

RL78 Family

Firmware Update Module

Introduction

This application note describes the firmware update module for the RL78 family. The module is referred to below as the firmware update module.

By using the module, users can easily incorporate secure boot and firmware update functionality into their applications. This application note explains the specifications of the firmware update module and how to incorporate its API functions into user applications.

The release package associated with this application note includes a demo project. You can confirm the basic operation of the firmware update functionality by following the steps described in Section 4.Demo Project, to build an environment to run the demo.

Target Devices

RL78/G13 (R5F100SLA)

RL78/G21 (R7F103GLJ)

RL78/G22 (R7F102GGE)

RL78/G23 (R7F100GSN)

RL78/G24 (R7F101GLG)

RL78/L23 (R7F100LPL)

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

Related Application Notes

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

- RL78 Family Board Support Package Module Using Software Integration System (R01AN5522)
- RL78 Family Renesas Flash Driver RL78 Type01 User's Manual (R20UT4830)
- RL78 Family Renesas Flash Driver RL78 Type11 User's Manual (R20UT5539)
- RL78 Family Renesas Flash Driver RL78 Type11 SC version (Bank Operation) (R20AN0781)
- RL78 Family Renesas Flash Driver RL78 Type11 SC version (Code Flash)(R20AN0778)
- RL78 Family Renesas Flash Driver RL78 Type11 SC version (Common)(R20AN0782)
- RL78 Family Renesas Flash Driver RL78 Type11 SC version (Data Flash)(R20AN0779)
- RL78 Family Serial NOR Flash Memory Control Module Software Integration System (R01AN7243)
- RL78 Family Flash Self-Programming Library Type 01 (R01US0050)
- RL78 Family Data Flash Library Type 04 (R01US0049)
- Renesas Microcontroller CompactECC Library: User's Manual (R01UW0220)
- RL78 Family CompactECC Library: Introduction Guide (R01AN8382)
- Renesas Microcomputer SHA Hash Function Library: User's Manual (R20UW0101)
- RL78 Family SHA Hash Function Library: Introduction Guide (R20AN0211)
- RL78 Smart Configurator User's Guide: e² studio (R20AN0579)
- Smart Configurator User's Guide: RL78 API Reference (R20UT4852)

Target Compilers

- CC-RL from Renesas Electronics
- IAR C/C++ Compiler for Renesas RL78 from IAR Systems
- IAR Assembler for Renesas RL78 from IAR Systems
- LLVM for Renesas RL78

For details of the environments on which operation has been confirmed, refer to Section 6.1, Confirmed Operation Environments.

Contents

1. Overview.....	8
1.1 About the Firmware Update Module	8
1.2 Configuration of Firmware Update Module	9
1.3 Firmware Update Operation	11
1.3.1 Dual-Bank(2-Bank) Method.....	12
1.3.1.1 Operation of Dual-Bank(2-Bank) Method.....	12
1.3.2 Partial Update Method.....	13
1.3.2.1 Operation of Partial Update Method.....	13
1.3.3 Full Update Method (without buffer plane).....	14
1.3.3.1 Operation of Full Update Method (without buffer plane).....	14
1.3.4 Full Update Method (with buffer plane).....	15
1.3.4.1 Operation of Full Update Method (with buffer plane).....	15
1.4 Initial State of Firmware Update.....	16
1.4.1 Initial State of Dual-Bank(2-Bank) Method Settings Utilizing Renesas Image Generator	16
1.4.2 Initial State of Partial Update Method Settings Utilizing Renesas Image Generator	16
1.4.3 Initial State of Full Update Method Settings Utilizing Renesas Image Generator.....	17
1.4.4 Initial State of Dual-Bank(2-Bank) Method Settings Utilizing Bootloader	17
1.4.5 Initial State of Partial Update Method Settings Utilizing Bootloader	18
1.4.6 Initial State of Full Update Method Settings Utilizing Bootloader.....	18
1.5 Package Contents	19
1.6 API Overview.....	21
2. API Information.....	22
2.1 Hardware Requirements	22
2.2 Software Requirements.....	22
2.3 Supported Toolchains	22
2.4 Header Files	22
2.5 Integer Types.....	22
2.6 Compile Settings	23
2.7 Demo Project Code Sizes	24
2.7.1 Demo Project for QB-R5F100SL-TB.....	24
2.7.2 Demo Project for FPB-RL78G21	25
2.7.3 Demo project for FPB-RL78G22	25
2.7.4 Demo Project for FPB-RL78G23-128p.....	26
2.7.5 Demo Project for FPB-RL78G24	26
2.7.6 Demo Project for FPB-RL78L23.....	27
2.8 Arguments	28
2.9 Return Values.....	28
2.10 Implementation Examples of APIs	29
2.10.1 Implementation Example of Dual-Bank(2-Bank) Method.....	29

2.10.2	Implementation Example of Partial Update Method and Full Update Method (with buffer plane)	31
2.10.3	Implementation Example of Full Update Method (without buffer plane)	33
3.	API Functions	34
3.1	R_FWUP_Open Function	34
3.2	R_FWUP_Close Function	34
3.3	R_FWUP_IsExistImage Function	34
3.4	R_FWUP_EraseArea Function	35
3.5	R_FWUP_GetImageSize Function	35
3.6	R_FWUP_WriteImage Function	35
3.7	R_FWUP_VerifyImage Function	36
3.8	R_FWUP_ActivateImage Function	36
3.9	R_FWUP_ExecuteImage Function	36
3.10	R_FWUP_SoftwareReset Function	37
3.11	R_FWUP_SoftwareDelay Function	37
3.12	R_FWUP_GetVersion Function	37
3.13	R_FWUP_WriteImageHeader Function	38
3.14	R_FWUP_WriteImageProgram Function	38
3.15	Wrapper Functions	39
3.15.1	r_fwup_wrap_com.c, h	39
3.15.1.1	r_fwup_wrap_disable_interrupt Function	39
3.15.1.2	r_fwup_wrap_enable_interrupt Function	39
3.15.1.3	r_fwup_wrap_software_reset Function	39
3.15.1.4	r_fwup_wrap_software_delay Function	40
3.15.2	r_fwup_wrap_flash.c, h	41
3.15.2.1	r_fwup_wrap_flash_open Function	41
3.15.2.2	r_fwup_wrap_flash_close Function	41
3.15.2.3	r_fwup_wrap_flash_erase Function	41
3.15.2.4	r_fwup_wrap_flash_write Function	42
3.15.2.5	r_fwup_wrap_flash_read Function	42
3.15.2.6	r_fwup_wrap_bank_swap Function	43
3.15.2.7	r_fwup_wrap_ext_flash_open Function	43
3.15.2.8	r_fwup_wrap_ext_flash_close Function	43
3.15.2.9	r_fwup_wrap_ext_flash_erase Function	44
3.15.2.10	r_fwup_wrap_ext_flash_write Function	44
3.15.2.11	r_fwup_wrap_ext_flash_read Function	44
3.15.3	r_fwup_wrap_verify.c, h	45
3.15.3.1	r_fwup_wrap_sha256_init Function	45
3.15.3.2	r_fwup_wrap_sha256_update Function	45
3.15.3.3	r_fwup_wrap_sha256_final Function	45
3.15.3.4	r_fwup_wrap_verify_ecdsa Function	46

3.15.3.5 r_fwup_wrap_get_crypt_context Function	46
4. Demo Project.....	47
4.1 Demo project Structure	47
4.2 Operating environment preparation	48
4.2.1 Installing TeraTerm	48
4.2.2 Installing the Python execution environment.....	48
4.2.3 Installing the OpenSSL execution environment	48
4.2.4 Installing the Flash Writer	48
4.2.5 USB serial conversion board.....	49
4.3 Execution environment preparation	50
4.3.1 Generating Keys for Signature Generation and Verification	50
4.3.2 Preparing the execution environment for Renesas Image Generator	50
4.4 Dual-Bank(2-Bank) Method.....	51
4.4.1 Execution Environment	51
4.4.2 Build Demo Project.....	51
4.4.3 Create initial and updated images.....	53
4.4.4 Program Initial Image	53
4.4.5 Update Firmware	54
4.5 Partial Update Method.....	55
4.5.1 Execution Environment	55
4.5.2 Build Demo Project.....	55
4.5.3 Create initial and updated images.....	57
4.5.4 Program Initial Image	57
4.5.5 Update Firmware	58
4.6 Full Update Method (without buffer plane)	59
4.6.1 Execution Environment	59
4.6.2 Build Demo Project.....	59
4.6.3 Create initial and updated images.....	60
4.6.4 Program Initial Image	60
4.6.5 Update Firmware	61
4.7 Full Update Method (with buffer plane)	62
4.7.1 Execution Environment	62
4.7.2 Build Demo Project.....	62
4.7.3 Create initial and updated images.....	64
4.7.4 Program Initial Image	64
4.7.5 Update Firmware	65
4.8 Notes on the CC-RL Demo Projects for RL78/G13.....	66
4.9 How to debug the demo project	67
4.9.1 How to Debug the Bootloader and Application Program	67
4.9.2 How to Debug the Application Program Only.....	76

4.10	How to Change the Update Image Retrieval Path for the Demo Project	78
4.11	How to Add Interrupt Handling to the Demo Project	81
4.11.1	Flow of Interrupt Processing in the Demo Project	81
4.11.2	How to Add Interrupt Processing to the Demo Project	82
4.12	How to Use a Memory Layout Different from That of the Demo Project	85
5.	Renesas Image Generator	89
5.1	Image Generation Methods	89
5.1.1	Initial Image Generation Method	91
5.1.2	Update Image Generation Method	91
5.2	Image File	92
5.2.1	Update Image File	92
5.2.2	Initial Image File	93
5.2.3	RSU Header	95
5.3	Parameter File	96
5.3.1	Contents of Parameter File	96
6.	Appendices	99
6.1	Confirmed Operation Environments	99
6.2	Operating Environment for Demo Project	100
6.2.1	Operation Confirmation Environment for RL78/G13	100
6.2.1.1	Information on demo project for partial update method	101
6.2.1.2	Information on demo project for full update method	103
6.2.2	Operation Confirmation Environment for RL78/G21	105
6.2.2.1	Information on demo project for partial update method	106
6.2.2.2	Information on demo project for full update method	108
6.2.3	Operation Confirmation Environment for RL78/G22	110
6.2.3.1	Information on demo project for full update method	111
6.2.4	Operation Confirmation Environment for RL78/G23	113
6.2.4.1	Information on demo project for partial update method	114
6.2.4.2	Information on demo project for full update method	116
6.2.5	Operation Confirmation Environment for RL78/G24	118
6.2.5.1	Information on demo project for partial update method	119
6.2.5.2	Information on demo project for full update method	121
6.2.6	Operation Confirmation Environment for RL78/L23	123
6.2.6.1	Information on demo project for dual-bank(2-bank) method	124
6.2.6.2	Information on demo project for partial update method	126
6.2.6.3	Information on demo project for full update method	128
7.	Notes	130
7.1	Notes on Transition from Bootloader to Application	130
7.2	Security measures for the bootloader area	130

7.3 Updating the Data Flash Area 130

Revision History 131

1. Overview

1.1 About the Firmware Update Module

A firmware update is a process in which a device overwrites its own firmware, the software that controls the device's hardware, with a new version of the firmware (called the "update image" in this document) obtained through unspecified means. Firmware updates may be applied to fix bugs, add new functions, or improve performance.

The firmware update module is middleware that, when firmware update functionality is added to the user's system, provides the following functionality as its components:

- Functionality for importing the update image to the MCU via a communication interface
- Functionality for validating the update image (ECDSA NIST P-256 and SHA256 are used for validation.)
- Functionality for programming the update image to the on-chip flash memory (self-programming)
- Functionality for activating the update image

The firmware update module consists of the following two programs:

- Application program: User program + firmware update program
- Bootloader: A secure boot program that verifies the integrity of the application program and launches it

The bootloader functionality is essential to the proper functioning of the firmware update. It guarantees that the sequence of processing that composes the firmware update, including validation of the update image, is legitimate.

The firmware update module provides functionality for the following four firmware update methods. For details on each method, please refer to Section 1.3.

- Dual-Bank(2-Bank) method
- Partial update method
- Full update method (without buffer plane)
- Full update method (with buffer plane) *

*) Use external flash memory. For details, refer to Section 1.3.4.

A tool (Renesas Image Generator) for creating firmware images is provided as a utility. Renesas Image Generator can generate the following types of images for use by the firmware update module.

- Initial image: An image file containing the bootloader and application program that is programmed using Flash Writer at the time of initial system configuration (extension: mot).
- Update image: An image file containing the firmware update (extension: rsu).

1.2 Configuration of Firmware Update Module

Figure 1.1 shows the configuration of the modules in the bootloader and application program incorporating the firmware update module, and Table 1.1 lists the modules used in the bootloader and application program.

The update image received by the communication interface is self-programmed to the on-chip flash memory of the target device via the firmware update module and the flash memory driver.

Figure 1.1 shows the configuration of the firmware update module for the RL78/G21, G22, G23, G24, and L23. Table 1.1 lists the modules.

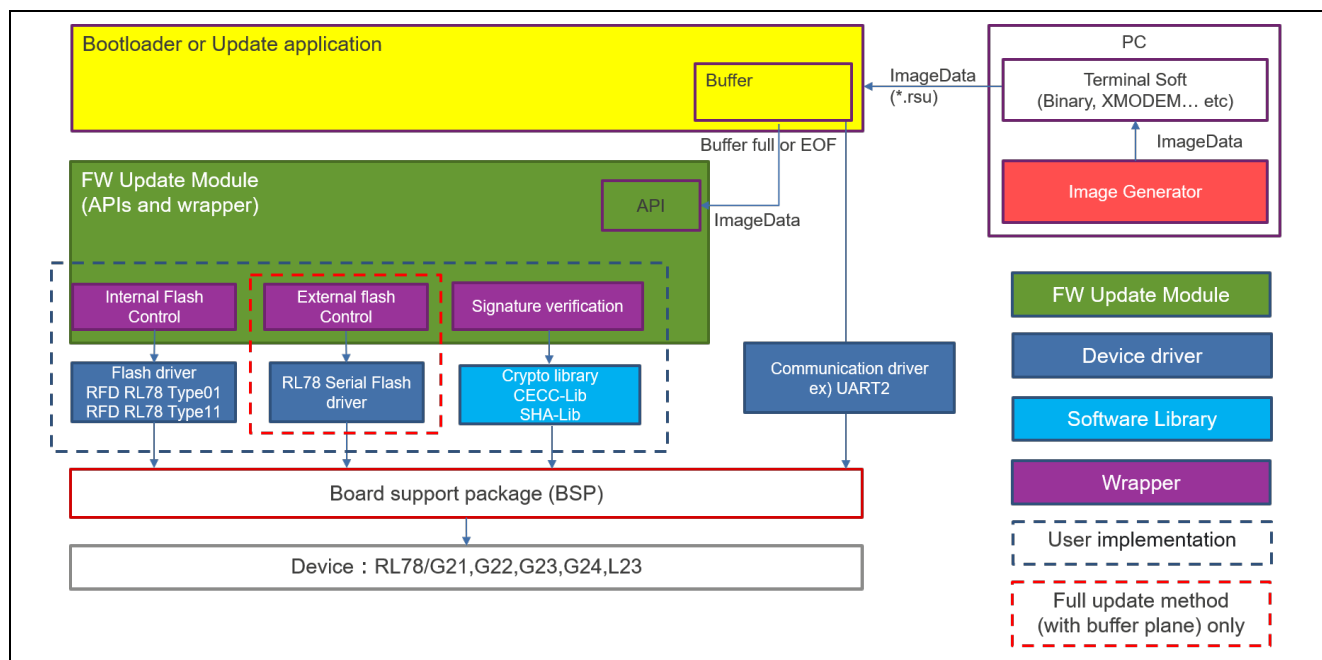


Figure 1.1 Firmware Update Module Configuration for RL78/G21, G22, G23, G24, and L23

Table 1.1 List of Modules Used by the Firmware Update Module for RL78/G21, G22, G23, G24, and L23

Function	Module Name	Notes
BSP	r_bsp	Automatic generation by Smart Configurator
UART	r_Config_UART1 : RL78/G21, RL78/G22, RL78/G24, RL78/L23 r_Config_UART2 : RL78/G23	Automatic generation by Smart Configurator
PORT	r_Config_PORT	Automatic generation by Smart Configurator
FLASH	RFD RL78 Type01 : RL78/G21, RL78/G22, RL78/G23, RL78/G24 RFD RL78 Type11 : RL78/L23	Automatic generation by Smart Configurator
CSI	Config_CSI00* : RL78/G21 Config_CSI20* : RL78/G24 Config_CSI31* : RL78/G23, RL78/L23	Automatic generation by Smart Configurator
Serial Flash	r_nor_flash*	Automatic generation by Smart Configurator
Crypt Library	CompactECC-Lib SHA-Lib	Implemented in wrapper

*) This module is only required for full update method (with buffer plane). It is not required for any other methods.

Figure 1.2 shows the configuration of the firmware update module for the RL78/G13. Table 1.2 lists the modules.

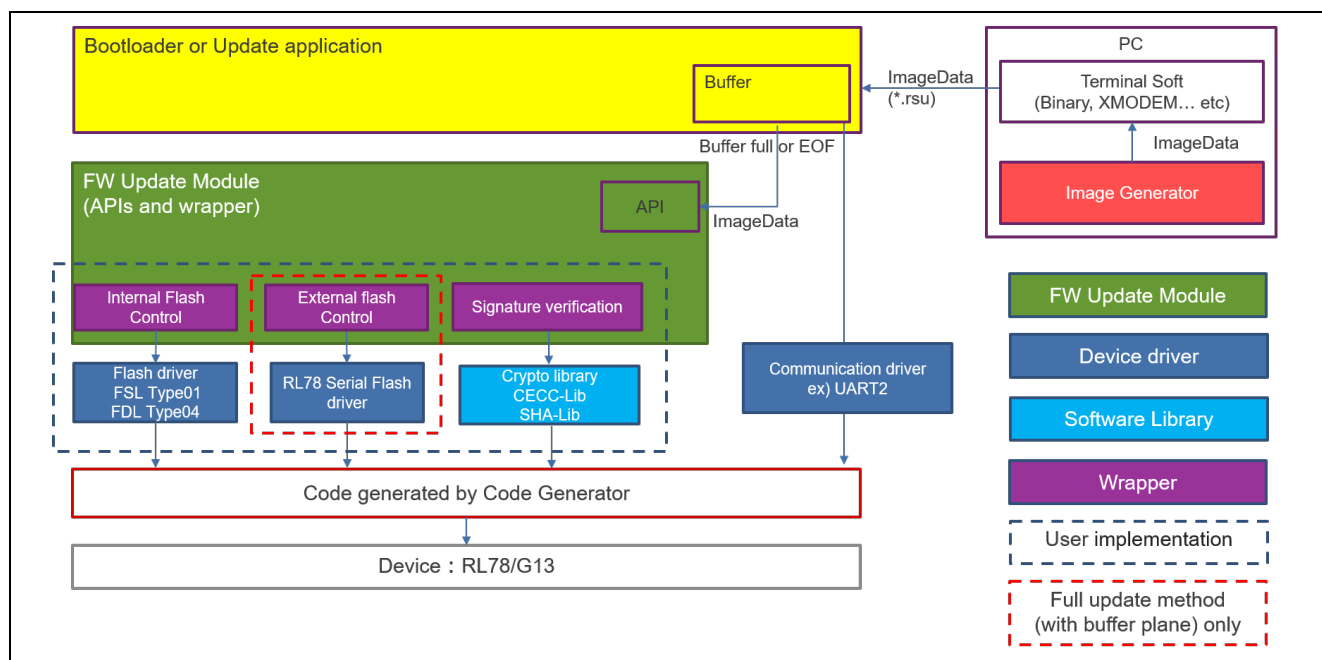


Figure 1.2 Firmware Update Module Configuration for RL78/G13

Table 1.2 List of Modules Used by the Firmware Update Module for RL78/G13

Function	Module Name	Notes
UART	UART2	Automatic generation by Code Generator
PORT	PORT	Automatic generation by Code Generator
FLASH	FSL Type01 FDL Type04	—
CSI	CSI31*	Automatic generation by Code Generator
Serial Flash	r_nor_flash*	
Crypt Library	CompactECC-Lib SHA-Lib	Implemented in wrapper

*) This module is only required for full update method (with buffer plane). It is not required for any other methods.

1.3 Firmware Update Operation

The RL78 family firmware update module provides two methods: once storing the firmware to be updated (update image) on the buffer plane and once writing it directly to the main plane. The buffer plane can be set in the internal flash memory or external flash memory.

- Main plane: Area for storing the image used for booting
- Buffer plane: Area for storing the image to be applied as an update

The method of writing the update image directly to the main plane allows all of the internal flash memory to be used as the main plane. However, since there is no buffer plane, it is not possible to restore the firmware to its pre-update state in the event of an update failure.

The update method support status varies by device and flash memory capacity, as detailed below.

Table 1.3 Supported Update Methods for Each Product

Flash Product	768KB	512KB	384KB	256KB	192KB	128KB	96KB	64KB
RL78/G13	—	L	L	L	L	L	L	L
RL78/G21	—	—	—	L	—	L	—	—
RL78/G22	—	—	—	—	—	—	—	L
RL78/G23	L	L	L	L	L	L	L	—
RL78/G24	—	—	—	—	—	L	—	L
RL78/L23	—	DB/L	—	DB/L	—	L	—	L
DB: Dual-Bank(2-Bank) Method L: Partial Update Method / Full Update Method -: Not supported red text: Demo Project								

1.3.1 Dual-Bank(2-Bank) Method

The update image is stored in the buffer plane in the on-chip flash memory, and, after it is validated, the banks are swapped, exchanging the main plane and buffer plane.

This method allows the application program to contain the firmware update functionality.

This means that if the firmware update fails before bank swapping occurs, the pre-update image in the main plane can be launched to retry the firmware update.

Since the on-chip flash memory is divided into two portions by the dual-bank(2-bank) functionality, the size of the on-chip flash memory available to store the application program is equal to the size of one of the two portions into which the on-chip flash memory has been divided minus the size of the bootloader.

1.3.1.1 Operation of Dual-Bank(2-Bank) Method

The update image is stored in the buffer plane using the dual-bank(2-bank) functionality of the on-chip flash memory, and the firmware update is accomplished by using the bank-swapping functionality to exchange the banks.

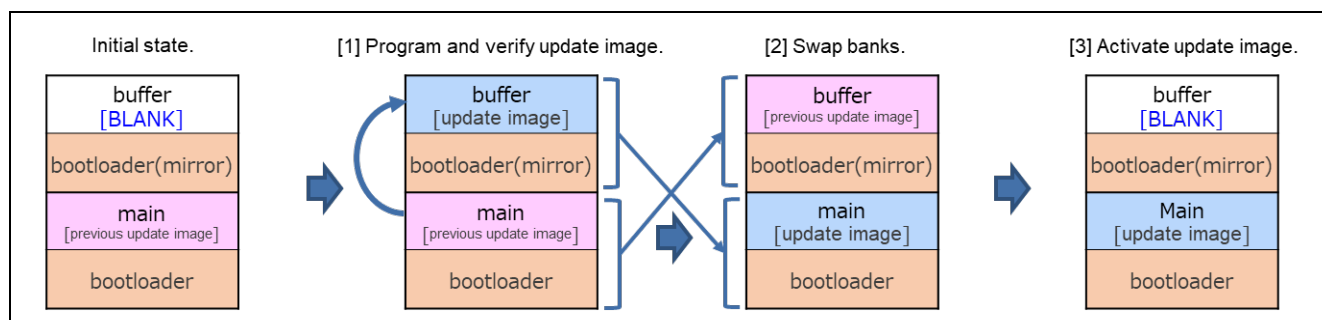


Figure 1.3 Operation of Dual-Bank(2-Bank) Method

[1] Program and verify update image.

The previous update image (application program) stored in the main plane is used to program the update image to the buffer plane and verify it.

[2] Swap banks.

If verification is successful, the banks are swapped.

[3] Activate update image.

The buffer plane is erased by the bootloader.

(The demo program does not erase the buffer plane. If you need to erase the image before updating for rollback measures, please add a process to erase the buffer plane image.)

1.3.2 Partial Update Method

The update image is stored temporarily in the buffer plane in the on-chip flash memory, and, after it is validated, it is self-programmed to the main plane.

This method allows the application program to contain the firmware update functionality.

This means that if the firmware update fails before self-programming to the main plane occurs, the pre-update image in the main plane can be launched to retry the firmware update.

The size that can store the application program is half the size of the remaining internal flash memory minus the bootloader.

1.3.2.1 Operation of Partial Update Method

This method divides the on-chip flash memory into a main plane and a buffer plane and then temporarily stores the update image in the buffer plane. Firmware is updated by storing the update image on the buffer plane and copying it from the buffer plane to the main plane.

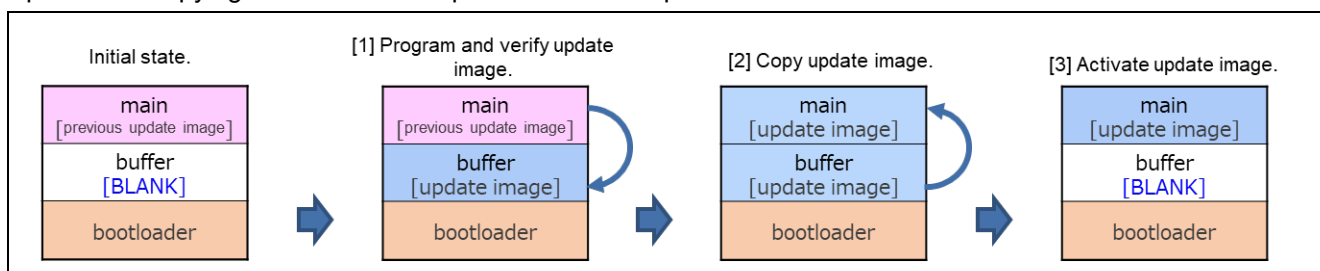


Figure 1.4 Operation of Partial Update Method

[1] Program and verify update image.

The previous update image (application program) stored in the main plane is used to program the update image to the buffer plane and verify it.

[2] Copy update image.

If verification is successful, the system is reset, the main plane is erased by the bootloader, and the updated image is copied from the buffer plane to the main plane.

[3] Activate update image.

The buffer plane is erased by the bootloader.

1.3.3 Full Update Method (without buffer plane)

The update image is self-programmed to the main plane, after which it is validated.

This method requires the bootloader to contain the firmware update functionality. This means that if the firmware update fails, the bootloader functionality can be used to retry the firmware update. The functionality of the application program cannot be used until the firmware update succeeds.

The size that can store the application program is the remaining size of the internal flash memory minus the bootloader.

1.3.3.1 Operation of Full Update Method (without buffer plane)

This method of writing the update image directly to the main plane allows all of the internal flash memory to be used as the main plane, but since there is no buffer plane, it is not possible to restore the firmware to its pre-update state in the event of an update failure.

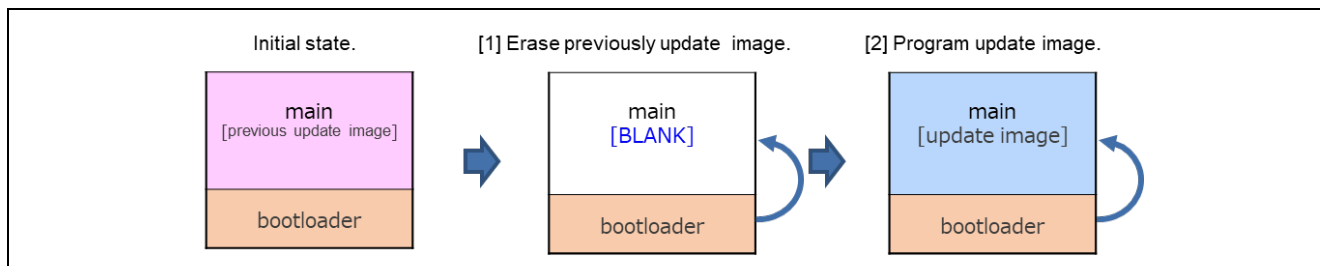


Figure 1.5 Operation of Full Update Method (without buffer plane)

[1] Erase previously update image.

The previous update image (application program) stored in the main plane configures the data indicating updates to the main plane and then applies a reset. After this, the bootloader runs and erases the initial image from the main plane.

[2] Program update image.

The bootloader downloads the update image from an external source and programs it to the main plane. The programmed update image is verified, and if verification is successful, the update image is activated.

1.3.4 Full Update Method (with buffer plane)

The update image is stored temporarily in the buffer plane in the on-chip flash memory, and, after it is validated, it is self-programmed to the main plane.

This method allows the application program to contain the firmware update functionality. This means that if the firmware update fails before self-programming to the main plane occurs, the pre-update image in the main plane can be launched to retry the firmware update.

The size that can store the application program is the size remaining after subtracting the bootloader from the internal flash memory, since only the main plane is provided in the internal flash memory.

1.3.4.1 Operation of Full Update Method (with buffer plane)

The update image is stored once in the buffer plane, with the main plane set in the internal flash and the buffer plane set in the external flash.

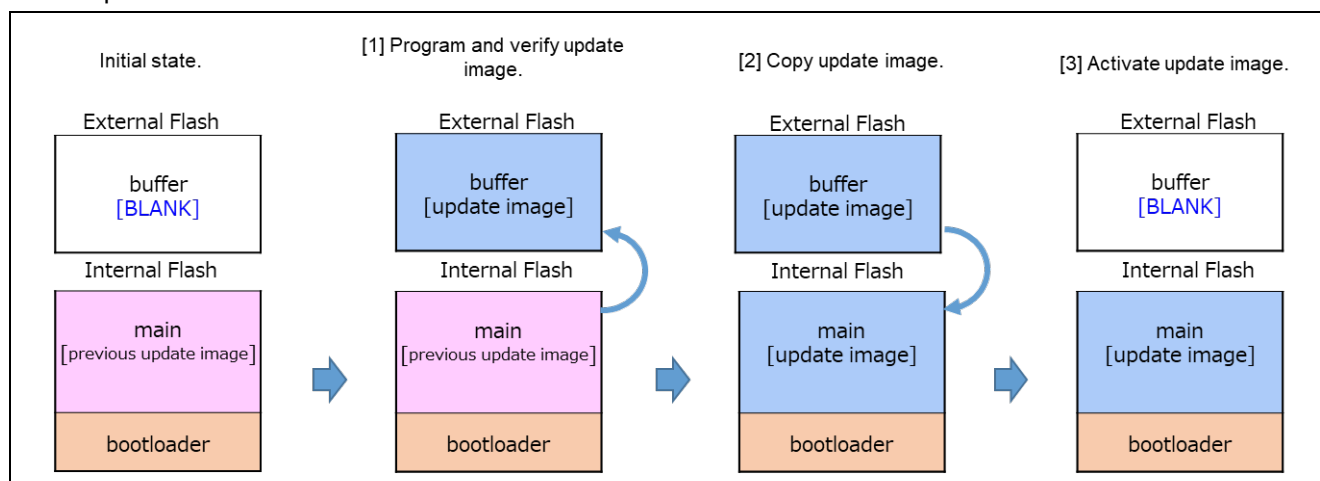


Figure 1.6 Operation of Full Update Method (with buffer plane)

[1] Program and verify update image.

The previous update image (application program) stored in the main plane is used to program the update image to the buffer plane and verify it.

[2] Copy update image.

If verification is successful, the system is reset, the main plane is erased by the bootloader, and the updated image is copied from the buffer plane to the main plane.

[3] Activate update image.

The buffer plane is erased by the bootloader.

1.4 Initial State of Firmware Update

To set the firmware update module using the firmware update module to the initial state, build the system by writing the initial image generated by the Renesas Image Generator to the built-in flash memory with a flash writer or similar device.

As an alternative method, it is also possible to build the system by first writing only the bootloader with a flash writer, etc., and then writing the updated image of the application program with the bootloader function.

1.4.1 Initial State of Dual-Bank(2-Bank) Method Settings Utilizing Renesas Image Generator

The following figure shows the construction of the initial state of the dual-bank(2-bank) method using the Renesas Image Generator.

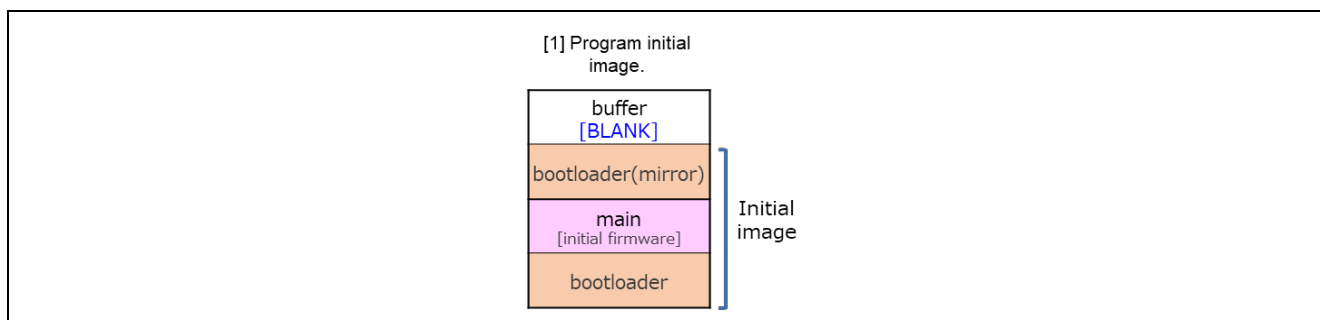


Figure 1.7 Initial Firmware Update Settings Utilizing Renesas Image Generator (Example of Dual-Bank(2-Bank) Method)

[1] Program initial image

The initial image is programmed to the on-chip flash memory using a tool such as Flash Writer.

1.4.2 Initial State of Partial Update Method Settings Utilizing Renesas Image Generator

The following figure shows the construction of the initial state of the partial update method using the Renesas Image Generator.

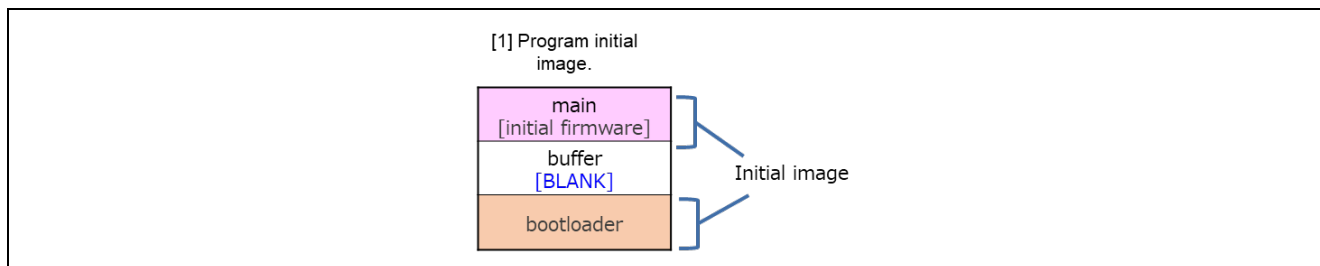


Figure 1.8 Initial Firmware Update Settings Utilizing Renesas Image Generator (Example of Partial Update Method)

[1] Program initial image

The initial image is programmed to the on-chip flash memory using a tool such as Flash Writer.

1.4.3 Initial State of Full Update Method Settings Utilizing Renesas Image Generator

The following figure shows the construction of the initial state of the full update method using the Renesas Image Generator.

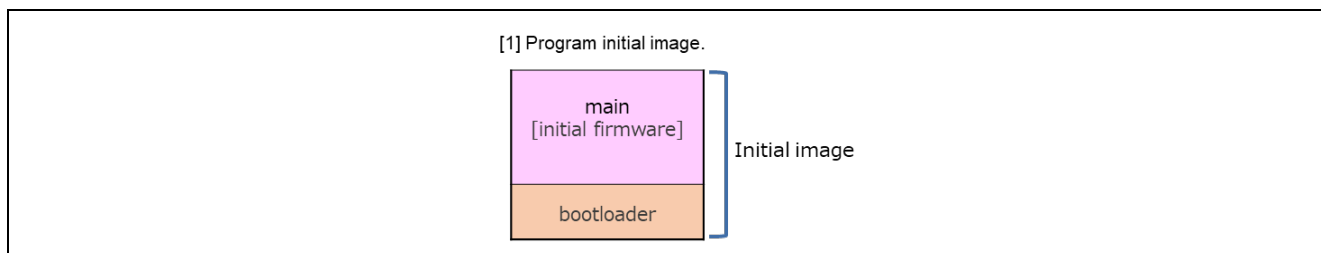


Figure 1.9 Initial Firmware Update Settings Utilizing Renesas Image Generator (Example of Full Update Method)

[1] Program initial image

The initial image is programmed to the on-chip flash memory using a tool such as Flash Writer.

1.4.4 Initial State of Dual-Bank(2-Bank) Method Settings Utilizing Bootloader

The following figure shows the construction of the initial state of the dual-bank(2-bank) method using the bootloader.

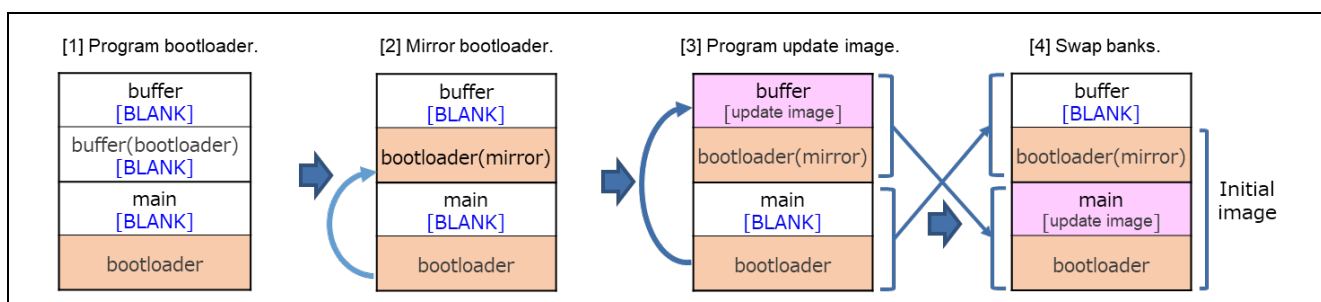


Figure 1.10 Initial Firmware Update Settings Utilizing Bootloader (Example of Dual-Bank(2-Bank) Method)

[1] Program bootloader.

The bootloader is programmed to the on-chip flash memory using a tool such as Flash Writer.

[2] Mirror bootloader.

The bootloader is mirrored to bank 1 by the bootloader.

[3] Program update image.

The initial image is downloaded from an external source and programmed to the buffer plane using the functionality of the bootloader. The programmed firmware is verified.

[4] Swap banks.

If verification is successful, the banks are swapped and processing ends.

1.4.5 Initial State of Partial Update Method Settings Utilizing Bootloader

The following figure shows the construction of the initial state of the dual-bank(2-bank) method using the bootloader.

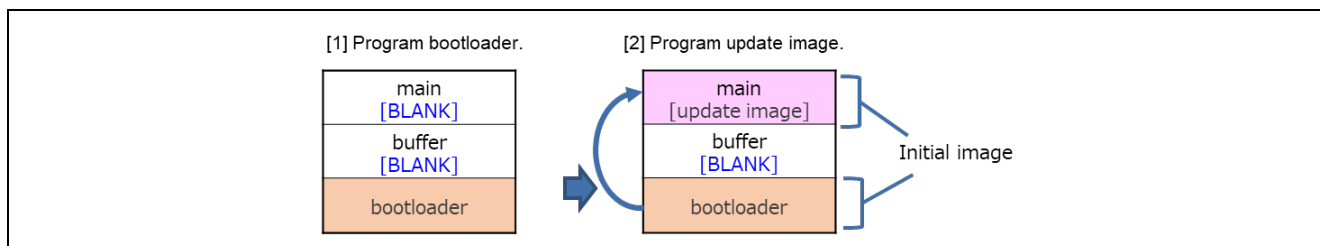


Figure 1.11 Initial Firmware Update Settings Utilizing Bootloader (Example of Partial Update Method)

[1] Program bootloader.

The bootloader is programmed to the on-chip flash memory using a tool such as Flash Writer.

[2] Program update image.

The initial image is downloaded from an external source and programmed to the main plane using the functionality of the bootloader. The programmed firmware is verified, and if verification is successful, processing ends.

1.4.6 Initial State of Full Update Method Settings Utilizing Bootloader

The following figure shows the construction of the initial state of the full update method using the bootloader.

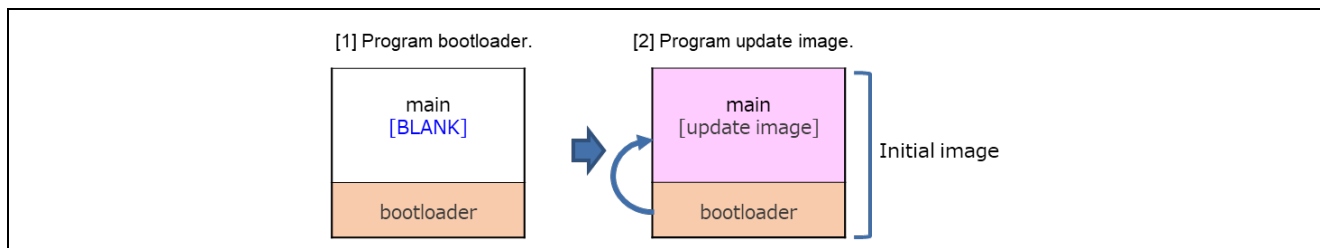


Figure 1.12 Initial Firmware Update Settings Utilizing Bootloader (Example of Full Update Method)

[1] Program bootloader.

