User's Manual

32

RX24U Group

Renesas Starter Kit Tutorial Manual
For e^2 studio

RENESAS 32-Bit MCU
RX Family / RX200 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 RX24U microcontroller may be found in the RX24U 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 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	R20UT3762EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample, on a single A4 sheet.	RSKRX24U Quick Start Guide	R20UT3763EG
Code Generator Tutorial	Provides a guide to code generation and importing into the e^2 studio IDE.	RSKRX24U Code Generator Tutorial Manual	R20UT3764EG
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
PSU	Power Supply Unit
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

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 initialization 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.

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.

> 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 E2 emulator Lite. 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 RX24U 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 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.

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.

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

e² 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 Connecting the Debugger

For this tutorial the E2 Lite debugger will provide power to the RSK, no external power supply is required.

The Quick Start Guide provided with the Renesas Starter Kit board gives detailed instructions on how to connect the E2 Lite to the host computer. The following assumes that the steps in the Quick Start Guide have been followed and the E2 Lite drivers have been installed.

- Fit the PMOD LCD display to the board. Ensure all the pins of the connector are correctly inserted in the socket.
- Connect the E2 Lite Debugger to a free USB port on your computer.
- Connect the E2 Lite Debugger to the target hardware ensuring that it is plugged into the connector marked ‘E1’.

3.3 Starting e² studio and Importing Sample Code

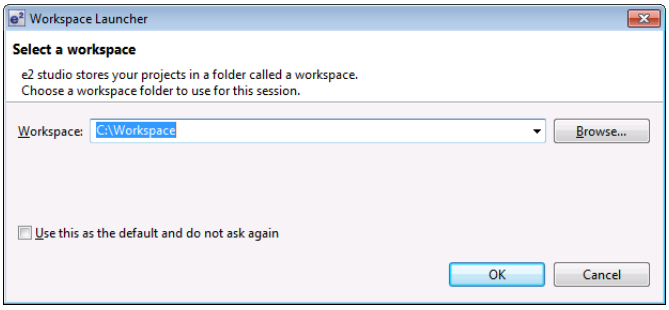
To use the program, start e²studio:

Windows™ 7 & Vista: Start Menu > All Programs > Renesas Electronics e2studio > e2 studio

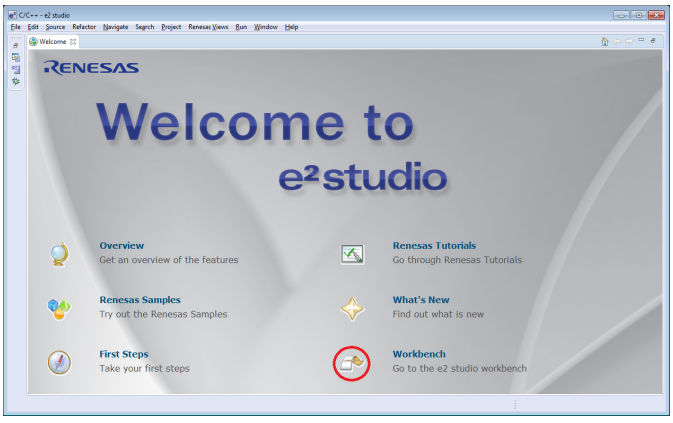
Windows™ 8.1 & 8: From Apps View, click ‘Renesas Electronics e2studio > e2 studio icon

Windows™ 10: Start Menu > All Apps > Renesas Electronics e2studio > e2 studio

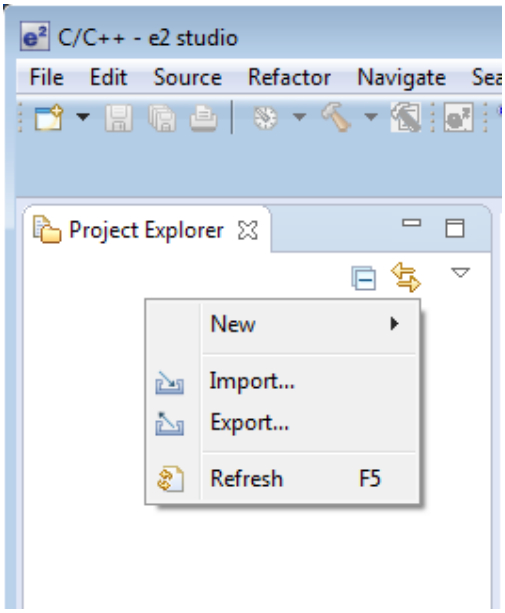
- The first dialog box to appear will be the Workspace Launcher.
- Click ‘Browse’ and select a suitable location to store your workspace, using the ‘Make New Folder’ option as necessary. Click ‘OK’.



