

# RX24T Group

Renesas Starter Kit Tutorial Manual  
For CS+

RENESAS 32-Bit MCU  
RX Family / RX200 Series

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## **Disclaimer**

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

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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 the CS+ 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 CS+, but does not intend to be a complete guide to software development on the RSK platform. Further details regarding operating the RX24T 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 RX24T 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.	RSKRX24T User's Manual	R20UT3436EG
Tutorial Manual	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSKRX24T Tutorial Manual	R20UT3437EG
Code Generator Tutorial Manual	Provides a guide to code generation and importing into the CS+ IDE.	RSKRX24T Code Generator Tutorial Manual	R20UT3439EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample, on a single A4 sheet.	RSKRX24T Quick Start Guide	R20UT3438EG
Schematics	Full detail circuit schematics of the RSK.	RSKRX24T Schematics	R20UT3435EG
Hardware Manual	Provides technical details of the RX24T microcontroller.	RX24T Group Hardware Manual	R01UH0576EJ

## 2. List of Abbreviations and Acronyms

<b>Abbreviation</b>	<b>Full Form</b>
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	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
Pmod™	This is a Digilent Pmod™ Compatible connector. Pmod™ is registered to <a href="#">Digilent Inc.</a> <a href="#">Digilent-Pmod_Interface_Specification</a>
PLL	Phase-locked Loop
RAM	Random Access Memory
ROM	Read Only Memory
RSK	Renesas Starter Kit
RTC	Realtime Clock
SAU	Serial Array Unit
SCI	Serial Communications Interface
SPI	Serial Peripheral Interface
TAU	Timer Array Unit
TFT	Thin Film Transistor
TPU	Timer Pulse Unit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WDT	Watchdog timer

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## 1. Overview

### 1.1 Purpose

This RSK is an evaluation tool for Renesas microcontrollers. This manual describes how to 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?

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 level is set to zero.
- 'Release' is a project with optimised compile options (level two) and no outputs debugging information options selected, producing code suitable for release in a product.

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 the CS+ debugger, 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 RX24T has been used to generate the sample code discussed in this document. Code Generator for CS+ is a plug in tool for generating template 'C' source code and project settings for the RX24T. 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.

Code Generator is not enabled by default during CS+ installation and is not required for this tutorial manual. For more information please refer to the 'Enabling Code Generator' section of the Code Generator Tutorial 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.

## 3. Tutorial Project Workspace

### 3.1 Introduction

CS+ is an integrated development tool that allows the user to write, compile, program and debug a software project on the RX, RL78 and RH850 family of Renesas microcontrollers. CS+ will have been installed during the installation of the software support for the Renesas Starter Kit product. This manual will describe the stages required to create and debug the supplied tutorial code.

### 3.2 Starting CS+

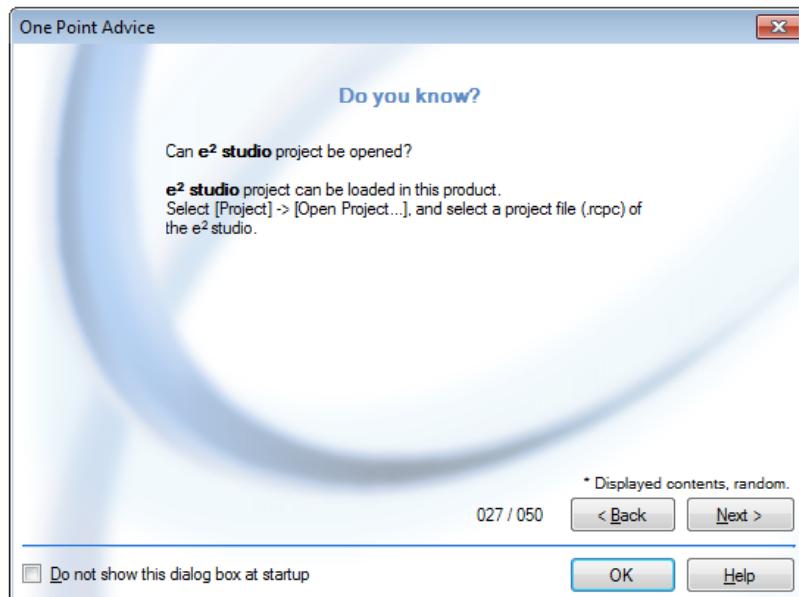
To use the program, start CS+:

Windows™ 7 & Vista: Start Menu

(Start Menu > All Programs > Renesas Electronics CS+ > CS+ for CC (RL78,RX,RH850)

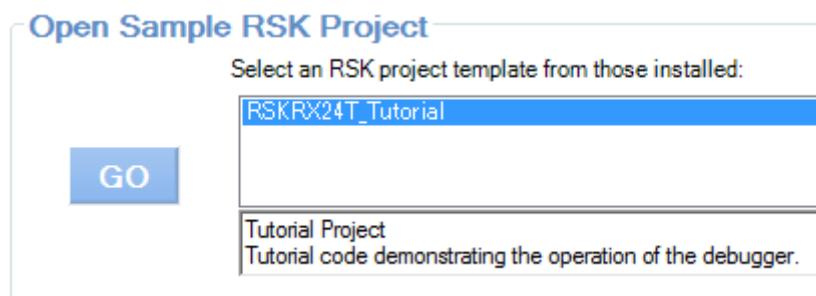
Windows™ 8.1 & 8: From Apps View , click 'CS+ for CC (RL78,RX, RH850)' icon