The bootloader is programmed to the on-chip flash memory using a tool such as Flash Writer.

[2] Program update image.

The initial image is downloaded from an external source and programmed to the main plane using the functionality of the bootloader. The programmed firmware is verified, and if verification is successful, processing ends.

1.5 Package Contents

The firmware update module package contains several files, including software and tools. These are listed in the table below.

Table 1.4 Folder Structure of Firmware Update Module Package

Folder Name	Description
r01an6374xx0300-rl78-fwupdate.zip\	
├─demos	Demo projects
│ └─r_fwup	Firmware update module
│ └─rl	
│ │ └─modules	Drivers, libraries, and wrappers
│ │ │ └─CECC-Lib	CompactECC Library
│ │ │ └─etc	
│ │ │ └─base64	Base64 decode, Serial output
│ │ │ └─flash	Flash Library
│ │ │ └─sha	SHA Library
│ │ └─r_nor_flash_rl78	Serial NOR Flash Memory Module
└─rl78g13-tb	QB-R5F100SL-TB
│ └─linear	
│ │ └─e2_ccrl	CCRL
│ │ │ └─boot_loader	Bootloader
│ │ │ └─fwup_leddemo	LED illumination application
│ │ │ └─fwup_main	User applications including firmware update
│ │ └─llvm	LLVM
└─rl78g21-fpb	FPB-RL78G21
│ └─linear	
│ │ └─e2_ccrl	CCRL
│ │ │ └─boot_loader	Bootloader
│ │ │ └─fwup_leddemo	LED illumination application
│ │ │ └─fwup_main	User applications including firmware update
│ │ └─iar	IAR
│ │ └─llvm	LLVM
└─rl78g22-fpb	FPB-RL78G22
│ └─linear	
│ │ └─e2_ccrl	CCRL
│ │ │ └─boot_loader	Bootloader
│ │ │ └─fwup_leddemo	LED illumination application
│ │ └─iar	IAR
│ │ └─llvm	LLVM
└─rl78g23-fpb	FPB-RL78G23-128p
│ └─linear	
│ │ └─e2_ccrl	CCRL
│ │ │ └─boot_loader	Bootloader
│ │ │ └─fwup_leddemo	LED illumination application
│ │ │ └─fwup_main	User applications including firmware update
│ │ └─iar	IAR
│ │ └─llvm	LLVM

Folder Name	Description
rl78g24-fpb	FPB-RL78G24
linear	
e2_ccrl	CCRL
boot_loader	Bootloader
fwup_leddemo	LED illumination application
fwup_main	User applications including firmware update
iar	IAR
llvm	LLVM
rl78l23-fpb	FPB-RL78L23
dualbank(2bank)	Dual-Bank(2-Bank) method
e2_ccrl	CCRL
boot_loader	Bootloader
fwup_leddemo	LED illumination application
fwup_main	User applications including firmware update
iar	IAR
llvm	LLVM
linear	Other than the Dual-Bank method
e2_ccrl	CCRL
boot_loader	Bootloader
fwup_leddemo	LED illumination application
fwup_main	User applications including firmware update
iar	IAR
llvm	LLVM
RenesasImageGenerator	Renesas Image Generator
image-gen.py	Python program for Renesas Image Generator
RL78_xxxx_ImageGenerator_PRM.csv	Parameter file for demo project (for CC-RL, IAR)
RL78_xxxx_ImageGenerator_PRM_llvm.csv	Parameter file for demo project (for LLVM)

1.6 API Overview

Table 1.5 lists the API functions included in the firmware update module.

Table 1.5 API Functions

Function	Function Description
R_FWUP_Open	Opens the module.
R_FWUP_Close	Performs processing to close the module.
R_FWUP_IsExistImage	Confirms the existence of an image in the specified area.
R_FWUP_EraseArea	Erases the specified area.
R_FWUP_GetImageSize	Obtains the size of the image.
R_FWUP_WriteImage	Writes the image (header portion + program portion).
R_FWUP_VerifyImage	Validates the image.
R_FWUP_ActivateImage	Activates a new image.
R_FWUP_ExecuteImage	Launches an image.
R_FWUP_SoftwareReset	Applies a software reset.
R_FWUP_SoftwareDelay	Applies a software delay.
R_FWUP_GetVersion	Returns the version number of the module.
R_FWUP_WriteImageHeader	Writes the header portion of the image. (For special purpose.)
R_FWUP_WriteImageProgram	Writes the program portion of the image. (For special purpose.)

Note: Special purpose refers to the use of AWS S3(OTA). If you are considering to use Rev2.0x firmware update module on bare metal without AWS S3(OTA), please skip this section.

2. API Information

2.1 Hardware Requirements

The MCU used must support the following functions:

- Flash memory

2.2 Software Requirements

The module is dependent upon the following drivers:

- Board support package (r_bsp)
- UART Driver (r_Config_UART)
- PORT Driver (r_Config_PORT)
- CSI Driver (r_Config_CSI)
- Renesas Flash Driver RL78 Type01 (RFD)*
- Renesas Flash Driver RL78 Type11 (RFD)*
- Flash Self-Programming Library Type 01 (FSL)*
- Data Flash Library Type 04 (FDL)*
- Serial NOR Flash Memory Control Module Software Integration System (r_nor_flash)
- Crypto Library (CompactECC library, SHA Hash function library)

*) The RL78/G13 uses the FSL/FDL flash library, while the other devices use the RFD flash driver.

2.3 Supported Toolchains

The module has been confirmed to work with the toolchains listed in Section 6.1, Confirmed Operation Environments.

2.4 Header Files

All API calls and their supporting interface definitions are located in r_fwup_if.h.

2.5 Integer Types

The driver uses ANSI C99. These types are defined in stdint.h.

2.6 Compile Settings

The configuration option settings of the module are contained in `r_fwup_config.h`.

The names of the options and descriptions of their setting values are listed in Table 2.1.

Table 2.1 Configuration Settings

Configuration options in <code>r_fwup_config.h</code>	
<code>FWUP_CFG_UPDATE_MODE</code>	Update method 0: Dual-Bank(2-Bank) Method (RL78/L23 only) 1: Partial Update Method 2: Full Update Method (without buffer plane) 3: Full Update Method (with buffer plane)
<code>FWUP_CFG_FUNCTION_MODE</code>	Specifies how the module is used. 0: Bootloader 1: Application program
<code>FWUP_CFG_MAIN_AREA_ADDR_L</code>	Specifies the start address of the main plane.
<code>FWUP_CFG_BUF_AREA_ADDR_L</code>	Specifies the start address of the buffer plane (in on-chip flash memory).
<code>FWUP_CFG_AREA_SIZE</code>	Specifies the size of the main plane and buffer plane.
<code>FWUP_CFG_CF_BLK_SIZE</code>	Specifies the block size of the on-chip code flash.
<code>FWUP_CFG_CF_W_UNIT_SIZE</code>	Specifies the writing unit for the on-chip code flash.
<code>FWUP_CFG_EXT_BUF_AREA_ADDR_L</code>	Specifies the start address of the buffer plane in external flash memory.
<code>FWUP_CFG_EXT_BUF_AREA_BLK_SIZE</code>	Specifies the block size or sector size of the external flash memory.
<code>FWUP_CFG_DF_ADDR_L</code>	Start address of data flash.
<code>FWUP_CFG_DF_BLK_SIZE</code>	Block size of data flash.
<code>FWUP_CFG_DF_NUM_BLKs</code>	Block count of data flash. Specify 0 if there is no data flash.
<code>FWUP_CFG_FWUPV1_COMPATIBLE</code>	FWUP V1 Compatibility Setting (For Special Purpose) 0: Disable (default) 1: Enable (For Special Purpose)
<code>FWUP_CFG_SIGNATURE_VERIFICATION</code>	Verification method 0: ECDSA + SHA256 (default) 1: SHA256
<code>FWUP_CFG_PRINTF_DISABLE</code>	Log display setting 0: Enable 1: Disable (default)

2.7 Demo Project Code Sizes

The table below shows the ROM size, RAM size, and maximum stack size of this module.

The values in the table below are confirmed under the following conditions.

Module revision: Firmware update module for RL78 v3.0.0

Compiler version: Renesas Electronics C Compiler Package for RL78 Family V1.16.0

IAR C/C++ Compiler for Renesas RL78 version 5.20.2

LLVM for Renesas RL78 17.0.1.202606

Configuration options: Configuration option settings are listed in each board

CC-RL

Optimization level: size & execution speed (-Odefault)

Delete variables/functions that have never been referenced (-optimize=symbol_delete)

IAR

Optimization level: High (balanced)

LLVM

Optimization level: -Os

Garbage collection (--gc-sections)

2.7.1 Demo Project for QB-R5F100SL-TB

Partial update method configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 1 : Single bank with buffer. (default)

FWUP_CFG_SIGNATURE_VERIFICATION 0 : ECDSA+SHA256. (default)

FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.2 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)	
		CC-RL	LLVM
boot_loader	ROM	22043	24773
	RAM	575	638
	Stack	658	614

Table 2.3 ROM, RAM, and Stack Code Size for fwup_main

Items	Category	Memory Used (byte)	
		CC-RL	LLVM
fwup_main	ROM	19455	22356
	RAM	573	636
	Stack	658	614

Note) The firmware update module for the RL78/G13 does not support the IAR compiler. This is because some of the mandatory drivers used for firmware updates do not support the IAR compiler.

2.7.2 Demo Project for FPB-RL78G21

Partial update method configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 1 : Single bank with buffer. (default)
 FWUP_CFG_SIGNATURE_VERIFICATION 0 : ECDSA+SHA256. (default)
 FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.4 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
boot_loader	ROM	21801	28077	23879
	RAM	1105	3428	1662
	Stack	658	1892	614

Table 2.5 ROM, RAM, and Stack Code Size for fwup_main

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
fwup_main	ROM	19231	26173	21375
	RAM	1103	3428	1660
	Stack	658	1898	614

2.7.3 Demo project for FPB-RL78G22

Full update method (without buffer plane) configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 2 : Single bank without buffer.
 FWUP_CFG_SIGNATURE_VERIFICATION 1 : SHA256
 FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.6 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
boot_loader	ROM	11230	12229	11451
	RAM	1019	2293	1534
	Stack	658	1006	400

2.7.4 Demo Project for FPB-RL78G23-128p

Partial update method configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 1 : Single bank with buffer. (default)
 FWUP_CFG_SIGNATURE_VERIFICATION 0 : ECDSA+SHA256. (default)
 FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.7 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
boot_loader	ROM	22482	28158	24001
	RAM	1095	3428	1662
	Stack	658	1892	614

Table 2.8 ROM, RAM, and Stack Code Size for fwup_main

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
fwup_main	ROM	20049	26310	21569
	RAM	1097	3937	1660
	Stack	658	1898	614

2.7.5 Demo Project for FPB-RL78G24

Partial update method configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 1 : Single bank with buffer. (default)
 FWUP_CFG_SIGNATURE_VERIFICATION 0 : ECDSA+SHA256. (default)
 FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.9 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
boot_loader	ROM	22833	28718	24331
	RAM	1109	3460	1662
	Stack	658	1892	614

Table 2.10 ROM, RAM, and Stack Code Size for fwup_main

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
fwup_main	ROM	20395	26652	22634
	RAM	1111	3970	1660
	Stack	658	1898	614

2.7.6 Demo Project for FPB-RL78L23

Partial update method configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 1 : Single bank with buffer. (default)
 FWUP_CFG_SIGNATURE_VERIFICATION 0 : ECDSA+SHA256. (default)
 FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.11 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
boot_loader	ROM	22894	28701	23792
	RAM	959	3858	2558
	Stack	658	1900	614

Table 2.12 ROM, RAM, and Stack Code Size for fwup_main

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
fwup_main	ROM	20553	26559	21474
	RAM	956	4523	2556
	Stack	658	1896	614

Dual-bank(2-Bank) method configuration settings and memory size.

FWUP_CFG_UPDATE_MODE 0 : Dual-bank(2-Bank).
 FWUP_CFG_SIGNATURE_VERIFICATION 0 : ECDSA+SHA256. (default)
 FWUP_CFG_PRINTF_DISABLE 1 : Disable. (default)

Table 2.13 ROM, RAM, and Stack Code Size for boot_loader

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
boot_loader	ROM	22877	28576	24175
	RAM	1095	3440	1918
	Stack	658	1892	614

Table 2.14 ROM, RAM, and Stack Code Size for fwup_main

Items	Category	Memory Used (byte)		
		CC-RL	IAR	LLVM
fwup_main	ROM	20414	26673	21663
	RAM	1093	3437	1916
	Stack	658	1896	614

2.8 Arguments

The return values of the API functions are shown below. This enumeration is located in `r_fwup_if.h`, as are the prototype declarations of the API functions.

```
typedef enum fwup_area
{
    FWUP_AREA_MAIN = 0,
    FWUP_AREA_BUFFER,
    FWUP_AREA_DATA_FLASH
} e_fwup_area_t;

typedef enum e_fwup_delay_units
{
    FWUP_DELAY_MICROSECS = 0,
    FWUP_DELAY_MILLISECS,
    FWUP_DELAY_SECS
} e_fwup_delay_units_t;
```

2.9 Return Values

The return values of the API functions are shown below. This enumeration is located in `r_fwup_if.h`, as are the prototype declarations of the API functions.

```
typedef enum fwup_err
{
    FWUP_SUCCESS = 0,                // Normally terminated.
    FWUP_PROGRESS,                  // Firmware update is in progress.
    FWUP_ERR_FLASH,                  // Detect error of flash module.
    FWUP_ERR_VERIFY,                 // Verify error.
    FWUP_ERR_FAILURE,                // General error.
} e_fwup_err_t;
```

2.10 Implementation Examples of APIs

The following is an example implementation of a bootloader and application program for each firmware update method.

For details, please refer to the source code of the demo project included in this application note package.

2.10.1 Implementation Example of Dual-Bank(2-Bank) Method

The following flowchart is an example of implementation of a bootloader in dual-bank(2-bank) method.

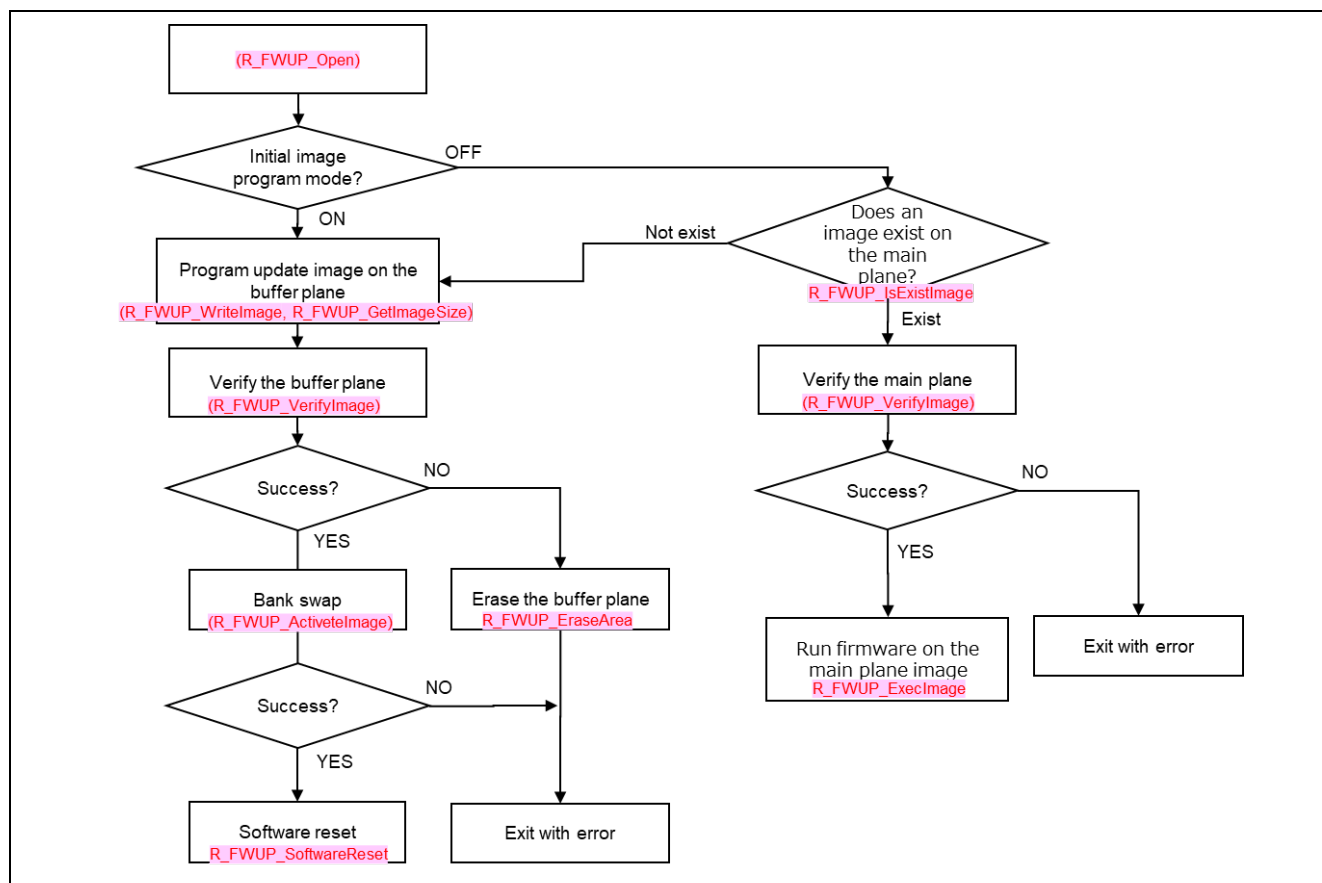


Figure 2.1 Bootloader Implementation Example of Dual-Bank(2-Bank) Method

The following flowchart is an example of implementation of an application program in dual-bank(2-bank) method.

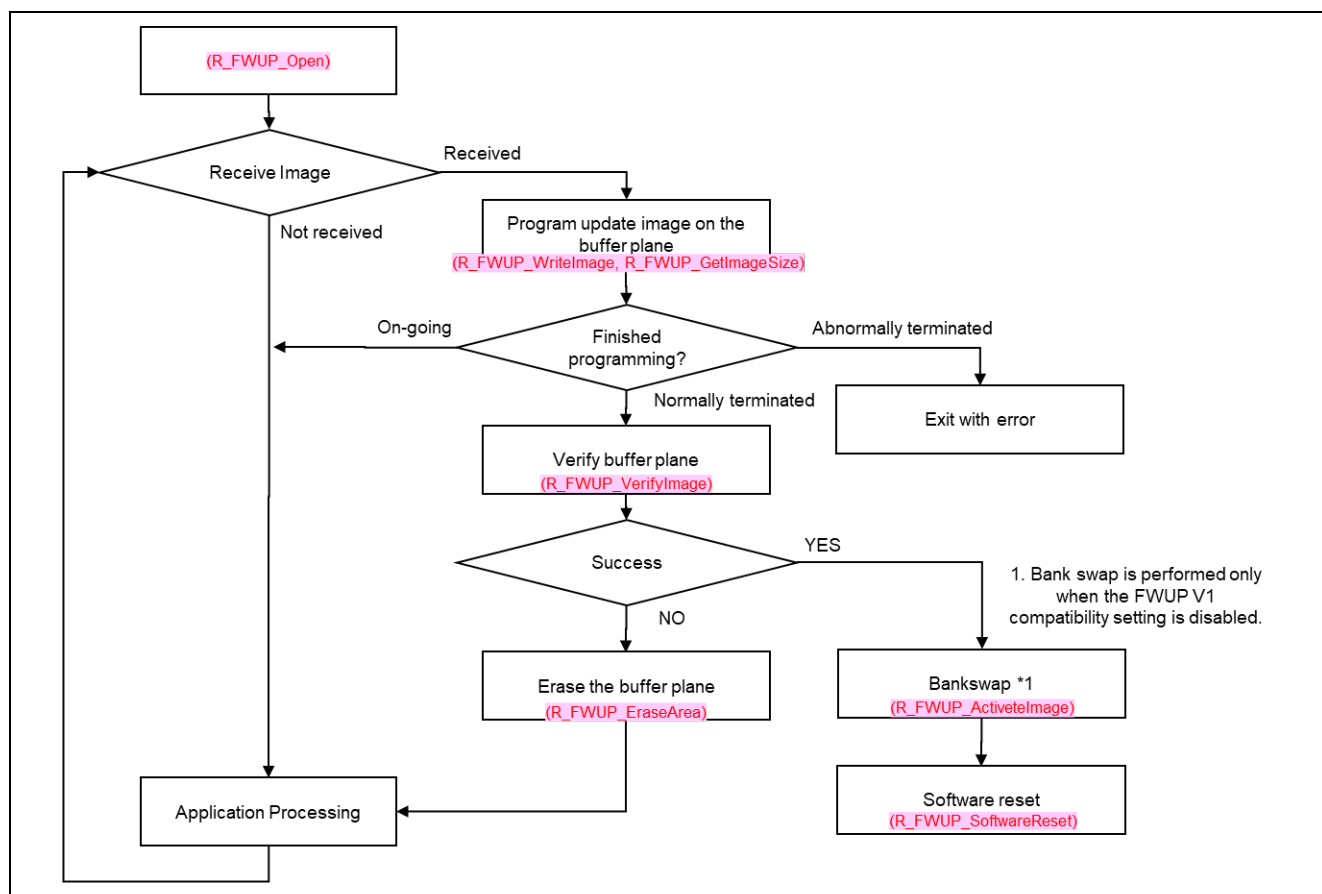


Figure 2.2 Application Program Implementation Example of Dual-Bank(2-Bank) Method

2.10.2 Implementation Example of Partial Update Method and Full Update Method (with buffer plane)

The following flowchart is an example of implementation of a bootloader in partial update method and full update method (with buffer plane).

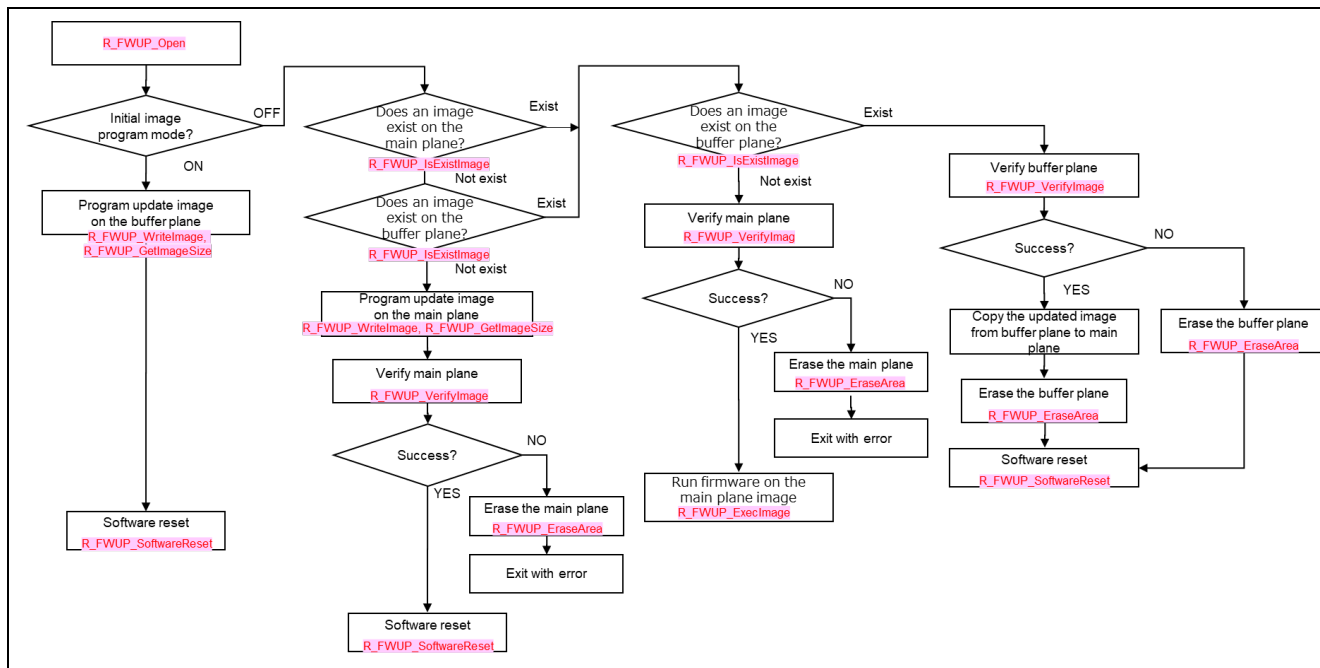


Figure 2.3 Bootloader Implementation Example of Partial Update Method and Full Update Method (with buffer plane)

The following flowchart is an example of implementation of an application program in partial update method and full update method (with buffer plane).

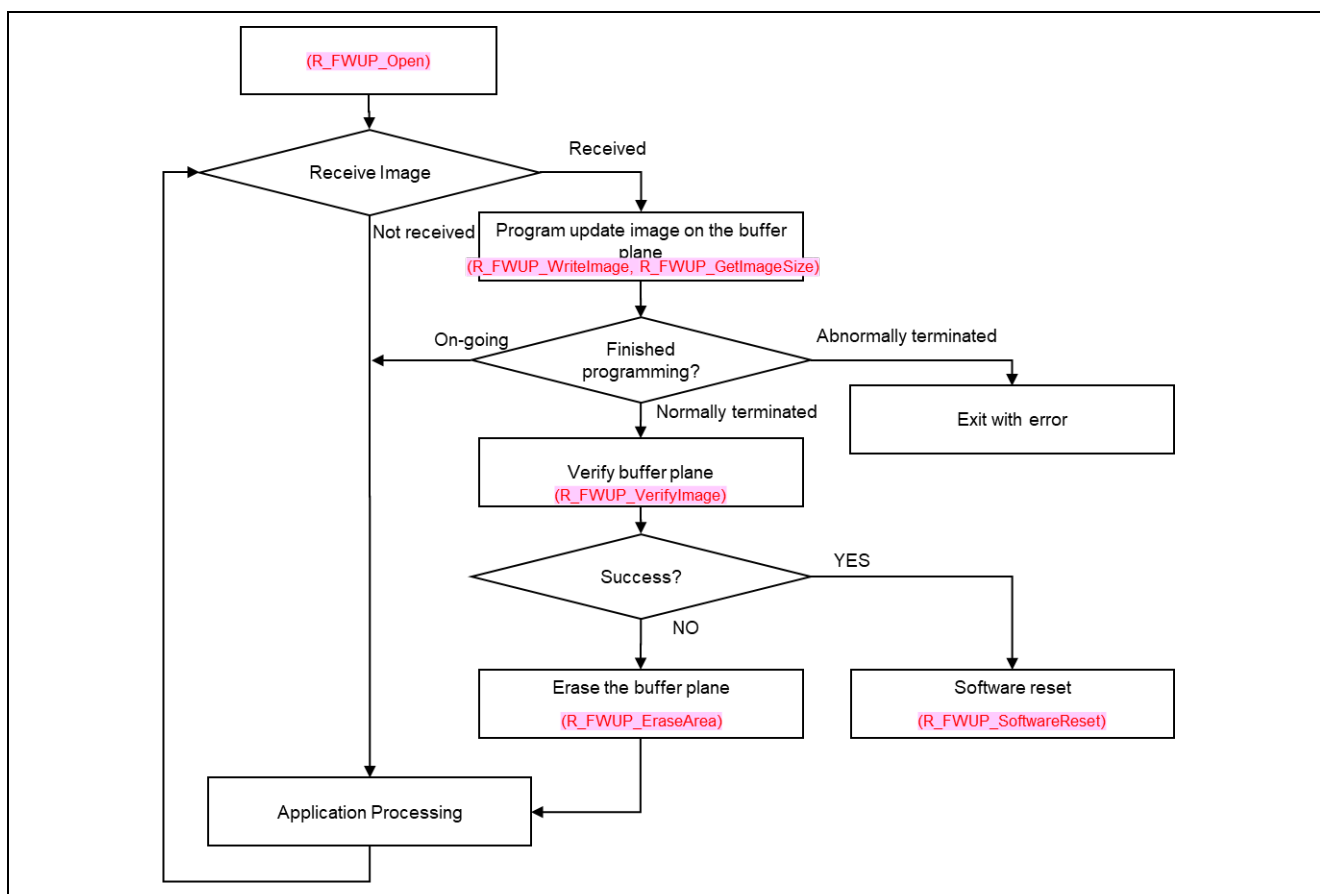


Figure 2.4 Application Program Implementation Example of Partial/Full Update Method (with buffer plane)

2.10.3 Implementation Example of Full Update Method (without buffer plane)

The following flowchart is an example of implementation of a bootloader in full update method (without buffer plane).

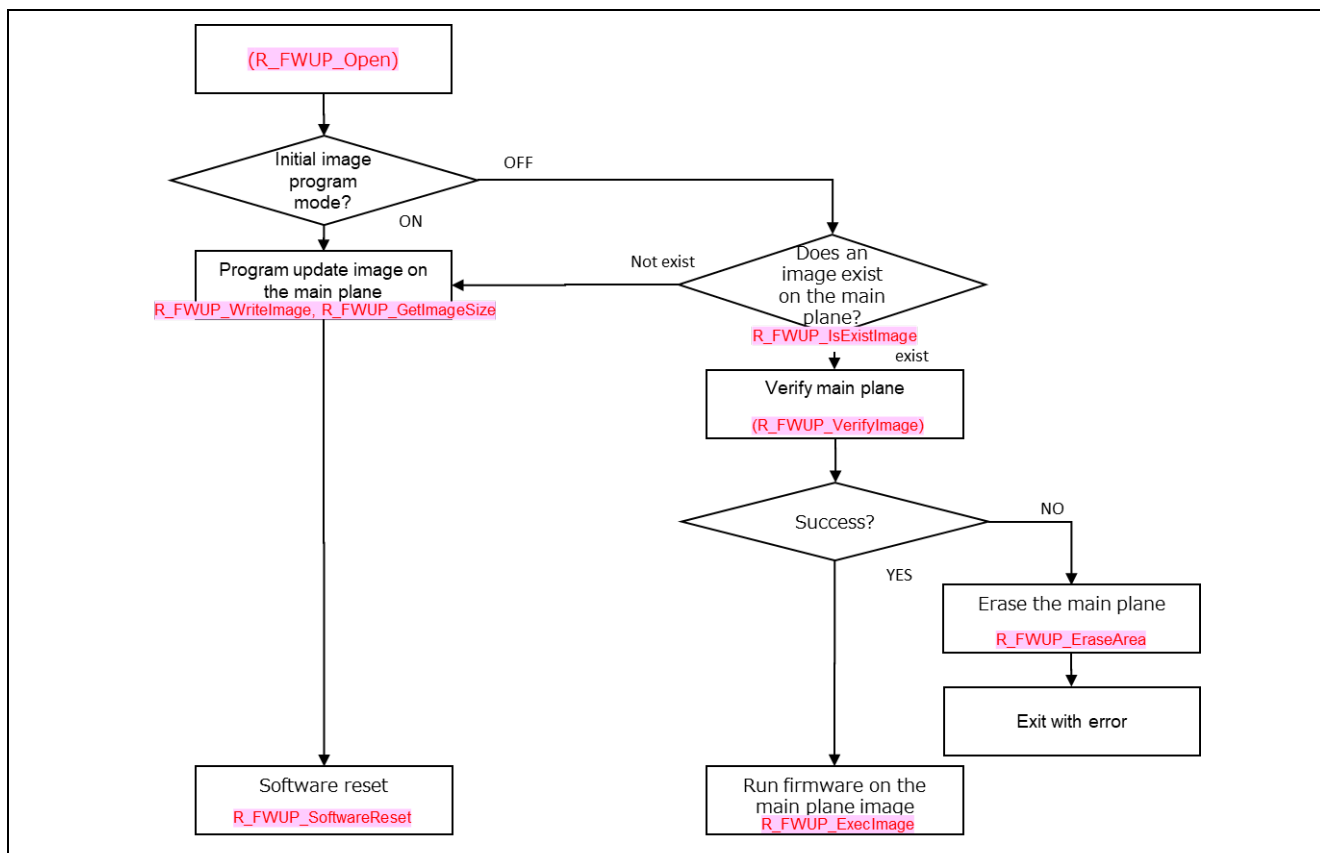


Figure 2.5 Bootloader Implementation Example of Full Update Method (without buffer plane)

3. API Functions

3.1 R_FWUP_Open Function

Table 3.1 R_FWUP_Open Function Specifications

Format	e_fwup_err_t R_FWUP_Open (void)		
Description	Performs processing to open the firmware update module. Implements processing to open the flash module.		
Parameters	None		
Return	FWUP_SUCCESS	Normal end	
Values	FWUP_ERR_FLASH	Flash module error	
Special Notes	—		

3.2 R_FWUP_Close Function

Table 3.2 R_FWUP_Close Function Specifications

Format	void R_FWUP_Close (void)		
Description	Performs processing to close the firmware update module. Implements processing to close the flash module.		
Parameters	None		
Return Values	None		
Special Notes	—		

3.3 R_FWUP_IsExistImage Function

Table 3.3 R_FWUP_IsExistImage Function Specifications

Format	bool R_FWUP_IsExistImage(e_fwup_area_t area)		
Description	Confirms the existence of an image in the specified area.		
Parameters	area: Main plane (FWUP_AREA_MAIN) or buffer plane (FWUP_AREA_BUFFER)		
Return	true	Image exists.	
Values	false	Image does not exist.	
Special Notes	Verify that the magic code is written correctly.		

3.4 R_FWUP_EraseArea Function

Table 3.4 R_FWUP_EraseArea Function Specifications

Format	e_fwup_err_t R_FWUP_EraseArea(e_fwup_area_t area)
Description	Erases the specified area.
Parameters	area: Main plane (FWUP_AREA_MAIN) or buffer plane (FWUP_AREA_BUFFER), Data Flash (FWUP_AREA_DATA_FLASH)
Return Values	FWUP_SUCCESS Normal end
	FWUP_ERR_FLASH Flash module error
Special Notes	Erasure of the main plane can only be performed by the bootloader.

3.5 R_FWUP_GetImageSize Function

Table 3.5 R_FWUP_GetImageSize Function Specifications

Format	uint32_t R_FWUP_GetImageSize(void)
Description	Returns the size of the image in bytes. This function obtains the byte size of the image based on the RSU header address information shown in Figure 4.1. Therefore, first write the RSU header address information to code flash using the R_FWUP_WriteImage function or the R_FWUP_WriteImageProgram function.
Parameters	None
Return Values	0 Acquisition in progress
	1 or more Image size
Special Notes	—

3.6 R_FWUP_WriteImage Function

Table 3.6 R_FWUP_WriteImage Function Specifications

Format	e_fwup_err_t R_FWUP_WriteImage(e_fwup_area_t area, uint8_t *p_buf, uint32_t buf_size)
Description	Writes an image (header portion + program portion) to the specified area. Continue calling this function until the total size of the image is reached. The image size is obtained by R_FWUP_GetImageSize().
Parameters	area: Main plane (FWUP_AREA_MAIN) or buffer plane (FWUP_AREA_BUFFER) p_buf: Image (header + program) buffer buf_size: Buffer size*1
Return Values	FWUP_SUCCESS Writing of all images is completed.
	FWUP_PROGRESS Writing of all images not completed (Writing of the specified number of images completed)
	FWUP_ERR_FLASH Flash module error
	FWUP_ERR_FAILURE Illegal parameter
Special Notes	1. Specify a multiple of the code flash write unit (for example, 64, 128, or 256). This size also applies to data flash. When FWUP_CFG_FWUPV1_COMPATIBLE is enabled, the magic code in the RSU header area used for processing is "Renesas" for FWUP V1.

3.7 R_FWUP_VerifyImage Function

Table 3.7 R_FWUP_VerifyImage Function Specifications

Format	e_fwup_err_t R_FWUP_VerifyImage(e_fwup_area_t area)	
Description	Verifies an image using the cryptographic library embedded in the module.	
Parameters	area: Main plane (FWUP_AREA_MAIN) or buffer plane (FWUP_AREA_BUFFER)	
Return Values	FWUP_SUCCESS	Verification successful
	FWUP_ERR_VERIFY	Verification failed
	FWUP_ERR_FAILURE	Illegal parameter
Special Notes	—	

3.8 R_FWUP_ActivateImage Function

Table 3.8 R_FWUP_ActivateImage Function Specifications

Format	e_fwup_err_t R_FWUP_ActivateImage(void)	
Description	Activates a new image. <ul style="list-style-type: none"> • Dual-bank(2-Bank) method <ul style="list-style-type: none"> — FWUP_CFG_FWUPV1_COMPATIBLE is disabled: Bank swap. — FWUP_CFG_FWUPV1_COMPATIBLE is enabled: Returns FWUP_SUCCESS without doing anything. • Partial update method, Full update method (with buffer plane) <ul style="list-style-type: none"> — Bootloader: Copies the buffer plane image to the main plane. — User program: Returns FWUP_SUCCESS without doing anything. • Full update method (without buffer plane) <ul style="list-style-type: none"> — Returns FWUP_SUCCESS without doing anything. 	
Parameters	None	
Return Values	FWUP_SUCCESS	Normal end
	FWUP_ERR_FLASH	Flash module error
Special Notes	—	

3.9 R_FWUP_ExecImage Function

Table 3.9 R_FWUP_ExecImage Function Specifications

Format	void R_FWUP_ExecImage(void)
Description	Runs the program in a valid image.
Parameters	None
Return Values	None
Special Notes	Disable interrupts when transitioning from the bootloader to the application program.

3.10 R_FWUP_SoftwareReset Function

Table 3.10 R_FWUP_SoftwareReset Function Specifications

Format	void R_FWUP_SoftwareReset(void)
Description	Execute software reset processing.
Parameters	None
Return Values	None
Special Notes	—

3.11 R_FWUP_SoftwareDelay Function

Table 3.11 R_FWUP_SoftwareDelay Function Specifications

Format	uint32_t R_FWUP_SoftwareDelay(uint32_t delay, e_fwup_delay_units_t units)	
Description	Execute software delay processing.	
Parameters	delay: Delay time units: Unit (μs, ms, or sec.)	
Return Values	0	Normal end
	Other	Abnormal end
Special Notes	—	

3.12 R_FWUP_GetVersion Function

Table 3.12 R_FWUP_GetVersion Function Specifications

Format	uint32_t R_FWUP_GetVersion(void)
Description	Returns the version number of the module.
Parameters	None
Return Values	Version number
Special Notes	—

3.13 R_FWUP_WritelImageHeader Function

This function is an API for special use where header information and program information must be written separately. Normally, use the R_FWUP_WritelImage function.

Table 3.13 R_FWUP_WritelImageHeader Function Specifications

Format	e_fwup_err_t R_FWUP_WritelImageHeader (e_fwup_area_t area, uint8_t FWUP_FAR *p_sig_type, uint8_t FWUP_FAR *p_sig, uint32_t sig_size)
Description	Writes a signature that the bootloader uses for verification to the header of the image in the designated area.
Parameters	area: Main plane (FWUP_AREA_MAIN) or buffer plane (FWUP_AREA_BUFFER) p_sig_type: Signature type character string "hash-sha256" or "sig-sha256-ecdsa" p_sig: Signature sig_size: Length of signature (Should be set to 64.)
Return Values	FWUP_SUCCESS Write completed
	FWUP_ERR_FLASH Flash module error
	FWUP_ERR_FAILURE Illegal parameter
Special Notes	When FWUP_CFG_FWUPV1_COMPATIBLE is enabled, the magic code in the RSU header area used for processing is "Renesas" for FWUP V1.

3.14 R_FWUP_WritelImageProgram Function

This function is an API for special use where header information and program information must be written separately. Normally, use the R_FWUP_WritelImage function.

Table 3.14 R_FWUP_WritelImageProgram Function Specifications

Format	e_fwup_err_t R_FWUP_WritelImageProgram (e_fwup_area_t area, uint8_t *p_buf, uint32_t offset, uint32_t buf_size)
Description	Writes the program portion of the image to the specified area. Continue calling this function until the total size of the image is reached. The image size is obtained by R_FWUP_GetImageSize(). This function writes a program by offset based on the address information in the RSU header shown in Figure 4.1. Therefore, be sure to set 0x100 bytes of data from the offset (0x200) in Table 4.3 in the first call to this function. (Specify 0x200 for the offset argument and 0x100 or more for the buf_size argument.)
Parameters	area: Main plane (FWUP_AREA_MAIN) or buffer plane (FWUP_AREA_BUFFER) p_buf: Buffer for program portion of image offset: Offset* ¹ buf_size: Buffer size* ²
Return Values	FWUP_SUCCESS Writing of all images is completed.
	FWUP_PROGRESS Writing of all images not completed (Writing of the specified number of images completed)
	FWUP_ERR_FLASH Flash module error
	FWUP_ERR_FAILURE Illegal parameter
Special Notes	1. The offset must be 0x200 or greater. 2. Specify a multiple of the code flash write unit (for example, 64, 128, or 256). This size also applies to data flash.

