User's Manual

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RX64M Group

Renesas Starter Kit+ Code Generator Tutorial Manual For CubeSuite+

RENESAS MCU
RX Family / RX600 Series

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Disclaimer

By using this Renesas Starter Kit+ (RSK+), the user accepts the following terms:

The RSK+ is not guaranteed to be error free, and the entire risk as to the results and performance of the RSK+ is assumed by the User. The RSK+ is provided by Renesas on an “as is” basis without warranty of any kind whether express or implied, including but not limited to the implied warranties of satisfactory quality, fitness for a particular purpose, title and non-infringement of intellectual property rights with regard to the RSK+. Renesas expressly disclaims all such warranties. Renesas or its affiliates shall in no event be liable for any loss of profit, loss of data, loss of contract, loss of business, damage to reputation or goodwill, any economic loss, any reprogramming or recall costs (whether the foregoing losses are direct or indirect) nor shall Renesas or its affiliates be liable for any other direct or indirect special, incidental or consequential damages arising out of or in relation to the use of this RSK+, even if Renesas or its affiliates have been advised of the possibility of such damages.

Precautions

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

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

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

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

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

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

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

How to Use This Manual

1. Purpose and Target Readers

This manual is designed to provide the user with an understanding of how to use Application Leading Tool (Code Generator) for RX together with the CubeSuite+ IDE to create a working project for the RSK+ platform. It is intended for users designing sample code on the RSK+ platform, using the many different incorporated peripheral devices.

The manual comprises of step-by-step instructions to generate code and import it into CubeSuite+, but does not intend to be a complete guide to software development on the RSK+ platform. Further details regarding operating the RX64M microcontroller may be found in the Hardware Manual and within the provided sample code.

Particular attention should be paid to the precautionary notes when using the manual. These notes occur within the body of the text, at the end of each section, and in the Usage Notes section.

The revision history summarizes the locations of revisions and additions. It does not list all revisions. Refer to the text of the manual for details.

The following documents apply to the RX64M Group. Make sure to refer to the latest versions of these documents. The newest versions of the documents listed may be obtained from the Renesas Electronics Web site.

Document Type	Description	Document Title	Document No.
User's Manual	Describes the technical details of the RSK+ hardware.	RSK+RX64M User's Manual	R20UT2590EG
Tutorial	Provides a guide to setting up RSK+ environment, running sample code and debugging programs.	RSK+RX64M Tutorial Manual	R20UT2591EG
Quick Start Guide	Provides simple instructions to setup the RSK+ and run the first sample.	RSK+RX64M Quick Start Guide	R20UT2592EG
Code Generator Tutorial	Provides a guide to code generation and importing into the CubeSuite+ IDE.	RSK+RX64M Code Generator Tutorial Manual	R20UT2930EG
Schematics	Full detail circuit schematics of the RSK+.	RSK+RX64M Schematics	R20UT2589EG
Hardware Manual	Provides technical details of the RX600 microcontroller.	RX600 Group Hardware Manual	R01UH0377EJ

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
ADC	Analog-to-Digital Converter
API	Application Programming Interface
CMT	Compare Match Timer
COM	COMmunications port referring to PC serial port
CPU	Central Processing Unit
DVD	Digital Versatile Disc
E1	On-chip Debugger
GUI	Graphical User Interface
IDE	Integrated Development Environment
IRQ	Interrupt Request line
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro-controller Unit
MSB	Most Significant Bit
PC	Personal Computer
Pmod™	Digilent Pmod™ Compatible connector. PmodTM is registered to Digilent Inc. Digilent-Pmod_Interface_Specification (Link valid at 26Jun2013)
PLL	Phase-locked Loop
RSK+	Renesas Starter Kit Plus
SCI	Serial Communications Interface
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter

Table of Contents

1. Overview

1.1 Purpose

This RSK+ is an evaluation tool for Renesas microcontrollers. This manual describes how to use the CubeSuite+ IDE code generator plug in to create a working project for the RSK+ platform.

1.2 Features

This RSK+ provides an evaluation of the following features:

- Project Creation with CubeSuite+
- Code Generation using the code generator plug in.
- User circuitry such as switches, LEDs and a potentiometer

The RSK+ board contains all the circuitry required for microcontroller operation.

2. Introduction

This manual is designed to answer, in tutorial form, how to use the code generator plug in for the RX family together with the CubeSuite+ IDE to create a working project for the RSK+ platform. The tutorials help explain the following:

- Project generation using the CubeSuite+
- Detailed use of the code generator plug in for CubeSuite+
- Integration with custom code
- Building the project CubeSuite+

The project generator will create a tutorial project with three selectable build configurations:

- 'DefaultBuild' is a project with debug support and optimisation level set to two.
- 'Debug' is a project built with the debugger support included. Optimisation is set to zero.
- 'Release' is a project with optimised compile options, producing code suitable for release in a product.

Some of the illustrative screenshots in this document will show text in the form RXxxx. These are general screenshots and are applicable across the whole RX family. In this case, simply substitute RXxxx for RX64M

> These tutorials are designed to show you how to use the RSK+ and are not intended as a comprehensive introduction to the CubeSuite+ debugger, compiler toolchains or the E1 emulator. Please refer to the relevant user manuals for more in-depth information.

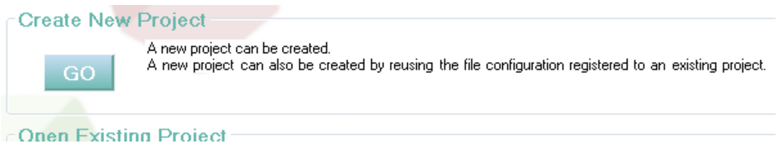
3. Project Creation with CubeSuite+

3.1 Introduction

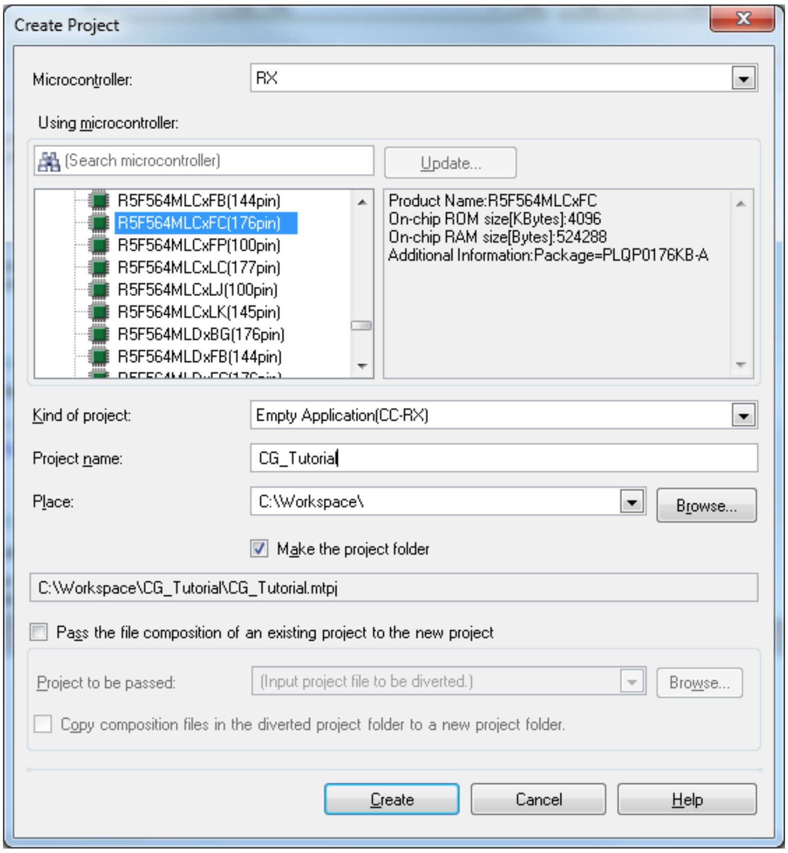
In this section the user will be guided through the steps required to create a new C project for the RX64M MCU, ready to generate peripheral driver code using Code Generator. This project generation step is necessary to create the MCU-specific project and debug files.

3.2 Creating the Project

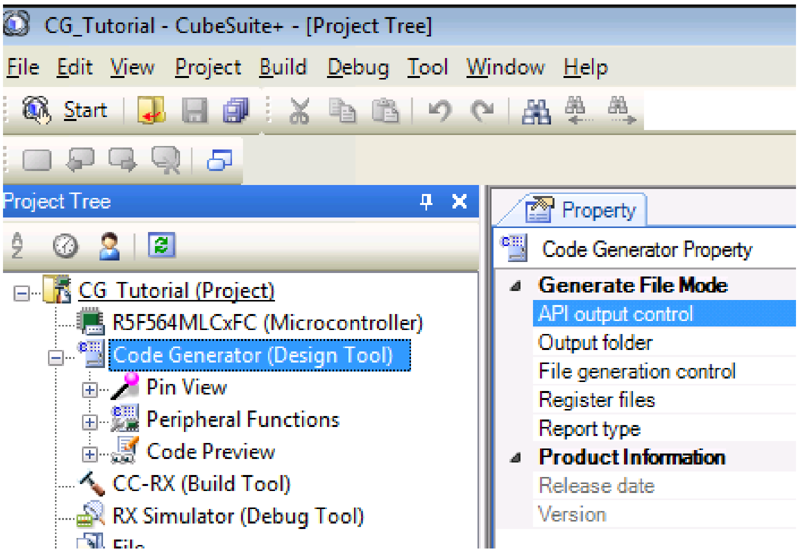
- Start Cubesuite+ by selecting it from the Start Menu. Cubesuite+ will show the Start Page. Use the 'GO' button to create a new project



- In the 'Create Project' dialog, select 'RX' from the 'Microcontroller' pull-down.
- In the 'Using Microcontroller' list control, scroll down to 'RX64M' and expand the tree control by clicking '+'. Select 'R5F564MLCxFC(176pin)'.
- Ensure that in the 'Kind of project' pull-down, 'Empty Application(CC-RX) is selected.
- Choose an appropriate name and location for the project, then click 'Create'.



- CubeSuite will create the project files and a 'Code Generator' node will be found in the left-hand 'Project Tree' window pane.



4.Code Generation Using the CubeSuite+ plug in

4.1 Introduction

Code Generator is a Windows™ GUI tool for generating template 'C' source code and project settings for the RX64M. When using Code Generator, the user is able to configure various MCU features and operating parameters using intuitive GUI controls, thereby bypassing the need in most cases to refer to sections of the Hardware Manual.

Once the user has configured the project, the 'Generate Code' function is used to generate three code modules for each specific MCU feature selected. These code modules are name 'r_cg_xxx.h', 'r_cg_xxx.c', and 'r_cg_xxx_user.c', where 'xxx' is a three letter acronym for the relevant MCU feature, for example 'adc'. Within these code modules, the user is then free to add custom code to meet their specific requirement. Custom code should be added, whenever possible, in between the following comment delimiters:

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

Code Generator will locate these comment delimiters, and preserve any custom code inside the delimiters on subsequent code generation operations. This is useful if, after adding custom code, the user needs to re-visit Code Generator to change any MCU operating parameters.

By following the steps detailed in this Tutorial, the user will generate a Cubesuite+ project called CG_Tutorial. The fully completed Tutorial project is contained on the DVD and may be imported into Cubesuite+ by following the steps in the Quick Start Guide. This Tutorial is intended as a learning exercise for users who wish to use the Code Generator to generate their own custom projects for Cubesuite+.

The CG_Tutorial project uses interrupts for switch inputs, the ADC module, the Compare Match Timer (CMT), the Serial Communications Interface (SCI) and uses these modules to perform A/D conversion and display the results via the Virtual COM port to a terminal program and also on the LCD display on the RSK+.

Following a tour of the key user interface features of Code Generator in §4.2, the reader is guided through each of the peripheral function configuration dialogs in §4.3. In §5, the reader is familiarised with the structure of the template code, as well as how to add their own code to the user code areas provided by the code generator.

4.2 Code Generator Tour

In this section a brief tour of Code Generator is presented. For further details of the Code Generator paradigm and reference, refer to the Application Leading Tool Common Operations manual (r20ut2663ej0100_Code Generator.pdf). Application Leading Tool is the stand-alone version of Code Generator and this manual is

In the Project Tree pane, expand the 'Code Generator' node and double-click the 'Peripheral Functions' node. The CubeSuite+ main window will now contain a 'Peripheral Functions' tab with the Initial View as show in Figure 4-1.

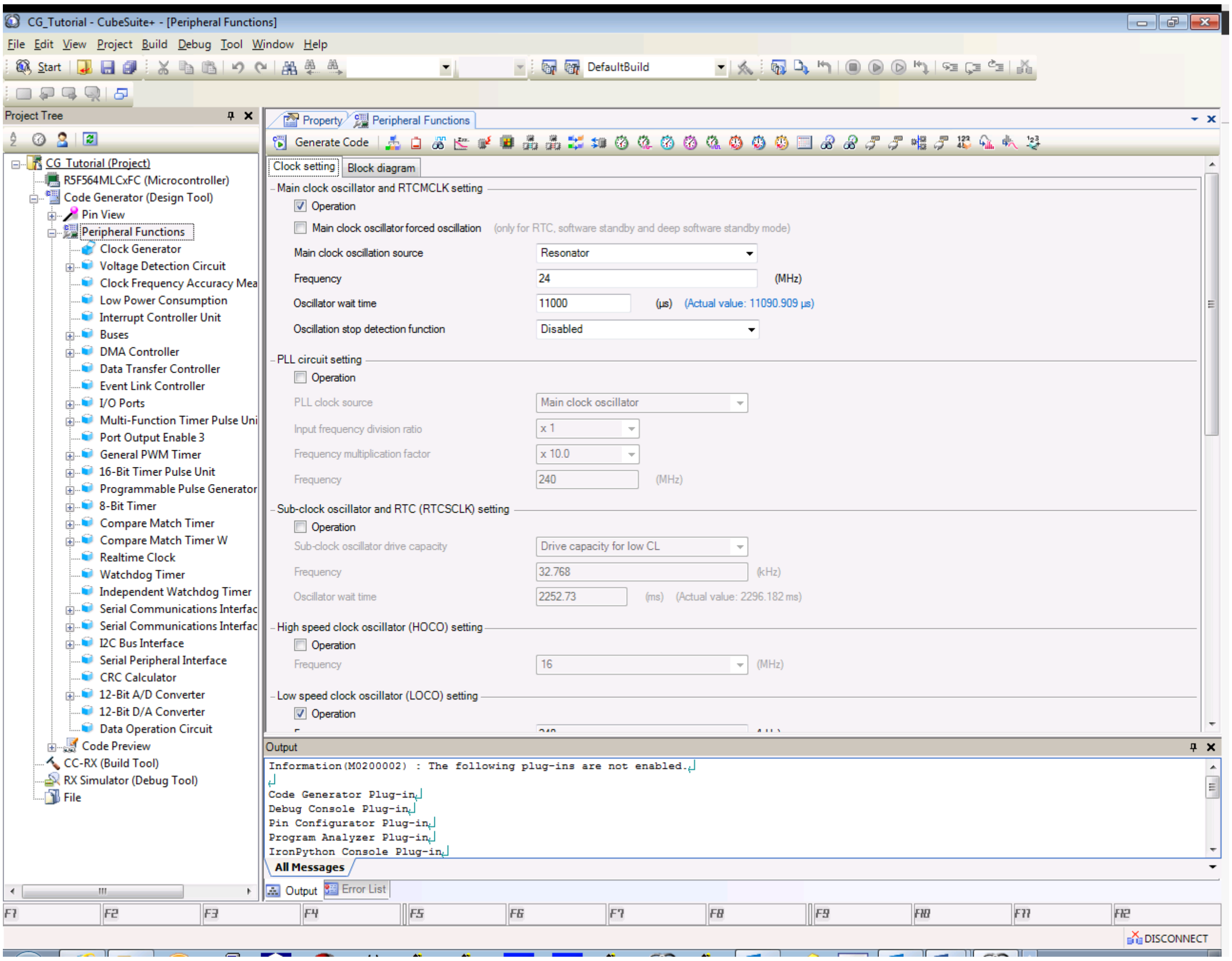


Figure 4-1 Initial View

Code Generator provides GUI features for configuration of MCU sub systems. Once the user has configured all required MCU sub systems and peripherals, the user can click the ‘Generate Code’ button, resulting in a fully configured CubeSuite+ project that builds and runs without error.

