User's Manual

32

RX113 Group

Renesas Starter Kit Tutorial Manual
For e^2 studio

RENESAS MCU
RX Family / RX100 Series

Renesas Electronics
www.renesas.com

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Disclaimer

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

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

Precautions

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

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

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

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

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

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

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

How to Use This Manual

1. Purpose and Target Readers

This manual is designed to provide the user with an understanding of how to use the e^2 studio IDE to develop and debug software 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 load and debug a project in e^2 studio, 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 RX113 Group 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.	RSK RX113 User's Manual	R20UT2756EG
Tutorial	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSK RX113 Tutorial Manual	R20UT2760EG
Code Generator Tutorial	Provides a guide to code generation and importing into the e^2 studio IDE.	RSK RX113 Code Generator Tutorial Manual	R20UT3255EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample, on a single A4 sheet.	RSK RX113 Quick Start Guide	R20UT2761EG
Schematics	Full detail circuit schematics of the RSK .	RSK RX113 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
E1	On-chip Debugger
GDB	GNU Debugger
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro-controller Unit
RSK	Renesas Starter Kit
SCI	Serial Communications Interface
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 get the RSK tutorial started, and basic debugging operations.

1.2 Features

This RSK provides an evaluation of the following features:

- Renesas microcontroller programming
- User code debugging
- User circuitry such as switches, LEDs and a potentiometer
- Sample application
- Sample peripheral device initialisation code

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

2. Introduction

This manual is designed to answer, in tutorial form, the most common questions asked about using a Renesas Starter Kit (RSK). The tutorials help explain the following:

- How do I compile, link, download and run a simple program on the RSK?
- How do I build an embedded application?
- How do I use Renesas' tools?

Files referred to in this manual are installed using the project generator as you work through the tutorials. 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 e^2 studio, the compiler toolchains or the E1 emulator. Please refer to the relevant user manuals for more in-depth information.

2.1 Code Generator Plug in

The Code Generator plug in for the RX113 has been used to generate the sample code discussed in this document. Code Generator for e^2 studio is a plug in tool for generating template 'C' source code and project settings for the RX113. When using Code Generator, the engineer is able to configure various MCU features and operating parameters using intuitive GUI controls, thereby bypassing the need in most cases to refer to sections of the Hardware Manual.

Once the engineer 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 engineer 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 engineer needs to re-visit Code Generator to change any MCU operating parameters.

2.2 Note Regarding Source Code

Due to the project generator, it is possible that line numbers for source code illustrated in this document do not match exactly with that in the actual source files. It is also possible that the source address of instructions illustrated in this manual differ from those in user code compiled from the same source. These differences are minor, and do not affect the functionality of the sample code nor the validity of this manual.

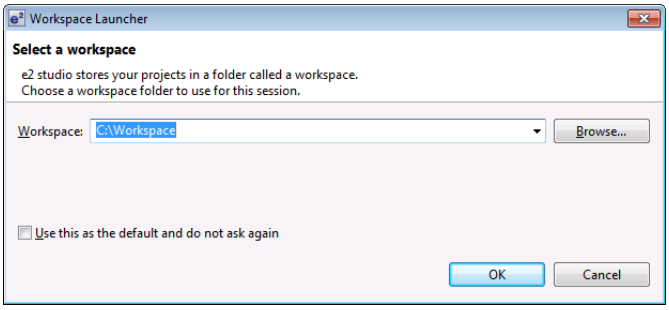
3. Tutorial Project Workspace

3.1 Introduction

e^2 studio is an open source integrated development tool that allows the user to write, compile, program and debug a software product on many of the Renesas microcontrollers.