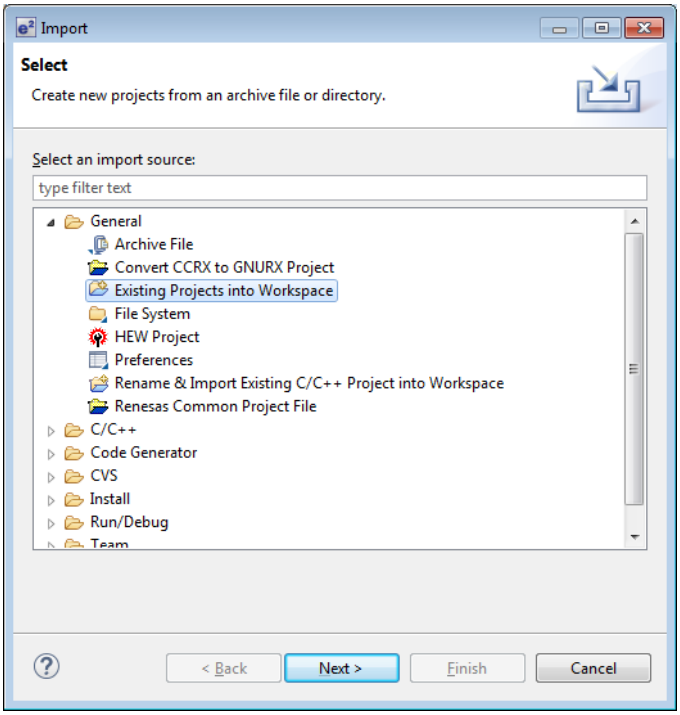
- The e² studio welcome splash screen will appear. Click the ‘Go to the e2 studio workbench’ arrow button on the far right (circled in the screenshot opposite).



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



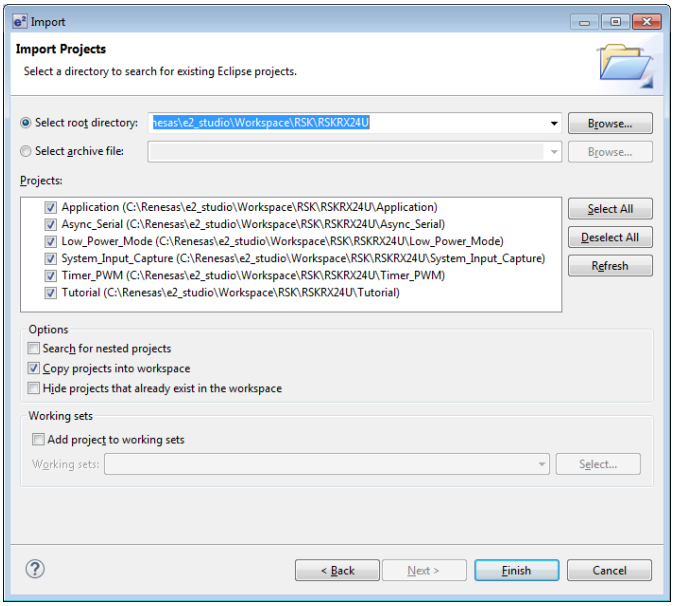
- The Import dialog box will be shown. Expand the ‘General’ folder icon, and select ‘Existing Projects into Workspace’, then click ‘Next’.