The first time CS+ is started, the One Point Advice dialog box will be shown:

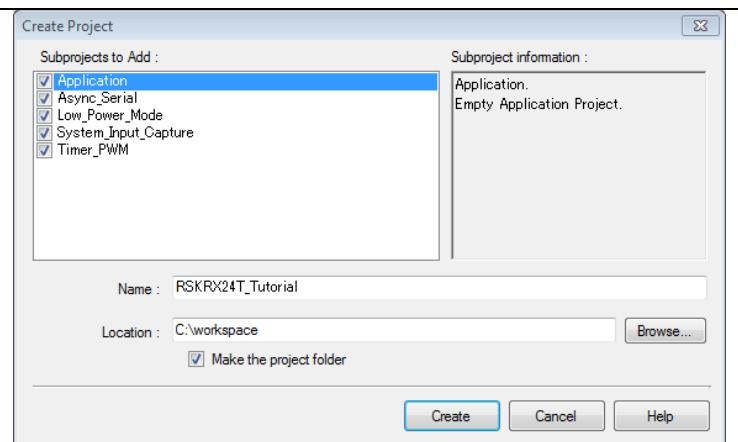


The One Point Advice dialog box provides some useful tips when using CS+. Press 'OK' to skip the advice and close the One Point Advice dialog. The user will then be presented with the Start panel.

Under the 'Open Sample RSK Project', open a new Tutorial project by selecting the RSKRX24T\_Tutorial project template and click on 'Go' as shown below. This will save a copy of the RSKRX24T\_Tutorial project.

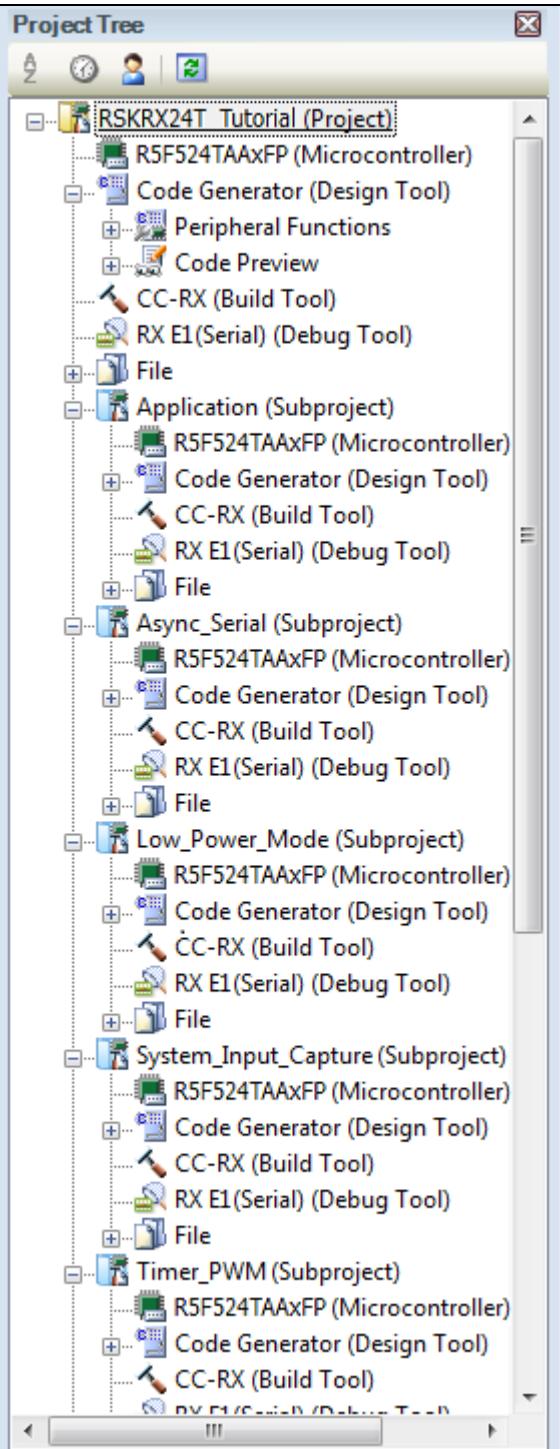


- CS+ will present a 'Create Project' dialog box.
- Select all sub-projects by clicking on each checkbox and observe the information displayed under the 'Subproject information' heading as you select each project.
- Specify a name and location for the new project and click on 'Create'
- A dialog box will appear if the location specified does not exist; asking to create the folder specified. Click 'OK'.