3.2 Starting e^2 studio and Importing Sample Code

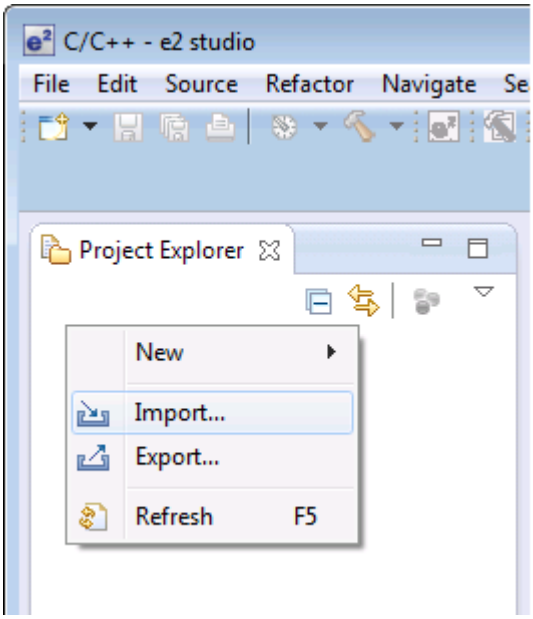
- Start e^2 studio by selecting it from the Windows™ Start Menu. The first dialog box to appear will be the Workspace Launcher.



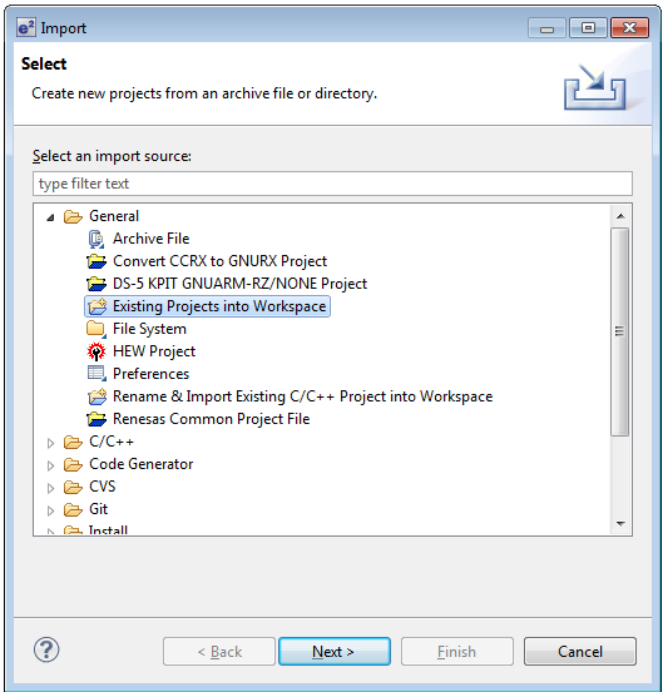
- Click 'Browse' and select a suitable location to store your workspace, using the 'Create New Folder' option as necessary. Click 'OK'.

- The e^2 studio welcome splash screen will appear. Click the 'Go to the workbench' arrow button on the far right (circled in the screenshot opposite).`

- Once the environment has initialised, right click in the ‘Project Explorer’ window and select ‘Import…’



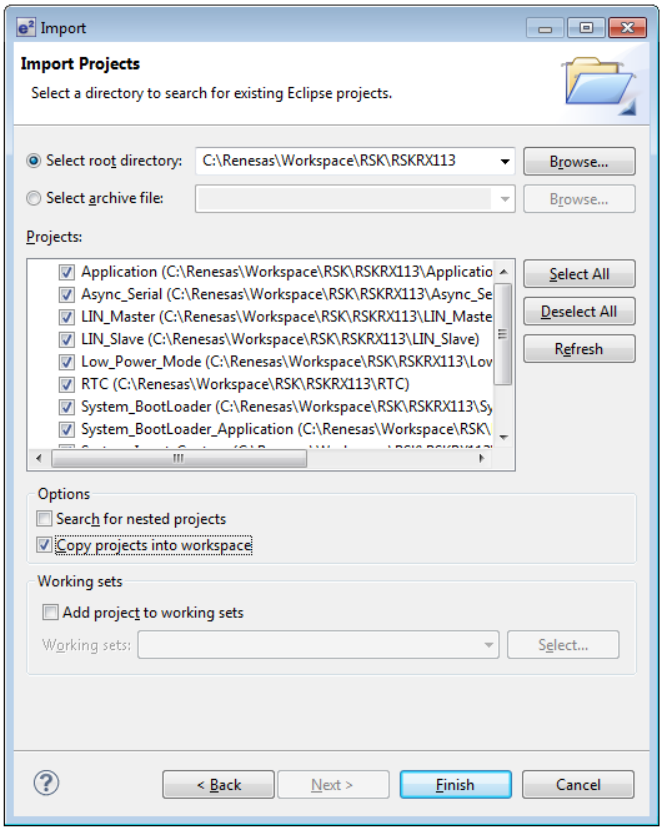
- The Import dialog box will now show. Expand the ‘General’ folder icon, and select ‘Existing Projects into Workspace’, then click ‘Next’.