Navigation to the MCU peripheral configuration screens may be performed by double-clicking the required function in the Project Tree -> Project Name -> Peripheral Function on the left.

It is also possible to see a preview of the code that will be generated for the current peripheral function settings by double-clicking the required function in the Project Tree -> Project Name -> Code Preview on the left.

4.3 Code Generation

In the following sub-sections, the reader is guided through the steps to configure the MCU for a simple project containing interrupts for switch inputs, timers, ADC and a UART.

4.3.1 Clock Generator

Figure 4-2 shows a screenshot of Code Generator with the Clock Generator function open. Click on the ‘Clock setting’ sub tab. Configure the system clocks as shown in the figure. In this tutorial we are using the on board 24 MHz crystal resonator for our main clock oscillation source and the PLL circuit is in operation. The PLL output is used as the main system clock and the divisors should be set as shown in Figure 4-2.

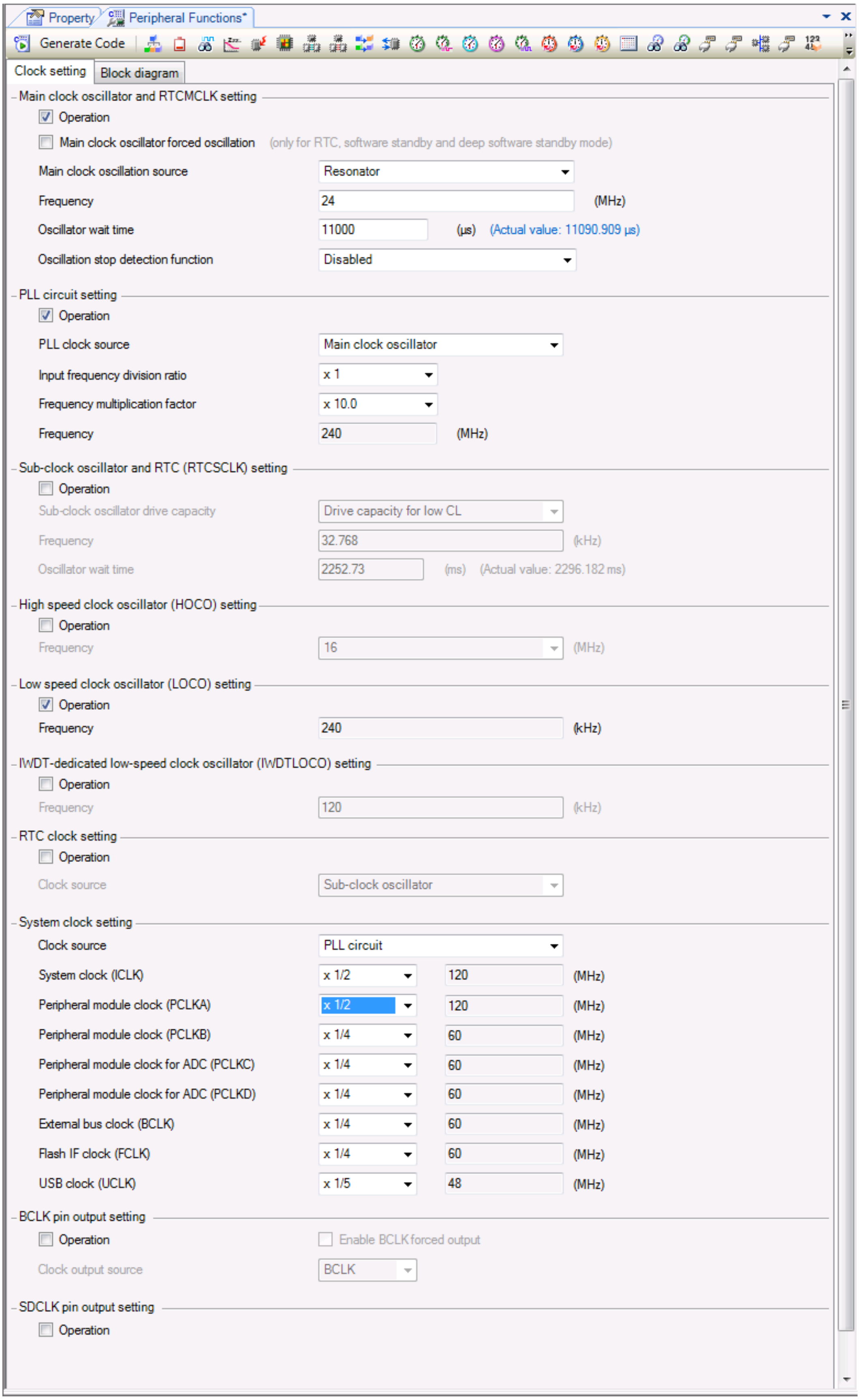


Figure 4-2 Clock setting tab

Proceed to the next section on Interrupt

4.3.1 Interrupt Controller Unit

Referring to the RSK+ schematic, SW1 is connected to IRQ5 (P15) and SW2 is connected to IRQ2 (P12). SW3 is connected to directly to the ADCTRG0n and will be configured later in §4.3.3. Navigate to the 'Interrupt Controller Unit' node in Code Generator and in the 'General' tab, configure these two interrupts as falling edge triggered as shown in Figure 4-3 below.

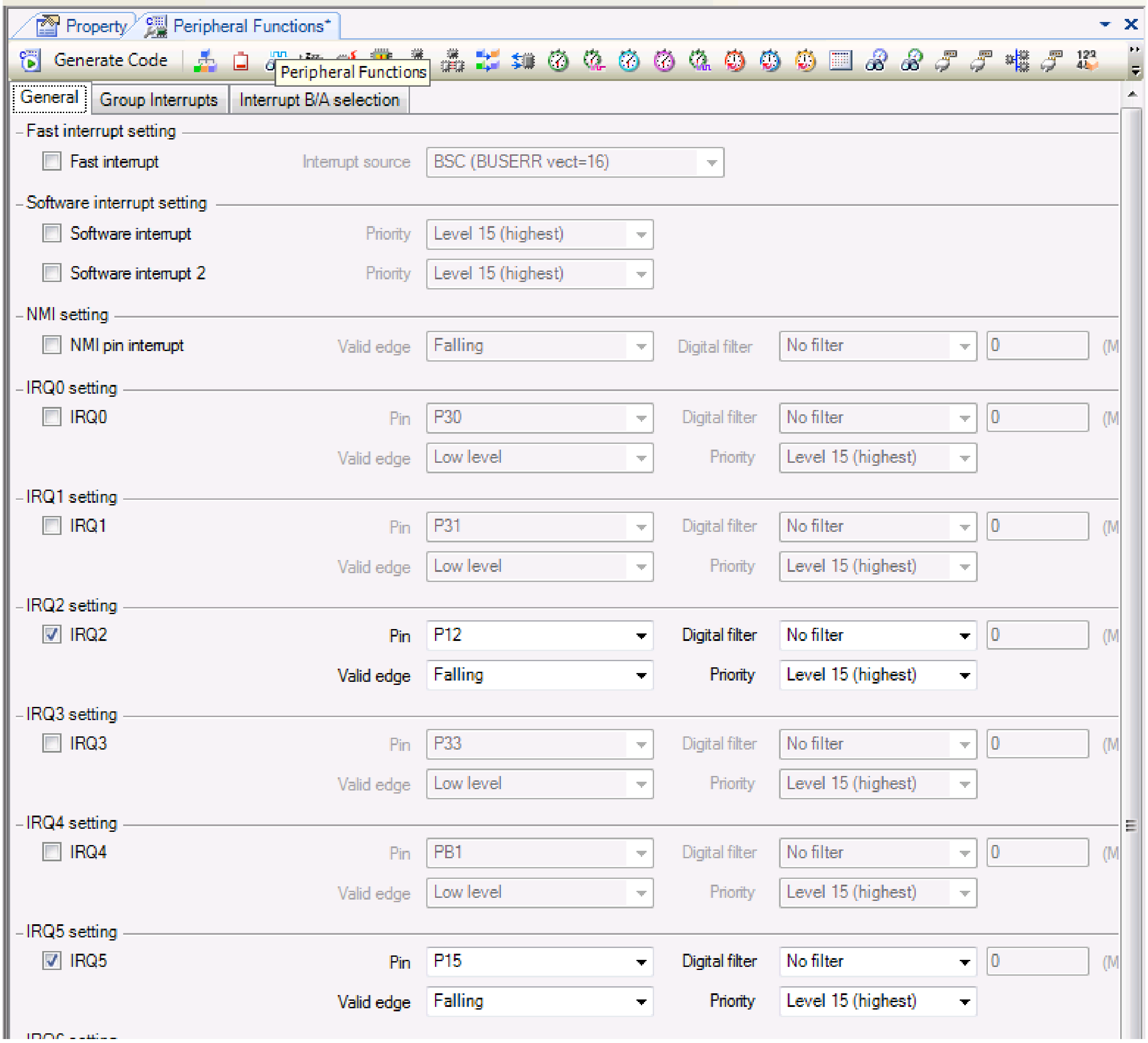


Figure 4-3 Interrupt Functions tab

Navigate to the 'Group Interrupts' sub tab and ensure that the 'Group BL0' interrupt is selected as shown in Figure 4-4. The Group BL0 interrupt is used for SCI Transmit End Interrupts (TEI) and Reception Error Interrupts (ERI) as described in §4.3.4.

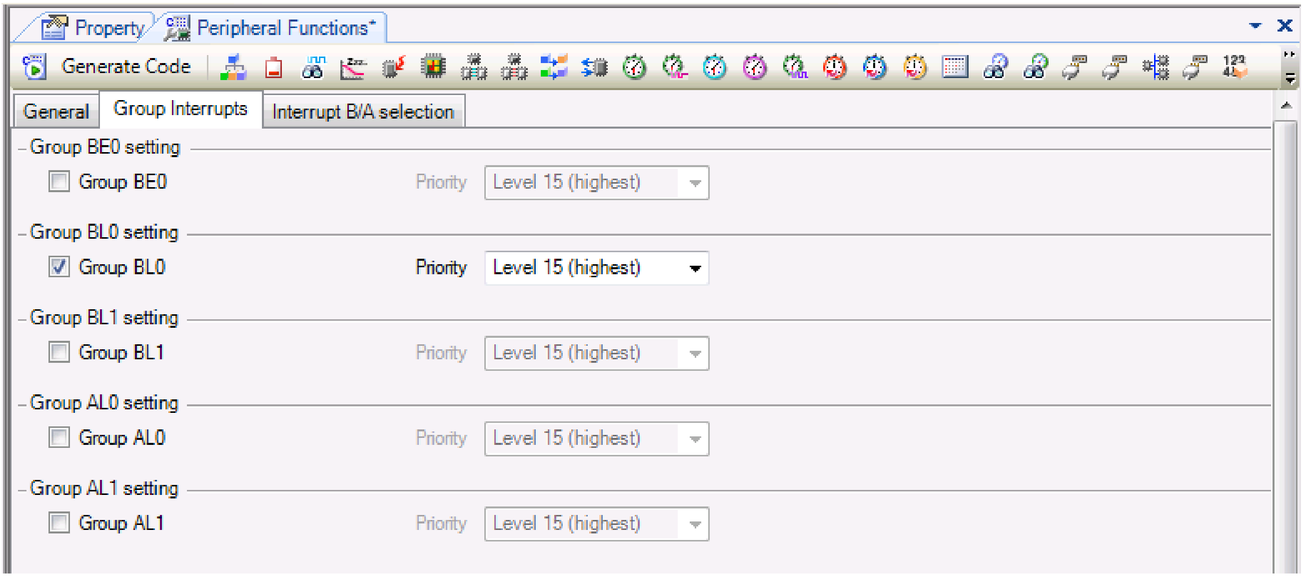


Figure 4-4 Group Interrupt Functions tab

4.3.2 Compare Match Timer

Navigate to the 'Compare Match Timer' node in Code Generator. CMT0 will be used as an interval timer for generation of accurate delays. CMT1 and CMT2 will be used as timers in de-bouncing of switch interrupts.

In the 'CMT0' sub-tab configure CMT0 as shown in Figure 4-5. This timer is configured to generate a High priority interrupt every 1ms. We will use this interrupt later in the tutorial to provide an API for generating high accuracy delays required in our application.

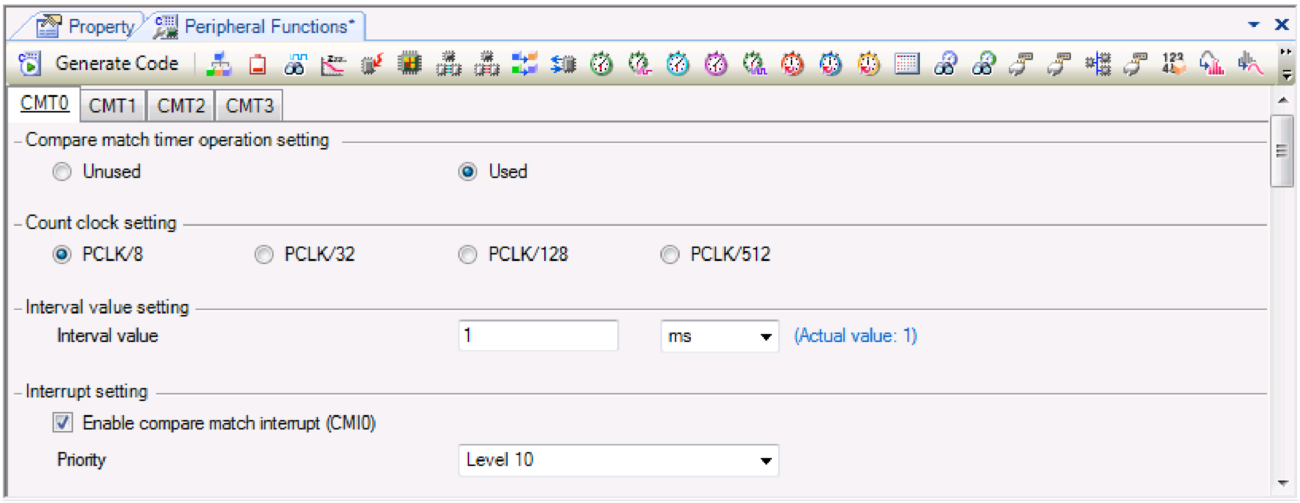


Figure 4-5 CMT0 tab

Navigate to the 'CMT1' sub-tab and configure CMT1 as shown in Figure 4-6. This timer is configured to generate a High priority interrupt after 20ms. This timer is used as our short switch de-bounce timer later in this tutorial.

