User's Manual

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RX113 Group

Renesas Starter Kit Code Generator Tutorial Manual For CS+

RENESAS MCU
RX Family / RX100 Series

Renesas Electronics
www.renesas.com

Rev. 1.01 Mar 2015

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Precautions

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

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

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

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

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

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

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

How to Use This Manual

1. Purpose and Target Readers

This manual is designed to provide the user with an understanding of how to use 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 RX113 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 RX113 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.	RSKRX113 User's Manual	R20UT2756EG
Tutorial Manual	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSKRX113 Tutorial Manual	R20UT2757EG
Code Generator Tutorial	Provides a guide to code generation and importing into the CS+ IDE.	RSKRX113 Code Generator Tutorial Manual	R20UT3254EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample, on a single A4 sheet.	RSKRX113 Quick Start Guide	R20UT2758EG
Schematics	Full detail circuit schematics of the RSK.	RSKRX113 Schematics	R20UT2755EG
Hardware Manual	Provides technical details of the RX113 microcontroller.	RX113 Group, User's Manual: Hardware	R01UH0448EJ

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
ADC	Analog-to-Digital Converter
API	Application Programming Interface
COM	COMmunications port referring to PC serial port
CPU	Central Processing Unit
DVD	Digital Versatile Disc
E1	Renesas On-chip Debugging Emulator
GUI	Graphical User Interface
IDE	Integrated Development Environment
IRQ	Interrupt Request line
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro-controller Unit
PC	Personal Computer
Pmod™	This is a Digilent Pmod™ Compatible connector. Pmod™ is registered to Digilent Inc. Digilent-Pmod_Interface_Specification
PLL	Phase-locked Loop
RAM	Random Access Memory
ROM	Read Only Memory
RSK	Renesas Starter Kit
SCI	Serial Communications Interface
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus

Table of Contents

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 tutorial guides the user through creating a project to evaluate 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 and running the project.

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. Optimisation is set to two.

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 E1 emulator. Please refer to the relevant user manuals for more in-depth information.

3. Project Creation with CS+

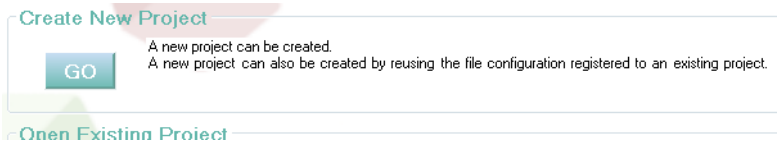
3.1 Introduction

In this section the user will be guided through the steps required to create a new 'C' project for the RX113 microcontroller, ready to generate peripheral driver code using Code Generator. This project generation step is necessary to create the MCU-specific source, project and debug files.

3.2 Creating the Project

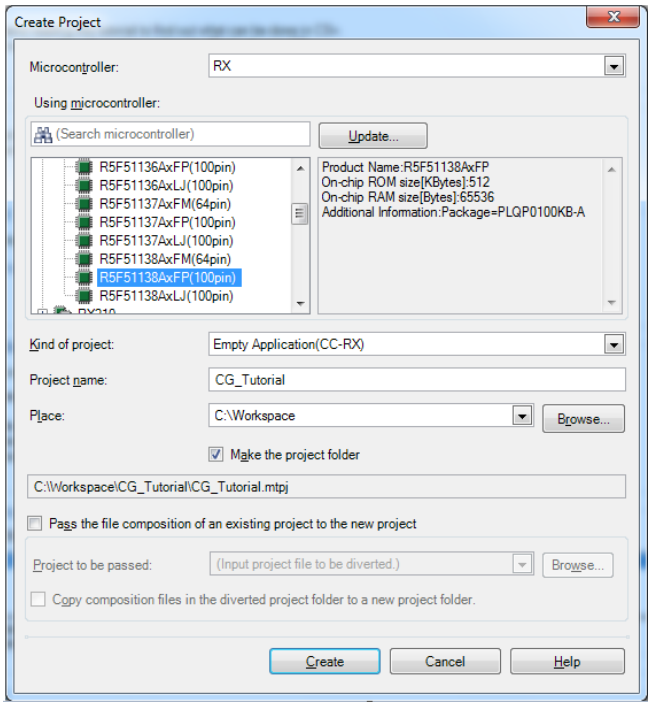
To use the program, start CS+:
Windows™ 7 & Vista: Start Menu (Start Menu > All Programs > Renesas Electronics CS+ > CS+ for CC (RX, RH850)
Windows™ 8: From Apps View, click 'CS+ for CC (RX,RH850)' icon

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

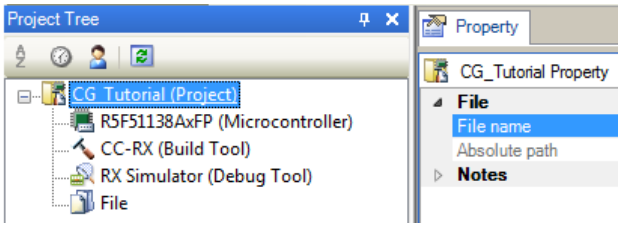


- In the 'Create Project' dialog, select 'RX' from the 'Microcontroller' pull-down.
- In the 'Using Microcontroller' list control, scroll down to 'RX113' and expand the tree control by clicking '+'. Select 'R5F51138AxFP (100pin)'.
- Ensure that in the 'Kind of project' pull-down, 'Empty Application(CC-RX)' 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 with 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.



4. Code Generation Using the CS+ plug in

4.1 Introduction

Code Generator is an CS+ plug in GUI tool for generating template 'C' source code for the RX113. When using Code Generator, the user is able to configure various MCU features and operating parameters using intuitive GUI controls, 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 free to add custom code to meet their specific requirement. Custom code should be added 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. Any code outside of these comment delimiters will be overwritten on subsequent code generation sessions.

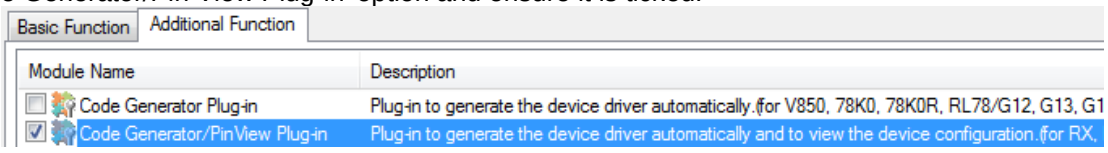
The CG_Tutorial project uses the ADC module with external trigger, Serial Communications Interface (SCI) and LCD Driver. These modules are used to perform an A/D conversion, display the results on a terminal program via the Virtual COM port and also on the LCD display attached to the RSK.

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 §6, the reader is familiarised with the structure of the template code, as well as how to add custom code in the areas provided by the Code Generator.

4.2 Enabling Code Generator

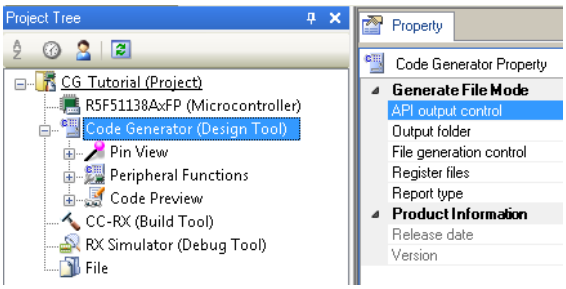
After installation of CS+, Code Generator must be enabled. This step is only required once, CS+ will remember this setting on subsequent launches.

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 (r20ut2663ej0100). 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.

