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RX Family

Board Support Package Module Using Firmware Integration Technology

Introduction

The foundation of any project that uses FIT modules is the Renesas Board Support Package (r_bsp). The r_bsp is easily configurable and provides all the code needed to get the MCU from reset to main(). The document covers conventions of the r_bsp so that users will know how to use it, configure it, and create a BSP for their own board.

Target Device

The following is a list of devices that are currently supported:

- **RX110, RX111, RX113 Groups**
- **RX210, RX21A Groups**
- **RX220 Group**
- **RX610 Group**
- **RX62N, RX62T, RX62G Groups**
- **RX630, RX631, RX63N, RX63T Groups**
- **RX64M Group (Note that building the RX64M BSP requires RXC compiler version 2.01.00 or higher and e2 studio version 3.0.0 or higher.)**

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

Related Documents

- Firmware Integration Technology User's Manual (R01AN1833EU)

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1. Overview

Before running the user application there are a series of operations that must be performed to get the MCU set up properly. These operations, and the number of operations, will vary depending on the MCU being used. Common examples include: setting up stack(s), initializing memory, configuring system clocks, and setting up port pins. No matter the application, these steps need to be followed. To make this process easier the Renesas Board Support Package, abbreviated as r_bsp, is provided.

At the lowest level the r_bsp provides everything needed to get the user's MCU from reset to the start of their application's main() function. The r_bsp also provides common functionality that is needed by many applications. Examples of this include callbacks for exceptions and functions to enable or disable interrupts.

While every application will need to address the same steps after reset, this does not mean that the settings will be the same. Depending on the application, stack sizes will vary and which clock is used will change. All r_bsp configuration options are contained in one header file for easy access.

Many customers start development on a Renesas development board and then transition to their own custom boards. When users move to their own custom hardware it is highly recommended they create a new BSP inside of the r_bsp. By following the same standards and rules that are used for the provided BSPs the user can get an early start on development knowing that their application code will move to their target board very easily. Details on how users can create their own BSPs are provided in this document.

1.1 Terminology

Term	Meaning
Platform	The user's development board. Used interchangeably with 'board'.
BSP	Short for Board Support Package. BSP's usually have source files related to a specific board.
Callback Function	This term refers to a function that is called when an event occurs. For example, the bus error interrupt handler is implemented in the r_bsp. The user will likely want to know when a bus error occurs. To alert the user, a callback function can be supplied to the r_bsp. When a bus error occurs the r_bsp will jump to the provided callback function and the user can handle the error. Interrupt callback functions should be kept short and be handled carefully because when they are called the MCU will still be inside of an interrupt and therefore will be delaying any pending interrupts.

1.2 File Structure

The r_bsp file structure is shown below in Figure 1-1. Underneath the root r_bsp folder there are 3 folders and 2 files. The first folder is named *doc* and contains r_bsp documentation. The second folder is the *board* folder which has one folder per supported board. In each board folder the user will find source files that are specific to that board. There is also a folder named *user* that is provided. This folder is merely a placeholder to remind users that it is recommended for them to create their own board folder. The third folder is the *mcu* folder which has one folder per supported MCU. There is also a folder named *all* in this directory containing source that is common to all MCUs in the r_bsp. While *board* folders have source files specific to a board, *mcu* folders contain source that is shared between MCUs in the same MCU Group. This means that if the user has two distinct boards that both use a version of the RX63N then each board will have its own *board* folder (i.e. *board >> my_board_1* & *board >> my_board_2*) but both will share the same *mcu* folder (i.e. *mcu >> rx63n*). Even if the two RX63N MCUs have different packages or memory sizes they will still share the same *mcu* folder.

The file *platform.h* is provided for the user to choose their current development platform. *platform.h,* in turn, selects all the proper header files from the *board* and *mcu* folders to be included in the user's project. This is discussed in more detail in later sections. The *readme.txt* file is a standard text file that is provided with all FIT Modules that provides brief information about the r_bsp.

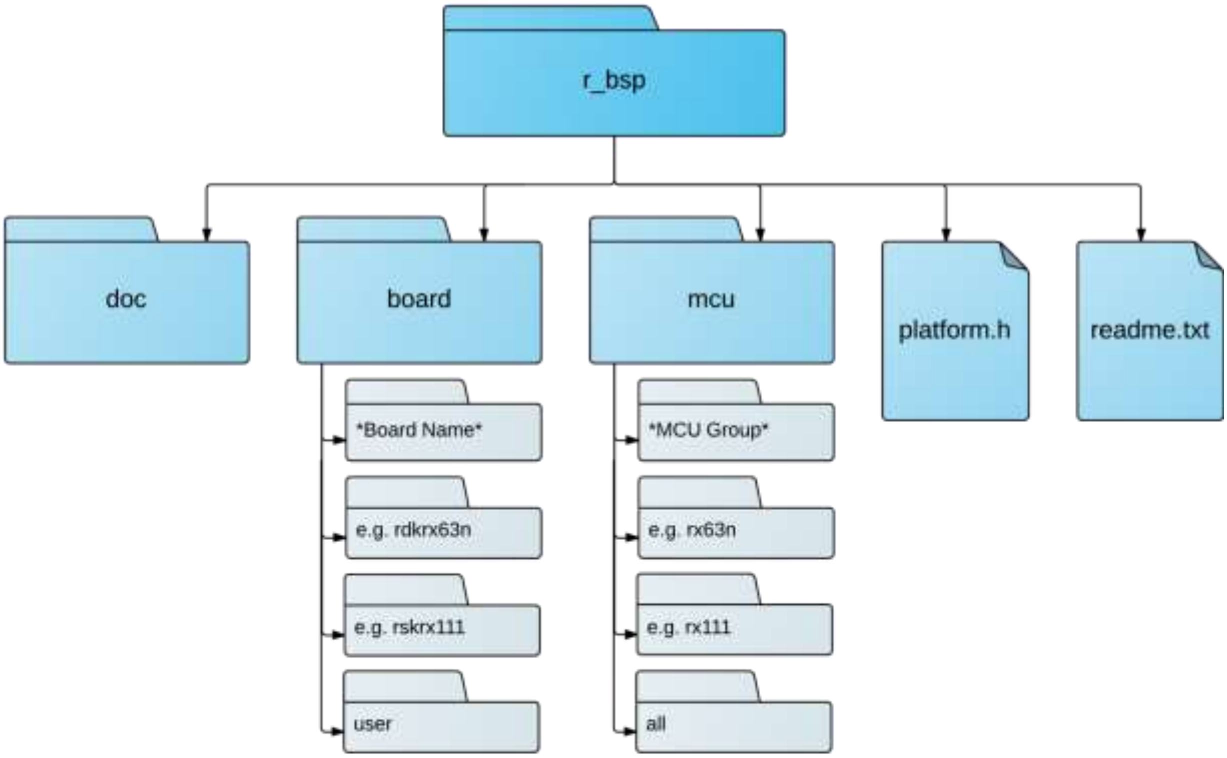


Figure 1-1 : r_bsp File Structure

2. Features

This section will go into more detail on the features provided by the r_bsp.

2.1 MCU Information

One of the main benefits of the r_bsp is that the user defines their global system settings only once, in a single place in the project. This information is defined in the r_bsp and then used by FIT Modules and user code. FIT Modules can use this information to automatically configure their code for the user's system configuration. If the r_bsp did not provide this information then the user would have to specify system information to each FIT Module separately.

Configuring the r_bsp is discussed in Section 3. The r_bsp uses this configuration information to set macro definitions in *mcu_info.h*. Each MCU may have different macros in *mcu_info.h*, but below are some common examples.

Define	Meaning
BSP_MCU_SERIES_<MCU_SERIES>	Which MCU Series this MCU belongs too. Example: BSP_MCU_SERIES_RX600 would be defined if the MCU was an RX62N, RX62T, RX630, RX63N, etc.
BSP_MCU_<MCU_GROUP>	Which MCU Group this MCU belongs too. Example: BSP_MCU_RX111 would be defined if the MCU was an RX111.
BSP_PACKAGE_<PACKAGE_TYPE>	The package of the MCU. Example: BSP_PACKAGE_LQFP100 would be defined for a 100-pin LQFP package MCU.
BSP_PACKAGE_PINS	How many pins this MCU has.
BSP_ROM_SIZE_BYTES	The size of the user application ROM space in bytes.
BSP_RAM_SIZE_BYTES	The size of the RAM available to the user in bytes.
BSP_DATA_FLASH_SIZE_BYTES	The size of the data flash area in bytes.
BSP_<CLOCK>_HZ	There will be one of these macros for each clock on the MCU. Each macro will define that clock's frequency in Hertz. Examples: BSP_LOCO_HZ defines the LOCO frequency in Hz. BSP_ICLK_HZ defines the CPU clock in Hz. BSP_PCLKB_HZ defines the Peripheral Clock B in Hz.
BSP_MCU_IPL_MAX	The maximum interrupt priority level for the MCU.
BSP_MCU_IPL_MIN	The minimum interrupt priority level for the MCU.
FIT_NO_FUNC **and** **FIT_NO_PTR**	These macros can be used as arguments in function calls to specify that the nothing is being supplied for an argument. For example, if a function takes an optional argument for a callback function then FIT_NO_FUNC could be used if the user did not wish to supply a callback function. These macros are defined to point to reserved address space. This is done so that if the argument is used improperly it is easier to catch. The reason for this is that if the MCU attempts to access reserved space then a bus error will occur and the user will know immediately. If NULL was used instead then a bus error would not occur because NULL is typically defined as 0 which is a valid RAM location on the RX.

2.2 Initialization

The PowerON_Reset_PC() function in *resetprg.c* is set as the reset vector for the MCU. This function performs a number of chip initialization actions to get the MCU ready to jump to the user's application. The flowchart below details the operations this function performs.

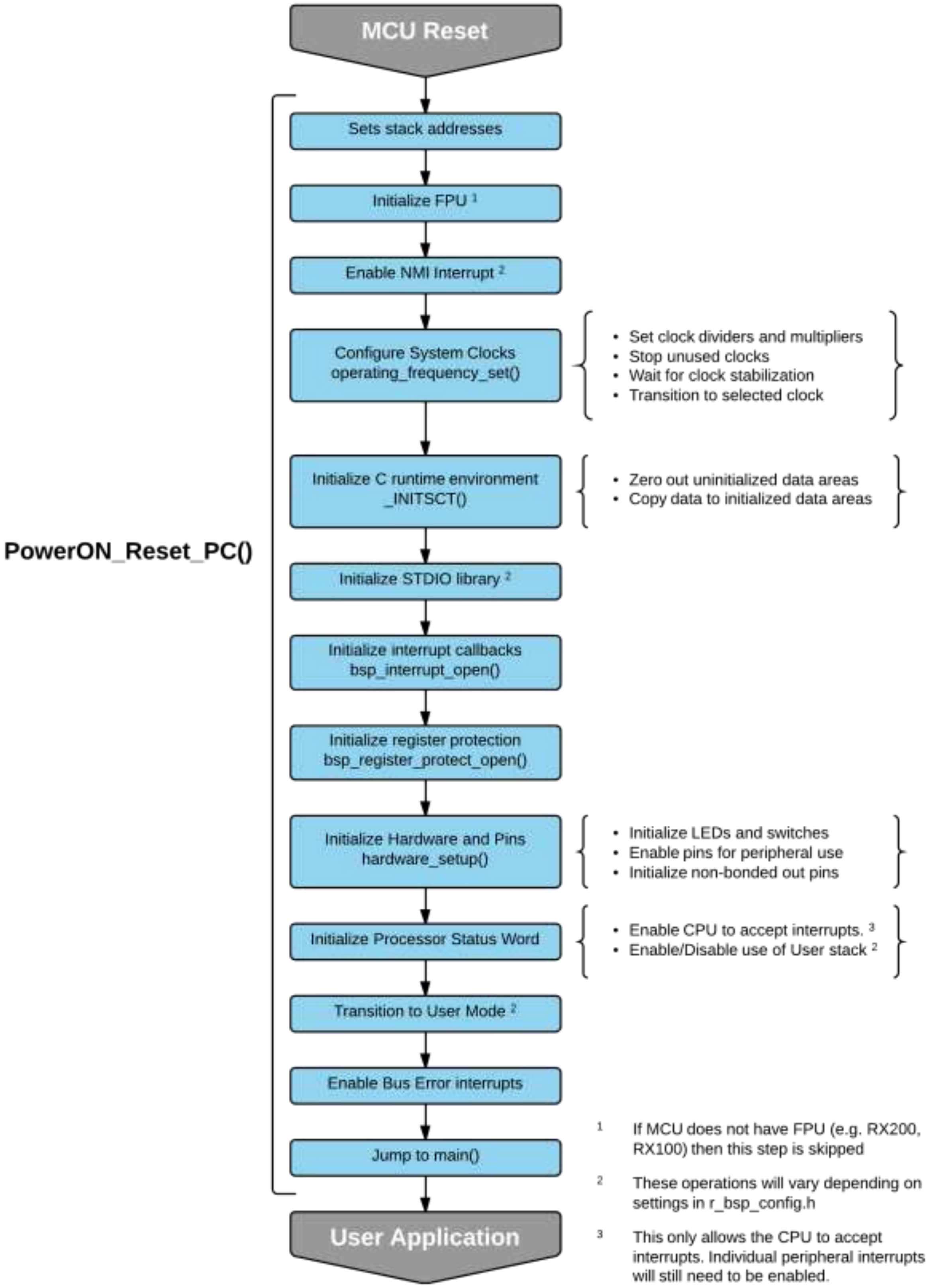


Figure 2-1: PowerON_Reset_PC() Flowchart

2.3 Global Interrupts

Interrupts on RX MCUs are disabled out of reset. The PowerON_Reset_PC() function will enable interrupts before the user's application is called (see Section 2.2).

RX devices have two vector tables: a relocatable vector table and a fixed vector table. As the names suggest the relocatable vector table can be anywhere in memory and the fixed vector table is at a static location at the top of the memory map.

The relocatable vector table holds peripheral interrupt vectors and is pointed to by the INTB register. This register is initialized after reset in the PowerON_Reset_PC() function. The vectors in the relocatable vector table are inserted by the RX toolchain. The RX toolchain knows about the user's interrupt vectors by the use of the '#pragma interrupt' directives in the user's code.

The fixed vector table holds exception vectors, the reset vector, as well as some flash-based option registers. The fixed vector table is defined in *vecttbl.c* along with default interrupt handlers for all exceptions, the NMI interrupt, bus errors, and undefined interrupts. The user has the option of dynamically setting callbacks (see Section 2.4) for all of these vectors using the functionality found in *mcu_interrupts.c*. The *vecttbl.c* file also takes care of setting up the User Boot reset vector when applicable.

All vectors in the fixed vector table are handled in *vecttbl.c*. All vectors in the relocatable vector table are not handled because the user will define these vectors and each application will be different. This means that in every application there will be unfilled vectors that should be taken care of in case that interrupt is triggered by accident. Many linkers support the filling of unused vectors with a static function. The undefined_interrupt_source_isr() function in *vecttbl.c* is provided for this purpose and the user is encouraged to setup the linker to fill in unused vectors with this function's address.

2.4 Interrupt Callbacks

The r_bsp provides several API functions (see Section 5.13 through 5.15) which allow the user to be alerted when certain interrupts are triggered. This works by the user selecting the interrupt and then providing a callback function. When the interrupt is triggered the r_bsp will call the supplied callback function.

Currently, the user can choose to register callbacks for all exception interrupts in the fixed vector table, the bus error interrupt, and the undefined interrupt. After the user callback function has been executed, the r_bsp interrupt handler will clear any interrupt flags as needed.

2.5 Non-Existent Port Pins

Within a MCU Group there can be many different packages with varying number of pins. For packages that have less pins than the maximum (e.g. 64 pin package in a MCU group that goes up to 144 pins), the non-bonded out pins can be initialized to lower power consumption. Based on the settings in *r_bsp_config.h* the r_bsp will automatically initialize these non-bonded out pins during the MCU initialization procedure. This feature is implemented in the *mcu_init.c* function and is called by the hardware_setup() function.

2.6 Clock Setup

All system clocks are setup during r_bsp initialization. The clocks are configured based upon the user's settings in the *r_bsp_config.h* file (see Section 3.2.6). Clock configuration is performed prior to initializing the C runtime environment. This is done to quicken this process since some RX MCUs startup on a relatively slow clock (i.e. RX63x starts on 125kHz Low-Speed On-Chip Oscillator). When selecting a clock the code in the r_bsp will implement the required delays to allow the selected clock to stabilize.

2.7 STDIO & Debug Console

When enabled (see Section 3.2.3), the STDIO library is initialized as part of the MCU initialization procedure. The r_bsp code is setup to send STDIO output to the debug console that can be viewed in HEW or e2studio. The source file *lowlvl.c* is responsible for sending and receiving bytes for STDIO functions and as previously stated is setup by default to use the debug console. If desired the user may redirect the stdio charget() and/or charput() functions to their own respective functions by modifying r_bsp_config.h and enabling BSP_CFG_USER_CHARGET_ENABLED and/or BSP_CFG_USER_CHARPUT_ENABLED, and providing and replacing the my_sw_charget_function and/or my_sw_charput_function function names with the names of their own functions.