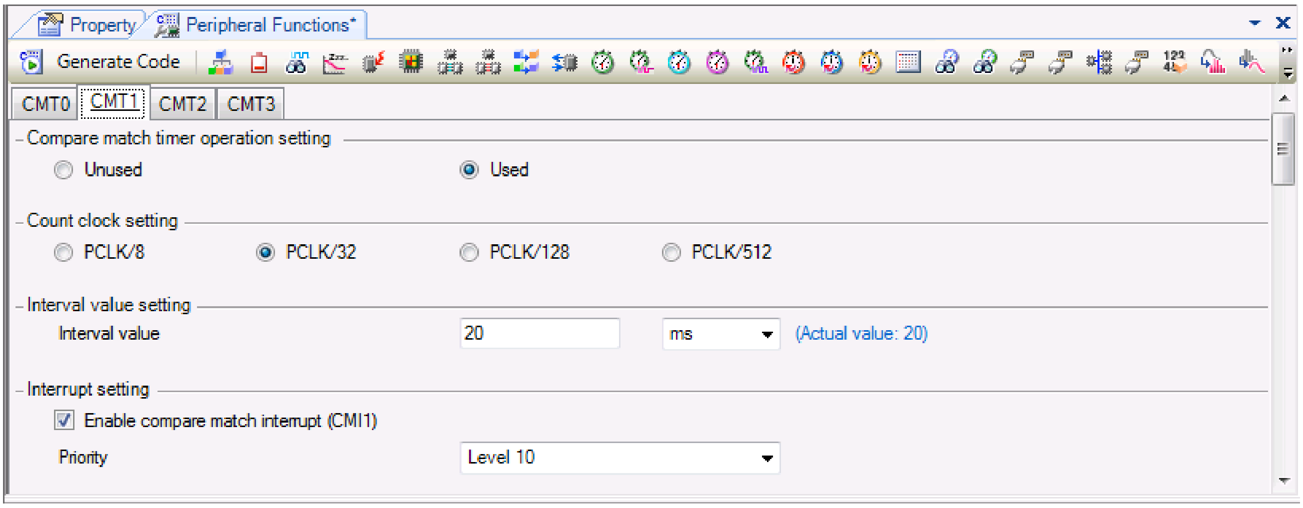


Figure 4-6 CMT1 tab

Navigate to the 'CMT2' sub-tab and configure CMT2 as shown in Figure 4-7. This timer is configured to generate a High priority interrupt after 200ms. This timer is used as our long switch de-bounce timer later in this tutorial.

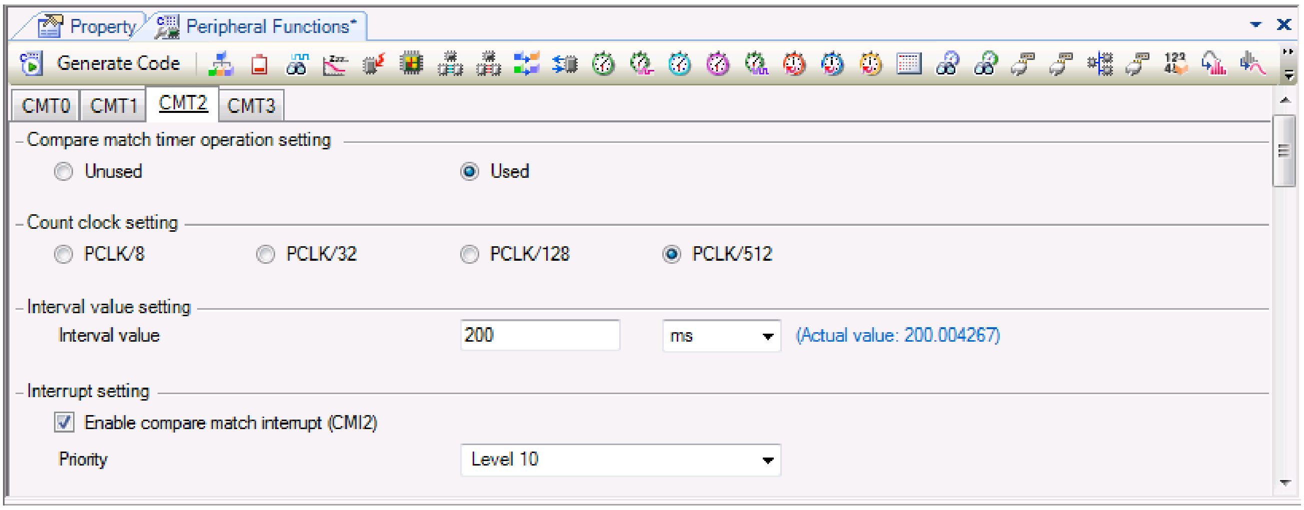


Figure 4-7 CMT2 tab

4.3.3 12-bit A/D Converter

Navigate to the '12-bit A/D Converter' tab in Code Generator. Refer to the screenshot shown in Figure 4-8 and configure the S12AD0 as shown. We will be using the S12AD0 in 12-bit one shot mode on the AN000 input, which is connected to the RV1 potentiometer output on the RSK+. The conversion start trigger will be via the pin connected to SW3.

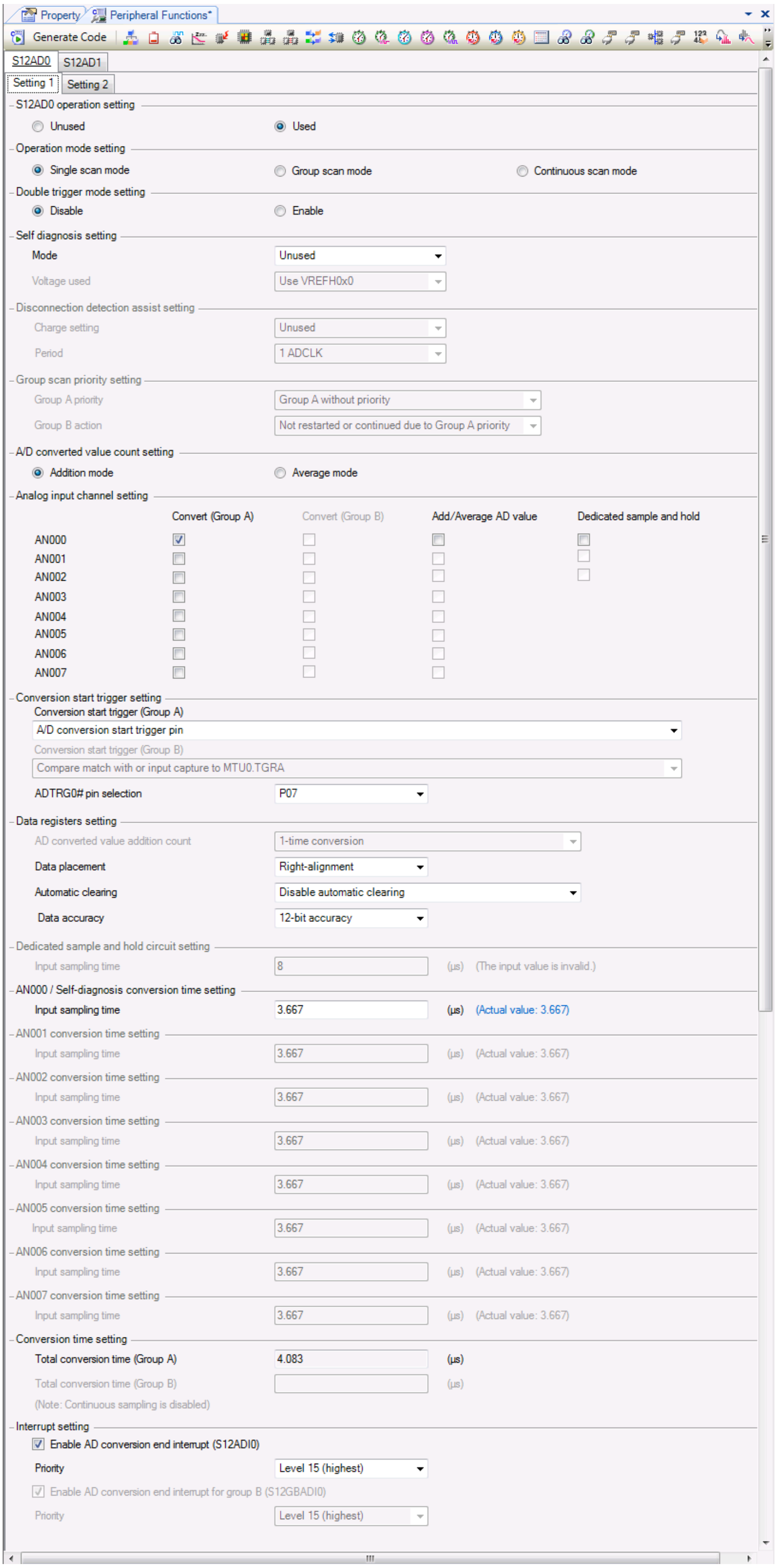


Figure 4-8 A/D Converter tab

4.3.4 Serial Communications Interface

Navigate to the ‘Serial Communications Interface’ tab in Code Generator, select the SCI6 sub-tab and apply the settings shown in Figure 4-9. In the RSK+RX64M SCI6 is used as an SPI master for the Okaya Pmod™ LCD on the PMOD1 connector as shown in the schematic.

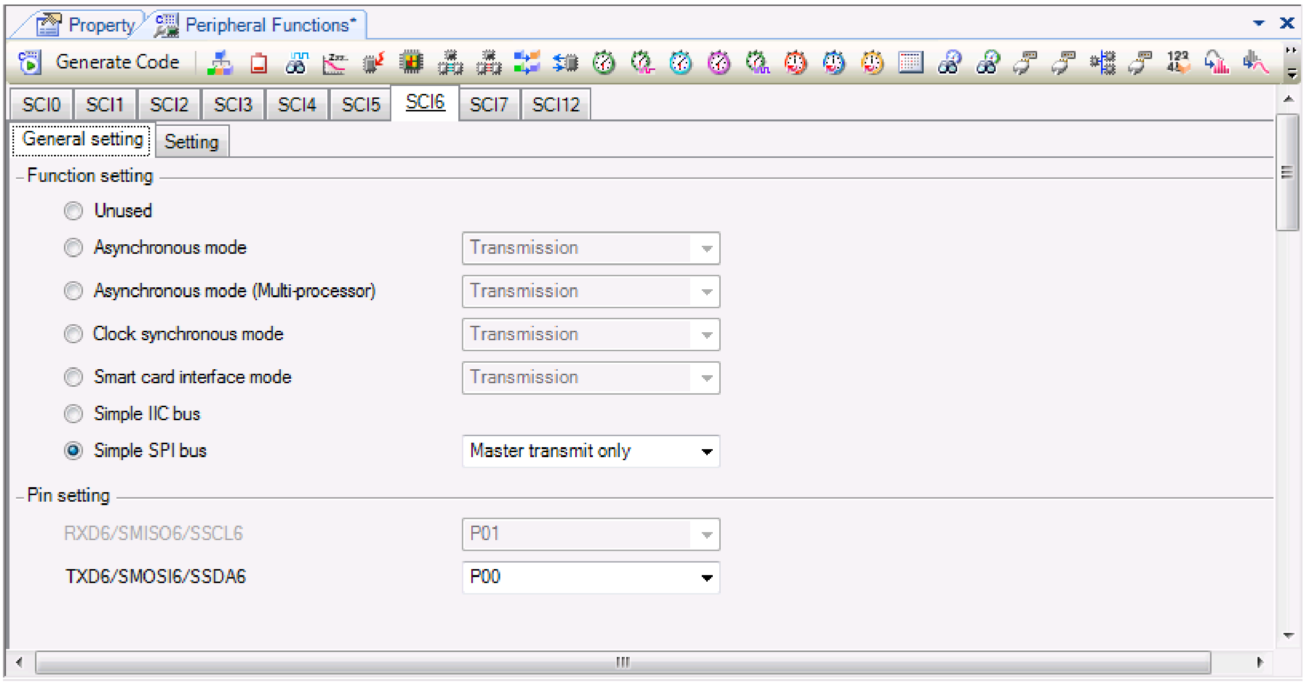


Figure 4-9 SCI6 General Setting tab

Select the SCI6 ‘Setting’ sub-tab and configure the SPI Master as illustrated in Figure 4-10. Make sure the ‘Transfer direction setting’ is set to ‘MSB-first’ and the ‘Bit rate’ is set to 1500000. All other settings remain at their defaults.

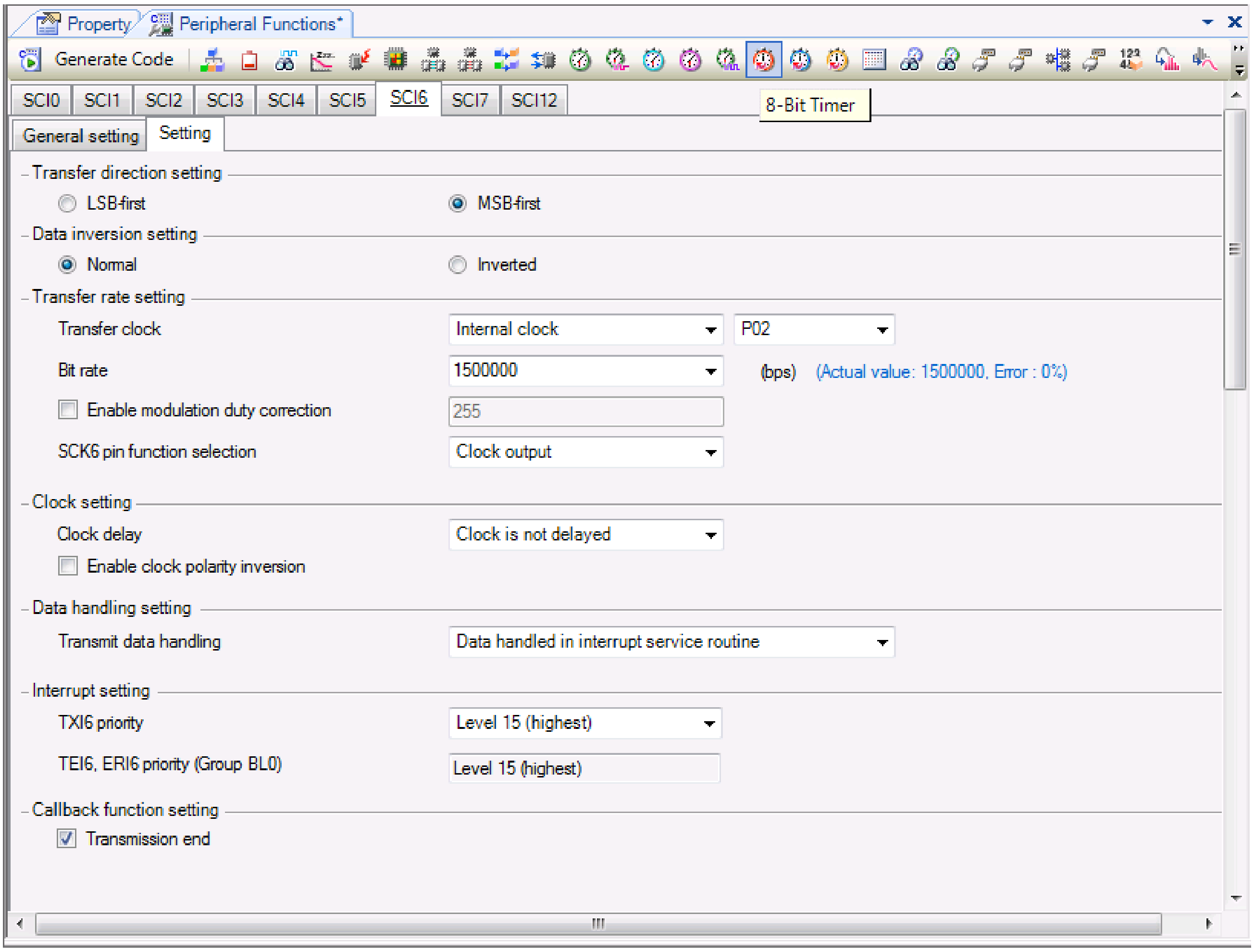


Figure 4-10 SCI6 SPI Master Setting

Staying in the 'Serial Communications Interface' tab in Code Generator, select the SCI7 sub-tab and apply the settings shown in Figure 4-11. In the RSK+RX64M SCI7 is connected via a Renesas RL78/G1C to provide a USB virtual COM port as shown in the schematic.