3.15 Wrapper Functions

This module implements the flash driver and cryptographic operations in a wrapper function. The process is implemented in the following comment section of the source file. Please refer to the demo project for the implementation method.

```
/**** Start user code ****/
```

```
/**** End user code ****/
```

3.15.1 r_fwup_wrap_com.c, h

3.15.1.1 r_fwup_wrap_disable_interrupt Function

Table 3.15 r_fwup_wrap_disable_interrupt Function Specifications

Format	void r_fwup_wrap_disable_interrupt (void)
Description	Disable Interrupt
Parameters	None
Return Values	None
Special Notes	—

3.15.1.2 r_fwup_wrap_enable_interrupt Function

Table 3.16 r_fwup_wrap_enable_interrupt Function Specifications

Format	void r_fwup_wrap_enable_interrupt (void)
Description	Enable Interrupt
Parameters	None
Return Values	None
Special Notes	—

3.15.1.3 r_fwup_wrap_software_reset Function

Table 3.17 r_fwup_wrap_software_reset Function Specifications

Format	void r_fwup_wrap_software_reset (void)
Description	Software reset
Parameters	None
Return Values	FWUP_SUCCESS : Normal end
	FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.1.4 r_fwup_wrap_software_delay Function**Table 3.18 r_fwup_wrap_software_delay Function Specifications**

Format	uint32_t r_fwup_wrap_software_delay (uint32_t delay, e_fwup_delay_units_t units)	
Description	Software delay	
Parameters	delay : Delay time units: unit (us,ms,sec) FWUP_DELAY_MICROSECS FWUP_DELAY_MILLISECS FWUP_DELAY_SECS	
Return Values	0	: normal end
	Other	: Abnormal end
Special Notes	—	

3.15.2 r_fwup_wrap_flash.c, h**3.15.2.1 r_fwup_wrap_flash_open Function****Table 3.19 r_fwup_wrap_flash_open Function Specifications**

Format	e_fwup_err_t r_fwup_wrap_flash_open (void)
Description	Open the internal flash.
Parameters	None
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.2 r_fwup_wrap_flash_close Function**Table 3.20 r_fwup_wrap_flash_close Function Specifications**

Format	void r_fwup_wrap_flash_close (void)
Description	Close the internal flash.
Parameters	None
Return Values	None
Special Notes	—

3.15.2.3 r_fwup_wrap_flash_erase Function**Table 3.21 r_fwup_wrap_flash_erase Function Specifications**

Format	e_fwup_err_t r_fwup_wrap_flash_erase (uint32_t addr, uint32_t num_blocks)
Description	Erase the internal flash in block units.
Parameters	addr : erase address num_blocks : erase block
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.4 r_fwup_wrap_flash_write Function

Table 3.22 r_fwup_wrap_flash_write Function Specifications

Format	e_fwup_err_t r_fwup_wrap_flash_write(uint32_t src_addr, uint32_t dest_addr, uint32_t num_bytes)
Description	Erase the internal flash in block units.
Parameters	src_addr: Pointer to write data dest_addr: Write address num_bytes: Write size (bytes)
Return Values	FWUP_SUCCESS : Normal end
	FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.5 r_fwup_wrap_flash_read Function

Table 3.23 r_fwup_wrap_flash_read Function Specifications

Format	e_fwup_err_t r_fwup_wrap_flash_read (uint32_t buf_addr, uint32_t src_addr, uint32_t size)
Description	Reads the internal flash.
Parameters	buf_addr: Address of the buffer to store the read data src_addr: Read address size: Read size
Return Values	FWUP_SUCCESS : Normal end
	FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.6 r_fwup_wrap_bank_swap Function

Table 3.24 r_fwup_wrap_bank_swap Function Specifications

Format	e_fwup_err_t r_fwup_wrap_bank_swap (void)
Description	<p>Perform bank swap processing.</p> <p>This function performs boot bank switching settings using R_RFD_SetExtraBootAreaReq and executes bank swap after a software reset.</p> <p>Boot bank switching settings cannot be used unless in code flash programming mode, so execute R_RFD_SetExtraProgrammingMode immediately beforehand.</p> <p>After completing the boot bank switch setting, execute R_RFD_CheckExtraSeqEndStep1 and R_RFD_CheckExtraSeqEndStep2 to confirm that the extra area sequencer has finished operating. After confirming completion, execute R_RFD_GetExtraSeqErrorStatus and R_RFD_ClearExtraSeqRegister to obtain error information and clear the registers used to control the extra area sequencer.</p> <p>Before executing a software reset, execute R_RFD_SetExtraNonProgrammingMode.</p>
Parameters	None
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	This function can only be called when FWUP_CFG_UPDATE_MODE is 0. (RL78/L23 dual-bank(2-bank) only)

3.15.2.7 r_fwup_wrap_ext_flash_open Function

Table 3.25 r_fwup_wrap_ext_flash_open Function Specifications

Format	e_fwup_err_t r_fwup_wrap_ext_flash_open (void)
Description	Open the external flash.
Parameters	None
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.8 r_fwup_wrap_ext_flash_close Function

Table 3.26 r_fwup_wrap_ext_flash_close Function Specifications

Format	void r_fwup_wrap_ext_flash_close (void)
Description	Close the external flash.
Parameters	None
Return Values	None
Special Notes	—

3.15.2.9 r_fwup_wrap_ext_flash_erase Function**Table 3.27 r_fwup_wrap_ext_flash_erase Function Specifications**

Format	e_fwup_err_t r_fwup_wrap_ext_flash_erase (uint32_t offsetadd, uint32_t num_sectors)
Description	Erase the external flash in sector units.
Parameters	offsetadd: Starting address of the sector to be erased num_sectors: Number of sectors
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.10 r_fwup_wrap_ext_flash_write Function**Table 3.28 r_fwup_wrap_ext_flash_write Function Specifications**

Format	e_fwup_err_t r_fwup_wrap_ext_flash_write (uint32_t src_addr, uint32_t dest_addr, uint32_t num_bytes);
Description	Writes data to external flash.
Parameters	src_addr: Pointer to write data dest_addr: Write address num_bytes: Write size (bytes)
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.2.11 r_fwup_wrap_ext_flash_read Function**Table 3.29 r_fwup_wrap_ext_flash_read Function Specifications**

Format	e_fwup_err_t r_fwup_wrap_ext_flash_read (uint32_t buf_addr, uint32_t src_addr, uint32_t size);
Description	Reads the external flash.
Parameters	buf_addr: Address of the buffer to store the read data src_addr: Read address size: Read size
Return Values	FWUP_SUCCESS : Normal end FWUP_ERR_FLASH : Flash module error
Special Notes	—

3.15.3 r_fwup_wrap_verify.c, h**3.15.3.1 r_fwup_wrap_sha256_init Function****Table 3.30 r_fwup_wrap_sha256_init Function Specifications**

Format	int32_t r_fwup_wrap_sha256_init (void *vp_ctx);
Description	Start hash value calculation.
Parameters	vp_ctx: pointer to the context of the cryptographic library
Return Values	0 : normal end Other : Abnormal end
Special Notes	—

3.15.3.2 r_fwup_wrap_sha256_update Function**Table 3.31 r_fwup_wrap_sha256_update Function Specifications**

Format	int32_t r_fwup_wrap_sha256_update (void *vp_ctx, const uint8_t *p_data, uint32_t datalen)
Description	Calculates hash values for a specified range.
Parameters	vp_ctx: pointer to the context of the cryptographic library p_data: starting address datalen: data length (bytes)
Return Values	0 : normal end Other : Abnormal end
Special Notes	—

3.15.3.3 r_fwup_wrap_sha256_final Function**Table 3.32 r_fwup_wrap_sha256_final Function Specifications**

Format	int32_t r_fwup_wrap_sha256_final (uint8_t *p_hash, void *vp_ctx)
Description	Finishes computing the hash value and returns the hash value.
Parameters	p_hash: Pointer to the buffer to store the calculated hash value vp_ctx: pointer to the context of the cryptographic library
Return Values	0 : normal end Other : Abnormal end
Special Notes	—

3.15.3.4 r_fwup_wrap_verify_ecdsa Function

Table 3.33 r_fwup_wrap_verify_ecdsa Function Specifications

Format	int32_t r_fwup_wrap_verify_ecdsa (uint8_t *p_hash, uint8_t *p_sig_type, uint8_t *p_sig, uint32_t sig_size)
Description	Perform verification with ECDSA.
Parameters	p_hash: Pointer to the buffer where the hash value is stored p_sig_type: signature type p_sig: signature sig_size: signature size
Return Values	0 : normal end Other : Abnormal end
Special Notes	—

3.15.3.5 r_fwup_wrap_get_crypt_context Function

Table 3.34 r_fwup_wrap_get_crypt_context Function Specifications

Format	void * r_fwup_wrap_get_crypt_context (void);
Description	Returns a pointer to the context of the cryptographic library.
Parameters	None
Return Values	Void * Pointer to cryptographic library context
Special Notes	—

4. Demo Project

The demo project is a sample program that shows how to implement firmware update functionality using the serial communications interface (SCI).

4.1 Demo project Structure

The demo project comprises the module, modules dependent on it, and a main() function that implements the firmware update demonstration. Versions of the demo project for the devices and compilers listed in 1.5 are provided.

The firmware update demo consists of the following projects.

Dual-Bank(2-Bank) method folder structure: Under XXX\dualbank(2bank)\YYY\

Partial/Full Update method folder structure: Under XXX\linear\YYY\

XXX: Board name

YYY: Compiler (e2_ccrl / iar / llvm)

- boot_loader: Bootloader
This program runs first after a reset. It verifies that the user program has not been tampered with and then, if verification is successful, launches the user program.
- fwup_main: Application program
An application program (initial firmware) that downloads updated firmware and performs signature verification.
- fwup_leddemo: Application program (for update)
This is an application program that blinks an LED.

4.2 Operating environment preparation

To run the firmware update demo project, you need to install the tools (refer to Section 4.2.1 to 4.2.4) on your Windows PC. Also, use a USB serial conversion board (refer to Section 4.2.5) that connects the Windows PC and the target board.

4.2.1 Installing TeraTerm

Used to transfer the firmware update image via serial communication from a Windows PC to the target board. In the demo project, we checked the operation with TeraTerm 5.4.0.

After installation, set the serial port communication settings as shown in Table 4.1

Table 4.1 Communication Specifications

Item	Description
Communication system	Asynchronous communication
Bit rate	115,200 bps
Data length	8 bits
Parity	None
Stop bit	1 bit
Flow control	CTS/RTS

4.2.2 Installing the Python execution environment

Used by Renesas Image Generator (image-gen.py) to create initial and update images.

Renesas Image Generator uses ECDSA to generate signature data. In the demo project, environment operation is confirmed with Python 3.12.7.

Install Python 3.12.7 or higher.

In addition, since the Python encryption library (pycryptodome) is used, after installing Python, execute the following pip command from the command prompt to install the library.

```
pip install pycryptodome
```

4.2.3 Installing the OpenSSL execution environment

OpenSSL is used to generate the keys needed to generate and verify ECDSA signature data for initial and update images.

Download the OpenSSL installer from the following URL and install it. There is no problem with the Light version.

<https://slproweb.com/products/Win32OpenSSL.html>

4.2.4 Installing the Flash Writer

A flash writer is required to write the initial image.

The demo project uses Renesas Flash Programmer v3.24.00.

[Renesas Flash Programmer \(Programming GUI\) | Renesas](#)

4.2.5 USB serial conversion board

Used to transfer the firmware update image via serial communication from a Windows PC to the target board.

For details on how to connect with the target board, refer to the operation confirmation environment (6.2) of the relevant target board.

Use Pmod USBUART (manufactured by DIGILENT).

<https://reference.digilentinc.com/reference/pmod/pmodusbuart/start>

4.3 Execution environment preparation

4.3.1 Generating Keys for Signature Generation and Verification

Use OpenSSL for key generation. Refer to Section 4.2.3 and install OpenSSL in advance.

Execute the following OpenSSL commands to generate an elliptic curve cryptography (secp256r1) key pair to be used to generate and verify image signatures, and to extract the private and public keys:

```
>openssl ecparam -genkey -name secp256r1 -out secp256r1.keypair
using curve name prime256v1 instead of secp256r1

>openssl ec -in secp256r1.keypair -outform PEM -out secp256r1.privatekey
read EC key
writing EC key

> openssl ec -in secp256r1.keypair -outform PEM -pubout -out
secp256r1.publickey
read EC key
writing EC key
```

4.3.2 Preparing the execution environment for Renesas Image Generator

Unzip ImageGenerator.zip included in the package to any folder on your Windows PC. Make sure the folder name does not contain double-byte characters.

Renesas Image Generator requires a Python execution environment. Refer to Section 4.2.2 and install Python in advance.

4.4 Dual-Bank(2-Bank) Method

This section describes the demo projects using the FPB-RL78L23 in dual-bank(2-bank) method.

Three demo projects, boot_loader, fwup_leddemo, and fwup_main, are available for the dual-bank(2-bank) method of the FPB-RL78L23.

The execution procedure of this demo project does not assume a debugger connection. Refer to 4.9 for information on how to debug the application program through a debugger connection.

4.4.1 Execution Environment

Refer to Section 6.2.6 and prepare the execution environment.

4.4.2 Build Demo Project

The following steps are used to build three demo projects for the dual-bank(2-bank) method.

The following procedure is described for the e² studio environment; when using the IAR environment, please read and follow the procedure for IAR's Integrated Development Environment.

1. Import the boot_loader, fwup_leddemo, and fwup_main demo projects into the integrated development environment.

Note:

The demo projects for each device access files in the \modules and \r_fwup directories using relative paths. Therefore, when importing the projects, make sure that the directory structure is maintained so that the relative paths remain valid.

The simplest way to avoid this issue is to place the "demos" folder in an appropriate location and specify it as the workspace when starting e² studio. This ensures that the relative path structure is preserved.

When importing a demo project into the workspace, clear the [Copy projects into workspace] check box before proceeding with the import.

2. Add the public key used to verify the image to the demo project.
Paste the contents of secp256r1.publickey into code_signer_public_key.h in project boot_loader and fwup_main.

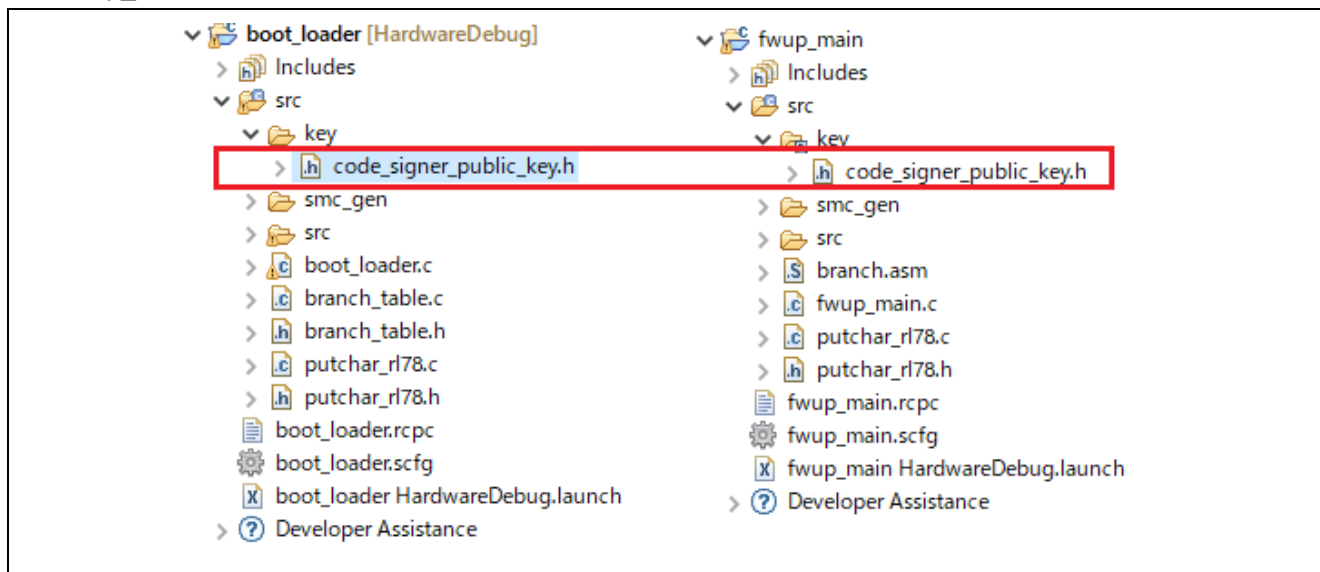


Figure 4.1 Location of the code_signer_public_key.h file for the demo project

```

/*
 * PEM-encoded code signer public key.
 *
 * Must include the PEM header and footer:
 * "-----BEGIN CERTIFICATE-----\n"\
 * "...base64 data...\n"\
 * "-----END CERTIFICATE-----"
 */
#define CODE_SIGNER_PUBLIC_KEY_PEM \
"-----BEGIN PUBLIC KEY-----"\
Paste the contents of secp256r1.publickey here.
"-----END PUBLIC KEY-----"\
#endif /* CODE_SIGNER_PUBLIC_KEY_H */

```

3. Set the configuration settings for the firmware update module.
Open r_fwup_config.h in the project and configure it according to Section 6.2.6.1.
Log output is off by default, so please set the following.
boot_loader, fwup_main : FWUP_CFG_PRINTF_DISABLE = 0
fwup_leddemo : FWUP_DEMO_PRINTF_DISABLE = 0
4. Build the demo project.
Build the three demo projects and verify that the following mot files have been generated:
boot_loader.mot, fwup_main.mot, fwup_leddemo.mot
Note: The mot file is renamed srec file in llvm.

4.4.3 Create initial and updated images

This section describes the procedure for creating the initial and updated images, assuming that the initial image name is `initial_firm.mot` and the updated image name is `fwup_leddemo.rsu`.

1. Store the mot file of the built demo project and the secret key generated in 4.3.1 in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_L23_ImageGenerator_PRM_dual.csv
boot_loader.mot
fwup_main.mot
fwup_leddemo.mot
secp256r1.privatekey
```

2. Execute the following command to create the initial image.

```
> python image-gen.py -iup fwup_main.mot -ip
RL78_L23_ImageGenerator_PRM_dual.csv -o initial_firm -ibp boot_loader.mot
-vt ecdsa -key secp256r1.privatekey

Successfully generated the initial_firm.mot file.
```

3. Execute the following command to create the updated image.

```
> python image-gen.py -iup fwup_leddemo.mot -ip
RL78_L23_ImageGenerator_PRM_dual.csv -o fwup_leddemo -vt ecdsa -key
secp256r1.privatekey

Successfully generated the fwup_leddemo.rsu file.
```

Initial and updated images are generated in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_L23_ImageGenerator_PRM_dual.csv
boot_loader.mot
fwup_main.mot
fwup_leddemo.mot
secp256r1.privatekey
fwup_leddemo.rsu
initial_firm.mot
```

4.4.4 Program Initial Image

Write the initial image (`initial_firm.mot`) to the MCU board using a flash writer. After programming, turn off the power to the board and disconnect the debugger (E2 Lite).

Note: Change the Renesas Flash Programmer settings only when using the dual-bank (2-bank) method.

- Operation Settings > Command
 - Check "Write Flash Options"
 - Check "Verify Flash Options"
- Flash Options > Boot Cluster Size/Bank Swap
 - Setting option: Set
 - BTBLS: 07

4.4.5 Update Firmware

Once the initial image firmware is activated, it waits for the transfer of the updated image via the terminal. The received update image is programmed into flash memory, and after the reception is completed, the signature of the update image is verified and the firmware of the update image is activated.

Follow the steps below to try the firmware update.

1. Connect the devices according to Section 6.2.6.
2. Start the terminal software on the PC, select the serial COM port, and configure the connection settings.
3. Turn on power to the board. The following message is output.

```
==== RL78/L23 : BootLoader [dual bank, bank0] ====
verify install area main [sig-sha256-ecdsa]...OK
execute new image ...

==== RL78/L23 : Update from User [dual bank] ver 1.0.0 ====
send image(*.rsu) via UART.
```

4. Send the updated image through the terminal software.

Send file>check binary>fwup_leddemo.rsu

The following message is output during the transfer of the update image.

```
W 0x41000, 128 ... OK
W 0x41080, 128 ... OK
...
W 0x43980, 128 ... OK
W 0x43A00, 128 ... OK
```

5. After installing the updated firmware and verifying the signature, it jumps to the updated firmware and executes the program after processing such as bank swap.

```
verify install area buffer [sig-sha256-ecdsa]...OK
software reset...
```

6. When the bootloader completes signature verification, the update image firmware is activated. When the process completes successfully, the following message is output and the LED flashes.

```
==== RL78/L23 : BootLoader [dual bank, bank1] ====
verify install area main [sig-sha256-ecdsa]...OK
execute new image ...

-----
FWUP demo (ver 0.1.1)
-----
Check the LEDs on the board.
```

Note: The demo program does not erase the buffer plane. If it is necessary to erase the image that existed before the update as a rollback countermeasure, add a procedure to erase the image in the buffer plane.

4.5 Partial Update Method

This section describes the demo projects using the FPB-RL78G23-128p.

The demo projects using the QB-R5F100SL-TB, FPB-RL78G21, FPB-RL78G24, and FPB-RL78L23 follow the same procedure as the FPB-RL78G23-128p demo project. Refer to this chapter for details.

Three demo projects (boot_loader, fwup_leddemo, and fwup_main) are available for the FPB-RL78G23-128p.

These demo projects support three firmware update methods: partial update method, full update method (with buffer plane), and full update method (without buffer plane) by changing the configuration settings.

The execution procedure of this demo project does not assume a debugger connection. Refer to Section 4.9 for information on how to debug the application program through a debugger connection.

4.5.1 Execution Environment

Refer to Section 6.2.4 and prepare the execution environment.

4.5.2 Build Demo Project

The following steps are used to build three demo projects for the partial update method (buffer plane is internal flash).

The following procedure is described for the e² studio environment; when using the IAR environment, please read and follow the procedure for IAR's Integrated Development Environment.

1. Import the boot_loader, fwup_leddemo, and fwup_main demo projects into the integrated development environment.

Note:

The demo projects for each device access files in the \modules and \r_fwup directories using relative paths. Therefore, when importing the projects, make sure that the directory structure is maintained so that the relative paths remain valid.

The simplest way to avoid this issue is to place the "demos" folder in an appropriate location and specify it as the workspace when starting e² studio. This ensures that the relative path structure is preserved.

When importing a demo project into the workspace, clear the [Copy projects into workspace] check box before proceeding with the import.

2. Add the public key used to verify the image to the demo project.
Paste the contents of secp256r1.publickey into code_signer_public_key.h in project boot_loader and fwup_main.

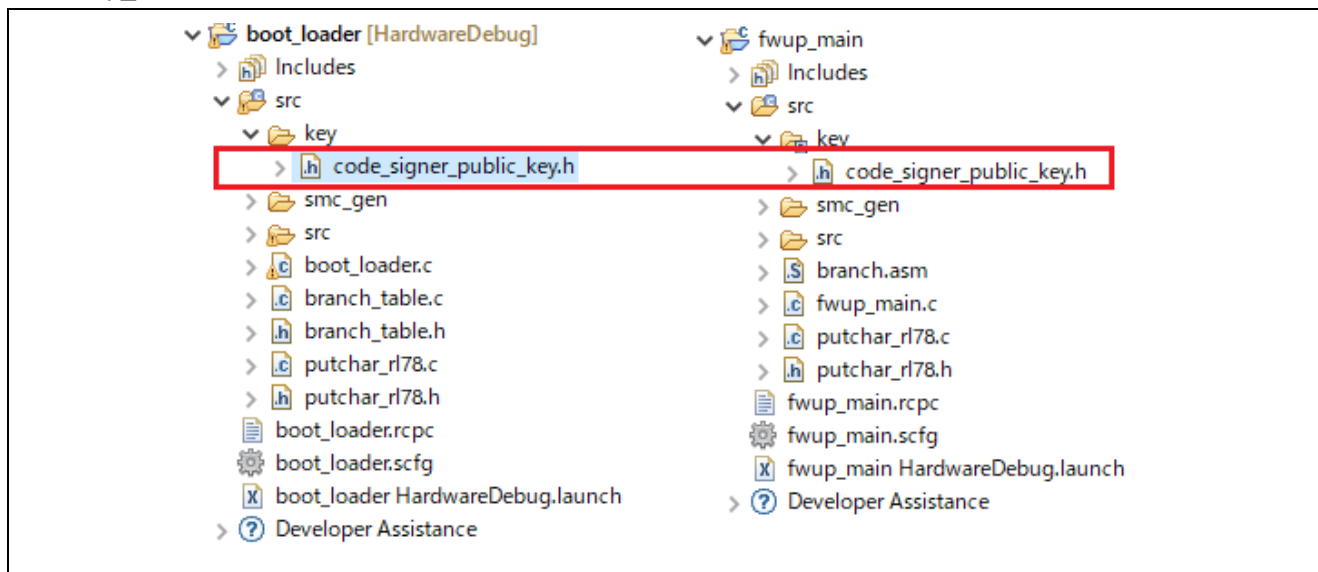


Figure 4.2 Location of the code_signer_public_key.h file for the demo project

```

/*
 * PEM-encoded code signer public key.
 *
 * Must include the PEM header and footer:
 * "-----BEGIN CERTIFICATE-----\n"\
 * "...base64 data...\n"\
 * "-----END CERTIFICATE-----"
 */
#define CODE_SIGNER_PUBLIC_KEY_PEM \
"-----BEGIN PUBLIC KEY-----"\
Paste the contents of secp256r1.publickey here.
"-----END PUBLIC KEY-----"\
#endif /* CODE_SIGNER_PUBLIC_KEY_H */

```

3. Set the configuration settings for the firmware update module.
Open r_fwup_config.h in the project and configure it according to Section 6.2.4.1.
Log output is off by default, so please set the following.
boot_loader, fwup_main : FWUP_CFG_PRINTF_DISABLE = 0
fwup_leddemo : FWUP_DEMO_PRINTF_DISABLE = 0
4. Build the demo project.
Build the three demo projects and verify that the following mot files have been generated:
boot_loader.mot, fwup_main.mot, fwup_leddemo.mot
Note: The mot file is renamed srec file in llvm.

4.5.3 Create initial and updated images

This section describes the procedure for creating the initial and updated images, assuming that the initial image name is `initial_firm.mot` and the updated image name is `fwup_leddemo.rsu`.

1. Store the mot file of the built demo project and the secret key generated in 4.3.1 in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_G23_ImageGenerator_PRM.csv
boot_loader.mot
fwup_main.mot
fwup_leddemo.mot
secp256r1.privatekey
```

2. Execute the following command to create the initial image.

```
> python image-gen.py -iup fwup_main.mot -ip RL78_G23_ImageGenerator_PRM.csv
-o initial_firm -ibp boot_loader.mot -vt ecdsa -key secp256r1.privatekey

Successfully generated the initial_firm.mot file.
```

3. Execute the following command to create the updated image.

```
> python image-gen.py -iup fwup_leddemo.mot -ip
RL78_G23_ImageGenerator_PRM.csv -o fwup_leddemo -vt ecdsa -key
secp256r1.privatekey

Successfully generated the fwup_leddemo.rsu file.
```

Initial and updated images are generated in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_G23_ImageGenerator_PRM.csv
boot_loader.mot
fwup_main.mot
fwup_leddemo.mot
secp256r1.privatekey
fwup_leddemo.rsu
initial_firm.mot
```

4.5.4 Program Initial Image

Write the initial image (`initial_firm.mot`) to the MCU board using a flash writer. After programming, turn off the power to the board and disconnect the debugger (E2 Lite).

4.5.5 Update Firmware

Once the initial image firmware is activated, it waits for the transfer of the updated image via the terminal. The received update image is programmed into flash memory, and after the reception is completed, the signature of the update image is verified and the firmware of the update image is activated.

Follow the steps below to try the firmware update.

1. Connect the devices according to Section 6.2.4.
2. Start the terminal software on the PC, select the serial COM port, and configure the connection settings.
3. Turn on power to the board. The following message is output.

```
==== RL78/G23 : BootLoader [with buffer] ====  
verify install area main [sig-sha256-ecdsa]...OK  
execute new image ...  
  
==== RL78/G23 : Update from User [with buffer] ver 1.0.0 ====  
send image(*.rsu) via UART.
```

4. Send the updated image through the terminal software.

Send file>check binary>fwup_leddemo.rsu

The following message is output during the transfer of the update image, and the software resets after installation and signature verification are complete.

```
W 0x59000, 128 ... OK  
W 0x59080, 128 ... OK  
...  
W 0x5BA00, 128 ... OK  
W 0x5BA80, 128 ... OK  
verify install area buffer [sig-sha256-ecdsa]...OK  
software reset...
```

5. Execute the activation process in the bootloader and perform a software reset again.

```
==== RL78/G23 : BootLoader [with buffer] ====  
verify install area buffer [sig-sha256-ecdsa]...OK  
copy to main area ... OK  
software reset...
```

6. When the signature verification is completed in the bootloader, the firmware of the updated image will boot. It is normal if the following message is output and the LED is blinking.

```
==== RL78/G23 : BootLoader [with buffer] ====  
verify install area main [sig-sha256-ecdsa]...OK  
execute new image ...  
  
-----  
FWUP demo (ver 0.1.1)  
-----  
Check the LEDs on the board.
```

4.6 Full Update Method (without buffer plane)

This section describes the demo projects using the FPB-RL78G22.

The demo projects using the QB-R5F100SL-TB, FPB-RL78G21, FPB-RL78G23-128p, FPB-RL78G24, and FPB-RL78L23 follow the same procedure as the FPB-RL78G22 demo project. Refer to this chapter for details.

Two demo projects (boot_loader and fwup_leddemo) are provided for the FPB-RL78G22.

The execution procedure of this demo project does not assume a debugger connection. Refer to 4.9 for information on how to debug the application program through a debugger connection.

4.6.1 Execution Environment

Refer to Section 6.2.3 and prepare the execution environment.

4.6.2 Build Demo Project

The following steps are used to build two demo projects for the full update method (without buffer plane).

1. Import the boot_loader and fwup_leddemo demo projects into the integrated development environment.

Note:

The demo projects for each device access files in the \modules and \r_fwup directories using relative paths. Therefore, when importing the projects, make sure that the directory structure is maintained so that the relative paths remain valid.

The simplest way to avoid this issue is to place the "demos" folder in an appropriate location and specify it as the workspace when starting e² studio. This ensures that the relative path structure is preserved.

When importing a demo project into the workspace, clear the [Copy projects into workspace] check box before proceeding with the import.

2. Set the configuration settings for the firmware update module.

Open r_fwup_config.h in the project and configure it according to Section 6.2.3.1.

Log output is off by default, so please set the following.

boot_loader : FWUP_CFG_PRINTF_DISABLE = 0
fwup_leddemo : FWUP_DEMO_PRINTF_DISABLE = 0

3. Build the demo project.

- a. Build the project (boot_loader) and generate boot_loader.mot.
- b. Build the project (fwup_leddemo) and generate fwup_leddemo.mot.
- c. Rename fwup_leddemo.mot to fwup_leddemo_011.mot.
- d. Change the version of the project (fwup_leddemo) as follows, build and generate fwup_leddemo.mot.

```
fwup_leddemo.c
---
#define FWUP_DEMO_VER_MAJOR      (0)
#define FWUP_DEMO_VER_MINOR     (1)
#define FWUP_DEMO_VER_BUILD     (1) ★1->2
```

- e. Rename fwup_leddemo.mot to fwup_leddemo_012.mot.

Note: The mot file is renamed srec file in IJVM.

4.6.3 Create initial and updated images

This section describes the procedure for creating the initial and updated images, assuming that the initial image name is `initial_firm.mot` and the updated image name is `fwup_leddemo_012.rsu`.

1. Store the mot file of the built demo project in the same folder as Renesas Image Generator.

```
image-gen.py
RL78_G22_ImageGenerator_PRM_full.csv
boot_loader.mot
fwup_leddemo_011.mot
fwup_leddemo_012.mot
```

2. Execute the following command to create the initial image.

```
> python image-gen.py -iup fwup_leddemo_011.mot -ip
RL78_G22_ImageGenerator_PRM_full.csv -o initial_firm -ibp boot_loader.mot

Successfully generated the initial_firm.mot file.
```

3. Execute the following command to create the updated image.

```
> python image-gen.py -iup fwup_leddemo_012.mot -ip
RL78_G22_ImageGenerator_PRM_full.csv -o fwup_leddemo_012

Successfully generated the fwup_leddemo_012.rsu file.
```

Initial and updated images are generated in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_G22_ImageGenerator_PRM_full.csv
boot_loader.mot
fwup_leddemo_011.mot
fwup_leddemo_012.mot
fwup_leddemo_012.rsu
initial_firm.mot
```

4.6.4 Program Initial Image

Write the initial image (`initial_firm.mot`) to the MCU board using a flash writer. After writing, turn off the board power and disconnect the debugger (E2 Lite).

4.6.5 Update Firmware

The LED will blink when the initial image is activated. Enter update mode by pressing RESET_SW while holding down USER_SW on the board and wait for the transfer of the update image via the terminal. Program the received update image into flash memory, verify the update image after the transfer is complete, and then boot the firmware of the update image.

Note: The QB-R5F100SL-TB board used with the RL78/G13 is not equipped with a RESET switch. Therefore, either install a RESET switch or perform a power cycle (power OFF → ON) in place of the RESET switch ON → OFF operation.

Follow the steps below to try the firmware update.

1. Connect the devices according to Section 6.2.3.
2. Start the terminal software on the PC, select the serial COM port, and configure the connection settings.
3. Power on the board. The following message is output.

```
==== RL78/G22 : BootLoader [without buffer] ====
verify install area main [hash-sha256]...OK
execute new image ...

-----
FWUP demo (ver 0.1.1)
-----
Check the LEDs on the board.Check the LEDs on the board.
```

4. Press RESET_SW while holding down USER_SW. The initial image program mode is switched on.

```
==== RL78/G22 : Image updater [without buffer] ====
send image(*.rsu) via UART.
```

5. Send the updated image through the terminal software.

Send file>check binary>fwup_leddemo_012.rsu

The following message is output during the transfer of the update image, and the software resets after installation and signature verification are complete.

```
W 0x2000, 64 ... OK
W 0x2040, 64 ... OK
...
W 0x4D00, 64 ... OK
W 0x4D40, 64 ... OK
verify install area 0 [hash-sha256]...OK
software reset...
```

6. When the signature verification is completed in the bootloader, the firmware of the updated image will boot. It is normal if the following message is output and the LED is blinking.

```
==== RL78/G22 : BootLoader [without buffer] ====
verify install area main [hash-sha256]...OK
execute new image ...

-----
FWUP demo (ver 0.1.2)
-----
Check the LEDs on the board.
```

4.7 Full Update Method (with buffer plane)

This section describes the demo projects using the FPB-RL78G23-128p.

The demo projects using the QB-R5F100SL-TB, FPB-RL78G21, FPB-RL78G24, and FPB-RL78L23 follow the same procedure as the FPB-RL78G23-128p demo project. Refer to this chapter for details.

Three demo projects (boot_loader, fwup_leddemo, and fwup_main) are available for the FPB-RL78G23-128p.

These demo projects support three firmware update methods: partial update method (buffer plane is internal flash), full update method (buffer plane is external flash), and full update method (without buffer plane) by changing the configuration settings.

The execution procedure of this demo project does not assume a debugger connection. Refer to 4.9 for information on how to debug the application program through a debugger connection.

4.7.1 Execution Environment

Refer to Section 6.2.4 and prepare the execution environment.

4.7.2 Build Demo Project

The following steps are used to build three demo projects for the partial update method (with buffer plane).

The following procedure is described for the e² studio environment; when using the IAR environment, please read and follow the procedure for IAR's Integrated Development Environment.

1. Import the boot_loader, fwup_leddemo, and fwup_main demo projects into the integrated development environment.

Note:

The demo projects for each device access files in the \modules and \r_fwup directories using relative paths. Therefore, when importing the projects, make sure that the directory structure is maintained so that the relative paths remain valid.

The simplest way to avoid this issue is to place the "demos" folder in an appropriate location and specify it as the workspace when starting e² studio. This ensures that the relative path structure is preserved.

When importing a demo project into the workspace, clear the [Copy projects into workspace] check box before proceeding with the import.

2. Add the public key used to verify the image to the demo project.
Paste the contents of secp256r1.publickey into code_signer_public_key.h in project boot_loader and fwup_main.

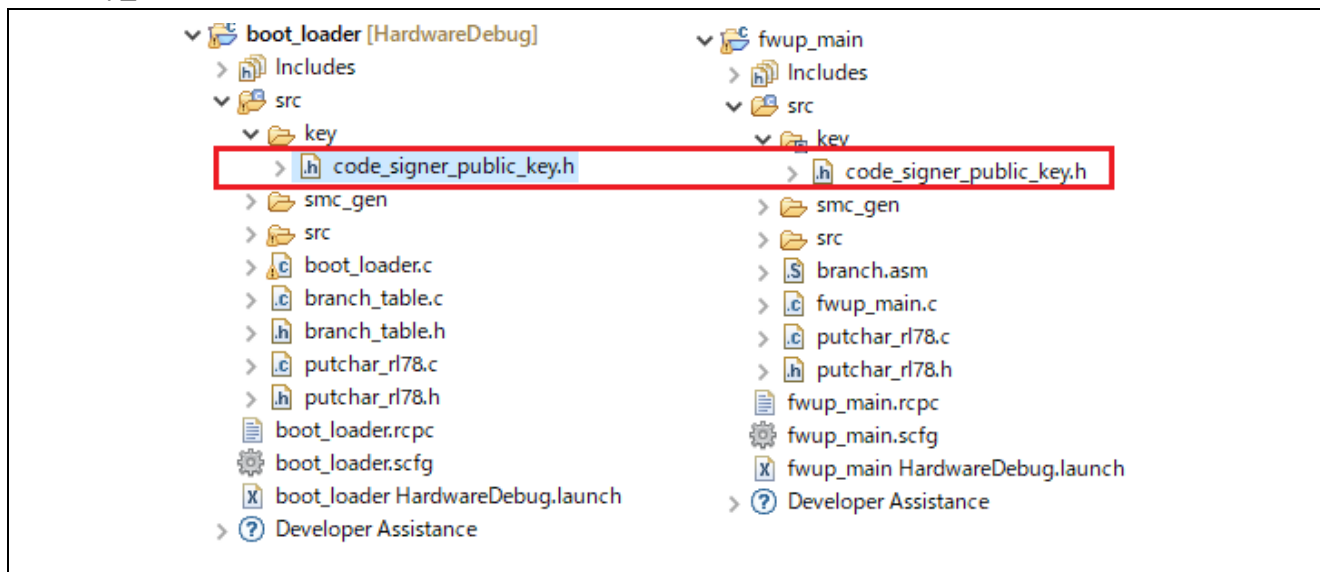


Figure 4.3 Location of the code_signer_public_key.h file for the demo project

```

/*
 * PEM-encoded code signer public key.
 *
 * Must include the PEM header and footer:
 * "-----BEGIN CERTIFICATE-----\n"\
 * "...base64 data...\n"\
 * "-----END CERTIFICATE-----"
 */
#define CODE_SIGNER_PUBLIC_KEY_PEM \
"-----BEGIN PUBLIC KEY-----"\
Paste the contents of secp256r1.publickey here.
"-----END PUBLIC KEY-----"\
#endif /* CODE_SIGNER_PUBLIC_KEY_H */

```

3. Set the configuration settings for the firmware update module.
Open r_fwup_config.h in the project and configure it according to Section 6.2.4.2.
Log output is off by default, so please set the following.

```

boot_loader, fwup_main    : FWUP_CFG_PRINTF_DISABLE = 0
fwup_leddemo              : FWUP_DEMO_PRINTF_DISABLE = 0

```
4. Build the demo project.
Build the three demo projects and verify that the following mot files have been generated:
boot_loader.mot, fwup_leddemo.mot, fwup_main.mot
Note: The mot file is renamed srec file in llvm.

4.7.3 Create initial and updated images

This section describes the procedure for creating the initial and updated images, assuming that the initial image name is `initial_firm.mot` and the updated image name is `fwup_leddemo.rsu`.

1. Store the mot file of the built demo project and the secret key generated in 4.3.1 in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_G23_ImageGenerator_PRM_full.csv
boot_loader.mot
fwup_main.mot
fwup_leddemo.mot
secp256r1.privatekey
```

2. Execute the following command to create the initial image.

```
> python image-gen.py -iup fwup_main.mot -ip
RL78_G23_ImageGenerator_PRM_full.csv -o initial_firm -ibp boot_loader.mot
-vt ecdsa -key secp256r1.privatekey

Successfully generated the initial_firm.mot file.
```

3. Execute the following command to create the updated image.

```
> python image-gen.py -iup fwup_leddemo.mot -ip
RL78_G23_ImageGenerator_PRM_full.csv -o fwup_leddemo -vt ecdsa -key
secp256r1.privatekey

Successfully generated the fwup_leddemo.rsu file.
```

Initial and updated images are generated in the same folder as the Renesas Image Generator.

```
image-gen.py
RL78_G23_ImageGenerator_PRM_full.csv
boot_loader.mot
fwup_main.mot
fwup_leddemo.mot
secp256r1.privatekey
fwup_leddemo.rsu
initial_firm.mot
```

4.7.4 Program Initial Image

Use Flash Writer to program the initial image (`initial_firm.mot`) to the MCU board. After programming, turn off the power to the board and disconnect the debugger (E2 Lite).

