User's Manual

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RX111 Group

Renesas Starter Kit Tutorial Manual
For e^2 studio

RENESAS MCU
RX Family / RX100 Series

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Disclaimer

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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 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 RX111 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 RX111 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.	RSKRX111 User's Manual	R20UT2196EG
Tutorial	Provides a guide to setting up RSK environment, running sample code and debugging programs.	RSKRX111 Tutorial Manual	R20UT2197EG
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample, on a single A4 sheet.	RSKRX111 Quick Start Guide	R20UT2198EG
Schematics	Full detail circuit schematics of the RSK.	RSKRX111 Schematics	R20UT2192EG
Hardware Manual	Provides technical details of the RX111 microcontroller.	RX111 Group Hardware Manual	R01UH0365EJ

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
ADC	Analog-to-Digital Converter
E1	On-chip Debugger
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro-controller Unit
Pmod™	This is a Digilent Pmod™ Compatible connector. Pmod™ is registered to Digilent Inc. Digilent-Pmod_Interface_Specification (Link valid at 26Jun2013)
RSK	Renesas Starter Kit

Table of Contents

1. Overview

1.1 Purpose

This RSK is an evaluation tool for Renesas microcontrollers. This manual describes how to get the RSK tutorial started, and basic debugging operations.

1.2 Features

This RSK provides an evaluation of the following features:

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

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

2. Introduction

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

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

Files referred to in this manual are installed using the project generator as you work through the tutorials. The tutorial examples in this manual assume that installation procedures described in the RSK Quick Start Guide have been completed. Please refer to the Quick Start Guide for details of preparing the configuration.

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 for RXxxx RX111.

These tutorials are designed to show you how to use the RSK and are not intended as a comprehensive introduction to the e^2 studio 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

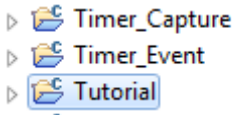
It is possible that line numbers for source code illustrated in this document do not match exactly with that in the actual source files. It is also possible that the source address of instructions illustrated in this manual differ from those in user code compiled from the same source. These differences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

3. Tutorial Project Workspace

3.1 Installation

Please refer to the included Quick Start guide to install the tools and support.
Following the instructions in the Quick Start Guide, import and open the tutorial project.

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



3.2 Build Configurations and Debug Sessions

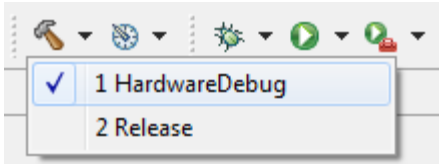
3.2.1 Build Configuration

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.

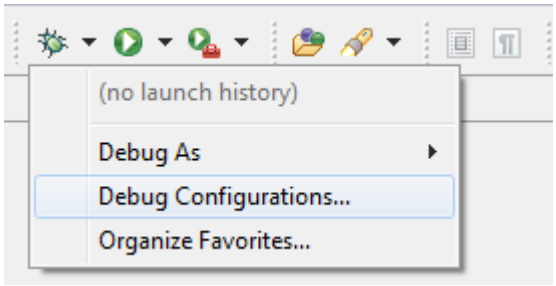
- Click the top level 'Tutorial' folder again, and then the arrow next to the build button (hammer icon), and select the 'HardwareDebug' option.



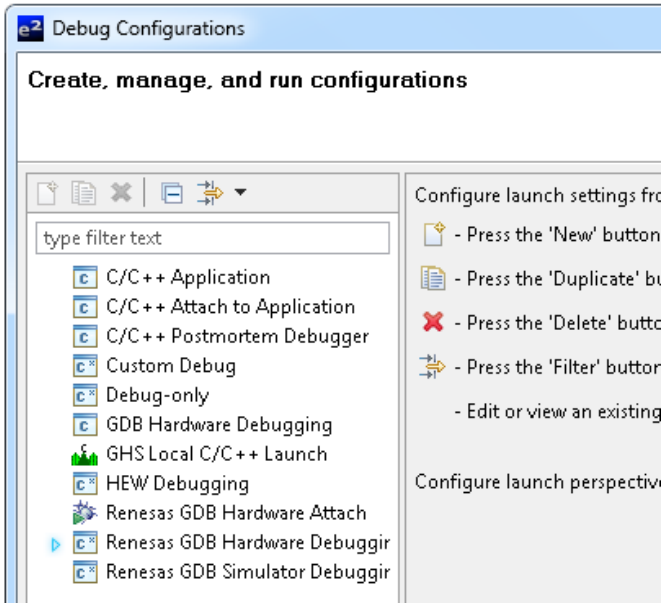
- e^2 studio will now build the code.

