User's Manual

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RX113 Group

Renesas Starter Kit for RX113 Boot Loader Application Note

RENESAS MCU
RX Family / RX100 Series

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(2012.4)

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Precautions

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

This Renesas 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 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 RX113 based system. It is intended for users working with a RSKRX113 platform.

Further details regarding operating the RX113 microcontroller may be found in the Hardware Manual and within the sample code.

The following documents applying to the RSK RX113 may provide assistance. Refer to the device specific versions located on the installation of the RSK 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 RSK hardware.	RSKRX113 User's Manual	R20UT2756EG
Tutorial	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSKRX113 Tutorial Manual	CS+: R20UT2757EG e2 studio: R20UT2760EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample.	RSKRX113 Quick Start Guide	CS+: R20UT2758EG e2 studio: R20UT2761EG
Code Generator Tutorial Manual	Provides a guide to code generation IDE.	RSKRX113 Code Generator Tutorial Manual	CS+: R20UT3254EG e2 studio: R20UT3255EG
Schematics	Full detail circuit schematics of the RSK.	RSKRX113 Schematics	R20UT2755EG
Hardware Manual	Provides technical details of the RX113 microcontroller.	RX113 Group, User's Manual: Hardware	R01UH0448EJ
Application Note	Application note for the Renesas Flash Module Using Firmware Integration Technology.	RX Family Flash Module Using Firmware Integration Technology	R01AN2184EU
Application Note	Application note detailing the use of Flash API without the Renesas Board Support Package.	RX Family Using the Simple Flash API for RX without the r_bsp Module	R01AN1890EU
Application Note	Application note detailing the operation of the RSK RX113 Bootloader Sample Program.	RSKRX113 Bootloader Application note	R20AN0339EG

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
API	Application Program Interface
bps	Bits Per Second
Bootloader	Program designed to update firmware on a device while it is running in application
CGC	Clock Generation Circuit
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
E1	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
RSK	Renesas Starter Kit

Table of Contents

1. Overview

1.1 Purpose

The RSK is an evaluation tool for Renesas microcontrollers. This application note describes the operation of the System Bootloader sample code on the RSK platform with a view to aiding development of similar applications.

1.2 Features

The System Bootloader sample code demonstrates the ability to update application code 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 RSK board contains all the circuitry required for microcontroller operation.

2. Introduction

This application note is designed to illustrate how the System Sample: System_Bootloader 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.

At the top of the flash memory is the Bootloader code, including the Flash Self-Programming Library.

Following this is the space for the Application Code, this area will hold the code for the application programmed using the Bootloader. This includes a pseudo-fixed vector table for the Application.

The RX113 fixed reset and exception vectors are located between addresses 0xFFFFFFD0 & 0xFFFFFFFF. The fixed reset vector always points to the Bootloader code to ensure that the system can verify the Application code space in the event of a reset.

Above this lies an area containing option bytes, endian select registers and security ids.

In the addresses immediately above is the user application area checksum bytes. 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 RX113 fitted to the RSK has 64k bytes of RAM.

Because Application code and Bootloader code run entirely separately, there is no shared RAM between them and no restrictions placed on application RAM use.