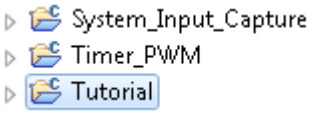
- The Import dialog box will allow you to specify a project to import. Click the 'Browse' button and locate the following directory:

  C:\Renesas\Workspace\RSK\RSKRX113

- Ensure that the 'Copy projects into workspace' option is ticked, and then click 'Finish'.



- Click on Tutorial from the list of projects in the 'Project Explorer' on the left-hand side.



3.3 Build Configurations and Debug Sessions

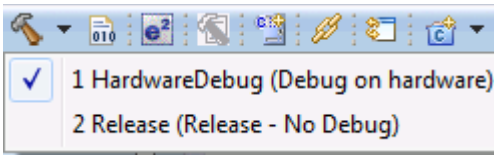
3.3.1 Build Configuration

The e^2 studio workspace will be created with two build configurations: 'HardwareDebug' and 'Release'.

Release
This build mode has optimisation turned on, and provides little debug information. The C code execution may appear to be out of order, due to the way compiler optimises the code. This build configuration is intended for final ROM-programmable code.

HardwareDebug
This default build mode has all optimisation turned off, and provides full debug information. This is the best configuration to use whilst developing code as C code execution will be linear.

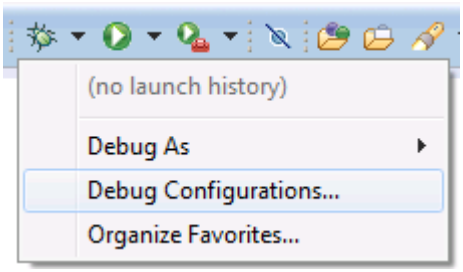
- Click the top level 'Tutorial' folder again, and then the arrow next to the build button (hammer icon), and select the 'HardwareDebug' option.



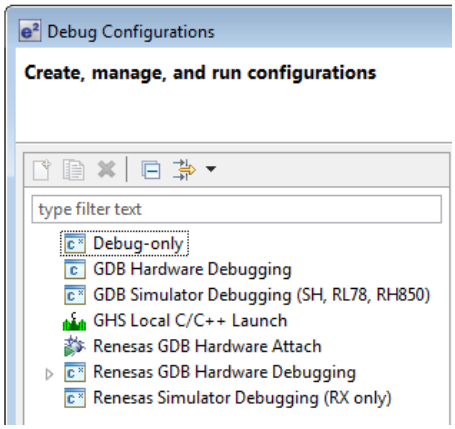
- e^2 studio will now build the code.