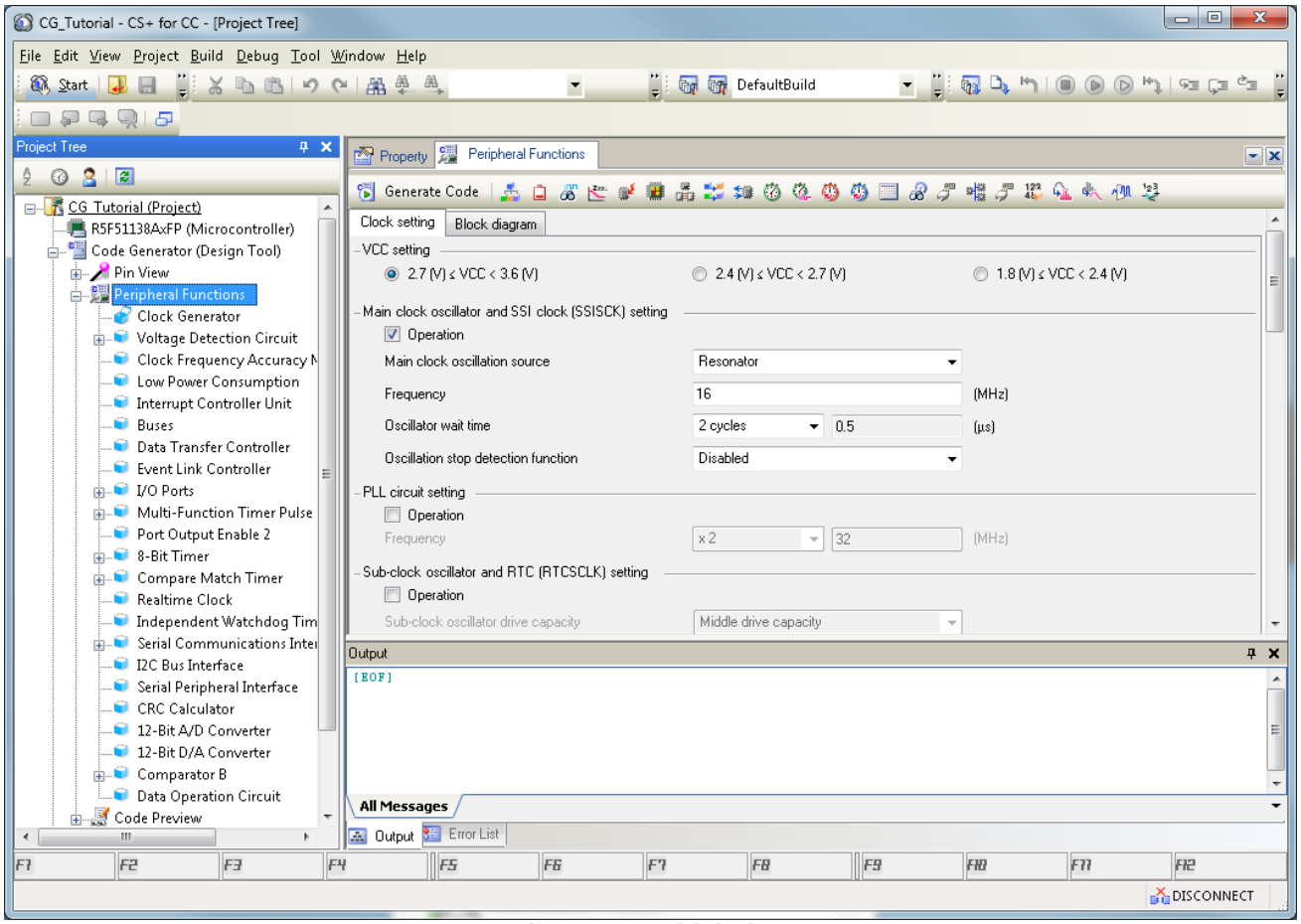


Figure 4-1 Initial View

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 Code Generator -> 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 Code Generator -> Code Preview on the left.

4.4 Code Generation

In the following sections, the reader is guided through the steps to configure the MCU for a simple tutorial project containing ADC with external switch trigger, Serial Communications Interface (SCI) and LCD Output.

4.4.1 Clock Generator

Figure 4-2 shows a screenshot of Code Generator with the Clock Generator function open.

In this tutorial we are using the 16 MHz crystal resonator for the main clock source with the PLL circuit used as a multiplier. The sub-clock oscillator is used as a clock source for the LCD peripheral.

Double click on the ‘Clock Generator’ entry in the Code Generator -> Peripheral Functions list.
Configure the Clock Generator options as shown in Figure 4-2.

Proceed to the next section to configure the I/O Ports.

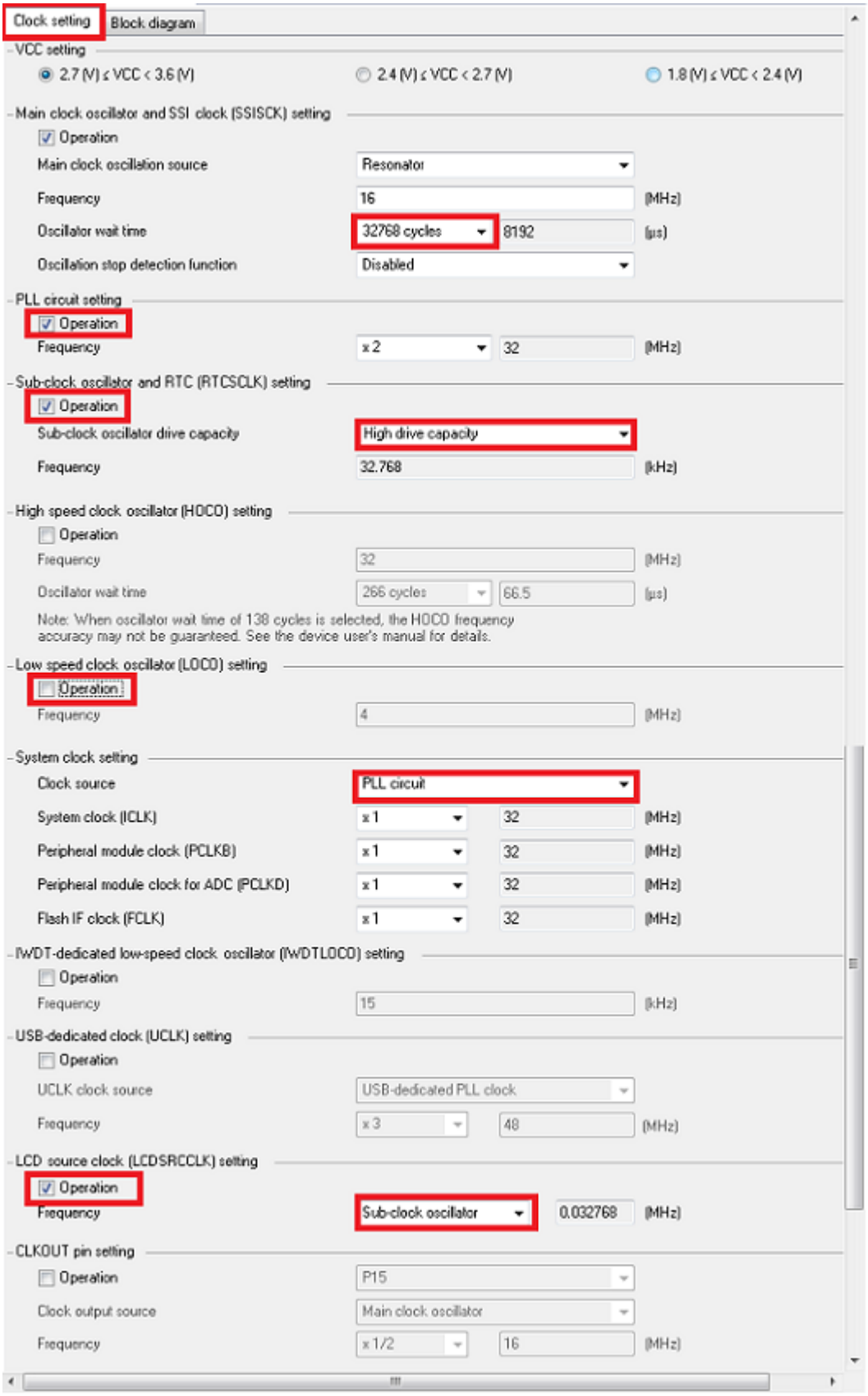


Figure 4-2 Clock setting tab

4.4.2 I/O Ports

This peripheral will be configured to assign output pins for user LEDs and input pins for user switches, with the exception of SW3 which is used as a trigger for the A/D Converter peripheral. Please refer to the RSK schematic for full details of the connectivity.