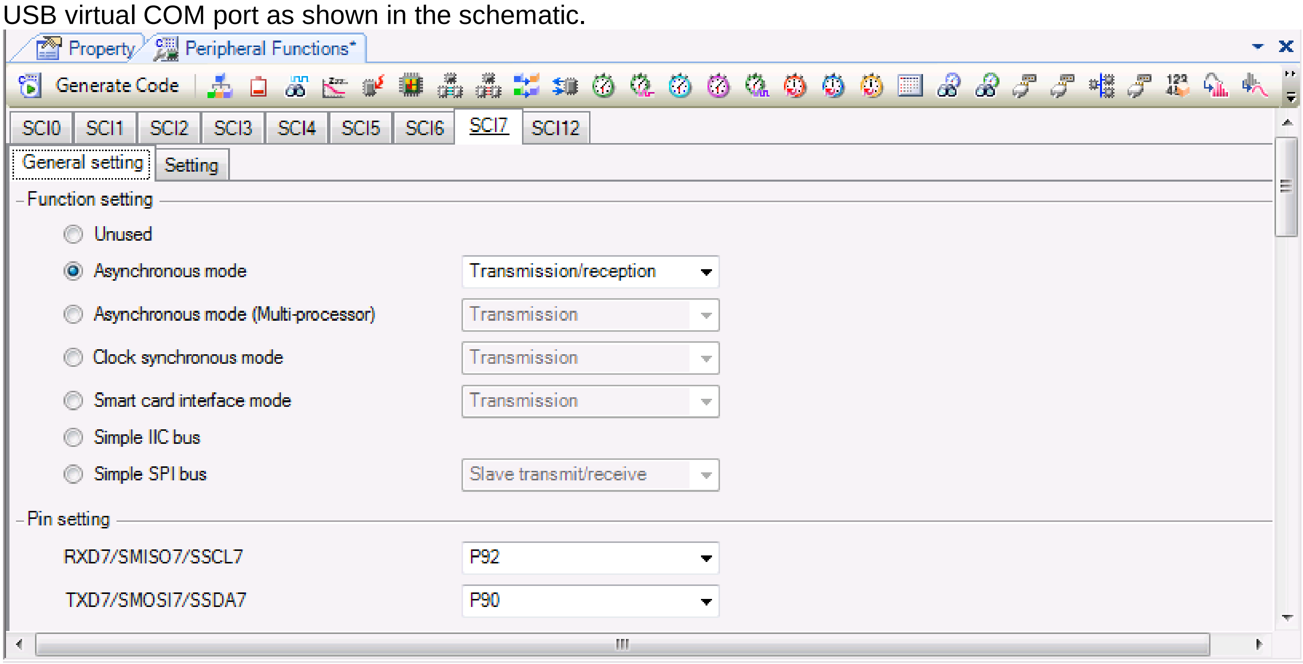


Figure 4-11 SCI7 General Setting tab

Select the SCI7 'Setting' sub-tab and configure SCI7 as illustrated in Figure 4-12. Make sure the 'Start bit edge detection' is set as 'Falling edge on RXD7 pin' and the 'Bit rate' is set to 19200 bps. All other settings remain at their defaults.

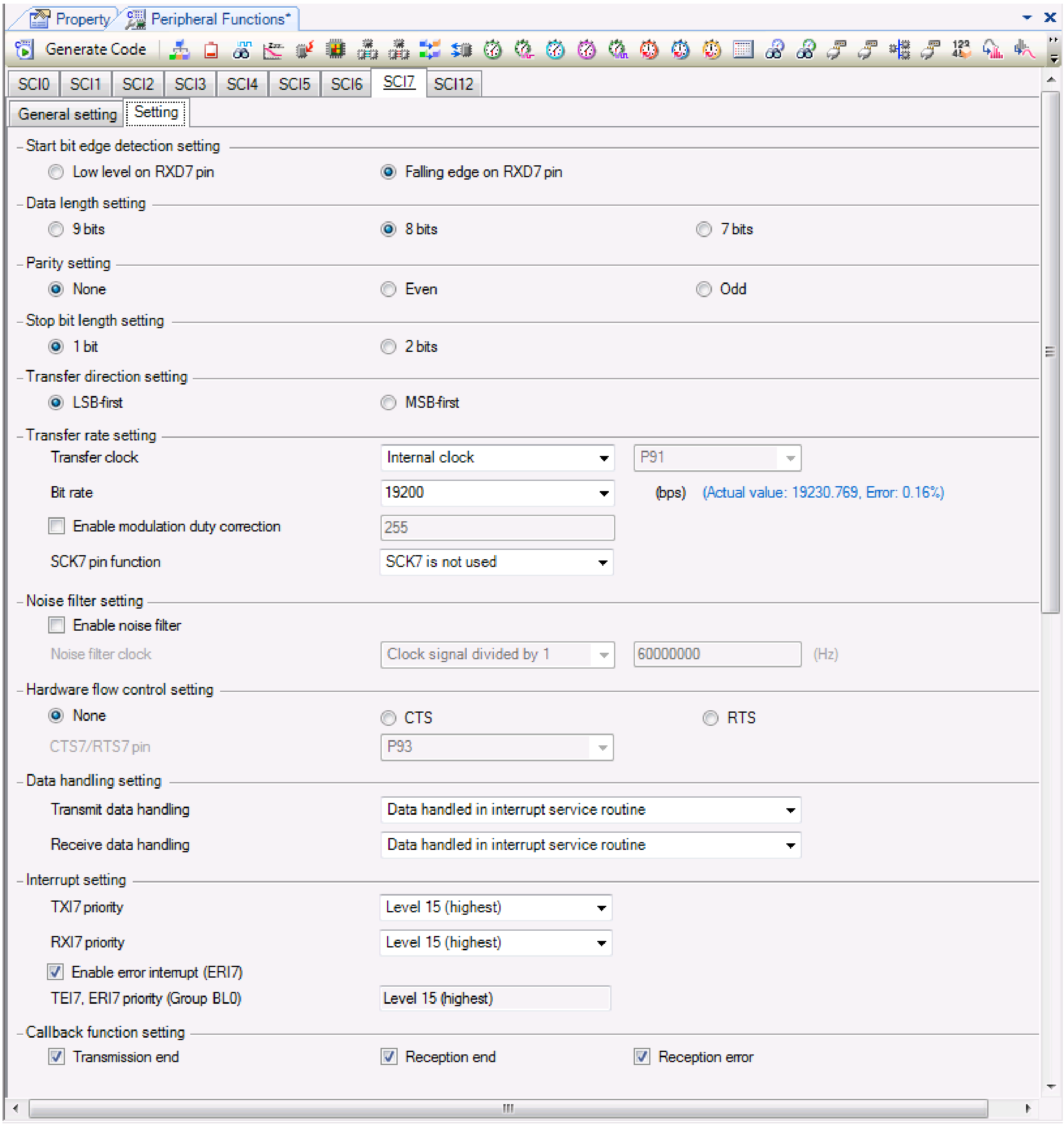


Figure 4-12 SCI7 Asynchronous Setting

4.3.5 I/O Ports

Referring to the RSK+ schematic, LED0 is connected to P03, LED1 is connected to P05, LED2 is connected to P26 and LED3 is connected to P27. Navigate to the 'I/O Ports' tab in Code Generator and configure these four I/O lines as shown in Figure 4-13 and Figure 4-14 below. Ensure that the 'Output 1' tick box is checked. This ensures that the code is generated to set LEDs initially off.

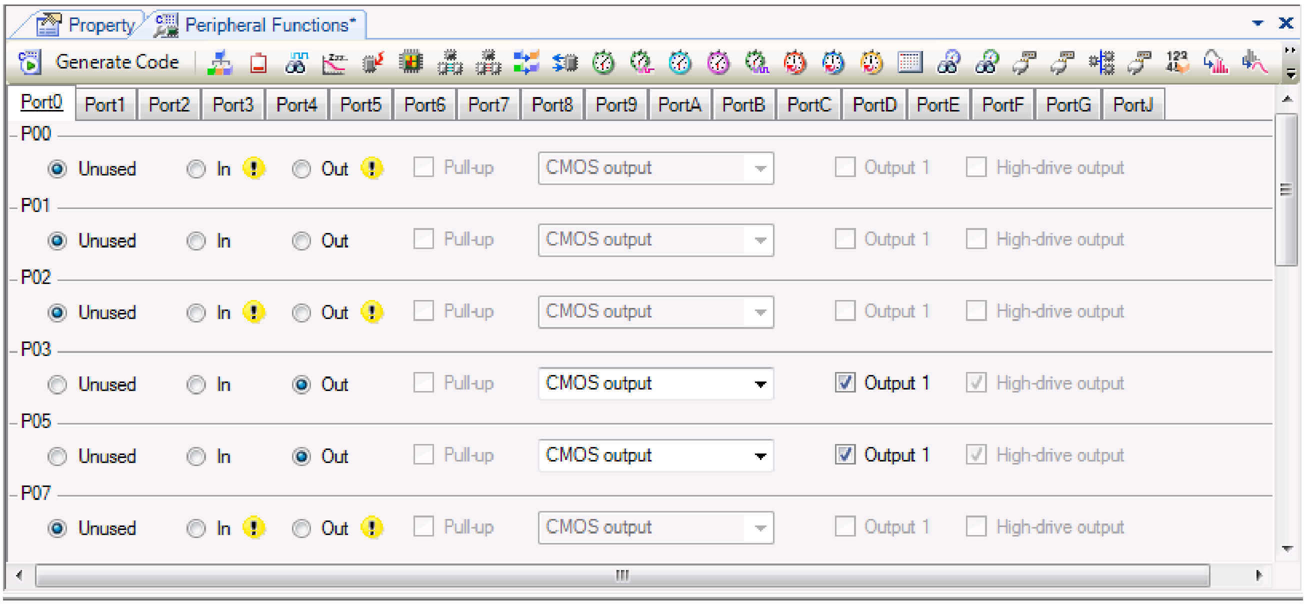


Figure 4-13 I/O ports – Port0

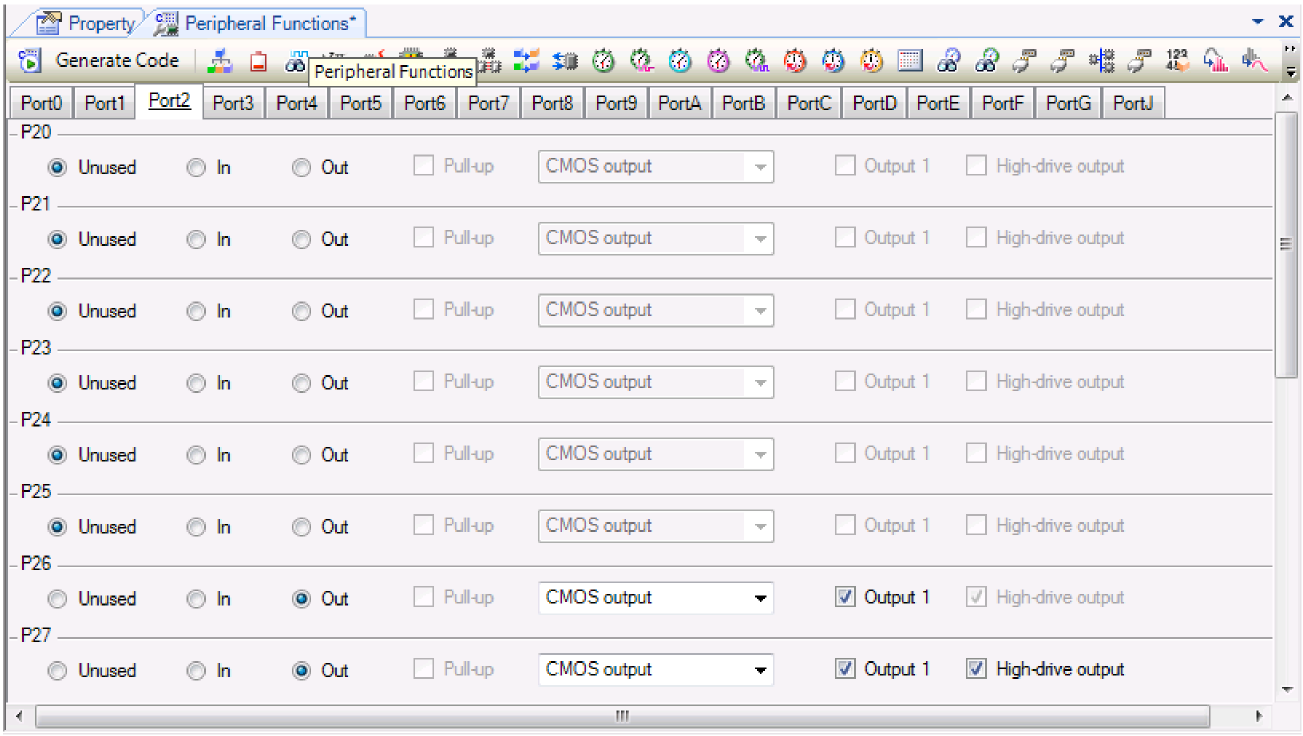


Figure 4-14 I/O ports – Port2

P45 is used as one of the LCD control lines, together with P46 and P47. Configure these lines as shown in Figure 4-15.