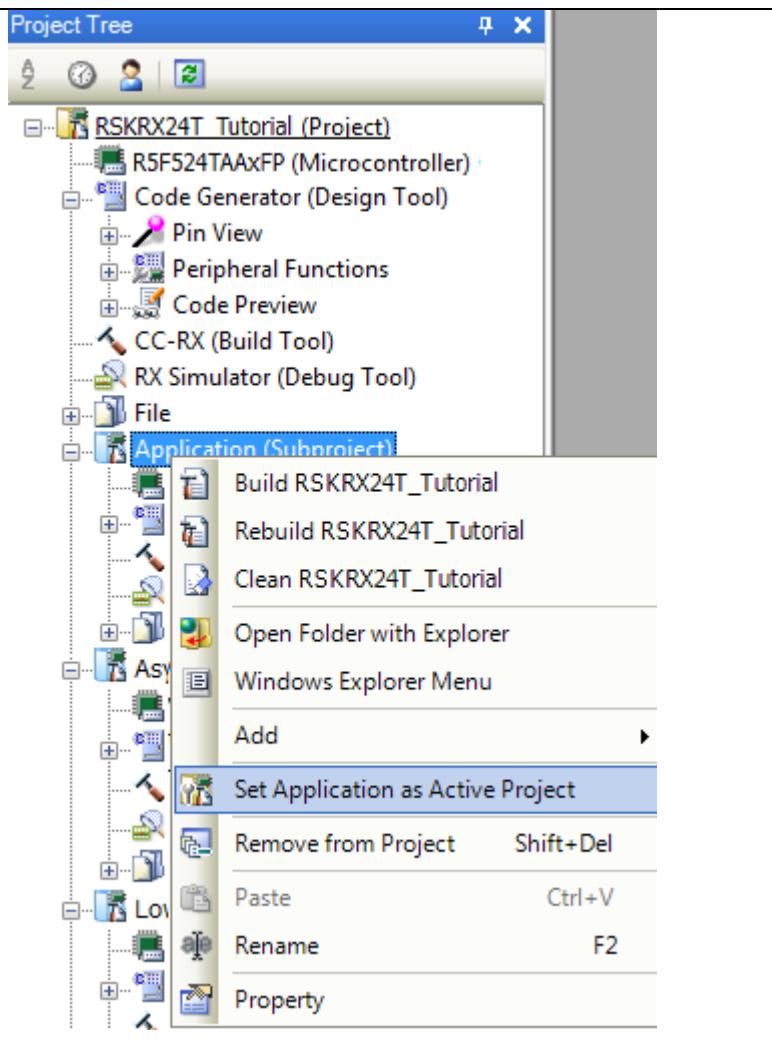


- CS+ will create and open the project showing the Project Tree as seen in the screenshot opposite.
- RSKRX24T\_Tutorial (Project) is the master project and includes the tools to modify, build and debug the code.
- The File folder seen in the screenshot belongs to the master project, RSKRX24T\_Tutorial.
- This folder contains and lists all project source and header files including text files arranged in separate folder structures.
- Folders containing the subprojects, indicated by “(Subproject)”, are listed below the File folder.
- Each subproject folder, when expanded, reveals an identical tools and folder structure to that of the master project, RSKRX24T\_Tutorial.
- By default the RSKRX24T\_Tutorial project is set as the active project, indicated by the line under the project name.

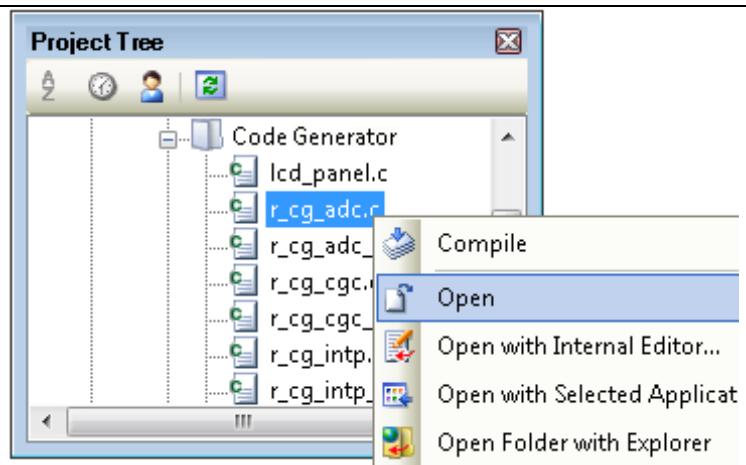
Note: ‘Code Generator (Design Tool)’ node is shown in the ‘Project Tree’ and indicates an optional plug-in has been enabled previously.



- To change the active project, right-click on the project/subproject name and select “Set x as Active Project” (x represents the project name).