Double click on the 'I/O Ports' entry in the Code Generator -> Peripheral Functions list.
Configuration is required for Port2, Port3 and PortJ. The port is selected from the tabs at the top of the Peripheral Functions window.

Configure the ports as shown in Figure 4-3 Port 2 Configuration, Figure 4-4 Port 3 Configuration & Figure 4-5 Port J Configuration.

Proceed to the next section to configure the Serial Communications Interface.

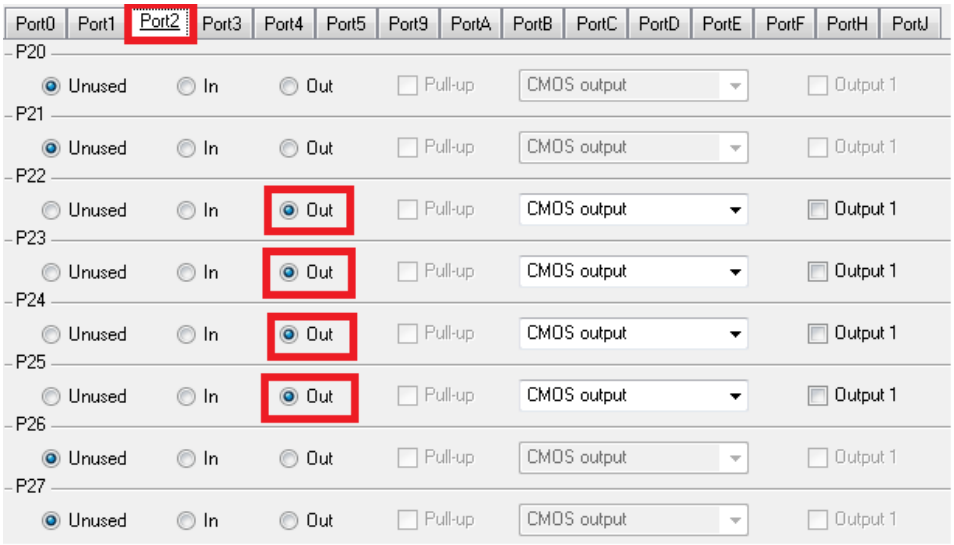


Figure 4-3 Port 2 Configuration

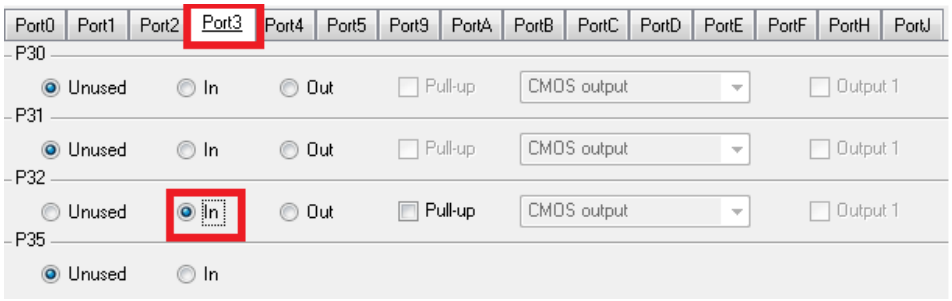


Figure 4-4 Port 3 Configuration

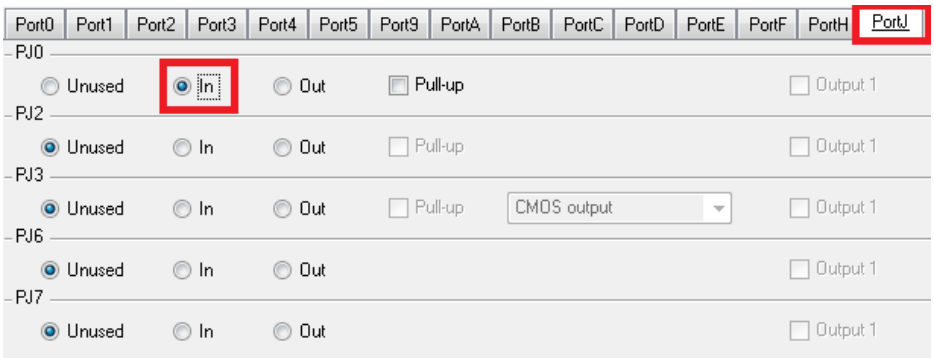


Figure 4-5 Port J Configuration

4.4.3 Serial Communications Interface

This peripheral is configured to use SCI1. This channel of the SCI is connected to the USB to serial converter and allows the application to send data to the terminal program running on the PC.

Double click on the 'Serial Communications Interface' entry in the Code Generator -> Peripheral Functions list. Configuration is required only SC1 which is selected from the tabs at the top of the Peripheral Functions window.

Configure the 'General setting' and 'Setting' sub-tabs as shown in Figure 4-6 SCI1 General Setting tab & Figure 4-7 SCI1 Setting tab.

This will configure the SCI1 channel to use asynchronous Tx/Rx using 8 data bits, No parity, 1 Stop bit at a rate of 19200 baud.

Proceed to the next section to configure the 12-Bit A/D Converter.