4.7.5 Update Firmware

Once the initial image firmware is activated, it waits for the transfer of the updated image via the terminal. The received update image is programmed into flash memory, and after the reception is completed, the signature of the update image is verified and the firmware of the update image is activated.

Follow the steps below to try the firmware update.

1. Connect the devices according to Section 6.2.4.
2. Start the terminal software on the PC, select the serial COM port, and configure the connection settings.
3. Turn on power to the board. The following message is output.

```
==== RL78/G23 : BootLoader [with ext-buffer] ====
verify install area main [sig-sha256-ecdsa]...OK
execute new image ...

==== RL78/G23 : Update from User [with ext-buffer] ver 1.0.0 ====
send image(*.rsu) via UART.
```

4. Send the updated image through the terminal software.

Send file>check binary>fwup_leddemo.rsu

The following message is output during the transfer of the update image, and the software resets after installation and signature verification are complete.

```
W 0x0000, 128 ... OK
W 0x0080, 128 ... OK
...
W 0x1A00, 128 ... OK
W 0x1A80, 128 ... OK
verify install area buffer [sig-sha256-ecdsa]...OK
software reset...
```

5. Execute the activation process in the bootloader and perform a software reset again.

```
==== RL78/G23 : BootLoader [with ext-buffer] ====
verify install area buffer [sig-sha256-ecdsa]...OK
copy to main area ... OK
software reset...
```

6. When the signature verification is completed in the bootloader, the firmware of the updated image will boot. It is normal if the following message is output and the LED is blinking.

```
==== RL78/G23 : BootLoader [with ext-buffer] ====
verify install area main [sig-sha256-ecdsa]...OK
execute new image ...

-----
FWUP demo (ver 0.1.1)
-----
Check the LEDs on the board.
```

4.8 Notes on the CC-RL Demo Projects for RL78/G13

When using the Code Generator with the CC-RL demo projects for RL78/G13 (boot_loader and fwup_main), sections such as .bss may be allocated so that they overlap with the SELFRAM area (F7F00-F82FF), which can result in linker errors.

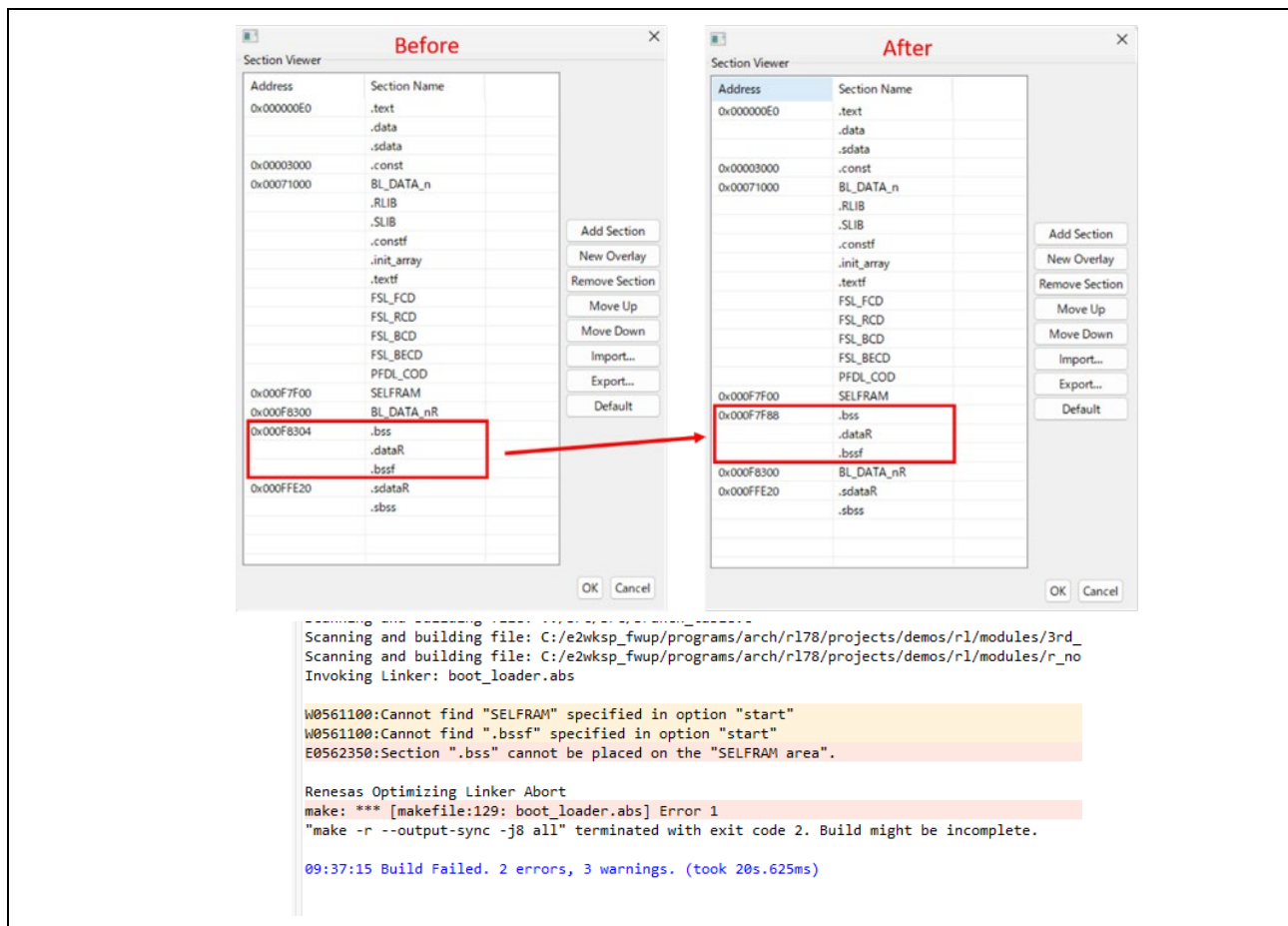


Figure 4.4 Section Definitions and Linker Errors After Code Generation

For details on the workaround, refer to the default section information file (*.esi) included in the project.

Alternatively, if no changes to the section settings from those in the sample project are required, the issue can be resolved by importing the section information file (*.esi).

The section information file (*.esi) is stored in the same folder as the project.

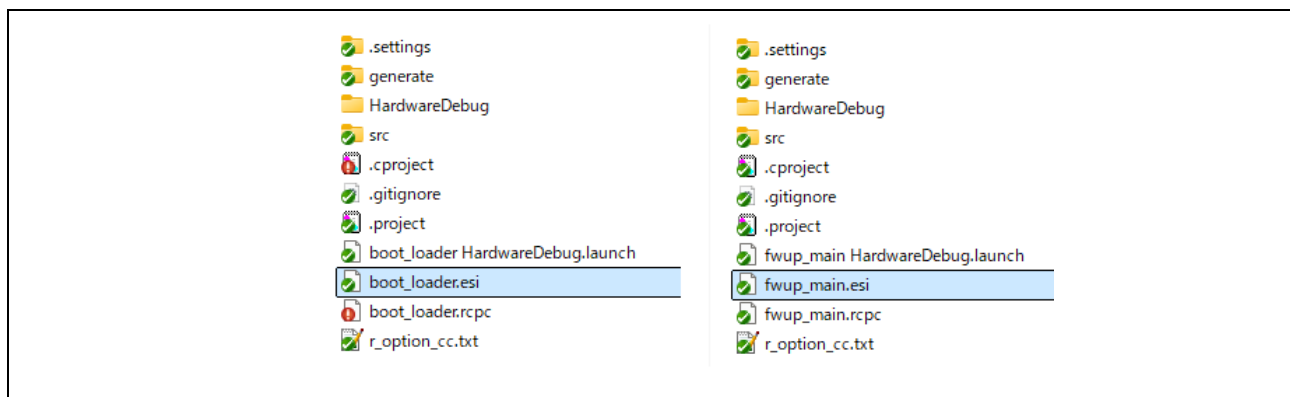


Figure 4.5 Location of the Section Information File (*.esi)

4.9 How to debug the demo project

4.9.1 How to Debug the Bootloader and Application Program

To debug this project (bootloader + application program) in the e² studio environment, follow the procedure described below.

This demo project is configured to receive power from the debugger (E2 Lite). When using another debugger or supplying power from the target board, change the debugger settings as appropriate.

(1) Build the bootloader and application program.

Build the bootloader (boot_loader) and application program (fwup_main).

(2) Generate the initial image.

The Renesas Image Generator generates an initial image file (.mot) consisting of a bootloader (boot_loader) and an application program (fwup_main).

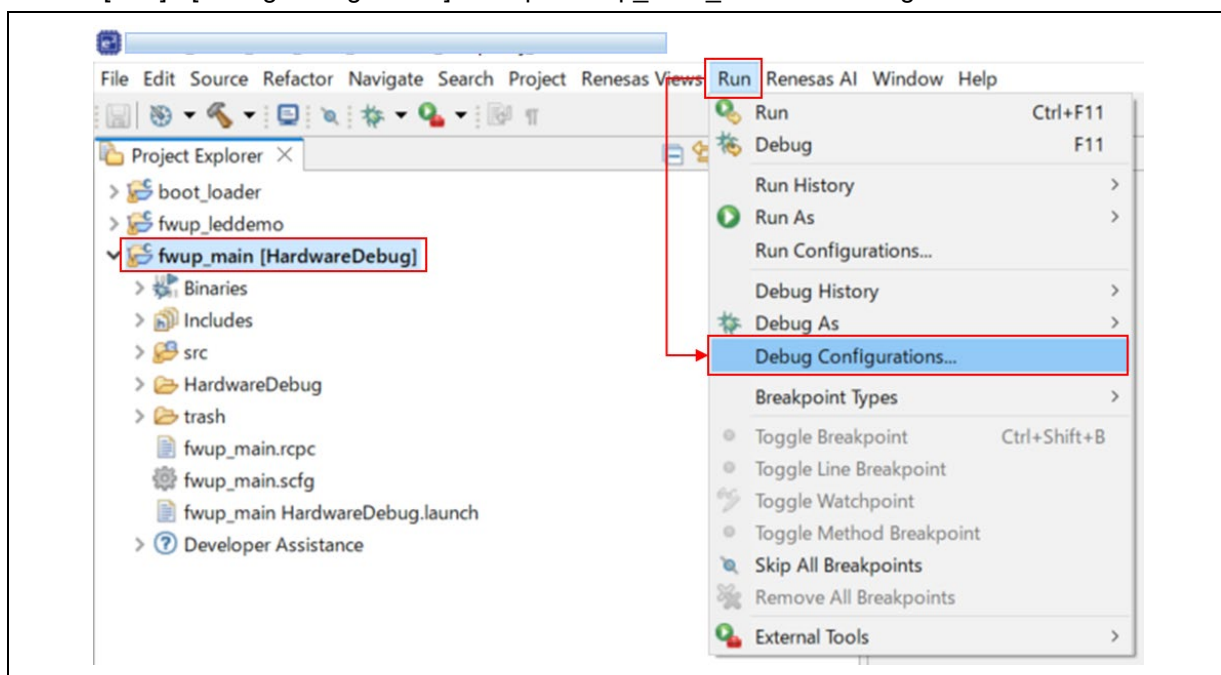
(3) Erase the flash memory. (Dual-bank (2-Bank) method only)

Use a flash programmer to perform a chip erase on the flash memory. This step is not required for configurations other than dual-bank (2-bank) method.

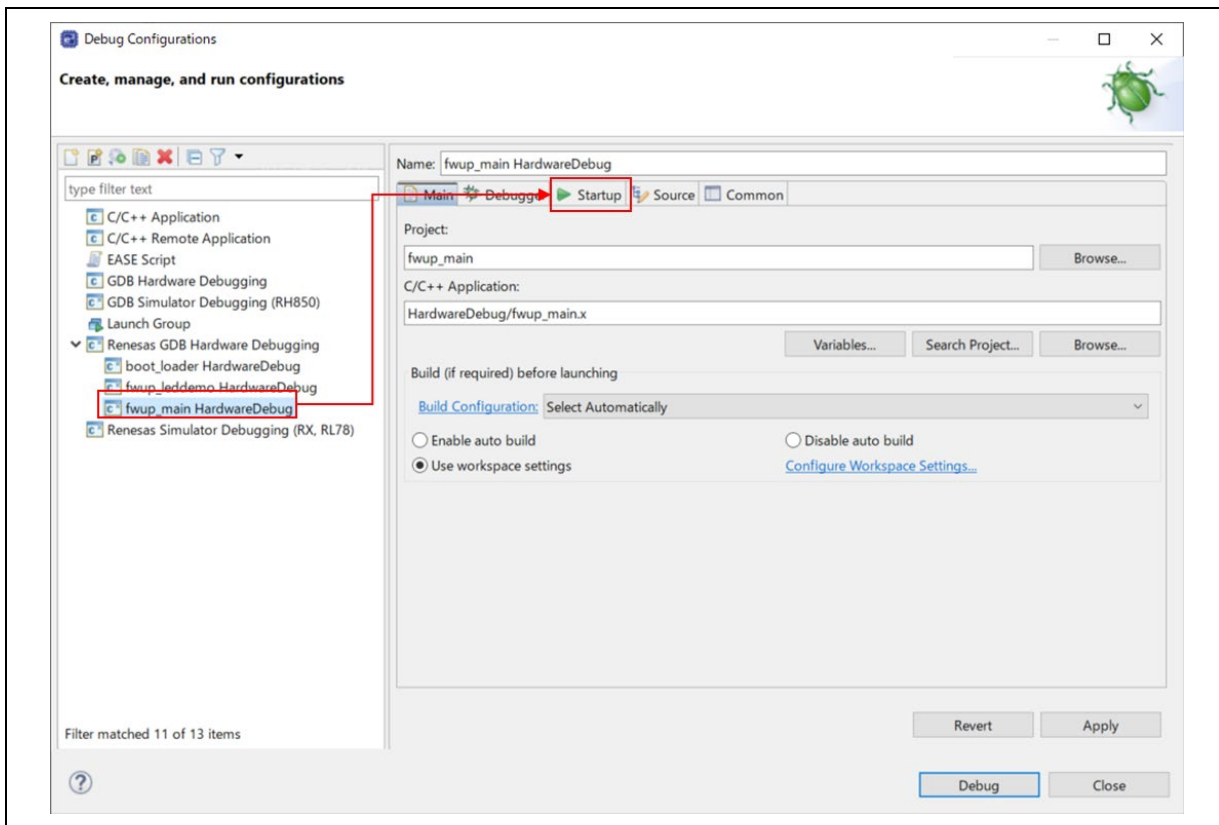
(4) Debug settings for the application program (fwup_main).

Follow the steps below to configure debugging settings for the application program (fwup_main).

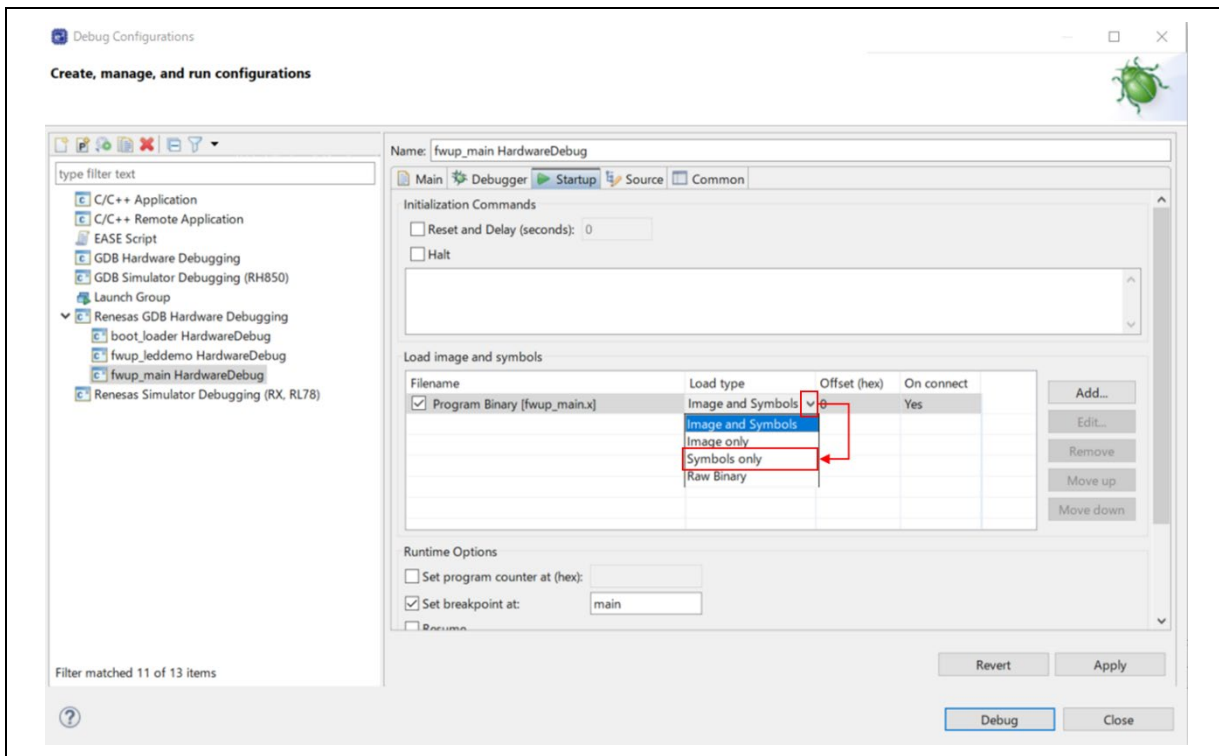
a) Select [Run]->[Debug Configuration] and open fwup_main_HardwareDebug.



- b) Select [fwup_main_HardwareDebug] and click [Startup].



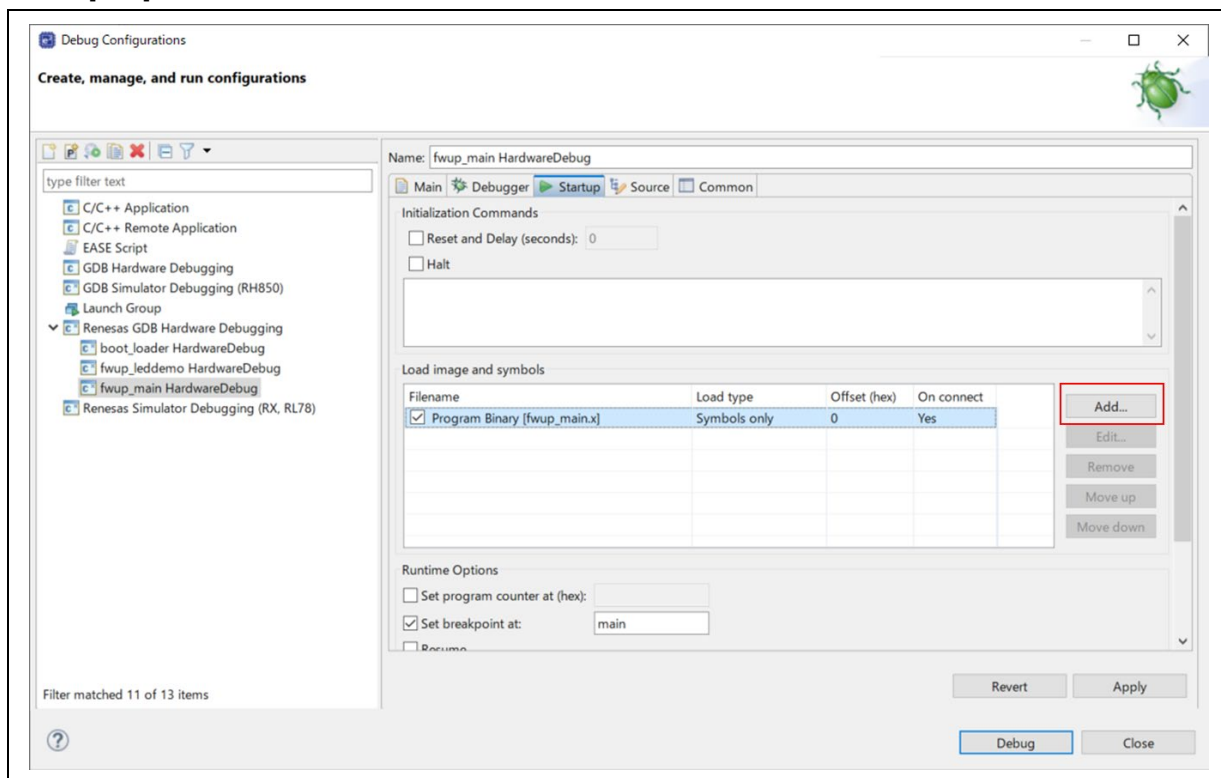
- c) Change the load type of the program binary [fwup_main.x] from [Image and Symbol] to [Symbol Only].



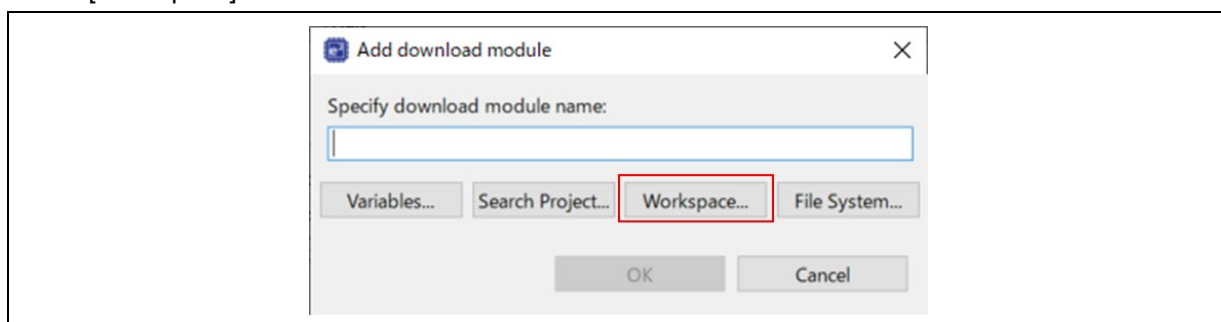
(5) Add the bootloader (boot_loader) symbol.

Follow the procedure below to add the boot loader (boot_loader) symbol built in step (1).

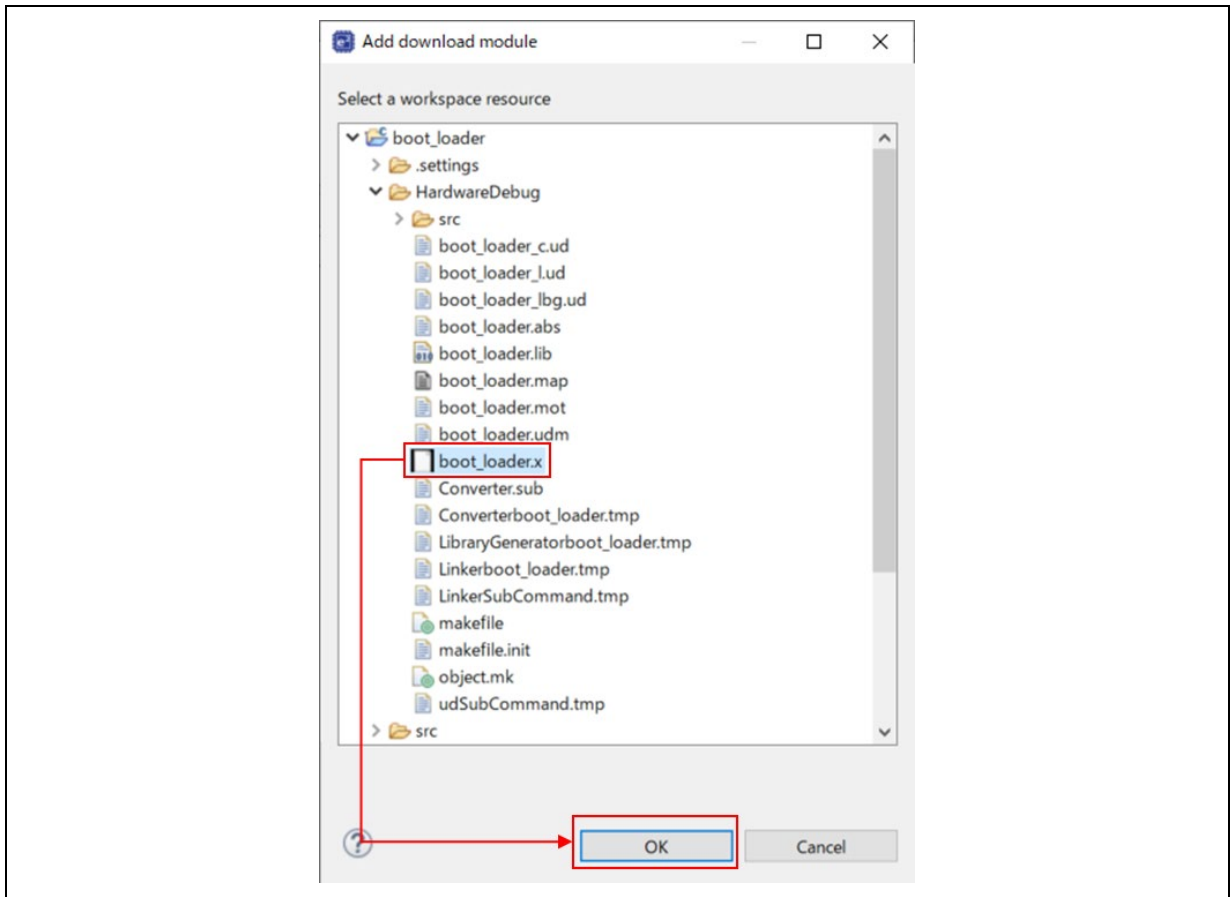
a) Click [Add].



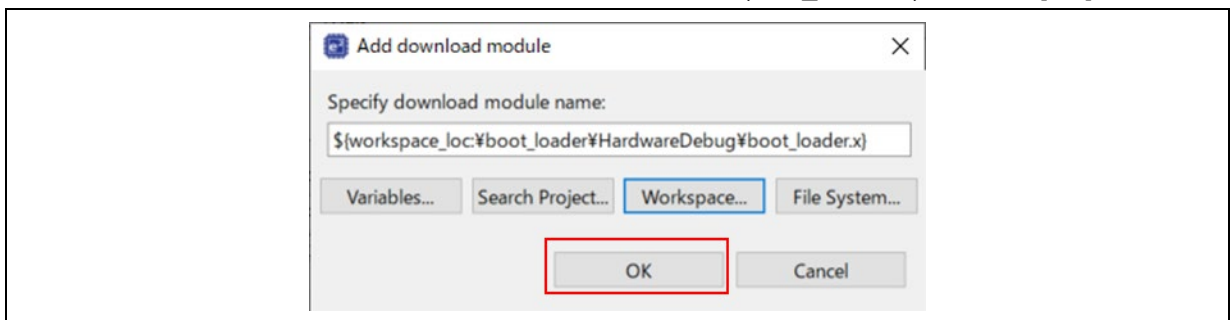
b) Click [Workspace].



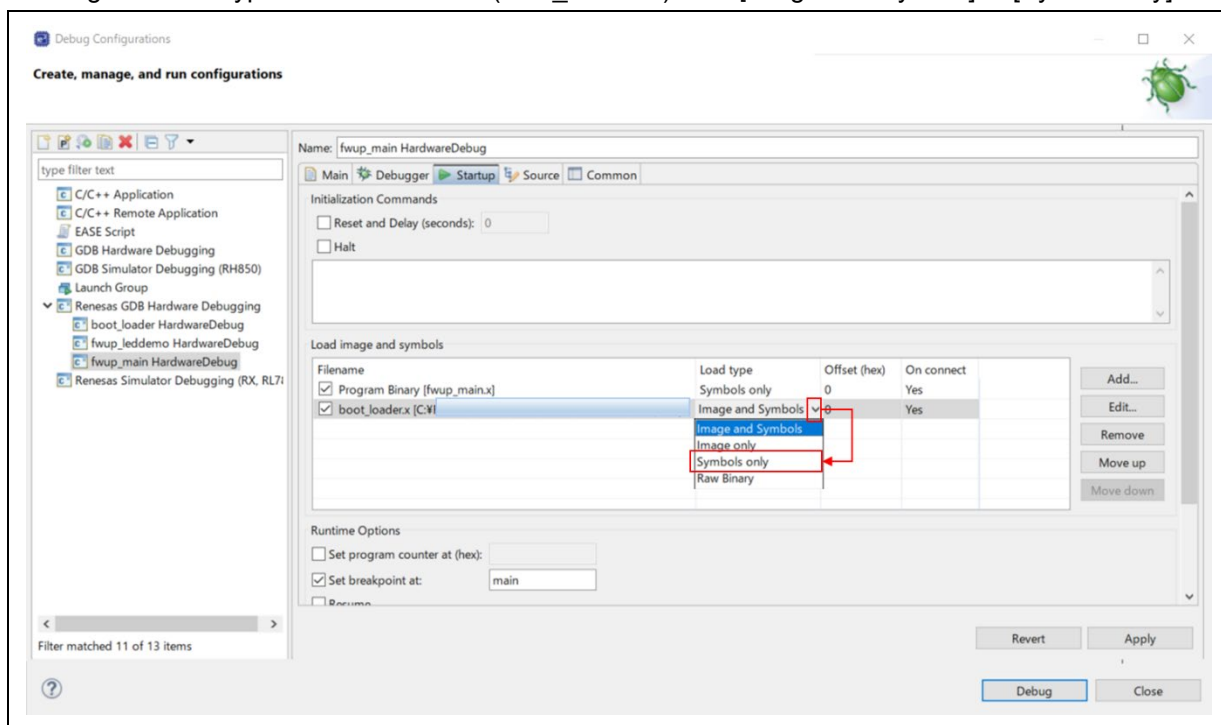
- c) Select the bootloader (boot_loader.x) and click [OK].



- d) Confirm that the download module name is set to bootloader (boot_loader.x) and click [OK].



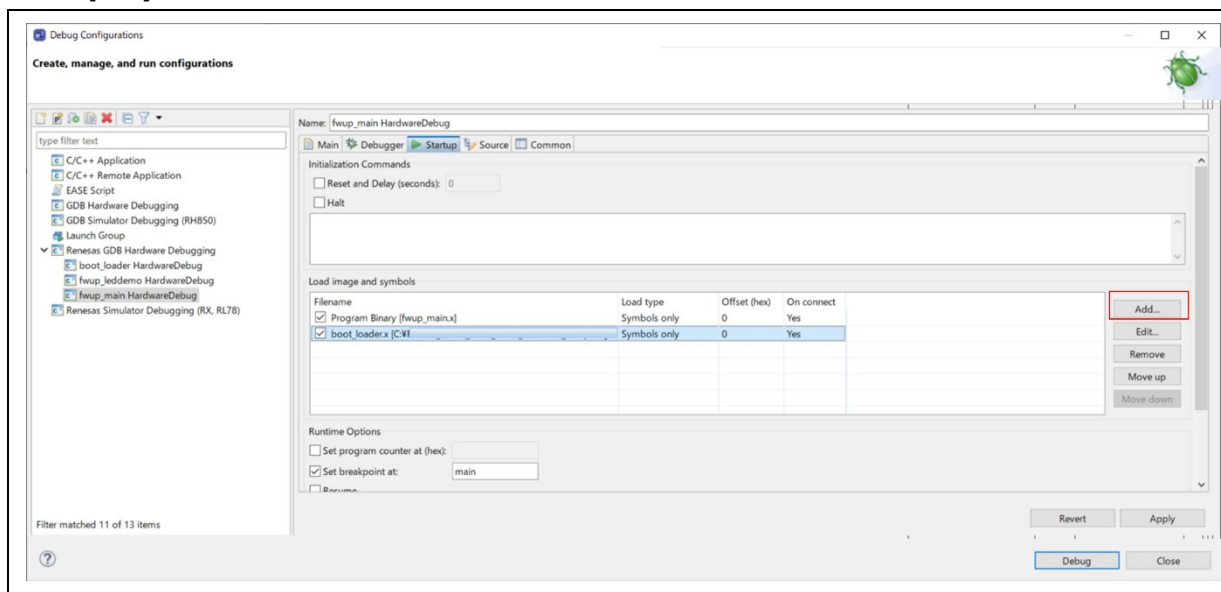
- e) Change the load type of the bootloader (boot_loader.x) from [Image and Symbol] to [Symbol only].



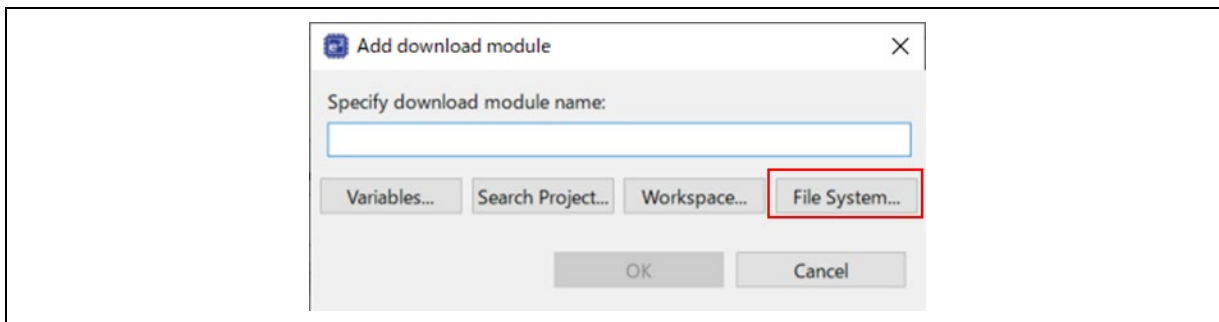
- (6) Add the image of the initial image (initial_firm.mot).

Add the image of the initial image (initial_firm.mot) generated in step (2) according to the following procedure.

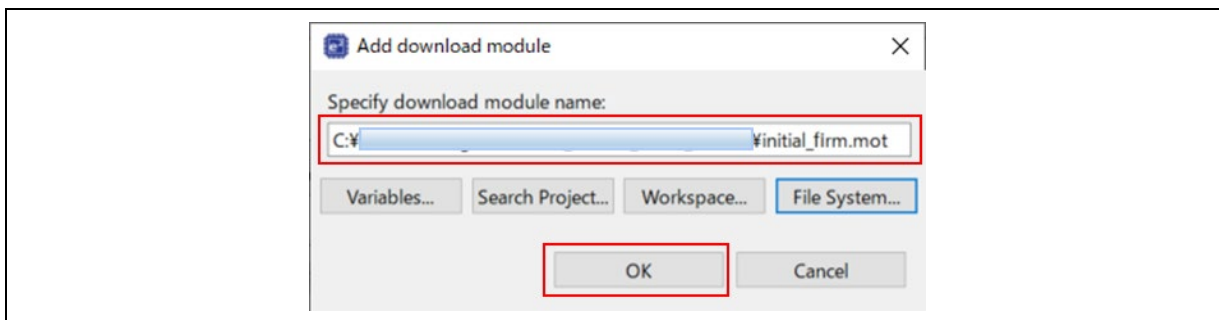
- a) Click [Add].



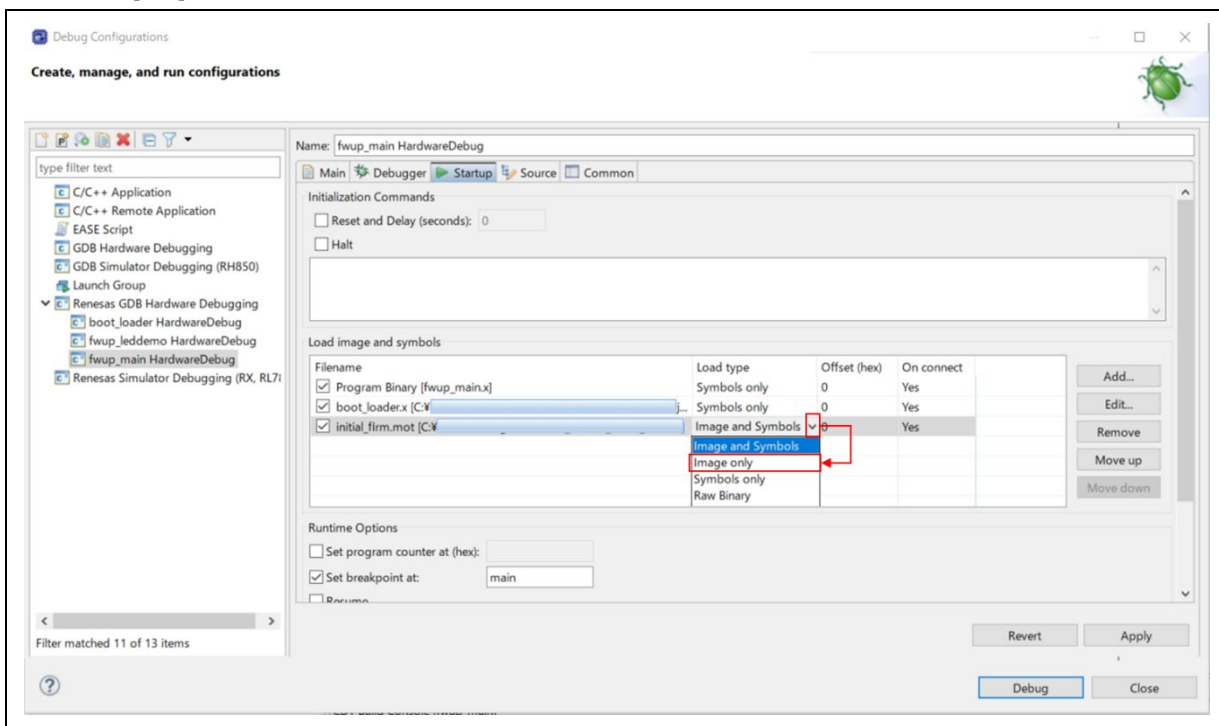
- b) Click [File System].



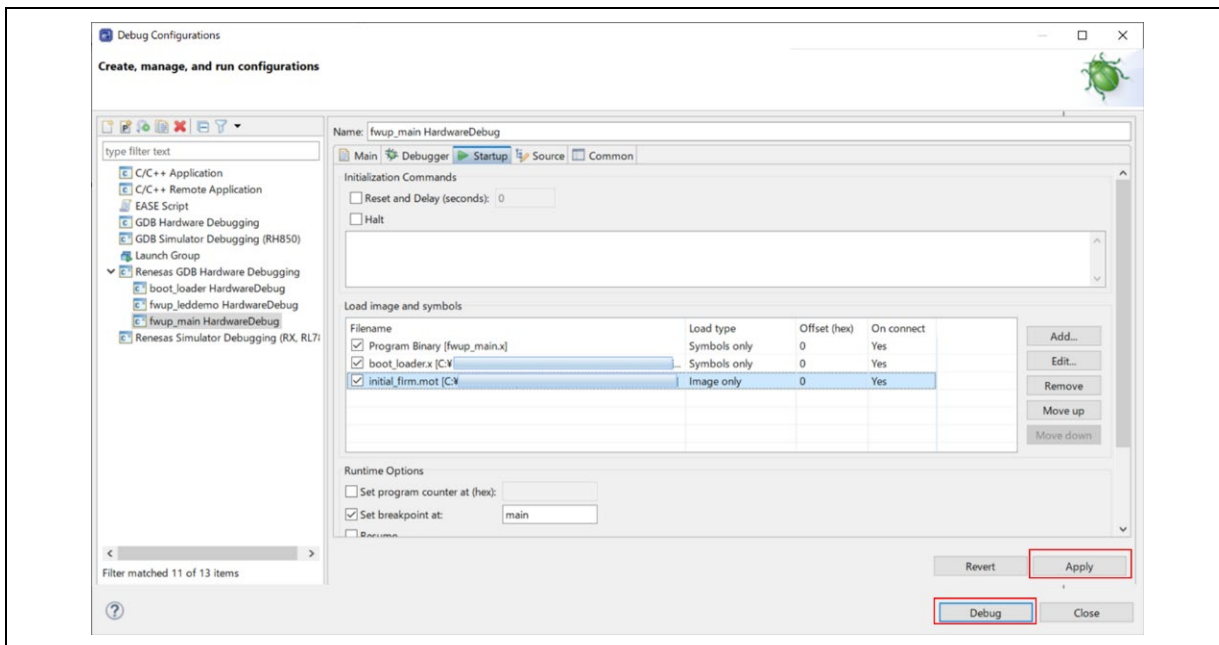
- c) Select the initial image (initial_firm.mot) and click [OK].



- d) Change the load type of the initial image (initial_firm.mot) from [Image and Symbol] to [Image only] and click [OK].