2.8 Stacks & Heap

RX MCUs have two stacks that can be used: the User stack and the Interrupt stack. When both stacks are used the User stack will be used during normal execution flow and the Interrupt stack will be used during interrupt handling. Having 2 stacks can make it easier to figure out how much stack space to allocate since the user does not have to worry about always having enough room on the User stack for if-and-when an interrupt occurs. Some users will not want 2 stacks though because it is not needed in all applications and can lead to wasted RAM (i.e. space in between stacks that is not used). If only 1 stack is used then it will always be the Interrupt stack.

The User and Interrupt stacks and the heap are all setup and initialized after reset inside of the r_bsp code. The sizes of the stacks and heap, and whether 1 or 2 stacks are used, is configured in *r_bsp_config.h* (see Section 3.2.2). The user also has the option of disabling the heap if desired.

2.9 CPU Mode

Out of reset, RX MCUs operate in Supervisor CPU Mode. In Supervisor Mode all CPU resources and instructions are available. The user has the option (see Section 3.2.4) of transitioning to User Mode before the r_bsp code jumps to main(). In User Mode there are restrictions to any instruction capable of writing to:

- Some bits (bits IPL[3:0], PM, U, and I) in the processor status word (PSW)
- Interrupt stack pointer (ISP)
- Interrupt table register (INTB)
- Backup PSW (BPSW)
- Backup PC (BPC)
- Fast interrupt vector register (FINTV)

If the MCU executes one of these instructions while in User Mode, an exception will trigger. If the user has a callback setup (see Section 2.4) then they will be alerted by a callback function of the exception.

2.10 ID Code

RX MCUs have a 16-byte ID Code in ROM that protects the MCU's memory from being read through a debugger, or in serial boot mode, in an attempt to extract the firmware from the device. The ID Code resides in the fixed vector table and can easily be set in *r_bsp_config.h* (see Section 3.2.7). For more information on available ID Code options please reference the ID Code subsection in the 'Flash Memory' or 'ROM' section of your MCU's hardware manual.

2.11 Parallel Programmer Protection

Similar to the ID Code, RX MCUs also have a 4-byte code in ROM that can protect access to the MCU's memory from parallel programmers. The user has the option of allowing reads and write, only allowing writes, and prohibiting all access. See Section 3.2.7 for information on how to enable this feature.

2.12 Endian

RX MCUs have the option of operating in big or little endian mode. Which mode is chosen is decided in different ways depending on which MCU is being used. RX610 and RX62x MCUs have a pin where the level decides. RX100, RX200, and RX63x MCUs have a register in ROM that decides the endian that will be used. For devices with the register in ROM, the r_bsp detects the endian selected in the toolchain and will use that to appropriately set the register. The r_bsp currently detects endian from the following toolchains:

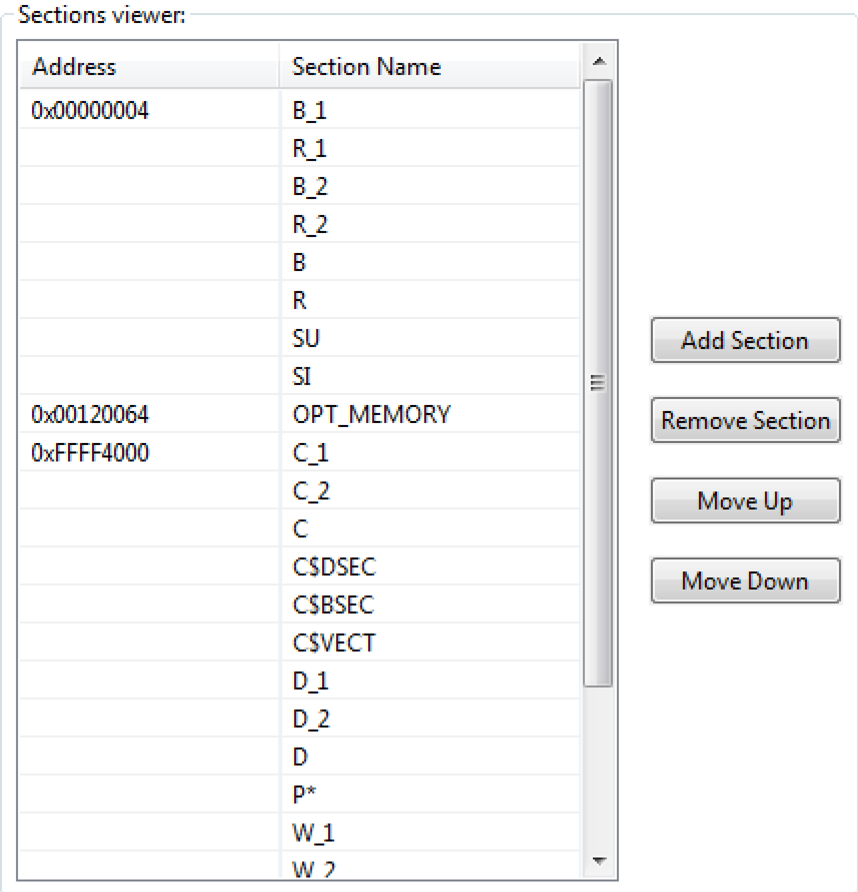
- Renesas RXC
- IAR
- KPIT GNU

The RX64M uses a register (MDE) in the configuration setting area. The bsp for the 64M requires that a section named "OPT_MEMORY" be created in the linker sections to allow access to this register.
Note that for RX devices with a User Boot area and a ROM register to set its endian the same practice as above applies.

2.13 Option Function Select Registers

Starting with RX63x, RX200, and RX100 MCUs, there are registers stored in ROM called Option Function Select registers. These registers are used to enable certain MCU features at reset instead of having to enable them in the user's code. Examples include the ability to enable low voltage monitoring, start the HOCO oscillating, and to configure and start the IWDT. The user can input the values to be used for these registers in *r_bsp_config.h* (see Section 3.2.7).

The RX64M uses Option Function Select (OFS) registers defined in the configuration setting area. The bsp for the 64M requires that a section named "OPT_MEMORY" be created at address 0x00120064 in the linker sections to allow access to these registers.



2.14 Board-Specific Defines

Each *board* folder has a board-specific header file which defines things such as which pins are used for LEDs, switches, and SPI slave selects. The name of the file is the name of the board with '.h' appended. For example, the file for the RSKRX111 is named *rskrx111.h*.

2.15 System Wide Parameter Checking

By default FIT modules will check input parameters to be valid. This is helpful during development but some users will want to disable this for production code. The reason for this would be to save execution time and code space. In *r_bsp_config.h* there is an option to globally enable or disable parameter checking. Local modules will use this value by default but can select to override the value locally if desired. To configure this option see Section 3.2.9.

2.16 Atomic Locking

The r_bsp provides API functions to implement atomic locking. These locks can be used to protect critical areas of code as a RTOS semaphore or mutex normally would. Care should be taken when using these locks though since they do not offer the advanced features one would expect from a modern RTOS. If used incorrectly then the locks could cause a deadlock in the user's system.

In each *mcu* folder the user will find a file named *mcu_locks.h*. This contains an enum named *mcu_lock_t* which has one lock per peripheral, and peripheral channel, on the MCU. These locks can be used to mark that a peripheral has been reserved. This could be used if the user wanted to use a FIT module to control three channels of a peripheral and their own custom code for one channel. By reserving the lock for the channel they need they have removed that channel from being used by the FIT Module. These locks can also be used if the user has more than one FIT module for the same peripheral. For example, if the user had one FIT module for using the SCI in asynchronous mode and another for using the SCI in I^2C mode then these locks will prevent these two modules from trying to use the same SCI channel. There are 4 locking API functions provided that are detailed in Section 5. The only difference between the hardware and software locking functions is that the hardware locking functions only use locks that are defined in *mcu_locks.h*. The software locking function takes locks allocated anywhere so the user could create their own as needed. FIT Modules that need locking and do not use a MCU peripheral will also create their own locks and use the software locking routines.

The user has the option of substituting the default r_bsp locking mechanisms for their own. See Section 3.2.8 for more information.

2.17 Register Protection

RX100, RX200, and RX63x MCUs have protect registers that protect various MCU registers from being written. Examples of registers that are protected include clock registers, low power consumption registers, the software reset register, and low voltage detection registers. The r_bsp provides API functions for easily manipulating these registers to enable or disable write access. Refer to Sections 5.7 and 5.8 for more information.

2.18 CPU Functions

API functions are provided for CPU functions such as enabling and disabling interrupts and setting the CPU's interrupt priority level. Refer to Section 5 for more information.

3. Configuration

The r_bsp provides two header files that are used for configuration. One header file is used for choosing which platform will be used. The other header file is used to configure the chosen platform.

3.1 Choosing a Platform

The r_bsp provides board support packages for many boards. Choosing which one is currently being used is done by modifying the *platform.h* header file found in the root of the r_bsp folder.

To choose a platform uncomment the #include for the board you are using. For example, to develop with a RSK+RX63N board, uncomment the #include for './board/rskrx63n/r_bsp.h' macro and make sure all other board #includes are commented out.

```
/***************************************************************************
DEFINE YOUR SYSTEM - UNCOMMENT THE INCLUDE PATH FOR THE PLATFORM YOU ARE USING.
****************************************************************************
/* RSKRX610 */
//#include "./board/rskrx610/r_bsp.h"

/* RSKRX62N */
//#include "./board/rskrx62n/r_bsp.h"

/* RSKRX62T */
//#include "./board/rskrx62t/r_bsp.h"

/* RDKRX62N */
//#include "./board/rdkrx62n/r_bsp.h"

/* RSKRX630 */
//#include "./board/rskrx630/r_bsp.h"

/* RSKRX63N */
#include "./board/rskrx63n/r_bsp.h"
```

3.2 Platform Configuration

Once a platform has been chosen, it will need to be configured. The user configures their platform using a file named *r_bsp_config.h*. Each platform has its own specific configuration file. This file is located in the platform's *board* folder and is named *r_bsp_config_reference.h*. To create an *r_bsp_config.h* file the user simply needs to copy the *r_bsp_config_reference.h* file from their *board* folder, rename it to *r_bsp_config.h*, and put it somewhere in their project where it can be included. The reference configuration file is provided so that users always have a known-good configuration file if needed. It is recommended that the *r_bsp_config.h* file is stored in a folder named *r_config* in the user's project. This is not a requirement but all FIT Modules have configuration files and having one designated location for these files makes them easy to find and easy to backup.

While each *r_bsp_config.h* file is different, there are many of the same options in each. The following sections will provide details on these configuration options. Note that each macro starts with the common prefix 'BSP_CFG_' which makes them easy to search for and easy for the user to identify.

3.2.1 MCU Product Part Number Information

The product part number for a MCU can provide the r_bsp with a lot of information about a MCU. For this reason, the beginning of the configuration file has definitions that are set based on the MCU's product part number. All of these macros have a prefix of 'BSP_CFG_MCU_PART_'. Some MCUs have more information in their product part numbers than others but the table below shows the standard set that most have.

Define	Value	Meaning
BSP_CFG_MCU_PART_PACKAGE	See comments above #define in r_bsp_config.h.	Defines which package is being used. Depending on package sizes MCUs will have different numbers of pins and may have more or less peripherals.
BSP_CFG_MCU_PART_MEMORY_SIZE	See comments above #define in r_bsp_config.h.	Defines the sizes of ROM, RAM, and Data Flash.
BSP_CFG_MCU_PART_GROUP	See comments above #define in r_bsp_config.h.	Defines the MCU Group (e.g. RX62N, RX63T) in a MCU series.
BSP_CFG_MCU_PART_SERIES	See comments above #define in r_bsp_config.h.	Defines the MCU Series (e.g. RX600, RX200, RX100).

Table 3-1 : Product Part Number Defines

3.2.2 Stack & Heap Sizes

Stack sizes for RX devices are defined using the #pragma directives for the RX toolchain.

Define	Value	Meaning
BSP_CFG_USER_STACK_ENABLE	0 = Use only Interrupt stack. 1 = Use Interrupt & User stacks.	Whether to use 1 stack (Interrupt stack) or 2 (Interrupt & User stack). For further explanation please see Section 2.8.
#pragma stacksize su=	Size of User Stack in bytes.	Defines the size of the User stack. This macro may be hidden from view if the user has code folding enabled in their editor.
#pragma stacksize si=	Size of Interrupt Stack in bytes.	Defines the size of the Interrupt stack. This macro may be hidden from view if the user has code folding enabled in their editor.
BSP_CFG_HEAP_BYTES	Size of heap in bytes.	Defines the size of the heap. To disable heap please read the comments above this #define.

Table 3-2 : Stack & Heap Defines

3.2.3 STDIO Enable

The use of the STDIO library requires extra code space, RAM space, and use of the heap. If the user does not require the use of STDIO then it is recommended to disable it and save the extra memory.

Define	Value	Meaning
BSP_CFG_IO_LIB_ENABLE	0 = Disable use of STDIO 1 = Enable use of STDIO	Determines whether STDIO initialization functions are called at startup to setup the STDIO libraries.

Table 3-3 : Stack & Heap Defines

3.2.4 CPU Modes & Boot Modes

RX MCUs have multiple boot modes including Serial Boot Mode, User Boot Mode, and Single-Chip Mode. RX610 and RX62x MCUs select which boot mode to use based on certain pin levels at startup. Later MCUs (e.g. RX63x, RX200, RX100) require a pin to be set as well as setting a value in ROM.

Define	Value	Meaning
BSP_CFG_RUN_IN_USER_MODE	0 = Stay in Supervisor Mode 1 = Transition to User Mode	Out of reset RX MCUs operate in Supervisor Mode. The user has the option of transitioning to User Mode (which has limited write access to certain registers). Unless needed it is recommended to keep the MCU in Supervisor mode.
BSP_CFG_USER_BOOT_ENABLE	0 = Disable User Boot Mode 1 = Enable User Boot Mode	In order for RX63x, RX200, and RX100 MCUs to enter User Boot Mode a value in ROM must be set. If this macro defines User Boot Mode to be enabled then the r_bsp will set the appropriate ROM value.

Table 3-4 : CPU Modes & Boot Modes Defines

3.2.5 RTOS

Define	Value	Meaning
BSP_CFG_RTOS_USED	0 = RTOS is not being used 1 = RTOS is being used	Defines if a RTOS is being used in the current application. Some FIT modules may use this information for their own configuration.

Table 3-5 RTOS Defines

3.2.6 Clock Setup

Available clocks vary amongst RX MCUs but the same basic concepts apply to all. After reset the r_bsp will initialize the MCU clocks using the clock configuration macros found in *r_bsp_config.h*.

Define	Value	Meaning
BSP_CFG_CLOCK_SOURCE	0 = Low Speed On-Chip Oscillator (LOCO) 1 = High Speed On-Chip Oscillator (HOCO) 2 = Main Clock Oscillator 3 = Sub-Clock Oscillator 4 = PLL Circuit	Defines which clock source will be in use when the r_bsp code jumps to main().
BSP_CFG_XTAL_HZ	Input clock frequency in Hz.	Defines the input clock frequency. This is used for calculating final clock speeds.
BSP_CFG_PLL_DIV	PLL Input Frequency Divider	Defines the PLL divider to be used. If the PLL is not used then this can be ignored.
BSP_CFG_PLL_MUL	PLL Frequency Multiplication Factor	Defines the PLL multiplier to be used. If the PLL is not used then this can be ignored.
BSP_CFG_<ClockAcronym>_DIV **Examples:** **BSP_CFG_ICK_DIV** **BSP_CFG_PCKA_DIV** **BSP_CFG_PCKB_DIV** **BSP_CFG_FCK_DIV**	The divisor to use for this clock.	RX MCUs have a number of clock domains on-chip. Dividers can be set for each of these independently to maximize performance while minimizing power consumption. <ClockAcronym> is a placeholder for the name of the clock to be set. For example to set the divider for the CPU clock (ICLK) then the user would set the BSP_CFG_ICK_DIV macro.
BSP_CFG_BCLK_OUTPUT	0 = BCLK is not output 1 = BCK frequency is output 2 = BCK/2 frequency is output	Defines if BCLK is output and if so what frequency is output.
BSP_CFG_SDCLK_OUTPUT	0 = SDCLK is not output 1 = BCK frequency is output	Defines if SDCLK is output.

BSP_CFG_USE_CGC_MODULE	0 = Use built-in clock code 1 = Use r_cgc_rx module for clock management.	Some RX Groups have the option of enabling use of the r_cgc_rx module. When this is enabled, the built-in clock setup code will be removed and replaced with calls to the r_cgc_rx module. The r_cgc_rx module is more sophisticated and offers many more features than the built-in clock code, including the ability to change clock settings at run-time. If your application does not require dynamic clock changes then setting this to 0 will result in smaller code size.

Table 3-6 : Clock Setup Defines

3.2.7 Registers in ROM & External Memory Access Protection

Some registers are located in ROM and therefore must be set at compile-time. These include some option-setting memory registers as well as certain memory protection registers.

