User's Manual

32

RENESAS

RX24U Group

Renesas Starter Kit Code Generator Tutorial Manual For CS+

RENESAS 32-Bit MCU
RX Family / RX200 Series

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- 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.

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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 CS+ 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 CS+, but does not intend to be a complete guide to software development on the RSK platform. Further details regarding operating the RX24U 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 RX24U 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.	RSKRX24U User's Manual	R20UT3758EG
Tutorial Manual	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSKRX24U Tutorial Manual	R20UT3759EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample.	RSKRX24U Quick Start Guide	R20UT3760EG
Code Generator Tutorial Manual	Provides a guide to code generation and importing into the CS+ IDE.	RSKRX24U Code Generator Tutorial Manual	R20UT3761EG
Schematics	Full detail circuit schematics of the RSK.	RSKRX24U Schematics	R20UT3757EG
Hardware Manual	Provides technical details of the RX24U microcontroller.	RX24U Group Hardware Manual	R01UH0658EJ

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
ADC	Analog-to-Digital Converter
API	Application Programming Interface
bps	bits per second
CMT	Compare Match Timer
COM	COMmunications port referring to PC serial port
CPU	Central Processing Unit
DVD	Digital Versatile Disc
E1/E2 Lite	Renesas On-chip Debugging Emulator
GUI	Graphical User Interface
IDE	Integrated Development Environment
IRQ	Interrupt Request
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LSB	Least Significant Bit
LVD	Low Voltage Detect
MCU	Micro-controller Unit
MSB	Most Significant Bit
PC	Personal Computer
PLL	Phase-locked Loop
Pmod™	This is a Digilent Pmod™ Compatible connector. Pmod™ is registered to Digilent Inc. Digilent-Pmod_Interface_Specification
RAM	Random Access Memory
ROM	Read Only Memory
RSK	Renesas Starter Kit
RTC	Real Time Clock
SAU	Serial Array Unit
SCI	Serial Communications Interface
SPI	Serial Peripheral Interface
TAU	Timer Array Unit
TFT	Thin Film Transistor
TPU	Timer Pulse Unit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WDT	Watchdog Timer

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1. Overview

1.1 Purpose

This RSK is an evaluation tool for Renesas microcontrollers. This manual describes how to use the CS+ 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 CS+
- 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 CS+ IDE to create a working project for the RSK platform. The tutorials help explain the following:

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

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 (level two) and no outputs debugging information options selected, producing code suitable for release in a product.

The tutorial examples in this manual assume that installation procedures described in the RSK Quick Start Guide have been completed. Please refer to the Quick Start Guide for details of preparing the configuration.

These tutorials are designed to show you how to use the RSK and are not intended as a comprehensive introduction to the CS+ debugger, compiler toolchains or the E2 emulator Lite. Please refer to the relevant user manuals for more in-depth information.

3. Project Creation with CS+

3.1 Introduction

In this section the user will be guided through the steps required to create a new C project for the RX24U 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.

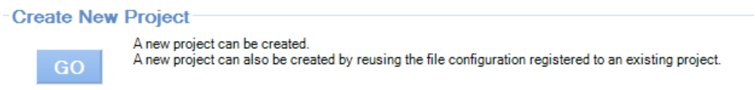
3.2 Creating the Project

To use the program, start CS+:
Windows™ 7 & Vista: Start Menu > All Programs > Renesas Electronics CS+ > CS+ for CC (RL78,RX,RH850)

Windows™ 8.1 & 8: From Apps View ⓘ, click 'CS+ for CC (RL78,RX,RH850)' icon

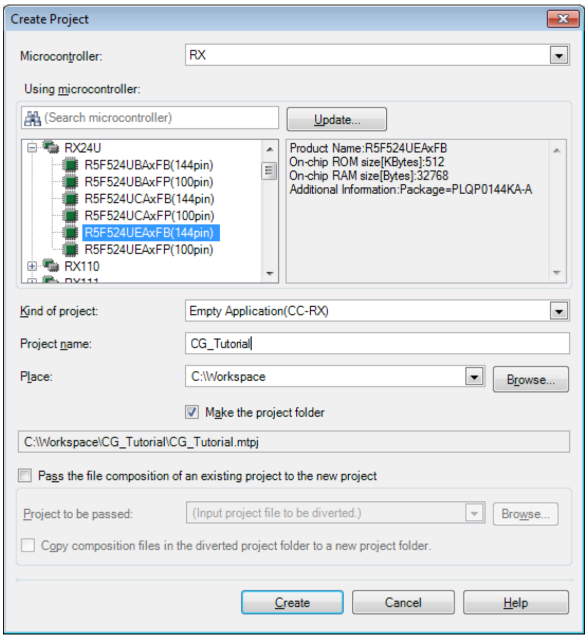
Windows™ 10: Start Menu > All Apps > Renesas Electronics CS+ > CS+ for CC (RL78,RX,RH850)

- CS+ will show the Start Page. Use the 'GO' button to Create a New Project.

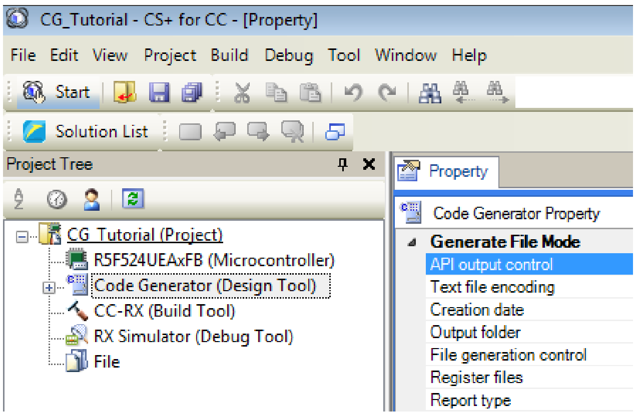


- In the 'Create Project' dialog, select 'RX' from the 'Microcontroller' pull-down.
- In the 'Using Microcontroller' list control, scroll down to 'RX24U' and expand the tree control by clicking '+'. Select 'R5F524UEAxFB(144pin)'.
- Ensure that in the 'Kind of project' pull-down, 'Empty Application(CC-RX)' is selected.
- Choose an appropriate name and location for the project, then click 'Create'.

  Note: this tutorial assumes the project is named and located at the place shown opposite.
- If the folder entered cannot be found a 'Question' dialogue will be displayed; click 'Yes'.



- CS+ will create the blank project with the standard project tree. A 'Code Generator' node may also be shown, if previously enabled. Enable Code Generator can be seen in section 4.2.



4. Code Generation Using the CS+ plug in

4.1 Introduction

Code Generator is a Windows™ GUI tool for generating template ‘C’ source code and project settings for the RX24U. 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.

By following the steps detailed in this tutorial, the user will generate a CS+ project called CG_Tutorial. A fully completed Tutorial project is contained on the DVD and may be imported into CS+ 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 CS+.

