User's Manual

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RX63T Group

Renesas Starter Kit Tutorial Manual For CubeSuite+

RENESAS MCU
RX Family / RX600 Series

Renesas Electronics
www.renesas.com

Rev.1.01 Mar 2014

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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 is 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 CubeSuite+ 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 CubeSuite+, but does not intend to be a complete guide to software development on the RSK platform. Further details regarding operating the RX63T 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 RX63T 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.	RSKRX63T144 User's Manual for CubeSuite+	R20UT2117EG
Tutorial	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSKRX63T144 Tutorial Manual for CubeSuite+	R20UT2118EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample, on a single A4 sheet.	RSKRX63T144 Quick Start Guide for CubeSuite+	R20UT2119EG
Schematics	Full detail circuit schematics of the RSK.	RSKRX63T144 Schematics	R20UT2116EG
Hardware Manual	Provides technical details of the RX63T microcontroller.	RX63T Group Hardware Manual	R01UH0238EJ

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
CPU	Central Processing Unit
E1	E1 Emulator
IDE	Integrated Development Environment
IRQ	Interrupt Request
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LVD	Low Voltage Detect
MCU	Micro-controller Unit
PC	Personal Computer
RAM	Random Access Memory
ROM	Read Only Memory
RSK	Renesas Starter Kit
SAU	Serial Array Unit
SCI	Serial Communications Interface
TAU	Timer Array Unit
TFT	Thin Film Transistor
TPU	Timer Pulse Unit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WDT	Universal Asynchronous Receiver/Transmitter

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?

The project generator will create a tutorial project with three selectable build configurations:

- 'DefaultBuild' is a project with debug support and optimisation level set to two.
- 'Debug' is a project built with the debugger support included. Optimisation is set to zero.
- 'Release' is a project with optimised compile options (level two), 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.

Some of the illustrative screenshots in this document will show text in the form RXxxx. These are general screenshots and are applicable across the whole RX family. In this case, simply substitute RX63T for RXxxx.

These tutorials are designed to show you how to use the RSK and are not intended as a comprehensive introduction to the CubeSuite+ debugger, compiler toolchains or the E1 emulator. Please refer to the relevant user manuals for more in-depth information.

2.1 Note Regarding Source Code

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

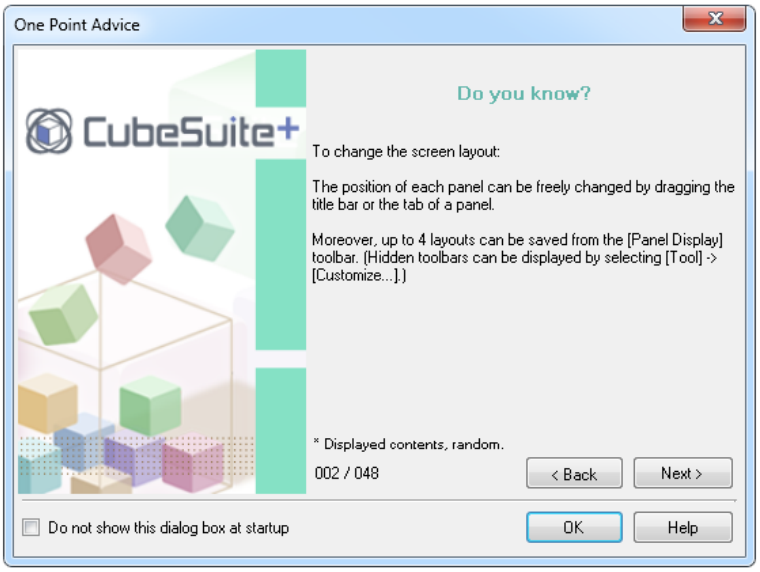
3.1 Introduction

CubeSuite+ is an integrated development tool that allows the user to write, compile, program and debug a software project on the RX, 78K, RL and V850 family of Renesas microcontrollers. CubeSuite+ 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 CubeSuite+ and Connecting the E1 Debugger

To use the program, start CubeSuite+ from the Windows™ Start Menu.