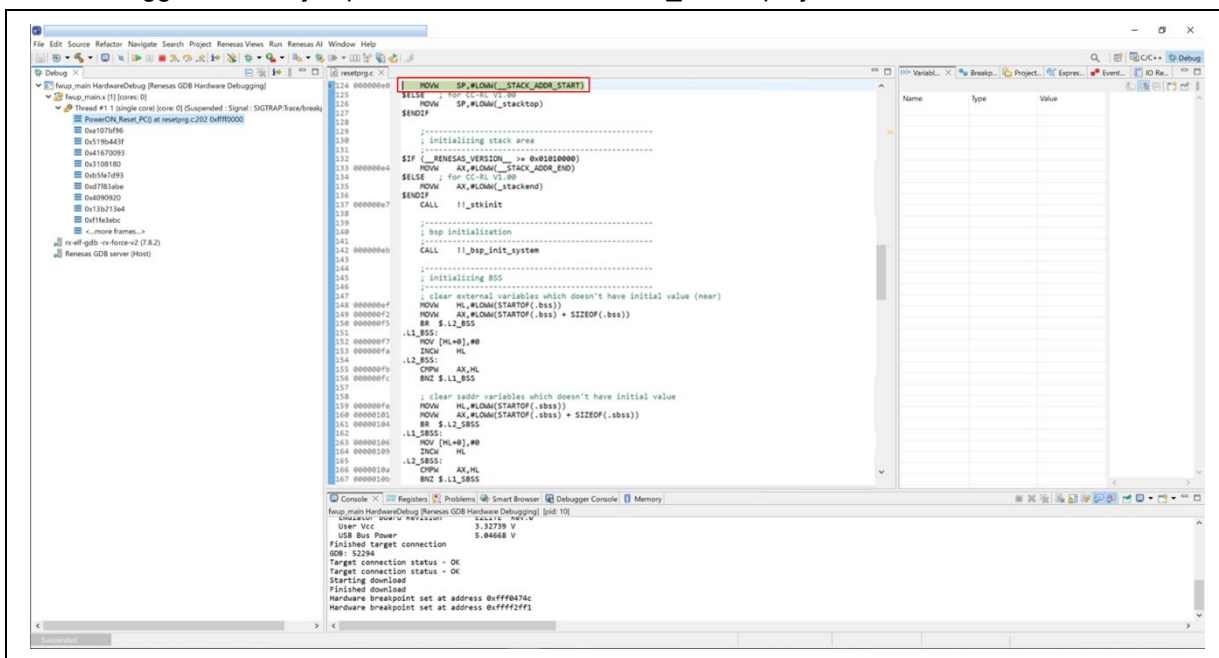


e) Click [Apply] and click [Debug].



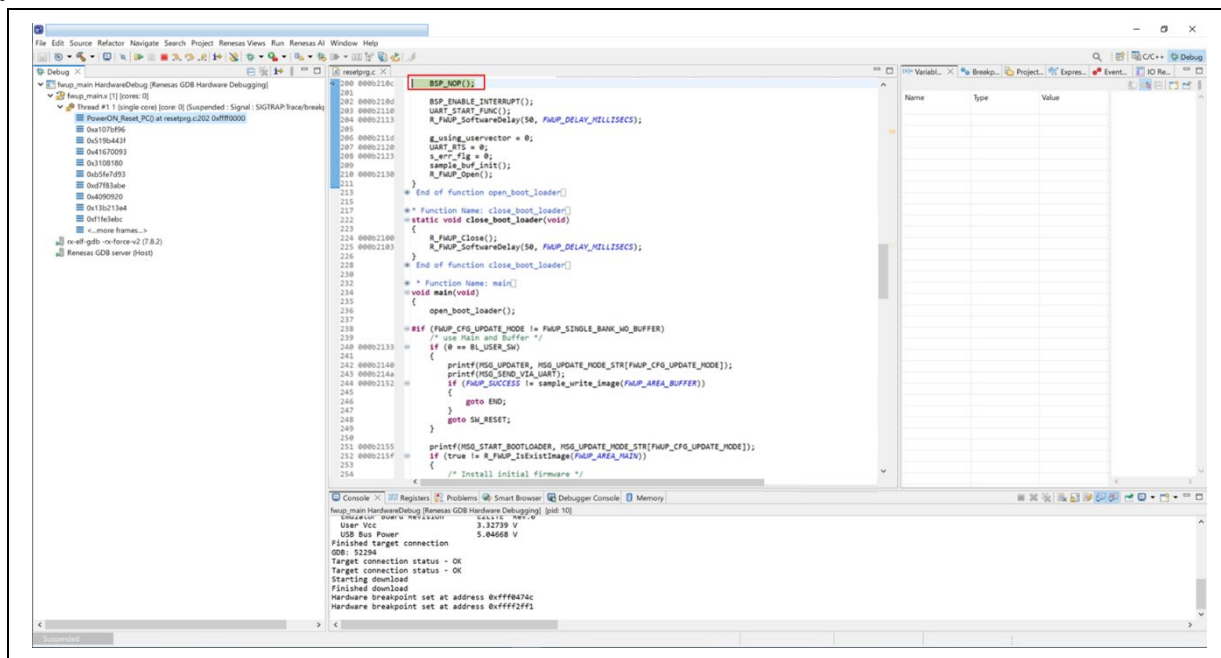
(7) Start the debugger.

When the debugger starts, it jumps to cstart.asm in the boot_loader project.



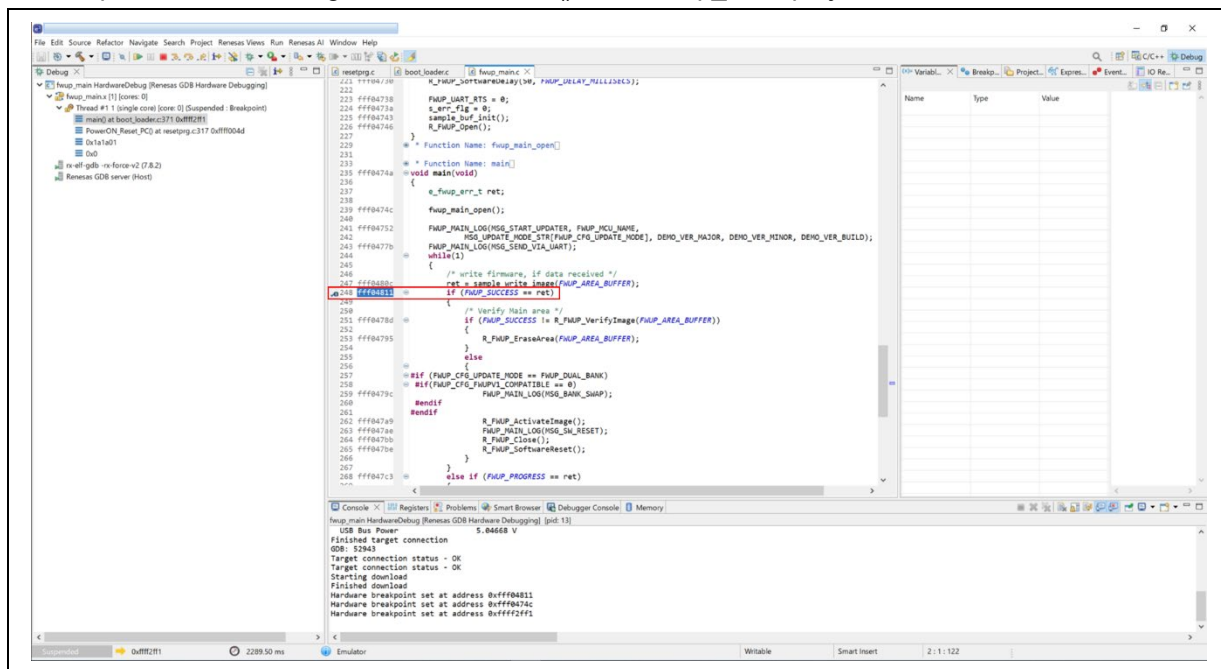
(8) Resume the program.

When you click [Resume], the program stops at the beginning of the main() function in boot_loader.c. project.



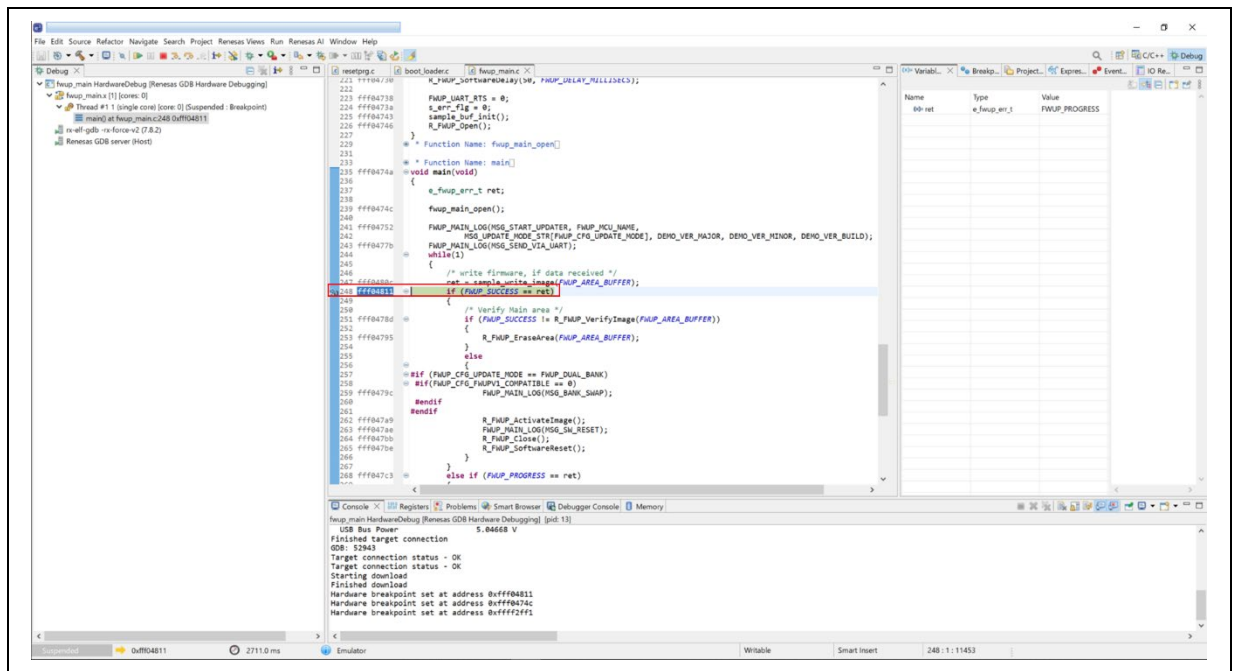
(9) Set a breakpoint in main() of the fwup_main project.

Set a breakpoint in the following red frame in main() of the fwup_main project.



(10) Resume the program.

Click [Resume] and stop at the breakpoint set in (8).



4.9.2 How to Debug the Application Program Only

To debug only the application program in the e² studio environment, follow the procedure described below.

This demo project is configured to receive power from the debugger (E2 Lite). When using another debugger or supplying power from the target board, change the debugger settings as appropriate.

(1) Build the application program.

Build the application program (fwup_main).

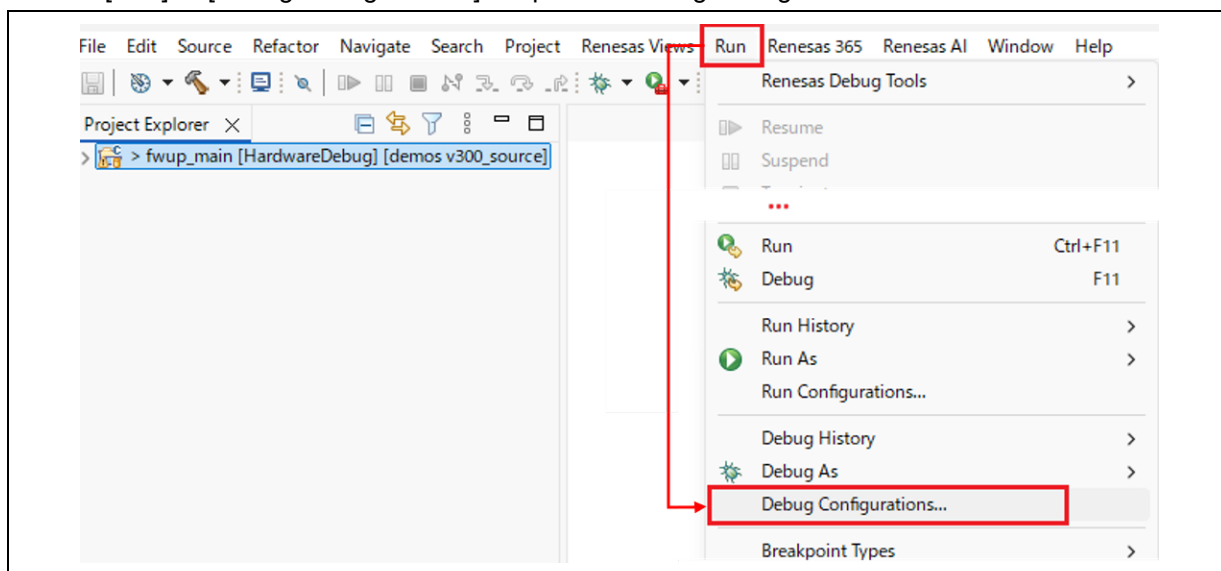
(2) Erase the flash memory. (Dual-bank (2-Bank) method only)

Use a flash programmer to perform a chip erase on the flash memory. This step is not required for configurations other than dual-bank (2-bank) method.

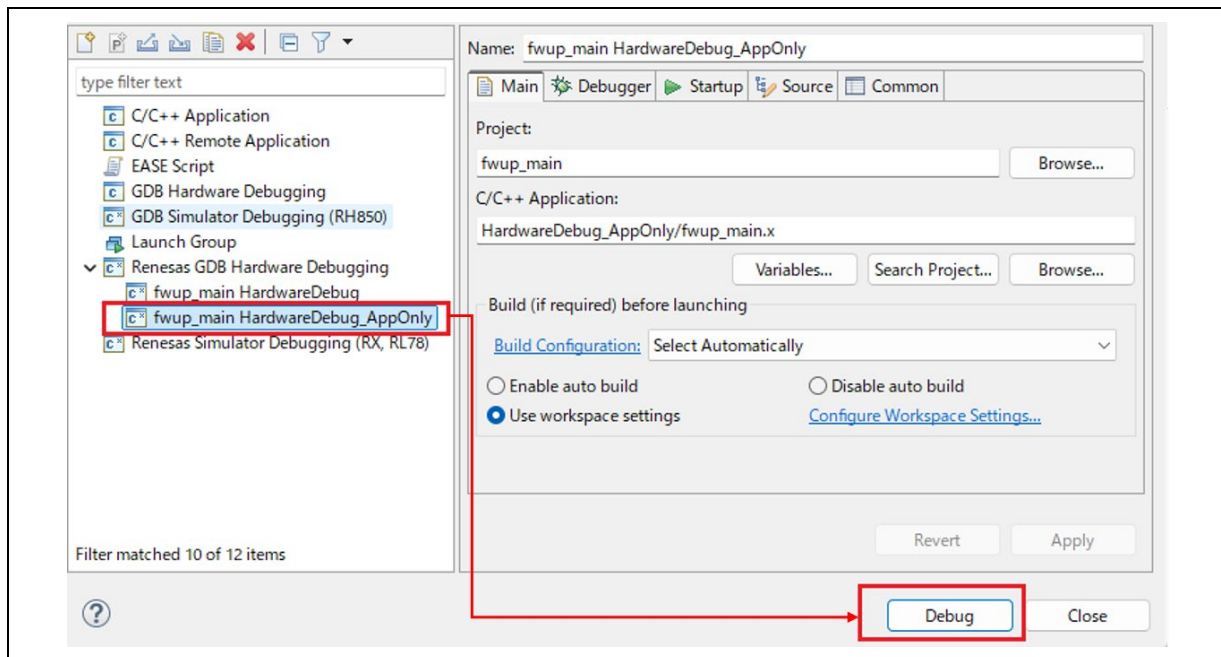
(3) Debug settings for the application program (fwup_main).

Follow the steps below to configure debugging settings for the application program (fwup_main).

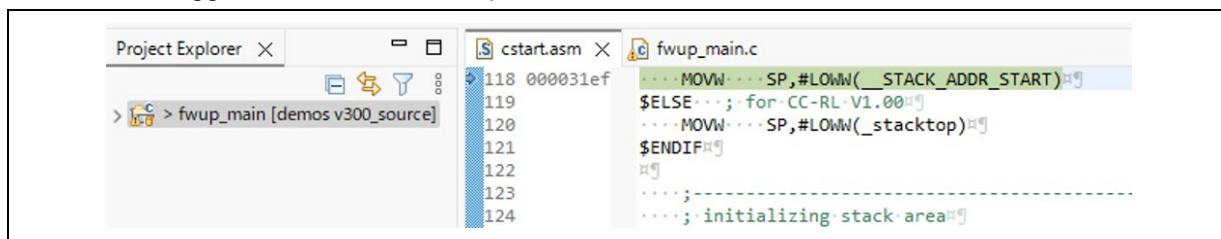
a) Select [Run] -> [Debug Configurations] to open the Debug Configurations window.



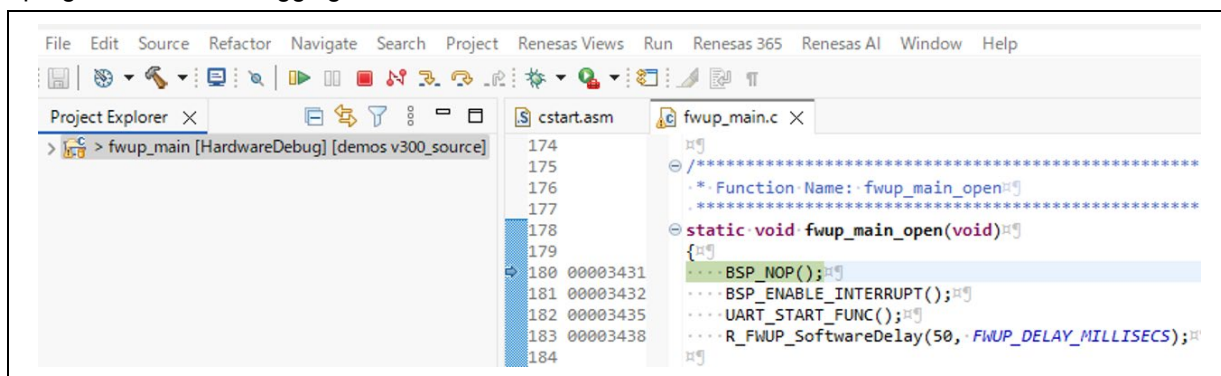
- b) Select [fwup_main_HardwareDebug_AppOnly], and then click [Debug].



- c) After the debugger starts, execution stops at cstart.asm.



- d) Click [Resume] to continue execution. The debugger stops at the beginning of the application program, where debugging can be started.



4.10 How to Change the Update Image Retrieval Path for the Demo Project

In this demo project, the update image is retrieved from a PC via serial communication. This section describes cases where the retrieval path for this image is changed (e.g., SD card, USB memory, etc.).

Figure 4.6 show the flowchart of the demo project (the main function in fwup_main.c). Please first refer to the demo project when considering how to change the retrieval path for the update image.

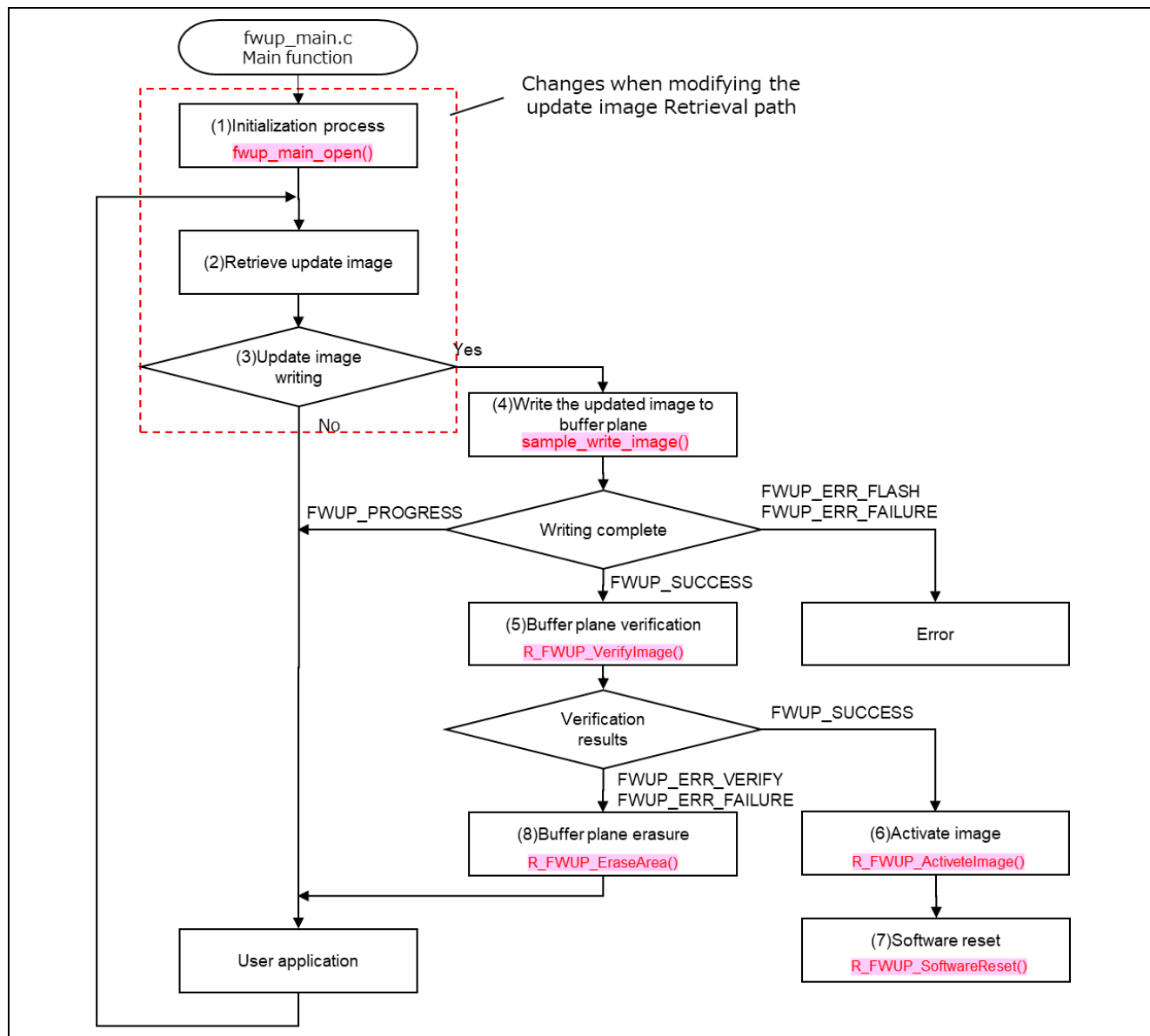


Figure 4.6 Flowchart for fwup_main in the demo project

Note: For full update method (without buffer plane), the bootloader is responsible for retrieving the update image. Therefore, if you are considering using this method, please interpret the explanations in this document as applying to the bootloader instead.

The sections that need to be modified when changing the retrieval path of the update image are parts (1), (2), and (3). Sections (4) and onward relate to the update process itself, so in principle, no changes are required.

- (1) For the initialization process, not only the Firmware Update Module initialization but also the initialization of various modules used to retrieve the update image is performed.

In the demo project, the initialization of the Serial Communication module, the Firmware Update module, and the related variables is performed.

- (2) Buffer the update image obtained from external sources in RAM or similar memory.

Various methods can be used to obtain the update image from external sources (e.g., SD cards, USB flash drives). For image acquisition, refer to Renesas application notes and other relevant documents, and implement the method on the user side.

In the demo project, the Serial Communication module is used, and the update image is retrieved through the callback function (`sci_callback`) that is invoked upon completion of the communication interrupt. Once buffering of the update image is completed, the RTS pin (`FWUP_UART_RTS`) is asserted to provide notification.

- (3) Once buffering of the update image is complete, proceed with the write operation.

It is not necessary to prepare the entire update image at once. You may retrieve and buffer the update image in chunks of a size convenient for your system, and perform the write operation sequentially. However, note that each product has a specific minimum write unit for its flash memory, so ensure that processing is performed in multiples of that write unit.

Example: For the RL78/G23, since the code flash write unit is 4 bytes, valid settings include 64, 128, and 256 bytes.

When writing the update image, interrupts will be disabled during the flash operation. Therefore, if the update image is retrieved via interrupt processing, there is a possibility of data loss during the write period. To avoid this, consider implementing a mechanism to temporarily suspend the retrieval of the update image—similar to the RTS control used for serial communication in the demo project.

In the demo project, the state of the RTS pin (`FWUP_UART_RTS`) is monitored, and the write operation is initiated once it is asserted.

The following summarizes additional notes for understanding the demo project.

<Notes regarding `fwup_main.c`>

- In the demo project, serial communication is used to retrieve the update image. Due to the characteristics of serial communication, there may be a delay before the transmission from the communication peer stops in response to RTS control. To prevent loss of update image data, a delay process is inserted before initiating the write operation.
- (4) Regarding the writing of the update image, please write the data sequentially from the beginning of the update image.
If the order of the data may be altered depending on the communication method, ensure that the data is rearranged into the correct order before writing.
Since the update image cannot be written in a single operation—depending on the buffer size—you must perform the write process in multiple iterations. During this period, until all data corresponding to the full size of the update image has been written, the function will return the status 'in progress' (`FWUP_PROGRESS`). Please continue retrieving and writing the update image until the entire image has been written.
Once all writing operations have been completed successfully, the function will return `FWUP_SUCCESS`.
- If the flash error (`FWUP_ERR_FLASH`) is returned during the update-image write process (4), it is highly likely that an error has occurred in the flash memory. In this case, please erase the buffer plane and restart the entire procedure from the beginning.

- The size of the update image is obtained using the `R_FWUP_GetImageSize` function. Since the size information is stored in the RSU header located at the beginning of the update image, the correct size cannot be obtained until the writing of the RSU header portion has been completed. Until it can be retrieved correctly, this API will return 0.
- (6) The process for activating the update image differs depending on the update method.
Dual-bank method: A bank-swap operation is performed.
Non-dual-bank methods: No special operation is performed.
Therefore, for non-dual-bank methods, the activation process for the update image is not required. In update methods other than dual-bank, operations such as copying from the buffer plane to the main area are handled by the bootloader.
- (7) Regarding software reset, while the demo project performs it immediately after writing completion, you may perform it at a convenient time for each system without issue.
- (8) Regarding the erasure of the buffer plane, the update image is erased if signature verification of the buffer plane fails. The behavior after erasure depends on the customer's system.
If signature verification fails in the field, it may indicate that the device is being updated with an invalid update image. Therefore, it is recommended to stop the update process in such cases.

<Notes regarding *bootloader.c*>

- The bootloader is designed to be used in a general-purpose manner, so it can essentially be used as is.
- In linear mode full update method (without buffer), the bootloader acquires the update image. Therefore, if considering this method, please review the processing within the bootloader.
The process from acquiring the update image in the bootloader to performing the update is nearly identical to the corresponding section in `fwup_main`.
- In the demo project for the dual-bank method, the buffer plane is not erased after the update.
If you do not want to retain the pre-update image—for example, to prevent rollback—please add a process to erase the buffer plane after the bootloader successfully verifies the signature of the main area.
In methods other than dual-bank, the buffer plane is erased after the bootloader completes the update process (copying from the buffer plane to the main area).
- If you are modifying and using the bootloader, please also refer to Section 7.1.

4.11 How to Add Interrupt Handling to the Demo Project

This section describes the flow of interrupt processing in the demo project, as well as how to add user-defined interrupt handling.

4.11.1 Flow of Interrupt Processing in the Demo Project

On the RL78, the vector table addresses (0x00 to 0x7F) are fixed; therefore, a common vector table must be used by both the bootloader and the application program. As a result, when an interrupt occurs, it is necessary to determine whether the interrupt is intended for the bootloader or the application program and dispatch it accordingly. These processes are handled by the bootloader.

This section describes the flow of interrupt processing using the RL78/G23 demo project.

- (1) An Interrupt occurs.
- (2) Control jumps to the interrupt handler registered in the vector table.
- (3) The interrupt handler determines the execution mode (Flag in RAM):
 - Flag = 0: Execute the bootloader interrupt callback
 - Flag = 1: Execute the user application program interrupt callback

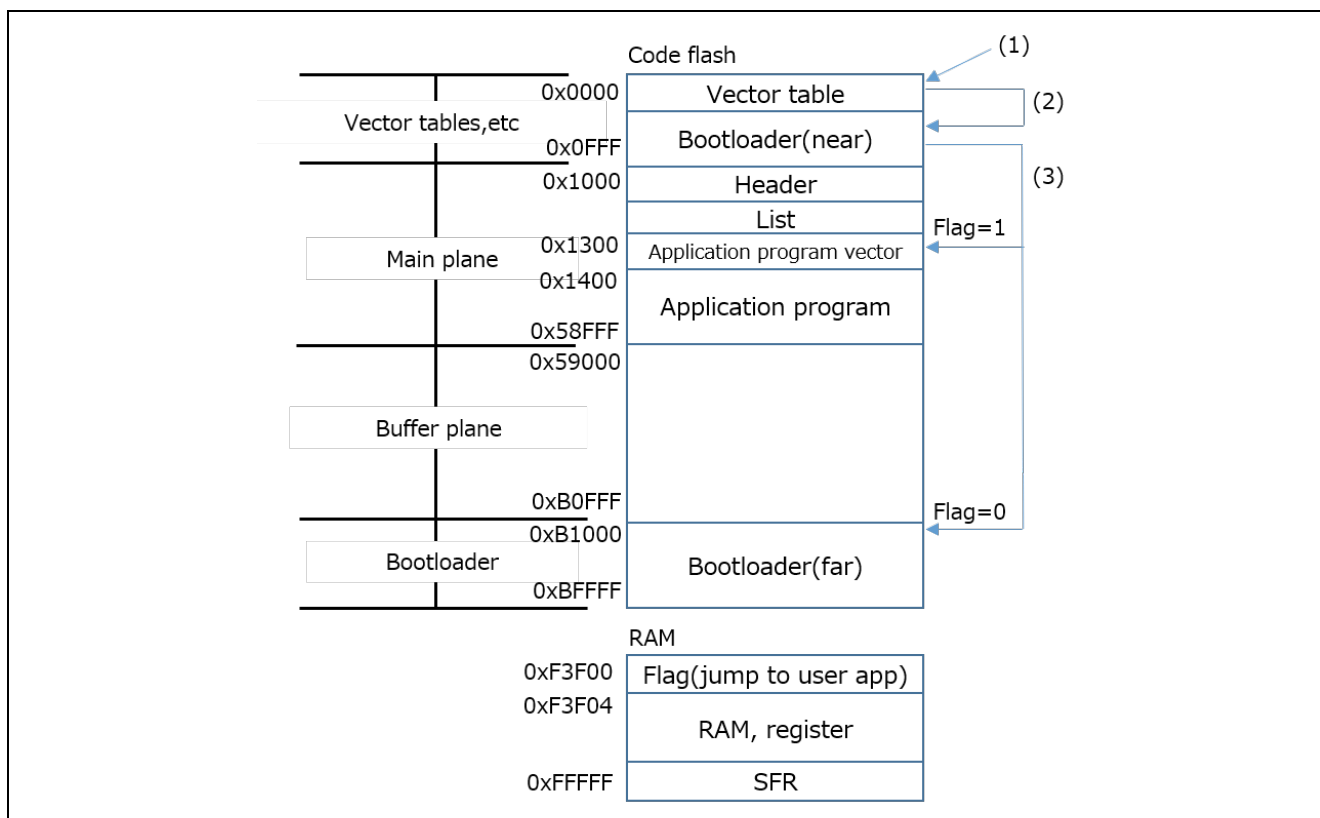


Figure 4.7 Interrupt Handling Flow

4.11.2 How to Add Interrupt Processing to the Demo Project

This section describes the procedure for adding interrupt handling to the demo project (fwup_main.c).

- (1) Add the component that uses interrupts by using the code generation function.
- (2) Remove the hardware interrupt handler definition from the added source code.

For example, when UART2 is added, remove the hardware interrupt handler definition from Config_UART2_user.c.

```
fwup_main\src\Config_UART2\Config_UART2_user.c
/*****
Includes
*****/
#include "r_cg_macrodriver.h"
#include "r_cg_userdefine.h"
#include "Config_UART2.h"
/* Start user code for include. Do not edit comment generated here */
/* End user code. Do not edit comment generated here */

/*****
Pragma directive
*****/
#pragma interrupt r_Config_UART2_interrupt_send(vect=INTST2)
#pragma interrupt r_Config_UART2_interrupt_receive(vect=INTSR2)
#pragma interrupt r_Config_UART2_interrupt_error(vect=INTSRE2)
/* Start user code for pragma. Do not edit comment generated here */
```

Remove

(3) Create a global interrupt handler function and replace the existing function with it.

For UART2, replace the following function in Config_UART2_user.c.

- static void __near r_Config_UART2_interrupt_send(void) ⇒ void r_isr_txi(void)
- static void __near r_Config_UART2_interrupt_receive(void) ⇒ void r_isr_rxi(void)
- static void __near r_Config_UART2_interrupt_error(void) ⇒ void r_isr_eri(void)

```
fwup_main\src\Config_UART2\Config_UART2_user.c
static void r_Config_UART2_callback_error(uint8_t err_type)
{
    /* Start user code for r_Config_UART2_callback_error. Do not edit comment generated here */
    /* End user code. Do not edit comment generated here */
}

static void __near r_Config_UART2_interrupt_send(void)
    ...
static void __near r_Config_UART2_interrupt_receive(void)
    ...
static void __near r_Config_UART2_interrupt_error(void)
    ...

/* Start user code for adding. Do not edit comment generated here */
void r_isr_txi(void)
{
    if (g_uart2_tx_count > 0U)
    {
        TXD2 = *gp_uart2_tx_address;
        gp_uart2_tx_address++;
        g_uart2_tx_count--;
    }
    else
    {
        r_Config_UART2_callback_sendend();
    }
}

void r_isr_rxi(void)
{
    uint8_t rx_data;
    rx_data = RXD2;
    sample_buffering(rx_data);
}

void r_isr_eri(void)
{
    uint8_t err_type;

    *gp_uart2_rx_address = RXD2;
    err_type = (uint8_t)(SSR11 & 0x0007U);
    SIR11 = (uint16_t)err_type;
    r_Config_UART2_callback_error(err_type);
}

/* End user code. Do not edit comment generated here */
```

Remove

Add

(4) Register the replaced interrupt handler function in branch.asm.

For UART2, register the function replaced in step (3) in the branch table at addresses 0x14 to 0x18.

```
fwup_main\src\ branch.asm
usr_vect  .cseg at 0x00001300
          br      !!_start      ;reset
          .db4    0xffffffff
          .db4    0xffffffff    ;vect=0x04
          .db4    0xffffffff    ;vect=0x06
          .db4    0xffffffff    ;vect=0x08
          .db4    0xffffffff    ;vect=0x0A
          .db4    0xffffffff    ;vect=0x0C
          .db4    0xffffffff    ;vect=0x0E
          .db4    0xffffffff    ;vect=0x10
          .db4    0xffffffff    ;vect=0x12
          br      !!_r_isr_txi   ;vect=0x14
          br      !!_r_isr_rxi   ;vect=0x16
          br      !!_r_isr_eri   ;vect=0x18
          .db4    0xffffffff    ;vect=0x1A
          .db4    0xffffffff    ;vect=0x1C
          .db4    0xffffffff    ;vect=0x1E
          .db4    0xffffffff    ;vect=0x20
```

Register

4.12 How to Use a Memory Layout Different from That of the Demo Project

If you want to perform a firmware update using a memory size different from that of the demo project, the parameter file included in the package cannot be used as-is. By modifying the required items according to the memory layout, you can generate the initial image and update images.

For details on the memory layout of the demo project, refer to Section 6.2.

For details on the parameter file, refer to Section 5.3.

As Example 1, this section shows the modified items when the parameter file provided for the RL78/G23 partial update method is changed to the following memory layout:

- Product name: RL78/G23
- Update method: Partial update method
- Code flash size: 768 KB -> 256 KB
- Bootloader size: 64 KB -> 48 KB

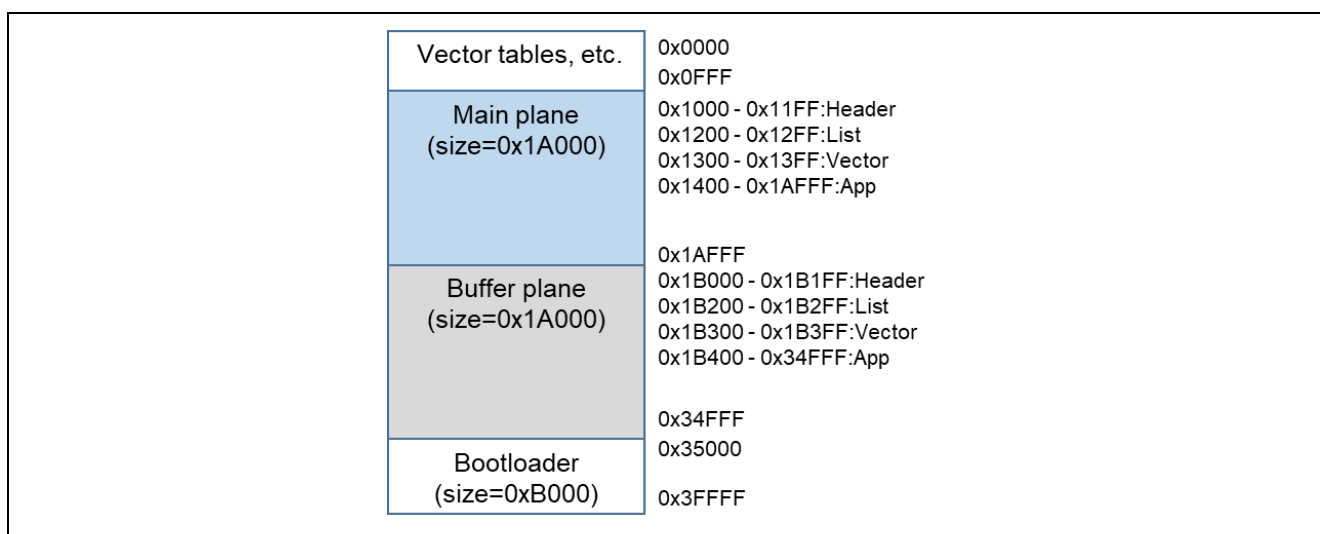


Figure 4.8 Memory map for the RL78/G23 (Code Flash: 256 KB, Bootloader: 48 KB) using the partial update method

In this example, the bootloader size allocated in the demo project is reduced from 64 KB to 48 KB.

Because the bootloader size varies depending on the firmware update configuration options, the memory region not used by the bootloader can be reallocated to the main area and buffer area as appropriate.

Note: The bootloader size includes the Vector table, etc.