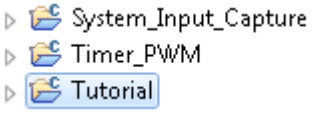
- The Import dialog box will allow you to specify a project to import. Click the 'Browse' button and locate the following directory:

  C:\Renesas\Workspace\RSK\RSKRX24U

- 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.



3.4 Build Configurations and Debug Sessions

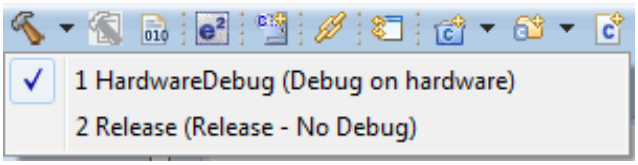
3.4.1 Build Configuration

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 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.

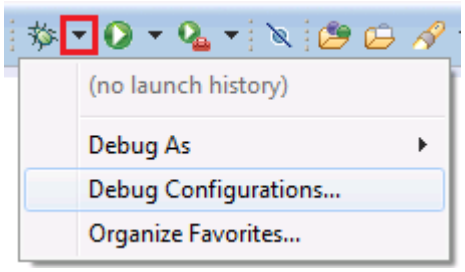
- Click the top level 'Tutorial' folder again, and then the arrow next to the build button (hammer icon), and select the 'HardwareDebug' option.



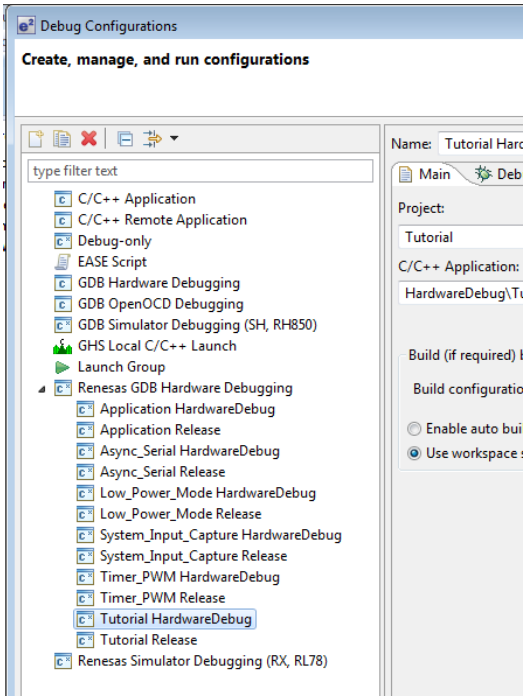
- e^2 studio will now build the code.

3.4.2 Debug Configuration

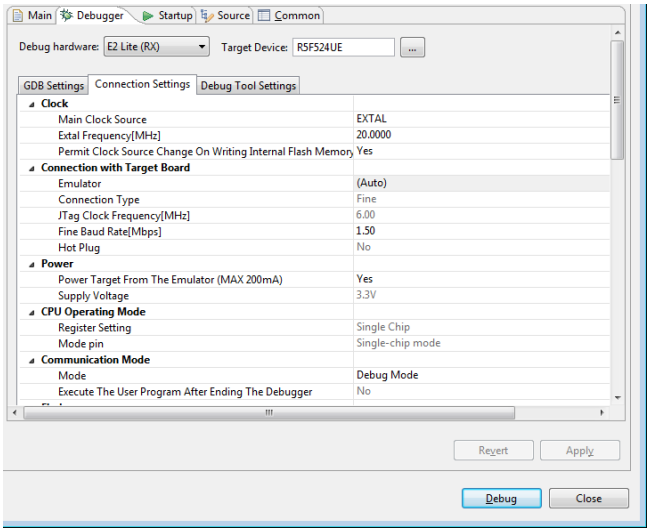
- Click the arrow next to the debug button (bug icon). Select ‘Debug Configurations’.



- 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 HardwareDebug’.