3.3.2 Debug Configuration

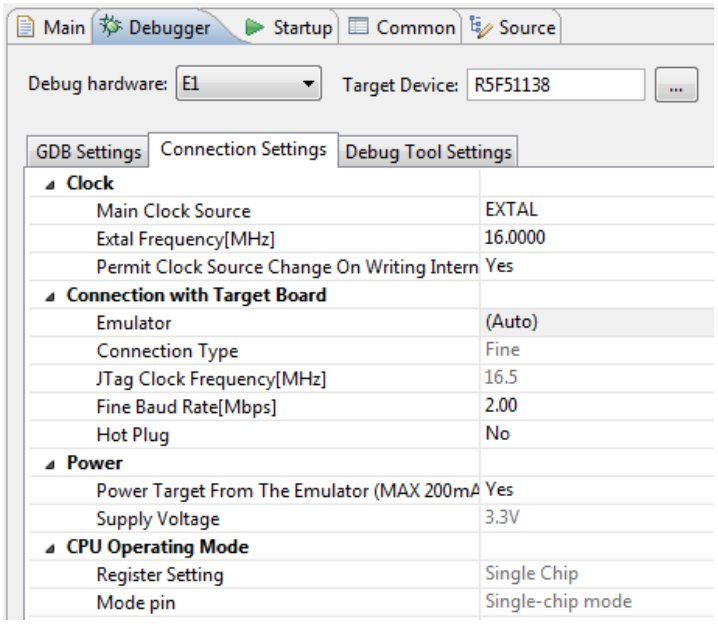
- Click the arrow next to the debug button (bug icon). Select 'Debug Configurations'.



- The 'Debug Configurations' dialog box will appear. Click the small arrow next to the 'Renesas GDB Hardware Debugging' option.
- The debug configurations for each project will appear. Select the entry for the 'Tutorial Hardware Debug'.



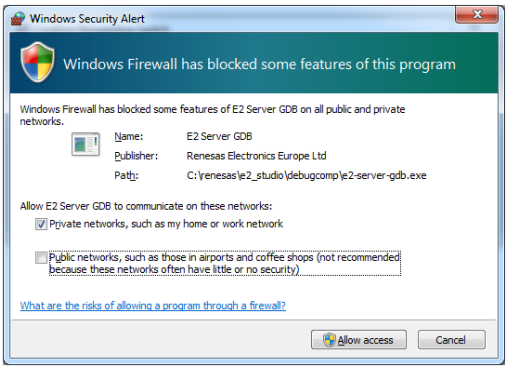
- The debug configurations control page will then show for the Tutorial project. Change the main tab to 'Debugger' and then select 'Connection Settings' on the secondary tab bar that appears.
- There is no need to change the debugger settings as they are preconfigured with the Tutorial project.
- For this tutorial the RSK RX113 will be powered from the E1 Emulator. Refer to the RSK RX113 User's Manual for details of power supply configuration.



> **Note**: e² studio will display a warning if you attempt to connect with an incorrect power supply setting.

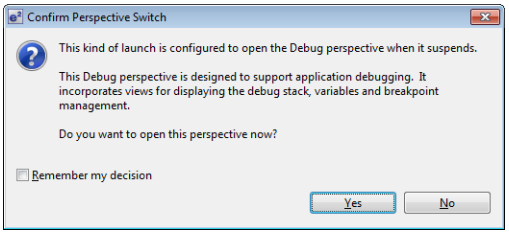
- Click the 'Debug' button to continue. e² studio will now connect to the debugger and download the code to the target.

- • A firewall warning may be displayed for ‘e2-server-gdb.exe’. Check the ‘Private networks, such as my home or work network’ box and click ‘Allow access’.



- A user account control dialog may be displayed. Enter the administrator password and click <Yes>

- e^2 studio may display a dialog, asking if you would like to switch to the ‘Renesas Debug perspective’. Click ‘Yes’.



- The new e^2 studio perspective layout is optimised for debugging.

3.4 Running the Tutorial

- Once the code has been downloaded, the program counter will stop at the entry vector, usually the ‘PowerON_Reset’ function.

- Click the ‘Resume’ button to let the code run. It will keep running up to the ‘main’ function. Execute the main code function. 

- It is recommended that you execute the entire tutorial demo first, before continuing to debug it. Please refer to the ‘description.txt’ for details of how to operatie this sample.