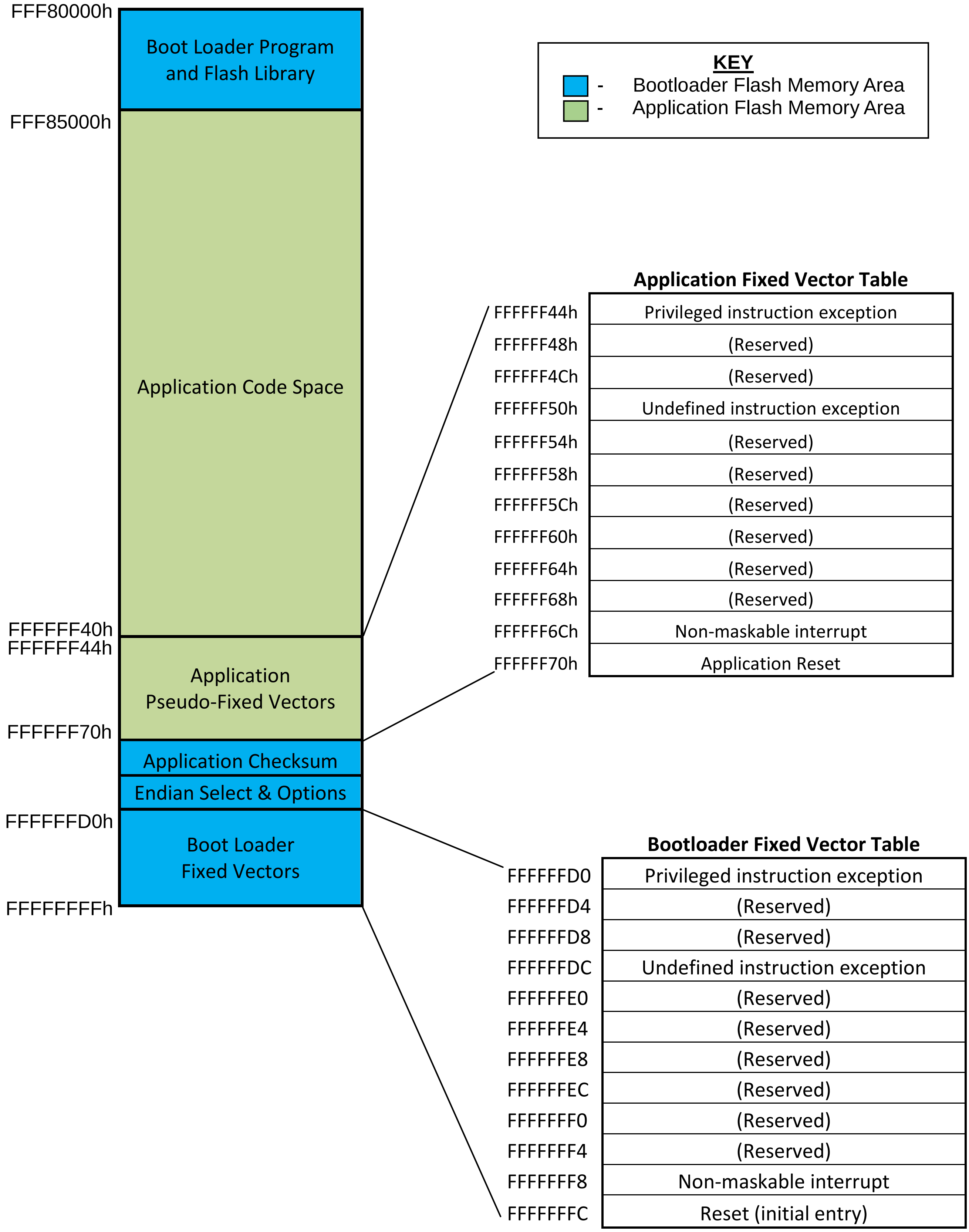

Figure 3.1 Flash Memory Map

3.3 Operation

Figure 3.2 Bootloader Flow Chart shows the workflow for the Bootloader

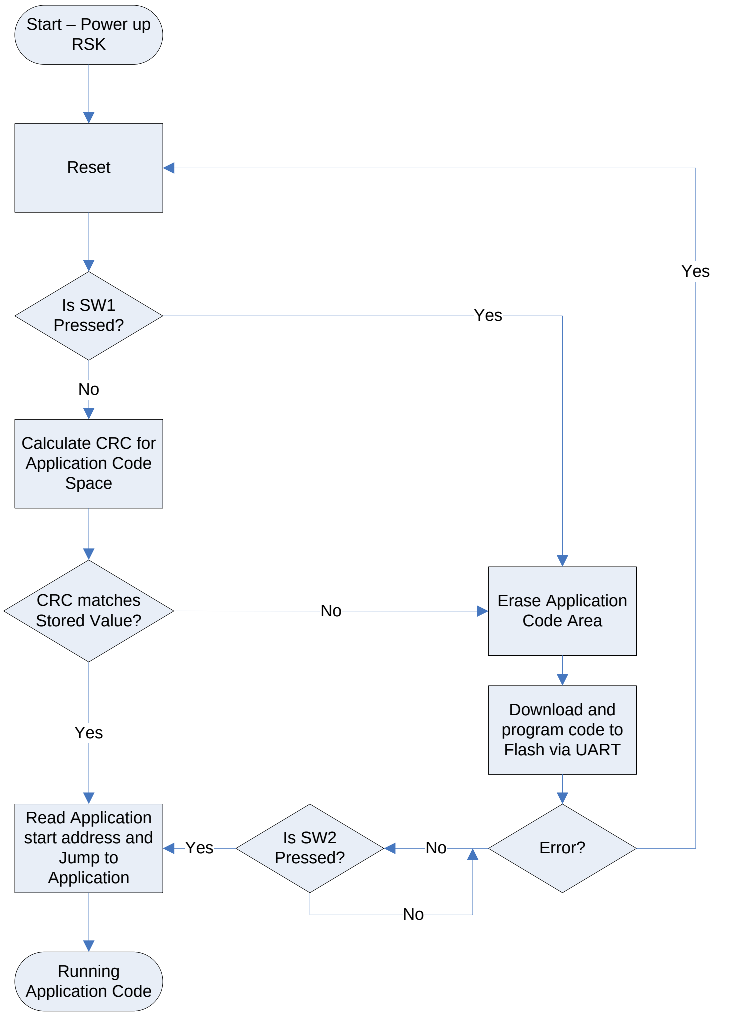

Figure 3.2 Bootloader Flow Chart

The MCU starts operation always by jumping to the location pointed to by the Bootloader fixed reset vector. This reset vector starts operation of the Bootloader (Not the Application). 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.

The Bootloader decides to update the Application if SW1 is pressed when the RSK starts or if a CRC check of the Application code space determines that the code is invalid.

The firmware update procedure consists of first erasing the Application code space, followed by reading in new code from a programmer file in S-Record or Intel Hex format received via a SCI connection from the RL78G1C USB to Serial converter, and programming the Application Flash block by block.

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.

Once the Application update process is complete and SW2 pressed, or if the application checksum is validated at start-up, the Bootloader will jump to the start address of the Application by reading the Reset vector entry in the Application's pseudo-fixed vector table.

4. Vector Handling

The RX113 processor has two vector tables: Re-locatable Vector table & Fixed Vector table.

4.1 Re-locatable Vector table

As the name suggests this vector table can be located anywhere in the RX113 flash area and stores addresses for the majority of standard interrupt vectors.

The user application is responsible for setting the INTB register to the location of the application's re-locatable table.

4.2 Fixed Vector table

This table contains a number of reserved vectors and vectors for:

Reset,
Non-maskable interrupt,
Undefined instruction exception &
Privileged instruction exception.

The RX113 uses the fixed locations of 0xFFFFFFD0 thru 0xFFFFFFFF for this vector table. This is within the bootloader address space and is not modifiable by the user's application.

The bootloader incudes a feature that forwards the vectors listed above to be services by application code. This is illustrated in Figure 4.1 Application Interrupt Forwarding Process.

The user application must have a pseudo-fixed vector table located at addresses 0xFFFFFF44 thru 0xFFFFFF73. This table is in the same format as a standard fixed vector table.

If an exception is generated during user application execution, the bootloader vector is invoked by the RX113. The bootloader code will read the relevant entry in the user's pseudo-fixed vector table and perform a jump to that address. This allows the user application to service the exception/interrupt as it would if running without the bootloader.

The vector forwarding requires additional processor cycles to complete, which marginally increases latency between the exception/interrupt and user's service routine being executed.