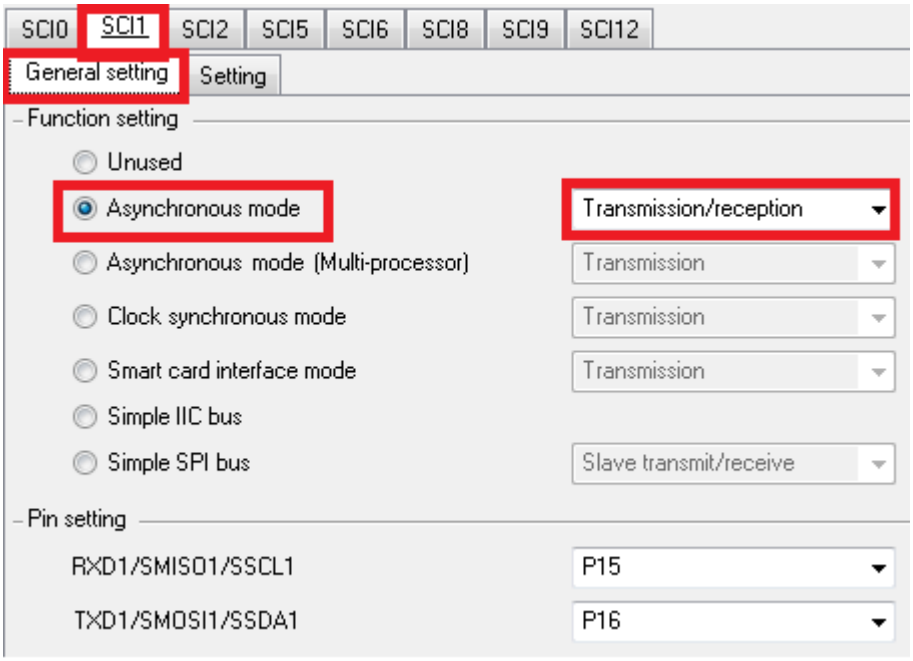


Figure 4-6 SCI1 General Setting tab

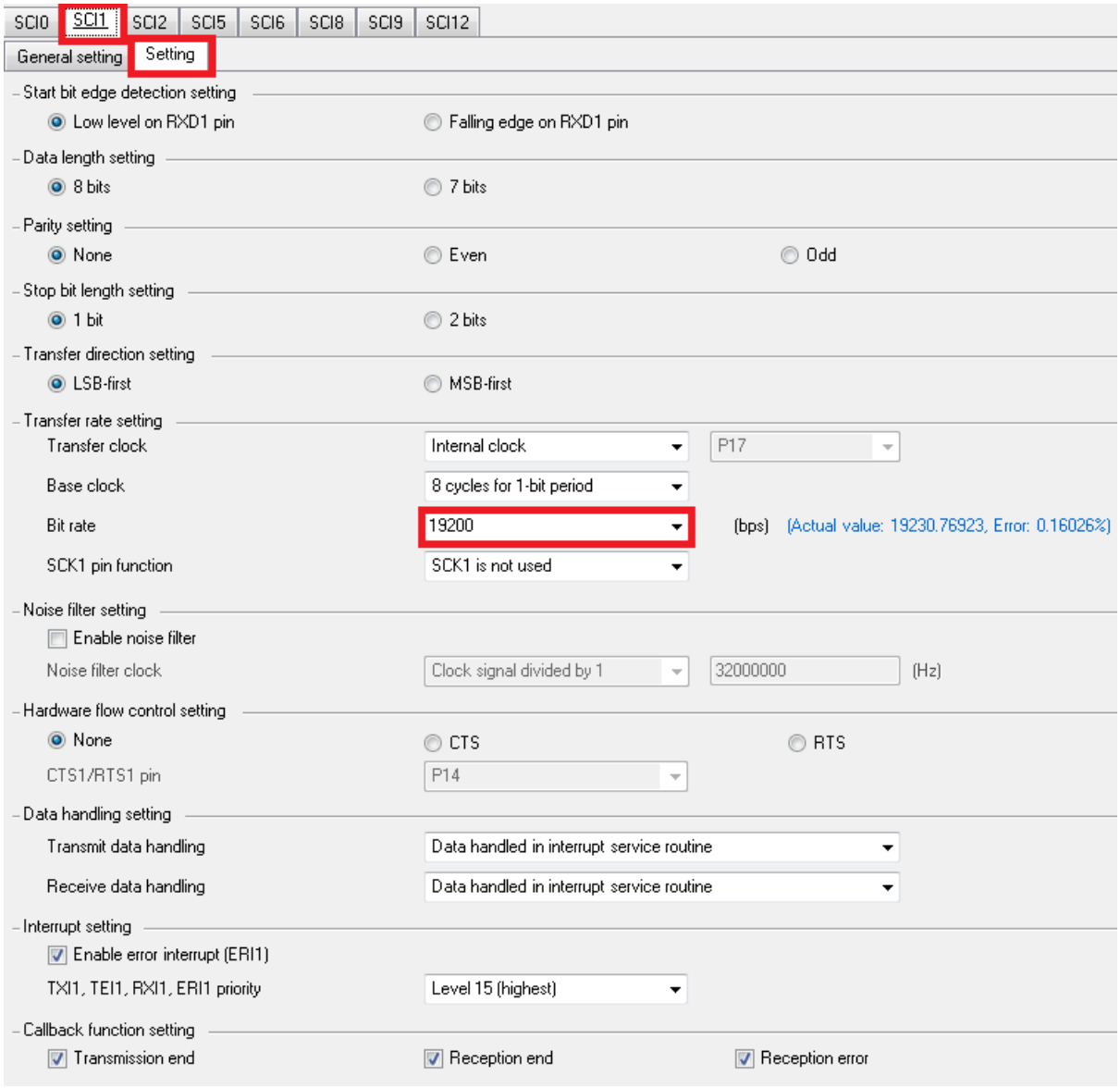


Figure 4-7 SCI1 Setting tab

4.4.4 12-bit A/D Converter

This peripheral is configured to sample the analogue output value of the RV1 potentiometer. The A/D Converter is set to perform a sample when the user presses SW3, which is connected to the ADTRG0 pin of the microcontroller.

Double click on the ’12-bit A/D Converter’ entry in the Code Generator -> Peripheral Functions list.

Configure the ‘General setting’ and ‘Setting’ sub-tabs as shown in Figure 4-8 A/D Converter General setting tab & Figure 4-9 A/D Converter Setting tab.

Code Generator configuration is now complete. Proceed to the next section to generate the code.