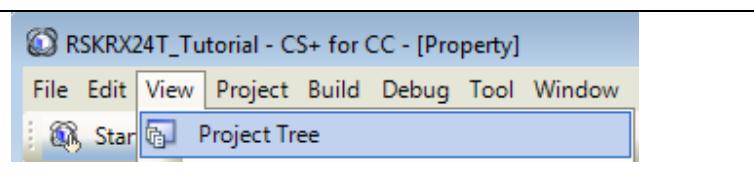
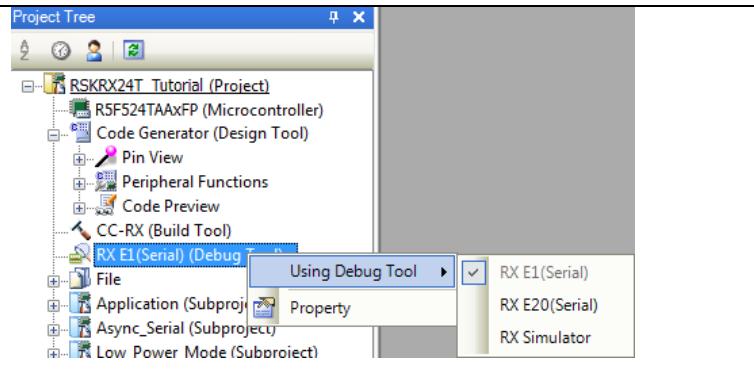
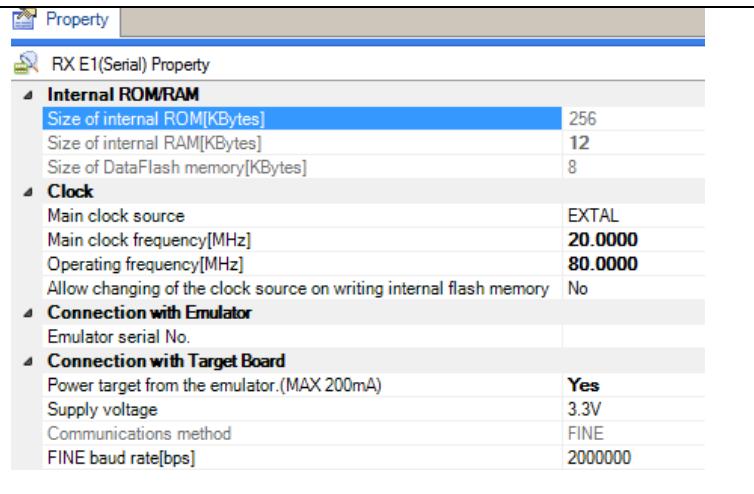
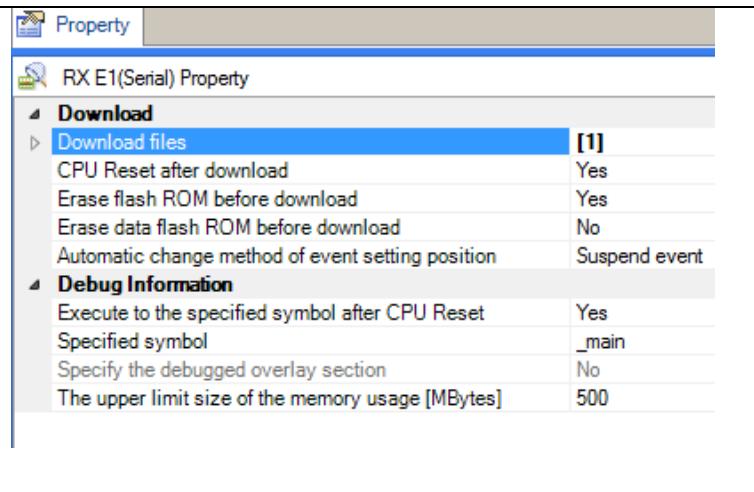


- The File folder contains four subfolders. This structure is common to all projects.
- Some of the source files were generated by Code Generator, which are grouped under the ‘Code Generator’ folder which itself is listed under the File folder in the Project Tree. These files are prefixed with ‘r\_cg’ to indicate that they were generated by a code generator. All other user-generated source files are contained in the ‘C Source Files’ folder.
- To open a file for viewing, right-click on the file and select ‘Open’. Alternatively, double-click on the file.



### 3.3 Configuring the Debug Tool (E1)

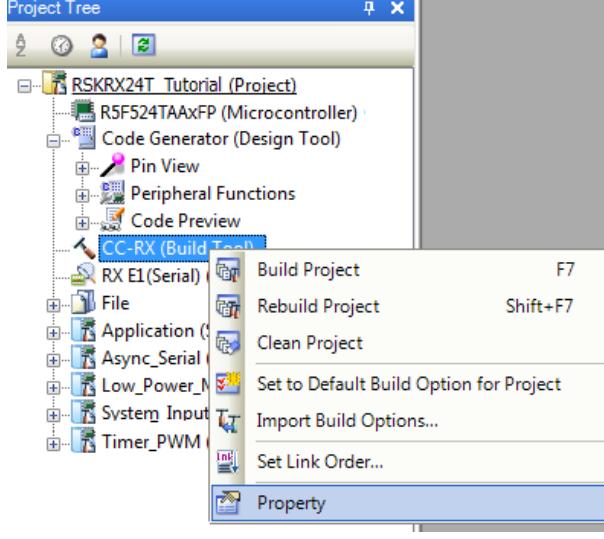
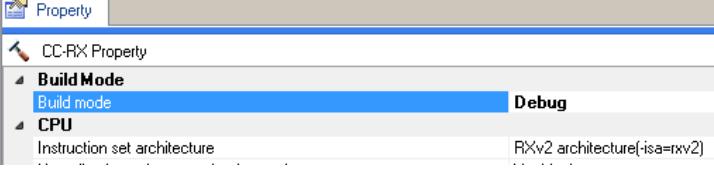
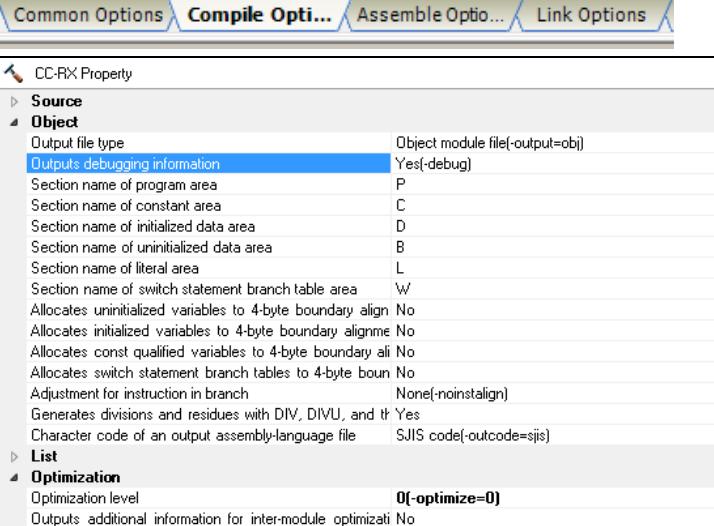
Note: The Tutorial sample project's settings are pre-configured. This section is intended to familiarise the user with the debug tool settings for when they create their own project.