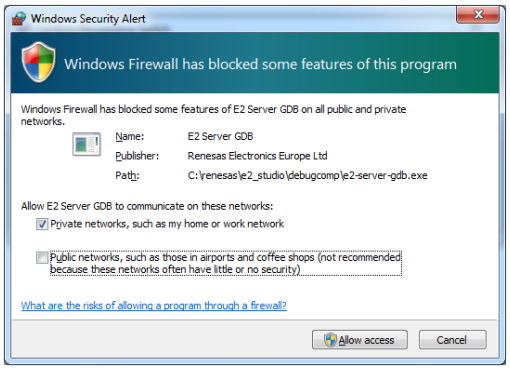
- The debug configurations control page will then show for the Tutorial project. Change the main tab to ‘Debugger’ and then select ‘Connection Settings’ on the secondary tab bar that appears.
- There is no need to change the debugger settings as they are preconfigured with the Tutorial project.
- Refer to the RSKRX24U User’s Manual for details of power supply configuration.



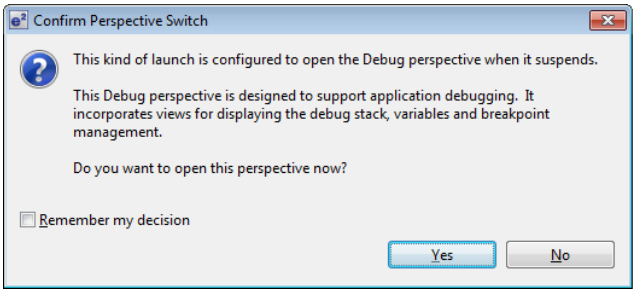
> **Note**: e² studio will display a warning if you attempt to connect with an incorrect power supply setting.

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

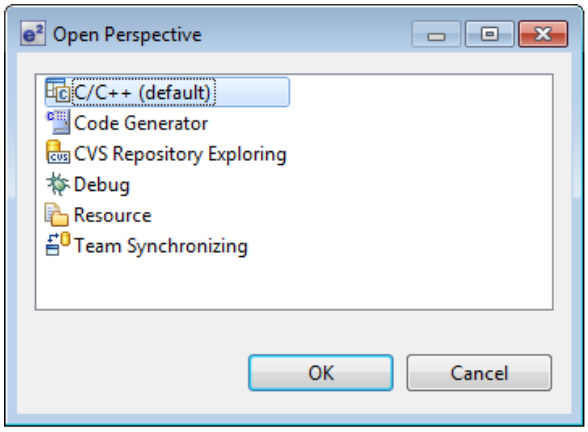
- A firewall warning may be displayed for ‘e2-server-gdb.exe’. Check the ‘Private networks, such as my home or work network’ box and click ‘Allow access’.
- A user account control dialog may be displayed. Enter the administrator password and click ‘Yes’.



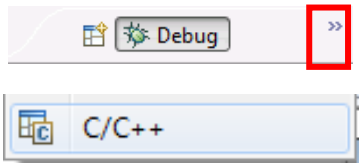
- After downloading the code a dialog box will appear asking if you would like to switch to the ‘Debug perspective’. Click ‘Remember my decision’ to prevent this dialog box from appearing in future, then click ‘Yes’.
- e² studio will load the new perspective, which is optimised for debugging.



- To change back to the default ‘C/C++’ perspective, from the menu bar select Window > Perspective >Open Perspective > Other.
- The ‘Open Perspective’ dialog box will appear. Click on the desired perspective to select it then ‘OK’.



- Alternatively, click on the button with the double arrow in the top right corner of the screen, as shown opposite, and select the ‘C/C++’ option that appears.



3.5 Running the Tutorial

- Refer to the description.txt file in doc folder of Tutorial project for instructions on how to configure the RSK and run the sample code.
- Once the code has been downloaded, click ‘Resume’ button to run the code to the main function. The main function is set as the program entry point by default. The program counter will stop on the first instruction in the main function.
- Click the ‘Resume’ button in the ‘Debug’ perspective to run the rest of the code.
- It is recommended that you run the entire tutorial demo first, before continuing to debug it.

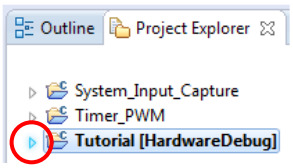
4. Reviewing the Tutorial Program

This section will look at each section of the tutorial code and basic debugging functionality in e² studio.