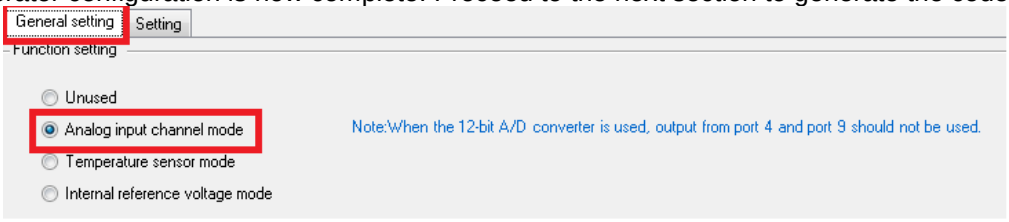


Figure 4-8 A/D Converter General setting tab

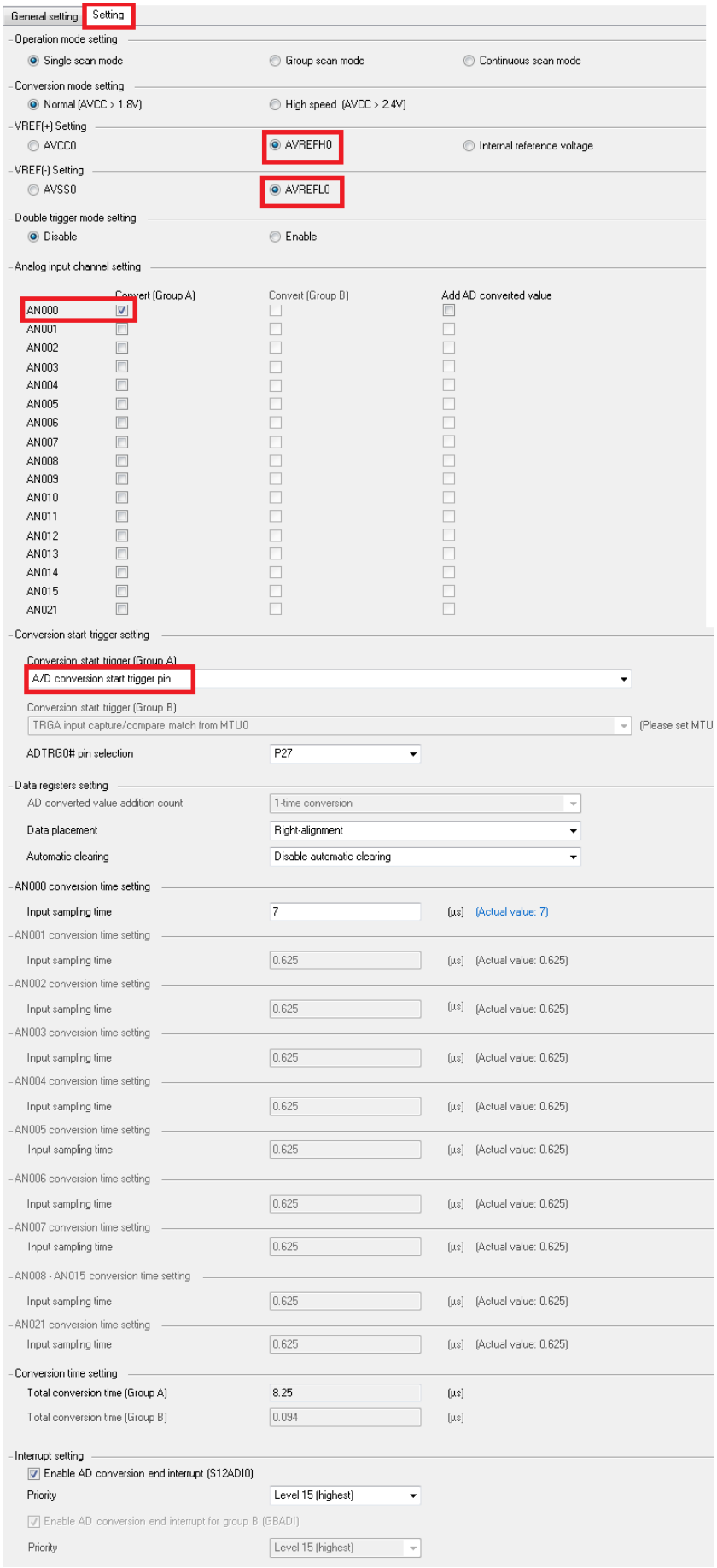


Figure 4-9 A/D Converter Setting tab

4.4.5 Generating the code

Peripheral function configuration is now complete. Click 'Generate Code' button located at the top right of the Peripheral Function tab. The Console pane should report 'The operation of generating file was successful', as shown Figure 4-10 below.

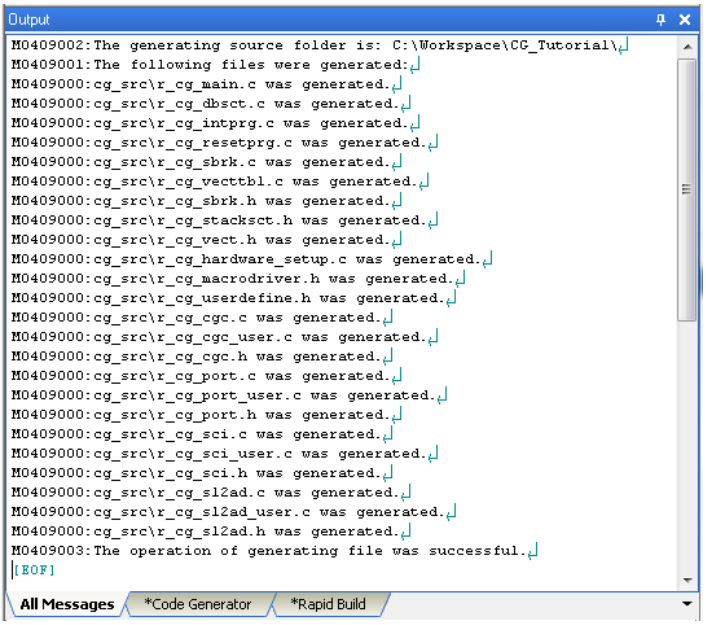


Figure 4-10 Code generator console

Figure 4-11 shows the Code Generator Files in the Project Tree pane. In the following sections the CG_Tutorial project will be completed by adding user code into these files and adding new source files to the project.

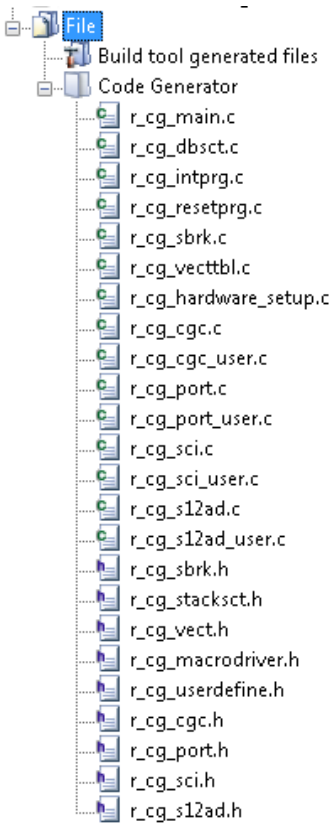
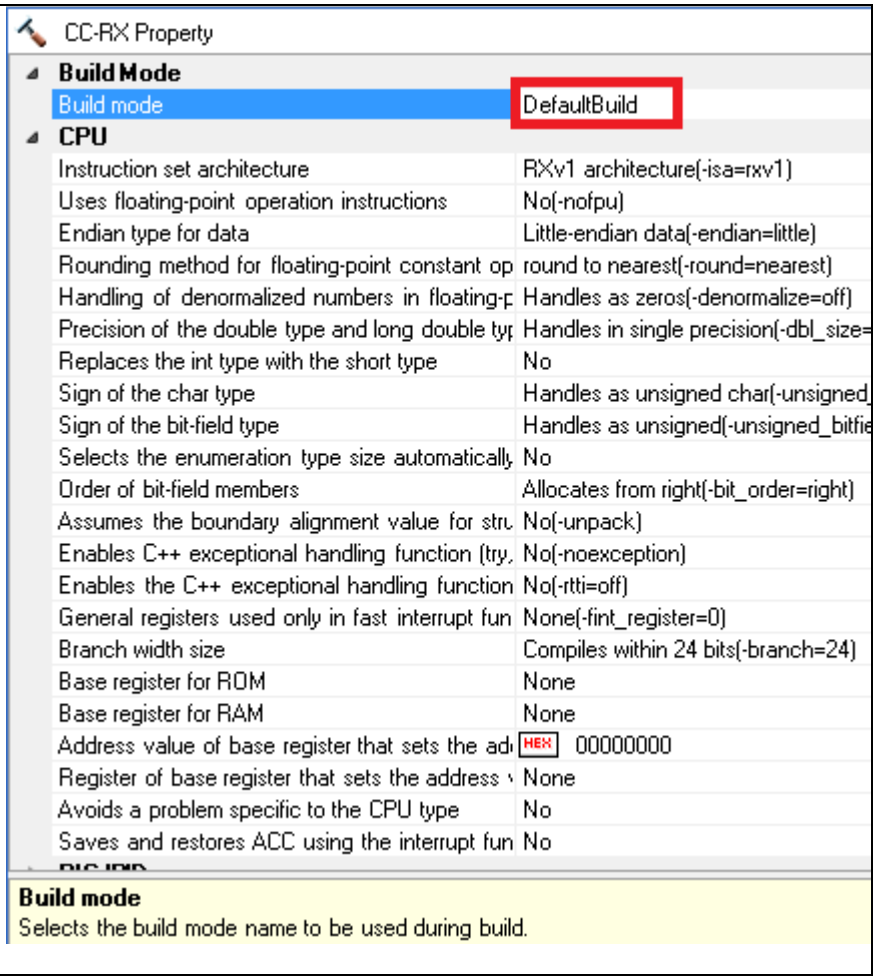


Figure 4-11 Generated Code in Project tree

5. Project Settings

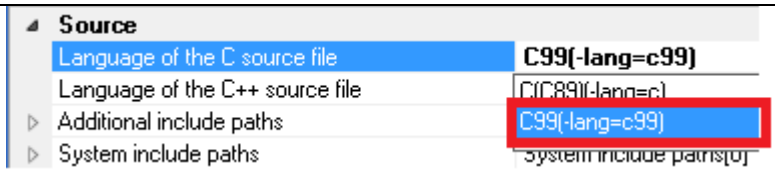
This section covers changes to the CS+ blank project to allow it to run on the RSK.