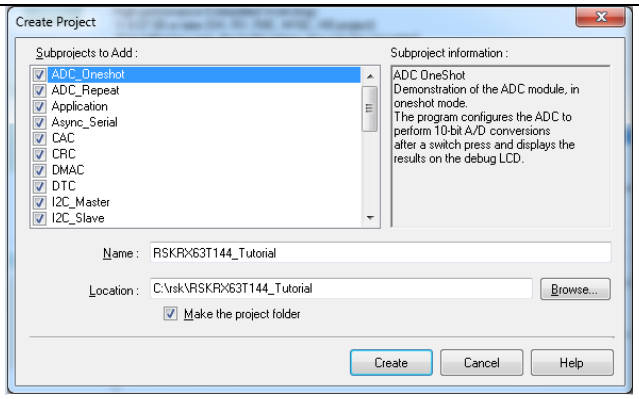
The first time CubeSuite+ is started, the One Point Advice dialog box will be shown:



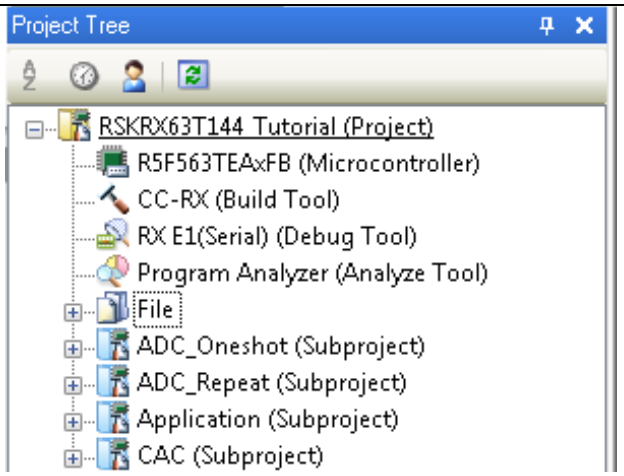
The One Point Advice dialog box provides some useful tips when using CubeSuite+. Press ‘OK’ to skip the advice and close the One Point Advice dialog. The user will then be presented with the Start panel.

Under the ‘Open Sample RSK Project’, open a new Tutorial project by selecting the RSKRX63T144_Tutorial project template and click on ‘Go’ as shown below. This will save a copy of the RSKRX63T144_Tutorial project.

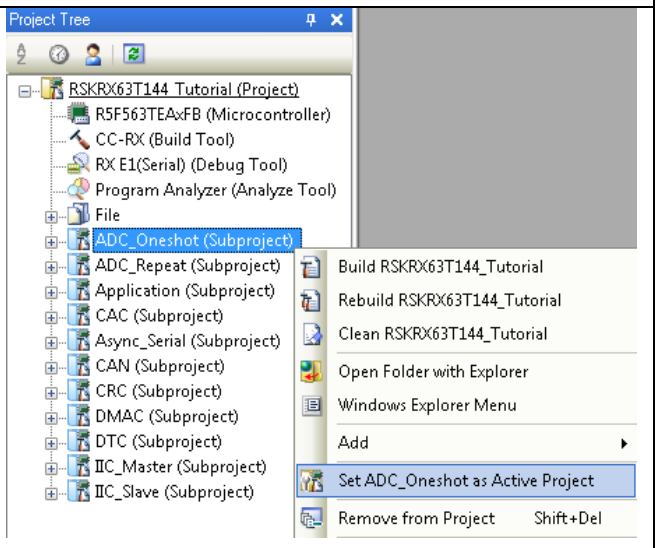
- CubeSuite+ will present a ‘Create Project’ dialog box.
- Select all sub-projects by clicking on each checkbox and observe the information displayed under the ‘Subproject information’ heading as you select each project.
- Specify a name and location for the new project and click on ‘Create’
- A dialog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



