User's Manual

32

RX111 Group

Renesas Promotional Board Tutorial Manual

RENESAS MCU
RX Family / RX100 Series

Renesas Electronics
www.renesas.com

Rev. 1.00 Jul 2013

Disclaimer

By using this Renesas Promotional Board (RPB), the user accepts the following terms:

The RPB is not guaranteed to be error free, and the entire risk as to the results and performance of the RPB is assumed by the User. The RPB 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 RPB. 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 RPB, 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 RPB product:

This Renesas Promotional Board 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 the RPB hardware functionality, and electrical characteristics. It is intended for users evaluating this microcontroller platform and using this promotional board.

The manual comprises of an overview of the capabilities of the product, but does not intend to be a guide to embedded programming or hardware design.

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 and this board. 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.
Tutorial Manual	Describes the RPB hardware, sample software and capabilities.	RPBRX111 Tutorial Manual	R20UT2699EG
Quick Start Guide	Provides simple instructions to setup the RPB and run the first sample, on a single A4 sheet.	RPBRX111 Quick Start Guide	R20UT2700EG
Design Manual	Layout diagrams and Bill of Materials (BoM) for the RPB.	RPBRX111 Design Manual	R20UT2698EG
Schematics	Full detail circuit schematics of the RPB.	RPBRX111 Schematics	R20UT2697EG
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
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
GUI	Graphical User Interface
IRQ	Interrupt Request
LED	Light Emitting Diode
MCU	Micro-controller Unit
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
n/a	Not applicable
NC	Not connected
J-Link OB	J-Link On-board debugger
PC	Personal Computer
PLL	Phase Locked Loop
ROM	Read Only Memory
RPB	Renesas Promotional Board
RSK	Renesas Starter Kit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus

Table of Contents

1. Overview

1.1 Purpose

This RPB is a promotional board for Renesas microcontrollers. This manual describes the technical details of the RPB hardware, how to get started debugging and analysing the sample code and to use the demonstration GUI to evaluate the low power capabilities of the device.

1.2 Features

This RPB provides the following features:

- Renesas microcontroller programming
- User code debugging
- User circuitry such as switches, LEDs and a potentiometer
- USB Host/Function connectivity
- Board-wide low power design for energy harvesting applications
- MCU current measurement

This product is not intended or supported for user solution development, and is designed solely for demonstration and evaluation. A Renesas Starter Kit (RSK) for the RX111 is available from your Renesas distributor.

1.3 Package Contents

- MCU current measurement
- YRPBRX111 Board
- USB Type A / Mini-B cable
- Potentiometer shaft to adjust the potentiometer voltage
- Mini DVD containing all the software, tools and documentation needed to quickly start evaluating the product.

2. Hardware Components

Figure 2-1 below shows the top and bottom component layouts of the board.