- In the ‘Project Tree’ pane, click on ‘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 (level 2).



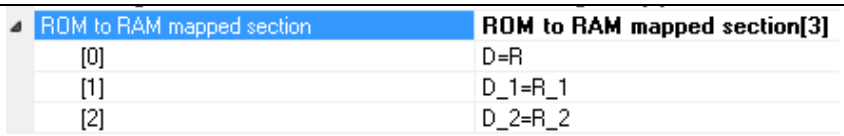
C Language

- 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.



Linker Section Mapping

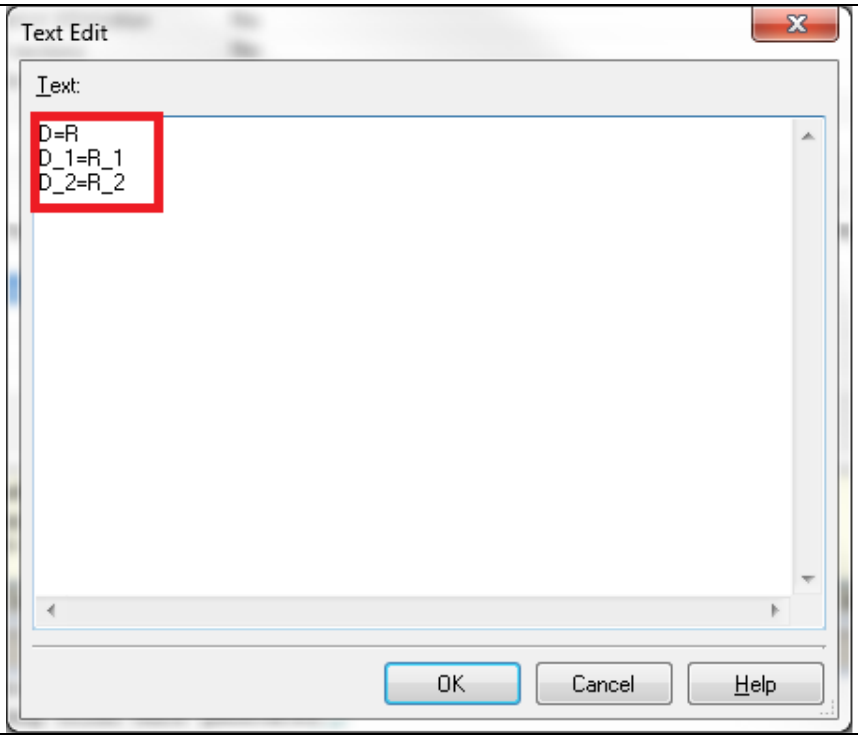
- Select the ‘Link Options’ tab at the bottom of the properties window pane. Under ‘Section -> ROM to RAM mapped section’, add the three mappings as shown opposite.



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

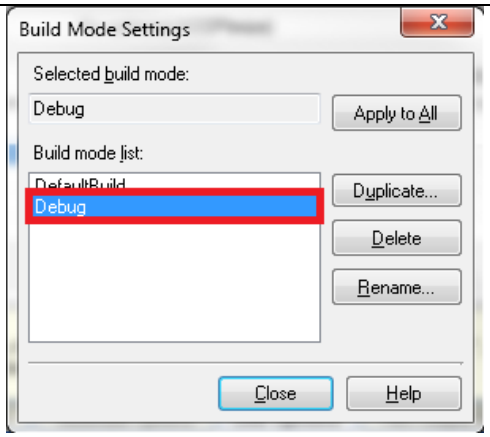
  D=R
  D_1=R_1
  D_2=R_2

This instructs the linker to assign RAM rather than ROM addresses to initialised C variables.

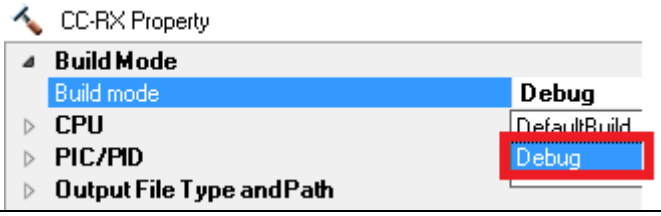


Build Mode Creation and Configuration - Debug

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



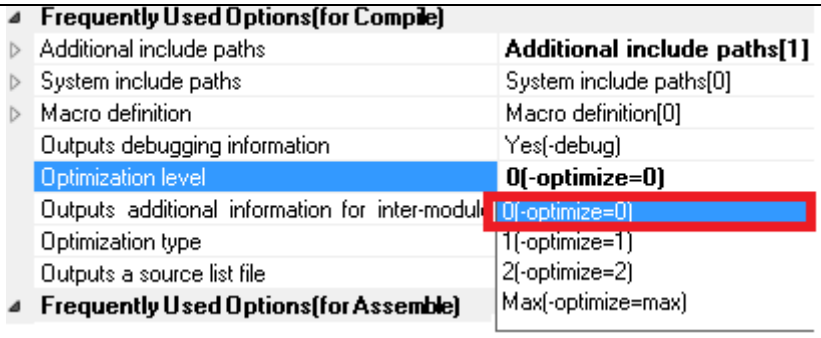
- In the main CC-RX Property window, under the 'Common Options' tab, click on the line containing 'Build Mode', click the pull-down arrow and select 'Debug' from the pull-down'.



- In the ‘Frequently Used Options (for Compile)’ group, select the ‘Optimization Level’ option and select ‘0’ from the pull-down.

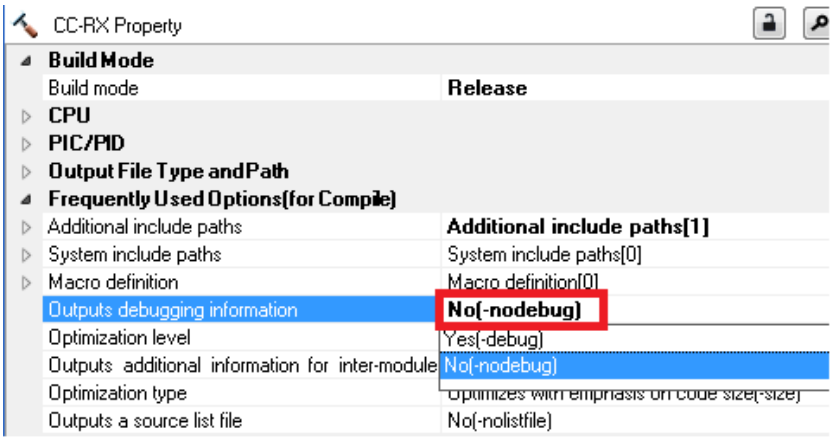
  This has now created a ‘Debug’ build mode, with no code optimisation.

  This Build Mode will be used throughout this tutorial to build and debug the project.



Build Mode Creation and Configuration - Release

- 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).

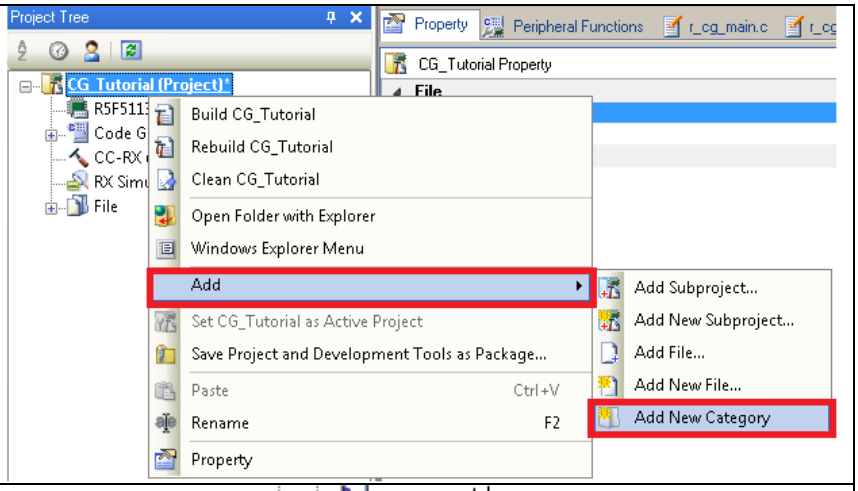


- The ‘Debug’ build will be used to the remainder of this tutorial:

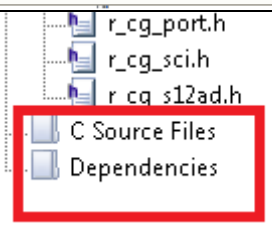
  Reset the build mode back to ‘Debug’ using the ‘Build Mode’ pull-down control
- From the menus, select ‘File -> Save All’ to save all project settings.

