User's Manual

32

RX23W Group

Renesas Solution Starter Kit for RX23W
Boot Loader Application Note

RENESAS 32-Bit MCU
RX Family / RX200 Series

Renesas Electronics
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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.).

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

8. Differences between products

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

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Precautions

The following precautions should be observed when operating any RSSK product:

This Renesas Solution Starter Kit is only intended for use in a laboratory environment under ambient temperature and humidity conditions. A safe separation distance should be used between this and any sensitive equipment. Its use outside the laboratory, classroom, study area or similar such area invalidates conformity with the protection requirements of the Electromagnetic Compatibility Directive and could lead to prosecution.

The product generates, uses, and can radiate radio frequency energy and may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment causes harmful interference to radio or television reception, which can be determined by turning the equipment off or on, you are encouraged to try to correct the interference by one or more of the following measures;

- ensure attached cables do not lie across the equipment
- reorient the receiving antenna
- increase the distance between the equipment and the receiver
- connect the equipment into an outlet on a circuit different from that which the receiver is connected
- power down the equipment when not in use
- consult the dealer or an experienced radio/TV technician for help NOTE: It is recommended that wherever possible shielded interface cables are used.

The product is potentially susceptible to certain EMC phenomena. To mitigate against them it is recommended that the following measures be undertaken;

- The user is advised that mobile phones should not be used within 10m of the product when in use.
- The user is advised to take ESD precautions when handling the equipment.

The Renesas Solution Starter Kit does not represent an ideal reference design for an end product and does not fulfil the regulatory standards for an end product.

How to Use This Manual

1. Purpose and Target Readers

This application note is designed to provide the user with an understanding of how the System_Bootloader sample works, in order to provide a guide on how such systems may be developed on a RX23W based system. It is intended for users working with the RSSKRX23W platform.

Further details regarding operating the RX23W microcontroller may be found in the Hardware Manual and within the sample code.

The following documents applying to the RSSKRX23W may provide assistance. Refer to the device specific versions located on the installation of the RSSK software or check the Renesas Electronics Web site for the latest versions.

Document Type	Description	Document Title	Document No.
User's Manual	Describes the technical details of the CPU Board hardware.	Renesas Solution Starter Kit for RX23W User's Manual	R20UT4446EG
Tutorial Manual	Provides a guide to setting up RSSK environment, running sample code and debugging programs.	Renesas Solution Starter Kit for RX23W Tutorial Manual	R20UT4447EG
Quick Start Guide	Provides simple instructions to setup the RSSK and run the first sample, on a single A4 sheet.	Renesas Solution Starter Kit for RX23W Quick Start Guide	R20UT4448EG
Smart Configurator Tutorial Manual	Provides a guide to code generation and importing into the e^{2}studio/CS+ IDE.	Renesas Solution Starter Kit for RX23W Smart Configurator Tutorial Manual	R20UT4449EG
Schematics	Full detail circuit schematics of the RSSK.	Renesas Solution Starter Kit for RX23W Schematics	R20UT4445EG
Hardware Manual	Provides technical details of the RX23W microcontroller.	RX23W Group User's Manual: Hardware	R01UH0823EJ
Application Note	Application note for the Renesas Flash Module Using Firmware Integration Technology.	RX Family Flash Module Using Firmware Integration Technology	R01AN2184EJ
Application Note	Application note detailing the operation of the RSSKRX23W Bootloader Sample Program.	Renesas Solution Starter Kit for RX23W Bootloader Application note	R20AN0520EG

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
API	Application Program Interface
Bootloader	Program designed to update firmware on a device while it is running in application
bps	Bits Per Second
CGC	Clock Generation Circuit
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
E1/E2 Lite	Renesas On-chip Debugging Emulator
FSL	Flash Self-programming Library
GUI	Graphical User Interface
I^2C (IIC)	Philips™ Inter-Integrated Circuit Connection Bus
IRQ	Interrupt Request
ISR	Interrupt Service Routine
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LSB	Least Significant Bit
MCU	Micro-controller Unit
NAK (NACK)	Negative Acknowledgement
RSSK	Renesas Solution Starter Kit

Table of Contents

Renesas Solution Starter Kit for RX23W

Boot Loader Application Note

1. Overview

1.1 Purpose

This application note describes the operation of the System Bootloader sample code on the RSSK platform with a view to aiding development of similar applications. In addition, this application note uses “RX Family Flash Module Using Firmware Integration Technology (FIT)”.