RX MCUs have 2 different mechanisms for protecting MCU memory from being read after production. The first is the use of ID codes. The RX ID code is 16 byte value that can be used to protect the MCU from being connected to a debugger or from connecting in Serial Boot Mode. There are different settings that can be set for the ID code; please refer to the hardware manual for your device for available options. The second mechanism is a 4 byte value called ROM Code Protection. This value determines what read and write access parallel programmers have to the MCU.

Option-Setting Memory registers (i.e. OFS0, OFS1) can be set so that certain operations occur at reset. For example, the IWDT can be configured and enabled, voltage detection can be enabled, and HOCO oscillation can be enabled. When these registers are set the operations are completed before the MCU's reset vector is fetched and execution begins.

Define	Value	Meaning
BSP_CFG_ID_CODE_LONG_1 **BSP_CFG_ID_CODE_LONG_2** **BSP_CFG_ID_CODE_LONG_3** **BSP_CFG_ID_CODE_LONG_4**	ID code setting in 4 byte units.	Defines the ID code of the MCU. The default value all 0xFF's means that protection is disabled. **NOTE:** if the ID code is set then it should be remembered because the code will be required if the MCU is going to be connected for debugging or in Serial Boot Mode again.
BSP_CFG_ROM_CODE_PROTECT_VALUE	0 = Read/Write access is disabled 1 = Read access is disabled Else = Read/Write access is enabled	Defines the read and write access allowed by parallel programmers.
BSP_CFG_OFS0_REG_VALUE	Value to be written to OFS0 register.	Defines the 4-byte value to be programmed into the OFS0 ROM location.
BSP_CFG_OFS1_REG_VALUE	Value to be written to OFS1 register.	Defines the 4-byte value to be programmed into the OFS1 ROM location.

Table 3-7 : ROM Register Defines

3.2.8 Atomic Locking

For an introduction into the r_bsp's atomic locking see 2.16. These macros allow the user to override the default locking mechanisms and implement their own. A user might wish to do this in order to replace the simple default mechanisms provided in the r_bsp with more feature rich objects such as semaphores or mutexes from their RTOS. If the user wished to do this they would first configure the r_bsp to use user defined locking mechanisms (see BSP_CFG_USER_LOCKING_ENABLED below). After that they would define BSP_CFG_USER_LOCKING_TYPE to be the type they wished to use for their locks. If using an RTOS semaphore then its type would be used here. Finally the user would need to define the four locking functions that would be used (see last 4 entries in table below). The arguments to these user defined functions have to match the arguments sent to the default locking functions. After these changes are made all locks in the user's project would be converted to the user defined locks. Whenever the r_bsp lock functions are called by user code, or FIT Module code, the user's functions would be called. At this point the user is responsible for implementing the locking features. Inside these functions the user would be free to use the more advanced locking features of their RTOS.

Define	Value	Meaning
BSP_CFG_USER_LOCKING_ENABLED	0 = Use default locking mechanisms 1 = Use user defined locking mechanisms	The default locking mechanisms provided with the r_bsp do not use an RTOS and therefore do not offer some of the advanced features that a user might expect from an RTOS when using a semaphore or mutex.
BSP_CFG_USER_LOCKING_TYPE	Data type to be used for locks (default is *bsp_lock_t*)	If the user decides to use their own locking mechanism then the data type for their locks should be defined here. For example, if the user replaces the default locks with an RTOS semaphore or mutex then that data type would be specified here.
BSP_CFG_USER_LOCKING_HW _LOCK_FUNCTION	User defined functions to be called when r_bsp lock functions are overridden by user.	If the user is using their own locking mechanisms then the function defined by this macro will be called when R_BSP_HardwareLock() is called.
BSP_CFG_USER_LOCKING_HW _UNLOCK_FUNCTION	User defined functions to be called when r_bsp lock functions are overridden by user.	If the user is using their own locking mechanisms then the function defined by this macro will be called when R_BSP_HardwareUnlock() is called.
BSP_CFG_USER_LOCKING_SW _LOCK_FUNCTION	User defined functions to be called when r_bsp lock functions are overridden by user.	If the user is using their own locking mechanisms then the function defined by this macro will be called when R_BSP_SoftwareLock() is called.
BSP_CFG_USER_LOCKING_SW _UNLOCK_FUNCTION	User defined functions to be called when r_bsp lock functions are overridden by user.	If the user is using their own locking mechanisms then the function defined by this macro will be called when R_BSP_SoftwareUnlock() is called.

Table 3-8 : Atomic Locking Defines

3.2.9 Parameter Checking

This macro is a global setting for enabling or disabling parameter checking. Each FIT module will also have its own local macro for this same purpose. By default the local macros will take the global value from here though they can be overridden. Therefore, the local setting has priority over this global setting. Disabling parameter checking should only performed when inputs are known to be good and the increase in speed or decrease in code space is needed.

Define	Value	Meaning
BSP_CFG_PARAM_CHECKING_ENABLE	0 = Parameter checking disabled 1 = Parameter checking enabled	Defines whether the global setting for parameter checking is enabled or disabled. Local modules will take this value by default but can be locally overridden.

Table 3-9 : Parameter Checking Defines

3.2.10 MCU Voltage

Define	Value	Meaning
BSP_CFG_MCU_VCC_MV	Voltage supplied to MCU (Vcc) in millivolts.	Some FIT Modules (e.g. LVD) need to know the voltage supplied to the MCU. This information is obtained from here.

Table 3-10 : MCU Voltage Defines

4. API Information

This Driver API follows the Renesas API naming standards.

4.1 Hardware Requirements

Not Applicable.

4.2 Hardware Resource Requirements

Not Applicable.

4.3 Software Requirements

None.

4.4 Limitations

None.

4.5 Supported Toolchains

This driver is tested and working with the following toolchains:

- Renesas RX Toolchain v2.01.00

4.6 Header Files

All API calls are accessed by including a single file *platform.h* which is supplied with this driver's project code.

4.7 Integer Types

This project uses ANSI C99 "Exact width integer types" in order to make the code clearer and more portable. These types are defined in *stdint.h*.

4.8 Configuration Overview

For configuration information please see Section 3.

4.9 API Data Structures

4.9.1 Software Lock

This data structure is used for implementing atomic locking on RX MCUs. The *lock* member must be 4-bytes in order to use the RX's atomic XCHG instruction. This structure is the default type defined by the BSP_CFG_USER_LOCKING_TYPE macro.

```
typedef struct
{
    /* The actual lock. int32_t is used because this is what the xchg()
       instruction takes as parameters. */
    int32_t     lock;
} bsp_lock_t;
```

4.9.2 Interrupt Callback Parameter

This data structure is used when calling an interrupt callback function. The interrupt handler will fill in this structure, cast it as '(void *)', and then send it as the argument to the callback function.

```
typedef struct
{
    bsp_int_src_t vector;         //Which vector caused this interrupt
} bsp_int_cb_args_t;
```

4.10 API Typedefs

4.10.1 Register Protection

This typedef defines the different register protection options that can be toggled. Notice that some registers are grouped together. For example, LPC, CGC, and software reset registers are all protected by the same bit. Which items, and how many, are in this typedef will vary depending on the MCU being used. Please reference *cpu.h* for your MCU to see the valid options for your MCU. The typedef below belongs to the RX111.

```
/* The different types of registers that can be protected. */
typedef enum
{
    /* Enables writing to the registers related to the clock generation circuit:
       SCKCR, SCKCR3, PLLCR, PLLCR2, MOSCCR, SOSCCR,LOCOCR, ILOCOCR, HOCOCR,
       OSTDCR, OSTDSR, CKOCR. */
    BSP_REG_PROTECT_CGC = 0,
    /* Enables writing to the registers related to operating modes, low power
       consumption, the clock generation circuit, and software reset: SYSCR1,
       SBYCR, MSTPCRA, MSTPCRB, MSTPCRC, OPCCR, RSTCKCR, SOPCCR, MOFCR, MOSCWTCR,
       SWRR. */
    BSP_REG_PROTECT_LPC_CGC_SWR,
    /* Enables writing to the registers related to the LVD: LVCMPCR, LVDLVLR,
       LVD1CR0, LVD1CR1, LVD1SR, LVD2CR0, LVD2CR1, LVD2SR. */
    BSP_REG_PROTECT_LVD,
    /* Enables writing to MPC's PFS registers. */
    BSP_REG_PROTECT_MPC,
    /* This entry is used for getting the number of enum items. This must be the
       last entry. DO NOT REMOVE THIS ENTRY!*/
    BSP_REG_PROTECT_TOTAL_ITEMS
} bsp_reg_protect_t;
```

4.10.2 Hardware Resource Locks

This typedef defines the available hardware resource locks. For each entry in this enum one software lock will be allocated in the hardware lock array. Which items are in this list, and how many, will vary depending on the MCU chosen. The typedef below is for the RX111.

```
typedef enum
{
    BSP_LOCK_BSC = 0,
    BSP_LOCK_CAC,
    BSP_LOCK_CMT,
    BSP_LOCK_CMT0,
    BSP_LOCK_CMT1,
    BSP_LOCK_CRC,
    BSP_LOCK_DA,
    BSP_LOCK_DOC,
    BSP_LOCK_DTC,
    BSP_LOCK_ELC,
    BSP_LOCK_FLASH,
    BSP_LOCK_ICU,
    BSP_LOCK_IRQ0,
    BSP_LOCK_IRQ1,
    BSP_LOCK_IRQ2,
    BSP_LOCK_IRQ3,
    BSP_LOCK_IRQ4,
    BSP_LOCK_IRQ5,
    BSP_LOCK_IRQ6,
    BSP_LOCK_IRQ7,
    BSP_LOCK_IWDT,
    BSP_LOCK_MPC,
    BSP_LOCK_MTU,
    BSP_LOCK_MTU0,
```

```
    BSP_LOCK_MTU1,
    BSP_LOCK_MTU2,
    BSP_LOCK_MTU3,
    BSP_LOCK_MTU4,
    BSP_LOCK_MTU5,
    BSP_LOCK_POE,
    BSP_LOCK_RIIC0,
    BSP_LOCK_RSPI0,
    BSP_LOCK_RTC,
    BSP_LOCK_RTCB,
    BSP_LOCK_S12AD,
    BSP_LOCK_SCI1,
    BSP_LOCK_SCI5,
    BSP_LOCK_SCI12,
    BSP_LOCK_SMCI1,
    BSP_LOCK_SMCI5,
    BSP_LOCK_SMCI12,
    BSP_LOCK_SYSTEM,
    BSP_LOCK_USB0,
    BSP_NUM_LOCKS   /* This entry is not a valid lock. It is used for sizing
                       g_bsp_Locks[] array below. Do not touch! */
} mcu_lock_t;
```

4.10.3 Interrupt Error Codes

This typedef defines the error codes that can be returned by the R_BSP_InterruptWrite(), R_BSP_InterruptRead(), and R_BSP_InterruptControl() functions.

The typedef below is for the RX111.

Other RX MCU’s may support additional interrupt control commands.

```
typedef enum
{
    BSP_INT_SUCCESS = 0,
    BSP_INT_ERR_NO_REGISTERED_CALLBACK, //There is not a registered callback
                                        //for this interrupt source
    BSP_INT_ERR_INVALID_ARG,            //Illegal argument input
    BSP_INT_ERR_UNSUPPORTED             //Operation is not supported by this API
} bsp_int_err_t;
```

4.10.4 Interrupt Control Commands

This typedef defines the available commands that can be used with the R_BSP_InterruptControl() function.

The typedef below is for the RX111.

Other RX MCU's may support additional interrupt control commands

```
typedef enum
{
    BSP_INT_CMD_CALL_CALLBACK = 0, //Calls registered callback function
                                   //if one exists
    BSP_INT_CMD_INTERRUPT_ENABLE,  //Enables a give interrupt (Available for NMI
                                   //pin, FPU, and Bus Error)
    BSP_INT_CMD_INTERRUPT_DISABLE  //Disables a given interrupt (Available for
                                   //FPU, and Bus Error)
} bsp_int_cmd_t;
```

4.10.5 Interrupt Callback Function

This typedef defines the callback function type. Callback functions should have a 'void' return type and should take an argument of type 'void *'.

```
typedef void (*bsp_int_cb_t)(void *);
```

4.10.6 Interrupt Sources

This typedef defines the interrupt vectors that can have callbacks registered to them. Note that the options in this typedef will vary depending on which MCU is being used. The typedef below is for the RX111. Other RX MCU's may support additional interrupt sources.

```
typedef enum
{
    BSP_INT_SRC_EXC_SUPERVISOR_INSTR = 0, //Occurs when privileged instruction
                                          //is executed in User Mode
    BSP_INT_SRC_EXC_UNDEFINED_INSTR,      //Occurs when MCU encounters an
                                          //unknown instruction
    BSP_INT_SRC_EXC_NMI_PIN,              //NMI Pin interrupt
    BSP_INT_SRC_EXC_FPU,                  //FPU exception
    BSP_INT_SRC_OSC_STOP_DETECT,          //Oscillation stop is detected
    BSP_INT_SRC_WDT_ERROR,                //WDT underflow/refresh error has
                                          //occurred
    BSP_INT_SRC_IWDT_ERROR,               //IWDT underflow/refresh error has
                                          //occurred
    BSP_INT_SRC_LVD1,                     //Voltage monitoring 1 interrupt
    BSP_INT_SRC_LVD2,                     //Voltage monitoring 2 interrupt
    BSP_INT_SRC_UNDEFINED_INTERRUPT,      //Interrupt has triggered for a vector
                                          //that user did not write a handler
                                          //for
    BSP_INT_SRC_BUS_ERROR,                //Bus error: illegal address access or
                                          //timeout
    BSP_INT_SRC_TOTAL_ITEMS               //DO NOT MODIFY! This is used for
                                          //sizing the interrupt callback array.
} bsp_int_src_t;
```

4.10.7 Group Interrupts

The RX64M MCU supports group interrupts, where (up to 32) multiple peripheral interrupt requests are grouped together as one interrupt request. Interrupts are grouped depending on the peripheral operating clock (PCLKA or PCLKB) and method to detect interrupt requests (edge or level detection). When a group interrupt request is generated, the source of the interrupt may be identified by examining the respective (A or B, edge or level) Group Interrupt Request Register.

4.10.8 Software Configurable Interrupts

The RX64M MCU allows peripheral interrupt sources to be dynamically assigned to a vector number from 128 to 255. Based on the peripheral operating clock they are divided into dynamic interrupt A and dynamic interrupt B. Dynamic interrupt B may be used for peripherals that operate in synchronization with PCLKB and can be assigned to interrupt numbers 128 – 207.
Dynamic interrupt A may be used for peripherals that operate in synchronization with PCKLA and can be assigned to interrupt numbers 208 – 255.

4.11 Return Values

None.

4.12 Adding Driver to Your Project

Please see Section 6.

5. API Functions

5.1 Summary

The following functions are included in this design:

Function	Description
R_BSP_GetVersion	Returns version of r_bsp
R_BSP_InterruptsDisable	Globally disables interrupts
R_BSP_InterruptsEnable	Globally enables interrupts
R_BSP_CpuInterruptLevelRead	Reads the CPU's Interrupt Priority Level
R_BSP_CpuInterruptLevelWrite	Writes the CPU's Interrupt Priority Level
R_BSP_RegisterProtectEnable	Enables write protection for selected registers
R_BSP_RegisterProtectDisable	Disables write protection for selected registers
R_BSP_SoftwareLock	Attempts to reserve a lock
R_BSP_SoftwareUnlock	Releases a lock
R_BSP_HardwareLock	Attempts to reserve a hardware peripheral lock
R_BSP_HardwareUnlock	Releases a hardware peripheral lock
R_BSP_InterruptWrite	Registers a callback function for an interrupt
R_BSP_InterruptRead	Gets the callback for an interrupt if one is registered.
R_BSP_InterruptControl	Executes various other interrupt features.
R_BSP_SoftwareDelay	Delays the specified duration.

5.2 R_BSP_GetVersion

Returns the current version of the r_bsp.

Format

```
uint32_t R_BSP_GetVersion(void);
```

Parameters

None.

Return Values

Version of the r_bsp.

Properties

Prototyped in file “r_bsp_common.h”
Implemented in file “r_bsp_common.c”

Description

This function will return the version of the currently installed r_bsp. The version number is encoded where the top 2 bytes are the major version number and the bottom 2 bytes are the minor version number. For example, Version 4.25 would be returned as 0x00040019.

Reentrant

Yes.

Example

```
uint32_t cur_version;

/* Get version of installed r_bsp. */
cur_version = R_BSP_GetVersion();

/* Check to make sure version is new enough for this application’s use. */
if (MIN_VERSION > cur_version)
{
    /* This r_bsp version is not new enough and does not have XXX feature
       that is needed by this application. Alert user. */
    ....
}
```

Special Notes:

- This function is specified to be an inline function in *r_bsp_common.c.*

5.3 R_BSP_InterruptsDisable

Globally disables interrupts.

Format

```
void R_BSP_InterruptsDisable(void);
```

Parameters

None.

Return Values

None.

Properties

Prototyped in file “cpu.h”
Implemented in file “cpu.c”

Description

This function globally disables interrupts. This is performed by clearing the ‘I’ bit in the CPU’s Processor Status Word (PSW) register.