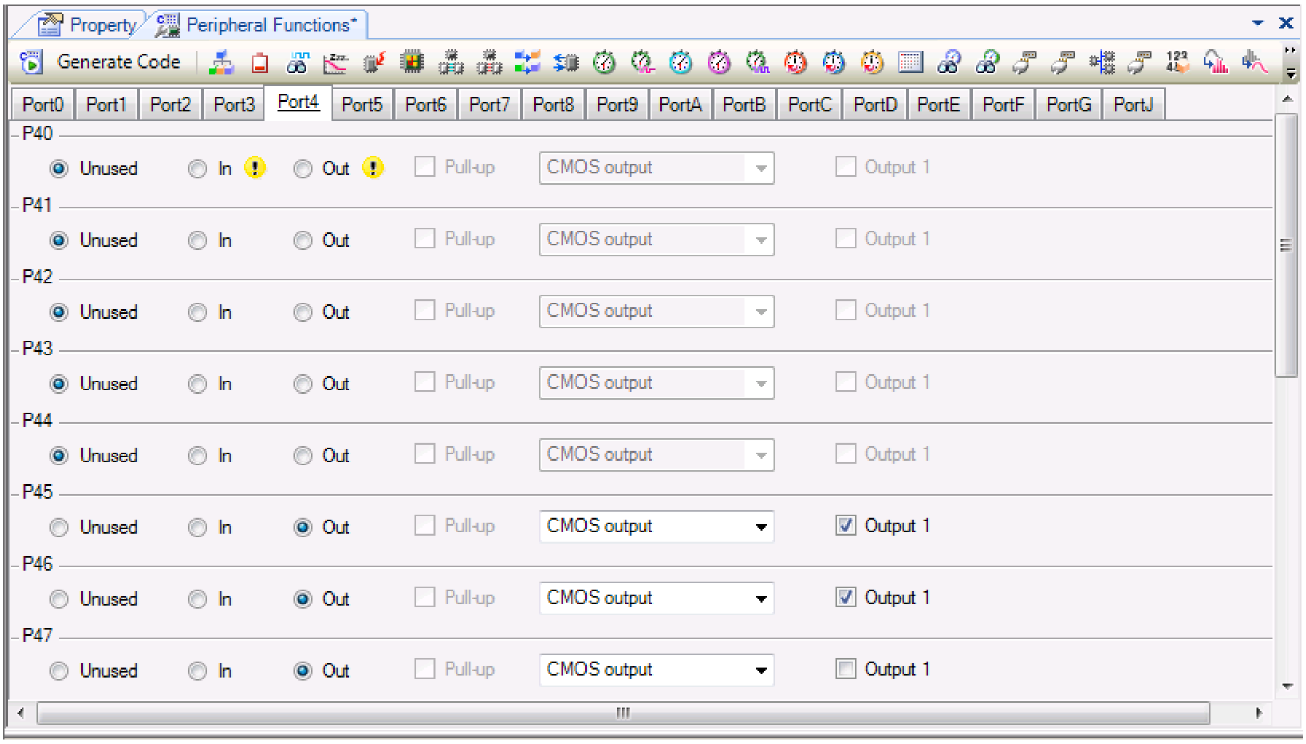


Figure 4-15 I/O ports – Port4

Peripheral function configuration is now complete. Save the project using the File -> Save Project menu item, then click 'Generate Code'. The Output pane should report 'The operation of generating file was successful', as shown Figure 4-16 below.

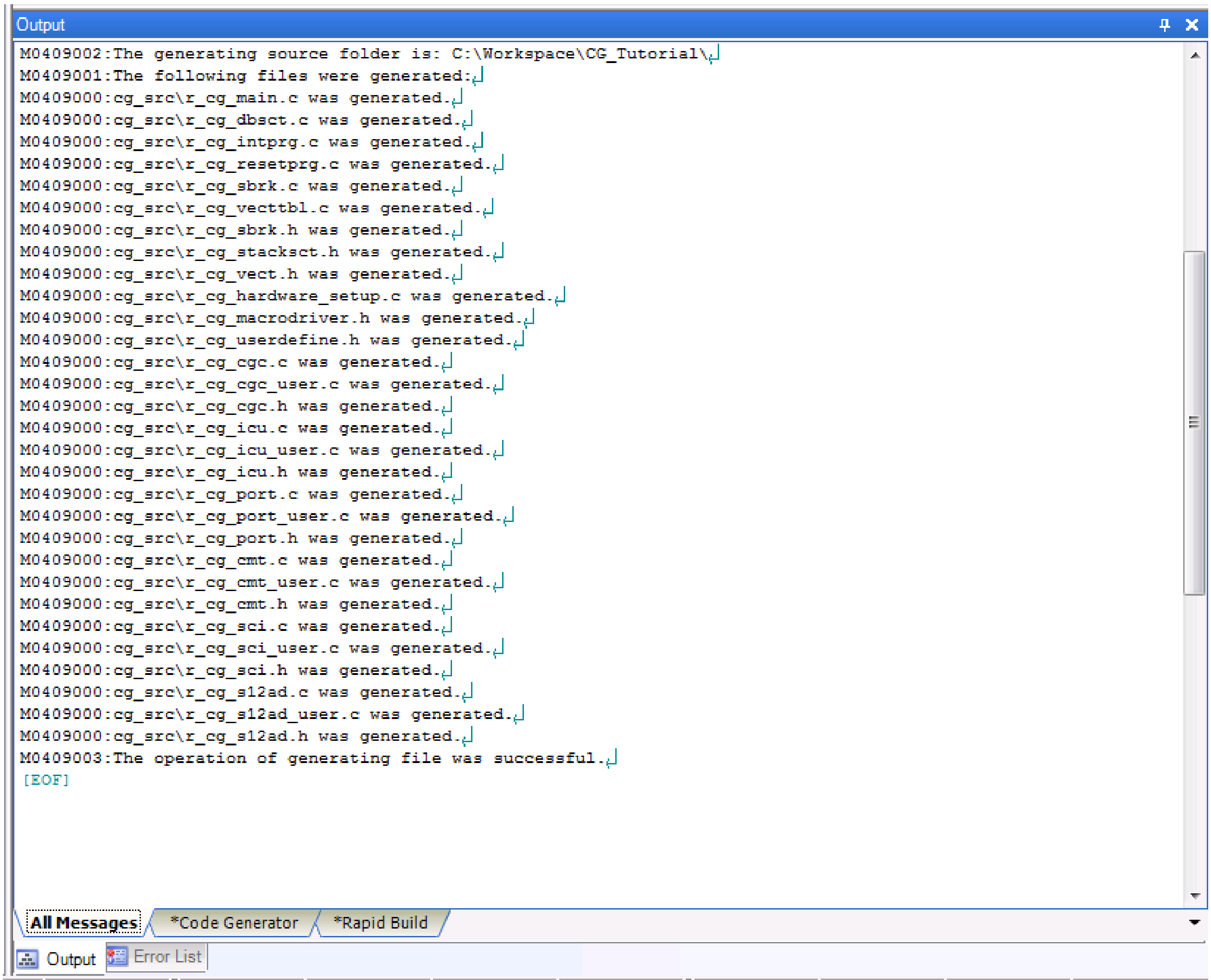


Figure 4-16 Code generator console

Figure 4-17 shows the Code Generator Files in the Project Tree pane. In the next section the CG_Tutorial project will be completed by adding user code into these files and adding new source files to the project.

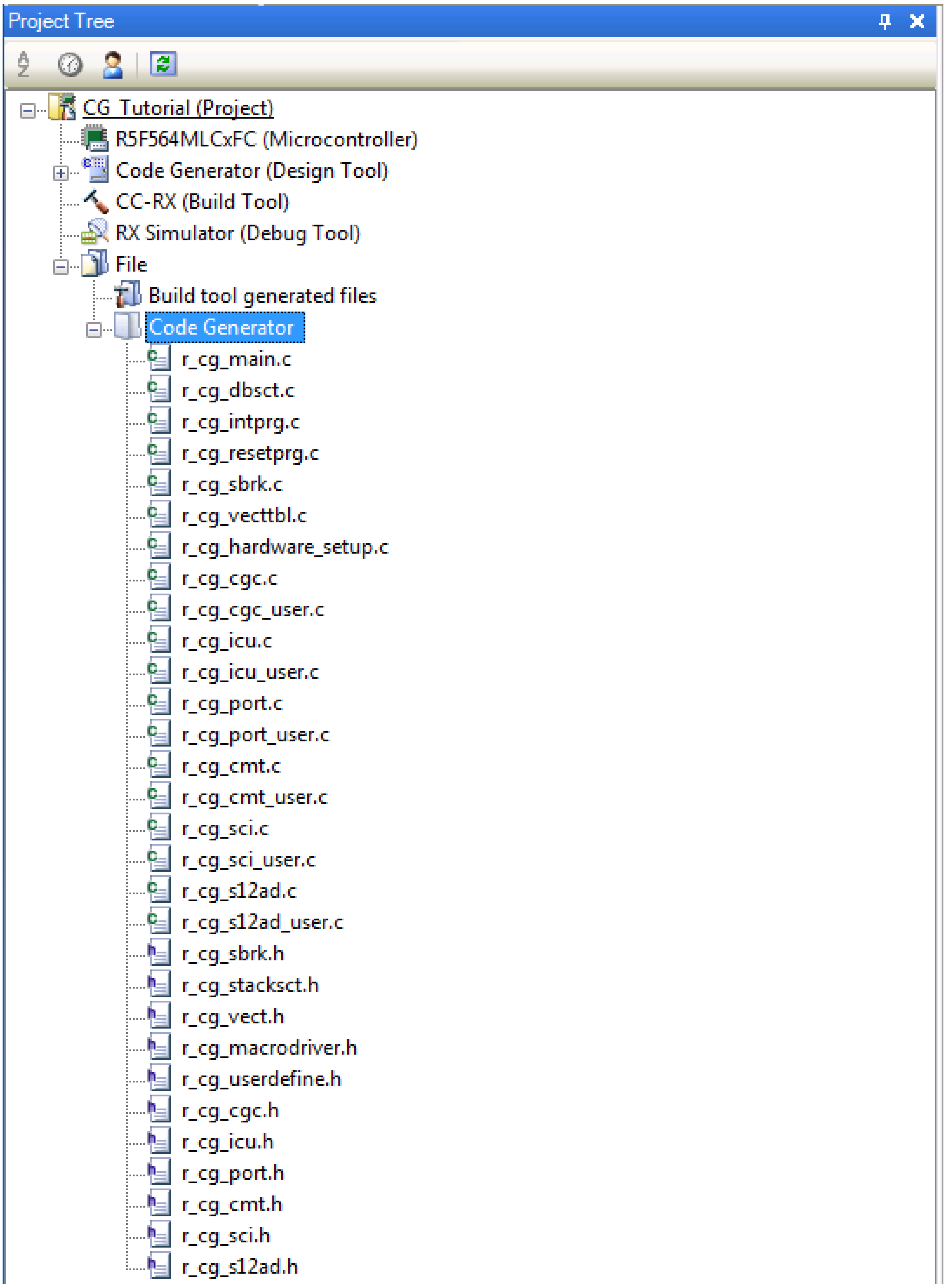
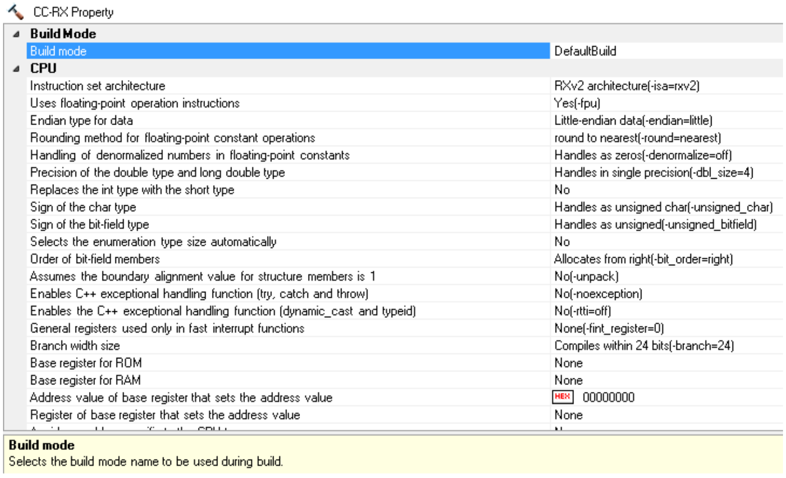


Figure 4-17 Code Generator Files in the Project Tree

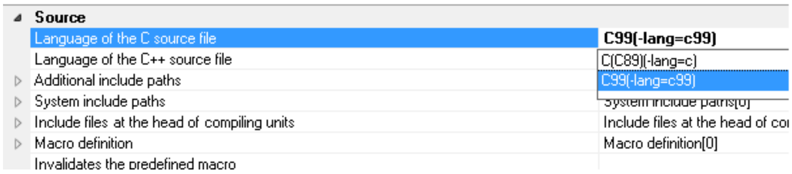
5. Completing the Tutorial Project

5.1 Project Settings

- In the 'Project Tree' pane, select 'CC-RX (Build Tool)'. The build properties will appear in the main window.
- CubeSuite+ creates a single build configuration called 'Default Build' for the project. This has standard code optimisation turned on by default.

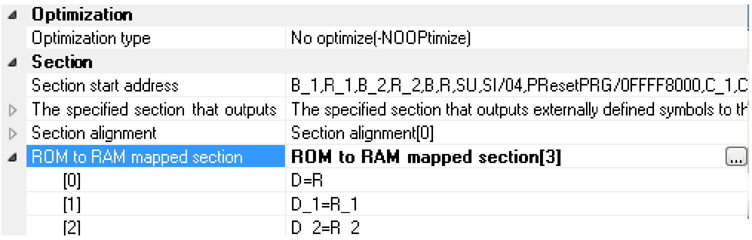


- Select the 'Compile Options' tab at the bottom of the properties window pane. Under 'Language of the C source file' select 'C99(-lang=c99)' as shown opposite.



- Select the 'Link Options' tab at the bottom of the properties window pane. Under 'Section -> ROM to RAM mapped section', add the three mappings as shown opposite.

.