1.2 Features

The System Bootloader sample code demonstrates the ability to update application code in the internal flash memory of RX23W via SCI while the system is running, using a standard S-Record or hex programmer file format. It incorporates system integrity checking facilities such as CRC Flash memory verification and a watchdog.

The RSSK board contains all the circuitry required for microcontroller operation.

2. Introduction

This application note is designed to illustrate how the System Bootloader sample code provides the ability to update application code located in on-board Flash memory on the MCU whilst running, via a serial connection from a PC or equivalent device.

3. System Bootloader

3.1 Memory Map - Flash

In order to understand the operation of the Bootloader and Application system it is important to have an appreciation of the memory space in which they are operating. This is shown in Figure 3-1 Flash Memory Map.

Block 255 to 224 (address 0xFFF80000-0xFFF8FFFF) of the flash memory is the Bootloader code, including the Flash Self-Programming Library. In addition to this, there is a bootloader exception vector table (address 0xFFFFFF80-0xFFFFFFFB). The reset vector is located at address 0xFFFFFFFC.

Block 223 (address 0xFFF90000-0xFFFFFEF3) of the flash memory is the user application code. In addition to this, there is an application exception vector table (address 0xFFFFFEF4-0xFFFFFF6F). The reset vector is located at the address 0xFFFFFF70.

The application code area checksum byte is located at address 0xFFFFFF7C-0xFFFFFF7F. This checksum is calculated and verified by the Bootloader to determine if the application area contains a valid application.

3.2 Memory Map - RAM

The RX23W fitted to the RSSK has 64K bytes of RAM.

The Application code and Bootloader code are executed completely separately, so there is no RAM to share between them.