The modified items in the parameter file are as follows:

- Bootloader Start Address: 0x000B1000 → 0x00035000
- Bootloader End Address: 0x000BFFFF → 0x0003FFFF
- User Program End Address: 0x00058FFF → 0x0001AFFF

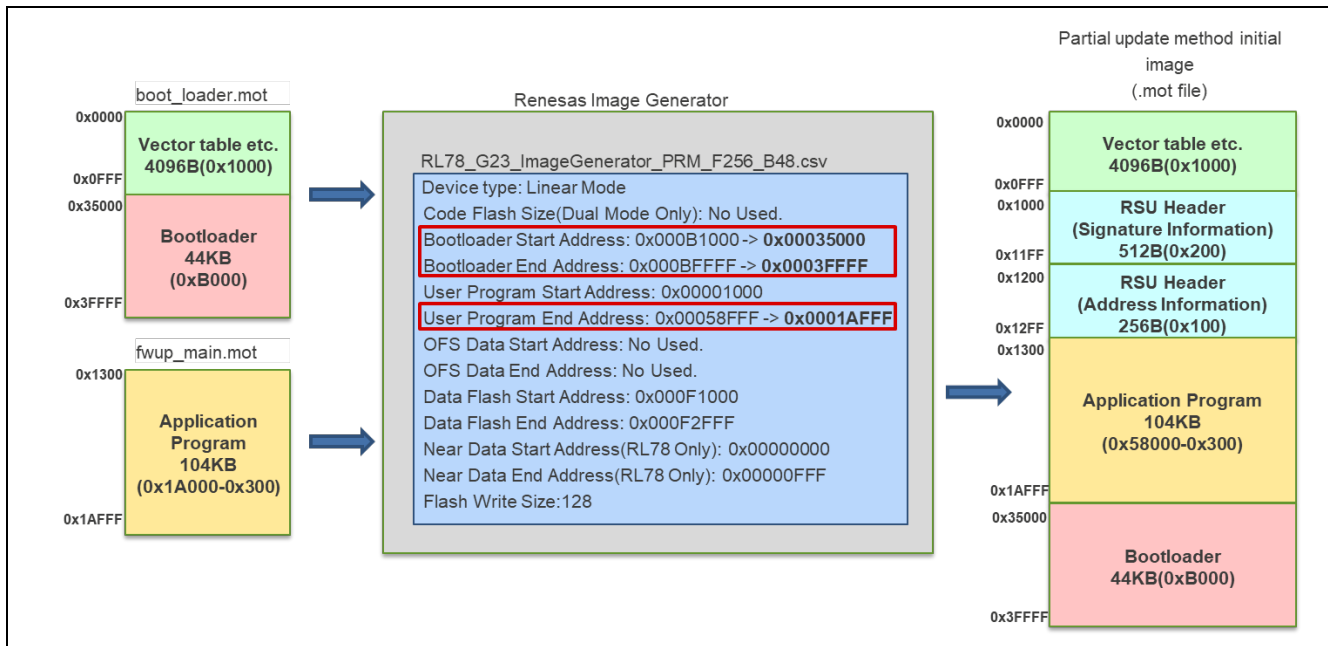


Figure 4.9 Example of parameter file settings for the partial update method for the RL78/G23 (Code Flash: 256 KB, Bootloader: 48 KB)

As Example 2, this section shows the modified items when the parameter file provided for the RL78/L23 dual-bank (2-bank) update method is changed to the following memory layout:

- Product name: RL78/L23
- Update method: Dual-bank (2-Bank) update method
- Code flash size: 512 KB -> 256 KB
- Bootloader size: 64 KB -> 48 KB

Vector tables, etc.	0x0000 0x0FFF
Main plane (size=0x14000)	0x1000 - 0x11FF:Header 0x1200 - 0x12FF:List 0x1300 - 0x13FF:Vector 0x1400 - 0x14FFF:App
Bootloader (size=0xB000)	0x14FFF 0x15000
Vector tables, etc.	0x1FFFF 0x20000 0x20FFF
Buffer plane (size=0x14000)	0x21000 - 0x211FF:Header 0x21200 - 0x212FF:List 0x21300 - 0x213FF:Vector 0x21400 - 0x34FFF:App
Bootloader (size=0xB000)	0x34FFF 0x35000 0x3FFFF

Figure 4.10 Memory map for the RL78/L23 (Code Flash: 256 KB, Bootloader: 48 KB) using the dual-bank(2-bank) method

The modified items in the parameter file are as follows:

- Code Flash Size(Dual Mode Only): 0x00080000 → 0x00040000
- Bootloader Start Address: 0x00031000 → 0x00015000
- Bootloader End Address: 0x0003FFFF → 0x0001FFFF
- User Program End Address: 0x00030FFF → 0x00014FFF

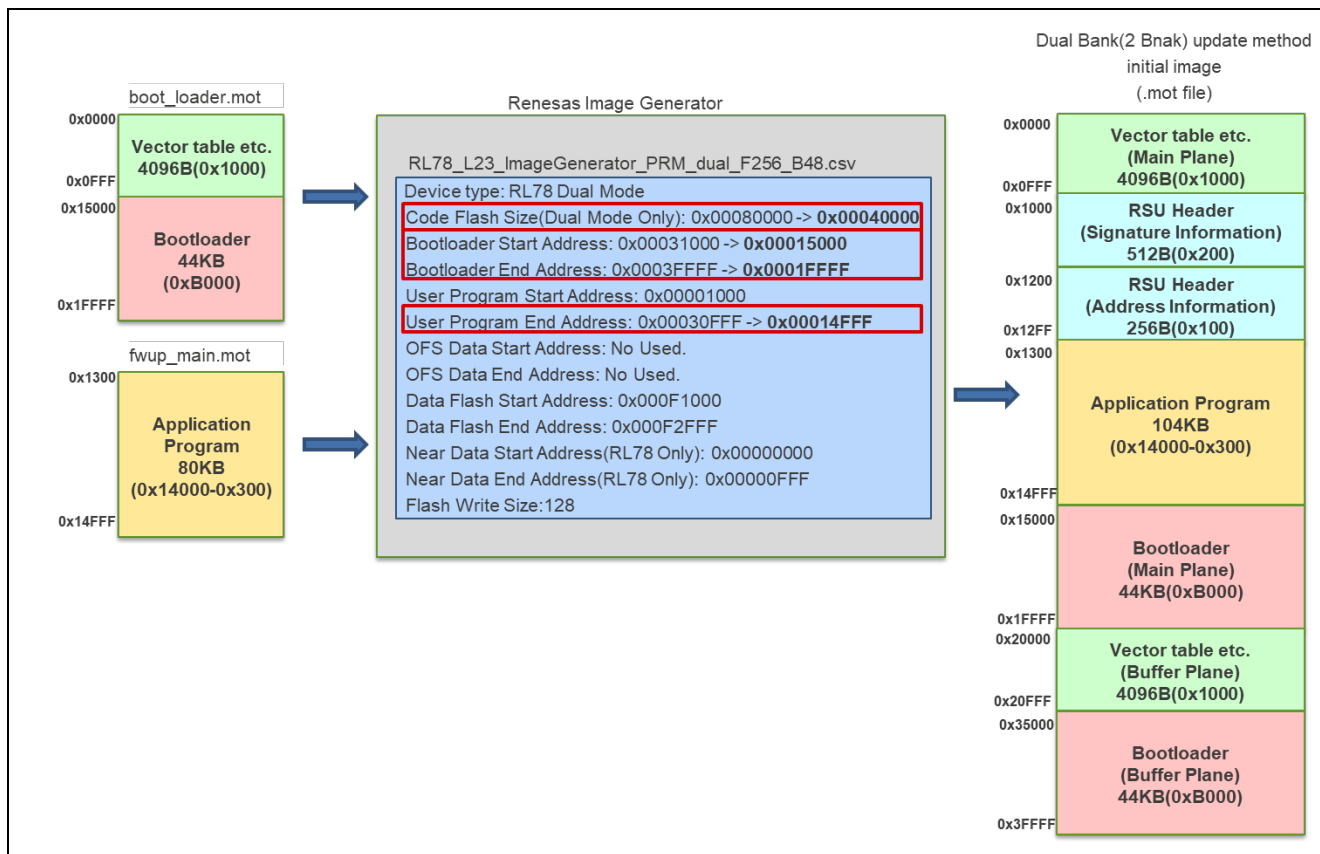


Figure 4.11 Example of parameter file settings for the dual-bank(2-bank) method for the RL78/L23(Code Flash: 256 KB, Bootloader: 48 KB)

5. Renesas Image Generator

Renesas Image Generator is a utility tool that generates firmware images for use with firmware update modules. The Renesas Image Generator can generate the following images used by the firmware update module.

- Initial image: An image file containing the bootloader and application program that is programmed using Flash Writer at the time of initial system configuration (extension: mot).
- Update image: An image file containing the firmware update (extension: rsu).

refer to Section 5.1 for how to generate an image, and 5.2 to 5.3 for details on image configuration and parameter files.

Renesas Image Generator is a program that runs on Python.

5.1 Image Generation Methods

Describes the specifications of Renesas Image Generator (image-gen.py) and how to generate an image file (initial image or update image) using this tool.

refer to Section 5.1.1 for how to generate an initial image, and 5.1.2 for how to generate an update image.

The format of the image-gen.py command is as follows:

```
python image-gen.py < options >
```

Some image-gen.py command options are required and others are optional. Table 5.1 lists the required image-gen.py options, and Table 5.2 lists the optional image-gen.py options.

Table 5.1 Required Options of image-gen.py

Option	Description
-iup <file>	Specifies the application program. For the character string < file >, specify the mot file name (the full path including the file name) of the user application program.
-ip <file>	Specifies a parameter file. For the character string < file >, specify the name of the file (the full path including the file name) containing the parameters to be input.
-o <file>	Specifies the file name of the output image. For the character string < file >, specify the file name (the full path including the file name), excluding the extension, of the firmware update image file to be output. The file extension is .mot because the output image is determined to be the initial image when the bootloader is specified with the -ibp <file> option. If you omit the -ibp <file> specification, the output image is determined to be an update image and becomes .rsu.

Table 5.2 Optional Options of image-gen.py

Option	Description
-ibp <file>	Specifies the bootloader. For the character string < file >, specify mot file name (the full path including the file name) of the bootloader program. Specify this option when generating a mot file.
-vt <VerificationType>[sha256 / ecdsa]	Specifies the image verification method in the firmware update module. The following VerificationType can be specified. sha256: Append a hash of the image. If this option is omitted, "sha256" is specified. ecdsa: Adds an image signature. The key file specified by -key is used to generate signature data. An error will result if the key file is not specified with -key.
-key <file>	Specify the name of the key file to be used to sign the image using ECDSA. (This option does not need to be set if sha256 is specified for the -vt option.) Store the file secp256r1.privatekey in the command execution folder. If the file name has been changed, specify the full path including the file name.
-ff <FileFormat>[BareMetal / RTOS]	Specifies the RSU format type. The following FileFormat can be specified BareMetal: Generates an image of the application program data with RSU header signature information. This is the RSU format used in the demo project. If this option is omitted, "BareMetal" is specified. RTOS: Generates an updated image for AWS S3 (OTA). Update images for AWS S3 (OTA) do not add RSU header signature information. If you are using a service other than AWS S3 (OTA), please configure BareMetal. BareMetal_FWUP_V2_V1_DATA: For special purpose. RTOS_FWUP_V2_V1_DATA: For special purpose.
-ud <UserData>	Specifies user-defined data (4 bytes). The data must be specified in hexadecimal format. Example:0x12345678 The specified 4-byte data is stored in the RSU header. The data is stored in little-endian format at offset 0x70 from the beginning of the header. For details of the RSU header, refer to Table 5.3. If this option is omitted, 0xFFFFFFFF is stored. This data is not included in signature verification. The firmware update module neither references nor processes this data. Therefore, the user may use it for any purpose as user-specific information.
-h	Output a list of commands. Specify this option to display help information for the tool.

5.1.1 Initial Image Generation Method

Renesas Image Generator has the bootloader file name (.mot) generated by build, application program (.mot), parameter file name (.csv), output file name (no extension), image verification method in firmware update module. Specify (ecdsa/sha256) as a command line option to generate an initial image file (.mot).

Command input example

```
> python image-gen.py -iup fwup_main.mot -ip  
RL78_G23_ImageGenerator_PRM.csv -o initial_firm -ibp boot_loader.mot  
-vt ecdsa -key secp256r1.privatekey
```

fwup_main.mot: The mot file name of the user application program

RL78_G23_ImageGenerator_PRM.csv: The name of the file containing the parameters to be input

initial_firm: The file name of the initial image file to be output

boot_loader.mot: The mot file name of the bootloader program

ecdsa: Specifies that ECDSA is used to sign the image.

secp256r1.privatekey: Key file name for signing images with ECDSA.

5.1.2 Update Image Generation Method

The Renesas Image Generator uses the update application program (.mot) generated by the build, parameter file name (.csv), output file name (no extension), image verification method (ecdsa/sha256) for the firmware update module. Set the command line options to generate an update image file (.rsu).

Command input example

```
> python image-gen.py -iup fwup_leddemo.mot -ip  
RL78_G23_ImageGenerator_PRM.csv -o fwup_leddemo -vt ecdsa -key  
secp256r1.privatekey
```

fwup_leddemo.mot: The mot file name of the user application program to be applied as an update

RL78_G23_ImageGenerator_PRM.csv: The name of the file containing the parameters to be input

fwup_leddemo: The file name of the update image file to be output

ecdsa: Specifies that ECDSA is used to sign the image.

secp256r1.privatekey: Key file name for signing images with ECDSA.

5.2 Image File

5.2.1 Update Image File

Figure 5.1 shows the configuration diagram of the update image file generated by Renesas Image Generator.

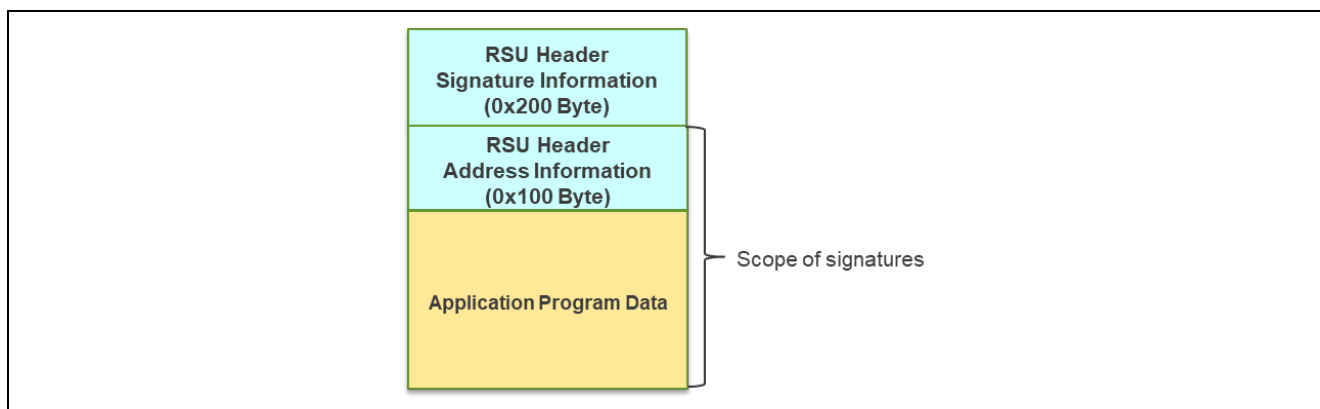


Figure 5.1 Configuring the update image file

The update image file consists of the RSU header and application program data. The application program data is located immediately after the RSU header.

The RSU header contains the application program address information required for application program integrity verification, as well as signature information generated from the application program based on that address information.

The application program data is stored in the following order: data to be programmed into the code flash area, followed by data to be programmed into the data flash area.

Renesas Image Generator extracts valid data from the application program file (.mot) generated by the user and outputs it in binary file (.rsu).

The update image file has the same format for all update methods.

Refer to Figure 5.2 for the mechanism of generating the update image file.

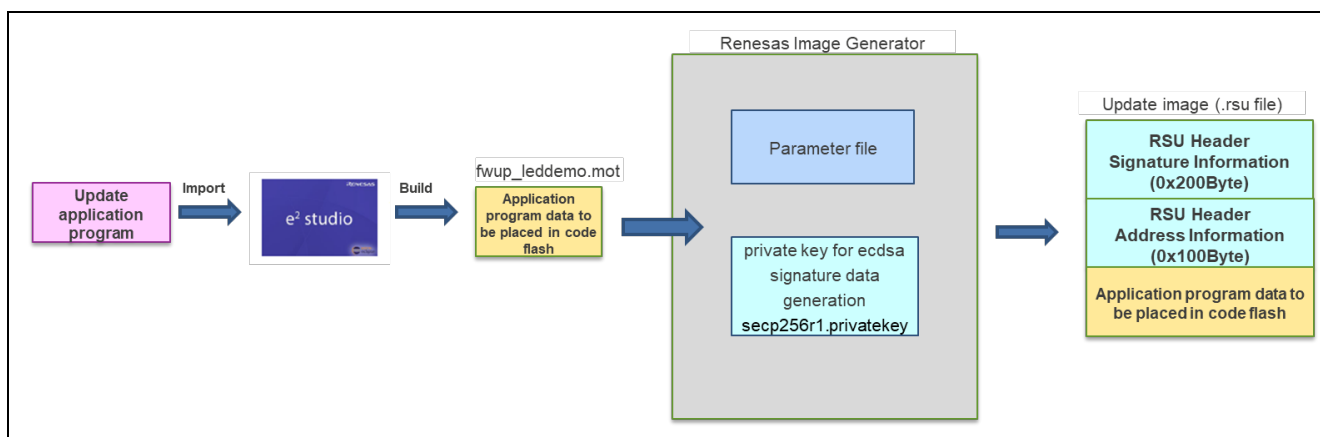


Figure 5.2 Updating image of partial / full updating method

- The parameter file is a CSV format file that contains the device address information required to generate the image file.
- The private key for generating the ecDSA signature value is used when ecDSA is specified as the image verification method in the firmware update module.

5.2.2 Initial Image File

The initial image file is the RSU header and application program data plus the bootloader program data. Figure 5.3 and 5.4 also show a diagram of the initial image file (partial / full update method).

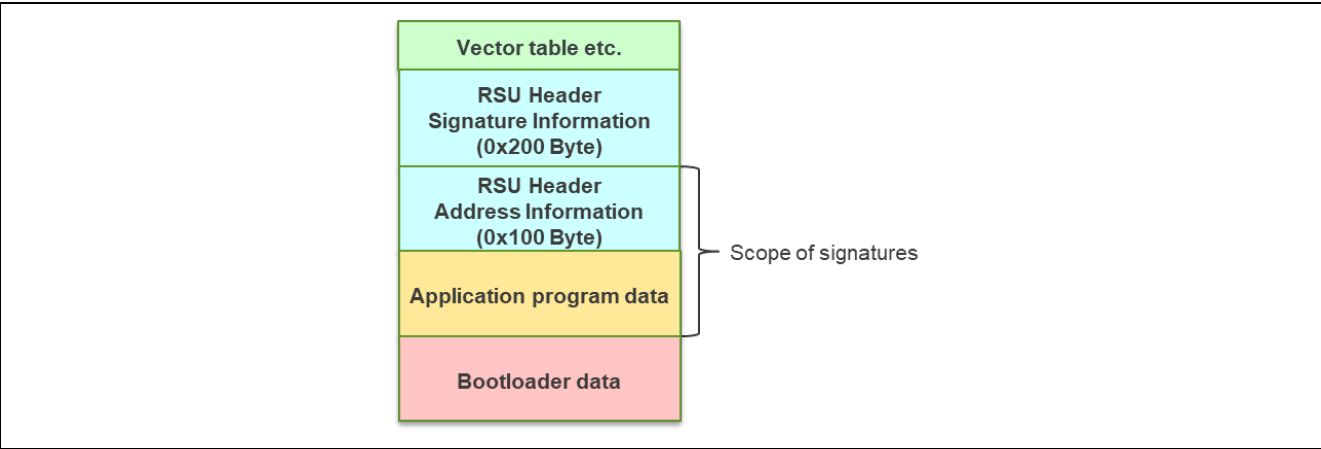


Figure 5.3 Composition of initial image file (partial / full update method)

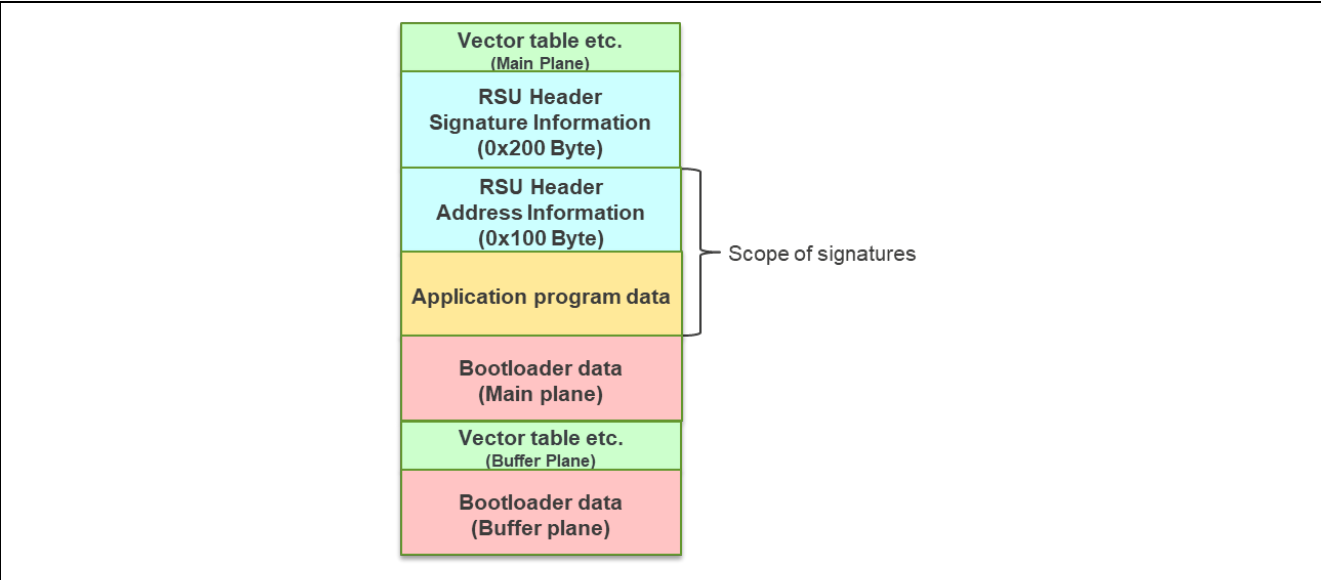


Figure 5.4 Composition of initial image file (dual-bank(2-bank) method)

In the initial image file of partial / full update method, the bootloader data to be placed on the main plane of the code flash uses the data in the user-generated bootloader file (boot_loader.mot) as is.

Refer to Figure 5.5 and 5.6 for the mechanism that generates the initial image file.

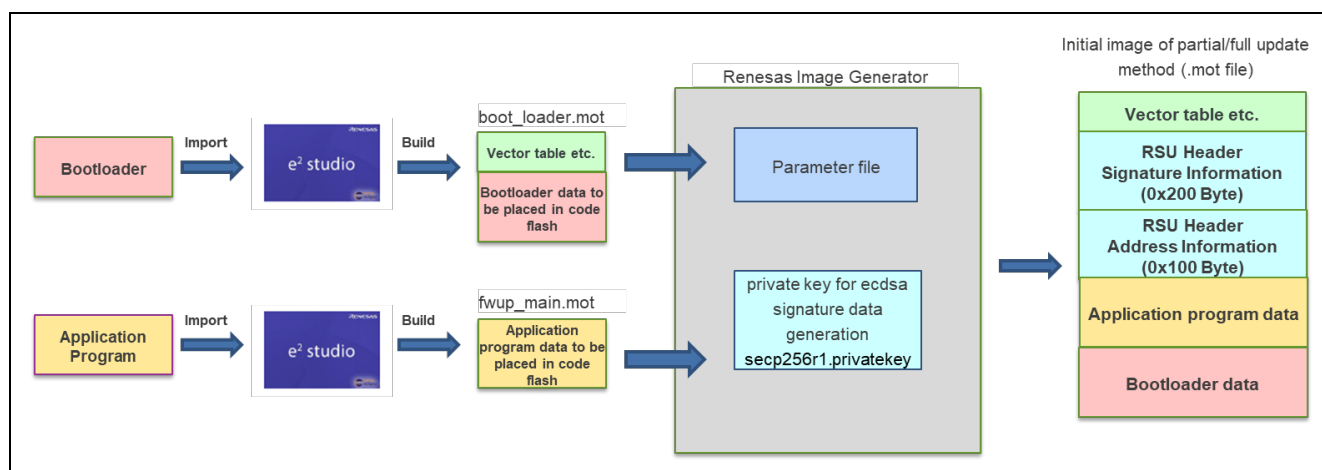


Figure 5.5 Initial image of partial/ full update method

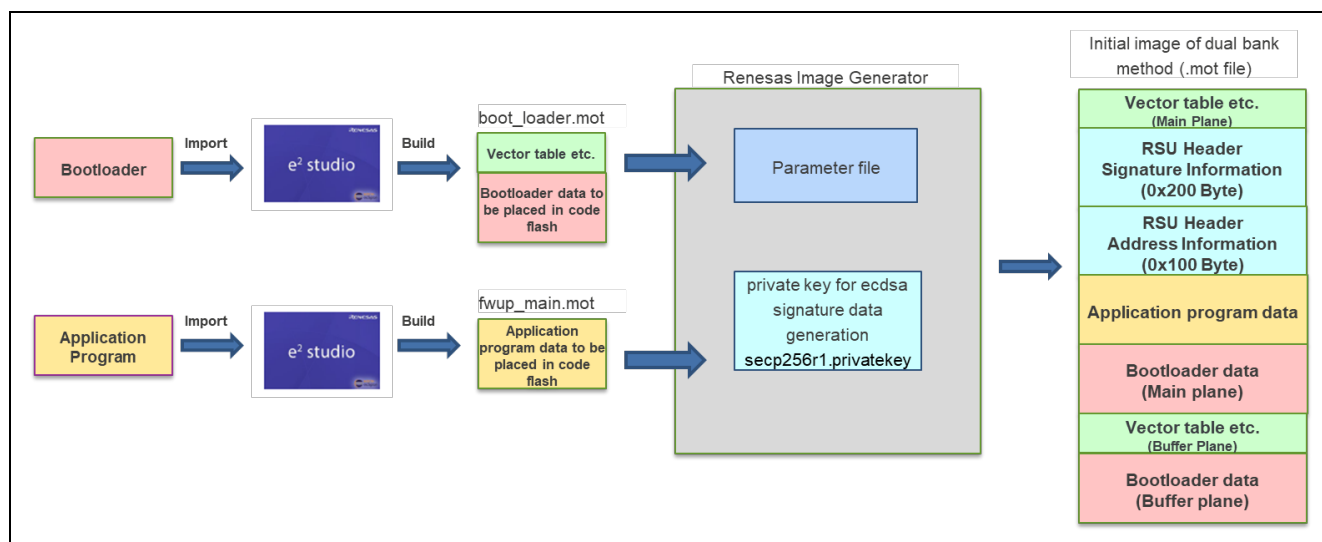


Figure 5.6 Initial image of dual-bank(2-bank) method

- The parameter file is a CSV format file that contains the device address information required to generate the image file.
- The private key for generating the ecDSA signature value is used when ecDSA is specified as the image verification method in the firmware update module.

5.2.3 RSU Header

For details of the RSU header format, refer to Table 5.3 and 5.4.

Table 5.3 RSU Header Signature Information Format

Offset	Item	Length (Bytes)	Description
0x00000000	Magic Code	7	Magic code ("RELFVW2")
0x00000007	Reserved	1	Reserved area
0x00000008	Firmware Verification Type	32	Image verification method Set sig-sha256-ecdsa to use ECDSA for image verification, and hash-sha256 to use hash.
0x00000028	Signature size	4	Data size of signature value or hash value stored in Signature Set 0x40 if Firmware Verification Type is sig-sha256-ecdsa, and 0x20 if hash-sha256.
0x0000002C	Signature	64	Signature value used for firmware verification For SHA-256 signature data, bytes 33 to 64 are set to 0x00.
0x0000006C	RSU File Size	4	File size of entire update image file
0x00000070	User Data	4	Specifies user-defined data (stored in little-endian format)
0x00000074	Reserved	396	Reserved area

Table 5.4 RSU Header Address Information Format

Offset	Item	Length (Bytes)	Description
0x00000200	Program Data Num	4	Number of subsequent divided application programs or data flashes (maximum 31)
0x00000204	Start Address[0]	4	Start address of the first application program or data flash
0x00000208	Data Size[0]	4	Size of the first application program or data flash
0x0000020C	Start Address[1]	4	Start address of second application program or data flash
0x00000210	Data Size[1]	4	Second application program or data flash size
:	:		
0x000002F4	Start Address[30]	4	Start address of the 31st application program or data flash
0x000002F8	Data Size[30]	4	Size of the 31st application program or data flash
0x000002FC	Reserved	4	Reserved area

5.3 Parameter File

The parameter file is the information required for Renesas Image Generator to generate the initial and updated image files for the sample program, and is included in the release package as part of the Renesas Image Generator Python. It is included in the release package as part of the Renesas Image Generator Python program set. When a customer generates an initial or updated image for a demo project, there is no need to change the contents of the parameter file.

If the parameter file needs to be modified due to changes in program placement or other reasons, refer to Section 4.12.

5.3.1 Contents of Parameter File

Table 5.5 lists the parameters in the parameter file.

The items listed in the parameter file are the same for all devices, but the settings differ for each device.

Table 5.5 Contents of parameter file

Parameter name	Description
Device Type	RL78 Dual Mode: Generation of mot file for dual-bank(2-bank) method Linear Mode : Generation of mot file for partial/full update method
Code Flash Size (Dual Mode Only)	Code Flash Size (Configure only the dual-bank (2-bank) method)
Bootloader Start Address	Bootloader start address
Bootloader End Address	Bootloader end address
User Program Start Address	Starting address of the application program on the main plane
User Program End Address	End address of the application program on the main plane (in dual mode, application program area on main plane)
OFS Data Start Address	OFSM data start address (For RL78, set 'No Used.')
OFS Data End Address	OFSM data end address (For RL78, set 'No Used.')
Data Flash Start Address	Data flush start address (Set 'No Used.' if data flush data is not to be generated)
Data Flash End Address	Data flash end address (Set 'No Used.' if data flash data is not to be generated)
Near Data Start Address (RL78 Only)	Near bootloader start address for RL78
Near Data End Address (RL78 Only)	Near boot loader start address for RL78
Flash Write Size	Flash write size (number of bytes required for one write to the flash in decimal)

The value specified for each parameter is specified in decimal for Flash Write Size and in hexadecimal (with 0x added at the beginning) for other parameters.

Next, the parameters referenced when generating an image file are described.

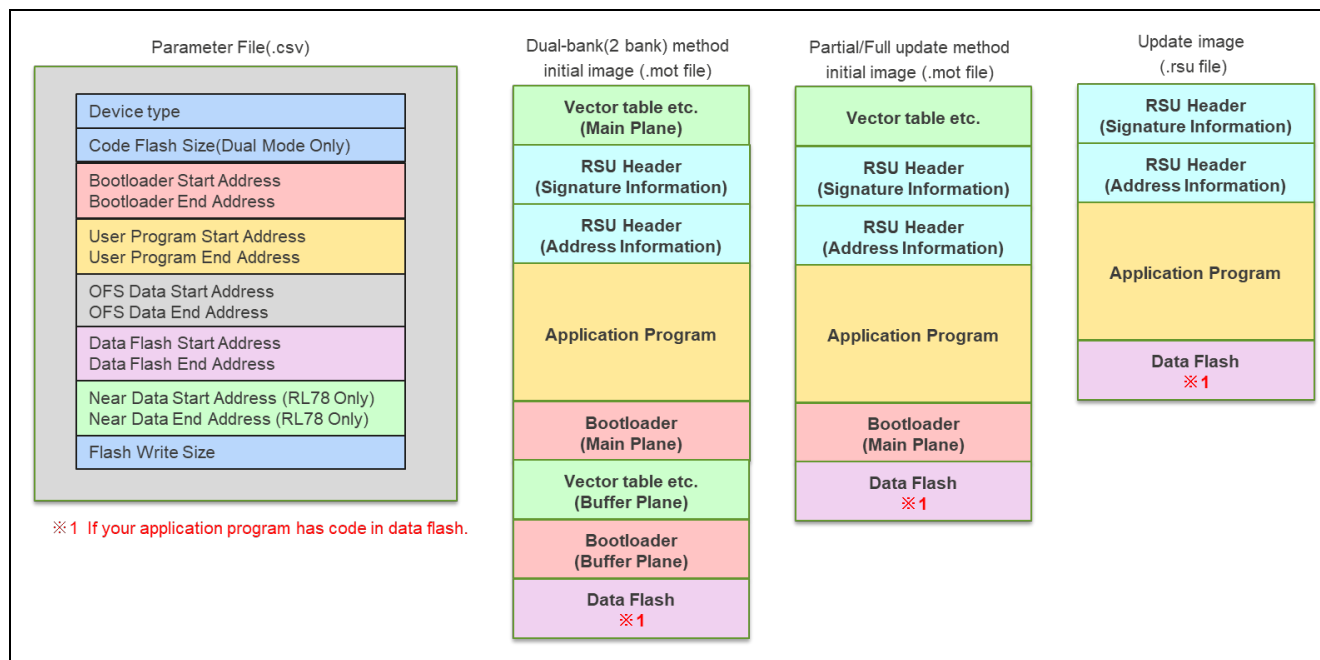


Figure 5.7 Parameters referenced when generating image files

- **Device Type:**
Used to determine whether to generate an initial image for the dual-bank (2-bank) configuration. When the Device Type is set to RL78 Dual Mode, both the bootloader (main plane) and the bootloader (buffer area) are generated. When set to Linear Mode, only the bootloader (main plane) is generated.
- **Code Flash Size (Dual Mode Only):**
Used to determine the address at which the bootloader (buffer plane) is placed.
- **Bootloader Start Address – Bootloader End Address:**
An image file is generated using the specified address range as the bootloader code. The bootloader file (.mot) is used as the input data.
- **User Program Start Address – User Program End Address:**
An image file is generated using the specified address range as the application program code. The application program file (.mot) is used as the input data.
- **Data Flash Start Address – Data Flash End Address:**
An image file is generated using the specified address range as data flash data. (Data flash is not used in this demo project.) The application program file (.mot) is used as the input data.
- **Near Data Flash Start Address (RL78 Only) – Near Data Flash End Address (RL78 Only):**
An image file is generated using the specified address range as code for the bootloader vector table and related components. The bootloader file (.mot) is used as the input data.
- **Flash Write Size:**
Used to set the data size of the RSU header (address information) as the minimum write unit when writing to flash memory.

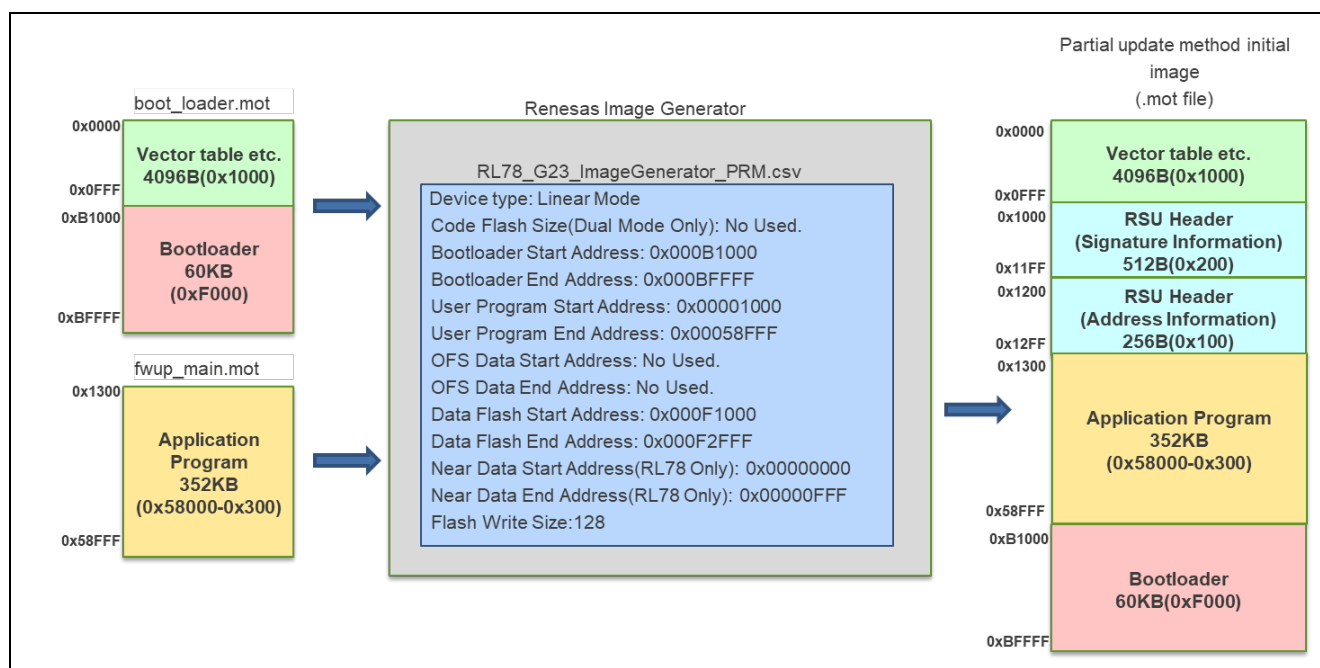


Figure 5.8 Example of parameters referred to when generating the initial image of RL78/G23 partial update method

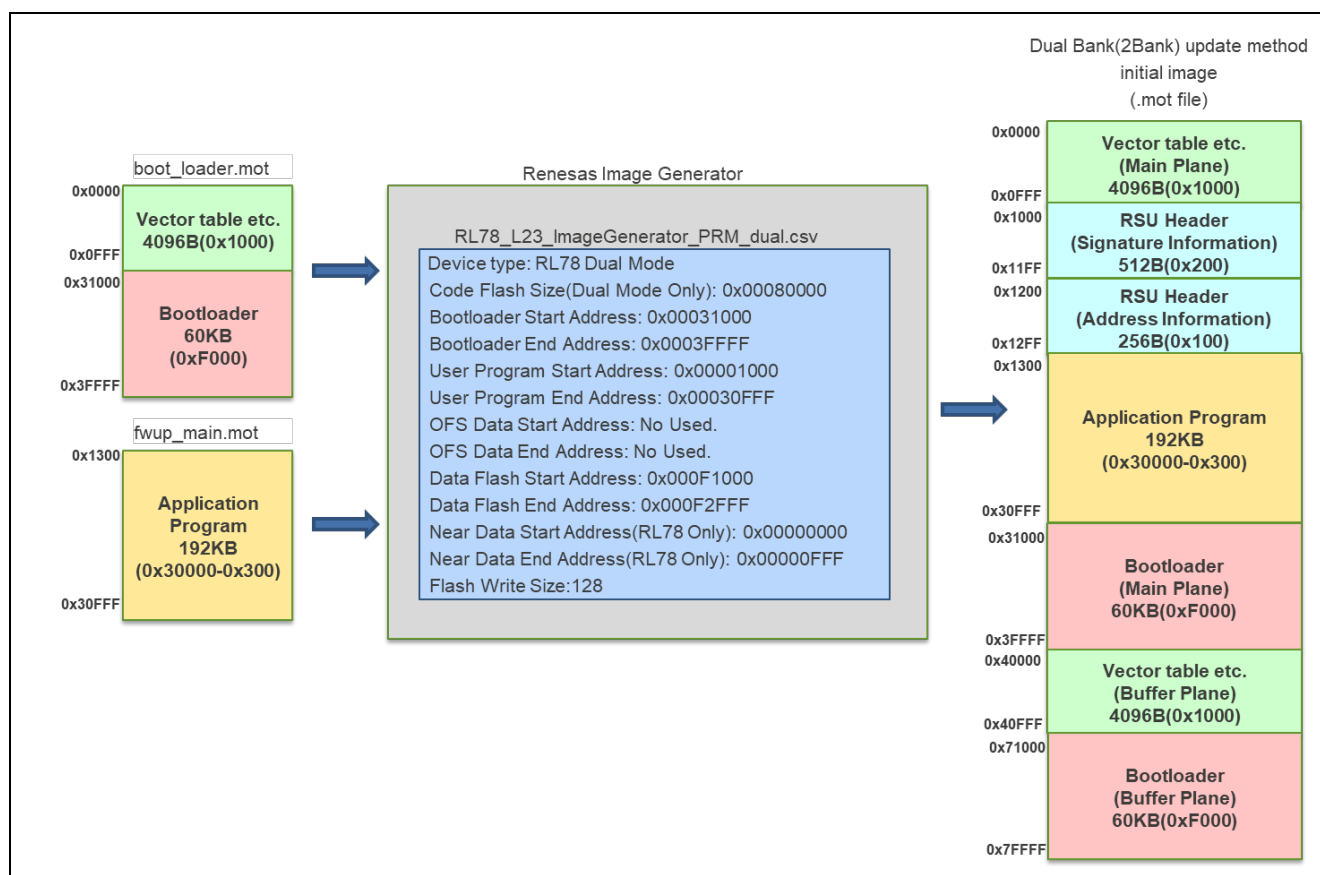


Figure 5.9 Example of parameters referred to when generating the initial image of RL78/L23 Dual-bank (2-Bank) method

6. Appendices

6.1 Confirmed Operation Environments

This section describes confirmed operation environment for the module.

Table 6.1 Confirmed Operation Environment (CC-RL)

Item	Description
Integrated development environment	Renesas Electronics e ² studio 2026-07
C compiler	Renesas Electronics CC-RL V1.16.00 Compiler option: The following option is added to the default settings of the integrated development environment. -lang = c99
Endian order	Little endian
Revision of the module	Rev.3.00
Board used	RL78/G13 : QB-R5F100SL-TB RL78/G21 : FPB-RL78G21 RL78/G22 : FPB-RL78G22 RL78/G23 : FPB-RL78G23-128p RL78/G24 : FPB- RL78G24 RL78/L23 : FPB- RL78L23

Table 6.2 Confirmed Operation Environment (IAR)

Item	Description
Integrated development environment	IAR Systems IAR Embedded Workbench for Renesas RL78 5.20.2
C compiler	IAR Systems IAR C/C++ Compiler for Renesas RL78 version 5.20.2 IAR Assembler for Renesas RL78 version 5.20.2 Compiler option: Default settings of the integrated development environment.
Endian order	Little endian
Revision of the module	Rev.3.00
Board used	RL78/G21 : FPB-RL78G21 RL78/G22 : FPB-RL78G22 RL78/G23 : FPB-RL78G23-128p RL78/G24 : FPB- RL78G24 RL78/L23 : FPB- RL78L23

Table 6.3 Confirmed Operation Environment (LLVM)

Item	Description
Integrated development environment	Renesas Electronics e ² studio 2026-07
C compiler	LLVM for Renesas RL78 17.0.1.202606
Endian order	Little endian
Revision of the module	Rev.3.00
Board used	RL78/G13 : QB-R5F100SL-TB RL78/G21 : FPB-RL78G21 RL78/G22 : FPB-RL78G22 RL78/G23 : FPB-RL78G23-128p RL78/G24 : FPB- RL78G24 RL78/L23 : FPB- RL78L23

6.2 Operating Environment for Demo Project

This module supports multiple compilers. When using this module, the different settings for each compiler are shown below.

6.2.1 Operation Confirmation Environment for RL78/G13

This section shows the connection diagram and pin assignments for the operation verification environment.