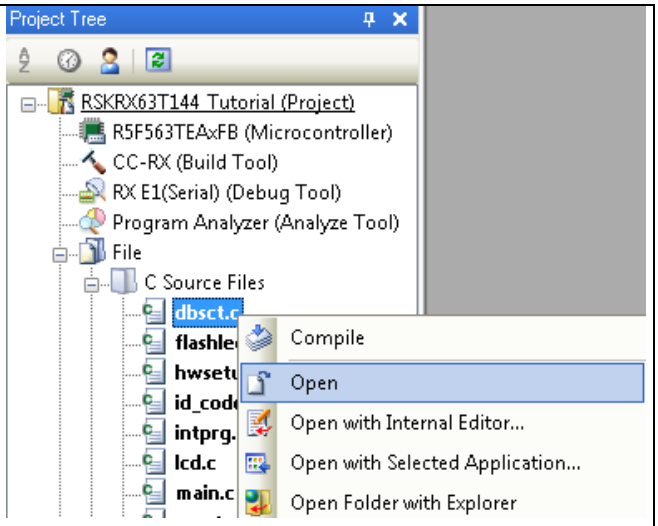
- CubeSuite+ will create and open the project showing the Project Tree as seen in the screenshot opposite.
- RSKRX63T144_Tutorial (Project) is the master project and includes the tools to modify, build and debug the code.
- The File folder seen in the screenshot belongs to the master project, RSKRX63T144_Tutorial.
- 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, RSKRX63T144_Tutorial.
- By default the RSKRX63T144_Tutorial project is set as the active project, indicated by the line under the project name.



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



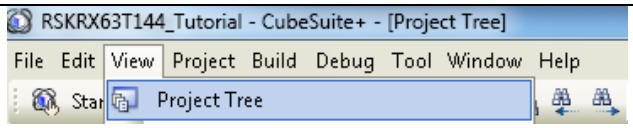
- The File folder contains three subfolders. This structure is common to all projects, with the exception of USB-related projects.
- To open a file for viewing, right-click on the file and select ‘Open’. Alternatively, double-click on the file.



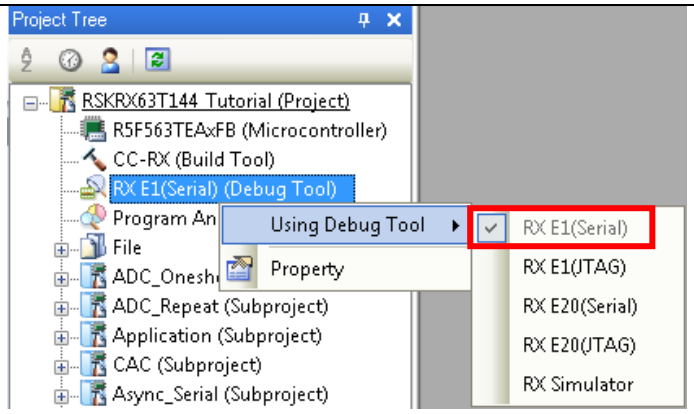
3.3 Configuring the Debug Tool (E1)

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.

- The Project Tree will be displayed on the left-hand pane of CubeSuite+.
- This can also be invoked from the menu bar [View > Project Tree].

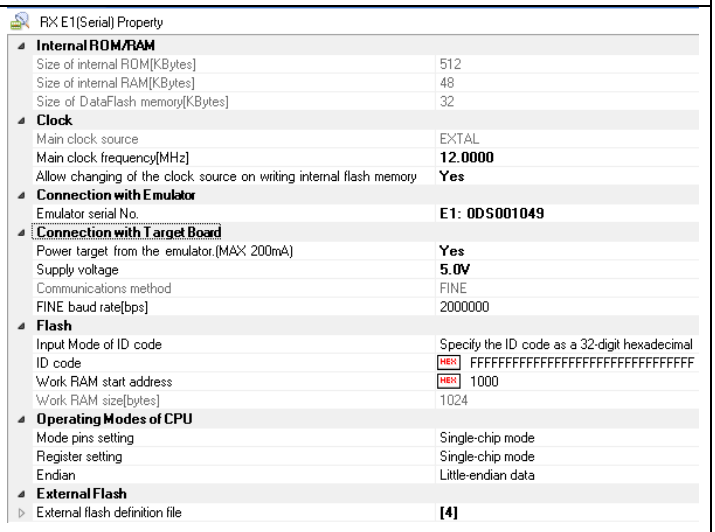


- The opposite screen-shot indicates that the selected Debug Tool is the E1.