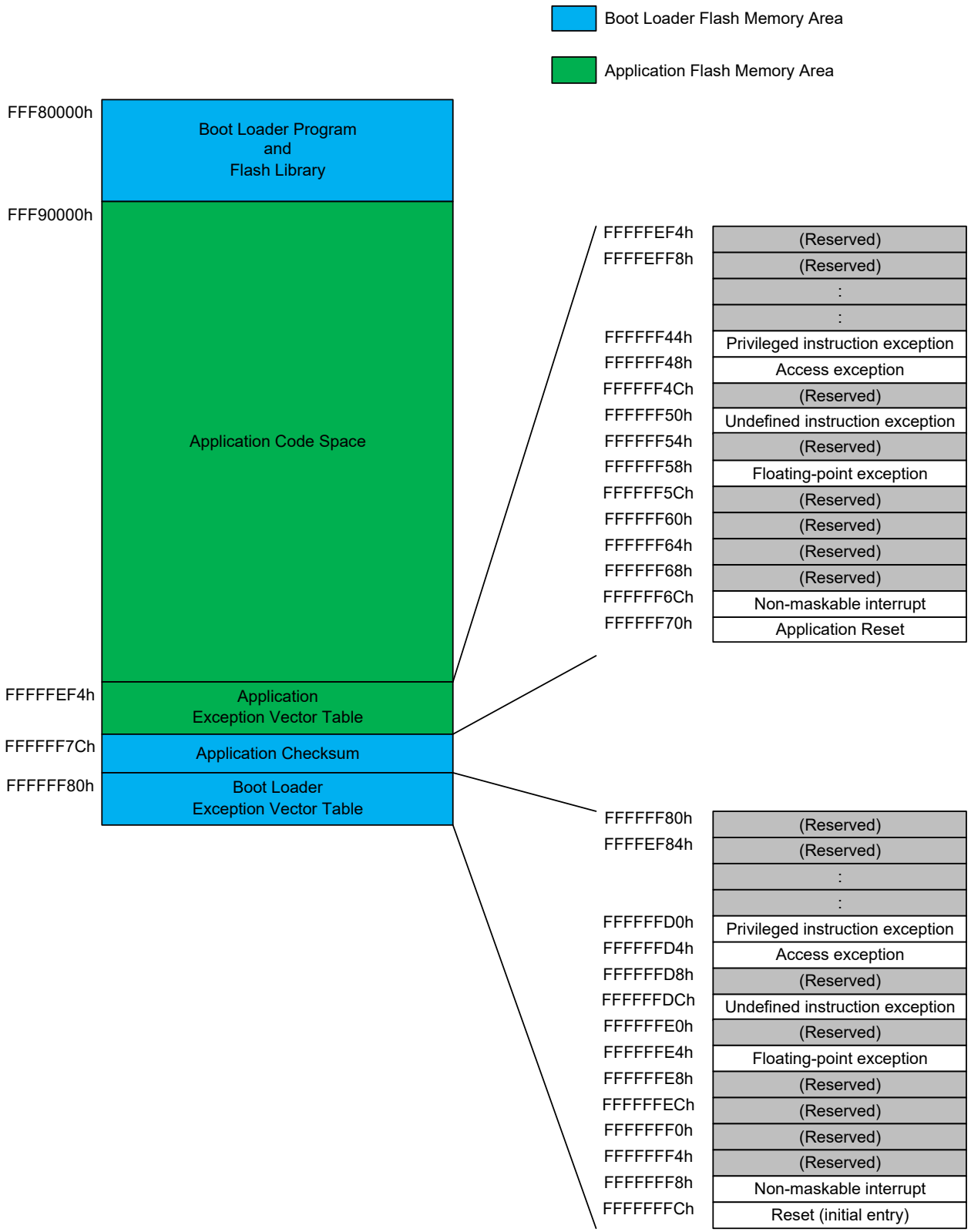

Figure 3-1 Flash Memory Map

3.3 Operation

Figure 3-2 Bootloader Flow Chart shows the workflow for the Bootloader.

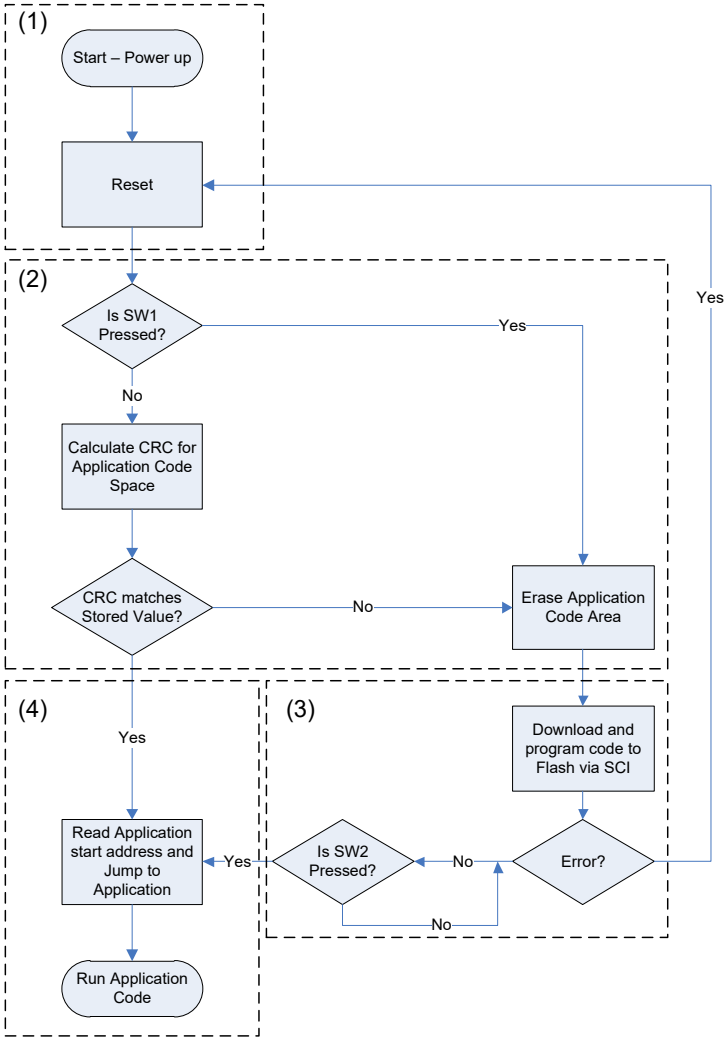

Figure 3-2 Bootloader Flow Chart

(1) The MCU starts operation always by jumping to the location pointed to by the Bootloader fixed reset vector.