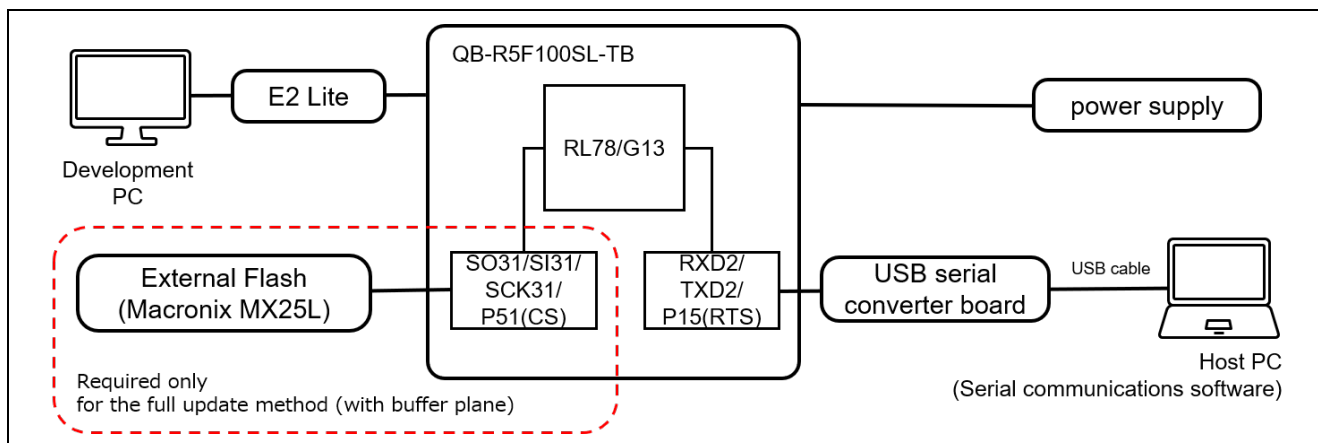


Figure 6.1 QB-R5F100SL-TB Device Connection Diagram

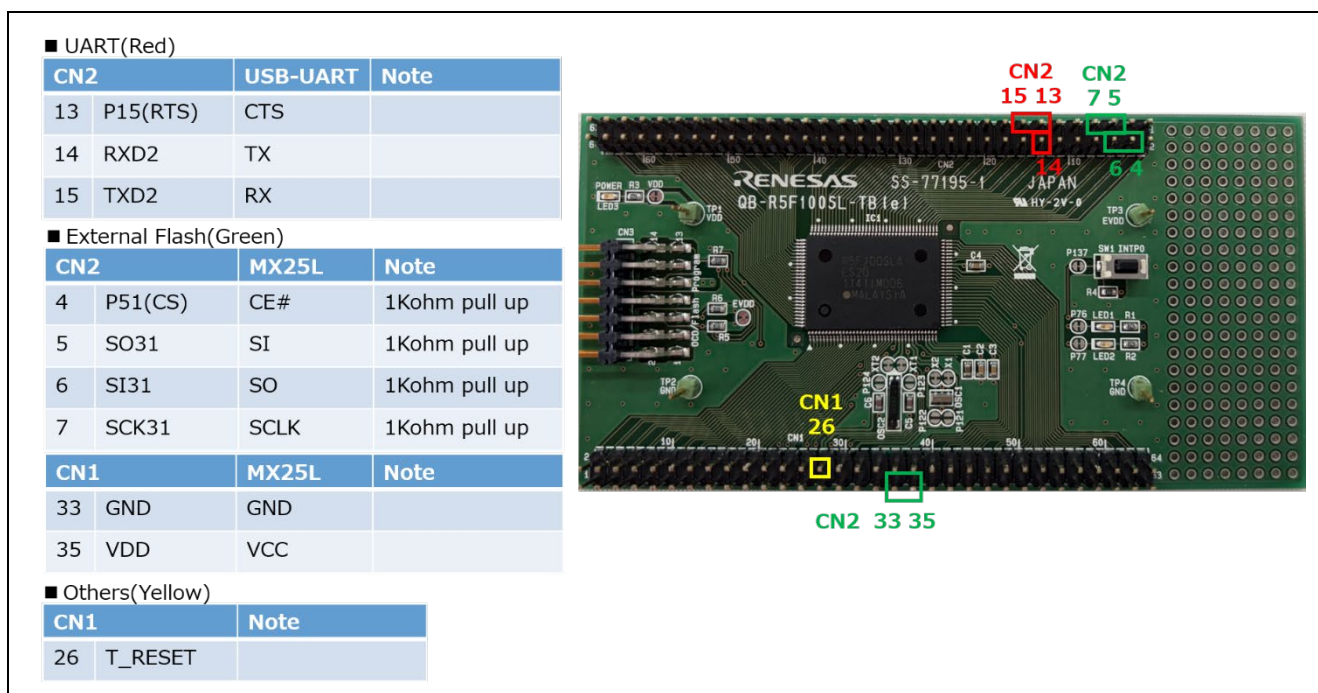


Figure 6.2 QB-R5F100SL-TB Device Connection Pin Information

6.2.1.1 Information on demo project for partial update method

Shown below are the memory map of the RL78/G13 partial update method demo project and the memory map of the configuration settings.

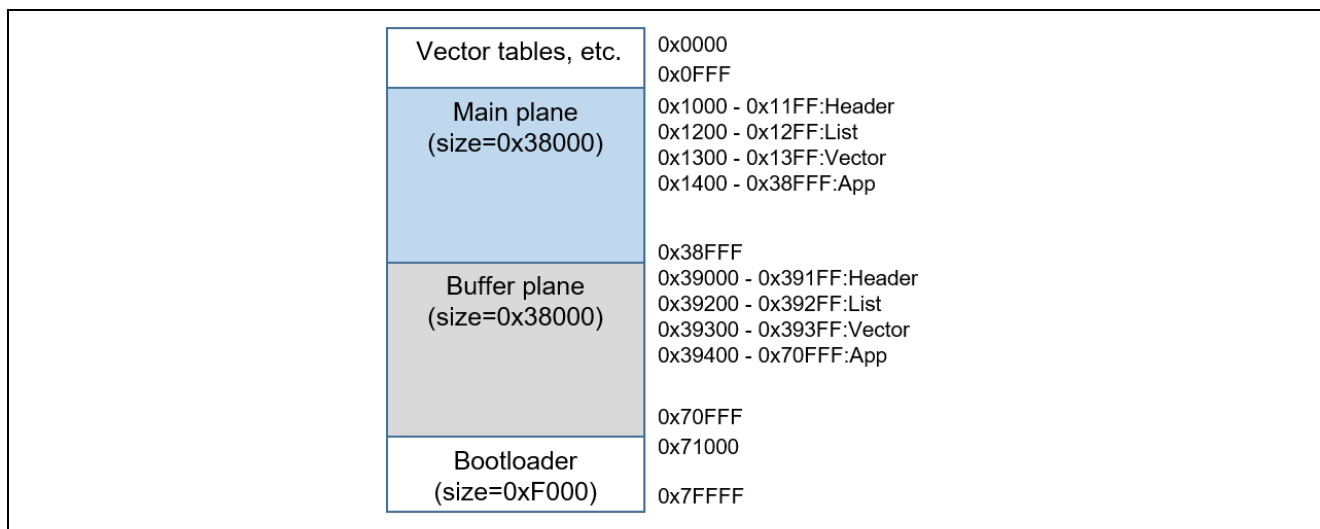


Figure 6.3 RL78/G13 partial update method demo project memory map (For CC-RL)

Table 6.4 RL78/G13 partial update method configuration setting (For CC-RL)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x39000	0x39000
FWUP_CFG_AREA_SIZE	0x38000	0x38000
FWUP_CFG_CF_BLK_SIZE	1024	1024
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

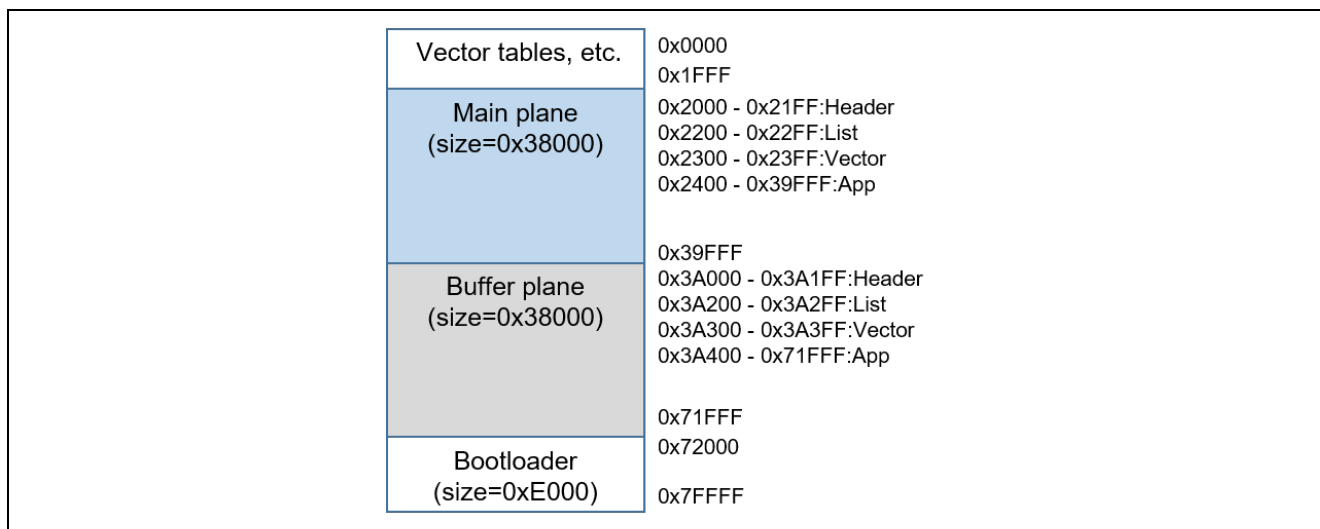


Figure 6.4 RL78/G13 partial update method demo project memory map (For LLVM)

Table 6.5 RL78/G13 partial update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x3A000	0x3A000
FWUP_CFG_AREA_SIZE	0x38000	0x38000
FWUP_CFG_CF_BLK_SIZE	1024	1024
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.1.2 Information on demo project for full update method

The memory map of the RL78/G13 full update method demo project and the memory map of the configuration settings are shown below.

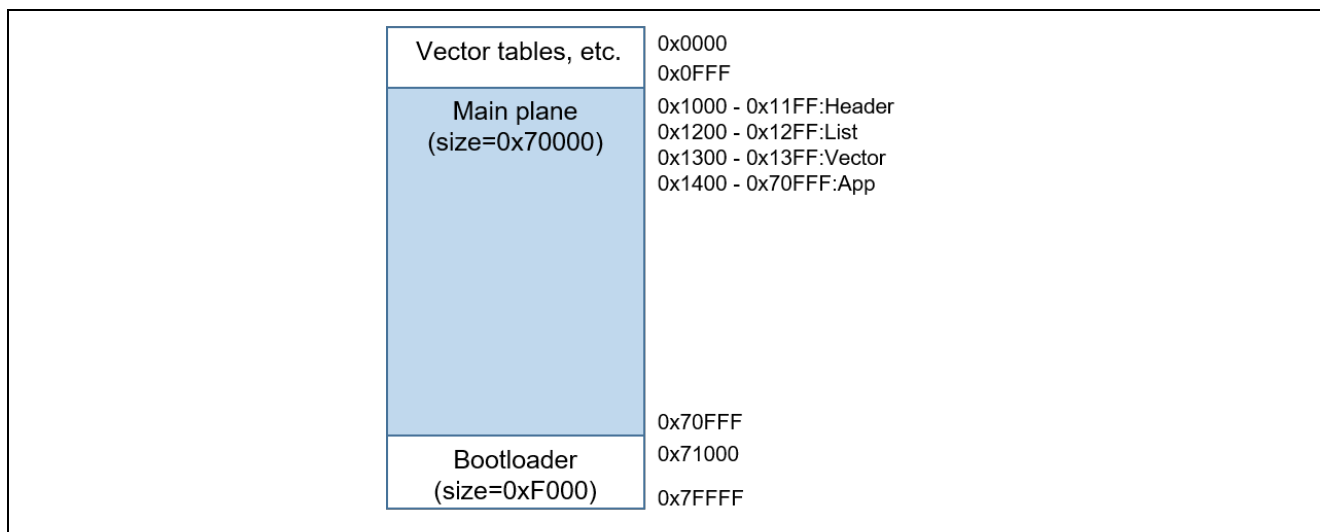


Figure 6.5 RL78/G13 full update method demo project memory map (For CC-RL)

Table 6.6 RL78/G13 full update method configuration setting (For CC-RL)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_AREA_SIZE	0x70000	0x70000
FWUP_CFG_CF_BLK_SIZE	1024	1024
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

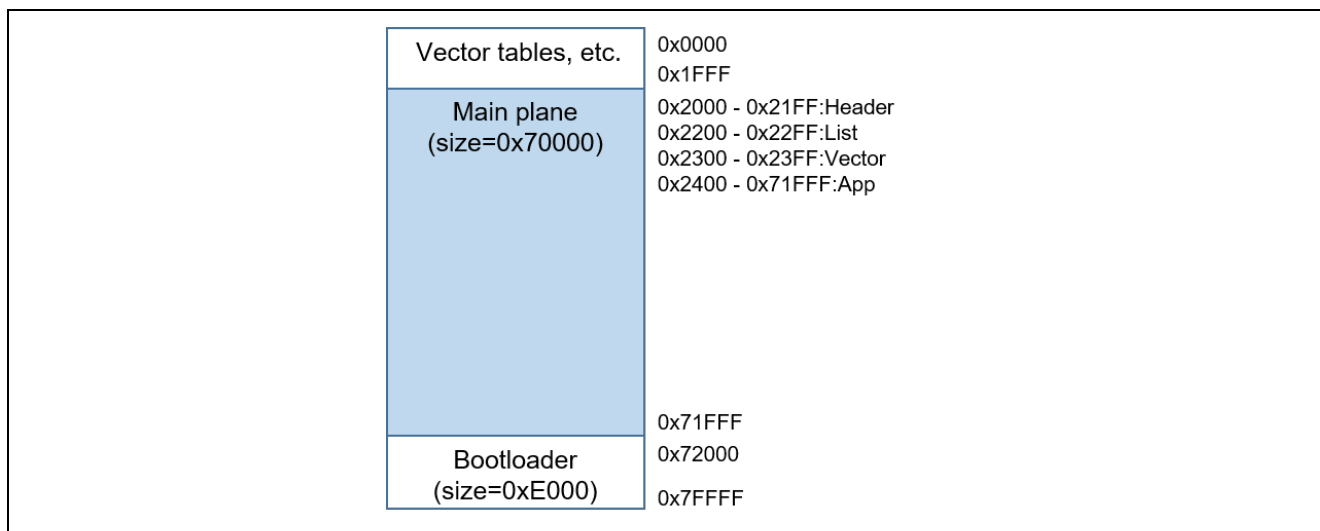


Figure 6.6 RL78/G21 full update method demo project memory map (For LLVM)

Table 6.7 RL78/G21 full update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_AREA_SIZE	0x70000	0x70000
FWUP_CFG_CF_BLK_SIZE	1024	1024
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.2 Operation Confirmation Environment for RL78/G21

This section shows the connection diagram and pin assignments for the operation verification environment.

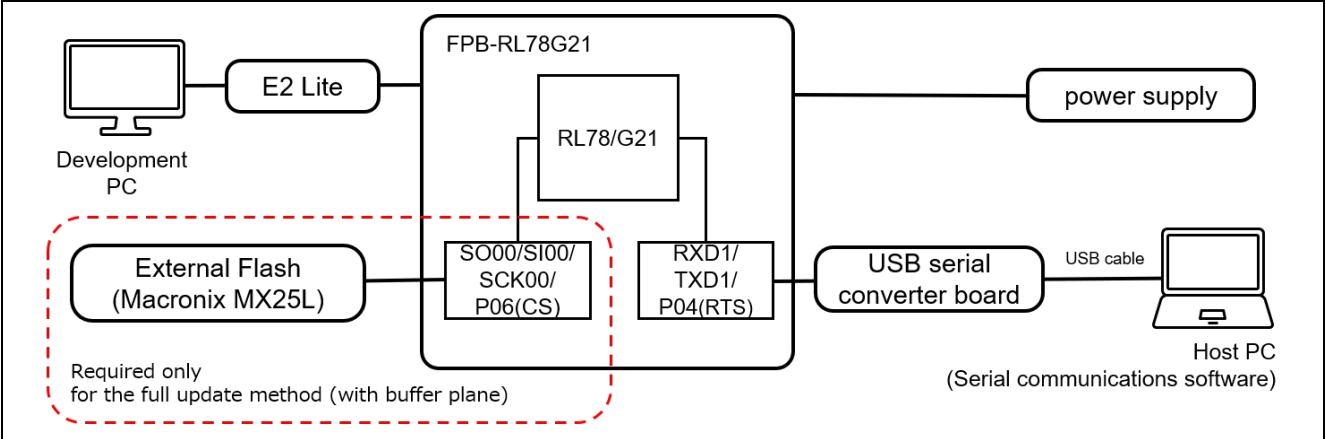


Figure 6.7 FPB-RL78G21 Device Connection Diagram

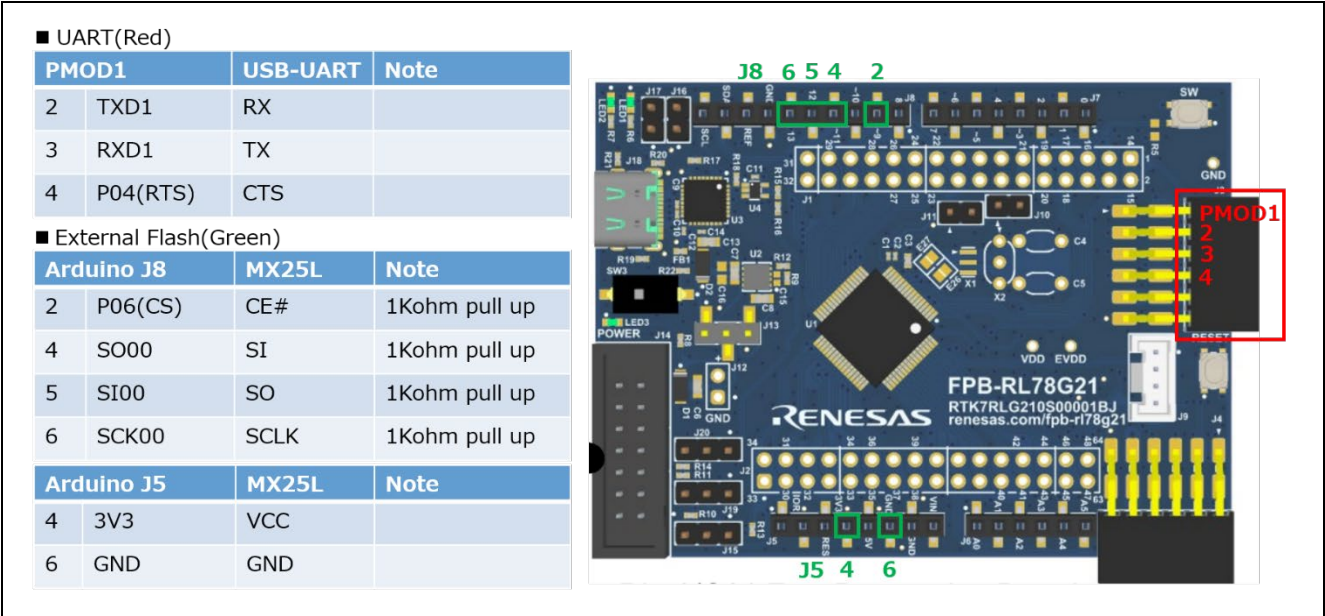


Figure 6.8 FPB-RL78G21 Device Connection Pin Information

6.2.2.1 Information on demo project for partial update method

Shown below are the memory map of the RL78/G21 partial update method demo project and the memory map of the configuration settings.

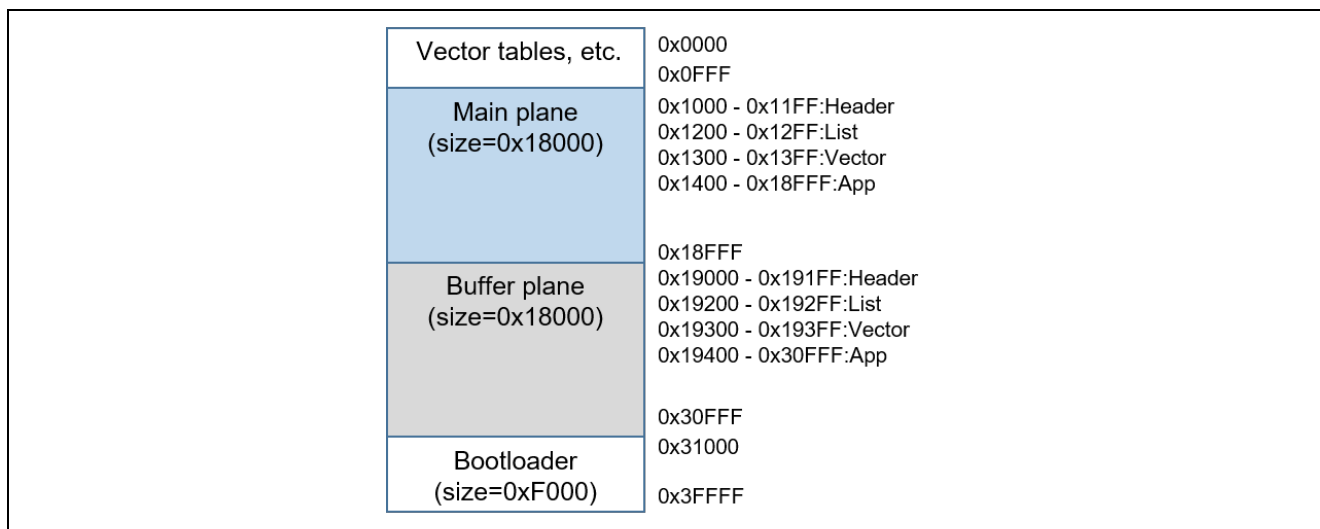


Figure 6.9 RL78/G21 partial update method demo project memory map (For CC-RL and IAR)

Table 6.8 RL78/G21 partial update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x19000	0x19000
FWUP_CFG_AREA_SIZE	0x18000	0x18000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

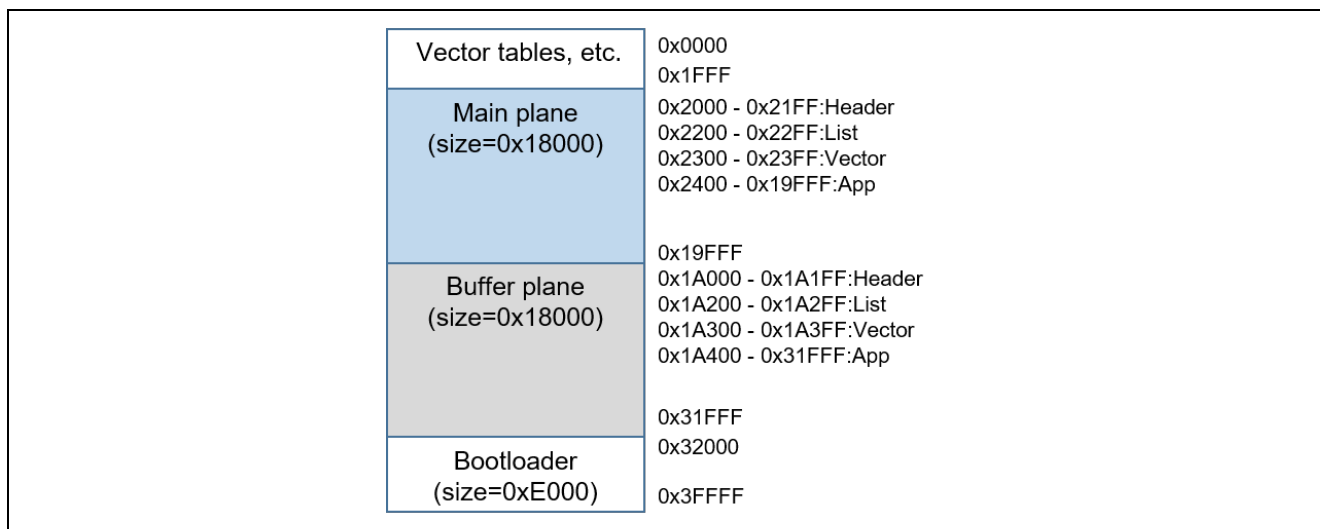


Figure 6.10 RL78/G21 partial update method demo project memory map (For LLVM)

Table 6.9 RL78/G21 partial update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x1A000	0x1A000
FWUP_CFG_AREA_SIZE	0x18000	0x18000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.2.2 Information on demo project for full update method

The memory map of the RL78/G21 full update method demo project and the memory map of the configuration settings are shown below.

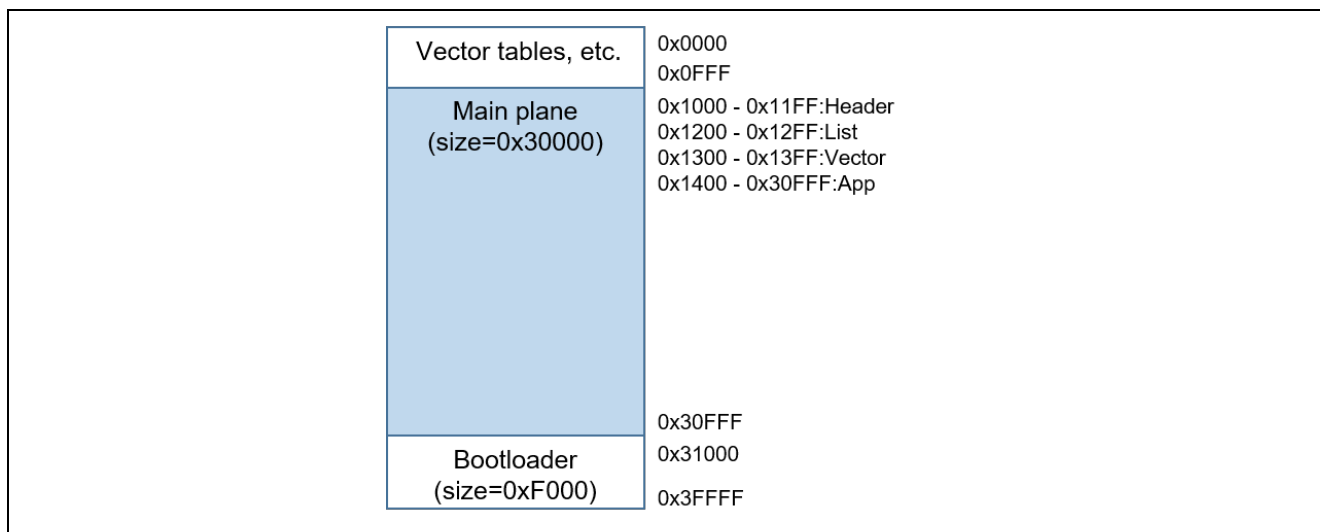


Figure 6.11 RL78/G21 full update method demo project memory map (For CC-RL and IAR)

Table 6.10 RL78/G21 full update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_AREA_SIZE	0x30000	0x30000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

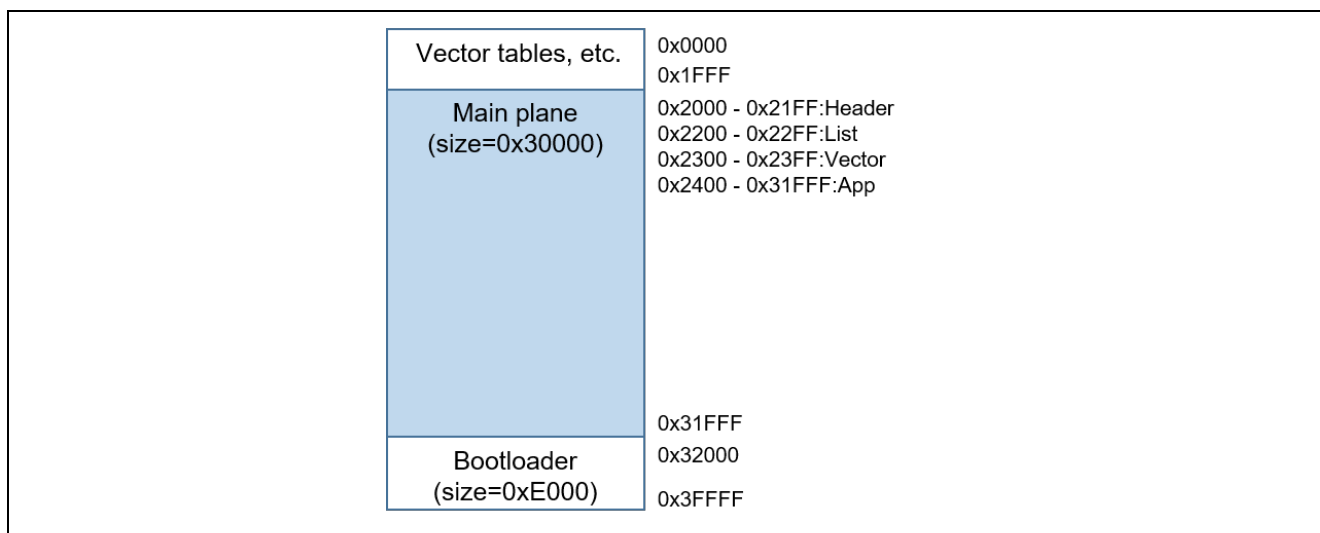


Figure 6.12 RL78/G21 full update method demo project memory map (For LLVM)

Table 6.11 RL78/G21 full update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_AREA_SIZE	0x30000	0x30000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.3 Operation Confirmation Environment for RL78/G22

This section shows the connection diagram and pin assignments for the operation verification environment.

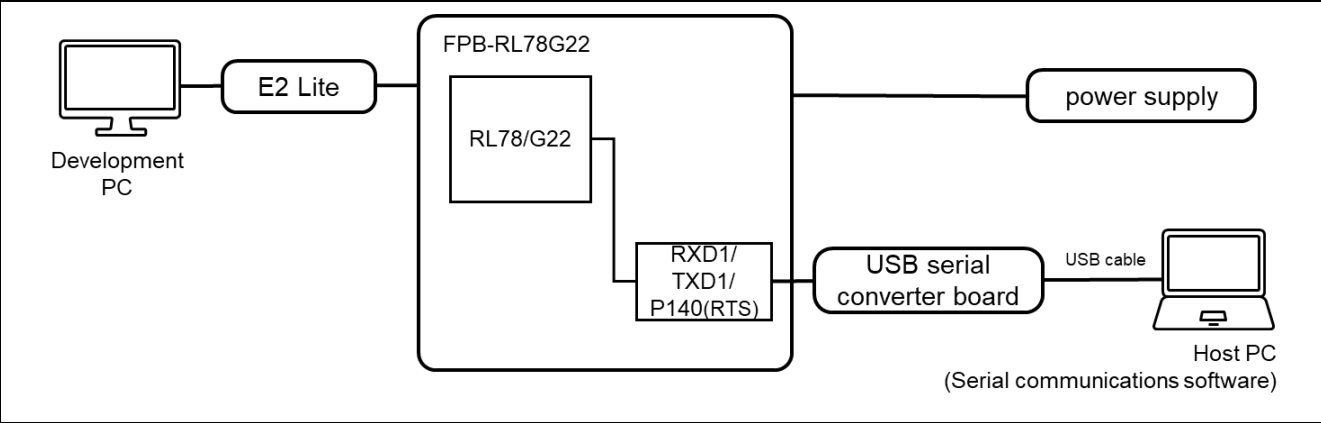


Figure 6.13 FPB-RL78G22 Device Connection Diagram

■ UART(Red)

Arduino J7	USB-UART	Note
1 RXD1	TX	
2 TXD1	RX	
3 P140(RTS)	CTS	

A photograph of the FPB-RL78G22 development board. A red box highlights the J7 header, with pins 1, 2, and 3 labeled in red. The board features a Renesas RTK7RLG220C0000QBJ chip and various components like capacitors (CAP1, CAP2, CAP3, CAP4, CAP5) and buttons (Touch Button1, Touch Button2).

Figure 6.14 FPB-RL78G22 Pin Information

6.2.3.1 Information on demo project for full update method

The memory map of the RL78/G22 full update method demo project and the memory map of the configuration settings are shown below.

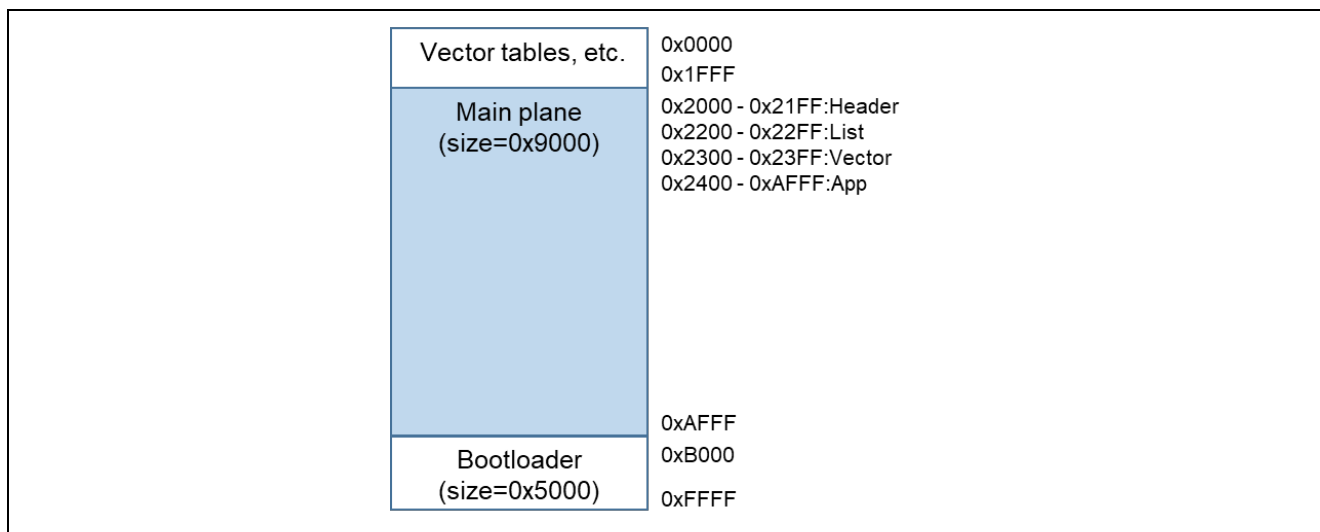


Figure 6.15 RL78/G22 full update method demo project memory map (For CC-RL and IAR)

Table 6.12 RL78/G22 full update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h	
parameter name	boot_loader
FWUP_CFG_UPDATE_MODE	2
FWUP_CFG_FUNCTION_MODE	0
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000
FWUP_CFG_AREA_SIZE	0x9000
FWUP_CFG_CF_BLK_SIZE	2048
FWUP_CFG_CF_W_UNIT_SIZE	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096
FWUP_CFG_DF_ADDR_L	0xF1000
FWUP_CFG_DF_BLK_SIZE	256
FWUP_CFG_DF_NUM_BLKs	8
FWUP_CFG_FWUPV1_COMPATIBLE	0
FWUP_CFG_SIGNATURE_VERIFICATION	1
FWUP_CFG_PRINTF_DISABLE	1

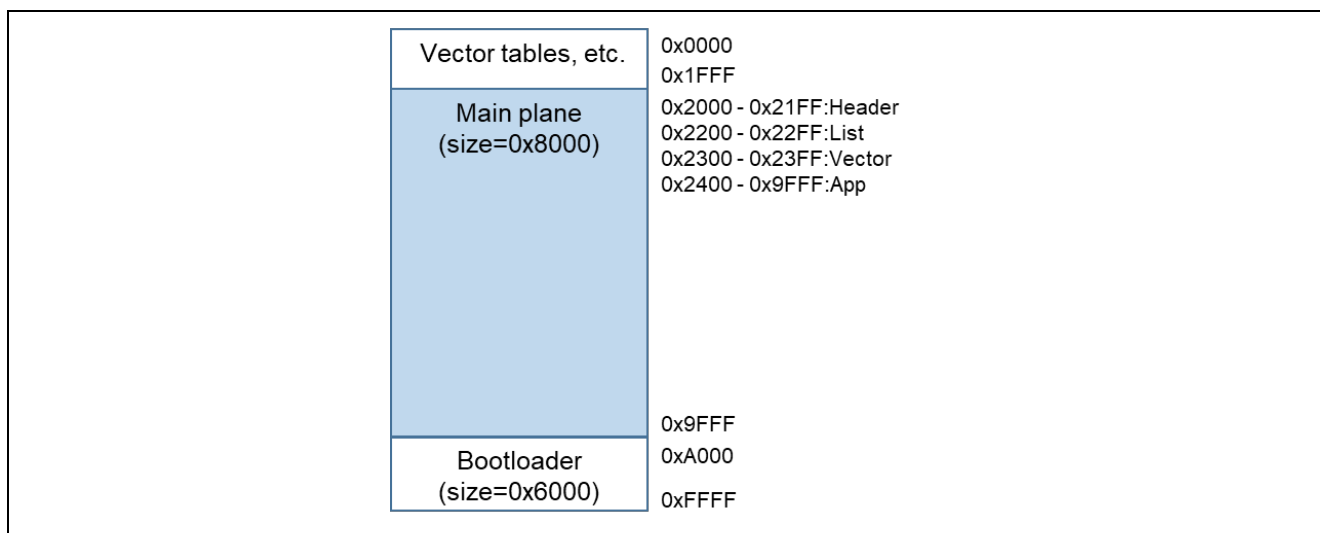


Figure 6.16 RL78/G22 full update method demo project memory map (For LLVM)

Table 6.13 RL78/G22 full update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h	
parameter name	boot_loader
FWUP_CFG_UPDATE_MODE	2
FWUP_CFG_FUNCTION_MODE	0
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000
FWUP_CFG_AREA_SIZE	0x8000
FWUP_CFG_CF_BLK_SIZE	2048
FWUP_CFG_CF_W_UNIT_SIZE	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096
FWUP_CFG_DF_ADDR_L	0xF1000
FWUP_CFG_DF_BLK_SIZE	256
FWUP_CFG_DF_NUM_BLKs	8
FWUP_CFG_FWUPV1_COMPATIBLE	0
FWUP_CFG_SIGNATURE_VERIFICATION	1
FWUP_CFG_PRINTF_DISABLE	1

6.2.4 Operation Confirmation Environment for RL78/G23

This section shows the connection diagram and pin assignments for the operation verification environment.

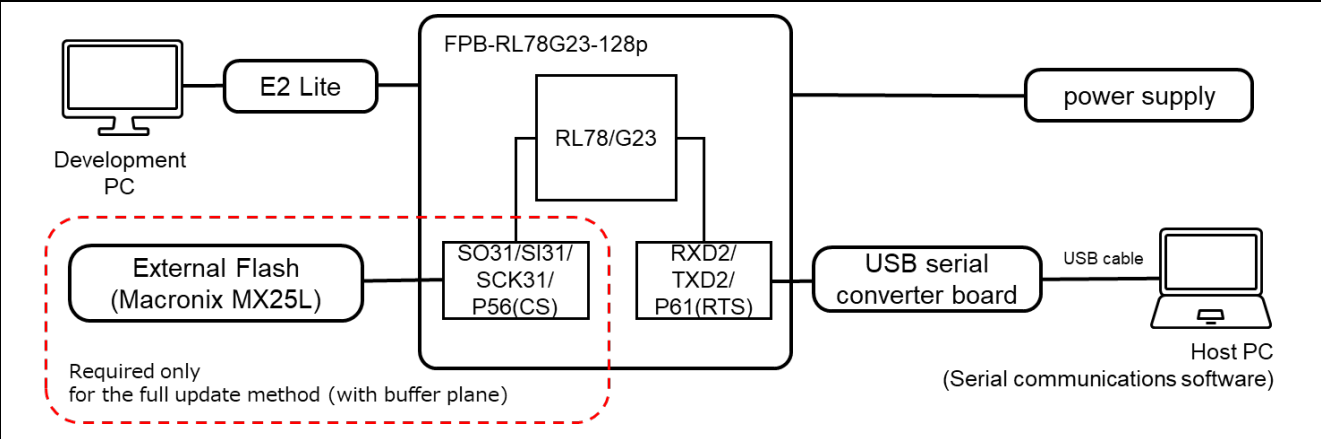


Figure 6.17 FPB-RL78G23-128p Device Connection Diagram

■ UART(Red)

Arduino J8		USB-UART
2	P61(RTS)	CTS
3	RXD2	TX
4	TXD2	RX

■ External Flash(Green)

MCU Header J1	MX25/66L	Note
14	SO31	SI
15	SI31	SO
16	SCK31	SCLK
18	P56(CS)	CE#

Arduino J5		MX25/66L	Note
4	3V3	VCC	
6	GND	GND	

Figure 6.18 FPB-RL78G23-128p Device Connection Pin Information

Figure 6.18 FPB-RL78G23-128p Device Connection Pin Information

6.2.4.1 Information on demo project for partial update method

Shown below are the memory map of the RL78/G23 partial update method demo project and the memory map of the configuration settings.