5.1 Adding Project 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 name 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’



6. User Code Integration

At this stage of a typical project development the user would expand on the generated code to create the application required. As a demonstration this tutorial will include code lines and files from the complete ‘Tutorial’ project, supplied on the RSK installation DVD.

When inserting code in Code Generator created files, it must be placed 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 refreshes the Code Generator-generated code.

6.1 Support file copying

RSK support and utility functions are provided in the following files:

iodefine.h,
r_rsk_utility.c,
r_rsk_utility.h,
rskrx113def.h.

Using Windows™ Explorer, locate the ‘Tutorial’ project folder and copy the files above to the project folder created in section 3.2, this will be ‘C:\Workspace\CG_Tutorial’ if following the example screenshots.
The ‘Tutorial’ project is a standard RSK sample and can be obtained by following the steps shown in the Quick Start Guide.

6.2 LCD file copying

API functions for the RSK LCD App v2 display are included in the following files:

r_lcd_appv2.c.
r_lcd_appv2.h.

Using Windows™ Explorer, locate the ‘Tutorial’ project folder and copy the files above to the project folder created in section 3.2, this will be ‘C:\Workspace\CG_Tutorial’ if following the example screenshots.
The ‘Tutorial’ project is a standard RSK sample and can be obtained by following the steps shown in the Quick Start Guide.

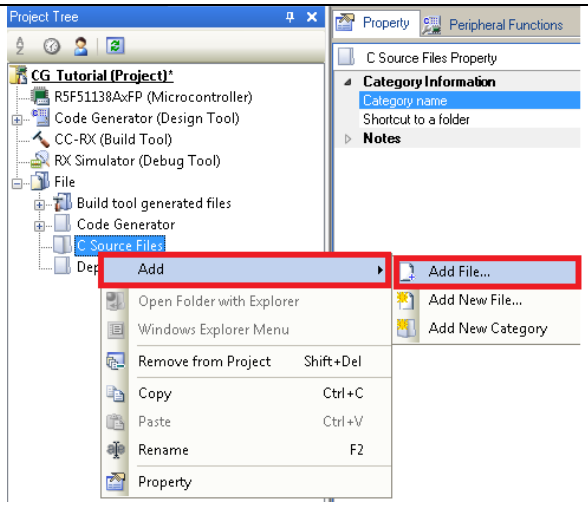
6.3 Including files in the CS+ Project

- Right-click on ‘C Source Files’ in the Project Tree and select ‘Add -> Add File…’.
- Browse to and select the following files copied in the section above and click ‘Add’:

  r_rsk_utility.c

  r_lcd_appv2.c
- Right-click on ‘Dependencies’ in the Project Tree and select ‘Add -> Add File…’.
- Browse to and select the following files copied in the section above and click ‘Add’:

  iodefine.h,
  r_rsk_utility.h,
  rskrx113def.h,
  r_lcd_appv2.h.



6.4 Adding Code to Generated Files

This section covers inserting code in to the newly created Code Generator files.

Each subsection is a Code Generated source file that needs to be opened by double clicking on the file name in the CS+ Project Tree window: ‘File -> Code Generator’.

The code from each section should be copied from this document and pasted in to the relevant file at the location indicated.

6.4.1 r_cg_userdefine.h Code Insertion

Open this file by double clicking on the file name in the CS+ Project Tree window.

Insert the following at the end of the file 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)

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

6.4.2 r_cg_s12ad.c Code Insertion

Open this file by double clicking on the file name in the CS+ Project Tree window.
Insert the following at the end of the file between the user code delimiter comments as shown below.

```
/* Start user code for adding. Do not edit comment generated here */
/***********************************************************************************
 * Function Name: R_S12AD_SWTriggerStart
 * Description  : This function starts the AD0 converter.
 * Arguments    : None
 * Return Value : None
 ***********************************************************************************/
void R_S12AD_SWTriggerStart (void)
{
    S12AD.ADCSR.BIT.ADST = 1U;
}

/***********************************************************************************
 End of function R_S12AD_SWTriggerStart
 ***********************************************************************************/

/***********************************************************************************
 * Function Name: R_S12AD_SWTriggerStop
 * Description  : This function stops the AD0 converter.
 * Arguments    : None
 * Return Value : None
 ***********************************************************************************/
void R_S12AD_SWTriggerStop (void)
{
    S12AD.ADCSR.BIT.ADST = 0U;
}

/***********************************************************************************
 End of function R_S12AD_SWTriggerStop
 ***********************************************************************************/

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

6.4.3 r_cg_s12ad.h Code Insertion

Open this file by double clicking on the file name in the CS+ Project Tree window.
Insert the following at the end of the file between the user code delimiter comments as 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_S12AD_SWTriggerStart (void);
void R_S12AD_SWTriggerStop (void);
/* End user code. Do not edit comment generated here */
```

6.4.4 r_cg_s12ad_user.c Code Insertion

Open this file by double clicking on the file name in the CS+ Project Tree window.

Insert the following between the user code delimiter comments as shown below in the file section designated Global variables and functions:

```
/* 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 in to the function `static void r_s12ad_interrupt(void)`:

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

    /* Flag that the ADC had completed a sample */
    g_adc_complete = 1;

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

6.4.5 r_cg_sci_user.c Code Insertion

Open this file by double clicking on the file name in the CS+ Project Tree window.

Insert the following between the user code delimiter comments as shown below in the file section designated Global variables and functions:

```
/* 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 sci1_txdone;

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

Insert the following in to the function `static 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 */
```

Insert the following in to the function `static void r_sci1_callback_receiveend(void)`

```
    /* Start user code. Do not edit comment generated here */
    /* Check the contents of g_rx_char */

        g_rx_char = g_rx_char & 0xDF;           /* Ensure ASCII char is in upper case */


        /* Check for the 'c' trigger command */
    if ('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 */
```

Insert the following between the user code delimiter comments at the end of the file:

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

/***********************************************************************
* 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
***********************************************************************/

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

6.4.6 r_cg_sci.h Code Insertion

Insert the following between the user code delimiter comments 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_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 */
```

6.4.7 r_cg_main.c Code Insertion

Insert the following between the user code delimiter comments as shown below in the file section designated `Includes:`

```
/* Start user code for include. Do not edit comment generated here */
#include "r_cg_s12ad.h"
#include "r_lcd_appv2.h"
#include "r_rsk_utility.h"
#include "rskrx113def.h"

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

Insert the following between the user code delimiter comments as shown below in the file section designated Global Variables and functions:

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

/* Welcome banner - displayed on serial port at startup*/
static uint8_t welcome_banner[] = "RSK RX113 - Tutorial - Press 'c' or SW3 for ADC Conversion\r\n\0";

/* 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 ADC 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);

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

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

Insert the following in to the function **`void main (void)`**.
Note this overwrites the while(1U) loop included by Code Generator.

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

/* Display Project Title on LCD*/
R_LCD_DisplayPanelString( PANEL_LCD_LINE1, (uint8_t*) "TUTOR");

/* Set up SCI1 receive buffer and callback function */
R_SCI1_Serial_Receive((uint8_t *) &g_rx_char, 1);

/* Enable SCI1 operations */
R_SCI1_Start();

/* Display Welcome Banner on Serial Port */
R_SCI1_AsyncTransmit(welcome_banner, sizeof(welcome_banner));
```