Reentrant

Yes.

Example

```
/* Disable interrupts so that accessing this critical area will be guaranteed
   to be atomic. */
R_BSP_InterruptsDisable();

/* Access critical resource while interrupts are disabled */
....

/* End of critical area. Enable interrupts. */
R_BSP_InterruptsEnable();
```

Special Notes:

- The ‘I’ bit of the PSW can only be modified when in Supervisor Mode. If the CPU is in User Mode and this function is called then a Privileged Instruction Exception will occur.

5.4 R_BSP_InterruptsEnable

Globally enables interrupts.

Format

```
void R_BSP_InterruptsEnable(void);
```

Parameters

None.

Return Values

None.

Properties

Prototyped in file “cpu.h”
Implemented in file “cpu.c”

Description

This function globally enables interrupts. This is performed by setting the ‘I’ bit in the CPU’s Processor Status Word (PSW) register.

Reentrant

Yes.

Example

```
/* Disable interrupts so that accessing this critical area will be guaranteed
   to be atomic. */
R_BSP_InterruptsDisable();

/* Access critical resource while interrupts are disabled */
....

/* End of critical area. Enable interrupts. */
R_BSP_InterruptsEnable();
```

Special Notes:

- The ‘I’ bit of the PSW can only be modified when in Supervisor Mode. If the CPU is in User Mode and this function is called then a Privileged Instruction Exception will occur.

5.5 R_BSP_CpuInterruptLevelRead

Reads the CPU's Interrupt Priority Level.

Format

```
uint32_t R_BSP_CpuInterruptLevelRead(void);
```

Parameters

None.

Return Values

The CPU's Interrupt Priority Level.

Properties

Prototyped in file "cpu.h"
Implemented in file "cpu.c"

Description

This function reads the CPU's Interrupt Priority Level. This is level is stored in the IPL bits of the Processor Status Word (PSW) register.

Reentrant

Yes.

Example

```
uint32_t cpu_ipl;

/* Read the CPU's Interrupt Priority Level. */
cpu_ipl = R_BSP_CpuInterruptLevelRead();
```

Special Notes:

None.

5.6 R_BSP_CpuInterruptLevelWrite

Writes the CPU's Interrupt Priority Level.

Format

```
bool R_BSP_CpuInterruptLevelWrite(uint32_t level);
```

Parameters

level

The level to write to the CPU's IPL.

Return Values

true: *Successful, CPU's IPL has been written*
false: *Failure, provided 'level' has invalid IPL value*

Properties

Prototyped in file "cpu.h"
Implemented in file "cpu.c"

Description

This function writes the CPU's Interrupt Priority Level. This is level is stored in the IPL bits of the Processor Status Word (PSW) register. This function does check to make sure that the IPL being written is valid. The maximum and minimum valid settings for the CPU IPL are defined in *mcu_info.h* using the BSP_MCU_IPL_MAX and BSP_MCU_IPL_MIN macros.

Reentrant

Yes.

Example

```
/* Response time is critical during this portion of the application. Set the
   CPU's Interrupt Priority Level so that interrupts below the set
   threshold are disabled. Interrupt vectors with IPLs higher than this
   threshold will still be accepted and will not have to contend with the
   lower priority interrupts. */
if (false == R_BSP_CpuInterruptLevelWrite(HIGH_PRIORITY_THRESHOLD))
{
    /* Error in setting CPU's IPL. Invalid IPL was provided. */
    ....
}

/* Only high priority interrupts (as defined by user) will be accepted during
   this period. */
....

/* Time sensitive period is over. Set CPU's IPL back to lower value so that
   lower priority interrupts can now be serviced again. */
if (false == R_BSP_CpuInterruptLevelWrite(LOW_PRIORITY_THRESHOLD))
{
    /* Error in setting CPU's IPL. Invalid IPL was provided. */
    ....
}
```

Special Notes:

- The CPU's IPL can only be modified by the user when in Supervisor Mode. If the CPU is in User Mode and this function is called then a Privileged Instruction Exception will occur.

5.7 R_BSP_RegisterProtectEnable

Enables write protection for selected registers.

Format

```
void R_BSP_RegisterProtectEnable(bsp_reg_protect_t regs_to_protect);
```

Parameters

regs_to_protect

Which registers to enable write protection for.

Return Values

None.

Properties

Prototyped in file “cpu.h”
Implemented in file “cpu.c”

Description

This function enables write protection for the input registers. Only certain MCU registers have the ability to be write protected. To see which registers are available to be protected by this function look at the *bsp_reg_protect_t* enum in *cpu.h* for your MCU.

This function, and R_BSP_RegisterProtectDisable(), use counters for each entry in the *bsp_reg_protect_t* enum so that users can call these functions multiple times without problem. An example of why this is needed is shown below in the Special Notes section below.

Reentrant

No.

Example

```
/* Write access must be enabled before writing to MPC registers. */
R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_MPC);

/* MPC registers are now writable. */
/* Setup Port 2 Pin 6 as TXD1 for SCI1. */
MPC.P26PFS.BYTE = 0x0A;

/* Setup Port 4 Pin 2 as AD input for potentiometer. */
MPC.P42PFS.BYTE = 0x80;

/* More pin setup. */
....

/* Enable write protection for MPC registers to protect against accidental
   writes. */
R_BSP_RegisterProtectEnable(BSP_REG_PROTECT_MPC);
```

Special Notes:

This is an example showing why counters are needed for register protection.

1. The user's application calls the open function for r_module1.
2. r_module1 disables write protection for some registers that are required to be written during initialization of this module by calling R_BSP_RegisterProtectDisable(). At this point the counter for this protected registers is incremented by 1.
3. r_module1 writes to unprotected registers that were made writable by previous step.
4. r_module1 also depends upon r_module2 and needs to call its open function, R_MODULE2_Open().
5. In the r_module2 function it also needs to write to the same protected registers as r_module1. r_module2 calls R_BSP_RegisterProtectDisable() again since it does not know that r_module1 already enabled write access to these registers. The counter for the protected register is incremented by 1 and is now 2.
6. r_module2 writes to unprotected registers that were made writable by previous step.
7. r_module2 is done writing to the protected registers so it calls R_BSP_RegisterProtectEnable() to re-enable write protection for the registers. The counter for the protected register is decremented by 1 and is now 1. Since the counter is not 0 the code knows that it should not actually re-enable protection yet.
8. Execution goes back to R_MODULE1_Open() where it continues to write to registers. Here is where the problem can occur. If counters are not used then the call to R_BSP_RegisterProtectEnable() by r_module2 (Step #7) can prevent the registers in r_module1 from being written.
9. r_module1 is done writing to the protected registers so it calls R_BSP_RegisterProtectEnable() to re-enable write protection for the registers. The counter for the protected register is decremented by 1 and is now 0. Since the counter is 0 the API code knows that it is safe to re-enable write protection for the registers.

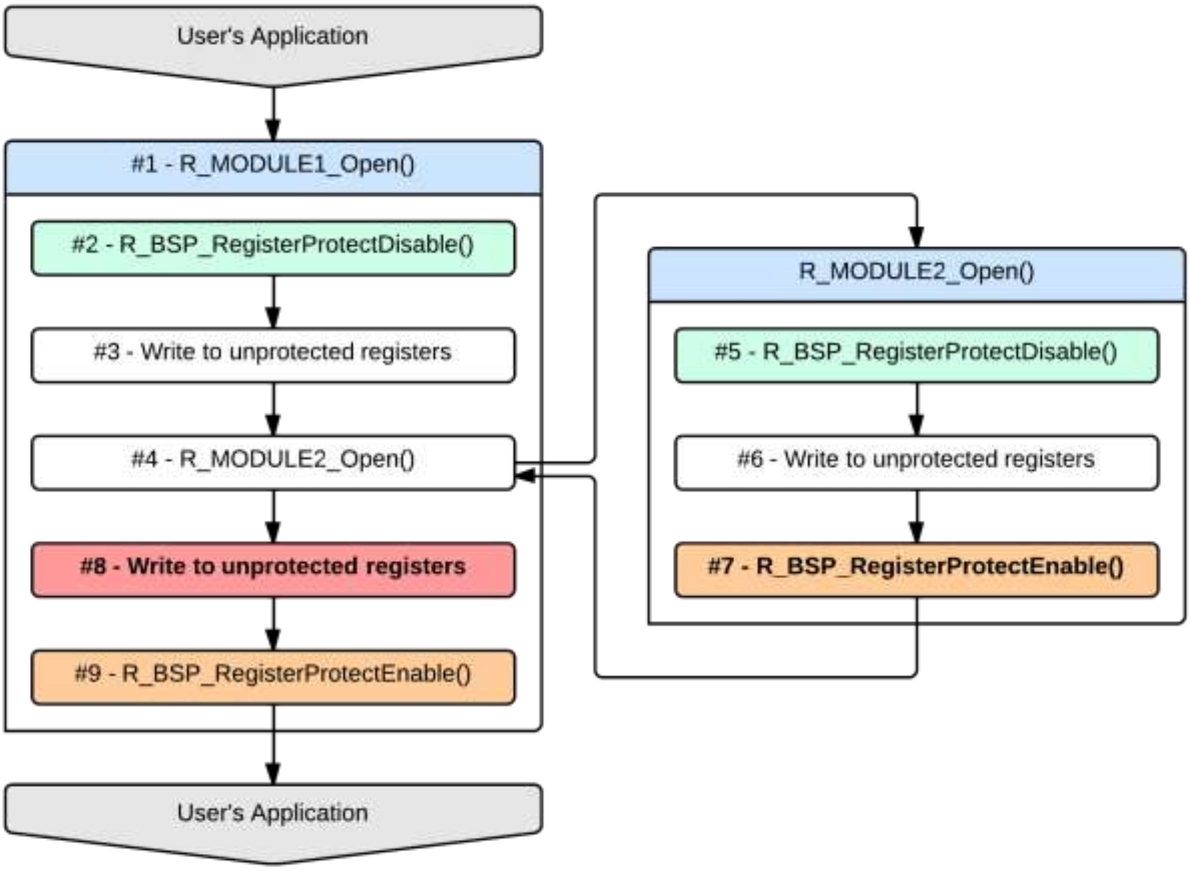


Figure 5-1 : Register Protection Example

5.8 R_BSP_RegisterProtectDisable

Disables write protection for selected registers.

Format

```
void R_BSP_RegisterProtectDisable(bsp_reg_protect_t regs_to_protect);
```

Parameters

regs_to_protect

Which registers to disable write protection for.

Return Values

None.

Properties

Prototyped in file “cpu.h”
Implemented in file “cpu.c”

Description

This function disables write protection for the input registers. Only certain MCU registers have the ability to be write protected. To see which registers are available to be protected by this function look at the *bsp_reg_protect_t* enum in *cpu.h* for your MCU.

This function, and R_BSP_RegisterProtectEnable(), use counters for each entry in the *bsp_reg_protect_t* enum so that users can call these functions multiple times without problem. An example of why this is needed is shown in the Special Notes section of Section 5.7.

Reentrant

No.

Example

```
/* Write access must be enabled before writing to CGC registers. */
R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_CGC);
/* CGC registers are spread amongst two protection bits. */
R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_LPC_CGC_SWR);

/* CGC registers are now writable. */
/* Select PLL as clock source. */
SYSTEM.SCKCR3.WORD = 0x0400;

/* More clock setup. */
....

/* Enable write protection for CGC registers to protect against accidental
   writes. */
R_BSP_RegisterProtectEnable(BSP_REG_PROTECT_CGC);
R_BSP_RegisterProtectEnable(BSP_REG_PROTECT_LPC_CGC_SWR);
```

Special Notes:

None.

5.9 R_BSP_SoftwareLock

Attempts to reserve a lock.

Format

```
bool R_BSP_SoftwareLock(BSP_CFG_USER_LOCKING_TYPE * const plock);
```

Parameters

plock

Pointer to lock structure with lock to try and acquire.

Return Values

true: *Successful, lock was available and acquired*
false: *Failure, lock was already acquired and is not available*

Properties

Prototyped in file “locking.h”
Implemented in file “locking.c”

Description

This function implements an atomic locking mechanism. Locks can be used in numerous ways. Two common uses of locks are to protect critical sections of code and to protect against duplicate resource allocation. For protecting critical sections of code the user would require that the code first obtain the critical section’s lock before executing. An example of protecting against duplicate resource allocation would be if the user had two FIT modules that used the same peripheral. For example, the user may have one FIT module that uses the SCI peripheral in UART mode and another FIT module that uses the SCI peripheral in I^2C mode. To make sure that both modules cannot use the same SCI channel, locks can be used.

Care should taken when using locks as they do not provide advanced features one might expect from an RTOS semaphore or mutex. If used improperly locks can lead to deadlock in the user’s system.

Users can override the default locking mechanisms. See Section 3.2.8 for more information.

Reentrant

Yes.

Example

This shows an example of using locks with the Virtual EEPROM code. This FIT module does not access any peripherals directly, but still needs protection against reentrancy.

```
/* Used for locking state of VEE */
static BSP_CFG_USER_LOCKING_TYPE g_vee_lock;

/******************************************************************************
* Function Name: vee_lock_state
* Description  : Tries to lock the VEE state
* Arguments    : state -
*                    Which state to try to transfer to
* Return value : VEE_SUCCESS -
*                    Successful, state taken
*                VEE_BUSY -
*                    Data flash is busy, state not taken
******************************************************************************/
static uint8_t vee_lock_state (vee_states_t state)
{
    /* Local return variable */
    uint8_t ret = VEE_SUCCESS;

    /* Try to lock VEE to change state. */
    /* Check to see if lock was successfully taken. */
    if(false == R_BSP_SoftwareLock(&g_vee_lock))
    {
        /* Another operation is on-going */
        return VEE_BUSY;
    }
```

```
    /* Check VEE status to make sure we are not interfering with another
       thread */
    if( state == VEE_READING )
    {
        /* If another read comes in while the state is reading then we are OK */
        if( ( g_vee_state != VEE_READY ) && ( g_vee_state != VEE_READING) )
        {
            /* VEE is busy */
            ret = VEE_BUSY;
        }
    }
    else
    {
        /* If we are doing something other than reading then we must be in the
           VEE_READY state */
        if( g_vee_state != VEE_READY )
        {
            /* VEE is busy */
            ret = VEE_BUSY;
        }
    }

    if( ret == VEE_SUCCESS )
    {
        /* Lock state */
        g_vee_state = state;
    }

    /* Release lock. */
    R_BSP_SoftwareUnlock(&g_vee_lock);

    return ret;
}
```

Special Notes:

None.

5.10 R_BSP_SoftwareUnlock

Releases a lock.

Format

```
bool R_BSP_SoftwareUnlock(BSP_CFG_USER_LOCKING_TYPE * const plock);
```

Parameters

plock

Pointer to lock structure with lock to release.

Return Values

true: *Successful, lock was released*
false: *Failure, lock could not be released*

Properties

Prototyped in file “locking.h”
Implemented in file “locking.c”

Description

This function releases a lock that was previously acquired using the R_BSP_SoftwareLock() function. Please see Section 5.9 for more information on locks.

Reentrant

Yes.

Example

This shows an example of using locks for a critical section of code.

```
/* Used for locking critical section of code. */
static BSP_CFG_USER_LOCKING_TYPE g_critical_lock;

static bool critical_area_example (void)
{
    /* Try to acquire lock for executing critical section below. */
    if(false == R_BSP_SoftwareLock(&g_critical_lock))
    {
        /* Lock has already been acquired. */
        return false;
    }

    /* BEGIN CRITICAL SECTION. */

    /* Execute critical section. */
    ....

    /* END CRITICAL SECTION. */

    /* Release lock. */
    R_BSP_SoftwareUnlock(&g_critical_lock);

    return true;
}
```

Special Notes:

None.

5.11 R_BSP_HardwareLock

Attempts to reserve a hardware peripheral lock.

Format

```
bool R_BSP_HardwareLock(mcu_lock_t const hw_index);
```

Parameters

hw_index

Index of lock to acquire from the hardware lock array.

Return Values

true: *Successful, lock was available and acquired*
false: *Failure, lock was already acquired and is not available*

Properties

Prototyped in file “locking.h”
Implemented in file “locking.c”

Description

This function attempts to acquire the lock for a hardware resource of the MCU. Instead of sending in a pointer to a lock as with the R_BSP_SoftwareLock() function, the user sends in an index to an array that holds 1 lock per MCU hardware resource. This array is shared amongst all FIT modules and user code therefore allowing multiple FIT modules (and user code) to use the same locks. The user can see the available hardware resources by looking at the *mcu_lock_t* enum in *mcu_locks.h*. These enum values are also the index into the hardware lock array. The same atomic locking mechanisms from the R_BSP_SoftwareLock() function are used with this function as well.

Reentrant

Yes.