- Right click on RX E1(Serial) (DebugTool).
- Click on Property.
- View the Connect Settings tab.
- Verify that the settings match the opposite screen-shot. In particular for the RSK the Main Clock Source should be EXTAL, the Main Clock Frequency should be 12MHz and supply voltage should be 5.0V

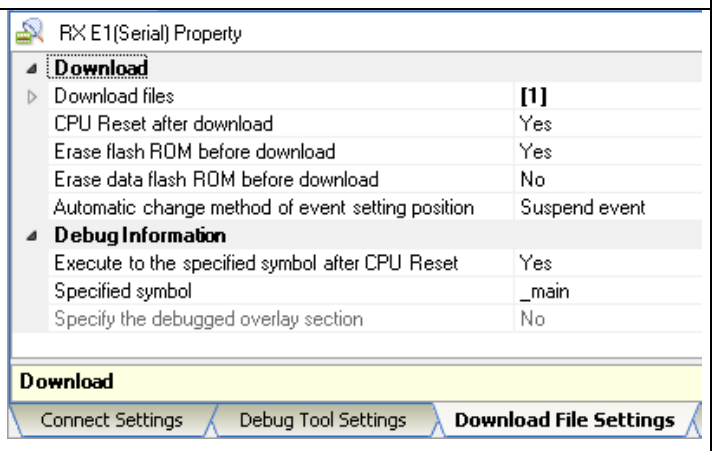
Note: To supply external power to the target board, set the 'Power target from emulator. (MAX 200mA)' entry to 'No'.



The project is configured to halt code execution on the first instruction of the main function after programming the micro-controller. To specify another function as the entry point:

- View the Download File Settings of the RX E1's property.
- Change the 'specified symbol' to another available function.
- Ensure to prefix the function name with an underscore ("_").

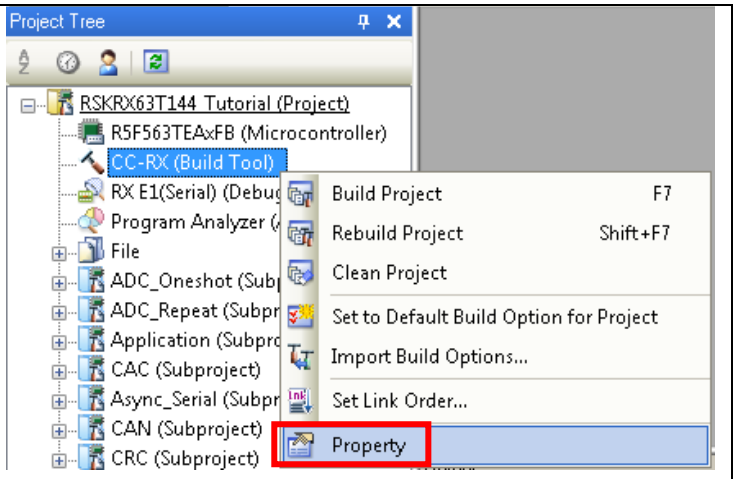
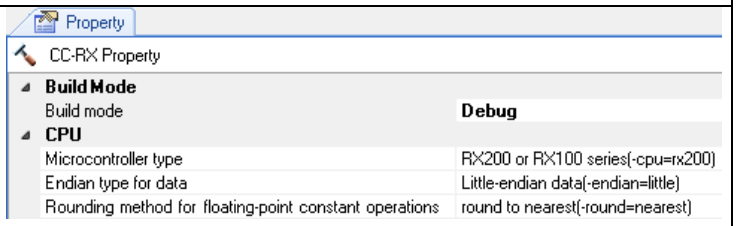
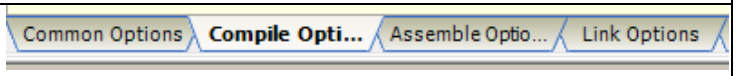
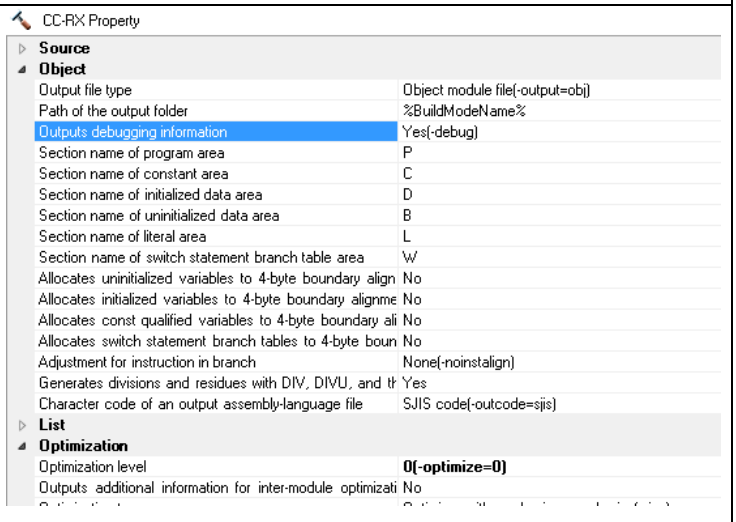
  Note: Do not specify an interrupt handler as the entry point.