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

    /* If the user has requested ADC sample via the serial port */
    if (TRUE == g_adc_trigger)
    {
        /* Call the function to perform an ADC conversion */
        adc_result = get_adc();

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

        /* Display count on LEDs */
        led_display_count(adc_count);

        /* Send the result to SCI1 UART */
        uart_display_adc(adc_count, adc_result);

        /* Increment the adc_count and check roll over */
        if (16 == (++adc_count))
        {
            adc_count = 0;
        }

        /* Reset the flag */
        g_adc_trigger = FALSE;
    }

    /* SW3 is directly wired into the ADTRG0n pin so will
     cause the conversion and interrupt */
    else if (TRUE == g_adc_complete)
    {
        /* Get the result of the ADC conversion */
        R_S12AD_Get_ValueResult(ADCHANNEL0, &adc_result);

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

        /* Display count on LEDs */
        led_display_count(adc_count);

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

        /* Increment the adc_count and check roll over */
        if (16 == (++adc_count))
        {
            adc_count = 0;
        }

        /* Reset the flag */
        g_adc_complete = FALSE;
    }
    else
    {
        /* do nothing */
    }
}
```

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

Insert the following in to the function **`void R_MAIN_UserInit (void):`**

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

```
/* Initialise the LCD for the RSK LCD APP V2 display board */
R_LCD_Create();
R_LCD_Start();

/* Start the ADC */
R_S12AD_Start();
```

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

Insert the following between the user code delimiter comments at the end of the file:

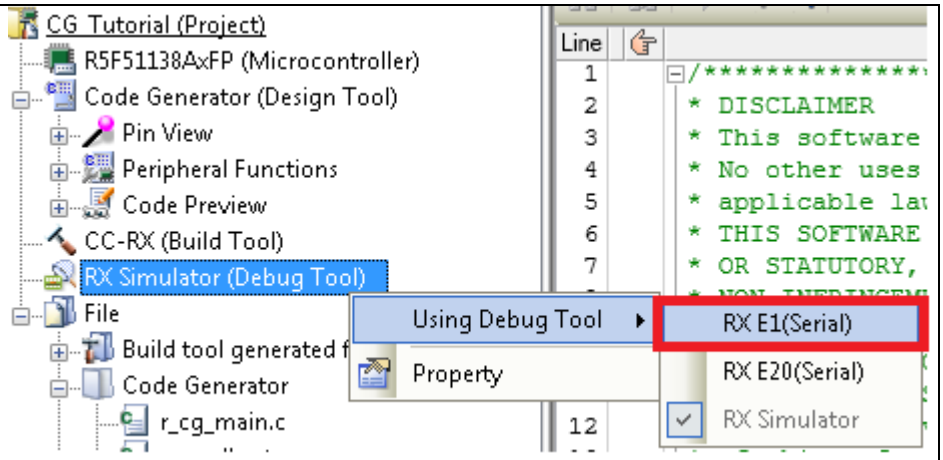
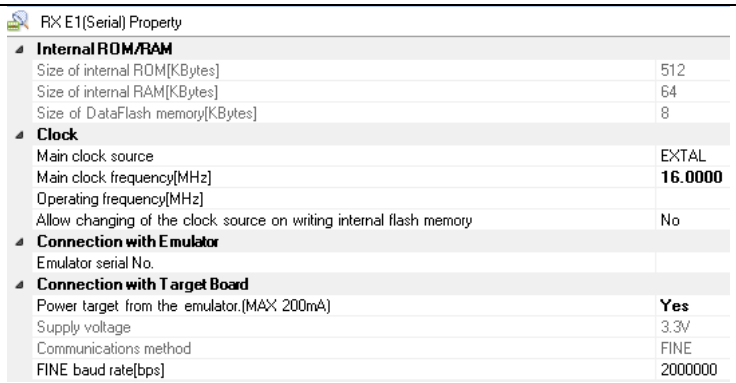
```
/* Start user code for adding. Do not edit comment generated here */

/***********************************************************************
 * Function Name : get_adc
 * Description   : Creates a ADC12 Software trigger and returns the ADC result,
 *                           once the ADC conversion is complete.
 * Argument      : none
 * Return value  : uint16_t ADC sample value
 ***********************************************************************/
static uint16_t get_adc (void)
{
    /* A variable to retrieve the ADC result */
    uint16_t adc_result;

    /* Start a conversion */
    R_S12AD_SWTriggerStart();

    /* Wait for the ADC conversion to complete */
    while (FALSE == g_adc_complete)
    {
        /* Wait */
    }

    /* Stop conversion */
    R_S12AD_SWTriggerStop();

    /* Clear ADC flag */
    g_adc_complete = FALSE;

    R_S12AD_Get_ValueResult(ADCHANNEL0, &adc_result);

    /* Set AD conversion start trigger source back to ADTRG0n pin */
    R_S12AD_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 temporary character string */
    char lcd_buf[4];

    /* Convert ADC result into a character string, and store in the
     local string lcd_buffer */
    uint16_to_string(lcd_buf, 0u, adc_result);

    /* Display the ADC value - Line 3 provides three
     * characters, so skip the unused leading zero
     */
    R_LCD_DisplayPanelString( PANEL_LCD_LINE3, (uint8_t *) lcd_buf + 1);
}

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

```
/***********************************************************************
 * 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 uint8_t 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_SCI1_AsyncTransmit(uart_buffer, sizeof(uart_buffer));
}

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

/***********************************************************************
 * 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 */
```

7. Project Build and Debugger Configuration

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

Configure the E1 debugger and board as follows.

• 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(MHz) to 16.000 MHz. • Under ‘Connection with Target Board’, change ‘Power target from the emulator.(MAX 200mA) to ‘Yes’ • All other settings can remain at their defaults.	
• Connect the E1 to the PC and the RSK E1 connector. • Ensure the LCD APP V2 display is connected to JA4.	

7.1 Running the Tutorial

Before launching the tutorial connect the RSK RL78G1C-USB 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 emulation program, such as HyperTerminal, connecting to COMx with the settings 19200 baud, 8 data bits , No parity, 1 stop bit.

From the CS+ ‘Debug’ menu select ‘Download’ to start the debug session and download code to the target.	
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.	

The program will display ’RSK RX113 - Tutorial - Press 'c' or SW3 for ADC Conversion’ on the serial terminal and ‘TUTOR’ on the bottom line of the LCD. Pressing SW3 or entering the character ‘C’ in the serial terminal window will trigger an ADC conversion and display the resulting value on the terminal window and the LCD.

8. Additional Information

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

Online technical support and information is available at: http://www.renesas.com/rskrx113

For information about the RX113 Group microcontrollers refer to the RX113 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:
http://www.renesas.com/

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REVISION HISTORY	RSK RX113 Code Generator Tutorial Manual (CS+)

Rev.	Date	Description	
		Page	Summary
1.00	Dec 15, 2014	—	First Edition issued
1.01	Mar 03, 2015	13-10	Updated Figure 4-2 - Figure 4-9
		19-31	Added a frame

Renesas Starter Kit Manual: Code Generator Tutorial Manual

Publication Date: Rev. 1.01 Mar 03, 2015

Published by: Renesas Electronics Corporation

Renesas Electronics Corporation

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R20UT3254EG0101