Example

This example shows hardware locks being used to control access to a RSPI channel.

```
/******************************************************************************
* Function Name: R_RSPI_Send
* Description  : Send data over RSPI channel.
* Arguments    : channel -
*                    Which channel to use.
*                pdata -
*                    Pointer to data to transmit
*                bytes -
*                    Number of bytes to transmit
* Return Value : true -
*                    Data sent successfully.
*                false -
*                    Could not obtain lock.
******************************************************************************/
bool R_RSPI_Send(uint8_t channel, uint8_t * pdata, uint32_t bytes)
{
    mcu_lock_t rspi_channel_lock;

    /* Check and make sure channel is valid. */
    ...

    /* Use appropriate RSPI channel lock. */
    if (0 == channel)
    {
        rspi_channel_lock = BSP_LOCK_RSPI0;
    }
    else
    {
        rspi_channel_lock = BSP_LOCK_RSPI1;
    }
```

```
    /* Attempt to obtain lock so we know we have exclusive access to RSPI
       channel. */
    if (false == R_BSP_HardwareLock(rspi_channel_lock))
    {
        /* Lock has already been acquired by another task. Need to try again
           later. */
        return false;
    }

    /* Else, lock was acquired. Continue on with send operation. */
    ...

    /* Now that send operation is completed, release hold on lock so that other
       tasks may use this RSPI channel. */
    R_BSP_HardwareUnlock(rspi_channel_lock);

    return true;
}
```

Special Notes:

Each entry in the *mcu_lock_t* enum in *mcu_locks.h* will be allocated a lock. On RX MCUs, each lock is required to be 4-bytes. If RAM space is an issue then the user can remove the entries from the *mcu_lock_t* enum that they are not using. For example, if the user is not using the CRC peripheral then they could delete the BSP_LOCK_CRC entry. The user will save 4-bytes per deleted entry.

5.12 R_BSP_HardwareUnlock

Releases a hardware peripheral lock.

Format

```
bool R_BSP_HardwareUnlock(mcu_lock_t const hw_index);
```

Parameters

hw_index

Index of lock to release from the hardware lock array.

Return Values

true: *Successful, lock was released*
false: *Failure, lock could not be released*

Properties

Prototyped in file “locking.h”
Implemented in file “locking.c”

Description

This function attempts to release the lock for a hardware resource of the MCU that was previously acquired using the R_BSP_HardwareLock() function. For more information on hardware locks please see Section 5.11.

Reentrant

Yes.

Example

This example shows hardware locks being used to prevent duplicate hardware resource allocation. The R_SCI_Open() function takes the lock so all modules know that the SCI channel is being used. R_SCI_Close() releases the lock thereby making it available for any module to use.

```
bool R_SCI_Open(uint8_t channel, ...)
{
    mcu_lock_t sci_channel_lock;

    /* Check and make sure channel is valid. */
    ...

    /* Use appropriate RSPI channel lock. */
    if (0 == channel)
    {
        sci_channel_lock = BSP_LOCK_SCI0;
    }
    else if (1 == channel)
    {
        sci_channel_lock = BSP_LOCK_SCI1;
    }
    ... continue for other channels ...

    /* Attempt to obtain lock so we know we have exclusive access to SCI
       channel. */
    if (false == R_BSP_HardwareLock(sci_channel_lock))
    {
        /* Lock has already been acquired by another task or another FIT module.
           Need to try again later. */
        return false;
    }

    /* Else, lock was acquired. Continue on initialization. */
    ...
}
```

```
bool R_SCI_Close(uint8_t channel, ...)
{
    mcu_lock_t sci_channel_lock;

    /* Check and make sure channel is valid. */
    ...

    /* Use appropriate RSPI channel lock. */
    if (0 == channel)
    {
        sci_channel_lock = BSP_LOCK_SCI0;
    }
    else if (1 == channel)
    {
        sci_channel_lock = BSP_LOCK_SCI1;
    }
    ... continue for other channels ...

    /* Clean up and turn off this SCI channel. */
    ....

    /* Release hardware lock for this channel. */
    R_BSP_HardwareUnlock(sci_channel_lock);
}
```

Special Notes:

Each entry in the *mcu_lock_t* enum in *mcu_locks.h* will be allocated a lock. On RX MCUs, each lock is required to be 4-bytes. If RAM space is an issue then the user can remove the entries from the *mcu_lock_t* enum that they are not using. For example, if the user is not using the CRC peripheral then they could delete the BSP_LOCK_CRC entry. The user will save 4-bytes per deleted entry.

5.13 R_BSP_InterruptWrite

Registers a callback function for an interrupt.

Format

```
bsp_int_err_t R_BSP_InterruptWrite(bsp_int_src_t vector,
                                    bsp_int_cb_t callback);
```

Parameters

vector

Which interrupt to register a callback for. See Section 4.10.6.

callback

Pointer to function to call when interrupt occurs. See Section 4.10.5.

Return Values

BSP_INT_SUCCESS: *Successful, callback has been registered*

BSP_INT_ERR_INVALID_ARG: *Invalid function address input, any previous function has been unregistered*

Properties

Prototyped in file “mcu_interrupts.h”
Implemented in file “mcu_interrupts.c”

Description

Registers a callback function for an interrupt. If FIT_NO_FUNC, NULL, or any other invalid function address is passed for the callback argument then any previously registered callbacks are unregistered.

If one of the interrupts that is handled by this code is triggered then the interrupt handler will query this code to see if a valid callback function is registered. If one is found then the callback function will be called. If one is not found then the interrupt handler will clear the appropriate flag(s) and exit.

If the user has a callback function registered and wishes to no longer handle the interrupt then the user should call this function again with FIT_NO_FUNC as the *vector* parameter.

Reentrant

No.

Example

```
/* Prototype for callback function. */
void bus_error_callback(void * pdata);

void main (void)
{
    bsp_int_err_t err;

    /* Register bus_error_callback() to be called whenever a bus error occurs */
    err = R_BSP_InterruptWrite(BSP_INT_SRC_BUS_ERROR, bus_error_callback);

    if (BSP_INT_SUCCESS != err)
    {
        /* Error in registering callback. Alert user. */
        ...
    }
}

void bus_error_callback (void * pdata)
{
    /* Bus error has occurred. Handle accordingly. */
    ...
}
```

Special Notes:

- Use of FIT_NO_FUNC is preferred over NULL since access to the address defined by FIT_NO_FUNC will cause a bus error which is easy for the user to catch. NULL typically resolves to 0 which is a valid address on RX MCUs.

5.14 R_BSP_InterruptRead

Gets the callback for an interrupt if one is registered.

Format

```
   bsp_int_err_t R_BSP_InterruptRead(bsp_int_src_t vector,
                                     bsp_int_cb_t * callback);
```

Parameters

vector

Which interrupt to read the callback for. See Section 4.10.6.

callback

Pointer to where to store callback address. See Section 4.10.5.

Return Values

BSP_INT_SUCCESS:	*Successful, callback address has been returned*
BSP_INT_ERR_NO_REGISTERED_CALLBACK:	*No valid callback has been registered for this interrupt source.*

Properties

Prototyped in file “mcu_interrupts.h”
Implemented in file “mcu_interrupts.c”

Description

Returns the callback function address for an interrupt if one has been registered. If a callback function has not been registered then an error is returned and nothing is stored to the *callback* address.

Reentrant

No.

Example

```
/* This function handles bus error interrupts. The address for this function
   is located in the bus error interrupt vector. */
void bus_error_isr (void)
{
    bsp_int_err_t  err;
    bsp_int_cb_t * user_callback;

    /* Bus error has occurred, see if a callback function has been registered */
    err = R_BSP_InterruptRead(BSP_INT_SRC_BUS_ERROR, user_callback);

    if (BSP_INT_SUCCESS == err)
    {
        /* Valid callback function found. Call it. */
        user_callback ();
    }

    /* Clear bus error flags. */
    ...
}
```

Special Notes:

- None.

5.15 R_BSP_SoftwareDelay

Delay the specified duration in units and return.

Format

```
bool R_BSP_SoftwareDelay(uint32_t delay, bsp_delay_units_t units)
```

Parameters

delay

the number of 'units' to delay.

units

the 'base' for the units specified. Valid values are:

BSP_DELAY_MICROSECS, BSP_DELAY_MILLISECS, BSP_DELAY_SECS

Return Values

True if delay executed

False if delay/units combination resulted in overflow/underflow

Properties

Prototyped in file “r_bsp_common.h”
Implemented in file “r_bsp_common.c”

Description

This is function that may be called for all MCU targets to implement a specific wait time. Accuracy is very good at millisecond and second level, less so at microsecond level simply due to the overhead associated with implementing the call.

Note that there is an additional overhead of 20 cycles for the actual delayWait() function call and return.

Reentrant

No.

Example

```
/* Delay 5 seconds before returning */
R_BSP_SoftwareDelay(5, BSP_DELAY_SECS);

/* Delay 5 milliseconds before returning */
R_BSP_SoftwareDelay(5, BSP_DELAY_MILLISECS);

/* Delay 50 microseconds before returning */
R_BSP_SoftwareDelay(50, BSP_DELAY_MICROSECS);
```

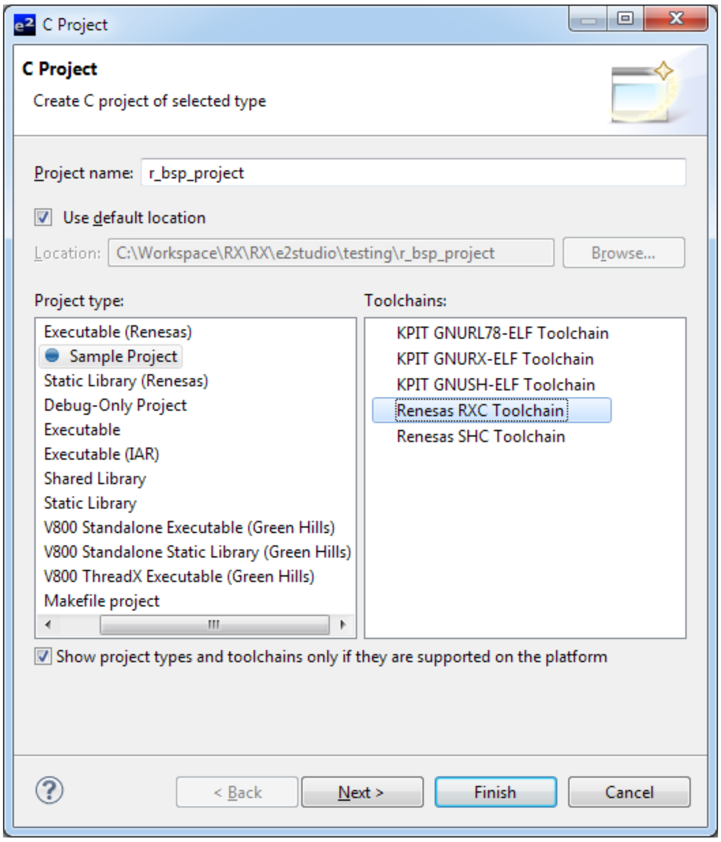
6. Project Setup

This section details creating an e2studio project and adding the r_bsp to it.

6.1 Creating Empty Project

To start off an e2studio project will be created and modified. For this example a project will be created for the RSKRX111.

1. Open your e2studio workspace.
2. Click File >> New >> C Project
3. Enter the project name. In 'Project type:' choose 'Sample Project'. In 'Toolchains' choose 'Renesas RXC Toolchain'. Click Next.



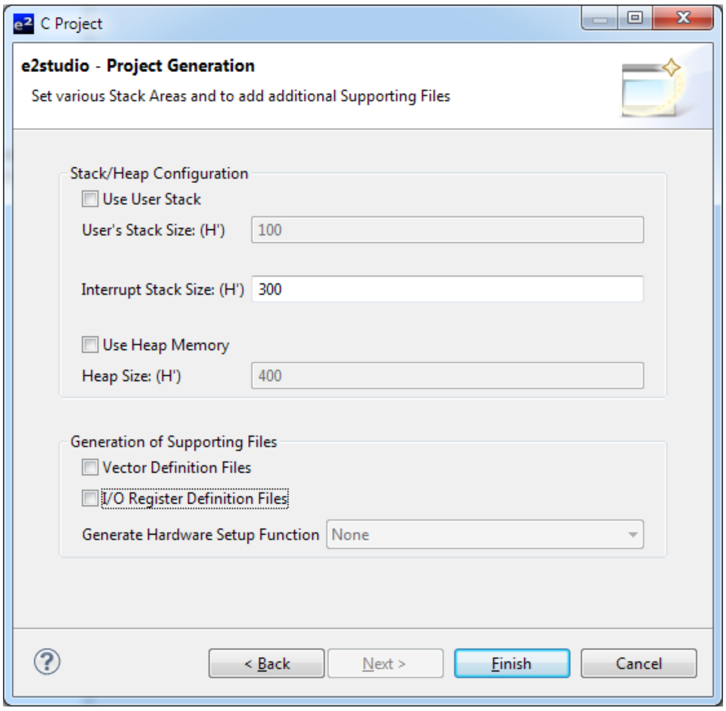
4. Choose your debug hardware and MCU.

5. For the ‘Select Additional CPU Options’ window, configure as needed and click Next.

6. For the ‘Global Options Settings’ window, configure as needed and click Next.

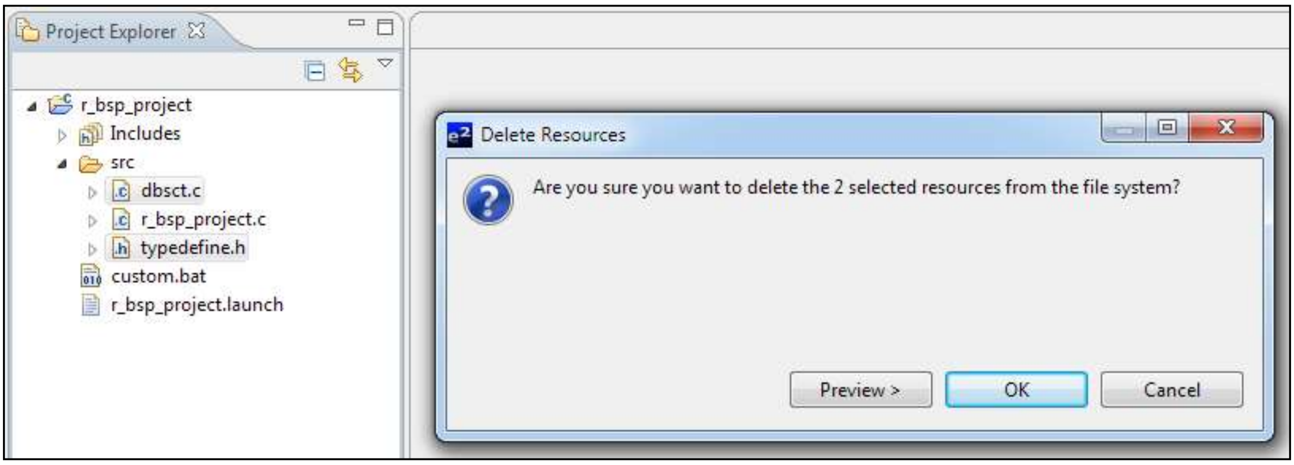
7. For the ‘Standard Header Files’ window, select ‘C(C99)’ for ‘Library configuration’. Configure which libraries are brought in as needed and click Next.