<ul style="list-style-type: none"> <li>The Project Tree will be displayed on the left-hand pane of CS+.</li> <li>This can also be invoked from the menu bar [View &gt; Project Tree].</li> </ul>																													
<ul style="list-style-type: none"> <li>The opposite screen-shot indicates that the selected Debug Tool is E1.</li> </ul>																													
<ul style="list-style-type: none"> <li>Right click on RX E1(Serial) (DebugTool).</li> <li>Click on Property.</li> <li>View the Connect Settings.</li> <li>Verify that the settings match the opposite screen-shot.</li> </ul>	 <table border="1"> <thead> <tr> <th>Internal ROM/RAM</th> </tr> </thead> <tbody> <tr> <td>Size of internal ROM[KBytes]</td> <td>256</td> </tr> <tr> <td>Size of internal RAM[KBytes]</td> <td>12</td> </tr> <tr> <td>Size of DataFlash memory[KBytes]</td> <td>8</td> </tr> <tr> <th>Clock</th> </tr> <tr> <td>Main clock source</td> <td>EXTAL</td> </tr> <tr> <td>Main clock frequency[MHz]</td> <td>20.0000</td> </tr> <tr> <td>Operating frequency[MHz]</td> <td>80.0000</td> </tr> <tr> <td>Allow changing of the clock source on writing internal flash memory</td> <td>No</td> </tr> <tr> <th>Connection with Emulator</th> </tr> <tr> <td>Emulator serial No.</td> <td></td> </tr> <tr> <th>Connection with Target Board</th> </tr> <tr> <td>Power target from the emulator.(MAX 200mA)</td> <td>Yes</td> </tr> <tr> <td>Supply voltage</td> <td>3.3V</td> </tr> <tr> <td>Communications method</td> <td>FINE</td> </tr> <tr> <td>FINE baud rate[bps]</td> <td>2000000</td> </tr> </tbody> </table>	Internal ROM/RAM	Size of internal ROM[KBytes]	256	Size of internal RAM[KBytes]	12	Size of DataFlash memory[KBytes]	8	Clock	Main clock source	EXTAL	Main clock frequency[MHz]	20.0000	Operating frequency[MHz]	80.0000	Allow changing of the clock source on writing internal flash memory	No	Connection with Emulator	Emulator serial No.		Connection with Target Board	Power target from the emulator.(MAX 200mA)	Yes	Supply voltage	3.3V	Communications method	FINE	FINE baud rate[bps]	2000000
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<p>The project is configured to halt code execution on the first instruction of the main function after programming the microcontroller. To specify another function as an entry point:</p> <ul style="list-style-type: none"> <li>View the 'Download files' Settings of the RX E1's property.</li> <li>Change the 'specified symbol' to another available function.</li> <li>Ensure to prefix the function name with an underscore ("_").</li> </ul> <p>Note: Do not specify an interrupt handler as the entry point.</p>	 <table border="1"> <thead> <tr> <th>Download</th> </tr> </thead> <tbody> <tr> <td>Download files</td> <td>[1]</td> </tr> <tr> <td>CPU Reset after download</td> <td>Yes</td> </tr> <tr> <td>Erase flash ROM before download</td> <td>Yes</td> </tr> <tr> <td>Erase data flash ROM before download</td> <td>No</td> </tr> <tr> <td>Automatic change method of event setting position</td> <td>Suspend event</td> </tr> <tr> <th>Debug Information</th> </tr> <tr> <td>Execute to the specified symbol after CPU Reset</td> <td>Yes</td> </tr> <tr> <td>Specified symbol</td> <td>_main</td> </tr> <tr> <td>Specify the debugged overlay section</td> <td>No</td> </tr> <tr> <td>The upper limit size of the memory usage [MBytes]</td> <td>500</td> </tr> </tbody> </table>	Download	Download files	[1]	CPU Reset after download	Yes	Erase flash ROM before download	Yes	Erase data flash ROM before download	No	Automatic change method of event setting position	Suspend event	Debug Information	Execute to the specified symbol after CPU Reset	Yes	Specified symbol	_main	Specify the debugged overlay section	No	The upper limit size of the memory usage [MBytes]	500								
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### 3.4 Build Configuration

The build configurations are selected from the build tool's Property panel. The options available are 'DefaultBuild', 'Debug' and 'Release'. 'DefaultBuild' and 'Debug' are configured for use with the debugger. 'Release' is configured for the final ROM programmable code.

A common difference between the two builds is the optimisation setting and the addition of debug information. With optimisation turned on, the debugger may seem to execute code in an unexpected order. To assist in debugging it is often helpful to turn optimisation off on the code being debugged.