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 */
```

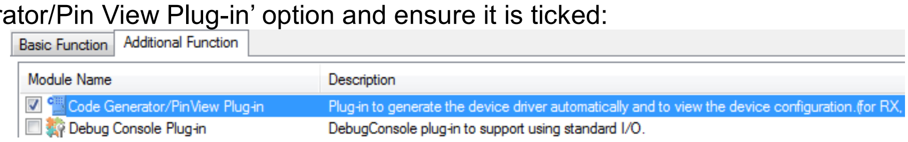
Code Generator will locate these comment delimiters, and preserve any custom code inside the delimiters on subsequent code generation operations. This is useful if, after adding custom code, the user needs to re-visit Code Generator to change any MCU operating parameters.

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.

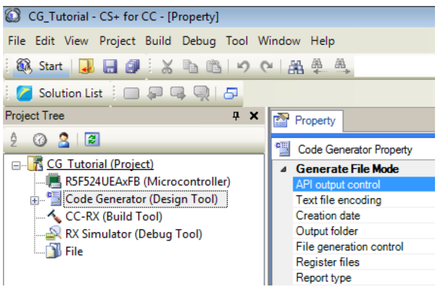
Following a tour of the key user interface features of Code Generator in §4.3, the reader is guided through each of the peripheral function configuration dialogs in §4.4. In §5, the reader is familiarised with the structure of the template code, as well as how to add their own code to the user code areas provided by the code generator.

4.2 Enabling Code Generator

After installation of CS+, Code Generator must be enabled. This step is only required once, CS+ will remember this setting on subsequent launches.
From the ‘Tool’ pull-down menu select ‘Plug-in Setting…’. On the ‘Additional Function’ tab, click the box next to the ‘Code Generator/Pin View Plug-in’ option and ensure it is ticked:



Click ‘OK’. CS+ needs to restart to enable this selection, select ‘Yes’ from the Question dialogue box.
After restarting, ‘Code Generator (Design Tool)’ node will now be shown in the left-hand ‘Project Tree’ window pane.



4.3 Code Generator Tour

This section presents a brief tour of Code Generator. For further details of the Code Generator paradigm and reference, refer to the Application Leading Tool Common Operations manual.
You can download the latest document from: https://www.renesas.com/applilet
Application Leading Tool is the stand-alone version of Code Generator and this manual is applicable to the Code Generator.

In the Project Tree pane, click on the icon next to 'Code Generator' node to expand the list.
Expand the 'Peripheral Functions' node by clicking on the next to it.