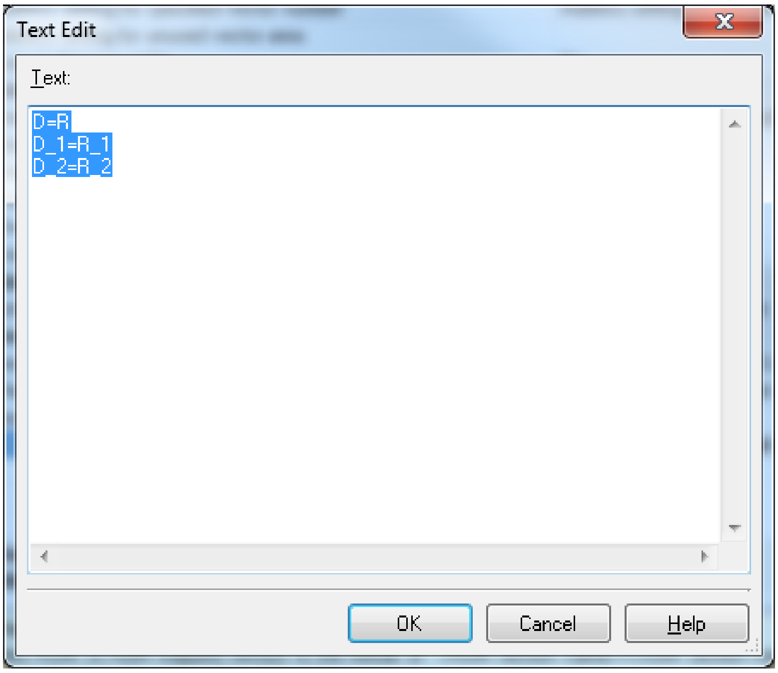
- These settings are easily added by clicking the button '…' and pasting the following text into the dialog:

D=R

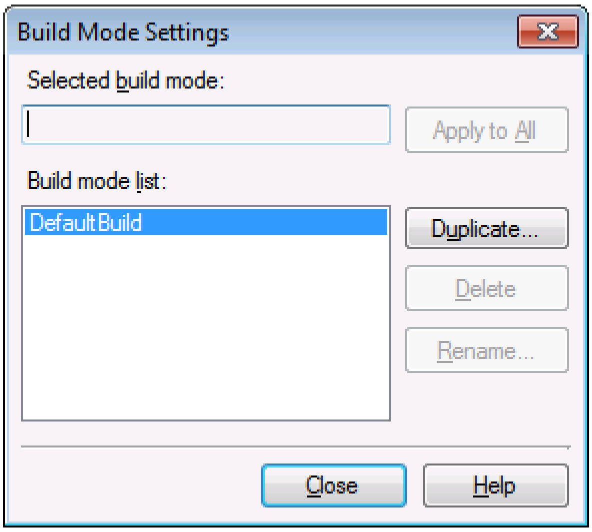
D_1=R_1

D_2=R_2

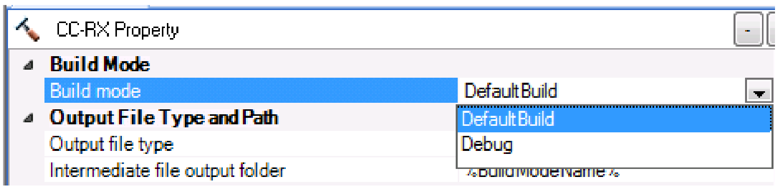
- This ensures that the linker assigns RAM rather than ROM addresses to C variables.



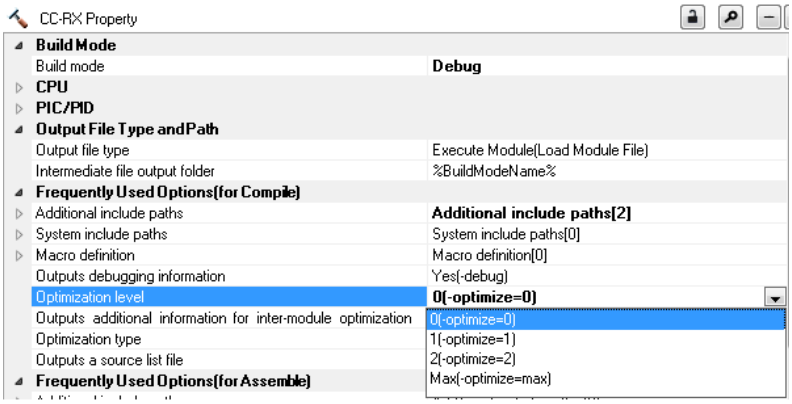
- From the 'Build' menu, select 'Build Mode Settings…'. Click 'Duplicate' and in the resulting 'Character String Input' dialog, enter 'Debug' for the name of the duplicate build mode.



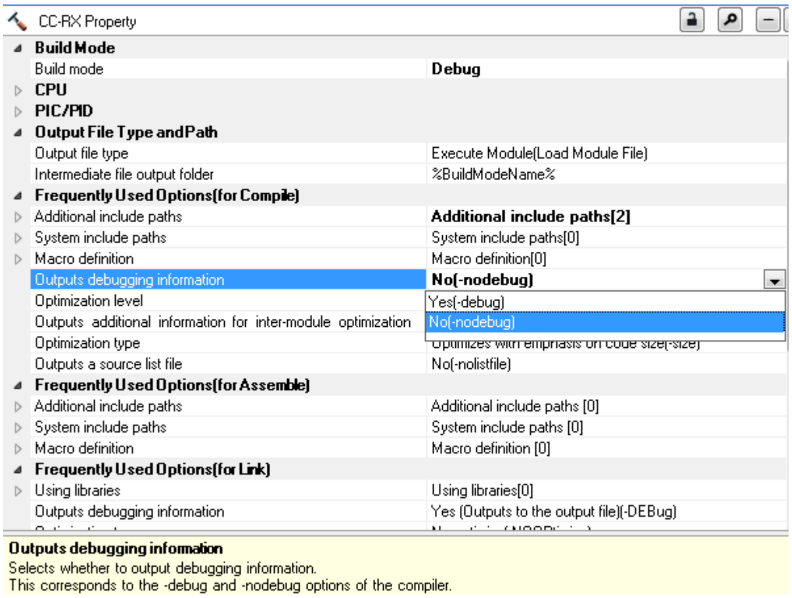
- The new 'Debug' build mode will be added to the Build mode list. Click 'Close'. Now, in the main CC-RX Property window, under the 'Common Options' tab, click on the line containing 'Build Mode', click the pull-down arrow and select 'Debug' from the pull-down'.



- In the ‘Frequently Used Options (for Compile)’ group, select the ‘Optimization Level’ option and select ‘0’ from the pull-down. We have now created a ‘Debug’ build mode with no code optimisation and will be using the Build mode to create and debug the project.

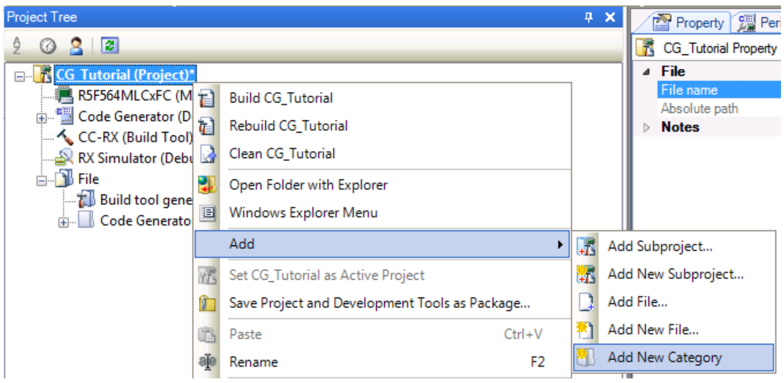


- All of the sample code projects contained in this RSK are configured with three Build modes; ‘DefaultBuild’, ‘Debug’ and ‘Release’. ‘Release’ is created in the same way as above; by duplicating ‘Default Build’. ‘Release’ build mode leaves code optimisation turned on and removes debug information from the output file.
- To remove debug information from the ‘Release’ build mode, in the ‘CC-RX Property’ window, select the ‘Common Options’ tab at the bottom of the window pane. For the ‘Outputs debugging information’ option, select ‘No(-nodebug).
- Reset the build mode back to ‘Debug’ using the ‘Build Mode’ pull-down control.
- From the menus, select ‘File -> Save All’ to save all project settings.

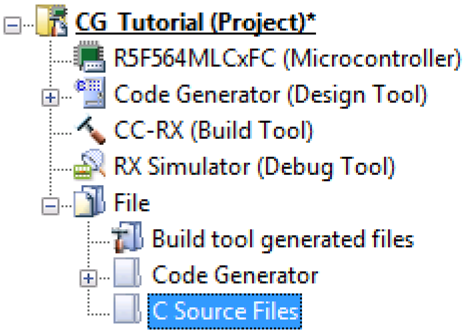


5.2 Additional Folders

- Before new source files are added to the project, we will create two additional folders in the CubeSuite+ Project Tree.
- In the Project Tree pane, right-click the CG_Tutorial project and select ‘Add -> Add New Category’.



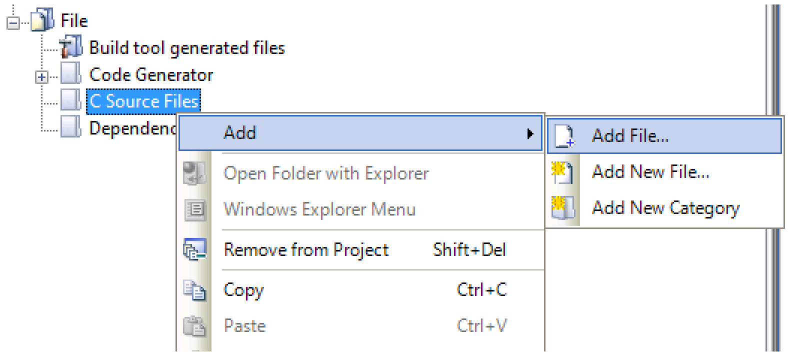
- Rename the newly-created 'New Category' folder to 'C Source Files'. Repeat these steps to create a new category folder for 'Dependencies'.



5.3 LCD Code Integration

API functions for the Okaya LCD display are provided with the RSK+. Locate the files ascii.h , r_okaya_lcd.h, ascii.c, and r_okaya_lcd.c on the RSK+ DVD. These files can be found in the RSK+RX64M_Tutorial project for CubeSuite+ in the 'Tutorial' folder. Copy these files into the C:\Workspace\CG_Tutorial folder.

- Right-click on the 'C Source Files' in the Project Tree and select 'Add -> Add File…'.
- Browse to the files ascii.c, and r_okaya_lcd.c in the C:\Workspace\CG_Tutorial folder and click 'Add'.
- Repeat the above steps to add the files ascii.h , r_okaya_lcd.h to the 'Dependencies' folder.



Code must be inserted in to the user code area in many files in this project, in the areas delimited by comments as follows:

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

Where _xxxx_ depends on the particular area of code, i.e. 'function' for insertion of user functions and prototypes, 'global' for insertion of user global variable declarations, or 'include' for insertion of pre-processor include directives. User code inserted inside these comment delimiters is protected from being overwritten by Code Generator, if the user needs to subsequently change any of the Code Generator-generated code.

In the Cubesuite+ Project Tree, expand the 'Code Generator' folder and open the file 'r_cg_userdefine.h' by double-clicking on it. Insert the following #defines in between the user code delimiter comments as shown below.

```
/* Start user code for global. Do not edit comment generated here */
#define TRUE            (1)
#define FALSE           (0)
/* End user code. Do not edit comment generated here */
```

In the Cubesuite+ Project Tree, open the file 'r_cg_main.c' by double-clicking on it. Insert #include "r_okaya_lcd.h" in between the user code delimiter comments as shown below.

```
/* Start user code for include. Do not edit comment generated here */
#include "r_okaya_lcd.h"
/* End user code. Do not edit comment generated here */
```

Scroll down to the 'main()' function and insert the highlighted code as shown below into the beginning of the user code area of the main() function:

```
void main(void)
{
    R_MAIN_UserInit();
    /* Start user code. Do not edit comment generated here */

    /* Initialise the debug LCD */
    R_LCD_Init();

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSK+RX64M ");
    R_LCD_Display(1, (uint8_t *)" Tutorial ");
    R_LCD_Display(2, (uint8_t *)" Press Any Switch ");
    while (1U)
    {
        ;
    }
    /* End user code. Do not edit comment generated here */
}
```

5.3.1 SPI Code

The Okaya LCD display is driven by the SPI Master that was configured using Code Generator in §4.3.4. In the Cubesuite+ Project Tree, open the file 'r_cg_sci.h' by double-clicking on it. Insert the following code in the user code area at the end of the file:

```
/* Start user code for function. Do not edit comment generated here */
MD_STATUS R_SCI6_SPIMasterTransmit(uint8_t * const tx_buf, const uint16_t tx_num);
/* End user code. Do not edit comment generated here */
```

Now, open the r_cg_sci_user.c file and insert the following code in the user area for global:

```
/* Start user code for global. Do not edit comment generated here */
/* Flag used locally to detect transmission complete */
static volatile uint8_t sci6_txdone;
/* End user code. Do not edit comment generated here */
```

Insert the following code in the transmitend call-back function for SCI6:

```
static void r_sci6_callback_transmitend(void)
{
    /* Start user code. Do not edit comment generated here */
    sci6_txdone = TRUE;
    /* End user code. Do not edit comment generated here */
}
```

Now insert the following function in the user code area at the end of the file:

```
/*******************************************************************************
* Function Name: R_SCI6_SPIMasterTransmit
* Description  : This function sends SPI6 data to slave device.
* Arguments    : tx_buf -
*                    transfer buffer pointer
*                tx_num -
*                    buffer size
* Return Value : status -
```

```
*                     MD_OK or MD_ARGERROR
**********************************************************************************/
MD_STATUS R_SCI6_SPIMasterTransmit (uint8_t * const tx_buf, const uint16_t tx_num)
{
    MD_STATUS status = MD_OK;

    /* clear the flag before initiating a new transmission */
    sci6_txdone = FALSE;

    /* Send the data using the API */
    status = R_SCI6_SPI_Master_Send(tx_buf, tx_num);

    /* Wait for the transmit end flag */
    while (FALSE == sci6_txdone)
    {
        /* Wait */
    }

    return (status);
}
/*********************************************************************************
* End of function R_SCI6_SPIMasterTransmit
**********************************************************************************/
```

This function uses the transmit end callback function to perform flow control on the SPI transmission to the LCD, and is used as the main API call in the LCD code module.

5.3.2 CMT Code

The LCD code needs to insert delays to meet the timing requirements of the display module. This is achieved using the dedicated timer which was configured using Code Generator in §4.3.2. Open the file r_cg_cmt.h and insert the following code in the user area for function at the end of the file:

```
/* Start user code for function. Do not edit comment generated here */
void R_CMT_MsDelay(const uint16_t millisec);
/* End user code. Do not edit comment generated here */
```

Open the file r_cg_cmt_user.c and insert the following code in the user area for global at the beginning of the file:

```
/* Start user code for global. Do not edit comment generated here */
static volatile uint8_t one_ms_delay_complete = FALSE;
/* End user code. Do not edit comment generated here */
```

Scroll down to the r_cmt_cmi0_interrupt() function and insert the following line in the user code area:

```
static void r_cmt_cmi0_interrupt(void)
{
    /* Start user code. Do not edit comment generated here */
    one_ms_delay_complete = TRUE;
    /* End user code. Do not edit comment generated here */
}
```

Then insert the following function in the user code area at the end of the file:

```
/*******************************************************************************
* Function Name: R_CMT_MsDelay
* Description  : Uses CMT0 to wait for a specified number of milliseconds
* Arguments    : uint16_t millisecs, number of milliseconds to wait
* Return Value : None
*******************************************************************************/
void R_CMT_MsDelay (const uint16_t millisec)
{
    uint16_t ms_count = 0;

    do
    {
        R_CMT0_Start();
        while (FALSE == one_ms_delay_complete)
        {
            /* Wait */
        }
        R_CMT0_Stop();
        one_ms_delay_complete = FALSE;
        ms_count++;
    } while (ms_count < millisec);


}
/*******************************************************************************
End of function R_CMT_MsDelay
*******************************************************************************/
```

Select ‘Build Project’ from the ‘Build’ menu, or press F7. Cubesuite+ will build the project with no errors.

The project may now be run using the debugger as described in §6. The program will display ‘RSK+X64M Tutorial Press Any Switch on 3 lines in the LCD display.