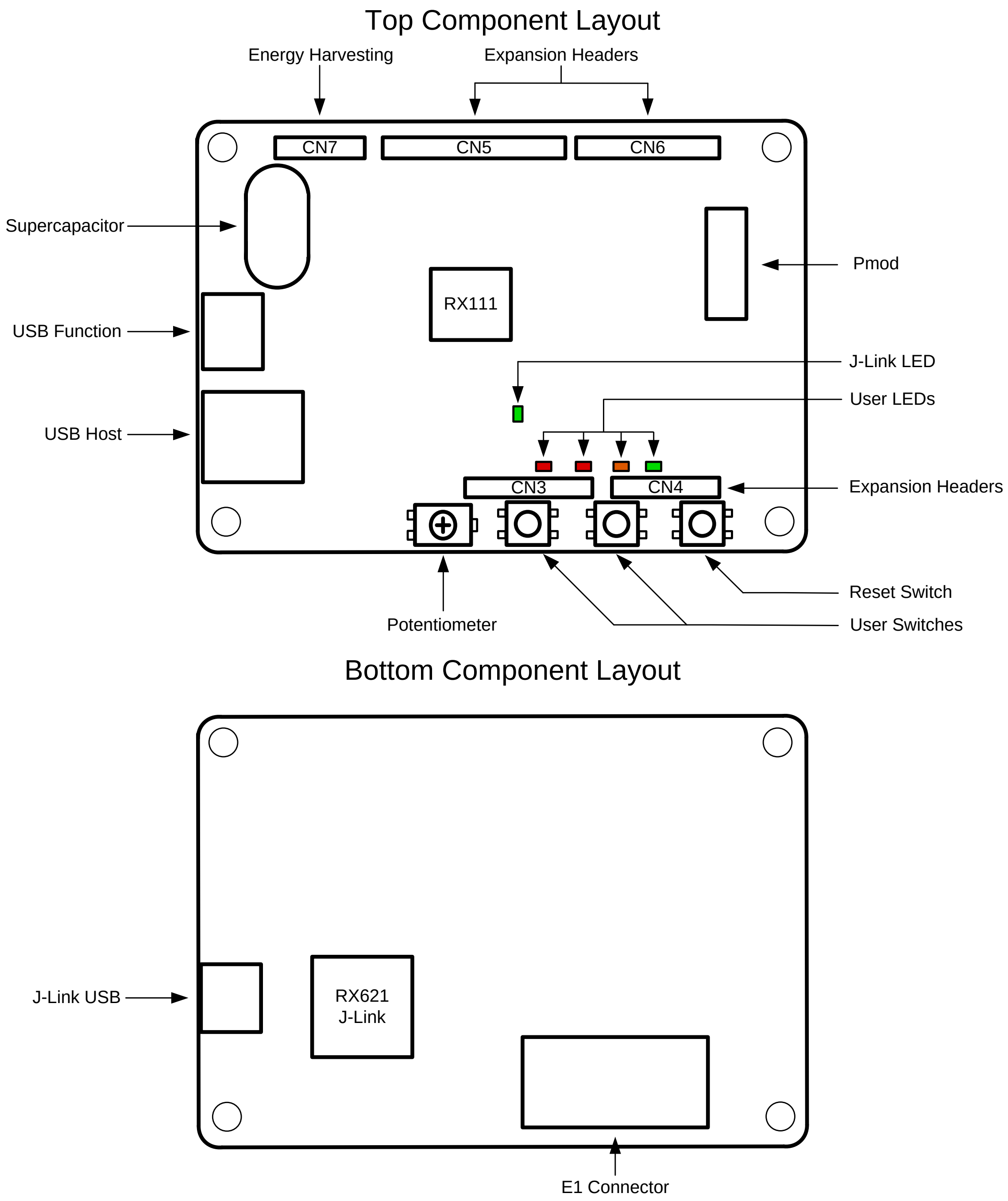


Figure 2-1 Board component layout

Component placement diagrams and the circuit routing can be found in the Design Manual.

2.1 User Switches, Potentiometer and LEDs

Two user switches (SW1 and SW2) and a potentiometer (RV1) are provided for direct user input to the board. The switches are connected to interrupt (IRQ) pins and the potentiometer to an ADC input on the RX111 device and are used to control several of the sample applications. The potentiometer and switch pins are described in Table 2-1 below.

Reference	Function	MCU	
		Signal (Port)	Pin
SW1	Connects to an IRQ input for user controls.	PB1_IRQ4_SW1 (PB1)	37
SW2	Connects to an IRQ input for user controls.	PE3_IRQ3_SW3 (PE3)	48
RV1	Connects to an ADC channel for analog input.	P40_ADPOT (P40, AN000)	60

Table 2-1 Switch and Potentiometer Connections

Four user LEDs are also included as described in Table 2-2 below.

LED	Colour	Function	MCU	
			Port	Pin
LED0	Green	User operated LED.	P05	64
LED1	Orange	User operated LED.	P41	58
LED2	Red	User operated LED.	PB7	33
LED3	Red	User operated LED.	PB6	34

Table 2-2 LED Connections

In order to use the LEDs and switches, the IDLE_VCC power rail must be activated, along with the POT_VCC power rail to operate the potentiometer (see section 2.4 for more information).

2.2 USB Connectors

Two USB connectors are included on the top of the RPB, CN1 and CN2, and connected to the USB pins on the RX111 (the USB connector on the bottom, CN8, is for the on-board debugger).

CN1 allows the board to be used as a USB peripheral along with providing power to the board (for other power supply options, see section 2.4).