Open the 'Peripheral Function' tab by double clicking on the 'Peripheral Functions' name.
The CS+ main window will now contain a 'Peripheral Functions' tab with the Initial View as show in **Figure 4-1**.

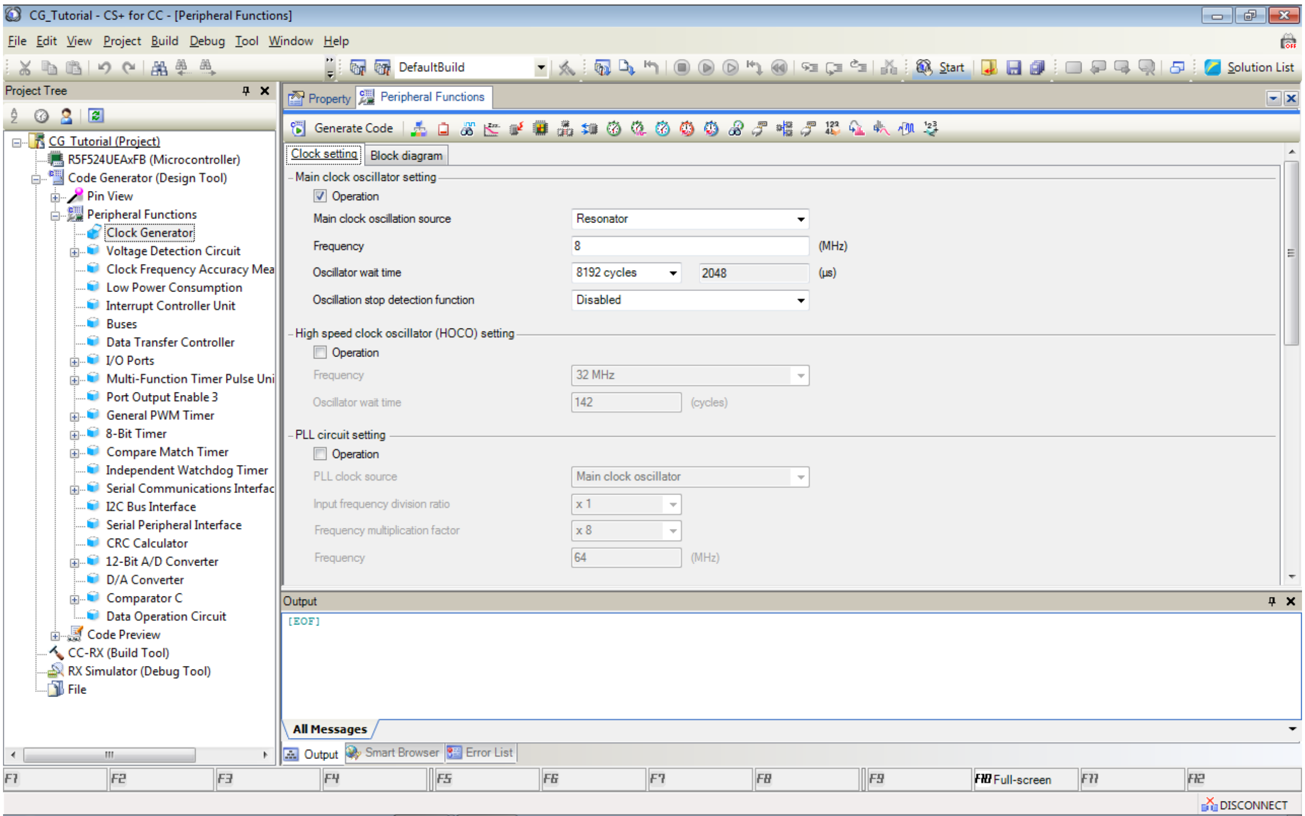


Figure 4-1 Initial View

Code Generator provides GUI features for configuration of MCU subsystems and peripherals. Once the user has configured all required MCU subsystems and peripherals, the user can click the 'Generate Code' button, resulting in a fully configured CS+ project.

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.

4.4 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 SCI.

4.4.1 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 20 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**.

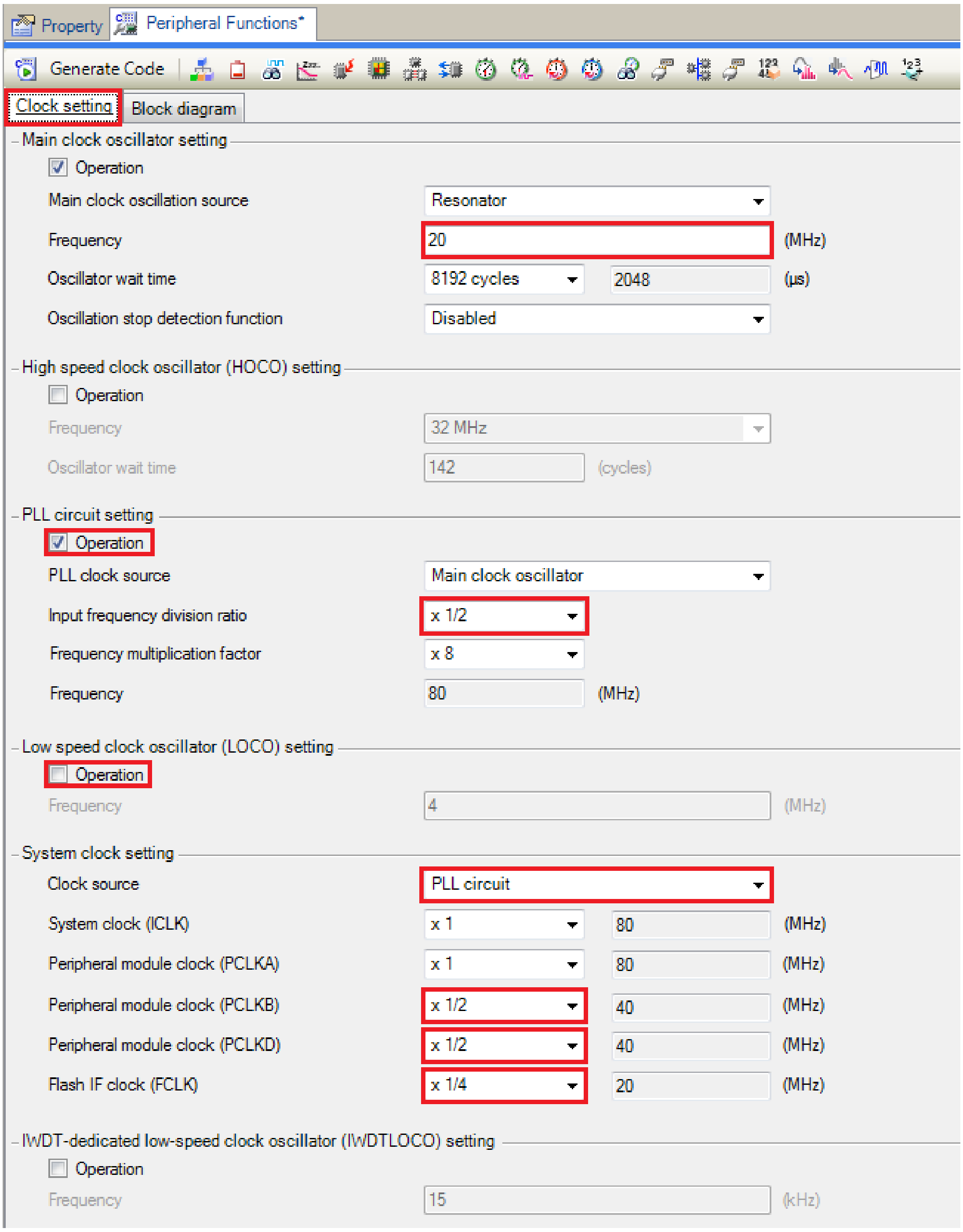


Figure 4-2 Clock setting tab

Proceed to the next section on 'Interrupt Controller Unit'. Double clicking on the 'Interrupt Controller Unit' name in 'Peripheral functions' on the Project Tree.

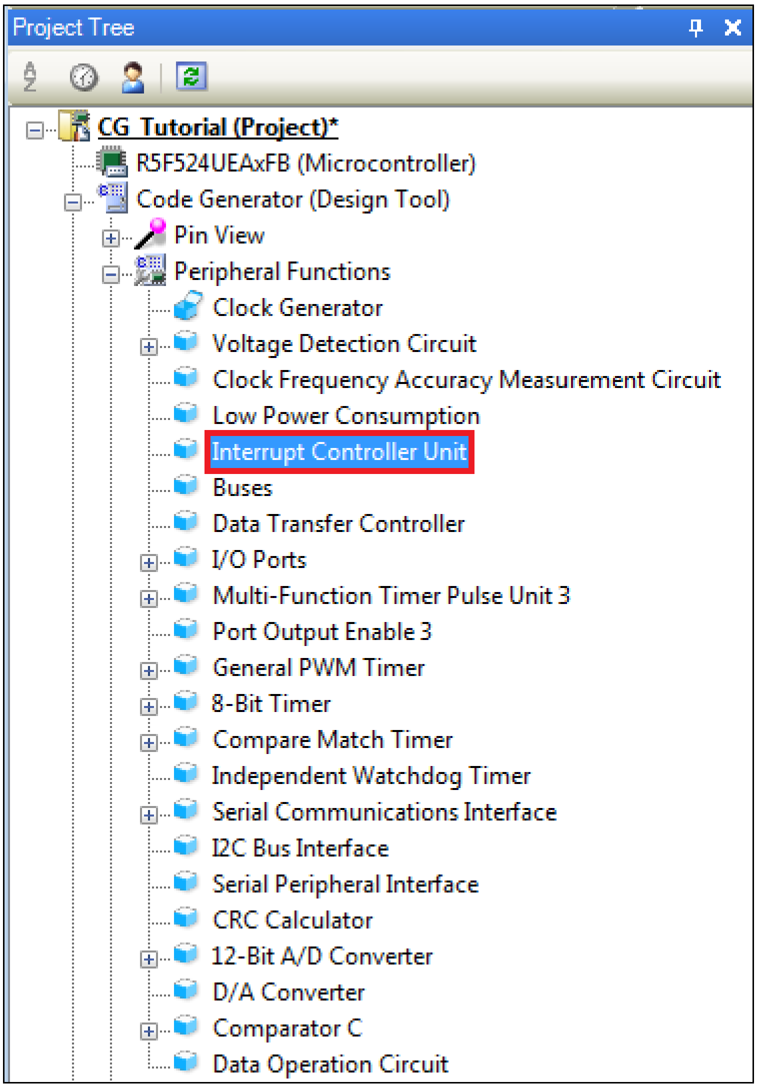


Figure 4-3 Select Interrupt Controller Unit

4.4.2 Interrupt Controller Unit

Referring to the RSK schematic, SW1 is connected to IRQ0 (P10) and SW2 is connected to IRQ4 (P60). SW3 is connected directly to the ADTRG0n and will be configured later in §4.4.4. 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 4-4** below.

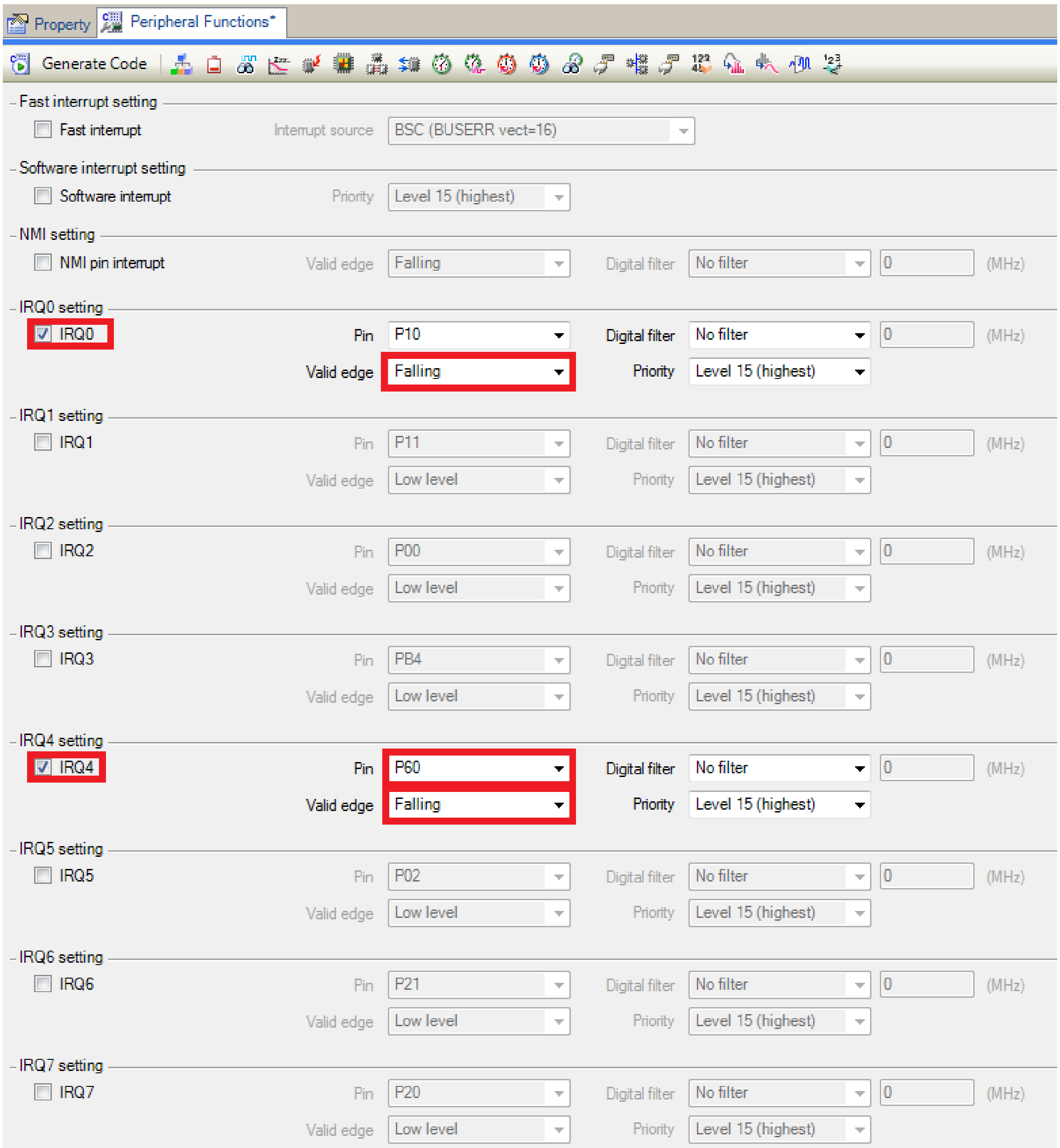


Figure 4-4 Interrupt Functions tab

Proceed to the next section on 'Compare Match Timer'. Double clicking on the 'Compare Match Timer' name in 'Peripheral functions' on the Project Tree.

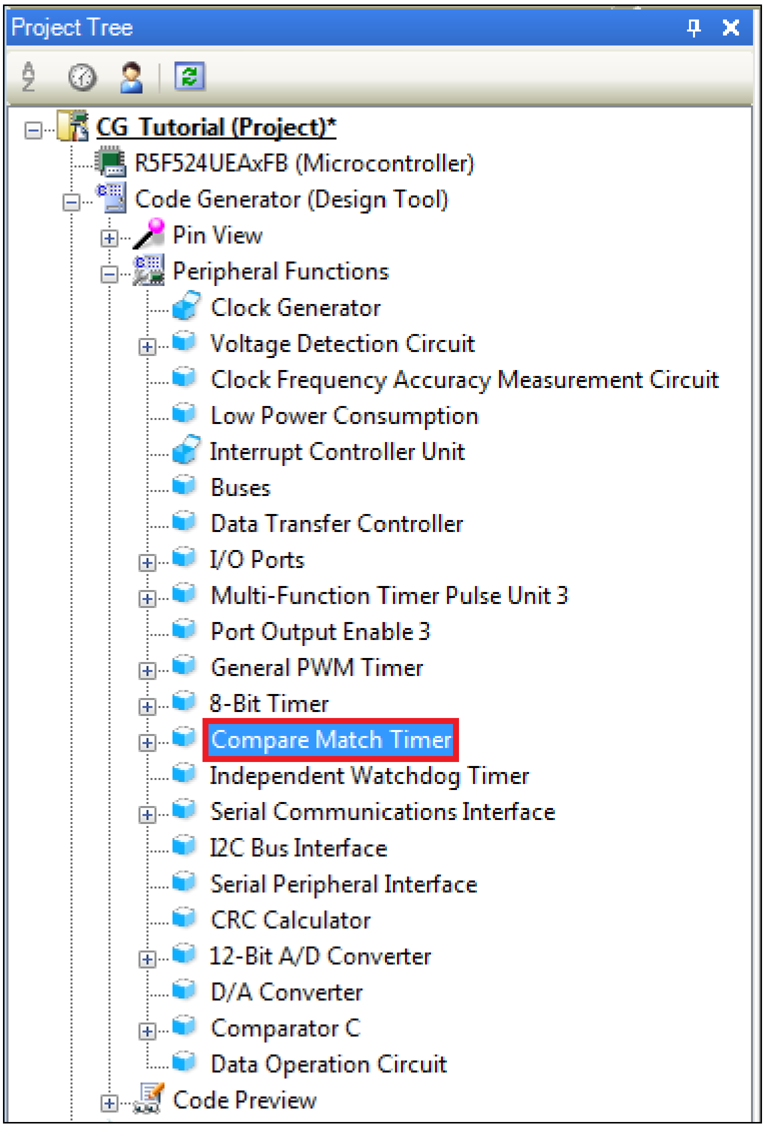


Figure 4-5 Select Compare Match Timer

4.4.3 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 4-6**. 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.

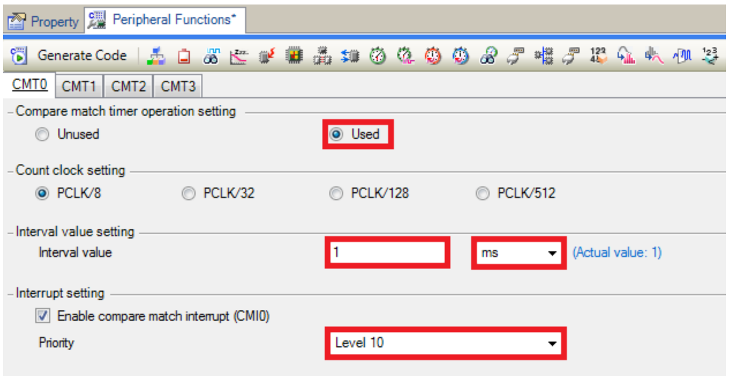


Figure 4-6 CMT0 tab

Navigate to the 'CMT1' sub-tab and configure CMT1 as shown in **Figure 4-7**. 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.