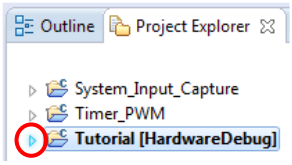
4. Reviewing the Tutorial Program

This section will look at each section of the tutorial code and basic debugging functionality in e^2 studio.

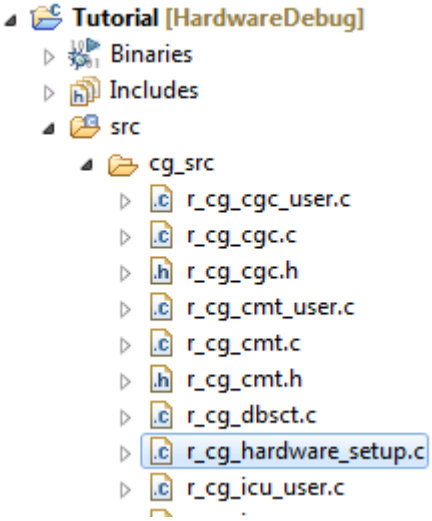
4.1 Program Initialisation

Before the main program can run, the microcontroller must be configured. The following parts of the tutorial program are used exclusively for initialising the RSK device so that the main function can execute correctly. The initialisation code is run every time the device is reset via the reset switch or from a power cycle.

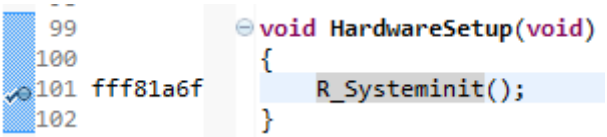
- Build and download the code as shown in Section 3.3.
- On the Project Explorer tab expand the 'Tutorial' folder by clicking on the arrow next to the folder icon, as highlighted by the red circle.



- Click the arrow next to the 'src' folder to show the source files.
- Expand the 'cg_src' folder in the same way and double click on 'r_cg_hardware_setup.c' to open the file.



- Breakpoints can be set by double clicking at the left-hand edge of the source window. On the line with instruction R_Systeminit(), double click next to the vertical line to set a breakpoint.



Note: As an alternative breakpoints may be set in the C/C++ perspective by selecting a line and using Run > Toggle Breakpoint.

- Click the ‘Resume’ button in the Debug perspective (or press [F8]) to run the code up to this breakpoint.

```
 99            void HardwareSetup(void)
100            {
101 fff81a6f       R_Systeminit();
102            }
```

Note: The program counter is indicated by the blue arrow next to the breakpoint.

- Click the ‘Step Into’ button (or press [F5]), to step into the ‘R_Systeminit’ function.

- The ‘R_Systeminit’ function calls several initialisation functions which configure the microcontroller for normal operation. For example this includes input/output ports, and system clocks.

- The user can step through all the initialisation code by clicking the ‘Step Into’ icon and reading the code however for the purpose of this manual, it will be skipped.

- Click the ‘Resume’ button, to run the code up to the main function.