5.4 Switch Code Integration

API functions for user switch control are provided with the RSK+. Locate the files rskrx64def.h, r_rsk_switch.h and r_rsk_switch.c on the RSK+ DVD. RSK+RX64M_Tutorial project for CubeSuite+ in the ‘Tutorial’ folder. Copy these files into the C:\Workspace\CG_Tutorial folder. Import these two files into the project in the same way as the lcd files.

The switch code uses interrupt code in the files r_cg_icu.h, r_cg_icu.c and r_cg_icu_user.c and timer code in the files r_cg_cmt.h, r_cg_cmt.c and r_cg_cmt_user.c, as described in §4.3.1 and §4.3.2. It is necessary to provide additional user code in these files to implement the switch press/release detection and de-bouncing required by the API functions in r_rsk_switch.c.

5.4.1 Interrupt Code

In the Cubesuite+ Project Tree, expand the ‘Code Generator’ folder and open the file ‘r_cg_icu.h’ by double-clicking on it. Insert the following code in the user code area at the end of the file:

```
/* Start user code for function. Do not edit comment generated here */
/* Function prototypes for detecting and setting the edge trigger of ICU_IRQ */
uint8_t R_ICU_IRQIsFallingEdge(const uint8_t irq_no);
void R_ICU_IRQSetFallingEdge(const uint8_t irq_no, const uint8_t set_f_edge);
void R_ICU_IRQSetRisingEdge(const uint8_t irq_no, const uint8_t set_r_edge);
/* End user code. Do not edit comment generated here */
```

Now, open the r_cg_icu.c file and insert the following code in the user code area at the end of the file:

```
/*******************************************************************************
* Function Name: R_ICU_IRQIsFallingEdge
* Description  : This function returns 1 if the specified ICU_IRQ is set to
*                falling edge triggered, otherwise 0.
* Arguments    : uint8_t irq_no
* Return Value : 1 if falling edge triggered, 0 if not
*******************************************************************************/
uint8_t R_ICU_IRQIsFallingEdge (const uint8_t irq_no)
{
    uint8_t falling_edge_trig = 0x0;

    if (ICU.IRQCR[irq_no].BYTE & _04_ICU_IRQ_EDGE_FALLING)
    {
        falling_edge_trig = 1;
    }

    return falling_edge_trig;

}
/*******************************************************************************
* End of function R_ICU_IRQIsFallingEdge
*******************************************************************************/

/*******************************************************************************
* Function Name: R_ICU_IRQSetFallingEdge
* Description  : This function sets/clears the falling edge trigger for the
*                specified ICU_IRQ.
* Arguments    : uint8_t irq_no
*                uint8_t set_f_edge, 1 if setting falling edge triggered, 0 if
*                clearing
* Return Value : None
*******************************************************************************/
void R_ICU_IRQSetFallingEdge (const uint8_t irq_no, const uint8_t set_f_edge)
{
    if (1 == set_f_edge)
    {
        ICU.IRQCR[irq_no].BYTE |= _04_ICU_IRQ_EDGE_FALLING;
    }
    else
    {
        ICU.IRQCR[irq_no].BYTE &= (uint8_t) ~_04_ICU_IRQ_EDGE_FALLING;
    }
}
/******************************************************************************
* End of function R_ICU_IRQSetFallingEdge
*******************************************************************************/

/*******************************************************************************
* Function Name: R_ICU_IRQSetRisingEdge
* Description  : This function sets/clear the rising edge trigger for the
*                specified ICU_IRQ.
* Arguments    : uint8_t irq_no
*                uint8_t set_r_edge, 1 if setting rising edge triggered, 0 if
*                clearing
* Return Value : None
*******************************************************************************/
void R_ICU_IRQSetRisingEdge (const uint8_t irq_no, const uint8_t set_r_edge)
{
    if (1 == set_r_edge)
    {
        ICU.IRQCR[irq_no].BYTE |= _08_ICU_IRQ_EDGE_RISING;
    }
    else
    {
        ICU.IRQCR[irq_no].BYTE &= (uint8_t) ~_08_ICU_IRQ_EDGE_RISING;
    }
}
/******************************************************************************
* End of function R_ICU_IRQSetRisingEdge
*******************************************************************************/
```

Open the r_cg_intp_user file.c file and insert the following code in the user code area for include near the top of the file:

```
/* Defines switch callback functions required by interrupt handlers */
#include "r_rsk_switch.h"
```

In the same file insert the following code in the user code area inside the function r_icu_irq2_interrupt ():

```
    /* Switch 2 callback handler */
    R_SWITCH_IsrCallback2();
```

In the same file insert the following code in the user code area inside the function r_icu_irq5_interrupt ():

```
    /* Switch 1 callback handler */
    R_SWITCH_IsrCallback1();
```

5.4.2 De-bounce Timer Code

Open the r_cg_cmt_user.c file and insert the following code in the user code area for include near the top of the file:

```
/* Defines switch callback functions required by interrupt handlers */
#include "r_rsk_switch.h"
```

In the same file insert the following code in the user code area inside the function r_cmt_cmi1_interrupt ():

```
    /* Stop this timer - we start it again in the de-bounce routines */
    R_CMT1_Stop();

    /* Call the de-bounce call back routine */
    R_SWITCH_DebounceIsrCallback();
```

In the same file insert the following code in the user code area inside the function r_cmt_cmi2_interrupt ():

```
    /* Stop this timer - we start it again in the de-bounce routines */
    R_CMT2_Stop();

    /* Call the de-bounce call back routine */
    R_SWITCH_DebounceIsrCallback();
```

5.4.3 Main Switch and ADC Code

In this part of the tutorial we add the code to act on the switch presses to activate A/D conversions and display the result on the LCD. In §4.3.3 we configured the ADC to be triggered from the ADTRG0# pin. In this code, we also perform software triggered A/D conversion from the user switches SW1 and SW2, by reconfiguring the ADC trigger source on-the-fly once an SW1 or SW2 press is detected.

In the Cubesuite+ Project Tree, expand the 'Code Generator' folder and open the file 'r_cg_userdefine.h' by double-clicking on it. Insert the following code the user code area, resulting in the code shown below

```
/* Start user code for function. Do not edit comment generated here */
#define TRUE            (1)
#define FALSE           (0)

extern volatile uint8_t g_adc_trigger;
/* End user code. Do not edit comment generated here */
```

Open the file 'r_cg_main.c' and insert #include "r_rsk_switch.h" in the user code area for include, resulting in the code shown below:

```
/* Start user code for include. Do not edit comment generated here */
#include "r_okaya_lcd.h"
#include "r_rsk_switch.h"
```

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

Next add the switch module initialisation function call highlighted in the user code area inside the main() function, resulting in the code shown below:

```
void main(void)
{
    R_MAIN_UserInit();
    /* Start user code. Do not edit comment generated here */

    /* Initialise the switch module */
    R_SWITCH_Init();

    /* Initialise the debug LCD */
    R_LCD_Init();

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSK+RX64M ");
    R_LCD_Display(1, (uint8_t *)" Tutorial ");
    R_LCD_Display(2, (uint8_t *)" Press Any Switch ");

    while (1U)
    {
        ;
    }
    /* End user code. Do not edit comment generated here */
}
```

In the same file, insert the declarations in the user code area for global, resulting in the code shown below:

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

/* Prototype declaration for cb_switch_press */
static void cb_switch_press (void);

/* Prototype declaration for get_adc */
static uint16_t get_adc(void);

/* Prototype declaration for lcd_display_adc */
static void lcd_display_adc (const uint16_t adc_result);

/* Variable for flagging user requested ADC conversion */
volatile uint8_t g_adc_trigger = FALSE;

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

Next add the highlighted code below in the user code area inside the main() function and the code inside the while loop, resulting in the code shown below:

```
void main(void)
{
    R_MAIN_UserInit();
    /* Start user code. Do not edit comment generated here */

    /* Initialise the switch module */
    R_SWITCH_Init();

    /* Set the call back function when SW1 or SW2 is pressed */
    R_SWITCH_SetPressCallback(cb_switch_press);

    /* Initialise the debug LCD */
    R_LCD_Init ();

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSK+RX64M ");
    R_LCD_Display(1, (uint8_t *)" Tutorial ");
    R_LCD_Display(2, (uint8_t *)" Press Any Switch ");


    /* Start the A/D converter */
    R_S12AD0_Start();

    while (1U)
    {
```

```
        uint16_t adc_result;

        /* Wait for user requested A/D conversion flag to be set (SW1 or SW2) */
        if (TRUE == g_adc_trigger)
        {
            /* Call the function to perform an A/D conversion */
            adc_result = get_adc();

            /* Display the result on the LCD */
            lcd_display_adc(adc_result);

            /* Reset the flag */
            g_adc_trigger = FALSE;
        }
        /* SW3 is directly wired into the ADTRG0n pin so will
           cause the interrupt to fire */
        else if (TRUE == g_adc_complete)
        {
            /* Get the result of the A/D conversion */
            R_S12AD0_Get_ValueResult(ADCHANNEL0, &adc_result);

            /* Display the result on the LCD */
            lcd_display_adc(adc_result);

            /* Reset the flag */
            g_adc_complete = FALSE;
        }
    }
    /* End user code. Do not edit comment generated here */
}
```

Then add the definition for the switch call-back, get_adc() and lcd_display_adc() functions in the user code area for adding at the end of the file, as shown below:

```
/*******************************************************************************
* Function Name : cb_switch_press
* Description   : Switch press callback function. Sets g_adc_trigger flag.
* Argument      : none
* Return value  : none
*******************************************************************************/
static void cb_switch_press (void)
{
    /* Check if switch 1 or 2 was pressed */
    if (g_switch_flag & (SWITCHPRESS_1 | SWITCHPRESS_2))
    {
        /* set the flag indicating a user requested A/D conversion is required */
        g_adc_trigger = TRUE;

        /* Clear flag */
        g_switch_flag = 0x0;
    }
}
/*******************************************************************************
* End of function cb_switch_press
*******************************************************************************/

/*******************************************************************************
* Function Name : get_adc
* Description   : Reads the ADC result, converts it to a string and displays
*                 it on the LCD panel.
* Argument      : none
* Return value  : uint16_t adc value
*******************************************************************************/
static uint16_t get_adc (void)
{
    /* A variable to retrieve the adc result */
    uint16_t adc_result;

    /* Stop the A/D converter being triggered from the pin ADTRG0n  */
    R_S12AD0_Stop();

    /* Start a conversion */
    R_S12AD0_SWTriggerStart();

    /* Wait for the A/D conversion to complete */
    while (FALSE == g_adc_complete)
    {
```

```
        /* Wait */
    }

    /* Stop conversion */
    R_S12AD0_SWTriggerStop();

    /* Clear ADC flag */
    g_adc_complete = FALSE;

    R_S12AD0_Get_ValueResult(ADCHANNEL0, &adc_result);

    /* Set AD conversion start trigger source back to ADTRG0n pin */
    R_S12AD0_Start();


    return adc_result;
}
/******************************************************************************
* End of function get_adc
******************************************************************************/

/******************************************************************************
* Function Name : lcd_display_adc
* Description   : Converts adc result to a string and displays
*                 it on the LCD panel.
* Argument      : uint16_t adc result
* Return value  : none
******************************************************************************/
static void lcd_display_adc (const uint16_t adc_result)
{
    /* Declare a temporary variable */
    uint8_t a;

    /* Declare temporary character string */
    char    lcd_buffer[11] = " ADC: XXXH";

    /* Convert ADC result into a character string, and store in the local.
       Casting to ensure use of correct data type. */
    a = (uint8_t)((adc_result & 0x0F00) >> 8);
    lcd_buffer[6] = (char)((a < 0x0A) ? (a + 0x30) : (a + 0x37));
    a = (uint8_t)((adc_result & 0x00F0) >> 4);
    lcd_buffer[7] = (char)((a < 0x0A) ? (a + 0x30) : (a + 0x37));
    a = (uint8_t)(adc_result & 0x000F);
    lcd_buffer[8] = (char)((a < 0x0A) ? (a + 0x30) : (a + 0x37));

    /* Display the contents of the local string lcd_buffer */
    R_LCD_Display(3, (uint8_t *)lcd_buffer);

}
/******************************************************************************
* End of function lcd_display_adc
******************************************************************************/
```

Open the file ‘r_cg_s12ad.h’ by double-clicking on it. Insert the following code in the in the user code area for function, resulting in the code shown below:

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

/* Flag indicates when A/D conversion is complete */
extern volatile uint8_t g_adc_complete;

/* Functions for starting and stopping software triggered A/D conversion */
void R_S12AD0_SWTriggerStart(void);
void R_S12AD0_SWTriggerStop(void);
/* End user code. Do not edit comment generated here */
```

Open the file ‘r_cg_s12ad.c’ by double-clicking on it. Insert the following code in the in the user code area for adding at the end of the file, resulting in the code shown below:

```
/* Start user code for adding. Do not edit comment generated here */
/******************************************************************************
* Function Name: R_S12AD0_SWTriggerStart
* Description  : This function starts the AD0 converter.
* Arguments    : None
```

```
* Return Value : None
*******************************************************************************/
void R_S12AD0_SWTriggerStart(void)
{
    IR(PERIB, INTB129) = 0U;
    IEN(PERIB, INTB129) = 1U;
    ICU.GENBL1.BIT.EN19 = 1U;
    S12AD.ADCSR.BIT.ADST = 1U;
}
/*******************************************************************************
End of function R_S12AD0_SWTriggerStart
*******************************************************************************/

/*******************************************************************************
* Function Name: R_S12AD0_SWTriggerStop
* Description  : This function stops the AD0 converter.
* Arguments    : None
* Return Value : None
*******************************************************************************/
void R_S12AD0_SWTriggerStop(void)
{
    S12AD.ADCSR.BIT.ADST = 0U;
    IEN(PERIB, INTB129) = 0U;
    IR(PERIB, INTB129) = 0U;
    ICU.GENBL1.BIT.EN19 = 0U;
}
/*******************************************************************************
End of function R_S12AD0_SWTriggerStop
*******************************************************************************/
/* End user code. Do not edit comment generated here */
```

Open the file r_cg_s12ad_user.c and insert the following code in the in the user code area for global, resulting in the code shown below:

```
/* Start user code for global. Do not edit comment generated here */
/* Flag indicates when A/D conversion is complete */
volatile uint8_t g_adc_complete;
/* End user code. Do not edit comment generated here */
```

Insert the following code in the in the user code area of the r_s12ad0_interrupt () function, resulting in the code shown below:

```
static void r_s12ad0_interrupt(void)
{
    /* Start user code. Do not edit comment generated here */
    g_adc_complete = TRUE;
    /* End user code. Do not edit comment generated here */
}
```

Select ‘Build Project’ from the ‘Build’ menu, or press F7. Cubesuite+ will build the project with no errors.

The project may now be run using the debugger as described in §6. When any switch is pressed, the program will perform an A/D conversion of the voltage level on the ADPOT line and display the result on the LCD panel. Return to this point in the Tutorial to add the UART user code.

5.5 Debug Code Integration

API functions for trace debugging via the RSK serial port are provided with the RSK. Locate the files r_rsk_debug.h and r_rsk_debug.c on the RSK DVD. RSK+RX64M_Tutorial project for CubeSuite+ in the ‘Tutorial’ folder. Copy these files into the C:\Workspace\CG_Tutorial folder. Import these two files into the project in the same way as the LCD files.

In the r_rsk_debug.h file, ensure the following macro definition is included:

```
/* Macro for definition of serial debug transmit function - user edits this */
#define SerialDbgWrite (R_SCI7_AsyncTransmit)
```

This macro is referenced in the r_rsk_debug.c file and allows easy re-direction of debug output if a different debug interface is used.

5.6 UART Code Integration

5.6.1 SCI Code

In the Cubesuite+ Project Tree, expand the ‘Code Generator’ folder and open the file ‘r_cg_sci.h’ by double-clicking on it. Insert the following code in the user code area at the end of the file:

```
/* Start user code for function. Do not edit comment generated here */
/* Exported functions used to transmit a number of bytes and wait for completion */
MD_STATUS R_SCI6_SPIMasterTransmit(uint8_t * const tx_buf, const uint16_t tx_num);
MD_STATUS R_SCI7_AsyncTransmit(uint8_t * const tx_buf, const uint16_t tx_num);

/* Character is used to receive key presses from PC terminal */
extern uint8_t g_rx_char;

/* Flag used to control transmission to PC terminal */
extern volatile uint8_t g_tx_flag;

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

Open the file ‘r_cg_sci_user.c. Insert the following code in the user area for global near the beginning of the file:

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

/* Global used to receive a character from the PC terminal */
uint8_t g_rx_char;

/* Flag used to control transmission to PC terminal */
volatile uint8_t g_tx_flag = FALSE;

/* Flag used locally to detect transmission complete */
static volatile uint8_t sci6_txdone;
static volatile uint8_t sci7_txdone;

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

In the same file, insert the following code in the user code area inside the r_sci7_callback_transmitend() function:

```
static void r_sci7_callback_transmitend(void)
{
    /* Start user code. Do not edit comment generated here */
    sci7_txdone = TRUE;

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

In the same file, insert the following code in the user code area inside the r_sci7_callback_receiveend() function:

```
static void r_sci7_callback_receiveend(void)
{
    /* Start user code. Do not edit comment generated here */
    /* Check the contents of g_rx_char */
    if (('c' == g_rx_char) || ('C' == g_rx_char))
    {
        g_adc_trigger = TRUE;
    }

    /* Set up SCI7 receive buffer and callback function again */
    R_SCI7_Serial_Receive((uint8_t *)&g_rx_char, 1);

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

At the end of the file, in the user code area for adding, add the following function definition:

```
/*******************************************************************************
* Function Name: R_SCI7_AsyncTransmit
```

```
* Description  : This function sends SCI7 data and waits for the transmit end flag.
* Arguments    : tx_buf -
*                    transfer buffer pointer
*                tx_num -
*                    buffer size
* Return Value : status -
*                    MD_OK or MD_ARGERROR
*******************************************************************************/
MD_STATUS R_SCI7_AsyncTransmit (uint8_t * const tx_buf, const uint16_t tx_num)
{
    MD_STATUS status = MD_OK;

    /* clear the flag before initiating a new transmission */
    sci7_txdone = FALSE;

    /* Send the data using the API */
    status = R_SCI7_Serial_Send(tx_buf, tx_num);

    /* Wait for the transmit end flag */
    while (FALSE == sci7_txdone)
    {
        /* Wait */
    }
    return (status);
}

/*******************************************************************************
* End of function R_SCI7_AsyncTransmit
*******************************************************************************/
```

5.6.2 Main UART code

Open the file 'r_cg_main.c'. Add the following declaration to the user code area for include near the top of the file:

```
#include "r_rsk_debug.h"
```

Add the following declaration to the user code area for global near the top of the file:

```
/* Prototype declaration for uart_display_adc */
static void uart_display_adc(const uint8_t adc_count, const uint16_t adc_result);

/* Variable to store the A/D conversion count for user display */
static uint8_t adc_count = 0;
```

Add the following highlighted code to the user code area in the main function:

```
void main(void)
{
    R_MAIN_UserInit();
    /* Start user code. Do not edit comment generated here */

    /* Initialise the switch module */
    R_SWITCH_Init();

    /* Set the call back function when SW1 or SW2 is pressed */
    R_SWITCH_SetPressCallback(cb_switch_press);

    /* Initialise the debug LCD */
    R_LCD_Init ();

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSK+RX64M ");
    R_LCD_Display(1, (uint8_t *)" Tutorial ");
    R_LCD_Display(2, (uint8_t *)" Press Any Switch ");

    /* Start the A/D converter */
    R_S12AD0_Start();

    /* Set up SCI7 receive buffer and callback function */
    R_SCI7_Serial_Receive((uint8_t *)&g_rx_char, 1);

    /* Enable SCI7 operations */
    R_SCI7_Start();
```

```
    while (1U)
    {
        /* Wait for user requested A/D conversion flag to be set */
        if (TRUE == g_adc_trigger)
        {
            uint16_t adc_result;

            /* Call the function to perform an A/D conversion  */
            adc_result = get_adc();

            /* Display the result on the LCD */
            lcd_display_adc(adc_result);

            /* Increment the adc_count */
            if (16 == ++adc_count)
            {
                adc_count = 0;
            }

            /* Send the result to the UART */
            uart_display_adc(adc_count, adc_result);

            /* Reset the flag */
            g_adc_trigger = FALSE;
        }
        /* SW3 is directly wired into the ADTRG0n pin so will
           cause the interrupt to fire */
        else if (TRUE == g_adc_complete)
        {
            /* Get the result of the A/D conversion */
            R_S12AD0_Get_ValueResult(ADCHANNEL0, &adc_result);

            /* Display the result on the LCD */
            lcd_display_adc(adc_result);

            /* Increment the adc_count */
            if (16 == ++adc_count)
            {
                adc_count = 0;
            }

            /* Send the result to the UART */
            uart_display_adc(adc_count, adc_result);

            /* Reset the flag */
            g_adc_complete = FALSE;
        }
    }
    /* End user code. Do not edit comment generated here */
}
```

Then, add the following function definition in the user code area at the end of the file:

```
/*******************************************************************************
* Function Name : uart_display_adc
* Description   : Converts adc result to a string and sends it to the UART1.
* Argument      : uint8_t : adc_count
*                 uint16_t: adc result
* Return value  : none
*******************************************************************************/
static void uart_display_adc (const uint8_t adc_count, const uint16_t adc_result)
{
    /* Declare a temporary variable */
    char a;

    /* Declare temporary character string */
    static char uart_buffer[] = "ADC xH Value: xxxH\r\n";

    /* Convert ADC result into a character string, and store in the local.
       Casting to ensure use of correct data type. */
    a = (char)(adc_count & 0x000F);
    uart_buffer[4] = (char)((a < 0x0A) ? (a + 0x30) : (a + 0x37));
    a = (char)((adc_result & 0x0F00) >> 8);
    uart_buffer[14] = (char)((a < 0x0A) ? (a + 0x30) : (a + 0x37));
    a = (char)((adc_result & 0x00F0) >> 4);
    uart_buffer[15] = (char)((a < 0x0A)                    ? (a + 0x30) : (a + 0x37));
```

```
    a = (char)(adc_result & 0x000F);
    uart_buffer[16] = (char)((a < 0x0A) ? (a + 0x30) : (a + 0x37));

    /* Send the string to the UART */
    R_DEBUG_Print(uart_buffer);

}

/******************************************************************************
* End of function uart_display_adc
******************************************************************************/
```

Select ‘Build Project’ from the ‘Build’ menu, or press F7. Cubesuite+ will build the project with no errors.

The project may now be run using the debugger as described in §6. Connect the RSK G1CUSB0 port to a USB port on a PC. If this is the first time the RSK+ has been connected to the PC then a device driver will be installed automatically. Open Device Manager, the virtual COM port will now appear under 'Port (COM & LPT)' as 'RSK USB Serial Port (COMx)', where x is a number.

Open a terminal program, such as HyperTerminal, on the PC with the same settings as for SCI7 (see §4.3.4). When any switch is pressed, or when ‘c’ is sent via the COM port, the program will perform an A/D conversion of the voltage level on the ADPOT line and display the result on the LCD panel and send the result to the PC terminal program via the via SCI7. Return to this point in the Tutorial to add the LED user code.

5.7 LED Code Integration

Open the file ‘r_cg_main.c’. Add the following declaration to the user code area for include near the top of the file:

```
#include "rskrx64mdef.h"
```

Add the following declaration to the user code area for global near the top of the file:

```
/* Prototype declaration for led_display_count */
static void led_display_count(const uint8_t count);
```

Add the following highlighted code to the user code area in the main function:

```
void main(void)
{
    R_MAIN_UserInit();
    /* Start user code. Do not edit comment generated here */

    /* Initialise the switch module */
    R_SWITCH_Init();

    /* Set the call back function when SW1 or SW2 is pressed */
    R_SWITCH_SetPressCallback(cb_switch_press);

    /* Initialise the debug LCD */
    R_LCD_Init ();

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSK+RX64M ");
    R_LCD_Display(1, (uint8_t *)" Tutorial ");
    R_LCD_Display(2, (uint8_t *)" Press Any Switch ");

    /* Sart the A/D converter */
    R_S12AD0_Start();

    /* Set up SCI7 receive buffer and callback function */
    R_SCI7_Serial_Receive((uint8_t *)&g_rx_char, 1);

    /* Enable SCI7 operations */
    R_SCI7_Start();

    while (1U)
    {
        uint16_t adc_result;
```

```
        /* Wait for user requested A/D conversion flag to be set(SW1 or SW2) */
        if (TRUE == g_adc_trigger)
        {
            /* Call the function to perform an A/D conversion */
            adc_result = get_adc();

            /* Display the result on the LCD */
            lcd_display_adc(adc_result);

            /* Increment the adc_count and display using the LEDs */
            if (16 == ++adc_count)
            {
                adc_count = 0;
            }
            led_display_count(adc_count);

            /* Send the result to the UART */
            uart_display_adc(adc_count, adc_result);

            /* Reset the flag */
            g_adc_trigger = FALSE;
        }
        /* SW3 is directly wired into the ADTRG0n pin so will
           cause the interrupt to fire */
        else if (TRUE == g_adc_complete)
        {
            /* Get the result of the A/D conversion */
            R_S12AD0_Get_ValueResult(ADCHANNEL0, &adc_result);

            /* Display the result on the LCD */
            lcd_display_adc(adc_result);

            /* Increment the adc_count and display using the LEDs */
            if (16 == ++adc_count)
            {
                adc_count = 0;
            }
            led_display_count(adc_count);

            /* Send the result to the UART */
            uart_display_adc(adc_count, adc_result);

            /* Reset the flag */
            g_adc_complete = FALSE;
        }
    }
    /* End user code. Do not edit comment generated here */
}
```

Then, add the following function definition in the user code area at the end of the file:

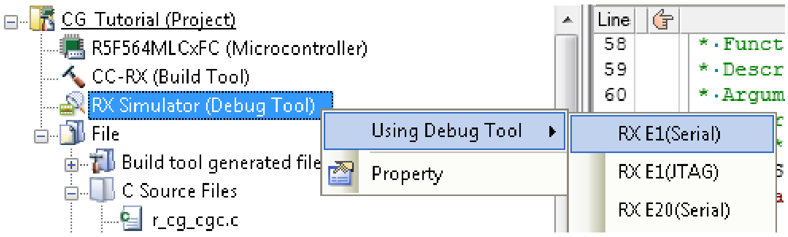
```
/******************************************************************************
* Function Name : led_display_count
* Description   : Converts count to binary and displays on 4 LEDS0-3
* Argument      : uint8_t count
* Return value  : none
******************************************************************************/
static void led_display_count (const uint8_t count)
{
    /* Set LEDs according to lower nibble of count parameter */
    LED0 = (count & 0x01) ? LED_ON : LED_OFF;
    LED1 = (count & 0x02) ? LED_ON : LED_OFF;
    LED2 = (count & 0x04) ? LED_ON : LED_OFF;
    LED3 = (count & 0x08) ? LED_ON : LED_OFF;

}
/******************************************************************************
* End of function led_display_count
******************************************************************************/
```

Select ‘Build Project’ from the ‘Build’ menu, or press F7. Cubesuite+ will build the project with no errors.

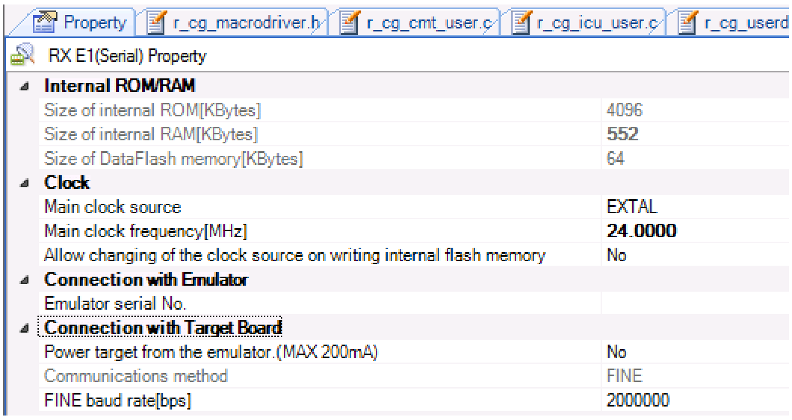
The project may now be run using the debugger as described in §6. The code will perform the same but now the LEDs will display the adc_count in binary form.

6. Debugging the Project

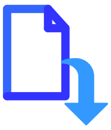
- In the 'Project Tree' pane, right-click the 'RX Simulator (Debug Tool)'. Select 'Using Debug Tool -> RX E1(Serial)'.



- Double-click 'RX E1(Serial) (Debug Tool)' to display the debugger tool properties. Under 'Clock', change the main clock frequency to 24 MHz.
- All other settings can remain at their defaults.



- Connect the E1 to the PC and the RSK+ E1 connector. Connect the +5V PSU to the PWR connector on the RSK+. Connect the Okaya PMOD LCD to the PMOD1 connector.
- From the 'Debug' menu select 'Download' to start the debug session and download code to the target.



7.Running the Code Generator Tutorial

7.1 Running the Tutorial

Once the program has been downloaded onto the RSK+ device, the program can be executed. Click the 'Go' button or press F5 to begin the program from the current program counter position. It is recommended that you run through the program once first, and then continue to the Tutorial manual to review the code.

8.Additional Information

Technical Support
For details on how to use CubeSuite+, refer to the manual available on the DVD or from the web site.

For information about the RX64M group microcontroller refer to the RX64M Group Hardware Manual.

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

Technical Contact Details

Please refer to the contact details listed in section 9 of the "Quick Start Guide"

General information on Renesas microcontrollers can be found on the Renesas website at:
http://www.renesas.com/

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Renesas Electronics America Inc.
2880 Scott Boulevard Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130
Renesas Electronics Canada Limited
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220
Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804
Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-65030, Fax: +49-211-6503-1327
Renesas Electronics (China) Co., Ltd.
7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679
Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 LanGao Rd., Putuo District, Shanghai, China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999
Renesas Electronics Hong Kong Limited
Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2886-9318, Fax: +852 2886-9022/9044
Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670
Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300
Renesas Electronics Malaysia Sdn.Bhd.
Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510
Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 2.0

RX64M Group

Renesas Electronics Corporation

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