01 SC version (Code Flash) (R20AN0653)

RL78 Family Renesas Flash Driver RL78 Type 01 SC version (Data Flash) (R20AN0654)

RL78 Family Renesas Flash Driver RL78 Type 01 SC version (Extra Area) (R20AN0655)

RL78 Family Renesas Flash Driver RL78 Type 01 SC version (Common) (R20AN0656)

RL78/G23-128p Fast Prototyping Board User's Manual (R20UT4870)

The latest versions can be downloaded from the Renesas Electronics website.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Aug,6.25	—	First Edition

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.

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