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 three 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.

• Right-click on CC-RX (Build Tool) from the Project Tree. • Select 'Property'.	
• The Common Options sheet will open by default. • Verify that the Build Mode is set to Debug.	
• Click on the Compile Options sheet to view compiler options.	
• Ensure the 'Outputs debug information' entry is set to 'Yes(-debug)'. • Ensure the 'Optimization' entry is set to '0(-optimize=0).	

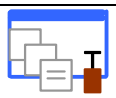
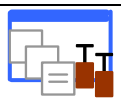
4. Building the Tutorial Program

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.

• 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. • When complete, the Property panel can be closed by clicking [x] on the right-hand corner of the Property window.	

4.1 Building the Code

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

• Selecting the ‘Build Project’ toolbar button will build all projects listed in the project tree.	
• Pressing [F7]. This is equivalent to pressing the ‘Build Project’ toolbar button.	
• Selecting the ‘Rebuild Project’ toolbar button will rebuild all project files.	
• Selecting the ‘Build & Download’ toolbar button will only build the active project and download the code to the target device after a successful build.	
• Pressing [F6]. This is equivalent to pressing the ‘Build & Download’ toolbar button.	

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 it is not necessary to provide an external power supply to the board. The power will be obtained from the USB port. Please be aware that if you have too many devices connected to your USB port it may be shut down by Windows. If this happens remove some devices and try again. Alternatively provide an external power source taking care to ensure the correct polarity and voltage.

Other sample code supplied with this RSK will require a variable power supply; in which case an external 0-5V variable power supply should be used. Refer to the RSKRX63T144 User Manual for further details.

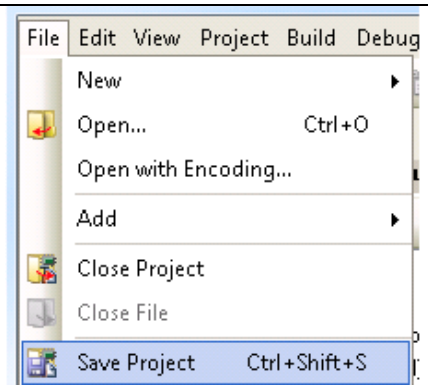
The Quick Start Guide provided with the Renesas Starter Kit board gives detailed instructions on how to connect the E1 to the host computer. The following assumes that the steps in the Quick Start Guide have been followed and the E1 drivers have been installed.

- Fit the 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’.
- If supplying external power to the board please refer to Section 3.3 to turn off the option of supplying power from the E1 before turning on the external power supply.

4.3 Saving Project Settings

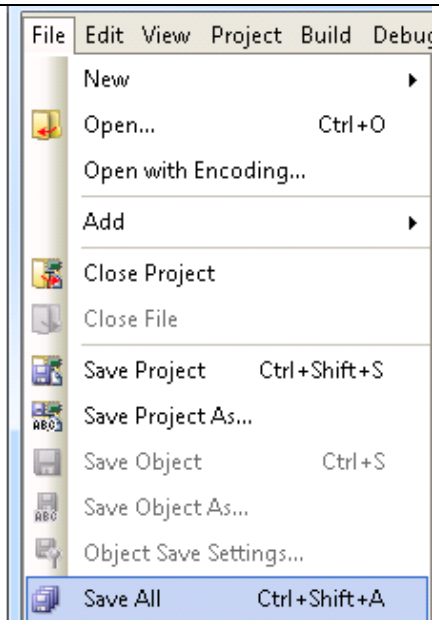
If you have changed any project settings this is a good time to save the project.