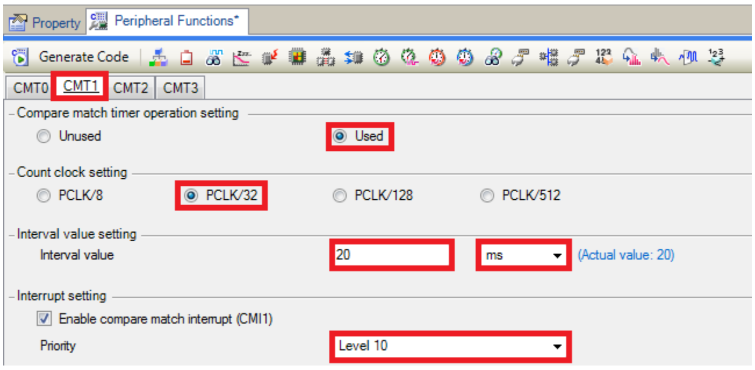


Figure 4-7 CMT1 tab

Navigate to the 'CMT2' sub-tab and configure CMT2 as shown in **Figure 4-8**. 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.

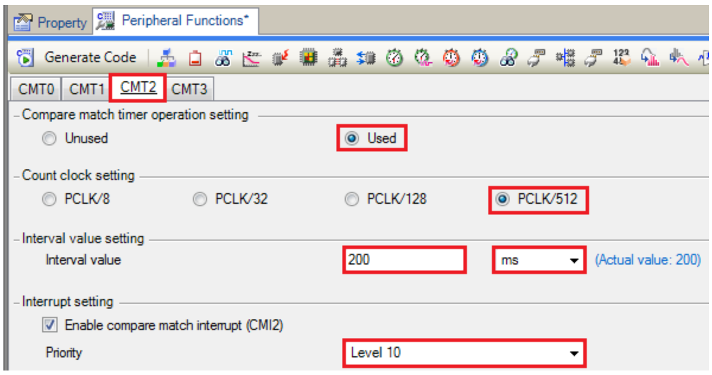


Figure 4-8 CMT2 tab

Proceed to the next section on '12-Bit A/D Converter'. Double clicking on the '12-Bit A/D Converter' name in 'Peripheral functions' on the Project Tree.

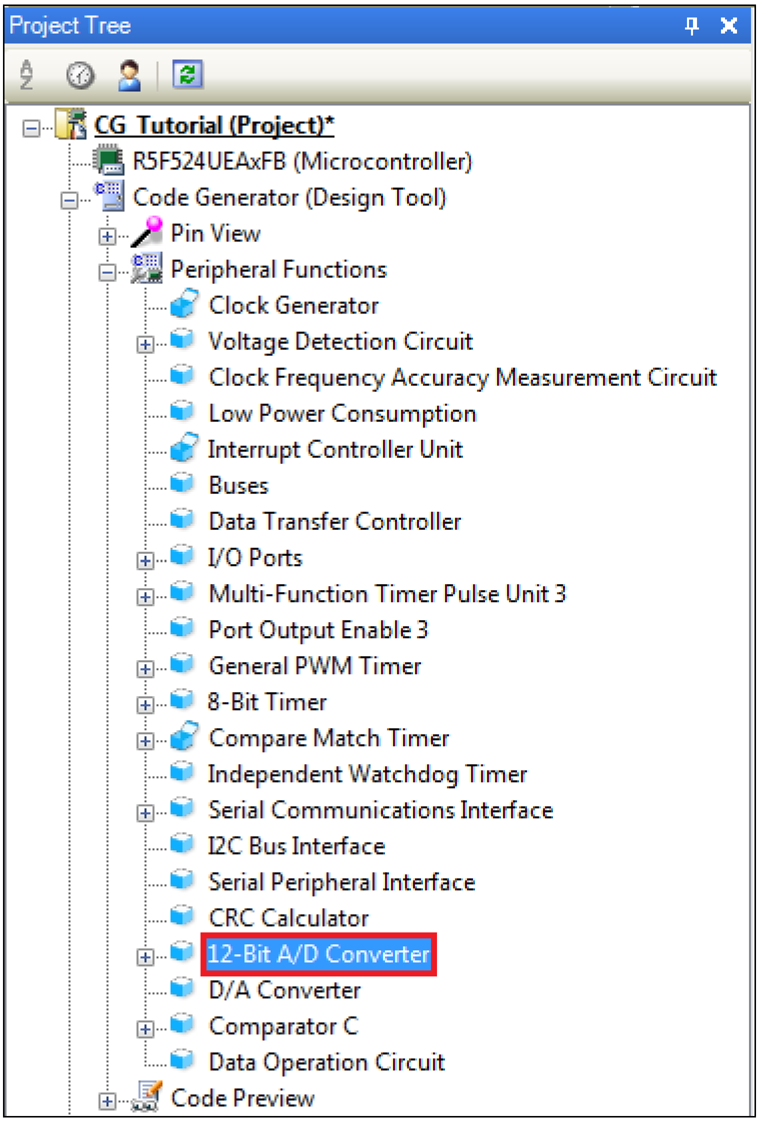


Figure 4-9 Select 12-Bit A/D Converter

4.4.4 12-Bit A/D Converter

Navigate to the '12-Bit A/D Converter' tab in Code Generator. In the 'S12AD0' sub-tab configure S12AD0 as shown in **Figure 4-10**, **Figure 4-11** 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.

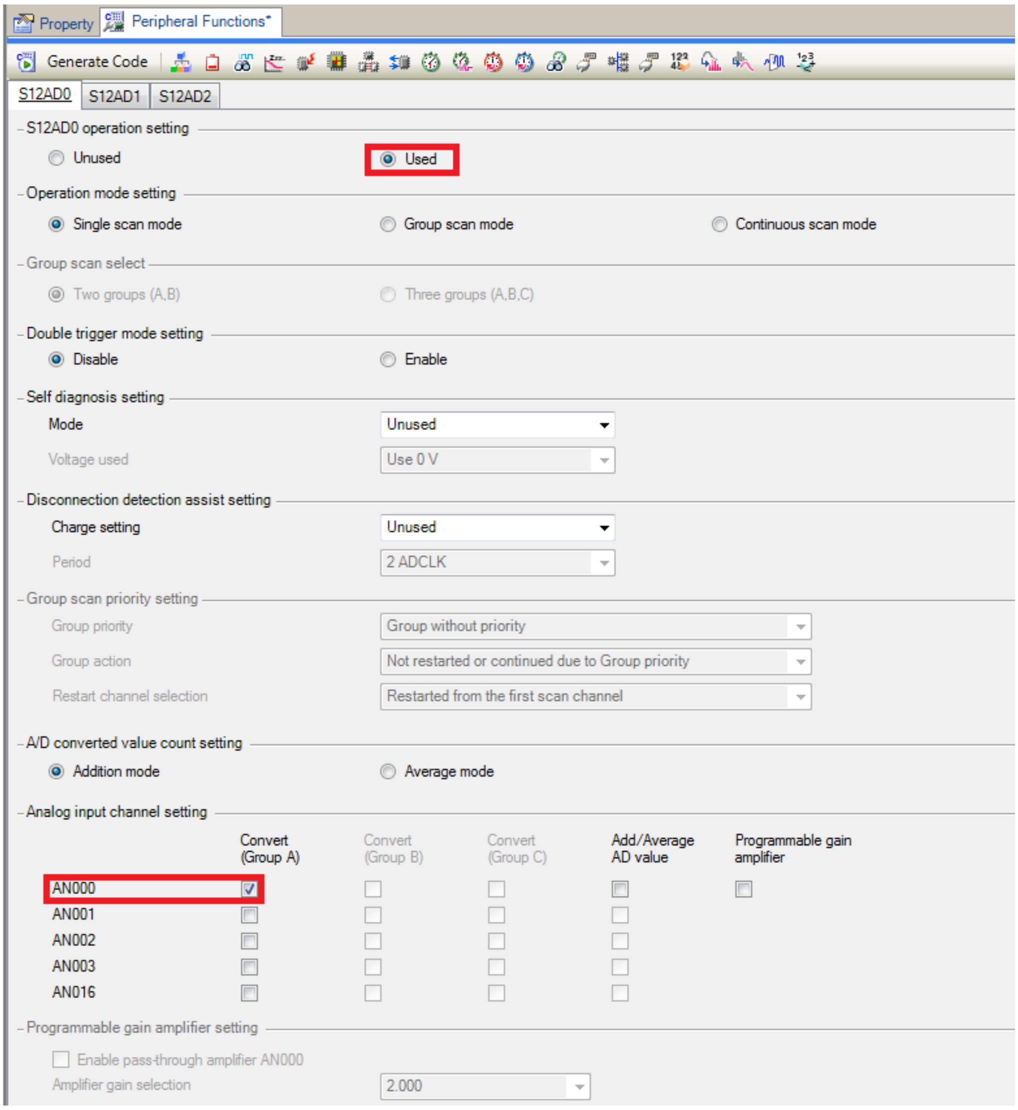


Figure 4-10 S12AD0 tab (1)

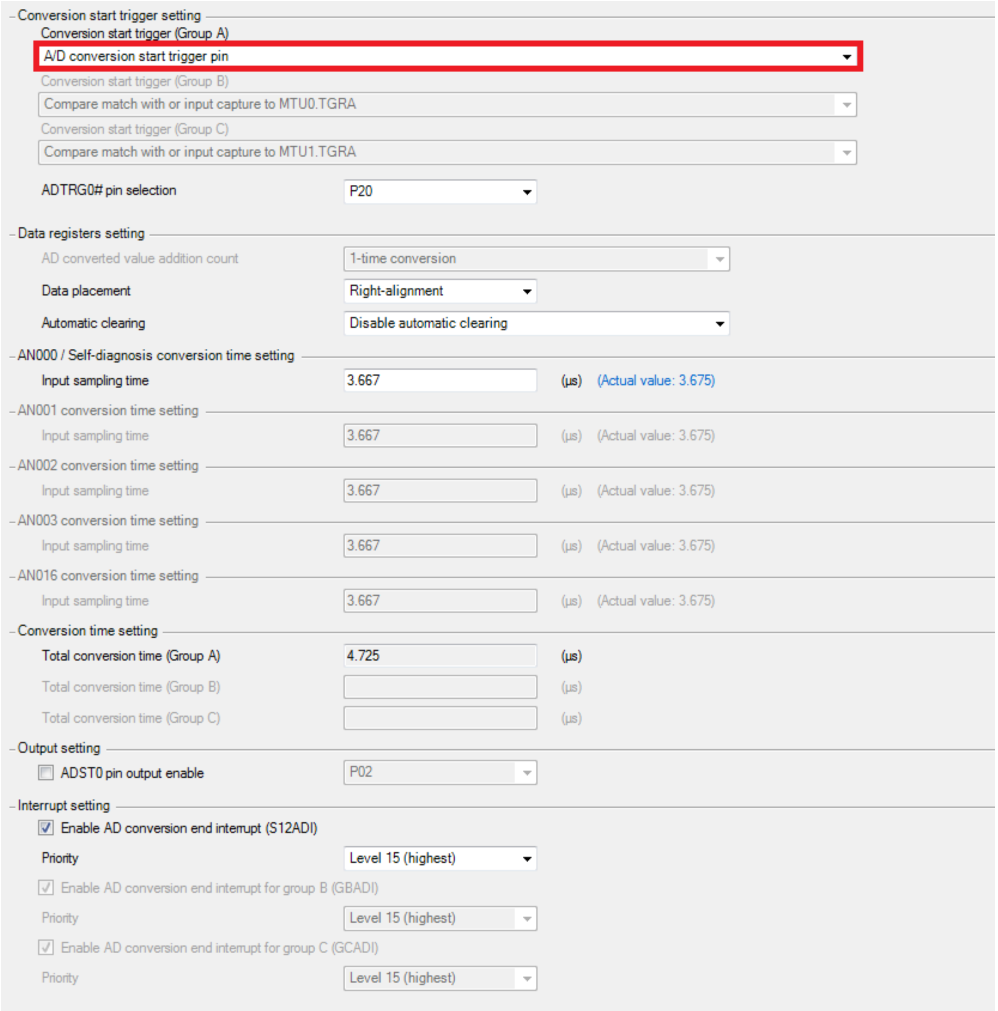


Figure 4-11 S12AD0 tab (2)

Proceed to the next section on ‘Serial Communications Interface’. Double clicking on the ‘Serial Communications Interface’ name in ‘Peripheral functions’ on the Project Tree.

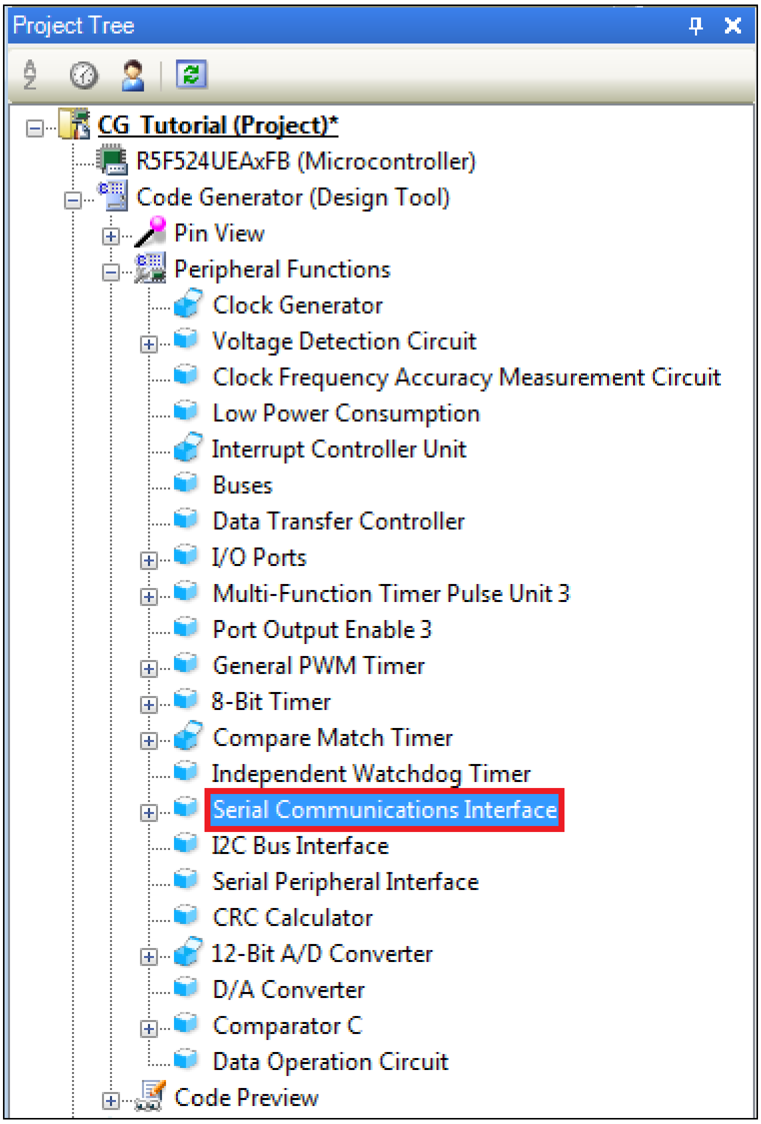


Figure 4-12 Select Serial Communications Interface

4.4.5 Serial Communications Interface

Navigate to the 'Serial Communications Interface' tab in Code Generator, select the SCI9 sub-tab and apply the settings shown in **Figure 4-13**. In the RSKRX24U SCI9 is used as an SPI master for the Pmod LCD on the PMOD1 connector as shown in the schematic.

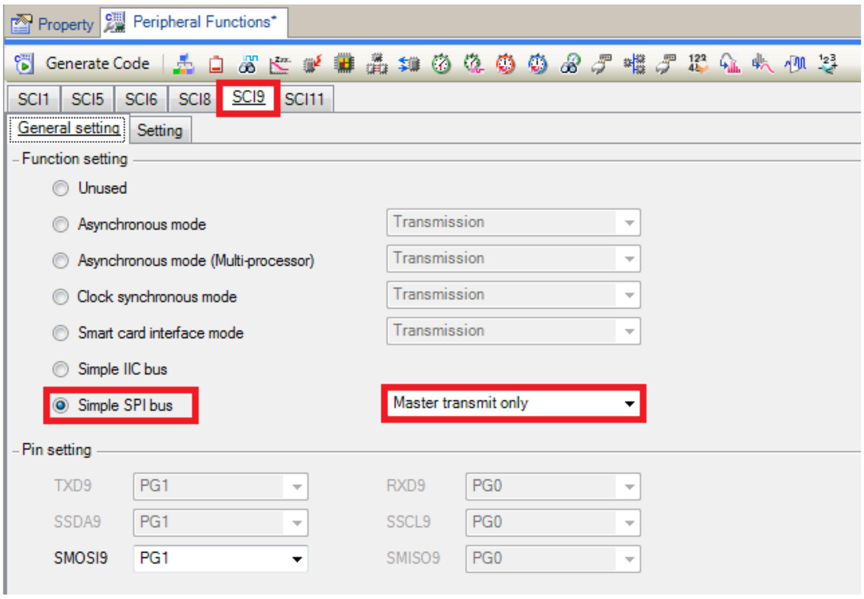


Figure 4-13 SCI9 General Setting tab

Select the SCI9 'Setting' sub-tab and configure the SPI Master as illustrated in **Figure 4-14**. Make sure the 'Transfer direction setting' is set to 'MSB-first' and the 'Bit rate' is set to 10000000. All other settings remain at their defaults.

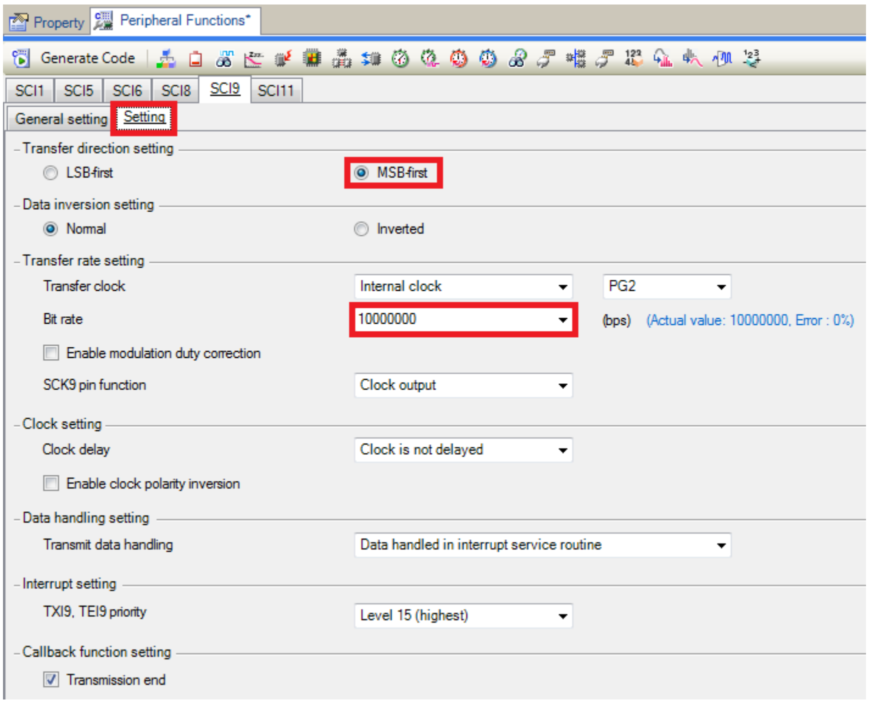


Figure 4-14 SCI9 Setting tab

Staying in the 'Serial Communications Interface' tab in Code Generator, select the SCI1 sub-tab and apply the settings shown in **Figure 4-15**. In the RSKRX24U SCI1 is connected via a Renesas RL78/G1C to provide a USB virtual COM port as shown in the schematic.