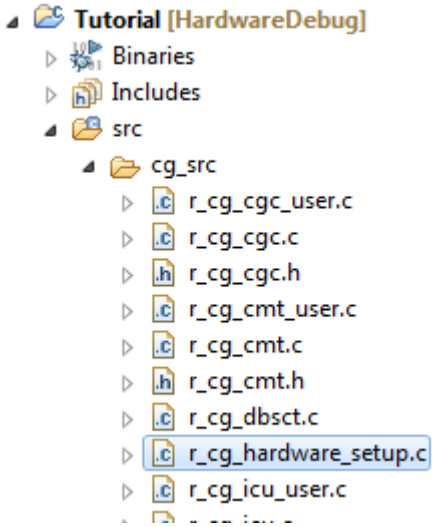
4.1 Program Initialization

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

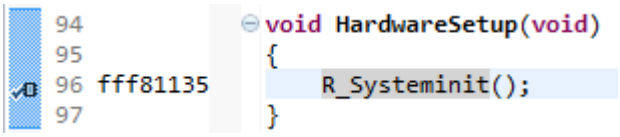
- Build and download the code as shown in Section 3.3.
- On the Project Explorer tab expand the 'Tutorial' folder by clicking on the arrow next to the folder icon, as highlighted by the red circle.



- 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.

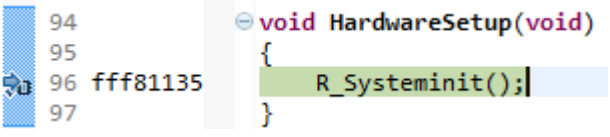


- Breakpoints can be set by double clicking at the left-hand edge of the source window. On the line with instruction 'R_Systeminit();', double click next to the vertical line to set a breakpoint.



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.



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 initialization functions which configure the MCU for normal operation. This includes input/output ports, and system clocks.
- The user can step through all the initialization 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.

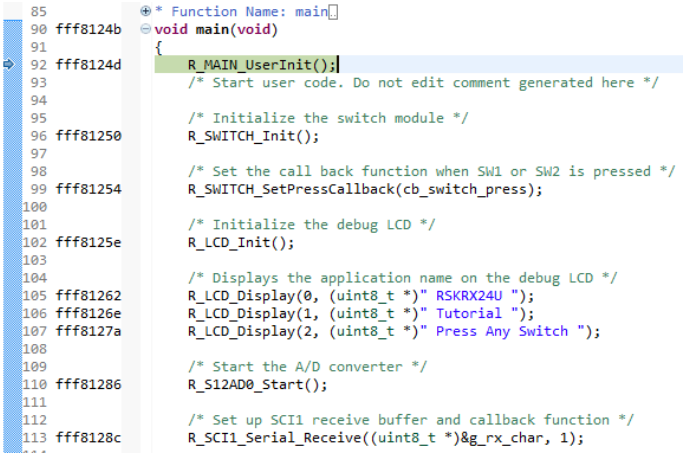
```
85          * Function Name: main
90 fff8124b void main(void)
91          {
92 fff8124d     R_MAIN_UserInit();
93             /* Start user code. Do not edit comment generated here */
94
95             /* Initialize the switch module */
96 fff81250   R_SWITCH_Init();
97
98             /* Set the call back function when SW1 or SW2 is pressed */
99 fff81254   R_SWITCH_SetPressCallback(cb_switch_press);
100
101            /* Initialize the debug LCD */
102 fff8125e   R_LCD_Init();
103
104            /* Displays the application name on the debug LCD */
105 fff81262   R_LCD_Display(0, (uint8_t *)" RSKRX24U ");
106 fff8126e   R_LCD_Display(1, (uint8_t *)" Tutorial ");
107 fff8127a   R_LCD_Display(2, (uint8_t *)" Press Any Switch ");
108
109            /* Start the A/D converter */
110 fff81286   R_S12AD0_Start();
111
112            /* Set up SCI1 receive buffer and callback function */
113 fff8128c   R_SCI1_Serial_Receive((uint8_t *)&g_rx_char, 1);
```

For further details regarding hardware configuration, please refer to the RSKRX24U User’s Manual and the RX24U Group Hardware Manual.