- Select ‘File’ | ‘Save Project’.



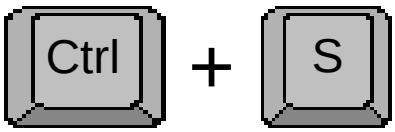
If you make any changes to files in CubeSuite+ and want to preserve these change, you can save them by:

- Select ‘File’ | ‘Save All’.



You can also save files by clicking the ‘Save’ or ‘Save All’ buttons from the CubeSuite+ 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 CubeSuite+ it needs to be downloaded to the RSK.

- Click on the program download button. Alternatively, select Debug from the Menu bar and click on Download.

- 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 and is located in main.c

```
/***********************************************************************
* Function Name : main
* Description   : The main program function. Displays the Renesas splash screen
*                 onto the LCD display, then calls the 'flashLED' and 'TimerADC'
*                 functions. The function then calls the statics test routine,
*                 before waiting in an infinite while loop.
* Argument      : none
* Return value  : none
***********************************************************************/
void main (void)
{
    /* Initialise the debug LCD */
    Init_LCD();

    /* Displays the Renesas splash screen */
    Display_LCD(LCD_LINE1, "Renesas");
    Display_LCD(LCD_LINE2, NICKNAME);

    /* Begins the initial LED flash sequence */
    Flash_LED();

    /* Begins the ADC-varying flash Sequence */
    Timer_ADC();

    /* Begins the static variable test */
    static_test();

    /* Infinite while loop */
    while (1)
    {
        /* Do nothing */
    }

}
```

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.

6. Reviewing the Tutorial Program

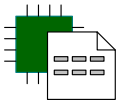
This section will look at each section of the tutorial code and basic debugging functionality in CubeSuite+.

6.1 Program Initialisation

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 initialisation code. Please refer to Section 3.3 to change the entry point after programming the microcontroller. Specify ‘HardwareSetup’ as the function name if viewing of hardware initialisation is desired. The initialisation 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 HardwareSetup function.

Ensuring the Tutorial program has been downloaded onto the RX63T; 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’.



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"

```
269:          while (counter--)
  ffff87de            471e          CMP       R1,R14
  ffff87e0            2103          BNE.B     _DisplayDelay+8H
273:      }
  ffff87e2            02            RTS
271:          nop();
  ffff87e3            03            NOP
  ffff87e4            621e          ADD       #1H,R14
  ffff87e6            2ef8          BRA.B     _DisplayDelay+6H
127:      Init_LCD();
          _main:
  ffff87e8            05cefeff      BSR.A     _Init_LCD
130:      Display_LCD(LCD_LINE1, "Renesas");
  ffff87ec            fb22f48effff  MOV.L     #-0000710CH,R2
  ffff87f2            6601          MOV.L     #0H,R1
  ffff87f4            0542ffff      BSR.A     _Display_LCD
131:      Display_LCD(LCD_LINE2, NICKNAME);
  ffff87f8            fb22fc8effff  MOV.L     #-00007104H,R2
  ffff87fe            754110        MOV.L     #10H,R1
  ffff8801            0535ffff      BSR.A     _Display_LCD
134:      Flash_LED();
  ffff8805            058bfdff      BSR.A     _Flash_LED
137:      Timer_ADC();
  ffff8809            05250400      BSR.A     _Timer_ADC
140:      static_test();
```

6.2 Main Functions

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

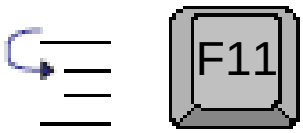
- Right click the 'Flash_LED()' function call and select 'Go to Here' to execute the program up to this line. The 'Display_LCD()' function is used to write "Renesas" onto the top line and "RX63T144" onto the bottom line.

```
/***********************************************************************
* Function Name : main
* Description   : The main program function. Displays the Renesas splash screen
*                 onto the LCD display, then calls the 'flashLED' and 'TimerADC'
*                 functions. The function then calls the statics test routine,
*                 before waiting in an infinite while loop.
* Argument      : none
* Return value  : none
***********************************************************************/
void main (void)
{
    /* Initialise the debug LCD */
    Init_LCD();

    /* Displays the Renesas splash screen */
    Display_LCD(LCD_LINE1, "Renesas");
    Display_LCD(LCD_LINE2, NICKNAME);

    /* Begins the initial LED flash sequence */
    Flash_LED();

    /* Begins the ADC-varying flash Sequence */
    Timer_ADC();
```