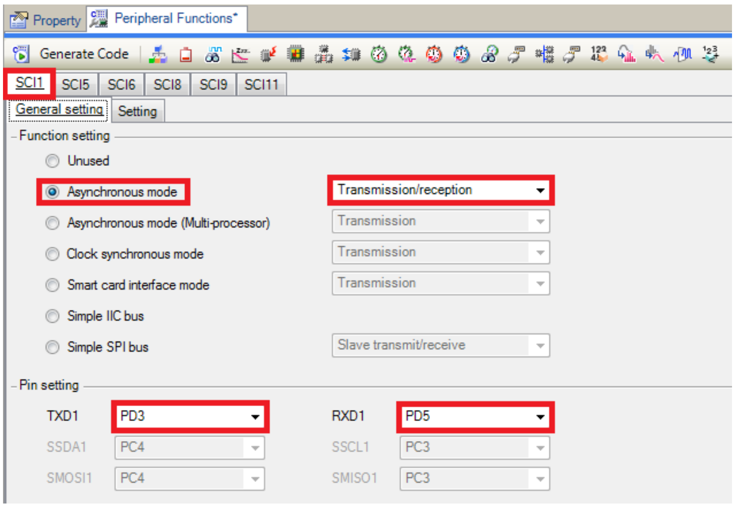


Figure 4-15 SCI1 General Setting tab

Select the SCI1 'Setting' sub-tab and configure SCI1 as illustrated in **Figure 4-16**. Make sure the 'Start bit edge detection' is set as 'Falling edge on RXD1 pin' and the 'Bit rate' is set to 19200 bps. All other settings remain at their defaults.

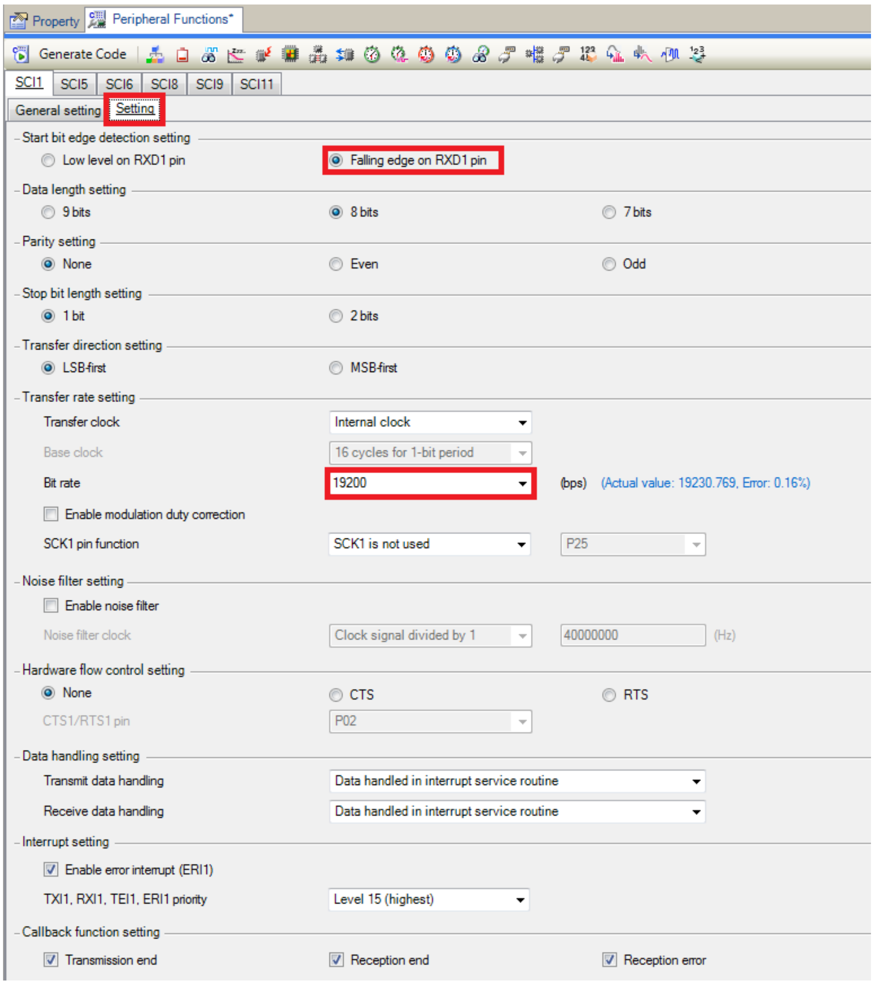


Figure 4-16 SCI1 Setting tab

Proceed to the next section on 'I/O Ports'. Double clicking on the 'I/O Ports' name in 'Peripheral functions' on the Project Tree.

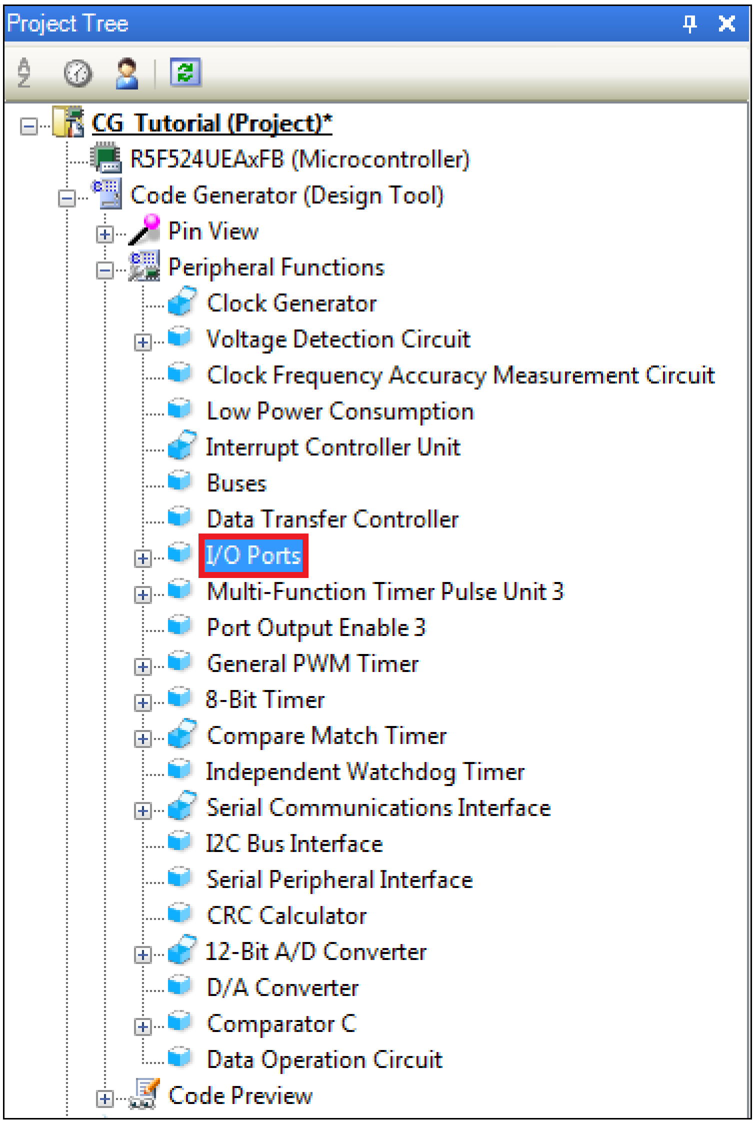


Figure 4-17 Select I/O Ports

4.4.6 I/O Ports

Referring to the RSK schematic, LED0 is connected to P21, LED1 is connected to P22, LED2 is connected to PC3 and LED3 is connected to PC4. Navigate to the 'I/O Ports' tab in Code Generator and configure these four I/O lines as shown in **Figure 4-18** and **Figure 4-19** below. Ensure that the 'Output 1' tick box is checked. This ensures that the code is generated to set LEDs initially off.

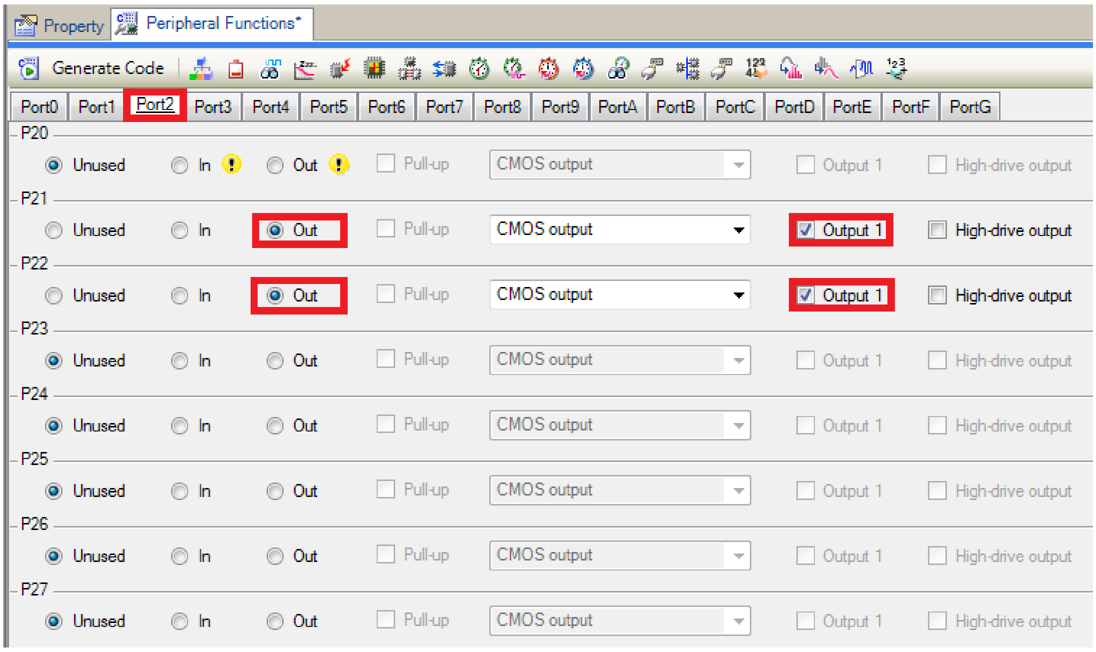


Figure 4-18 I/O ports – Port2

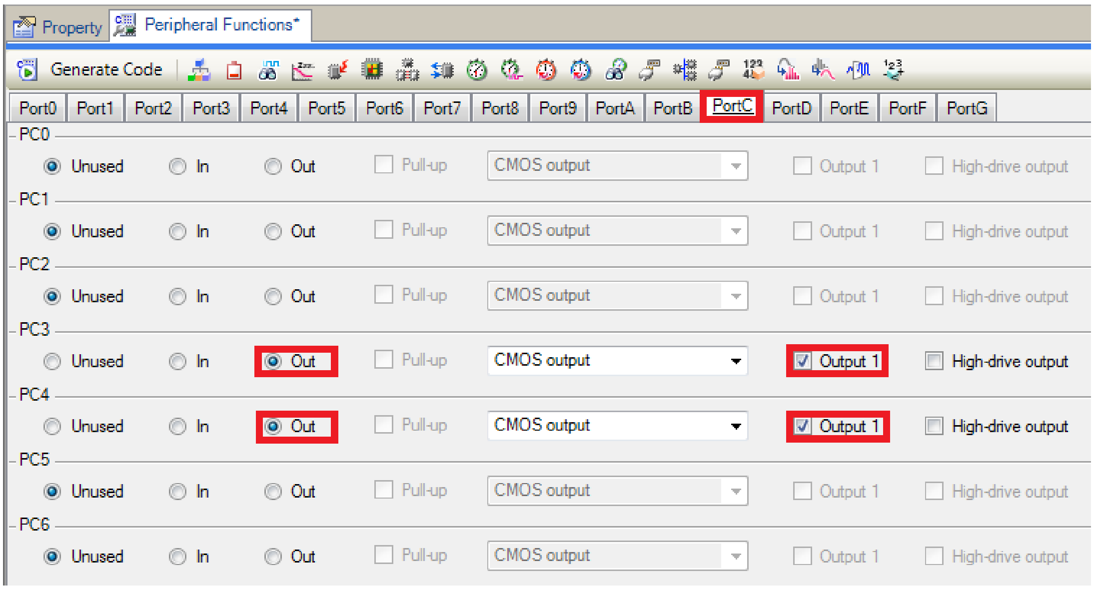


Figure 4-19 I/O ports – PortC

P27 is used as one of the LCD control lines, together with P34, P55 and P65. Configure these lines as shown in **Figure 4-20**, **Figure 4-21, Figure 4-22 and Figure 4-23**.

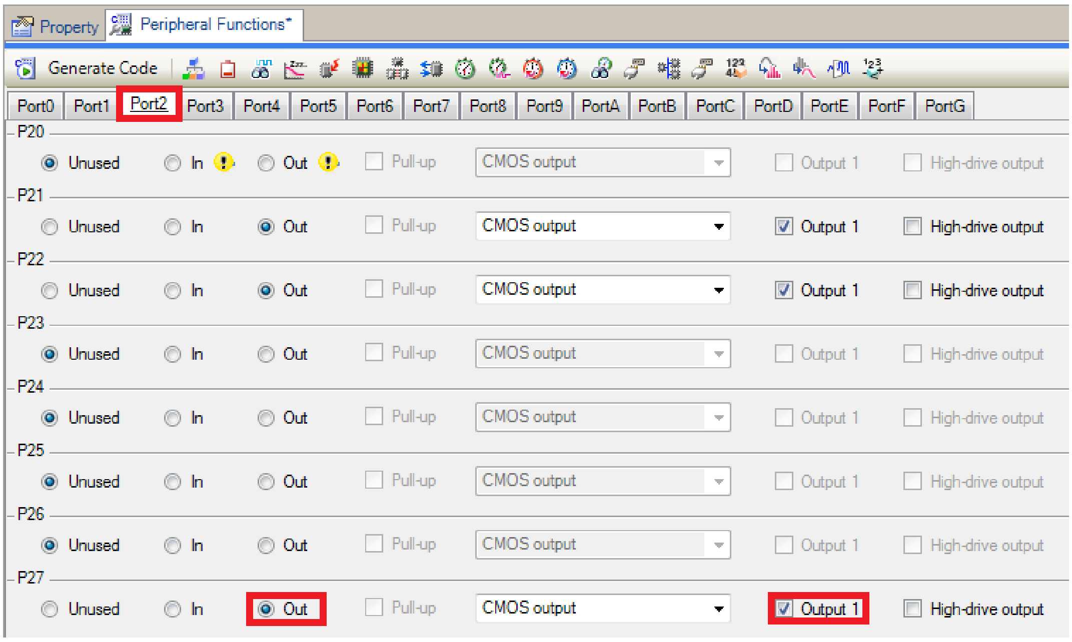


Figure 4-20 I/O ports – Port2

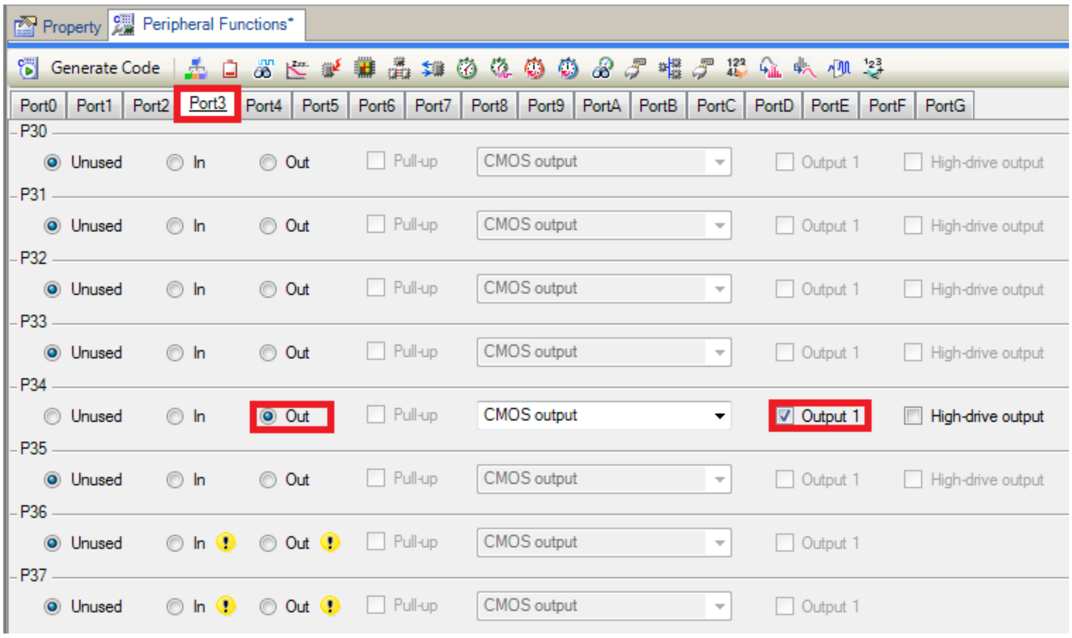


Figure 4-21 I/O ports – Port3

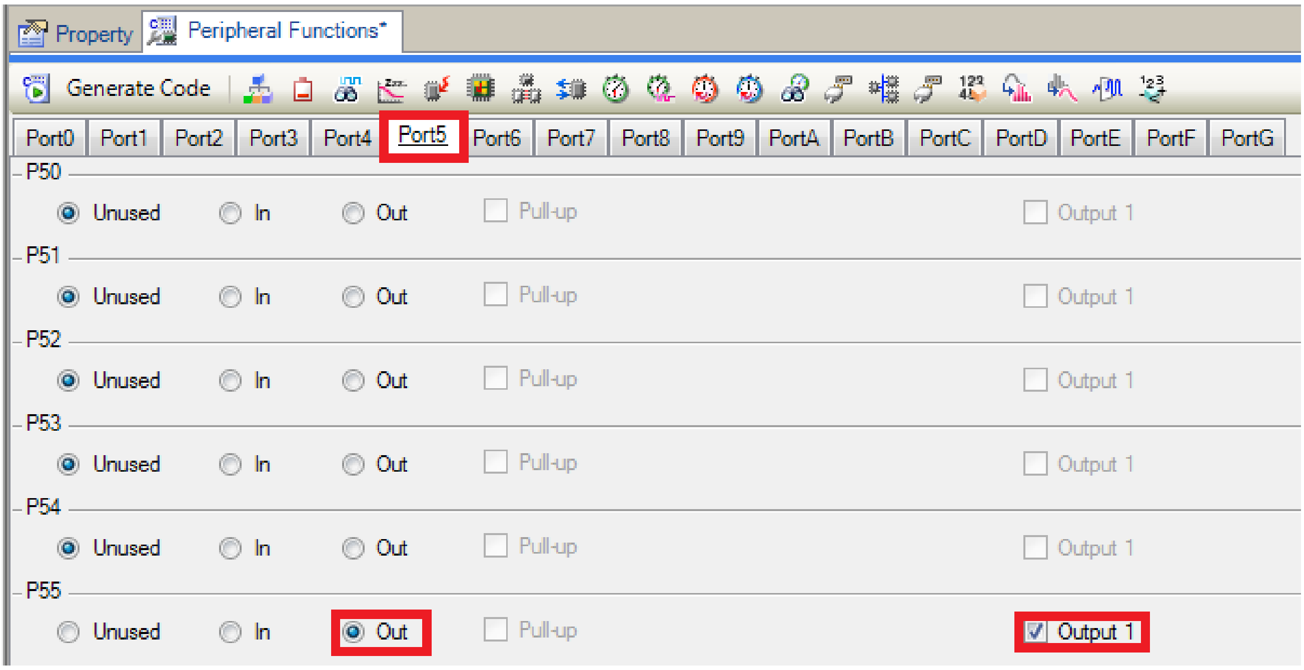


Figure 4-22 I/O ports – Port5

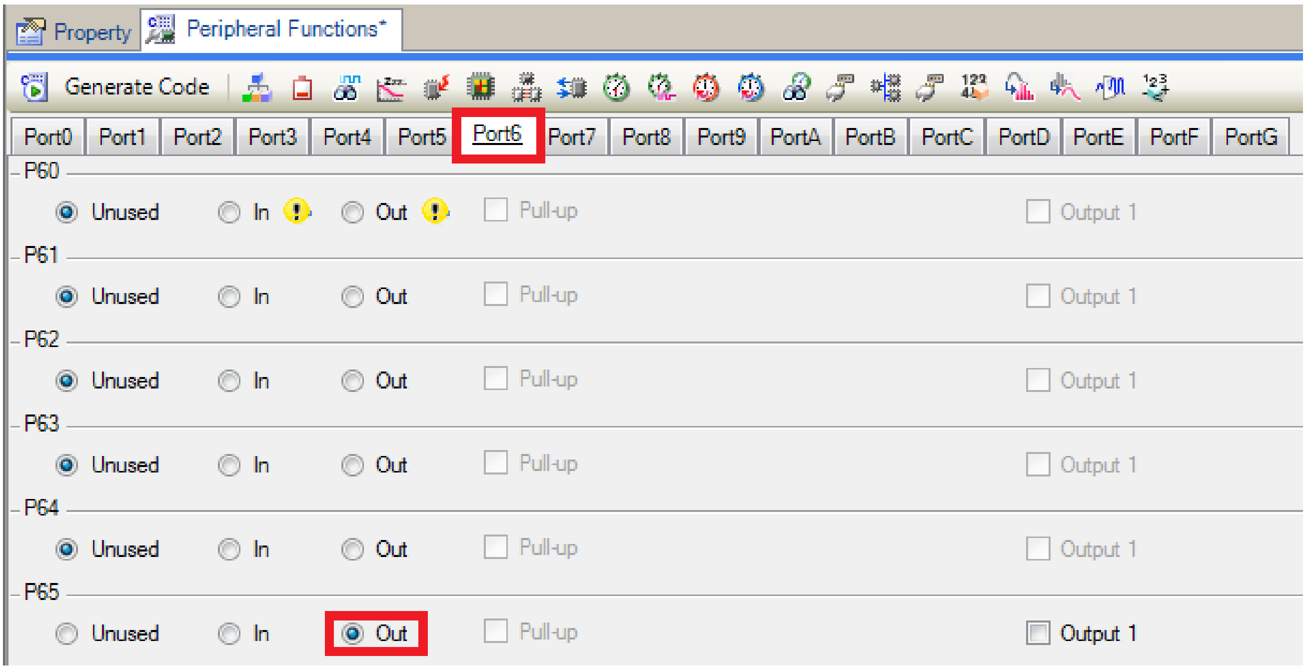


Figure 4-23 I/O ports – Port6

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 4-24** below.

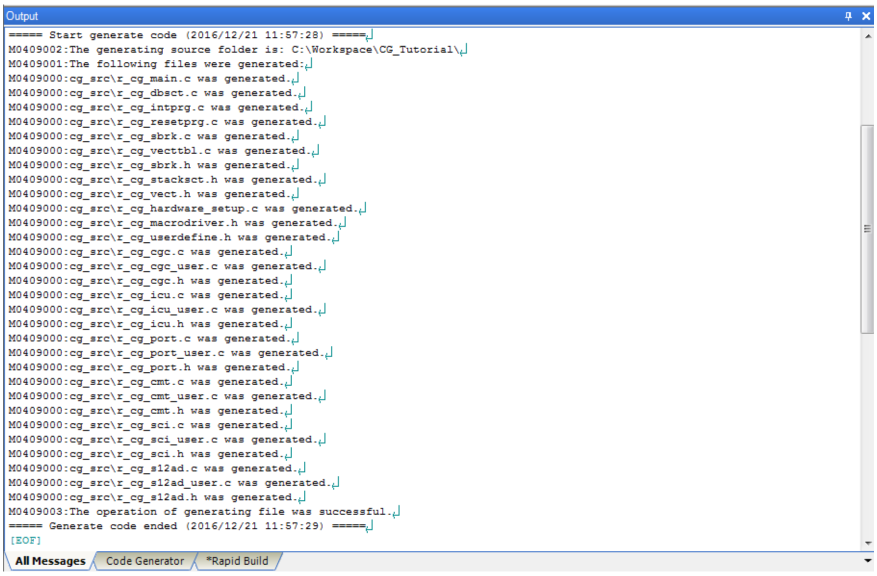


Figure 4-24 Code generator console

Figure 4-25 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.

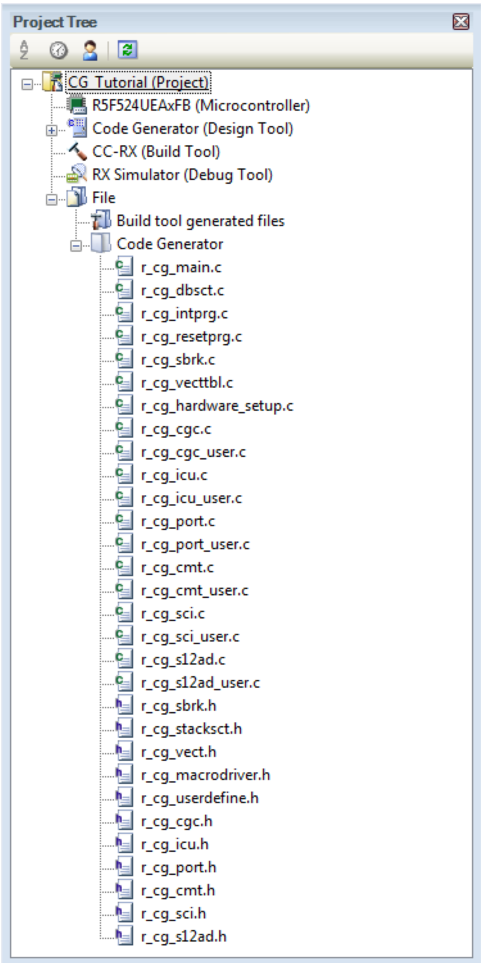