r_cg_resetprg.c | r_cg_hardware_setup.c

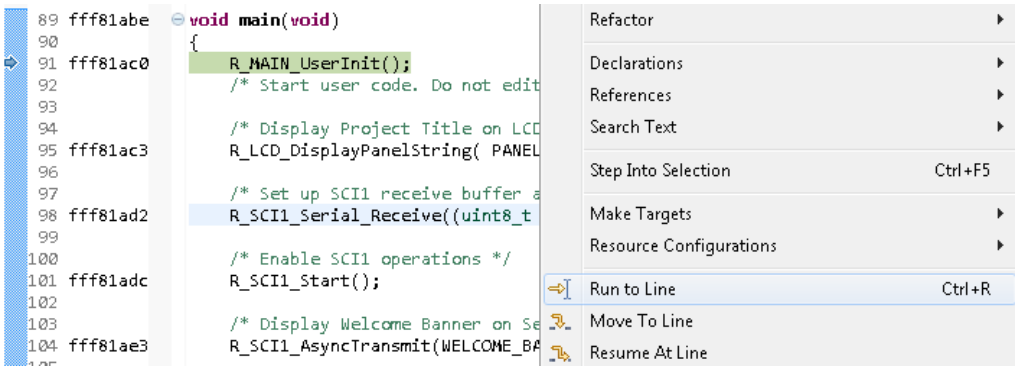
```
60 fff819ec  void R_Systeminit(void)
61           {
62               /* Enable writing to registers rela
63 fff819f1       SYSTEM.PRCR.WORD = 0xA50FU;
64
65               /* Enable writing to MPC pin functi
66 fff819fa       MPC.PWPR.BIT.B0WI = 0U;
67 fff81a01       MPC.PWPR.BIT.PFSWE = 1U;
68
69               /* Initialize non-existent pins */
70 fff81a08       PORT0.PDR.BYTE = 0x6BU;
71 fff81a10       PORT3.PDR.BYTE = 0xD8U;
72 fff81a18       PORT4.PDR.BYTE = 0xA0U;
73 fff81a20       PORT5.PDR.BYTE = 0x80U;
74 fff81a28       PORT9.PDR.BYTE = 0xF8U;
75 fff81a30       PORTD.PDR.BYTE = 0xE0U;
76 fff81a38       PORTF.PDR.BYTE = 0x3FU;
77 fff81a40       PORTJ.PDR.BYTE = 0x32U;
78
79               /* Set peripheral settings */
80 fff81a43       R_CGC_Create();
81 fff81a47       R_ICU_Create();
82 fff81a4b       R_PORT_Create();
83 fff81a4f       R_SCI1_Create();
84 fff81a53       R_S12AD_Create();
85
```

For further details regarding hardware configuration, please refer to the RSK RX113 User’s Manual and the RX113 Group Hardware Manual.

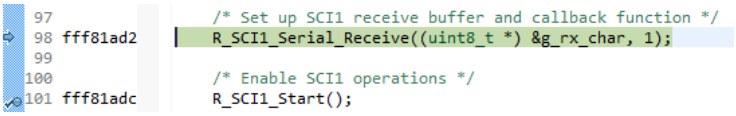
4.2 Main Functions

This section will look at the program code called from with the 'main' function, and how it works. It is necessary to connect the RSK RL78G1C-USB connection to a PC USB port and open a terminal emulation program, such as HyperTerminal, with the settings 19200, 8, N, 1. For information on installation of the RSK virtual COM port driver, refer to the file 'Description.txt' in the e^2 studio Tutorial project.

- Right click the 'R_SCI1_Serial_Receive' function call and select 'Run to Line' to execute the program up to this line. The 'R_LCD_DisplayPanelString' call will write "TUTOR" onto the LCD.



- Set a breakpoint on the 'R_SCI1_Start' function call by double-clicking in the breakpoint column.



- Click the 'Step Into' button to step into the 'R_SCI1_Serial_Receive' function.

- The program counter will now move into the 'R_SCI1_Serial_Receive' function definition. This function is an API function provided by the Code Generator. It sets up the SCI interrupt handler code to receive a specified number of bytes into a receive buffer. Once the specified number of bytes has been received, the interrupt handler code calls a callback function as shown later on in this section.
- For full details on how to configure a project using Code Generator refer to the Code Generator Tutorial Manual.

```
149 fff8213d  MD_STATUS R_SCI1_Serial_Receive(uint8_t * const rx_buf, uint16_t rx_num)
150           {
151 fff82143      MD_STATUS status = MD_OK;
152
153 fff82146      if (rx_num < 1U)
154           {
155 fff8214b          status = MD_ARGERROR;
156           }
157           else
158           {
159 fff82150          g_sci1_rx_count = 0U;
160 fff82159          g_sci1_rx_length = rx_num;
161 fff82162          gp_sci1_rx_address = rx_buf;
162 fff82170          SCI1.SCR.BIT.RIE = 1U;
163 fff82177          SCI1.SCR.BIT.RE = 1U;
164           }
165
166 fff82179      return (status);
167 fff8217f  }
```

- Click the 'Resume' button to resume program execution.