8. Uncheck all boxes for the window shown below:

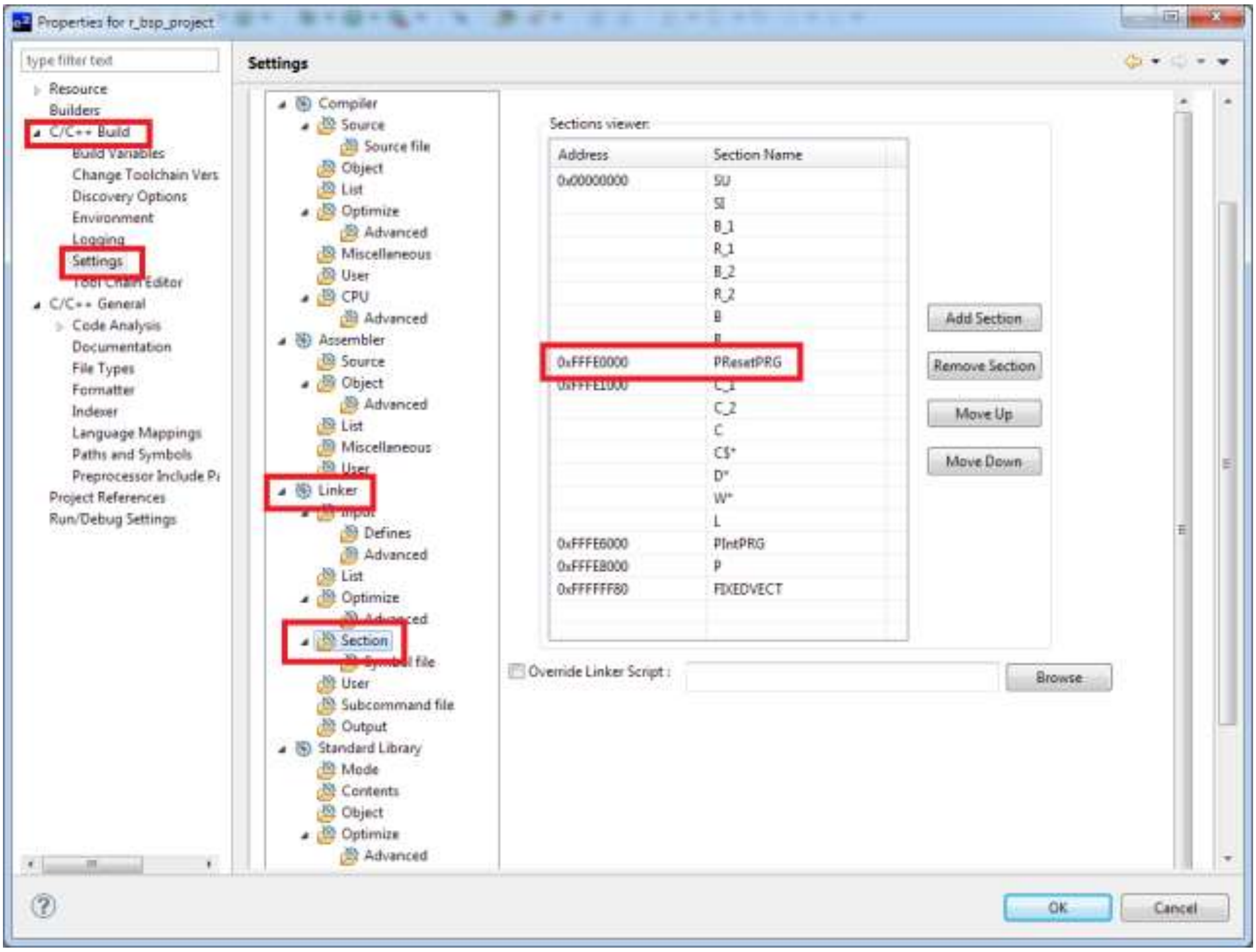


9. Click Finish. In the ‘Summary’ window that pops up, click OK.

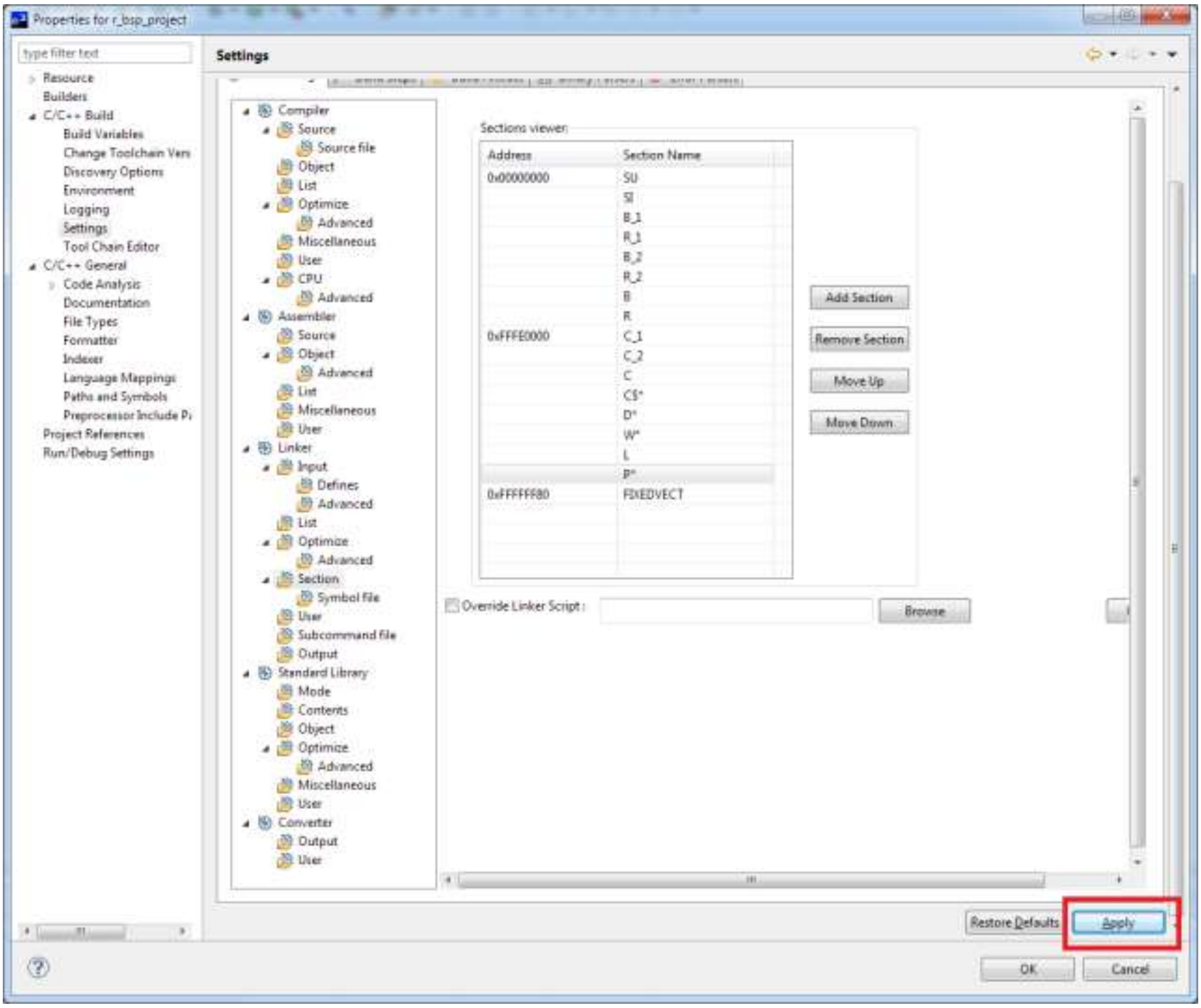
10. Expand your newly created project in the 'Project Explorer' pane. Expand the 'src' directory and delete all files except for the one that contains the main() function. In this example the *dbsct.c* and *typedefine.h* files were deleted.



11. Right-click on the project in the 'Project Explorer' pane and click Properties.
12. We will now setup the linker sections. The main change in these steps will be removing some default linker sections that are not used by the r_bsp.
13. Expand 'C/C++ Build' and click 'Settings'.
14. Under 'Tool Settings' select Linker >> Section.

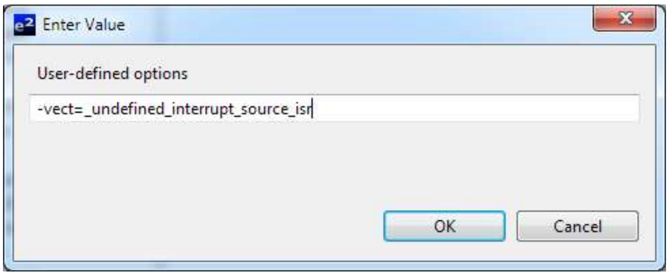


15. In the ‘Sections viewer’ pane note the address that is allocated for the section ‘PResetPRG’. This address should be beginning of user ROM for your MCU. Write down this address then click on the ‘PResetPRG’ section and click ‘Remove Section’.
16. Click on the section that was directly beneath ‘PResetPRG’ (in this example it is ‘C_1’) and change its address to the address that you recorded for ‘PResetPRG’.
17. Click on the ‘PIntPRG’ section and click ‘Remove Section’.
18. Click on the ‘P’ section and click the ‘Move Up’ button. This should remove the address from the section and combine it with the previous section block.
19. Click on the ‘P’ section and change it to ‘P*’. The use of the ‘*’ character acts as a wildcard and will catch all ‘P’ sections used in your project.
20. Verify that the address for the ‘FIXEDVECT’ section is set to 0xFFFFFF80.
21. **VERY IMPORTANT,** remember to click the Apply button. If the Apply button is not visible in your screen then use the scroll bars on the right of the window to find it.
22. Your linker screen should now look similar to the one below.

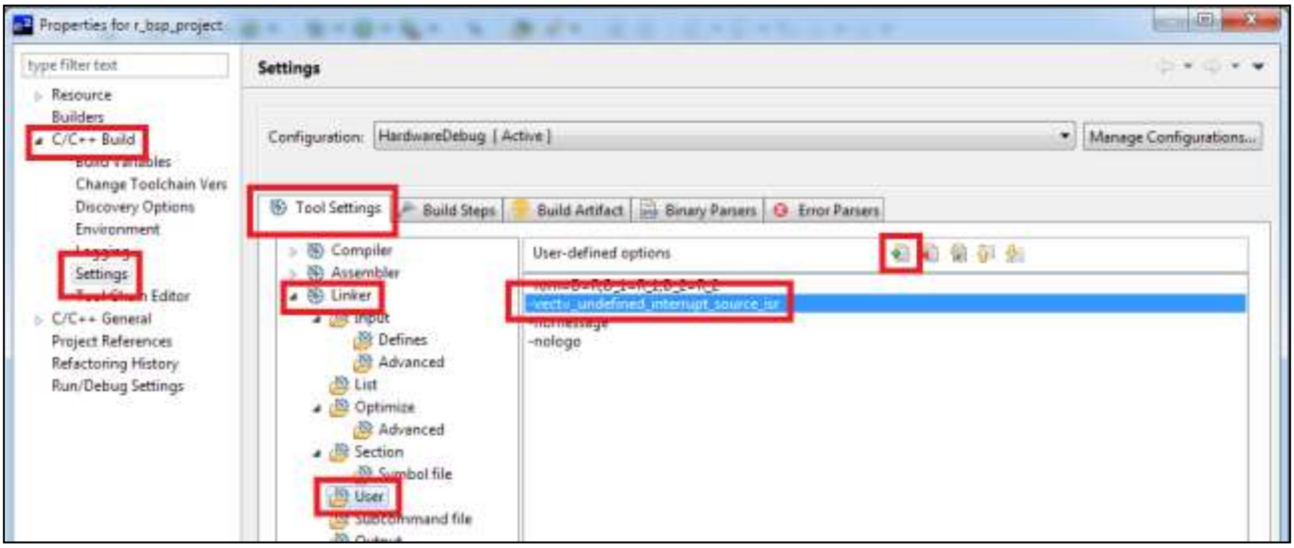


23. We will now setup the linker to fill in unused interrupt vectors with the address of the undefined_interrupt_source_isr() function. Under 'Tool Settings' select Linker >> User.
24. Click the 'Add' button (with green '+' symbol) and in the window that pops up enter:

-vect=_undefined_interrupt_source_isr



25. Click OK to close the pop up window. Verify the option has been added to the list and click Apply.

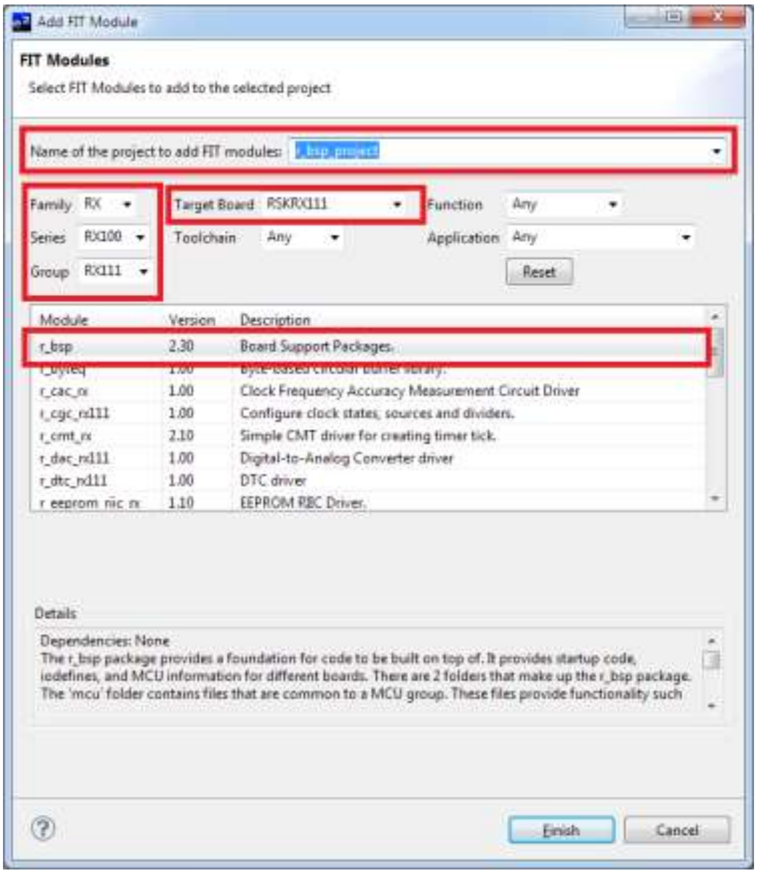


26. Click OK to return to your project.

6.2 Adding r_bsp with e2studio FIT Plug-in

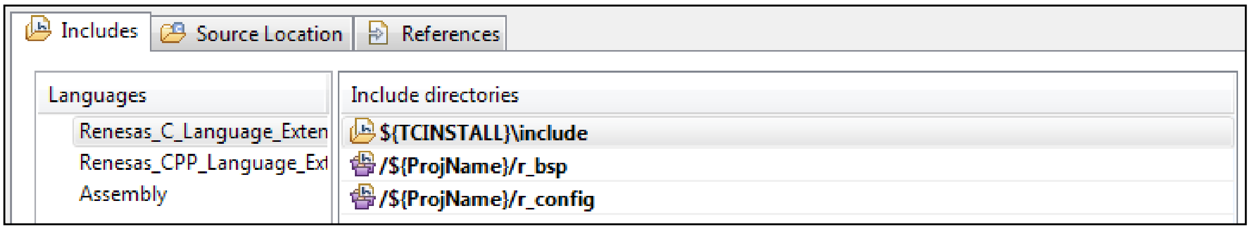
Now that we have an empty e2studio project the r_bsp code can be added. Two methods will be presented. The first is to use the FIT Plug-in which is described in this section. The other method is to add the r_bsp manually which will be discussed in Section **Error! Reference source not found.**.

1. Open up the FIT Plug-in by clicking File >> New >> Renesas FIT Module.
2. Choose which board and MCU you are using by selecting options in the Family, Series, Group, and Target Board dropdowns. In this example the RSKRX111 is being used.
3. Click on the version of the r_bsp you wish to use in the module list.
4. Verify that your project is shown in the 'Name of the project to add FIT modules' dropdown near the top of the window.



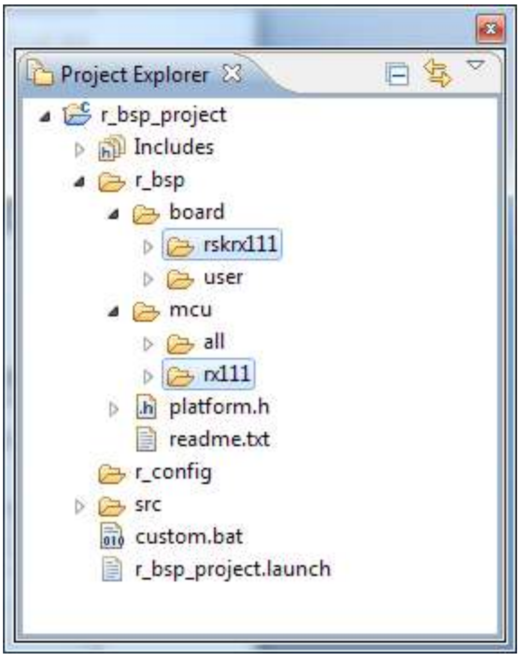
5. Click Finish.
6. A window will pop up alerting you that the plug-in has automatically updated your include paths for the new module. Click OK.

7. The plug-in will pop up the include paths for your project. Verify that an include is present for the r_bsp and r_config folders. Click Apply and then click OK to close the window.



8. Verify that there are now *r_bsp* and *r_config* folders in your project.

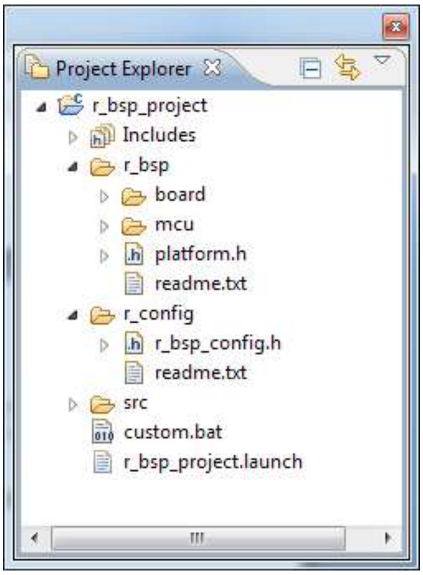
9. Expand the r_bsp folder and verify that the proper *board* and *mcu* folders were copied.