<ul style="list-style-type: none"> <li>Right-click on CC-RX (Build Tool) from the Project Tree.</li> <li>Select 'Property'.</li> </ul>	
<ul style="list-style-type: none"> <li>The Common Options sheet will open by default.</li> <li>Verify that the Build Mode is set to 'Debug'.</li> </ul>	
Click on the 'Compile Options' sheet to view compiler options.	

## 4. Building the Tutorial Program

The tutorial project build settings have been pre-configured in the toolchain options. To view the toolchain options double-click on CC-RX(Build Tool) from the Project Tree and select the available tabs. It is important when changing settings to be aware of the current configuration before modifying the settings.

<ul style="list-style-type: none"> <li>Review the options on each of the tabs to be aware of the options available. For the purposes of the tutorial, leave all options at default.</li> <li>When complete, the Property panel can be closed by clicking [x] on the right-hand corner of the Property window.</li> </ul>	
--	--

### 4.1 Building the Code

There is a choice of three shortcuts available for building the project:

<ul style="list-style-type: none"> <li>Selecting the 'Build Project' toolbar button will build all projects listed in the project tree.</li> </ul>	
<ul style="list-style-type: none"> <li>Pressing [F7]. This is equivalent to pressing the 'Build Project' toolbar button.</li> </ul>	
<ul style="list-style-type: none"> <li>Selecting the 'Rebuild Project' toolbar button will rebuild all project files.</li> </ul>	
<ul style="list-style-type: none"> <li>Selecting the 'Build &amp; Download' toolbar button will only build the active project and download the code to the target device after a successful build.</li> </ul>	
<ul style="list-style-type: none"> <li>Pressing [F6]. This is equivalent to pressing the 'Build &amp; Download' toolbar button.</li> </ul>	

Build the project now by pressing [F7] or pressing one of the build icons as shown above. During the build each stage will be reported in the Output Window. The build will complete with an indication of any errors and warnings encountered during the build.

## 4.2 Connecting the Debugger

For this tutorial the E1 debugger will provide power to the RSK, no external power supply is required.

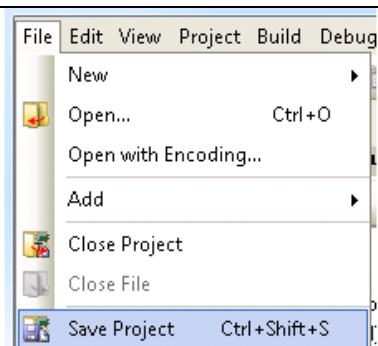
The Quick Start Guide provided with the Renesas Starter Kit board gives detailed instructions on how to connect the E1 to the host computer. The following assumes that the steps in the Quick Start Guide have been followed and the E1 drivers have been installed.

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

## 4.3 Saving Project Settings

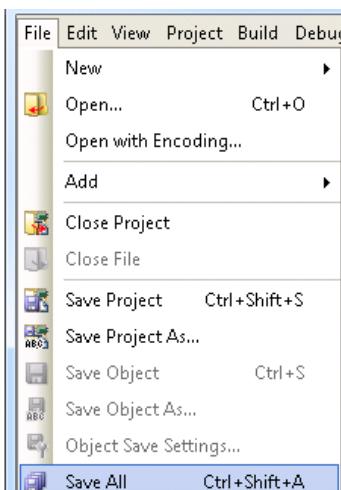
If you have changed any project settings this is a good time to save the project.

- Select 'File' | 'Save Project'.



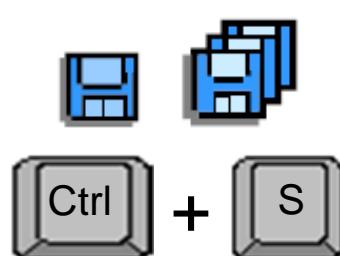
If you make any changes to files in CS+ and want to preserve these changes, you can save them by:

- Select 'File' | 'Save All'.



You can also save files by clicking the 'Save' or 'Save All' buttons from the CS+ toolbar.

In addition files can be saved using the keyboard shortcut [Ctrl + S]:



## 5. Downloading and Running the Tutorial

### 5.1 Downloading the Program Code

Now that the code has been built in CS+ it needs to be downloaded to the RSK.

<ul style="list-style-type: none"> <li>Click on the program download button. Alternatively, select Debug from the Menu bar and click on Download.</li> <li>On completion of program download, the debugger and code are ready to be executed. The program counter indicator will point to first line of code inside the 'main' function; this is the program's entry point.</li> </ul>	 <pre> /*  * Function Name: main  * Description : This function implements main function.  * Arguments   : None  * Return Value: None  */ void main(void) {     R_MAIN_UserInit();     /* Start user code. Do not edit comment generated here */      /* Initialize the switch module */     R_SWITCH_Init();      /* Set the call back function when SW1 or SW2 is pressed */     R_SWITCH_SetPressCallback(cb_switch_press);      /* Initialize the debug LCD */     R_LCD_Init();      /* Displays the application name on the debug LCD */     R_LCD_Display(0, (uint8_t *)" RSKRX24T ");     R_LCD_Display(1, (uint8_t *)" Tutorial ");     R_LCD_Display(2, (uint8_t *)" Press Any Switch "); } </pre>
--	---

Before proceeding, it is necessary to connect to the RSK G1CUSB0 port to a PC using a USB Type A to mini B cable. The first time this port is connected to the PC an 'Installing Device Driver Software' pop-up will appear and the device driver will be automatically installed. Open Device Manager, the virtual COM port will appear under 'Port (COM & LPT)' as 'RSK USB Serial Port (COMx)', where x is a number. Open a terminal; emulation program, such as HyperTerminal, with the settings 19200, 8, N, 1 on the virtual COM port.