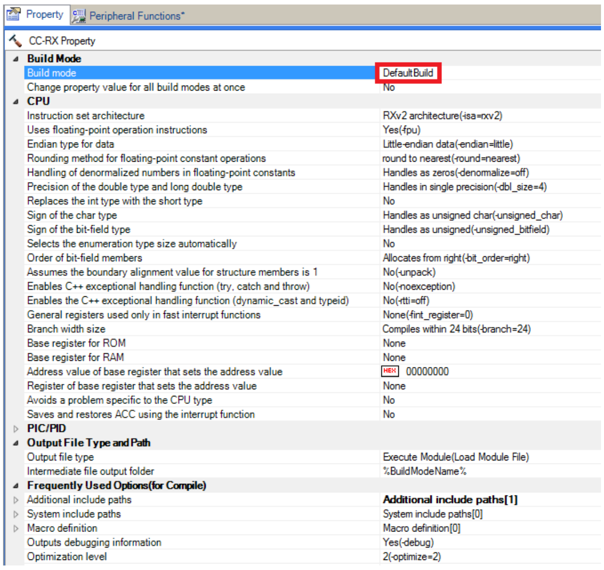


Figure 4-25 Code Generator Files in the Project Tree

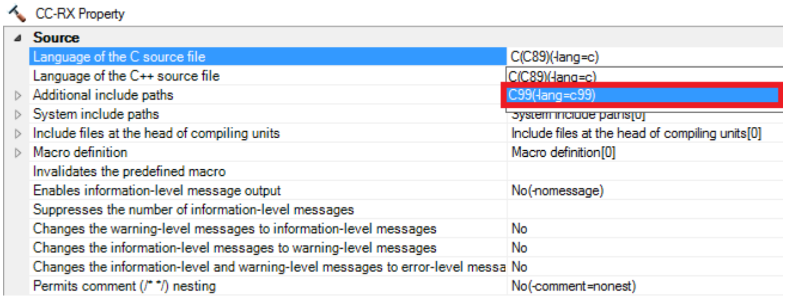
5. Completing the Tutorial Project

5.1 Project Settings

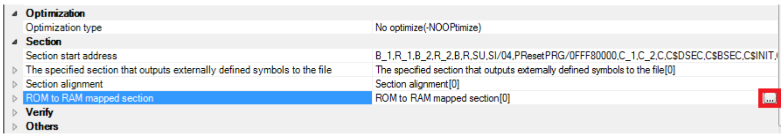
- In the 'Project Tree' pane, select 'CC-RX (Build Tool)'. The build properties will appear in the main window.
- CS+ creates a single build configuration called 'Default Build' for the project. This has standard code optimisation turned on by default.



- 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. .



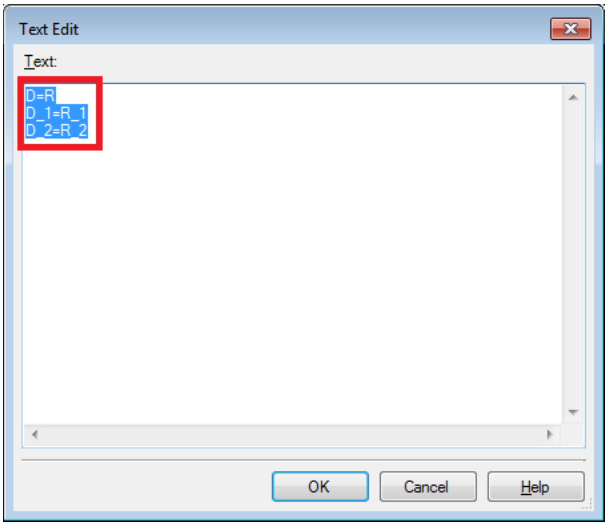
- These settings are easily added by clicking the button '…' and pasting the following text into the dialog:

D=R

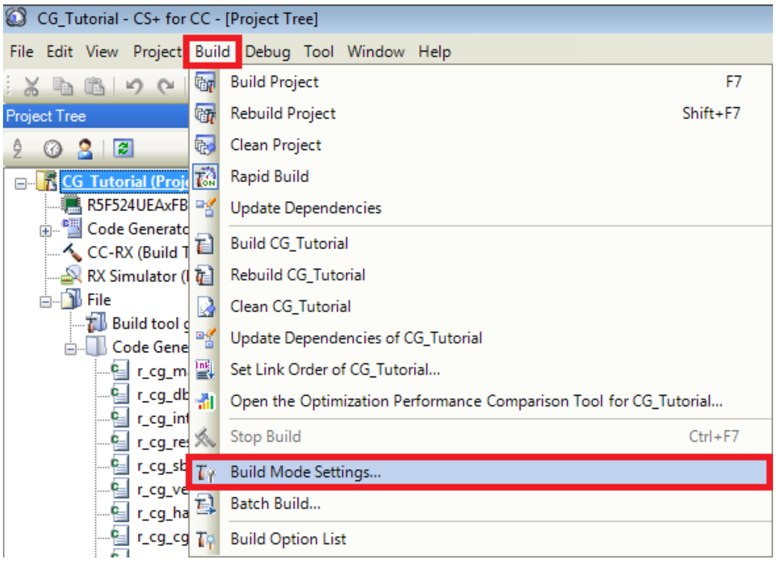
D_1=R_1

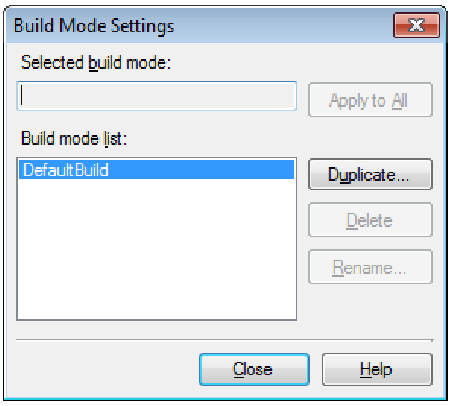
D_2=R_2

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

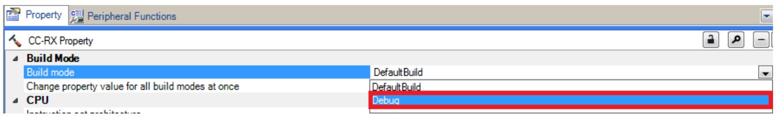


- From the ‘Build’ menu, select ‘Build Mode Settings…’. Click ‘Duplicate’ and in the resulting ‘Character String Input’ dialog, enter ‘Debug’ for the name of the duplicate Build Mode.

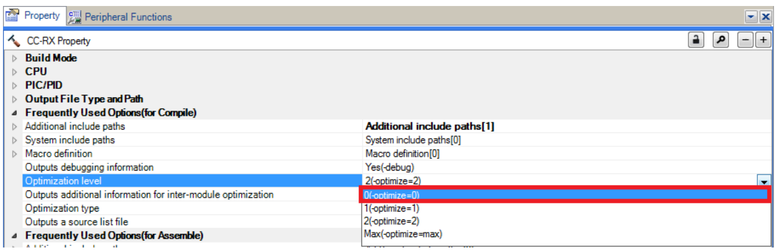




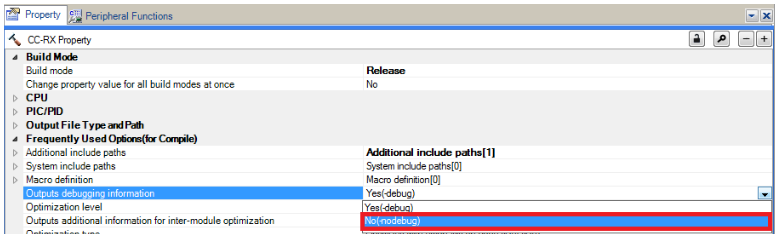
- The new ‘Debug’ Build Mode will be added to the Build Mode list. Click ‘Close’. Now, in the main CC-RX Property window, under the ‘Common Options’ tab, click on the line containing ‘Build Mode’, click the pull-down arrow and select ‘Debug’ from the pull-down’.



- 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.

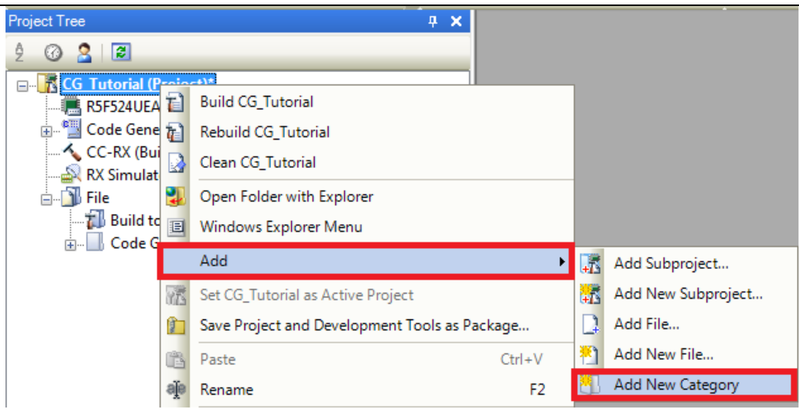


- All of the sample code projects contained in this RSK are configured with three Build Modes; ‘DefaultBuild’, ‘Debug’ and ‘Release’. ‘Release’ is created in the same way as above; by duplicating ‘Default Build’. ‘Release’ Build Mode leaves code optimisation turned on and removes debug information from 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.

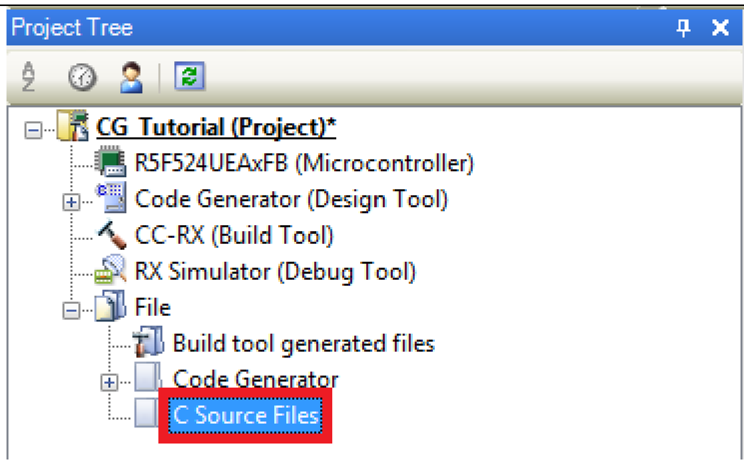


5.2 Additional Folders