- Set a combination break on the 'Timer_ADC()' function call by clicking on the On-Chip Breakpoint column to the left of the number column.

```
    /* Begins the initial LED flash sequence */
    Flash_LED();

    /* Begins the ADC-varying flash Sequence */
    Timer_ADC();

    /* Begins the static variable test */
    static_test();
```

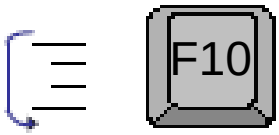
- Click the 'Step In' button to step into the 'Flash_LED()' function. Alternatively, press [F11].



- The Flash_LED function toggles the LEDs, through the Toggle_LED function at regular intervals.
- The 'while' statement checks the g_switch_flag variable for switch press detections and the value of the flash_count variable, which counts down with every LED flash. Once a switch has been pressed or the count variable reaches zero, the function exits the 'while' loop.
- Press the  button to resume program execution.
- The LEDs will flash 200 times, unless a switch on the RSK is pressed.

```
void Flash_LED (void)
{
    /* Variable used to count down the number of LED flashes */
    static uint16_t flash_count = 0xC8;

    /* Declare a delay count variable */
    uint32_t        ulLed_Delay = 0;

    /* Flash the LEDs for 200 times or until a user switch is pressed */
    while ((0 == g_switch_flag ) && (--flash_count > 0))
    {
        for (ulLed_Delay = 0; ulLed_Delay < 4000000; ++ulLed_Delay)
        {
            /* delay */
        }

        /* Toggles the LEDs after a specific delay. */
        Toggle_LED();
    }

    /* Reset the g_switch_flag flag variable */
    g_switch_flag = 0;
}
```

- The program counter should come to a halt at the Timer_ADC function.
- Step over the function by clicking the 'Step Over' button. Alternatively, press F10.

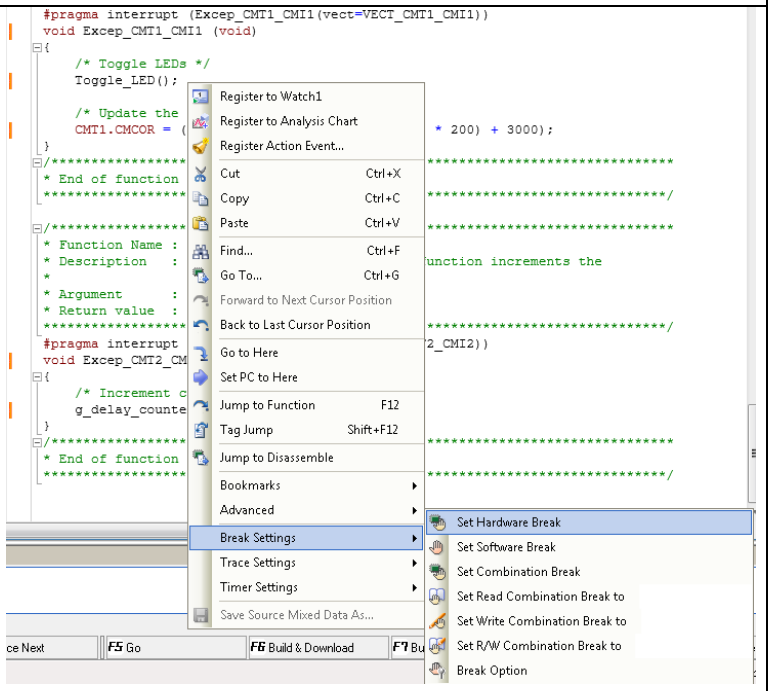


The Timer_ADC function starts a continuous A/D conversion and a periodic timer whose period is up-dated with the ADC result.