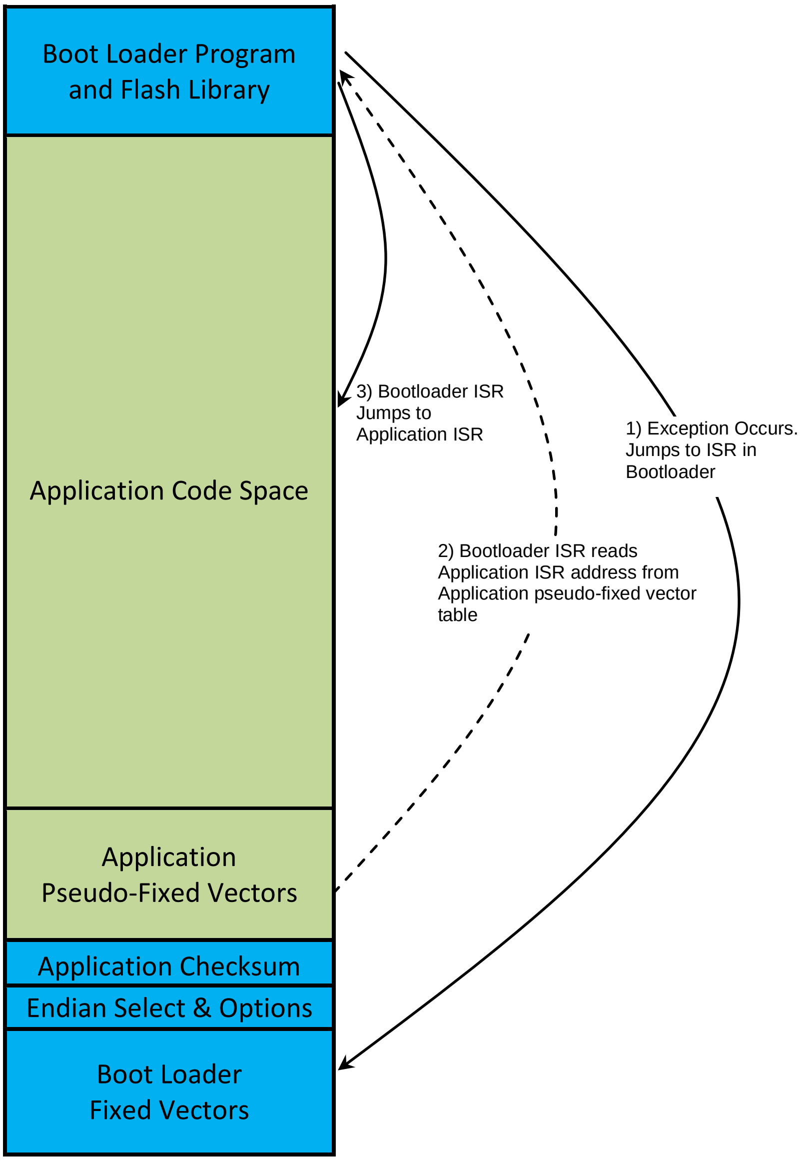

Figure 4.1 Application Interrupt Forwarding Process

4.3 Code Description

The System_Bootloader project has been based on code generated by the Code Generator. 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. Code Generator files prefixed by “r_cg_” are files controlled by the Code Generator 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 re-generated by Code Generator.

For a more detailed guide to using Code Generator, refer to Code Generator Tutorial manual.

r_cg_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 Figure 3.2 Bootloader Flow Chart.

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 r_cg_sci.c. By default the SCI is set to use 38400 Baud, 8 Data Bits, No Parity, 1 Stop Bit. These parameters may be changed using Code Generator.

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 Flash Self-Programming library 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 Flash_Write 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 r_cg_wdt.c file. The function R_WDT_Restart in the Bootloader code resets the watchdog to prevent timeout and reset.

r_bootloader_vecttbl.c & r_bootloader_intprg.c implements the interrupt vector forwarding and replace the functionality found in the Code Generator files r_cg_vecttbl.c and r_cg_intprg.c, which are excluded from the build.

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 RSK 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. To reduce Bootloader code footprint, full Renesas Board Support Package (r_bsp) has not been used. The reduced size approach detailed in the 'Using the Simple Flash API for RX without the r_bsp_ Module Application Note' has been employed.

4.4 Bootloader Section Link Addresses

To implement the memory map detailed in section 3.1 Memory Map, the following settings are used for the Bootloader linker sections.

Address	Section Name	Comment
0x00001000	SU	Bootloader work RAM start
	SI	
	B_1	
	R_1	
	B_2	
	R_2	
	B	
	R	
	RPFRAM	
0xFFF80000	PResetPRG	Start of Bootloader code
	C_1	
	C_2	
	C	
	C$*	
	D*	
	W*	
	L	
	PIntPRG	Bootloader re-locatable vector table
	P	
	PFRAM	
0xFFFFFFD0	FIXEDVECT	Bootloader Fixed Vector Table

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.

Address	Contents	Comment
0xFFF85000	User Application Code	All user application code
0xFFFFFF44 to 0xFFFFFF70	Pseudo-Fixed Vector Table	Pseudo-Fixed Vector Table in the standard RX113 Fixed vector table order.

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.

Please note that Code Generator in e^2 studio adjusts Linker Section addresses each time code generated. If using Code Generator in e^2 studio the user needs to manually change the sections to the addresses required.

4.5.2 Fixed Register Configuration

The RX113 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.

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

Code Generator creates the file ‘r_cg_vecttbl.c’ which has configuration for these registers as standard. The Bootloader Application excludes this file from the build and includes ‘r_bootloader_vecttbl.c’ instead which contains the application vector table. This duplicates the vectors found in ‘r_cg_vecttbl.c’ but does not include the fixed configuration register setup.

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 RX113 group microcontroller refer to the RX113 Group Hardware Manual.

For information about the RX assembly language, refer to the RX Series Software Manual.

Technical Contact Details

Please refer to the contact details listed in section 8 of the "Quick Start Guide"

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