(2) When the Bootloader starts and one of the following conditions is met, the application code area is erased.
1. SW1 is pressed when the RSSK starts.
2. A CRC check of the Application code space determines that the code is invalid.

(3) The Bootloader is responsible for deciding whether to run code located within the Application area, or to download new code via SCI and reprogram the flash area with this code. Once Application flash programming is complete, the Bootloader then calculates a CRC value for the Application space and programs it to a fixed location in Flash.

(4) The Bootloader executes an application under either of the following conditions.
1. Once the Application update process is complete and SW2 pressed.
2. At start-up, when a CRC check result is matches the Application checksum.

The Bootloader will jump to the start address of the Application by reading the Reset vector entry in the Application's exception vector.

4. Vector Handling

The RX23W processor has two vector tables: the interrupt vector table & the exception vector table.

4.1 Interrupt Vector Table

This vector table can be located anywhere in the RX23W flash area and stores addresses for the majority of standard interrupt vectors.

The user application is responsible for setting the interrupt table register (INTB) to the location of the application's interrupt table.

4.2 Exception Vector Table

The exception vector table contains reserved vectors in addition to interrupt vectors. For details, see the exception vector table in Figure 3-1.

The RX23W uses the fixed locations of 0xFFFFFF80 through 0xFFFFFFFF for this vector table. This is within the bootloader address space and is not modifiable by the user's application.
The exception vector table (EXTB) is set to 0xFFFFFF80 after reset.

The user application must have an exception vector table located at addresses 0xFFFFFEF4 through 0xFFFFFF73. This table is in the same format as a standard exception vector table.
The exception vector table (EXTB) is changed from 0xFFFFFF80 to 0xFFFFFEF4 after jumping to the user application.
If an exception other than reset has occurred, exception handling by the user application is invoked. If a reset has occurred, exception handling by the Bootloader is invoked.

4.3 Code Description

The System_Bootloader project has been based on code generated by the Smart Configurator. Many configuration options can be quickly modified to suit the application using a GUI, for example, changing the baud rate of the SCI connection etc. Smart Configurator files prefixed by “Config_” are files controlled by the Smart Configurator and within such files it is important to make modifications only in areas between the comments such as shown.

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

Any code additions or modifications performed outside of these comments will be overwritten if the code regenerated by Smart Configurator.

For a more detailed guide to using Smart Configurator, refer to Smart Configurator Tutorial manual.

main.c is the file of the project containing the main function. The function main.c provides a high level guide of the process, following the bootloader flow chart in Figure 3-2.

Function update_from_data_source guides the update procedure of reading data from the SCI and programming the Flash with this data. It handles the incoming data byte by byte, determining the format of the file being sent (Intel Hex or S-Record) automatically, and assigning function pointers to handle the data reception appropriately. When complete lines of records from the file are received, it determines what to do with the information; whether it is code and needs to be programmed to Flash or otherwise.

The SCI code is in the file ‘src\smc_gen\Config_SCI8\Config_SCI8.c’. By defaults the SCI is set to use 38400 Baud, 8 Data Bits, No Parity, 1 Stop Bit. These parameters may be changed using Smart Configurator.

To control the flow of data from the host PC, XModem transfer protocol has been employed. This is a 128-byte packet based protocol and allows the System_Bootloader to hold off further transfers from the PC while decoding and programming operations are in progress.

XModem packets are fed into a buffer, which is controlled in buffer.c. The buffer is circular, i.e. when the end of the buffer is reached it loops back to the start. The buffer handling code has been deliberately constructed so as to make it easy to replace the data reception functions with those from a different communications medium.

Programming or erasing Flash via the FIT flash API is achieved via the file code_flash.c. This employs functions to write to the Flash independently of block size or location, encapsulating the FSL library functions. Furthermore repetitive calls to the write_flash function will just append the data to a buffer held in RAM and only write the data to the Flash if new data is passed to it that lies outside of the Flash block, in order to reduce the number of Flash writes. Any remaining data held in the Flash Write buffer can be written to the Flash by calling the flash_flush_buffer function.