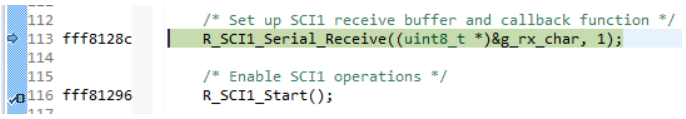
4.2 Main Functions

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 G1CUSB0 to a PC USB port and open a terminal emulation program, such as HyperTerminal, with the settings 19200, 8, N, 1 and N. For information on installation of the RSK virtual COM port driver, refer to the file 'description.txt' in doc folder of the e^2 studio Tutorial project.

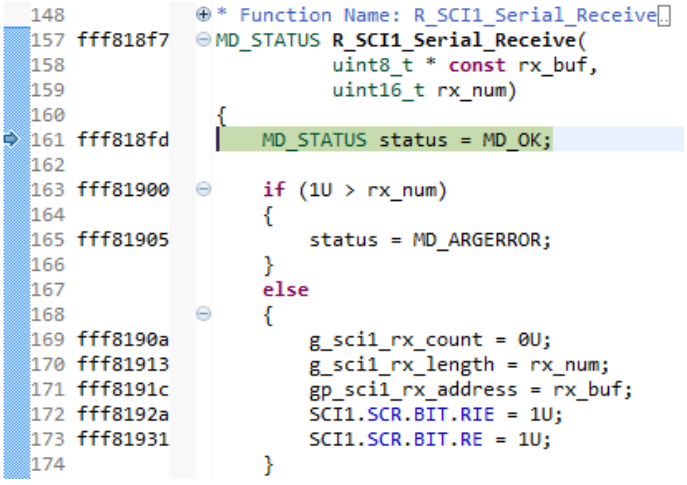
- Right click the 'R_SCI1_Serial_Receive' function call and select 'Run to Line' to execute the program up to this line. The 'R_LCD_Init' function call enables and configures the LCD panel, and 'R_LCD_Display' will write "RSKRX24U Tutorial Press Any Switch" onto the LCD.



- 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 should 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.
- 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].

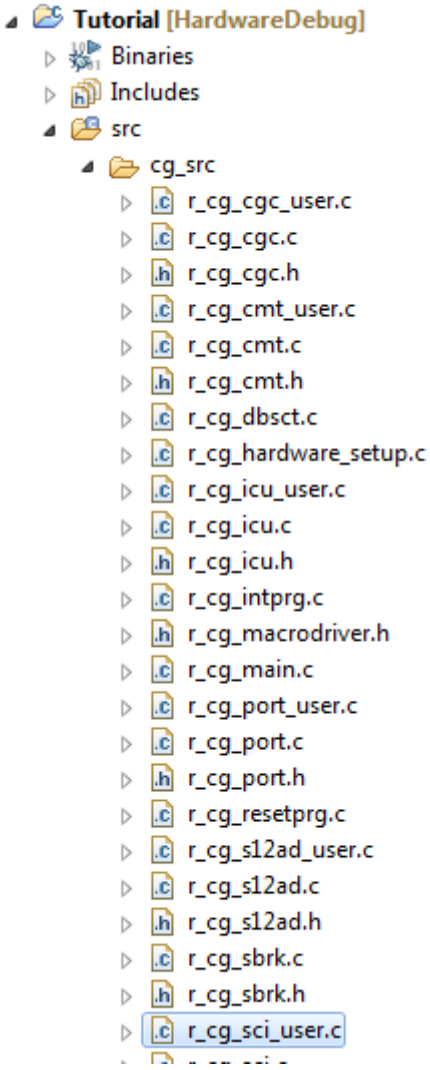
The ‘R_SCI1_Start’ function enables the UART interrupts. The program then proceeds to the main while(1U) loop. The code inside the loop waits for user input from either the SCI or RSK switches, and then performs an A/D conversion.

```
112                 /* Set up SCI1 receive buffer and callback function */
113 fff8128c         R_SCI1_Serial_Receive((uint8_t *)&g_rx_char, 1);
114
115                 /* Enable SCI1 operations */
116 fff81296         R_SCI1_Start();
```