### 5.2 Running the Tutorial

Once the program has been downloaded onto the RSK device, the program can be executed. Click the 'Go' button or press F5 to begin the program from the current program counter position. It is recommended that you run through the program once first, and then continue to the review section. Operating instructions for the program can be found in the file 'Description.txt', under the 'Text Files' folder in the CS+ Project Tree.



## 6. Reviewing the Tutorial Program

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

### 6.1 Program Initialization

Before the main program can run, the microcontroller must be configured. Due to the debugger configuration used for the Tutorial project and the rest of the sample projects, the user will not be able to step through the hardware initialization code. Please refer to Section 3.3 to change the entry point after programming the microcontroller. Specify '\_R\_Systeminit' as the function name if viewing of hardware initialization is desired. The initialization code is executed every time the device is reset via the reset switch or from a power reboot. The user is advised not to use the 'step' feature of the debugger to exit the 'R\_Systeminit' function.

Ensuring the Tutorial program has been downloaded onto the RX24T; press the 'CPU Reset' button on the Debug Toolbar.



- From the Menu bar select View > Disassemble > Disassemble1. Alternatively, use the Display Disassemble button to open and view the 'source and disassembly'.
- To make the Display Disassemble button available on the toolbar, right-click on the toolbar and select 'View Panels'.



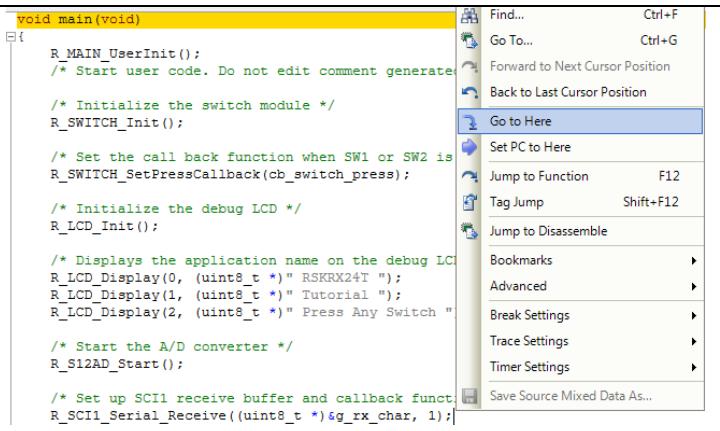
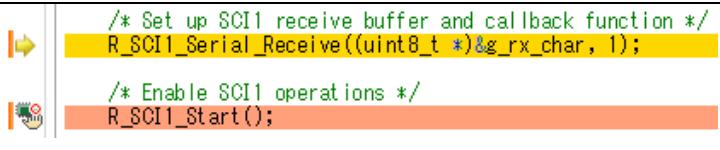
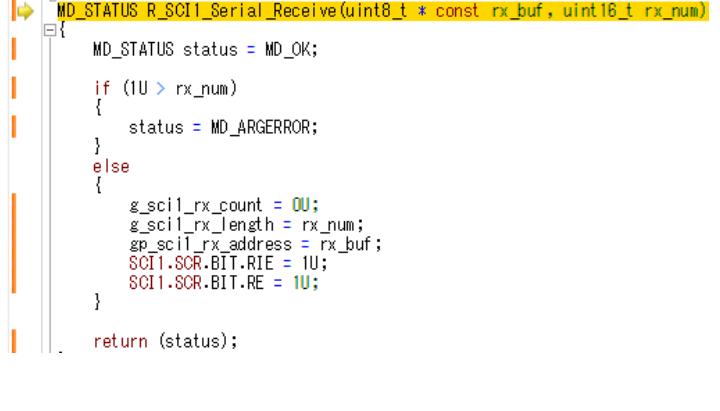
Disassemble button

Line Number	Assembly Code	OpCode	Comment
01:	void main(void)		
	main:	8040	SUB #4H,R0
03:	fffc07dc	39f400	BSR.W _R_MAIN_UserInit
03:	fffc07de	05991900	BSR.A _R_SWITCH_Init
07:	fffc07e1	05991900	BSR.A _R_SWITCH_SetPressCallback(cb_switch_press);
100:	fffc07e5	fb72dc08fcff	MOV.L #0003F724H,R1
	fffc07eb	05951300	BSR.A _R_SWITCH_SetPressCallback
103:	fffc07ef	058a0e00	BSR.A _R_LCD_Init
106:	fffc07f3	fb22501dfcff	MOV.L #0003E2B0H,R2
	fffc07f9	6601	MOV.L #0H,R1
	fffc07fb	05910e00	BSR.A _R_LCD_Display
107:	fffc07ff	fb225b1dfcff	MOV.L #0003E2A5H,R2
	fffc0805	6611	MOV.L #1H,R1
	fffc0807	05850e00	BSR.A _R_LCD_Display
108:	fffc080b	fb22661dfcff	MOV.L #0003E29AH,R2
	fffc0811	6621	MOV.L #2H,R1
	fffc0813	05790e00	BSR.A _R_LCD_Display

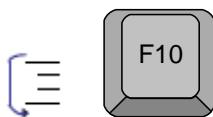
Revert back to the source by clicking on the file containing the function pointed to by the program counter indicator. Alternatively, right click in the Disassemble1 window and click "Jump to Source".