3.2.2 Debug Configuration

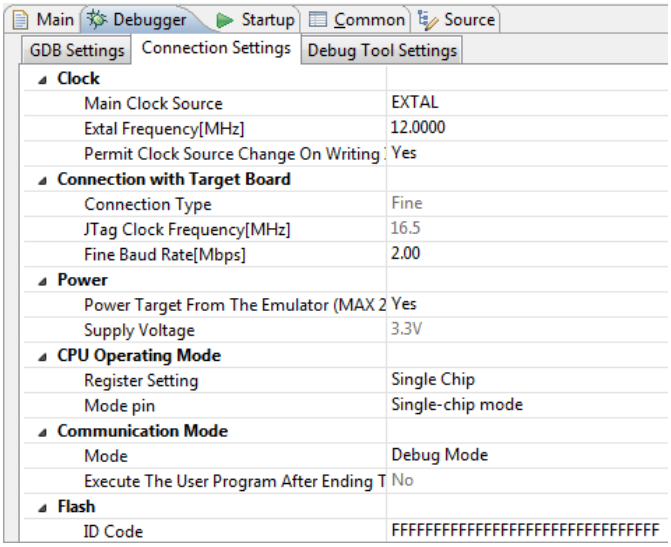
- Click the arrow next to the debug button (bug icon). Select 'Debug Configurations'.



- 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 project.



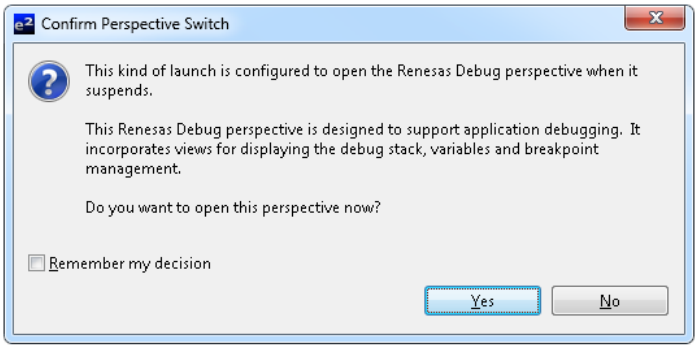
- The debug configurations control page will then show for the tutorial project. Change the main tab to ‘Debugger’ and then select ‘Connection Settings’ on the secondary tab bar that appears.
- There is no need to change the debugger settings as they are preconfigured with the tutorial project, however if you intend to use an external power supply, set the ‘Power Target From The Emulator’ option to No (drop-down menu).
- Refer to the RSKRX111 User’s Manual for details of power supply configuration.



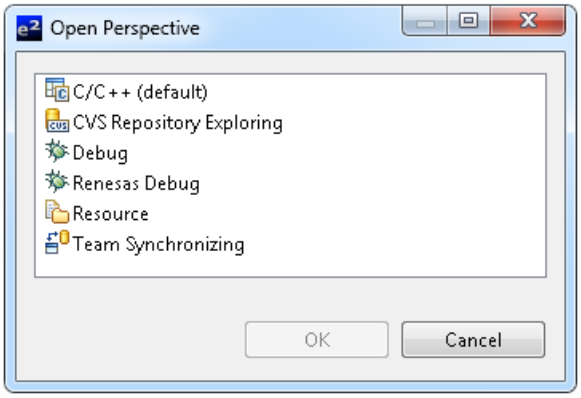
Note: e² studio will display a warning if you attempt to connect with an incorrect power supply setting.