This timer is used to flash the LEDs at a variable rate.

```
/* Begins the initial LED flash sequence */
Flash_LED();

/* Begins the ADC-varying flash Sequence */
Timer_ADC();

/* Begins the static variable test */
static_test();
```

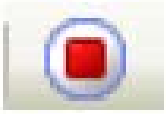
- Open the 'timeradc.c' file.
- Set a hardware breakpoint on the first line of code inside the 'Excep_CMT1_CMI1()' interrupt handler by right-clicking on the first instruction line > Break Settings > Set Hardware Break.
- Continue to execute the program by pressing the  button.



- The program will halt at the hardware breakpoint due to the timer's period elapsing.
- Remove the hardware breakpoint by clicking on the icon once.

```
#pragma interrupt (Excep_CMT1_CMI1(vect=VECT_CMT1_CMI1))
void Excep_CMT1_CMI1 (void)
{
    /* Toggle LEDs */
    Toggle_LED();

    /* Update the timer */
    CMT1.CMCOR = (uint16_t)(((g_adc_result / 50) * 200) + 3000);
}
```

• Press [F5] to resume program execution.
• Observe the string on the bottom line of the LCD change one character at a time from 'STATIC' to 'TESTTEST' as the 'static_test' function is executed.
• After all characters have been changed, the LCD panel's second line will return to displaying 'RX63T144'.
	`static void static_test (void)`
	`{`
	`  /* Declare loop count variable */`
	`  uint8_t uicount = 0;`
	`  /* Write cStr variable, "STATIC" to LCD */`
	`  Display_LCD(LCD_LINE2, cStr);`
	`  /* Begin for loop which writes one letter of ucReplace to the LCD at a time`
	`  The nested while loops generate the delay between each letter change */`
	`  for (uicount = 0; uicount < 8; uicount++)`
	`  {`
	`  /* Start a one-shot timer to create a delay between each loop`
	`  iteration */`
	`  Timer_Delay(40, MILLISECS);`
	`  /* Replace letter number 'uiCount' of 'ucStr' from 'ucReplace' */`
	`  cStr[uicount] = cReplace[uicount];`
	`  Display_LCD(LCD_LINE2, cStr);`
	`  }`
	`  /* Clear LCD Display */`
	`  cStr[uicount] = '\0';`
	`  /* Add a delay before overwritting the string */`
	`  Timer_Delay(40, MILLISECS);`
	`  /* Write MCU nickname to LCD again */`
	`  Display_LCD(LCD_LINE2, NICKNAME);`
	`}`

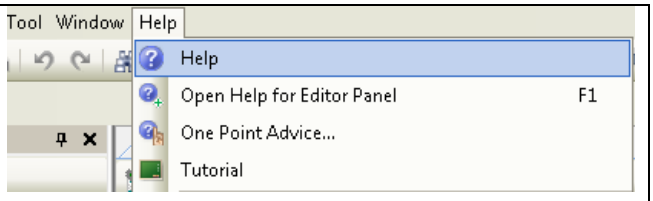
• Press the 'Stop' button to halt program execution. • This is the extent of the tutorial code.	

For further details regarding hardware configuration, please refer to the RX Family Software Manual and the RX63T 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

7. Additional Information

Technical Support

For details on how to use CubeSuite+, refer to the help file by opening CubeSuite+ and clicking 'Help' and selecting 'Contents'.	

For information about the RX63T Group microcontrollers refer to the RX63T Group Hardware Manual.

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

Online technical support and information is available at: http://www.renesas.com/rskrx63t144

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	RSKRX63T144 Tutorial Manual

Rev.	Date	Description	
		Page	Summary
1.00	Dec 12, 2013	—	First Edition issued
1.01	Mar 19, 2014	8	Optimisation level was added to ‘Release’ build configuration.
		10 to 22	Frames were added to some explanations and figures.
		13	Explanation “A common difference between the two builds is…” of Section 3.4 was fixed.

Renesas Starter Kit Tutorial Manual

Publication Date: Rev. 1.01 Mar 19, 2014

Published by: Renesas Electronics Corporation

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

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
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

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 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022/9044

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 906, 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 Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Ku, Seoul, 135-920, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 3.0

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