- The program counter should come to a halt at the R_SCI1_Start function.
- Step over the function by clicking the 'Step Over' button. Alternatively, press [F6].

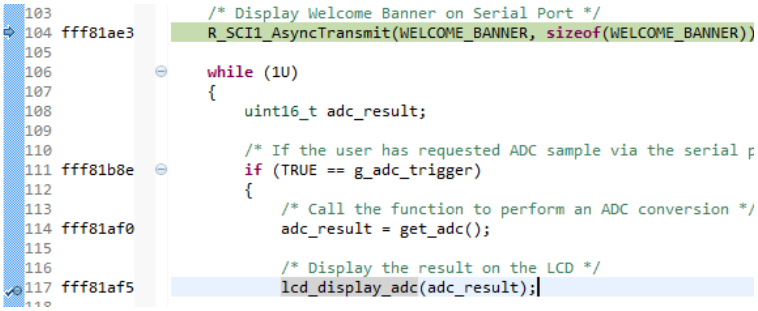
```
 97                /* Set up SCI1 receive buffer and callback function */
 98 fff81ad2      R_SCI1_Serial_Receive((uint8_t *) &g_rx_char, 1);
 99
100                /* Enable SCI1 operations */
101 fff81adc      R_SCI1_Start();
```

The R_SCI1_Start() function enables the SCI interrupts.

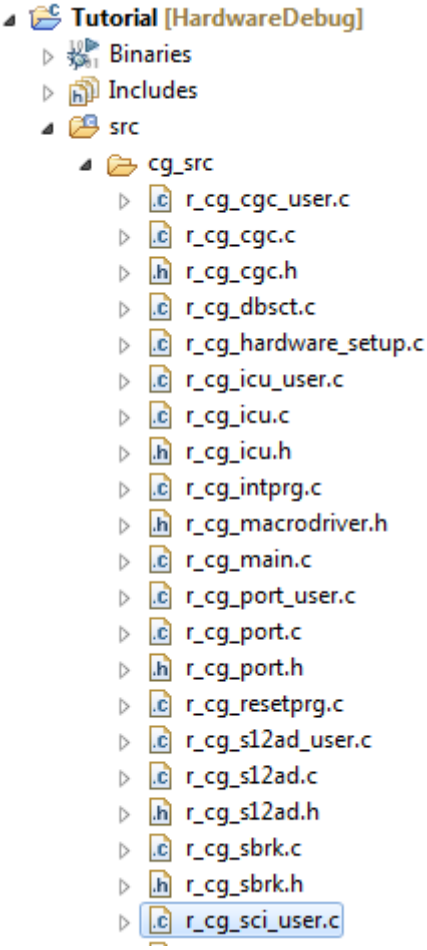
The program then proceeds to transmit a welcome banner to the serial port.

After the banner is displayed, the program enters the main while() loop, the code inside the loop waits for user input from either the SCI or switch SW3, and then performs an A/D conversion.

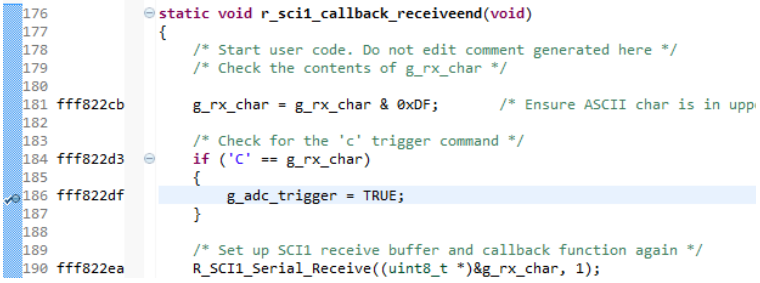
- Locate the function call to 'lcd_display_adc' inside the while loop.
- Set a breakpoint on the 'lcd_display_adc' function call by double-clicking in the breakpoint column.