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

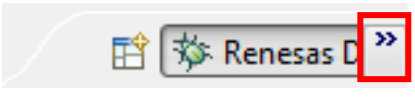
- After downloading the code a dialog box will appear asking if you would like to switch to the ‘Renesas Debug perspective’. Click ‘Remember my decision’ to prevent this dialog box from appearing in future, then click ‘Yes’
- e² studio will load the new perspective, which is optimised for debugging.

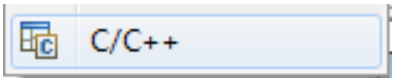


- To change back to the default ‘C/C++’ perspective, from the menu bar select Window > Open Perspective > Other
- The ‘Open Perpsective’ dialog box will appear. Click on the desired perspective to select it then ‘OK’.



- 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.





3.3 Running the Tutorial

- Refer to the Description.txt file for instructions on how to configure the RSK and run the sample code.
- Once the code has been downloaded, click ‘Resume’ 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 ‘Renesas 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

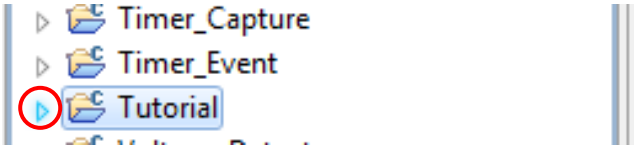
4. Reviewing the Tutorial Program

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

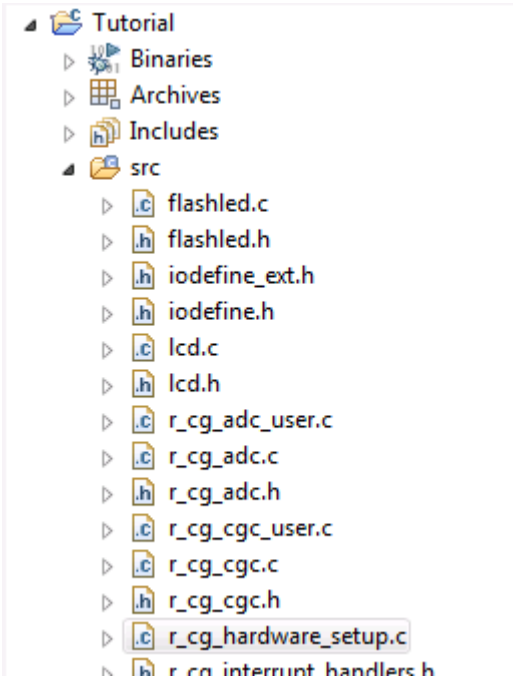
4.1 Program Initialisation

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

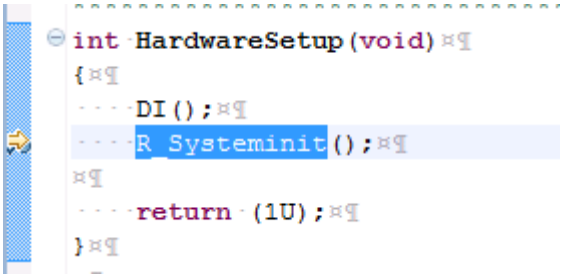
- After downloading the code, switch back to the C/C++ perspective and navigate to the Project Explorer window on the left-hand side.
- Expand the 'Tutorial' folder by clicking on the arrow next to the folder icon, as highlighted by the red circle.



- Click the arrow next to the 'src' folder to show the source files.
- 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 Renesas 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.

```
int HardwareSetup(void)
{

    R_Systeminit();

    return      ;
}
```

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

- The ‘R_Systeminit’ function calls several initialisation functions which configure the MCU for normal operation. This includes input/output ports, and system clocks.
- The user can step through all the initialisation code by clicking the ‘Step Into’ icon and reading the code however for the purpose of this manual, it will be skipped.
- Click the ‘Resume’ button, to run the code up to the main function.

```
/*************************************
* Function Name: R_Systeminit
* Description  : This function initial
* Arguments    : None
* Return Value : None
*************************************
void R_Systeminit(void)
{
    PIOR = 0x00U;
    R_CGC_Get_ResetSource();
    R_PORT_Create();
    R_CGC_Create();
    R_TAU0_Create();
    R_ADC_Create();
    R_INTC_Create();
    R_KEY_Create();
    CRC0CTL = 0x00U;
    IAWCTL = 0x00U;
    PMS = 0x00U;
}
```

For further details regarding hardware configuration, please refer to the RSKRX111 User’s Manual and the RX111 Group Hardware Manual.