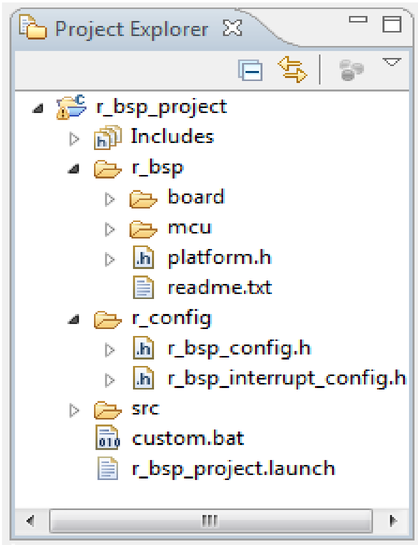
10. Which board is being used needs to be selected in the *platform.h* header file. Open up *platform.h* and uncomment the #include for the board you are using. In this example the RSKRX111 is being used so the #include for "./board/rskrx111/r_bsp.h" is uncommented.

```
/* RSKRX63N */
//#include "./board/rskrx63n/r_bsp.h"

/* RSKRX63T_64PIN */
//#include "./board/rskrx63t_64pin/r_bsp.h"

/* RSKRX63T_144PIN */
//#include "./board/rskrx63t_144pin/r_bsp.h"

/* RDKRX63N */
//#include "./board/rdkrx63n/r_bsp.h"

/* RSKRX210 */
//#include "./board/rskrx210/r_bsp.h"

/* RSKRX111 */
#include "./board/rskrx111/r_bsp.h"
```

11. In order to configure the r_bsp the user needs to create an *r_bsp_config.h* file. Copy the *r_bsp_config_reference.h* file from your *board* folder and paste it into the *r_config* folder. Right-click on the file in the *r_config* folder and click Rename. Rename the file to *r_bsp_config.h*.



12. Configure the r_bsp for your board by going through and modifying the *r_bsp_config.h* file as needed.
13. For RX64M MCU's configuring the bsp requires that the user also create an *r_bsp_interrupt_config.h* file. Copy the *r_bsp_interrupt_config_reference.h* file from your *board* folder and paste it into the *r_config* folder. Right-click on the file in the *r_config* folder and click Rename. Rename the file to *r_bsp_interrupt_config.h*.

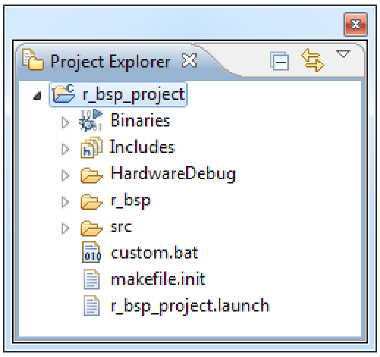


14. Configure the dynamic interrupts for your RX64M board by going through and modifying the *r_bsp_interrupt_config.h* file as needed.
15. Build the project.

7. Adding r_bsp manually

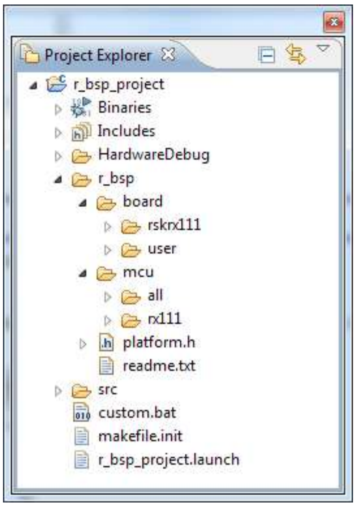
This section will give instruction on how to add the r_bsp to an e2studio project manually (without use of the FIT Plug-in).

1. Copy the r_bsp folder to your e2studio project's root. Once clicking Copy in Windows you can right-click on your project in e2studio and click Paste.



2. Expand the *r_bsp* >> *board* folder and delete all of the folders except the one for the board you are using. You can leave the 'user' directory if you wish to have a directory to start off with when you create your own BSP.

3. Expand the *r_bsp* >> *mcu* folder and delete all of the folders except the one for your MCU group and the one named *all*.

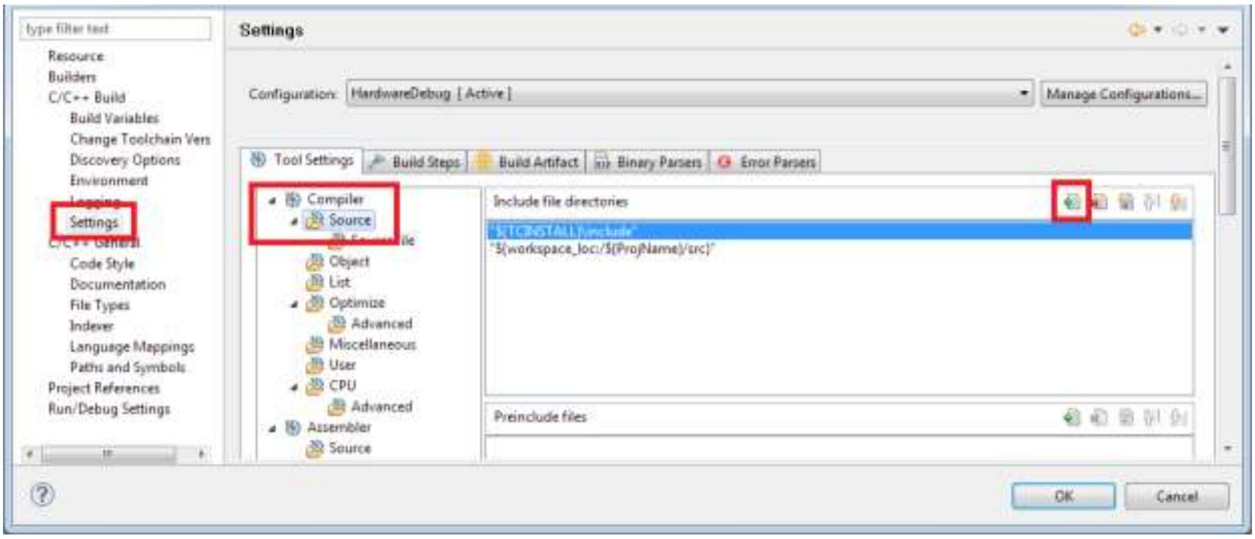


4. It is recommended to create a directory to store all FIT configuration files. Having one place for configuration files make them easy to find and easy to backup. The default name for this folder is *r_config*. If an *r_config* folder was not included in your r_bsp zip file then we will create one here. Create an *r_config* folder for your project by right-clicking on your project and choosing New >> Folder. In the window that pops up enter 'r_config' for the folder name and click Finish.

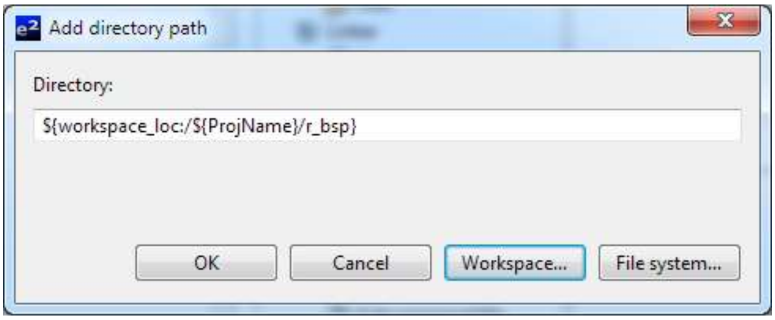
5. We will now setup include paths for the r_bsp and r_config folders. Right-click on your project and click Properties.

6. Under 'Tool Settings' select Compiler >> Source.

7. In the 'Include file directories' box click the 'Add' button.



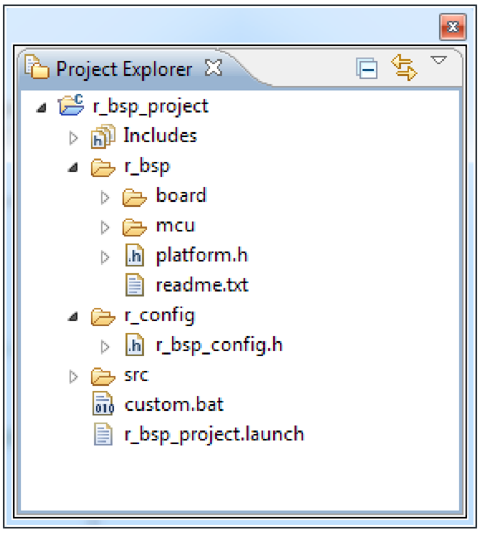
8. The ‘Add directory path’ window will pop up; click the Workspace button.
9. In the ‘Folder selection’ window choose the r_bsp folder and click OK.



10. Verify that your window looks like the one above and click OK.
11. Back in the main Properties window verify that you now have an include path for the r_bsp.
12. Follow the same steps to add an include path for the *r_config* folder.
13. Back in the main Properties window verify that you now have an include path for the *r_bsp* and *r_config* folders and click Apply. Click OK to return to your project.
14. Which board is being used needs to be selected in the *platform.h* header file. Open up *platform.h* and uncomment the #include for the board you are using. In this example the RSKRX111 is being used so the #include for “./board/rskrx111/r_bsp.h” is uncommented.

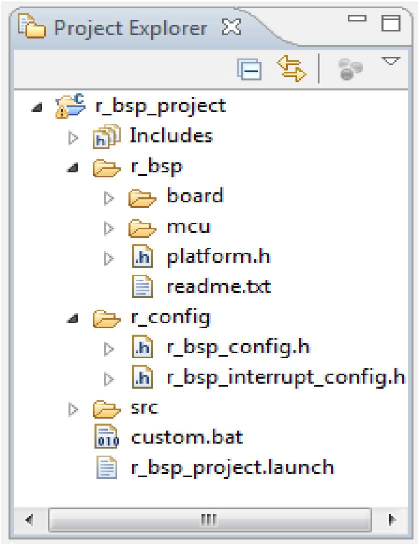
```
/* RSKRX63N */
//#include "./board/rskrx63n/r_bsp.h"

/* RSKRX63T_64PIN */
//#include "./board/rskrx63t_64pin/r_bsp.h"

/* RSKRX63T_144PIN */
//#include "./board/rskrx63t_144pin/r_bsp.h"

/* RDKRX63N */
//#include "./board/rdkrx63n/r_bsp.h"

/* RSKRX210 */
//#include "./board/rskrx210/r_bsp.h"

/* RSKRX111 */
#include "./board/rskrx111/r_bsp.h"
```

15. In order to configure the r_bsp the user needs to create an *r_bsp_config.h* file. Copy the *r_bsp_config_reference.h* file from your *board* folder and paste it into the *r_config* folder. Right-click on the file in the *r_config* folder and click Rename. Rename the file to *r_bsp_config.h*.



16. Configure the r_bsp for your board by going through and modifying the *r_bsp_config.h* file as needed.

17. For RX64M MCU's configuring the bsp requires that the user also create an *r_bsp_interrupt_config.h* file. Copy the *r_bsp_interrupt_config_reference.h* file from your *board* folder and paste it into the *r_config* folder. Right-click on the file in the *r_config* folder and click Rename. Rename the file to *r_bsp_interrupt_config.h*.



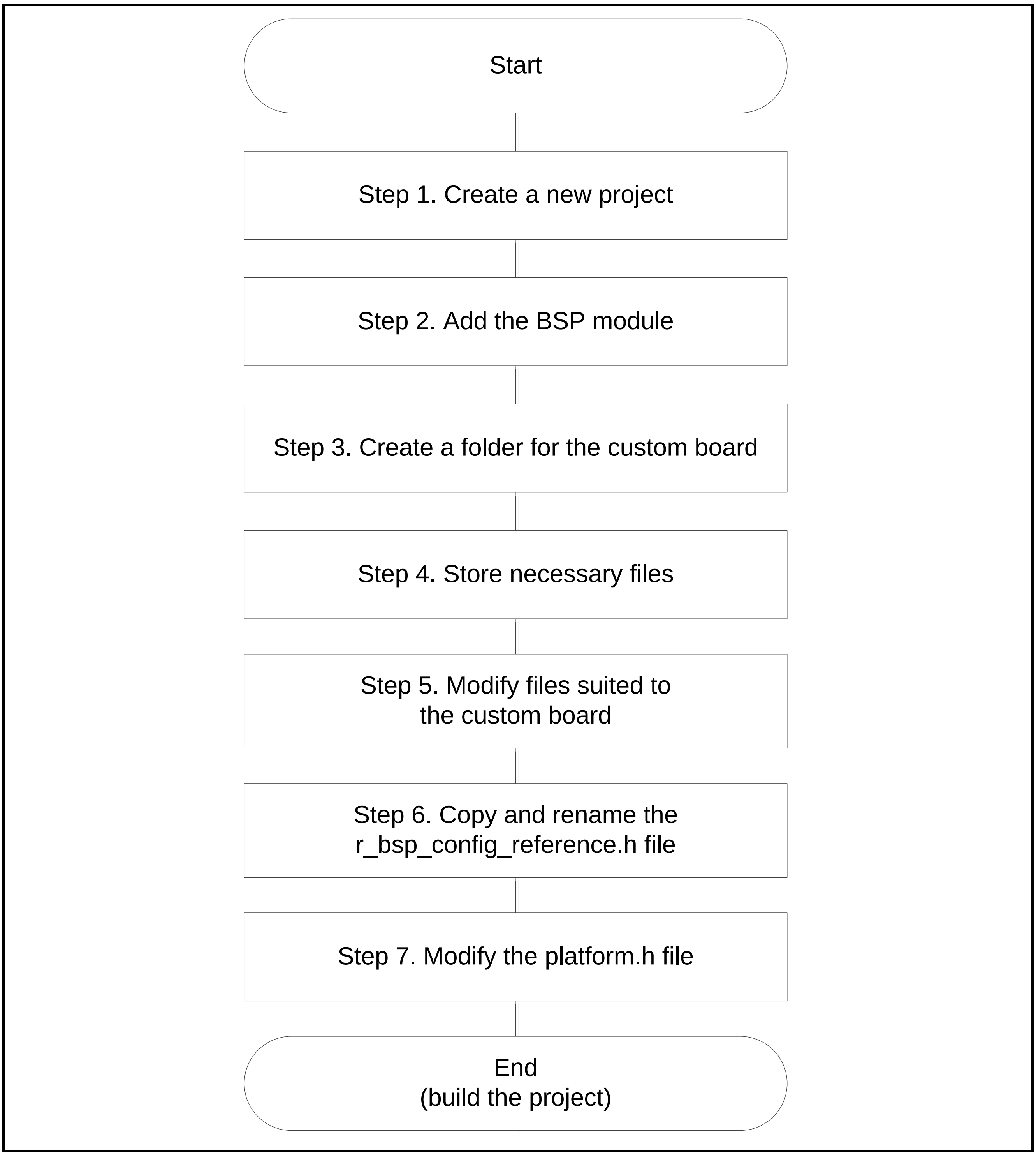
18. Configure the dynamic interrupts for your RX64M board by going through and modifying the *r_bsp_interrupt_config.h* file as needed.

19. Build the project.

7.1 Creating a BSP Module for a Custom Board

The r_bsp is provided for users to create their own r_bsp for a custom board (custom BSP). This section describes how to create and build a new project when using a custom BSP. The RX111 MCU is used as an example in this document.

The figure below shows the procedure for creating a new bsp.



Step 1. Create a New Project (Mandatory)

To create a new project, refer to "Creating Empty Project" in the "Board Support Package Module Using Firmware Integration Technology" application note (R01AN1685).

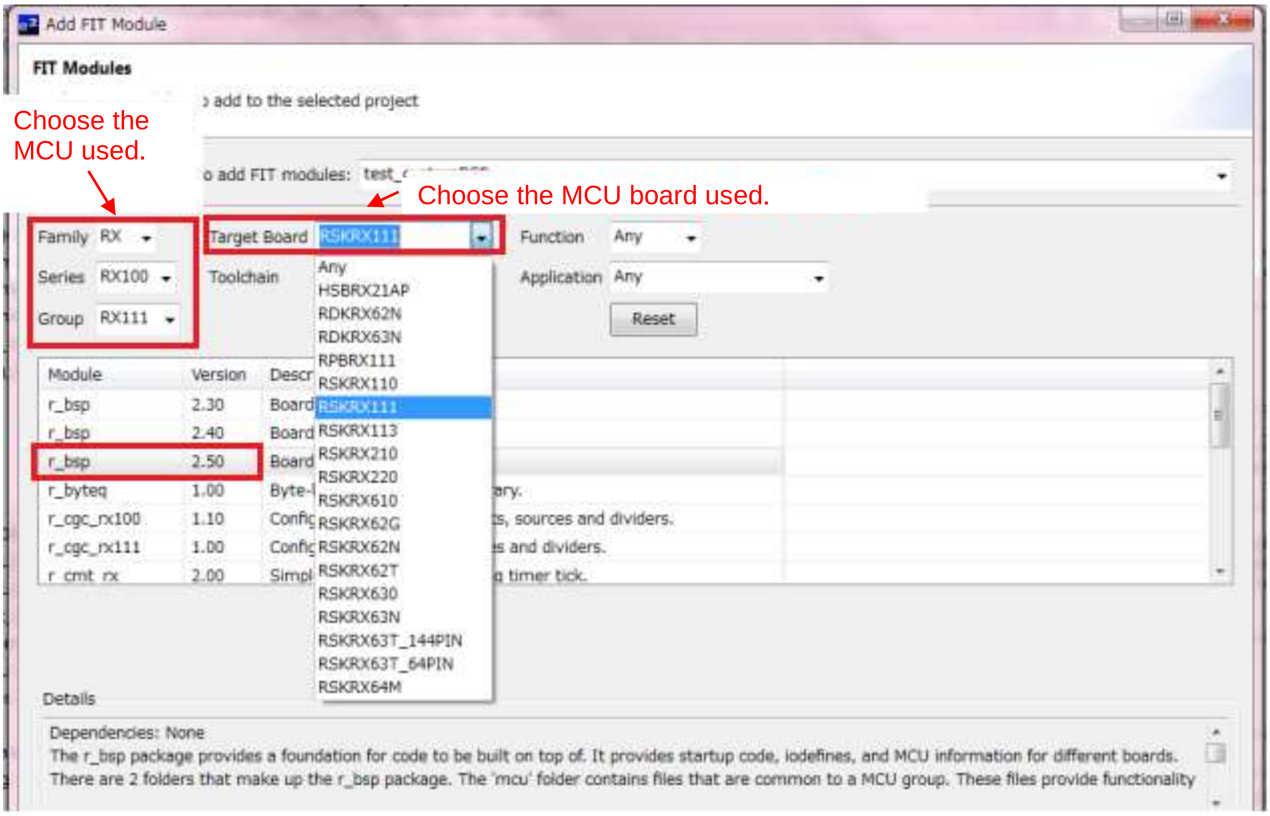
Step 2. Add the BSP Module (Mandatory)

To add the BSP module to the new project (user project) created in step 1, refer to "Adding r_bsp with e2studio FIT Plug-in" in the "Board Support Package Module Using Firmware Integration Technology" application note (R01AN1685).