Vector tables, etc.	0x0000 0x0FFF
Main plane (size=0x58000)	0x1000 - 0x11FF:Header 0x1200 - 0x12FF:List 0x1300 - 0x13FF:Vector 0x1400 - 0x58FFF:App
Buffer plane (size=0x58000)	0x58FFF 0x59000 - 0x591FF:Header 0x59200 - 0x592FF:List 0x59300 - 0x593FF:Vector 0x59400 - 0xB0FFF:App
Bootloader (size=0xF000)	0xB0FFF 0xB1000 0xBFFFF

Figure 6.19 RL78/G23 partial update method demo project memory map (For CC-RL and IAR)

Table 6.14 RL78/G23 partial update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x59000	0x59000
FWUP_CFG_AREA_SIZE	0x58000	0x58000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

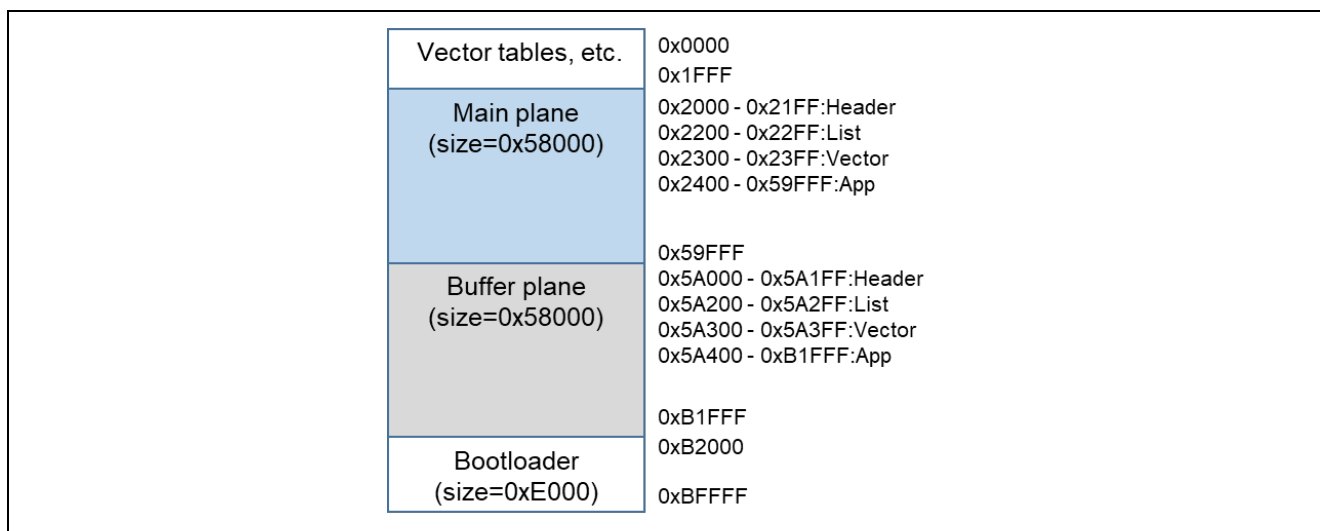


Figure 6.20 RL78/G23 partial update method demo project memory map (For LLVM)

Table 6.15 RL78/G23 partial update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x5A000	0x5A000
FWUP_CFG_AREA_SIZE	0x58000	0x58000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.4.2 Information on demo project for full update method

The memory map of the RL78/G23 full update method demo project and the memory map of the configuration settings are shown below.

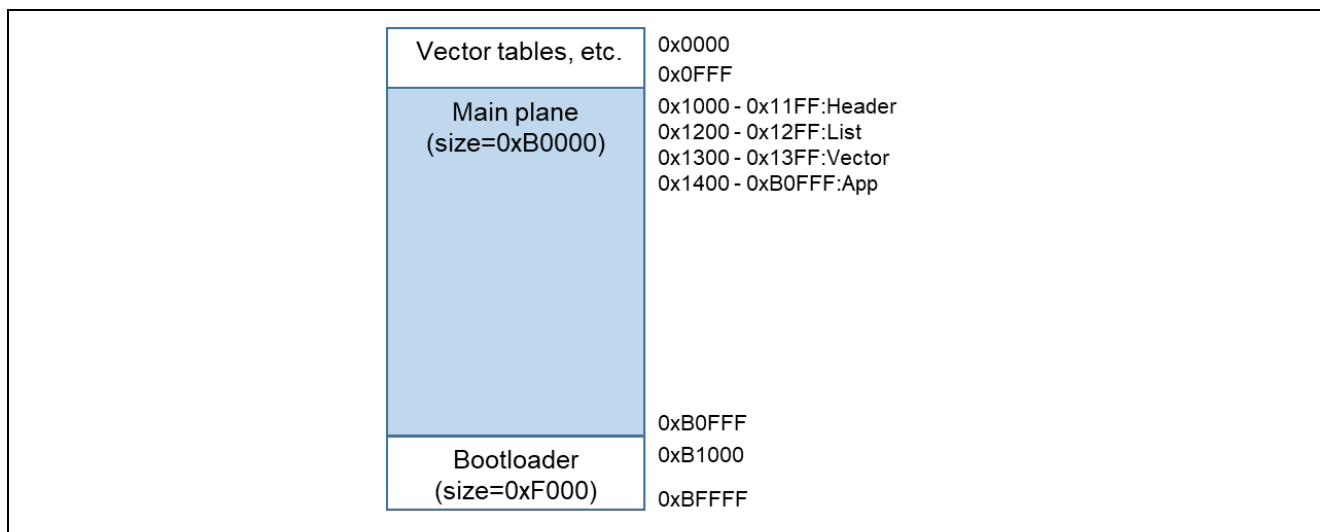


Figure 6.21 RL78/G23 full update method demo project memory map (For CC-RL and IAR)

Table 6.16 RL78/G23 full update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_AREA_SIZE	0xB0000	0xB0000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

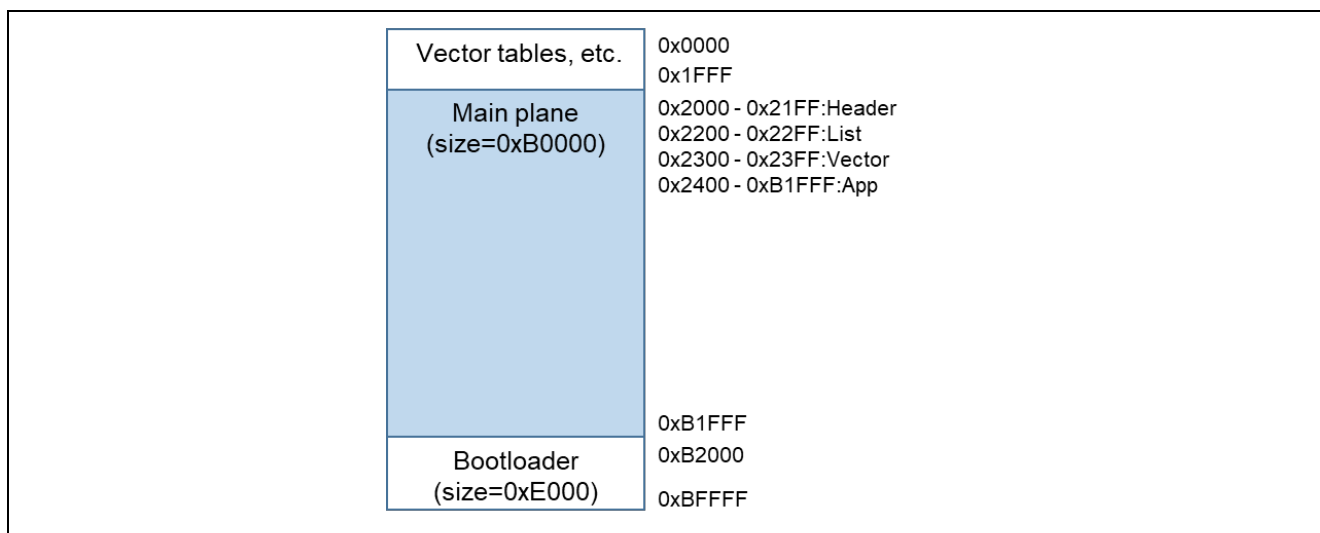


Figure 6.22 RL78/G23 full update method demo project memory map (For LLVM)

Table 6.17 RL78/G23 full update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_AREA_SIZE	0xB0000	0xB0000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.5 Operation Confirmation Environment for RL78/G24

This section shows the connection diagram and pin assignments for the operation verification environment.

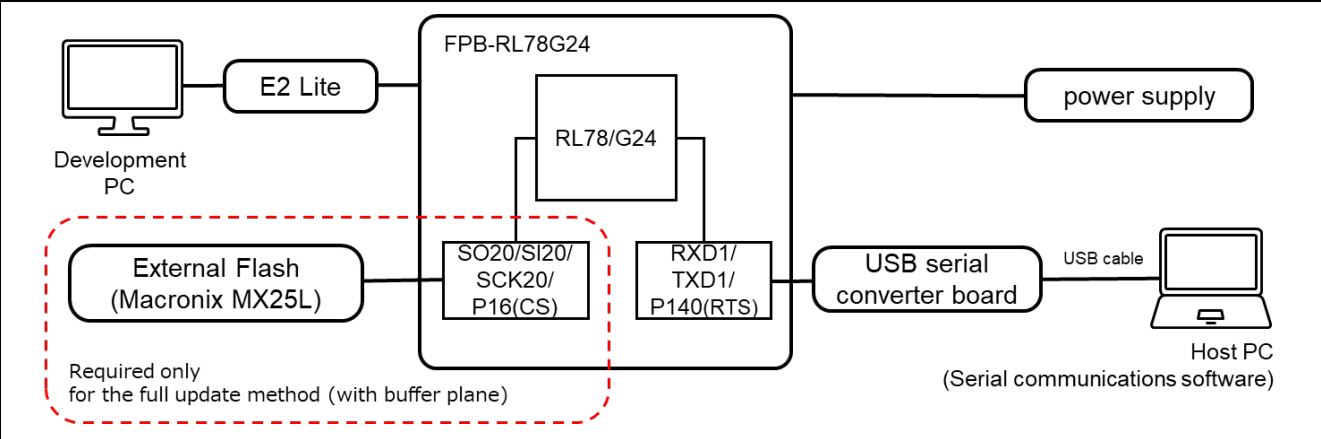


Figure 6.23 FPB-RL78G24 Device Connection Diagram

■ UART(Red)

Arduino J5	USB-UART	Note
1 RXD1	TX	
2 TXD1	RX	
3 P140(RTS)	CTS	

■ External Flash(Green)

Arduino J5,J6	MX25L	Note
J6 3 SO20	SI	1Kohm pull up
J6 2 SI20	SO	1Kohm pull up
J5 7 SCK20	SCLK	1Kohm pull up
J5 6 P16(CS)	CE#	1Kohm pull up

Arduino J3	MX25L	Note
4 3V3	VCC	
6 GND	GND	

The photograph shows the physical FPB-RL78G24 board. Pin headers J3, J5, and J6 are highlighted with green boxes, and the UART pins (1, 2, 3) on J5 are highlighted with a red box. The board is labeled 'RENEASAS' and 'RTK7RLG240C00000B.J REV. A'.

Figure 6.24 FPB-RL78G24 Pin Information

6.2.5.1 Information on demo project for partial update method

Shown below are the memory map of the RL78/G24 partial update method demo project and the memory map of the configuration settings.

Vector tables, etc.	0x0000 0x0FFF
Main plane (size=0x8000)	0x1000 - 0x11FF:Header 0x1200 - 0x12FF:List 0x1300 - 0x13FF:Vector 0x1400 - 0x8FFF:App
Buffer plane (size=0x8000)	0x8FFF 0x9000 - 0x91FF:Header 0x9200 - 0x92FF:List 0x9300 - 0x93FF:Vector 0x9400 - 0x10FFF:App
Bootloader (size=0xF000)	0x10FFF 0x11000 0x1FFFF

Figure 6.25 RL78/G24 partial update method demo project memory map (For CC-RL and IAR)

Table 6.18 RL78/G24 partial update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x9000	0x9000
FWUP_CFG_AREA_SIZE	0x8000	0x8000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

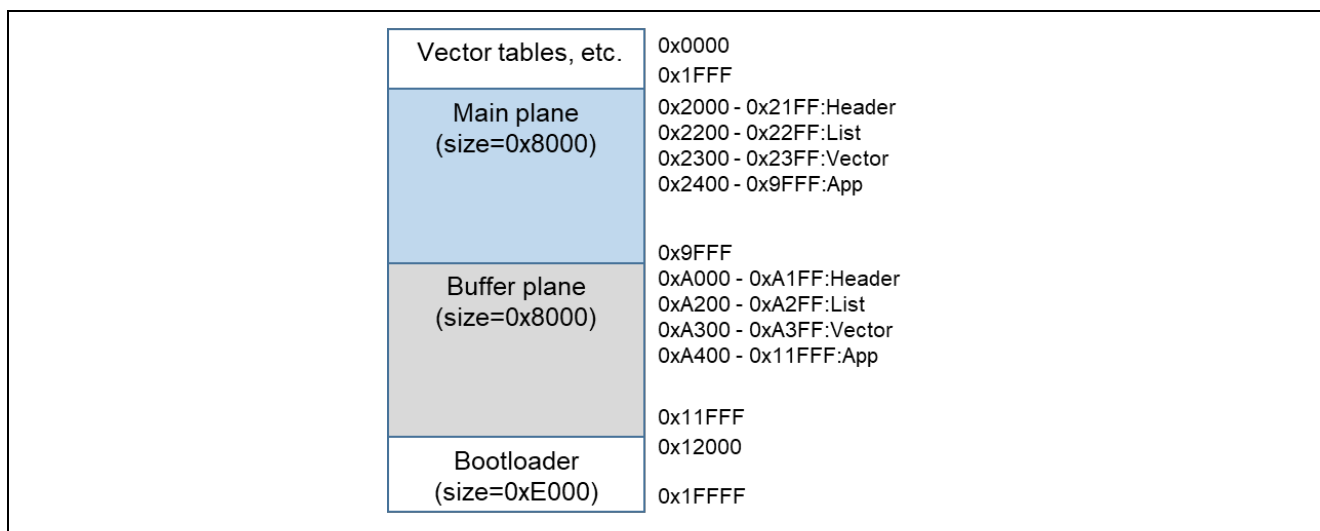


Figure 6.26 RL78/G24 partial update method demo project memory map (For LLVM)

Table 6.19 RL78/G24 partial update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0xA000	0xA000
FWUP_CFG_AREA_SIZE	0x8000	0x8000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.5.2 Information on demo project for full update method

The memory map of the RL78/G24 full update method demo project and the memory map of the configuration settings are shown below.

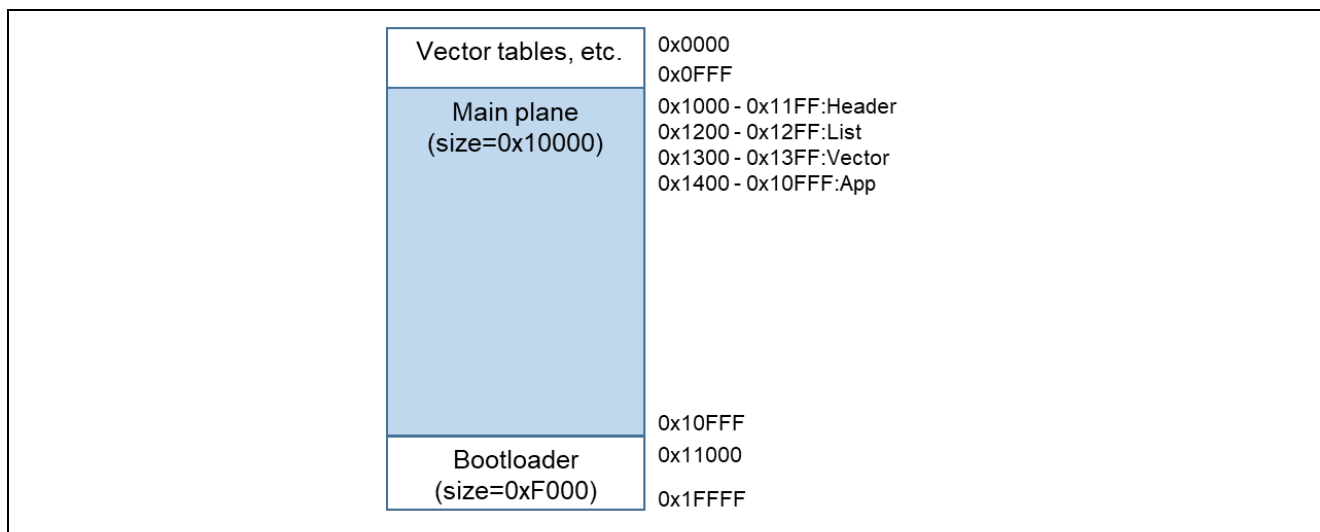


Figure 6.27 RL78/G24 full update method demo project memory map (For CC-RL and IAR)

Table 6.20 RL78/G24 full update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x9000	0x9000
FWUP_CFG_AREA_SIZE	0x10000	0x10000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

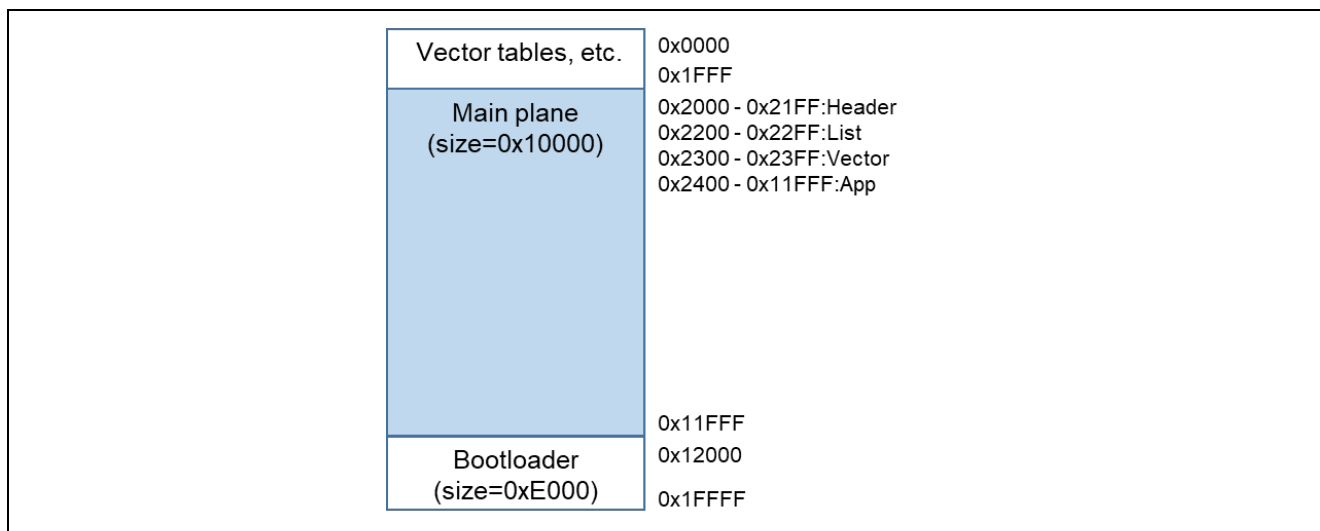


Figure 6.28 RL78/G24 full update method demo project memory map (For LLVM)

Table 6.21 RL78/G24 full update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_AREA_SIZE	0x10000	0x10000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	16	16
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.6 Operation Confirmation Environment for RL78/L23

This section shows the connection diagram and pin assignments for the operation verification environment.

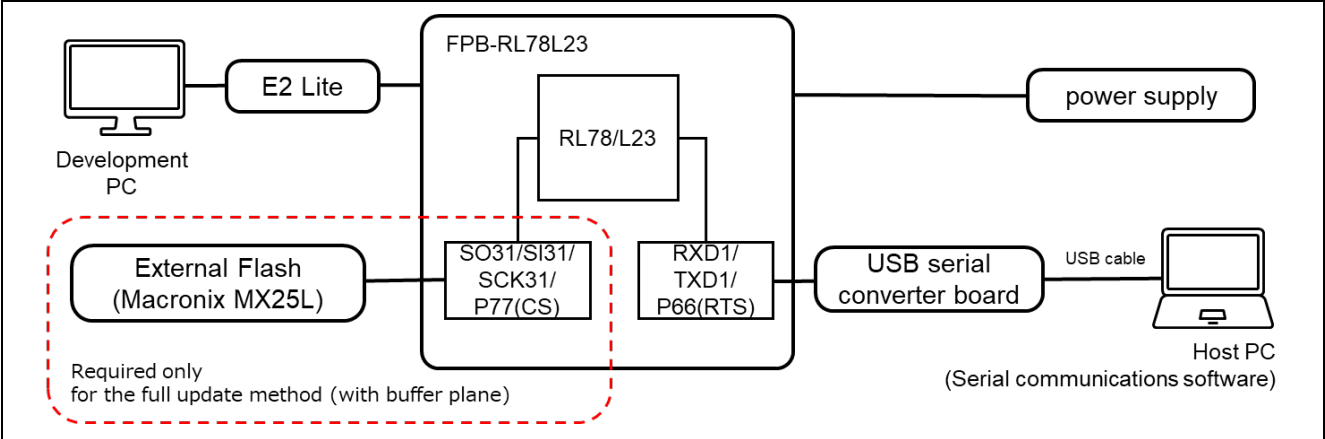


Figure 6.29 FPB-RL78L23 Device Connection Diagram

■ UART(Red)

PMOD1	USB-UART	Note
2 RXD1	TX	
3 TXD1	RX	
4 P66(RTS)	CTS	

■ External Flash(Green)

Arduino J10	MX25L	Note
2 P77(CS)	CE#	1Kohm pull up
4 SO31	SI	1Kohm pull up
5 SI31	SO	1Kohm pull up
6 SCK31	SCLK	1Kohm pull up

Arduino J7	MX25L	Note
4 3V3	VCC	
6 GND	GND	

Figure 6.30 FPB-RL78L23 Device Connection Pin Information

6.2.6.1 Information on demo project for dual-bank(2-bank) method

Shown below are the memory map of the RL78/L23 dual-bank(2-bank) method demo project and the memory map of the configuration settings.

Vector tables, etc.	0x0000 0x0FFF
Main plane (size=0x30000)	0x1000 - 0x11FF:Header 0x1200 - 0x12FF:List 0x1300 - 0x13FF:Vector 0x1400 - 0x30FFF:App
Bootloader (size=0xF000)	0x30FFF 0x31000
Vector tables, etc.	0x3FFFF 0x40000 0x40FFF
Buffer plane (size=0x30000)	0x41000 - 0x41FF:Header 0x41200 - 0x412FF:List 0x41300 - 0x413FF:Vector 0x41400 - 0x70FFF:App
Bootloader (size=0xF000)	0x70FFF 0x71000 0x7FFFF

Figure 6.31 RL78/L23 dual-bank(2-bank) method demo project memory map (For CC-RL and IAR)

Table 6.22 RL78/L23 dual-bank(2-bank) method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	0	0
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x41000	0x41000
FWUP_CFG_AREA_SIZE	0x30000	0x30000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

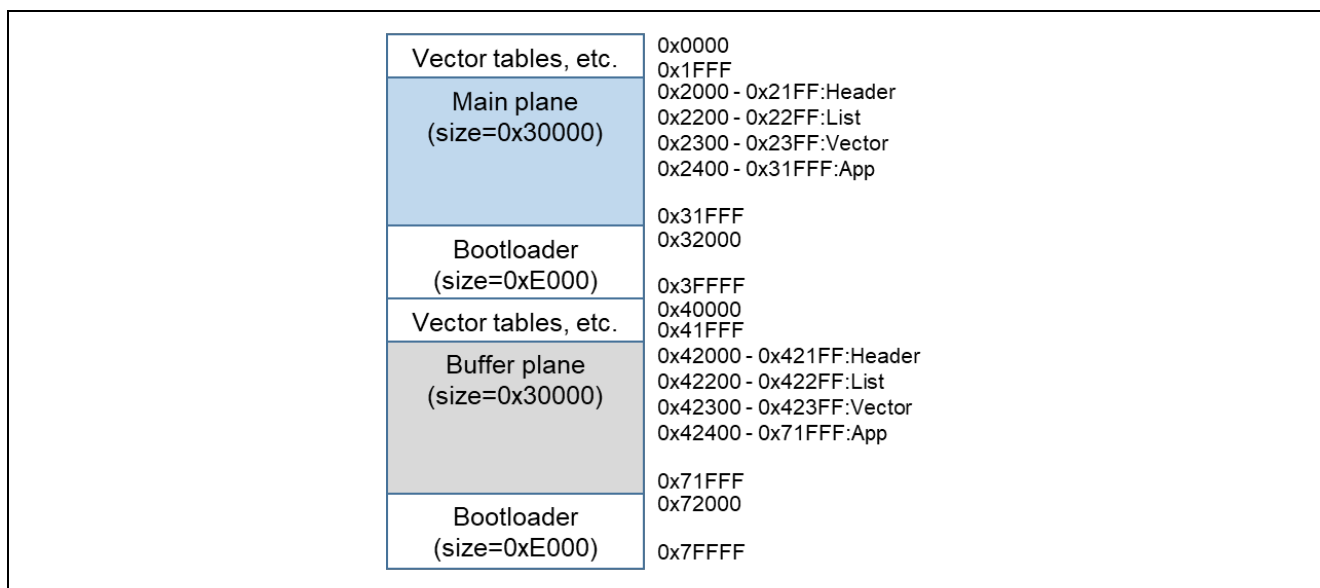


Figure 6.32 RL78/L23 dual-bank(2-bank) method demo project memory map (For LLVM)

Table 6.23 RL78/L23 dual-bank(2-bank) method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	0	0
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x42000	0x42000
FWUP_CFG_AREA_SIZE	0x30000	0x30000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.6.2 Information on demo project for partial update method

Shown below are the memory map of the RL78/L23 partial update method demo project and the memory map of the configuration settings.

Vector tables, etc.	0x0000 0x0FFF
Main plane (size=0x38000)	0x1000 - 0x11FF:Header 0x1200 - 0x12FF:List 0x1300 - 0x13FF:Vector 0x1400 - 0x38FFF:App
Buffer plane (size=0x38000)	0x38FFF 0x39000 - 0x391FF:Header 0x39200 - 0x392FF:List 0x39300 - 0x393FF:Vector 0x39400 - 0x70FFF:App
Bootloader (size=0xF000)	0x70FFF 0x71000 0x7FFFF

Figure 6.33 RL78/L23 partial update method demo project memory map (For CC-RL and IAR)

Table 6.24 RL78/L23 partial update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x39000	0x39000
FWUP_CFG_AREA_SIZE	0x38000	0x38000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

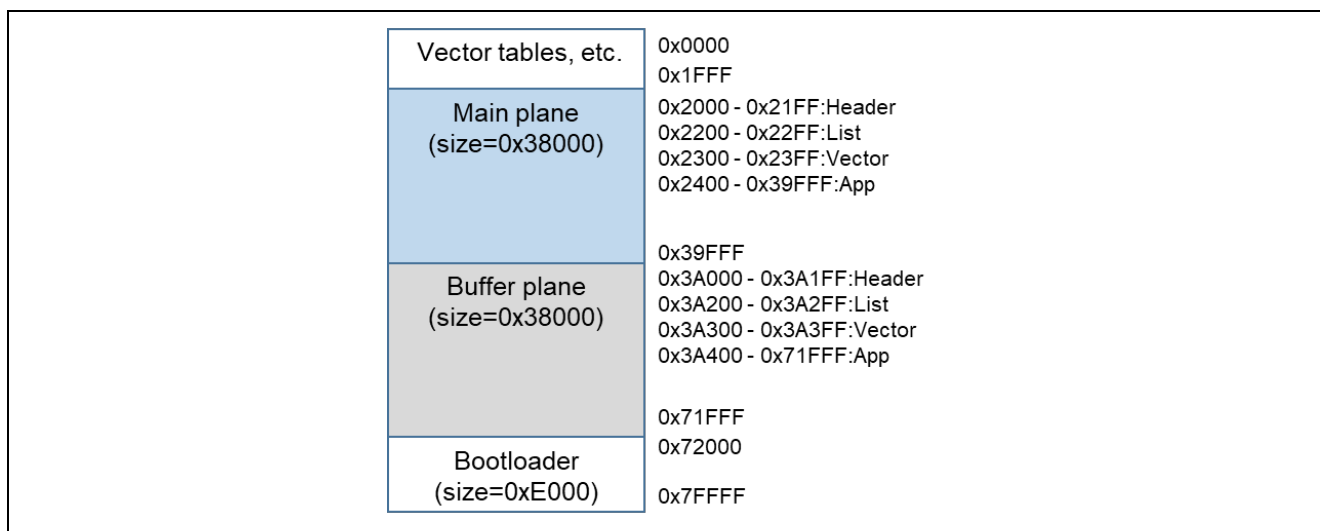


Figure 6.34 RL78/L23 partial update method demo project memory map (For LLVM)

Table 6.25 RL78/L23 partial update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	1	1
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x3A000	0x3A000
FWUP_CFG_AREA_SIZE	0x38000	0x38000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

6.2.6.3 Information on demo project for full update method

The memory map of the RL78/L23 full update method demo project and the memory map of the configuration settings are shown below.

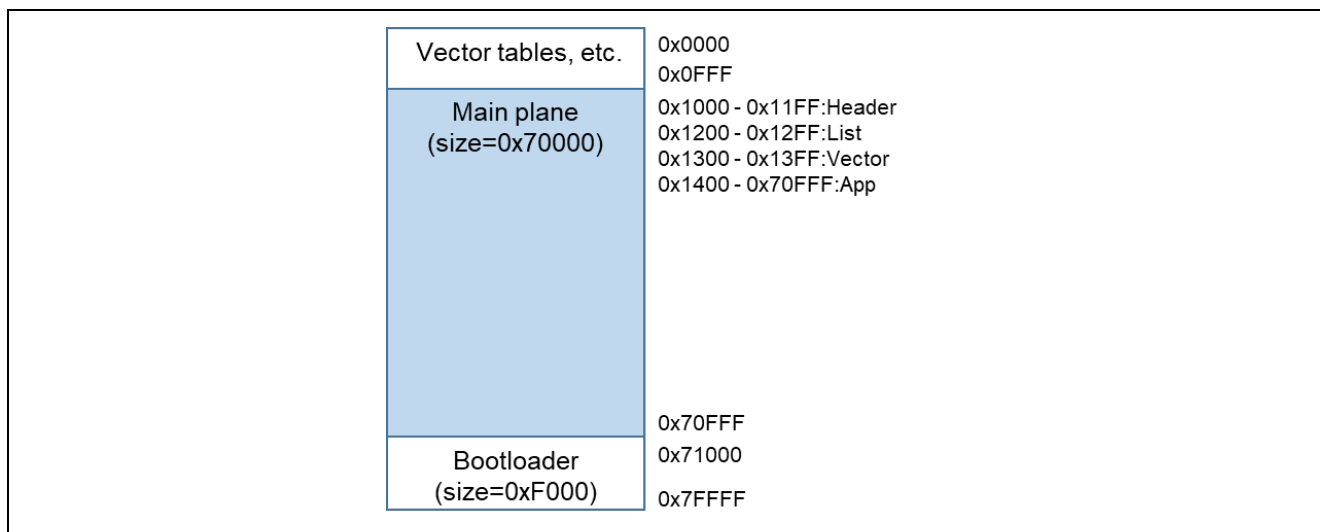


Figure 6.35 RL78/L23 full update method demo project memory map (For CC-RL and IAR)

Table 6.26 RL78/L23 full update method configuration setting (For CC-RL and IAR)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_BUF_AREA_ADDR_L	0x1000	0x1000
FWUP_CFG_AREA_SIZE	0x70000	0x70000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

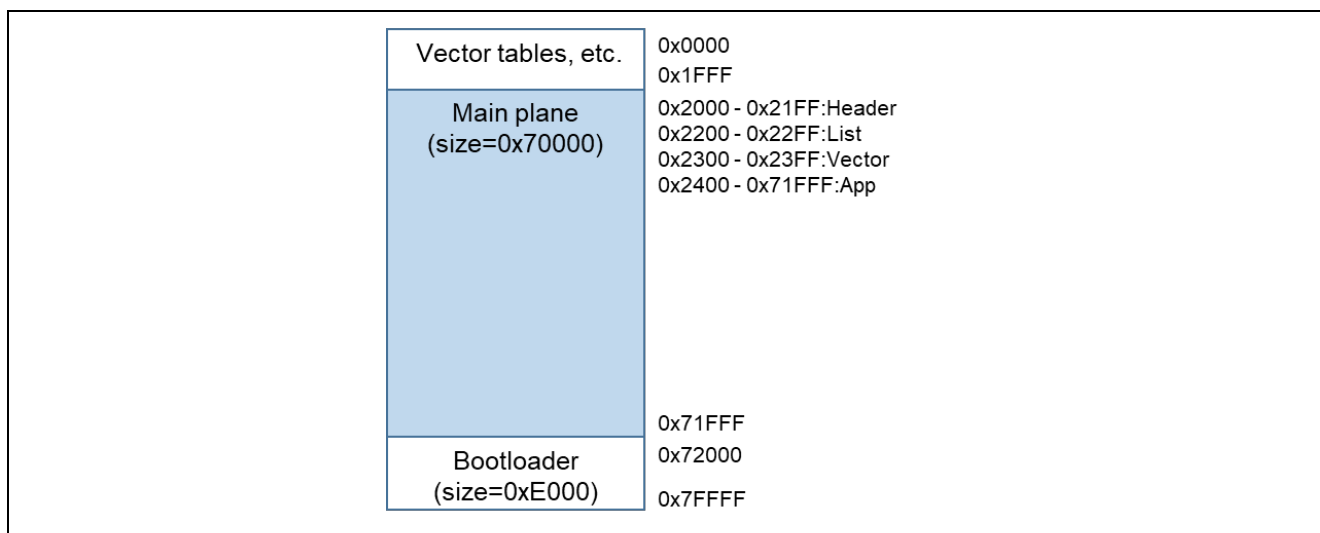


Figure 6.36 RL78/L23 full update method demo project memory map (For LLVM)

Table 6.27 RL78/L23 full update method configuration setting (For LLVM)

Configuration options in r_fwup_config.h		
parameter name	boot_loader	fwup_main
FWUP_CFG_UPDATE_MODE	2 or 3	3
FWUP_CFG_FUNCTION_MODE	0	1
FWUP_CFG_MAIN_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_BUF_AREA_ADDR_L	0x2000	0x2000
FWUP_CFG_AREA_SIZE	0x70000	0x70000
FWUP_CFG_CF_BLK_SIZE	2048	2048
FWUP_CFG_CF_W_UNIT_SIZE	128	128
FWUP_CFG_EXT_BUF_AREA_ADDR_L	0x0000	0x0000
FWUP_CFG_EXT_BUF_AREA_BLK_SIZE	4096	4096
FWUP_CFG_DF_ADDR_L	0xF1000	0xF1000
FWUP_CFG_DF_BLK_SIZE	256	256
FWUP_CFG_DF_NUM_BLKs	32	32
FWUP_CFG_FWUPV1_COMPATIBLE	0	0
FWUP_CFG_SIGNATURE_VERIFICATION	0	0
FWUP_CFG_PRINTF_DISABLE	1	1

7. Notes

7.1 Notes on Transition from Bootloader to Application program.

When transitioning from the sample bootloader to the application program, the settings of the bootloader's peripheral functions will be taken over by the application program.

For the peripheral functions used in the sample bootloader, the API functions of each module are closed at the end of the bootloader. Other settings are default values when the smart configurator is used.

If the customer modifies the bootloader sample program for use, the settings of the peripheral functions set in the bootloader will be inherited by the application program side. Therefore, it is recommended to initialize the settings of the peripheral functions before moving from the bootloader to the application program, or to share the settings of the peripheral functions with the application program.

When creating an application program, please take the implementation of the bootloader into consideration.

Table 7.1 Notes on peripheral functions used in the bootloader

Peripheral Functions	Settings and Notes on the Boot Loader
Board Functions	These are the default values when the module is embedded in the Smart Configurator. The settings are not changed in the bootloader.
Functions of Flash Memory	The Flash API performs Close for peripheral functions related to flash memory and transitions to the application program.
Serial Communication Functions	For peripheral functions related to serial communication, Close is performed by the SCI API and the transition is made to the application program. For the SCI channels used in the bootloader, refer to the device connection diagram for each product in 6.2 Operating Environment for Demo Project.
Option Setting Memory	For the option setting memory, set the same value in the bootloader and the application program.
Other Functions	As for the settings of other functions, these are the default values when using the Smart Configurator. The interrupt enable flag is set to interrupt disabled to transition to the application program.

7.2 Security measures for the bootloader area

When the firmware update module is commercialized by the customer, it is recommended to protect the area of the code flash where the bootloader (boot_loader) is deployed.

7.3 Updating the Data Flash Area

The firmware update module can include the data flash area in the update image.

However, because the data flash area is also subject to signature verification, the contents of the data flash cannot be modified by the application program after the update. Therefore, the data flash area included in the update target cannot be used for general-purpose data storage.

In addition, the data flash area is not covered by recovery processing if the update process is interrupted, for example, by a power failure during the update. Therefore, when including the data flash area in the update image, the user must implement appropriate measures to ensure data integrity and recovery.

For these reasons, including the data flash area in the update image is not recommended.

If the data flash area must also be updated, it is recommended to store the update data as ROM data in the code flash area and, after the application program update has been completed, update the data flash using this data during the first startup of the application program.

Revision History

Rev.	Date	Description	
		Page	Summary
2.00	Jul. 20, 2023	—	First edition issued
2.01	Nov. 22, 2023	1	Added RL78/G24 to Target Devices
		13-14	Added device to folder structure
		18	Added FWUP_CFG_CF_W_UNIT_SIZE and FWUP_CFG_FWUPV1_COMPATIBLE to configuration settings
		20	Added device in ROM/RAM/Stack
		23	Added parameter to R_FWUP_EraseArea function
		23	Added description to R_FWUP_GetImageSize function
		23	Added description to R_FWUP_GetImageSize function
		24	Added parameter to R_FWUP_WriteImageProgram function
		24	Added return value to R_FWUP_WriteImage function
		25	Added return value to R_FWUP_VerifyImage function
		58	Added board used for operation check environment
		59-67	Added device to Operation check environment
		69	Added note
2.02	Dec.13.2024	12-13	Modified chapter 1.4.
		22-23	Moved figures from chapter 1.6 to chapter 2.10.
		28	Moved the R_FWUP_WriteImageHeader function to chapter 3.13.
		28	Moved the R_FWUP_WriteImageProgram function to chapter 3.14.
		-	Replaced chapters 4 and 5.
		37-52	Modified the description of 4.demo project.
		53-61	Added chapter 4.6 Debugging demo projects.
		62-70	Modified chapter 5 Renesas Image Generator.
		83	Added chapter 7.2 Security measures for the bootloader area
2.03	Apr.18.2025	1	Executive summary LLVM is added to the target compiler.
		14,15	1.5 LLVM content added to the package configuration table.
		18	2.6 Default log display setting changed to Disable.
		19	2.7 Added LLVM to the code size of the demo project.
		22,23	2.10 Changed the flow of the example bootloader implementation.
		41	4.4 Added LLVM contents.
		74	6.1 Added LLVM testing environment.
		77,78	6.2.1.1 LLVM figures and tables added.
		79,80	6.2.1.2 LLVM figures and tables added.

Rev.	Date	Description	
		Page	Summary
2.04	Aug.27.2025	1	Added RL78/G24 to Target Devices
		1	Added Flash Driver RL78 Type11 to related application notes.
		6,9,13,14	Added description related to dual-bank method in Section 1.1, 1.3.1, 1.4.1, 1.4.4
		16,17	Added the RL78/L23 FPB folder to Table 1-2.
		19	Added Flash Driver RL78 Type11 to the software requirements in Section 2.2.
		20	Added dual-bank method to update method in Table 2-1.
		23	Added code size for RL78/L23 in Section 2.7.4.
		25,26	Added an example of dual-bank method implementation to Section 2.10.1.
		38	Added details of bank swap processing to Section 3.15.2.6.
		47-51	Added dual bank method demo project execution procedure to Section 4.4.
		78,79	Added initial image files for the dual bank method to Section 5.2.2.
		96-100	Added RL78/L23 operation verification environment to Section 6.2.4.
2.05	May.22.2026	6	Renaming of update methods in Section 1.1.
		8	Added Supported Update Methods for Each Product to Table 1-2.
		16,17	Changed the Package Folder Structure in Table 1-3.
		50,54,58, 61	Unified the Compiler-Specific Log Output Descriptions in Sections 4.4.5, 4.5.5, 4.6.5, and 4.7.
		71-73	Added How to Change the Update Image Retrieval Path for the Demo Project in Section 4.9
		74-77	Added How to Add Interrupts Handling to the Demo Project in Section 4.10
		78-81	Added How to Use a Memory Layout Different from That of the Demo Project in Section 4.11
		92	Added LLVM to the operation verification environment in Section 6.1.
		93-112	Added LLVM to the operation verification environment for the demo project in Section 6.2.

Rev.	Date	Description	
		Page	Summary
3.00	Oct.21.2026	1	Added RL78/G13 and RL78/G21 to Target Devices list.
		2	Added related application notes.
		10	Added the RL78/G13 module configuration diagram to Section 1.2.
		11	Added RL78/G13 and RL78/G21 entries to Table 1-3.
		19	Added RL78/G13 and RL78/G21 to Table 1-4.
		22	Added related drivers and libraries to Section 2.2.
		24,25	Added code sizes for RL78/G13 and RL78/G21 to Section 2.7.
		76,77	Added a procedure for debugging the application program only to Section 4.9.2.
		90	Added the "-ud <UserData>" option to Table 5-2.
		95	Added User Data to Table 5-3.
		99	Added boards for RL78/G13 and RL78/G21 to Tables 6-1, 6-2, and 6-3.
		100-104	Added the RL78/G13 verified environment to Section 6.2.1.
		105-109	Added the RL78/G21 verified environment to Section 6.2.2.
		130	Added notes on the data flash area to Section 7.3.

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 be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. 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.
6. 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.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. 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.5.0-1 October 2020)

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/.