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.

4.2 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 'Run to Line' to execute the program up to this line. The 'Init_LCD()' function call enables and configures the LCD panel, and 'Display_LCD()' will write "Renesas" on the top line and "RX111" onto the bottom line.

```
void main(void)
{
    R_MAIN_UserInit();
    /* Start user code. Do not edit comment generated here */

    /* Initialise the debug LCD */
    Init_LCD();

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

    /* Initialise the switch module */
    Switch_Init();

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

- Set a breakpoint on the 'timer_adc()' function call by double-clicking in the breakpoint column.
- Click the 'Step Into' button to step into the 'Flash_LED()' function.

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

    /* Start the timer_adc function */
    timer_adc();

    /* static_test function */
```

- Click the 'Resume' button to resume program execution.
- The program will now run the Flash_LED functions. This function periodically polls the user switches and flashes all the LEDs 200 times or until a user switch has been 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 < 60000; ++ulLed_Delay)
        {
            /* delay */
        }

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

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

    /* Disable switch interrupts */
    ControlSwitchInterrupts(0);
}
```

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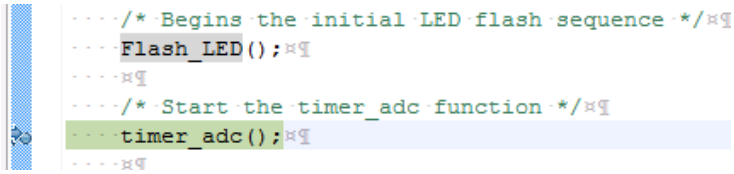
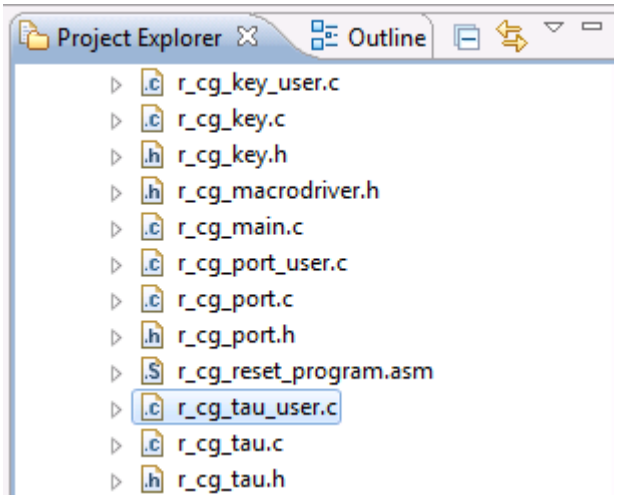
- The program counter should come to a halt at the timer_adc function.
- Step over the function by clicking the 'Step Over' button. Alternatively, press [F6].



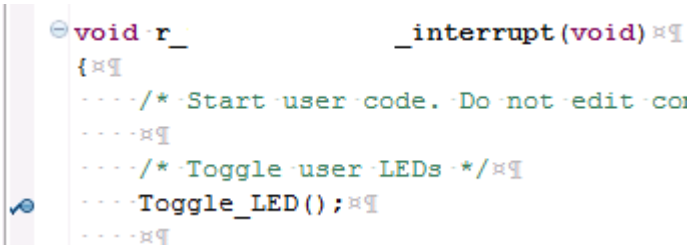
The timer_adc function starts a continuous A/D conversion and a periodic timer whose period is up-dated with the ADC result.

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

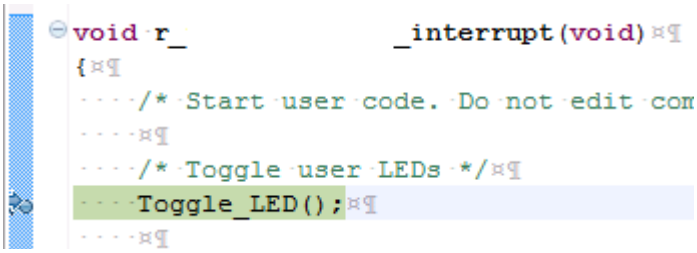
- Open the 'r_cg_cmt_user.c' file (using the Project Explorer, on the right-hand side).



- Set a breakpoint on the first line of code inside the timer interrupt handler (The name will vary) '<name>_interrupt()' interrupt handler.
- Continue to execute the program by clicking the 'Resume' button.



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



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- Press [F8] to resume program execution.
- Observe the string on the LCD panel 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 ‘RX111’.