Choose the following options when adding the BSP module on the FIT plug-in.

- Family, Series, Group: MCU used.
- Target Board: MCU board used.

For example, when using the RX111 to create the user board, choose "RSKRX111" or "RSKRX64M". By choosing the appropriate options here, the board folder for the custom board can be created easily.

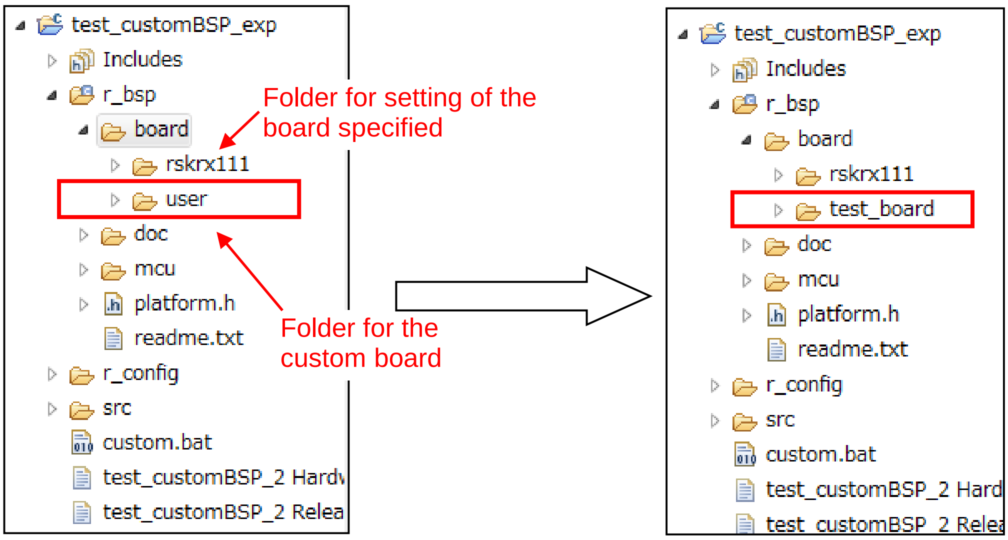


Step 3. Create a Folder for the Custom Board

The r_bsp folder should now be present in the user project. Below, the board folder under the r_bsp folder is modified to create the custom BSP. The code in the mcu folder does not require modification.

1) Confirm that the board folder (rskrx111 here) specified in step 2 and the user folder are generated in the board folder under the r_bsp folder.

2) Use the user folder as the folder for the custom board (optional).
Rename the folder name (optional). The folder name does not have to be changed.



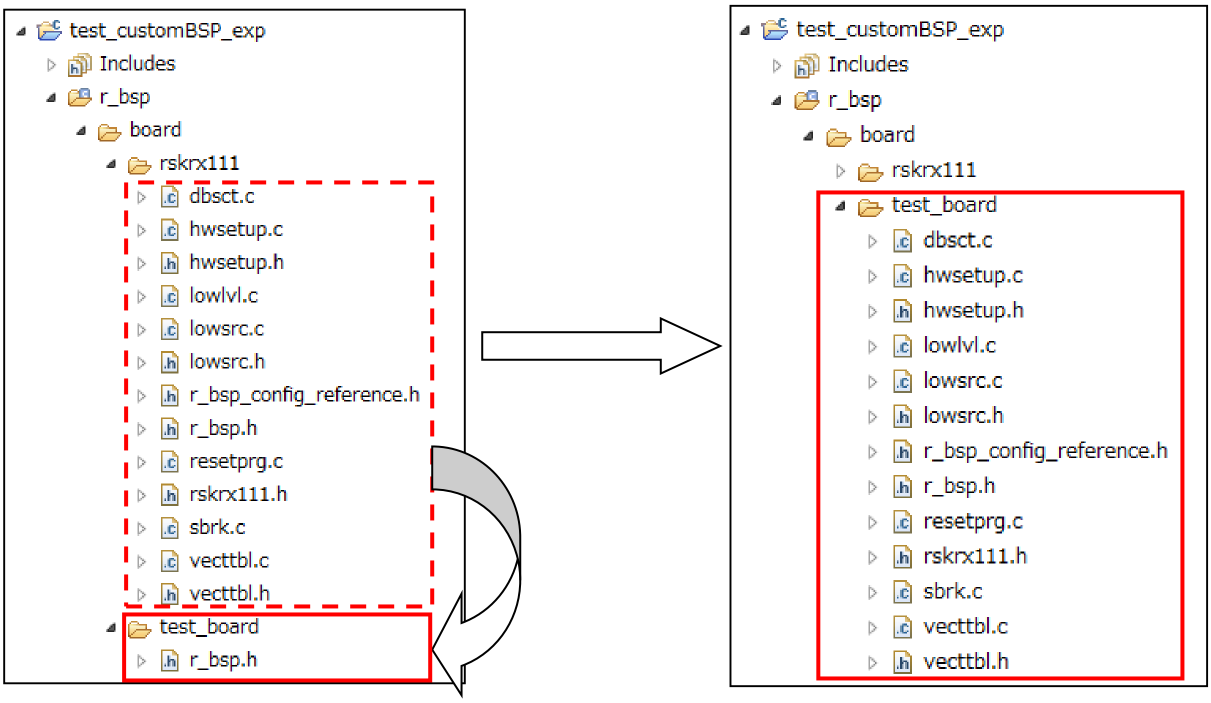
Folder structure after the BSP module is added.

Example when the folder name is changed for the custom board

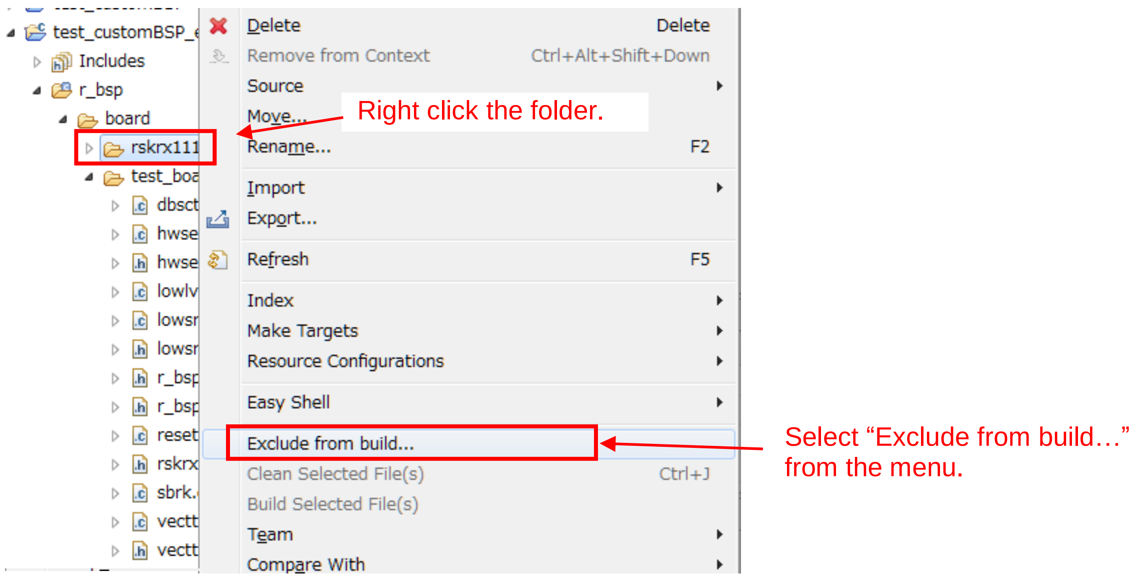
Step 4. Store Necessary Files (Mandatory)

Store necessary files in the folder created in step 3.

1) Copy all files in the rskrx111 folder and paste them in the folder for the custom board. Then overwrite the r_bsp.h file.



2) Exclude the rskrx111 folder from build.
(The folder can be deleted if it is not necessary after the folder for the custom board is created.)



Step 5. Modify Files Suited to the Custom Board (Mandatory)

Modify the following four files suited to the custom board.

1. hwsetup.c

This file executes the following four functions.

- **Function: output_ports_configure**

This function initializes ports used for LEDs, switchs, SCI, and ADC.

Ports need to be configured with either of procedures below according to the board used.

If not configuring pins in this function:

1) Comment out or delete the function declaration of the output_ports_configure function.
2) Delete the output_ports_configure function which is called in the hardware_setup function.
3) Comment out or delete the output_ports_configure function.

Then configure settings described in "2. *board_specific_defines*.h" as well.

If configuring pins in this function:

1) Comment out or delete the source code in the output_ports_configure function.
2) Configure pins according to the board used.

- **Function: bsp_non_existent_port_init**

This function initializes nonexistent ports. No additional processing is required for this function.

- **Function: interrupts_configure**

This function configures interrupt settings which are performed prior to the main function.

When such settings are required, add the settings in this function.

- **Function: peripheral_modules_enable**

This function configures settings for peripheral functions which are performed prior to the main function.

When such settings are required, add the settings in this function.

Examples of processing are shown below when not configuring pins in the output_ports_configure function.

```
/***********************************************************************************************************************
Private global variables and functions
***********************************************************************************************************************/
/* MCU I/O port configuration function declaration */
static void output_ports_configure(void);

/* Interrupt configuration function declaration */
static void interrupts_configure(void);

/* MCU peripheral module configuration function declaration */
static void peripheral_modules_enable(void);
```

Comment out or delete this part.

```
/*******************************************************************************
* Function name: hardware_setup
* Description  : Contains setup functions called at device restart
* Arguments    : none
* Return value : none
*******************************************************************************/
void hardware_setup(void)
{
    output_ports_configure();
    interrupts_configure();
    peripheral_modules_enable();
    bsp_non_existent_port_init();
}
```

Comment out or delete this line.

```
static void output_ports_configure(void)
{
    /* Enable LEDs. */
    /* Start with LEDs off. */
    LED0 = LED_OFF;
    LED1 = LED_OFF;
    LED2 = LED_OFF;
    LED3 = LED_OFF;

    /* Set LED pins as outputs. */
    LED0_PDR = 1;
    LED1_PDR = 1;
    LED2_PDR = 1;
    LED3_PDR = 1;

    /* Enable switches. */
    /* Set pins as inputs. */
    SW1_PDR = 0;
    SW2_PDR = 0;
    SW3_PDR = 0;

    /* Set port mode registers for switches. */
    SW1_PMR = 0;
    SW2_PMR = 0;
    SW3_PMR = 0;

    /* Unlock MPC registers to enable writing to them. */
    R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_MPC);

    /* TXD1 is output. */
    PORT1.PMR.BIT.B6 = 0;
    MPC.P16PFS.BYTE  = 0x0A;
    PORT1.PDR.BIT.B6 = 1;
    PORT1.PMR.BIT.B6 = 1;
    /* RXD1 is input. */
    PORT1.PMR.BIT.B5 = 0;
    MPC.P15PFS.BYTE  = 0x0A;
    PORT1.PDR.BIT.B5 = 0;
    PORT1.PMR.BIT.B5 = 1;

    /* Configure the pin connected to the ADC Pot as an analog input */
#if   (BSP_CFG_BOARD_REVISION == 0)
    PORT4.PMR.BIT.B4 = 0;
    MPC.P44PFS.BYTE = 0x80;     //Set ASEL bit and clear the rest
    PORT4.PDR.BIT.B4 = 0;
#elif (BSP_CFG_BOARD_REVISION == 1)
    PORT4.PMR.BIT.B0 = 0;
    MPC.P40PFS.BYTE = 0x80;     //Set ASEL bit and clear the rest
    PORT4.PDR.BIT.B0 = 0;
#endif
```

Comment out or delete this part.

2. *board_specific_defines*.h

The board used becomes the name of this file (e.g. rskrx111.h). This file has definitions of pins used for switches, LEDs, and so on, and their settings vary depending on the board used.

However this file is not necessary when using the custom board. Perform the following steps.

1) Delete the *board_specific_defines*.h file from the folder for the custom board.

2) Delete the following line in the r_bsp.h file.

```
#include    "board/rskrx111/rskrx111.h"
```

3. r_bsp.h

This header file is included in platform.h and has all #includes required for the board and the MCU. The include paths associated with the board need to be modified.

1) Modify the include paths which start with "board/" as follows:

Change the path to "board/*name of the folder for the custom board*/file name".

<u>Example:</u>

Before modification: `#include    "board/rskrx111/rskrx111.h"`

After modification: `#include    "board/`*`test_board`*`/rskrx111.h"`

```
/***********************************************************************************************************************
INCLUDE APPROPRIATE MCU AND BOARD FILES
***********************************************************************************************************************/
#include    "mcu/all/r_bsp_common.h"
#include    "r_bsp_config.h"
#include    "mcu/rx111/register_access/iodefine.h"
#include    "mcu/rx111/mcu_info.h"
#include    "mcu/rx111/mcu_locks.h"
#include    "mcu/rx111/locking.h"
#include    "mcu/rx111/cpu.h"
#include    "mcu/rx111/mcu_init.h"
#include    "mcu/rx111/mcu_interrupts.h"
#include    "board/test_board/rskrx111.h"
#include    "board/test_board/hwsetup.h"
#include    "board/test_board/lowsrc.h"
#include    "board/test_board/vecttbl.h"

#endif /* BSP_BOARD_RSKRX111 */
```

Change this part to the folder name for the custom board.

4. r_bsp_config_reference.h

This header file has settings to provide default options of the board. Macro definitions that are included in this file and need to be modified according to the custom board are listed in the table below. Change the settings as required.

For example, when the setting in the copied board folder uses the PLL as the system clock while the user system uses the HOCO, change the clock setting for BSP_CFG_CLOCK_SOURCE from PLL to HOCO.

Also confirm usage conditions for macros not in the table below and modify them as required.

Table 7.1 Macros to be modified to reflect the Custom Board

Macro	Description
BSP_CFG_CLOCK_SOURCE	Selects a crystal on the board and a clock source.
BSP_CFG_XTAL_HZ	Specifies a value according to the crystal on the board (default value: RSK setting).
BSP_CFG_PLL_DIV	When using the PLL: Specifies an available setting value using the crystal on the board.
BSP_CFG_PLL_MUL	When using the PLL: Specifies an available setting value using the crystal on the board.
BSP_CFG_ICK_DIV	Specifies an available setting value using the crystal on the board.
BSP_CFG_PCKB_DIV	Specifies an available setting value using the crystal on the board.
BSP_CFG_PCKD_DIV	Specifies an available setting value using the crystal on the board.
BSP_CFG_FCK_DIV	Specifies an available setting value using the crystal on the board.

Step 6. Copy and Rename the r_bsp_config_reference.h File (Mandatory)

After step 5, copy the r_bsp_config_reference.h file, paste it in the r_config folder, and rename the copied file to "r_bsp_config.h".

Step 7. Modify the platform.h File (Mandatory)

This header file needs to be modified to specify the r_bsp.h file in the newly created folder for the custom board. Follow the steps below for the modification.

1) Uncomment the line under the comment "/* User Board - Define your own board here. */ ".

2) Change the folder name after "board/" to the folder name for the custom board.

Before modification:

```
/* User Board - Define your own board here. */
//#include "./board/user/r_bsp.h"
```

After modification:

```
/* User Board - Define your own board here. */
#include "./board/test_board/r_bsp.h"
```

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Revision Record

Rev.	Date	Description Page	Summary
2.30	Nov 15, 2013	—	First Release.
2.40	Feb 18, 2014	—	Added support for RX21A, RX220, RX110. Expanded ‘MCU Information’ subsection.
2.50	Mar 13, 2014	—	Added support for RX64M.
2.60	July 15, 2014	—	Added section for Creating a BSP Module for a Custom Board.
2.70	Aug 05, 2014	—	Added support for RX113.

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU 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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the 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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