## 6.2 Main Functions

This section will look at the program code called from with the ‘main()’ function, and how it works.

<ul style="list-style-type: none"> <li>Right click the ‘R_SCI1_Serial_Receive()’ function call and select ‘Go to Here’ 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 “RSKRX24T” onto the top line, “Tutorial” on the second line and “Press Any Switch” on the third.</li> </ul>	 <pre>void main(void) {     R_MAIN_UserInit();     /* Start user code. Do not edit comment generated by Code Generator */     /* Initialize the switch module */     R_SWITCH_Init();      /* Set the call back function when SW1 or SW2 is pressed */     R_SWITCH_SetPressCallback(cb_switch_press);      /* Initialize the debug LCD */     R_LCD_Init();      /* Displays the application name on the debug LCD */     R_LCD_Display(0, (uint8_t *)"RSKRX24T");     R_LCD_Display(1, (uint8_t *)"Tutorial");     R_LCD_Display(2, (uint8_t *)"Press Any Switch");      /* Start the A/D converter */     R_S12AD_Start();      /* Set up SCI1 receive buffer and callback function */     R_SCI1_Serial_Receive((uint8_t *)&amp;g_rx_char, 1); }</pre>
<ul style="list-style-type: none"> <li>Set a breakpoint on the ‘R_SCI1_Start()’ function call by clicking on the On-Chip Breakpoint column to the left of the number column.</li> </ul>	 <pre>/* Set up SCI1 receive buffer and callback function */ R_SCI1_Serial_Receive((uint8_t *)&amp;g_rx_char, 1);  /* Enable SCI1 operations */ R_SCI1_Start();</pre>
<ul style="list-style-type: none"> <li>Click the ‘Step In’ button to step into the ‘R_SCI1_Serial_Receive()’ function. Alternatively, press [F11].</li> </ul>	
<ul style="list-style-type: none"> <li>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 SCI1 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.</li> <li>For full details on how to configure a project using Code Generator refer to the Code Generator Tutorial Manual.</li> <li>Press the  button to resume program execution.</li> </ul>	 <pre>MD_STATUS R_SCI1_Serial_Receive(uint8_t * const rx_buf, uint16_t rx_num) {     MD_STATUS status = MD_OK;      if (1U &gt; rx_num)     {         status = MD_ARGUMENT_ERROR;     }     else     {         g_sci1_rx_count = 0U;         g_sci1_rx_length = rx_num;         gp_sci1_rx_address = rx_buf;         SCI1.SCR.BIT.RIE = 1U;         SCI1.SCR.BIT.RE = 1U;     }      return (status); }</pre>

- 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 F10.



The 'R\_SCI1\_Start()' function enables the SCI interrupts. The program then proceeds to the main while() loop. The code inside the loop waits for user input from either SCI reception or RSK switches, 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 clicking on the On-Chip Breakpoint column to the left of the number column.
- In the Project Tree 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 pressing the button.

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

/* Enable SCI1 operations */
R_SCI1_Start();

while (1U)
```

- 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 clicking on the breakpoint column.
- Continue to execute the program by pressing the button.

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

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

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

```
static void r_sci1_callback_receiveend(void)
{
    /* Start user code. Do not edit comment generated here */

    /* Check the contents of g_rx_char */
    if ((‘c’ == g_rx_char) || (‘0’ == 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 */
}
```

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

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

/* Increment the adc_count and display using the
if (16 == (++adc_count))
{
    adc_count = 0;
} 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 any switch on the RSK and an additional A/D conversion will be performed.

- Press the ‘Stop’ button to halt program execution.
- This is the extent of the tutorial code.



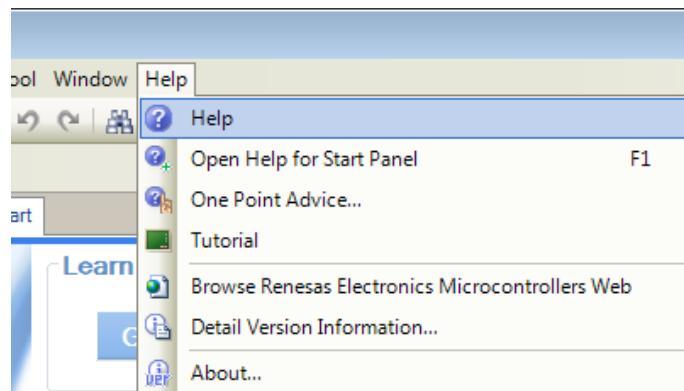
For further details regarding hardware configuration, please refer to the RX Family Software Manual and the RX24T Group Hardware Manual.

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/E20 Emulator User’s Manual

## 7. Additional Information

### Technical Support

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



Parts of the sample code provided with the RSKRX24T can be reproduced using the Code Generator plug in tool.

Source files and functions generated by Code Generator are prefixed with 'r\_' and 'R\_', respectively. For information about the RX24T Group microcontrollers refer to the RX24T 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		RSKRX24T Tutorial Manual	
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Rev.	Date	Description	
		Page	Summary
1.00	Dec 29, 2015	—	First Edition issued

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Renesas Starter Kit Manual: Tutorial Manual

Publication Date: Rev. 1.00 Dec 29, 2015

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Published by: Renesas Electronics Corporation



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