```
/***********************************************************************
* Function Name: static_test
* Description  : Static variable test routine. The function replaces the
*                contents of the string ucStr with that of ucReplace, one
*                element at a time. Right-click the variable c_str, and
*                select instant watch - click add in the subsequent dialog.
*                If you step through the function, you can watch the string
*                elements being overwritten with the new data.
* Arguments    : none
* Return value : none
***********************************************************************/
static void static_test (void)
{
    /* Declare loop count variable */
    uint8_t     ui_count = 0;

    /* Declare string variable to hold the string to be copied */
    char        c_str[] = "STATIC \0";

    /* Declare variable buffer to store the copied string */
    const char  c_replace[] = "TESTTEST\0";

    /* Declare a delay count variable */
    uint32_t    ul_delay;

    /* Write ucStr variable, "STATIC" to LCD */
    Display_LCD(LCD_LINE2, c_str);

    /* Delay */
    for (ul_delay = 0; ul_delay < 100000; ul_delay++)
    {
        /* Delay */
    }

    /* 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 (ui_count = 0; ui_count < 8; ui_count++)
    {
        /* Replace letter number uiCount of ucStr from ucReplace */
        c_str[ui_count] = c_replace[ui_count];

        /* Display the character on the debug LCD */
        Display_LCD(LCD_LINE2, c_str);

            /* LED Flashing Delay */
        for (ul_delay = 0; ul_delay < 100000; ul_delay++)
        {
            /* Delay */
        }
    }

    /* Clear LCD Display */
    c_str[ui_count] = '\0';

    /* Write MCU nickname to LCD again */
    Display_LCD(LCD_LINE2, NICKNAME);
}
```

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

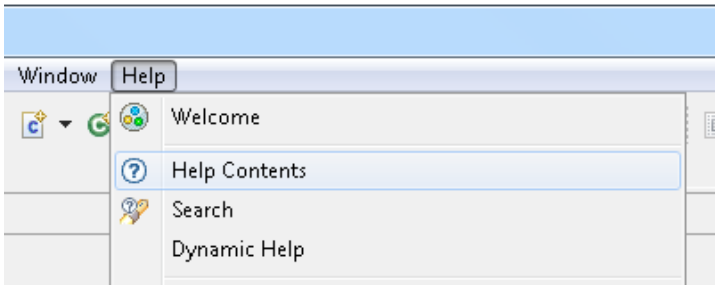
It is possible that line numbers for source code illustrated in this document do not match exactly with that in the actual source files. It is also possible that the source address of instructions illustrated in this manual differ from those in user code compiled from the same source.

For further details regarding hardware configuration, please refer to the RL78 Series Software Manual and the RX111 Group Hardware Manual.

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

5. Additional Information

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



Parts of the sample code provided with the RSKRX111 can be reproduced using the 'Application Leading Tool' (Applilet) code generator tool. Applilet can be downloaded from the Renesas website.
Source files and functions generated by Applilet are prefixed with 'r_' and 'R_', respectively.

For information about the RX111 series microcontrollers refer to the RX111 Group Hardware Manual.

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

Technical Contact Details

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

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

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