- 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.

```
118             while (1U)
119             {
120                 uint16_t adc_result;
121
122                 /* Wait for user requested A/D conversion fl
123 fff8133b       if (TRUE == g_adc_trigger)
124             {
125                 /* Call the function to perform an A/D c
126 fff8129d       adc_result = get_adc();
127
128                 /* Display the result on the LCD */
129 fff812a2       lcd_display_adc(adc_result);
```

- 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.

```
181          * Function Name: r_sci1_callback_receiveend
186 fff81bb6 void r_sci1_callback_receiveend(void)
187          {
188              /* Start user code. Do not edit comment generated here */
189
190              /* Check the contents of g_rx_char */
191 fff81bb8    if (('c' == g_rx_char) || ('C' == g_rx_char))
192              {
193 fff81bdd        g_adc_trigger = TRUE;
194              }
195
196               /* Set up SCI1 receive buffer and callback function again */
197 fff81be8     R_SCI1_Serial_Receive((uint8_t *)&g_rx_char, 1);
198
199              /* End user code. Do not edit comment generated here */
200          }
```

- 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.

```
190              /* Check the contents of g_rx_char */
191 fff81bb8     if (('c' == g_rx_char) || ('C' == g_rx_char))
192              {
193 fff81bdd          g_adc_trigger = TRUE;
194              }
```

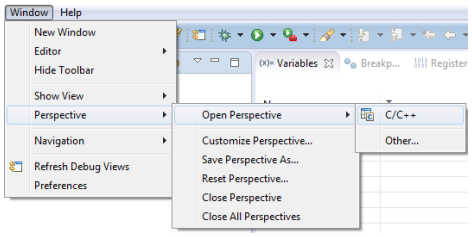
- The program will halt at the breakpoint in the main while loop.
- Remove the breakpoint by double-clicking on the breakpoint column. Continue to execute the program by clicking the ‘Resume’ button.

```
128              /* Display the result on the LCD */
129 fff812a2     lcd_display_adc(adc_result);
130
131              /* Increment the adc_count and display
132 fff812a7     if (16 == (++adc_count))
133              {
134 fff812b9         adc_count = 0;
135              }
136 fff812c2     led_display_count(adc_count);
```

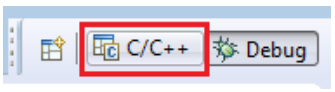
The program proceeds to display the result of the A/D conversion on the LCD and in the terminal window. In addition, the running count of A/D conversions performed is displayed in binary form using LEDs 0-3 on the RSK. Adjust the potentiometer and press SW1, SW2 or SW3 on the RSK and an additional A/D 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 > Perspective >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.

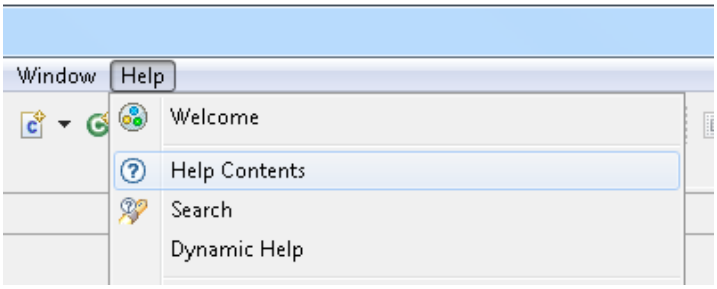
For further details regarding hardware configuration, please refer to the RX Series Software Manual and the RX24U Group Hardware Manual.

The E2 emulator Lite 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 E2 Emulator Lite User’s Manual.

5. Additional Information

Technical Support

For details on how to use e² studio, refer to the help file by opening e² studio, then selecting Help > Help Contents from the menu bar.



Parts of the sample code provided with the RSKRX24U can be reproduced using the Code Generator tool. Code Generator is included as a plug in with e² studio.
Source files and functions generated by Code Generator are prefixed with 'r_' and 'R_', respectively.

For information about the RX24U Group microcontrollers 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:
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Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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