- Before new source files are added to the project, we will create two additional folders in the CS+ 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’.



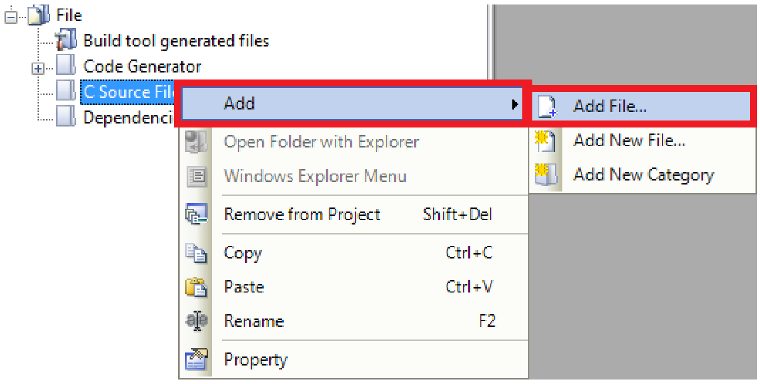
5.3 LCD Code Integration

API functions for the Okaya LCD display are provided with the RSK. Refer to the Tutorial project folder created according to the Quick Start Guide procedure. Locate the files ascii.h, r_okaya_lcd.h, iodefine.h, ascii.c, and r_okaya_lcd.c in this folder. Copy these files into the C:\Workspace\CG_Tutorial folder.

<table>
<tr>
<td>

- Right-click on the ‘C Source Files’ in the Project Tree and select ‘Add -> Add File…’.

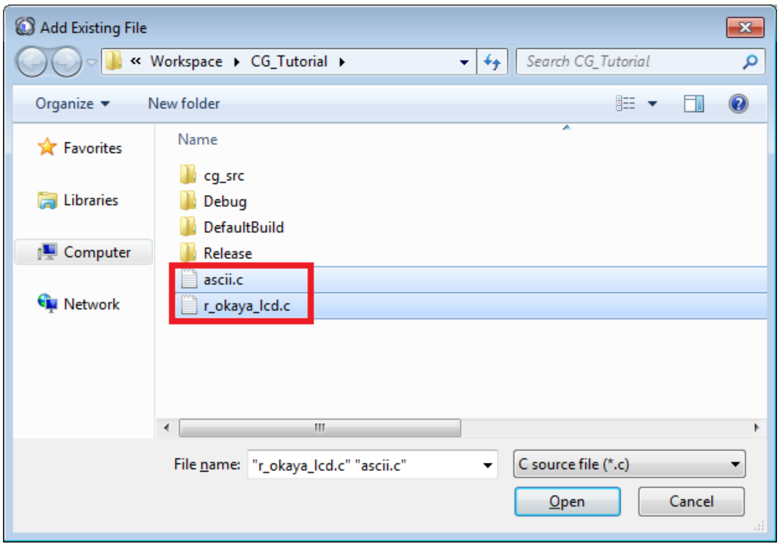
</td>
<td>



</td>
</tr>
<tr>
<td>

- Browse to the files ascii.c, and r_okaya_lcd.c in the C:\Workspace\CG_Tutorial folder and click ‘Open’.

</td>
<td>

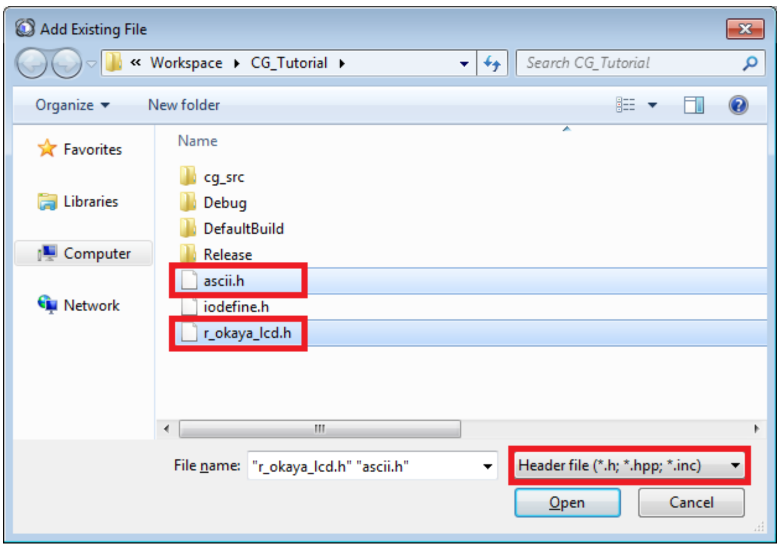


</td>
</tr>
<tr>
<td>

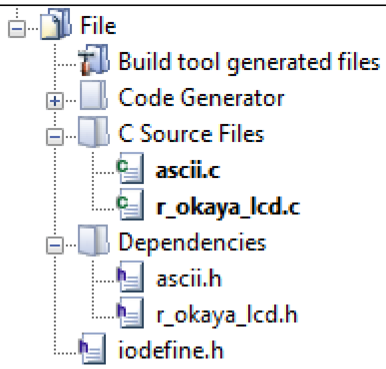
- Repeat the above steps to add the files ascii.h and r_okaya_lcd.h to the ‘Dependencies’ folder.

Note: Choose ‘Header file (*.h; *.hpp; *.inc)’ from file list.

</td>
<td>



</td>
</tr>
</table>

• Repeat the above steps to add the file iodefine.h to the 'File' 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 CS+ 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 function. Do not edit comment generated here */

#define TRUE            (1)
#define FALSE           (0)

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

In the CS+ 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 */

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

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSKRX24U ");
    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 §4.4.5. In the CS+ 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_SCI9_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 sci9_txdone;

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

Insert the following code in the transmit end call-back function for SCI9:

```
void r_sci9_callback_transmitend(void)
{
    /* Start user code. Do not edit comment generated here */
    sci9_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:

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

/*******************************************************************************
* Function Name: R_SCI9_SPIMasterTransmit
* Description  : This function sends SPI9 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_SCI9_SPIMasterTransmit (uint8_t * const tx_buf, const uint16_t tx_num)
{
    MD_STATUS status = MD_OK;

    /* Clear the flag before initiating a new transmission */
    sci9_txdone = FALSE;

    /* Send the data using the API */
    status = R_SCI9_SPI_Master_Send(tx_buf, tx_num);

    /* Wait for the transmit end flag */
    while (FALSE == sci9_txdone)
    {
        /* Wait */
    }

    return (status);
}

/*******************************************************************************
* End of function R_SCI9_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 §4.4.3. 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:

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

/*******************************************************************************
* 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. CS+ will build the project with no errors.

The project may now be run using the debugger as described in §6. The program will display 'RSKRX24U 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. Refer to the Tutorial project folder created according to the Quick Start Guide procedure. Locate the files rskrx24udef.h, r_rsk_switch.h and r_rsk_switch.c in this folder. Copy these files into the C:\Workspace\CG_Tutorial folder. Import these three 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 §4.4.2 and §4.4.3. 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 CS+ 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:

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

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

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

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

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

In the same file insert the following code in the user code area inside the function r_icu_irq0_interrupt:

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

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

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

In the same file insert the following code in the user code area inside the function r_icu_irq4_interrupt:

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

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

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

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:

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

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

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

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

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

    /* 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();

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

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

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

    /* 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();

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

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 §4.4.4, we configured the ADC to be triggered from the ADTRG0# pin, SW3. 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 CS+ 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 initialization 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 */

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

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

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSKRX24U ");
    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 */

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

/* 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);

/* 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 */

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

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

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

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSKRX24U ");
    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;
        }
        else
        {
            /* do nothing */
        }
    }

    /* 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:

```
/* Start user code for adding. Do not edit comment generated here */
/******************************************************************************
* 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 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 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 AD converter.
* Arguments    : None
* Return Value : None
***********************************************************************/
void R_S12AD0_SWTriggerStart(void)
{
    IR(S12AD, S12ADI) = 0U;
    IEN(S12AD, S12ADI) = 1U;
    S12AD.ADCSR.BIT.ADST = 1U;
}
/***********************************************************************
End of function R_S12AD0_SWTriggerStart
***********************************************************************/
```

```
/*******************************************************************************
* Function Name: R_S12AD0_SWTriggerStop
* Description  : This function stops the AD converter.
* Arguments    : None
* Return Value : None
*******************************************************************************/
void R_S12AD0_SWTriggerStop(void)
{
    S12AD.ADCSR.BIT.ADST = 0U;
    IEN(S12AD, S12ADI) = 0U;
    IR(S12AD, S12ADI) = 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 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 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. CS+ 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 CG_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. Refer to the Tutorial project folder created according to the Quick Start Guide procedure. Locate the files r_rsk_debug.h and r_rsk_debug.c in this 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 SERIAL_DEBUG_WRITE (R_SCI1_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 CS+ 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_SCI9_SPIMasterTransmit(uint8_t * const tx_buf, const uint16_t tx_num);
MD_STATUS R_SCI1_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 sci9_txdone;
static volatile uint8_t sci1_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_sci1_callback_transmitend function:

```
void r_sci1_callback_transmitend(void)
{
    /* Start user code. Do not edit comment generated here */

    sci1_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_sci1_callback_receiveend function:

```
void r_sci1_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 SCI1 receive buffer and callback function again */
    R_SCI1_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_SCI1_AsyncTransmit
* Description  : This function sends SCI1 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_SCI1_AsyncTransmit (uint8_t * const tx_buf, const uint16_t tx_num)
{
    MD_STATUS status = MD_OK;

    /* clear the flag before initiating a new transmission */
    sci1_txdone = FALSE;

    /* Send the data using the API */
    status = R_SCI1_Serial_Send(tx_buf, tx_num);

    /* Wait for the transmit end flag */
    while (FALSE == sci1_txdone)
    {
        /* Wait */
    }
    return (status);
}

/*******************************************************************************
* End of function R_SCI1_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:

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

#include "r_okaya_lcd.h"
#include "r_rsk_switch.h"
#include "r_rsk_debug.h"

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

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

```
/* Start user code for global. Do not edit comment generated here */
/* Variable for flagging user requested ADC conversion */
volatile uint8_t g_adc_trigger = FALSE;

/* 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);

/* 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;

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

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 */

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

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

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

    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSKRX24U ");
    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 SCI1 receive buffer and callback function */
    R_SCI1_Serial_Receive((uint8_t *)&g_rx_char, 1);

    /* Enable SCI1 operations */
    R_SCI1_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 */
            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;
        }
        else
        {
            /* do nothing */
        }
    }
    /* 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. CS+ 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 appears 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 SCI1 (see §4.4.5). 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 SCI1. Return to this point in the CG_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:

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

#include "r_okaya_lcd.h"
#include "r_rsk_switch.h"
#include "r_rsk_debug.h"
#include "rskrx24udef.h"

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

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

```
/* Start user code for global. Do not edit comment generated here */
/* Variable for flagging user requested ADC conversion */
volatile uint8_t g_adc_trigger = FALSE;

/* 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);

/* 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;

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

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

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

    /* Set the call back function when SW1 or SW2 is pressed */
    R_SWITCH_SetPressCallback(cb_switch_press);
    /* Initialize the debug LCD */
    R_LCD_Init();
    /* Displays the application name on the debug LCD */
    R_LCD_Display(0, (uint8_t *)" RSKRX24U ");
    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 SCI1 receive buffer and callback function */
    R_SCI1_Serial_Receive((uint8_t *)&g_rx_char, 1);
    /* Enable SCI1 operations */
    R_SCI1_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;
        }
        else
        {
            /* do nothing */
        }
    }

    /* 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 = (uint8_t)((count & 0x01) ? LED_ON : LED_OFF);
    LED1 = (uint8_t)((count & 0x02) ? LED_ON : LED_OFF);
    LED2 = (uint8_t)((count & 0x04) ? LED_ON : LED_OFF);
    LED3 = (uint8_t)((count & 0x08) ? LED_ON : LED_OFF);
}
/******************************************************************************
* End of function led_display_count
******************************************************************************/
```

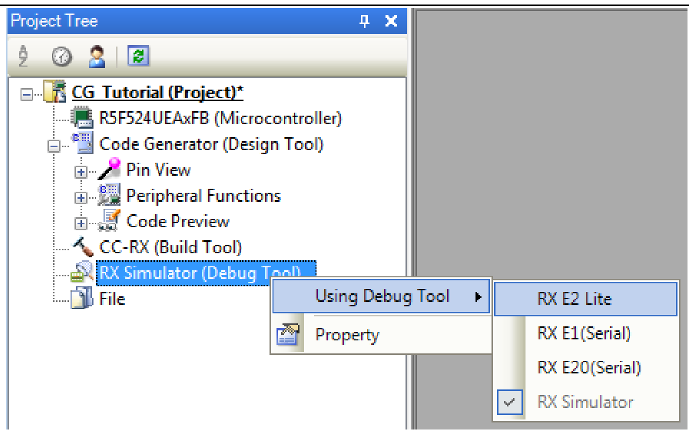
```
/* End user code. Do not edit comment generated here */
```

Select 'Build Project' from the 'Build' menu, or press F7. CS+ will build the project with no errors.

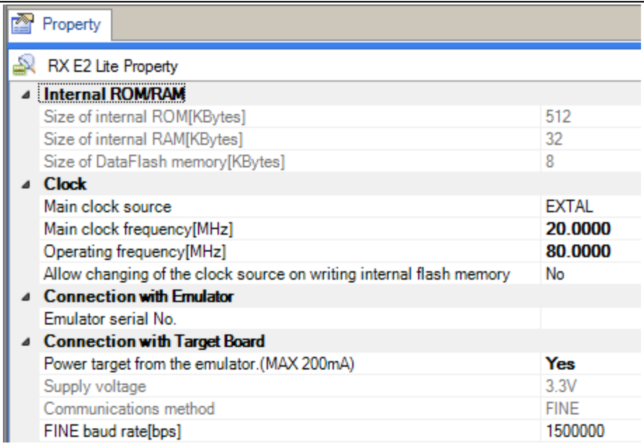
The project may now be run using the debugger as described in §6. The code will perform the same but now the LEDs will display the adc_count in binary form.

6. Debugging the Project

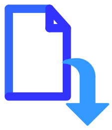
- In the 'Project Tree' pane, right-click the 'RX Simulator (Debug Tool)'. Select 'Using Debug Tool -> RX E2 Lite'.



- Double-click 'RX E2 Lite (Debug Tool)' to display the debugger tool properties. Under 'Clock', change the main clock frequency to 20 MHz and operating frequency to 80MHz.'
- Under 'Connection with TargetBoard', change 'Power targetfrom the emulator.(MAX 200mA)to 'Yes'
- All other settings can remain at their defaults.



- Connect the E2 Lite to the PC and the RSK E1/E2 Lite connector. Connect the 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

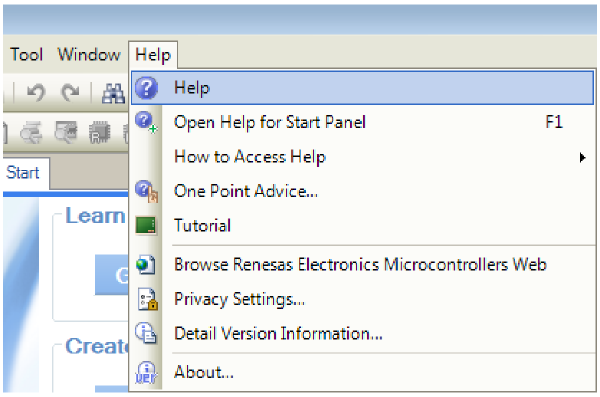
7.1 Running the Tutorial

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 CS+, refer to the help file by opening CS+, then selecting Help > Help Contents from the menu bar.



For information about the RX24U group microcontroller refer to the RX24U 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 8 of the "Quick Start Guide".

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

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