Decoding of S-Record formatted files is handled in srec.c. Further information on the S-Record file format can be obtained at the following link: http://en.wikipedia.org/wiki/SREC_(file_format)

Decoding of Intel hex formatted files is handled in hex.c. Further information on the hex file format can be obtained at the following link: http://en.wikipedia.org/wiki/Intel_HEX

The Bootloader activates the watchdog timer, as a system integrity function. This is achieved in the file ‘src\smc_gen\Config_IWDT\Config_IWDT.c’. The function R_Config_IWDT_Restart in the Bootloader code resets the watchdog to prevent timeout and reset.

4.3.1 XModem transfer implementation

Details of the XModem protocol may be found at the following link: http://en.wikipedia.org/wiki/XMODEM.

The Bootloader implements the standard XModem protocol and not any variant such as XModem-1K or XModem-CRC.

In line with the standard protocol implementation, NAKs are sent by the RSSK every 10 seconds before the first packet is received. As such there may be up to ten seconds delay between initialising the transfer on the terminal and the first packet being sent.

A <CAN> flag is sent to the terminal if the Bootloader detects a problem during the XModem transfer. This will cancel the transfer from the PC and allow the error message to be displayed to the user. <CAN> aborts are not supported by all PC terminal programs.

4.3.2 Flash API and FIT

The Renesas Flash API is used to perform the flash erase and programming. Please refer to 'RX Family Flash Module Using Firmware Integration Technology' Application Note (R01AN2184) for the details.

4.4 Bootloader Section Link Addresses

To implement the memory map detailed in section 3.1 Memory Map, **Table 4-1** settings are used for the Bootloader linker sections.

Table 4-1. Section setting of the boot loader

Address	Section Name	Comment
0x00001000	SU	Start address of RAM
	SI	
	B_1	
	R_1	
	B_2	
	R_2	
	B	
	R	
	RPFRAM	
0xFFF80000	C_1	Start address of program code
	C_2	
	C	
	C$*	
	D*	
	W*	
	L	
	P*	
0xFFFFFF80	EXCEPTVECT	Bootloader Exception Vector Table
0xFFFFFFFC	RESETVECT	Reset

4.5 Considerations for Bootloader Application Code

4.5.1 Section Link Addresses

The Bootloader application code and vector tables must be linked within the section shown in **Figure 3-1 Flash Memory Map**, summarised below.

Table 4-2. Section setting of the boot loader application

Address	Section Name	Comment
0x00008000	SU	Start address of RAM
	SI	
	B_1	
	R_1	
	B_2	
	R_2	
	B	
	R	
0xFFF90000	C_1	Start address of program code
	C_2	
	C	
	C$*	
	D*	
	W*	
	L	
	P*	
0xFFFFFEF4	EXCEPTVECT	Application Exception Vector Table
0xFFFFFF70	RESETVECT	Application Reset

During download the image will be rejected if the Bootloader Application has code placed outside of the Application area shown in Figure 3-1 Flash Memory Map. If this occurs, analysis of the Bootloader Application linker map output file should indicate what has been set incorrectly.

4.5.2 Fixed Register Configuration

The RX23W has a number of registers that store non-volatile configuration information in the code flash. These include:

a) Endian Select Register (MDE)
b) Option Function Select (OFS0 & OFS1)
c) ID Code.
etc.

These registers are configured by, and located within, the Bootloader area of flash.

Smart Configurator creates the file 'src\smc_gen\r_bsp\mcu\rx23w\vecttbl.c' which contains the configuration for these registers. However, these registers are not used in Bootloader Application.

4.5.3 Microcontroller Defaults

Before the user application is launched the Bootloader runs, this sets up various peripherals including the CGC, SCI and WDT. The Bootloader Application should be such that it is can accommodate peripherals not being in their default power-on state.

5. Additional Information

Technical Support
For information about the RX23W group microcontroller refer to ‘RX23W Group User’s Manual: Hardware’.

For information about the RX assembly language, refer to ‘RX Family User’s Manual: Software’.

Technical Contact Details

Please refer to the contact details listed in section 9 of the “*Quick Start Guide*”

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