- In the Project Explorer pane, locate the file 'r_cg_sci_user.c' and double-click to open the source file. Scroll down to the function r_sci1_callback_receiveend.



- Set a breakpoint on the line of code inside the r_sci1_callback_receiveend function as shown opposite.
- Continue to execute the program by clicking the 'Resume' button.



- In the terminal emulation window, press the ‘c’ button on the keyboard.
- The program will halt at the breakpoint in the r_sci1_callback_receiveend function as shown opposite. Remove the breakpoint by double-clicking on the breakpoint column.
- Continue to execute the program by clicking the ‘Resume’ button.
- The program will continue to run until normally.
- Press the ‘c’ button on the keyboard, and observe execution stop at the breakpoint in the main while loop.
- Remove the breakpoint by double-clicking on the breakpoint column. Continue to execute the program by clicking the ‘Resume’ button.

.

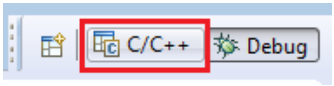
```
183                     /* Check for the 'c' trigger command */
184 fff822d3            if ('C' == g_rx_char)
185                     {
186 fff822df                g_adc_trigger = TRUE;
187                     }
188
```

```
116                     /* Display the result on the LCD */
117 fff81af5            lcd_display_adc(adc_result);
118
119                     /* Increment the adc_count and display
120 fff81afa            if (16 == (++adc_count))
121                     {
122 fff81b0c                adc_count = 0;
123                     }
124 fff81b15            led_display_count(adc_count);
```

The program proceeds to display the result of the A/D conversion on the LCD and in the terminal window. In addition, the running count of A/D conversions performed is displayed in binary form using LEDs 0-3 on the RSK . Adjust the potentiometer and press SW3 on the RSK and an additional A/D conversion will be performed.

- Press the ‘Suspend’ button to halt program execution.

- To change back to the default ‘C/C++’ perspective, from the menu bar select Window > Open Perspective > ‘C/C++’
- Alternatively, click on the ‘C/C++’ button in the top right corner of the screen, as shown opposite.



- This is the extent of the tutorial code.

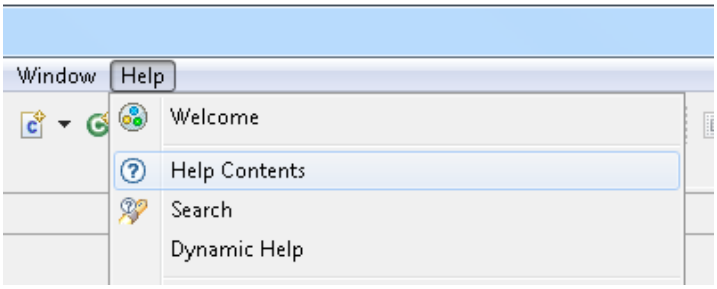
For further details regarding hardware configuration, please refer to the RX Series Software Manual and the RX113 Group Hardware Manual.

The E1 emulator features advanced logic-based event point trigger system, and full instruction on its use is outside the scope of this tutorial. For further details, please refer to the E1 Emulator User’s Manual

5. Additional Information

Technical Support

For details on how to use e^2 studio, refer to the help file by opening e^2 studio, then selecting Help > Help Contents from the menu bar.



Parts of the sample code provided with the RSK RX113 can be reproduced using the Code Generator tool. Code Generator is included as a plug in with e^2 studio.
Source files and functions generated by Code Generator are prefixed with 'r_' and 'R_', respectively.

For information about the RX113 series microcontrollers refer to the RX113 Group, User's Manual: Hardware.

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

Technical Contact Details

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

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

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