CN2 can be used to connect USB peripherals such as flash drives, and the board will act as the host device. In order to operate as a host device, the IDLE_VCC power rail must be activated, and the bus switch IC4 must be enabled by driving MCU port P55 (pin 25) low (see the board schematics for more information).

2.3 Expansion Headers

Expansion headers provide access to spare MCU pins and further information about pin assignments may be found on page 5 of the board schematics. Some expansion pins are not available by default and require changes to 0Ω surface mount link resistors. Table 2-3 below shows the configuration changes available, by showing the path of a signal from the MCU on the left to a board function or header pin on the right. Default configuration is shown in **bold, blue text**.

Signal Name	MCU		Exclusive function			Header connection		
	Port	Pin	Purpose	Fit	Remove	Header Pin	Fit	Remove
PC5_SCK1	PC5	29	**PMOD-4**	**R106**	**R114**	CN5-5	R114	R106
P15_RXD1	P15	19	**PMOD-3**	**R108**	**R111**	CN5-6	R111	R108
PC7_TXD1	PC7	27	**PMOD-2**	**R105**	**R115**	CN5-7	R115	R105
PA0_LDOEN	PA0	45	**IC2-3 (LDO Enable)**	**R61**	**R110**	CN6-3	R110	R61
PE1_AN009_TXD12	PE1	50	**CN7-2**	**R118**	**R103**	CN4-4	R118	R103
PE2_AN010_VSUP	PE2	49	**Supply voltage monitor**	**R154, R155**	**R156**	CN4-5	R156	R154, R155
PE7_AN015_VCAP	PE7	52	**Supercapacitor voltage monitor**	**R52, R56**	**R104**	CN4-6	R104	R52, R56

Table 2-3 Expansion header link resistor configuration

In addition the board includes space for pull-up resistors on every MCU I/O pin, as shown on page 2 of the schematic, which are not used by any of the sample code but may be fitted by the user is needed.

A Digilent Pmod™ compatible connector can be fitted and used to interface with a variety of external peripherals, including the RSK Pmod display (not included in this kit). Some samples will use the display if connected. It will be necessary to fit a suitable 12-pin right-angle header, similar to Samtec SSW-106-02-T-D-RA, to make use of the Pmod connector. The pinout of the Pmod connector is shown in Table 2-4.

Pin	Function	Pin	Function
1	CS#	7	INT
2	TXD/MOSI	8	RESET
3	RXD/MISO	9	GPIO
4	SCK	10	GPIO
5	GND	11	GND
6	VCC	12	VCC

Table 2-4 Pmod Connector Pinout

This board is not compatible with 5V-only Pmods and cannot supply 5V power, nor tolerate 5V logic input from an external peripheral.

Header CN7 connects to a Cymbet Energy Harvesting evaluation kit (CBC-EVAL-09. This connector provides two-way communication with the Energy Processor for monitoring, as well as the power supply. The pinout of the energy harvesting connector is shown in Table 2-5. MCU port PA0 (pin 45) should be driven low to activate the power supply from the external harvesting kit, and disable the linear voltage regulator IC2.

Pin	Function
1	RXD
2	TXD
3	NC
4	GND
5	VCC (input)

Table 2-5 CN7 Energy Harvesting Connector Pinout

2.4 Power Supply

Power for the RPB can be supplied from either USB connector CN1 or CN8, along with a supercapacitor or an energy harvesting evaluation kit connected to CN7. The board will use 5V USB power by default, falling back to the supercapacitor (boosted to 5V by a DC-DC converter) if this is unavailable and finally using the 3.6V energy harvesting board if connected. The power supply options, limitations and the order power sources are used if several are available are summarised in Table 2-6 below.

Power Source	Input Voltage	5V?	3.3V?	J-Link Debugger?	Priority
J-Link USB (CN8)	5V	Y	Y	Y	1
USB Function (CN1)	5V	Y	Y	N (Power off)	1
Supercapacitor (C18)	Up to 5V	Y	Y	N (Power off)	2
Energy Harvesting (CN7)	3.6V	N	Y (at 3.6V)	N (Power off)	3
E1 Connector	3.3V	N	Y	N (Power off)	4

Table 2-6 Power Supply Options

Table 2-7 describes the MCU pins used for monitoring the power supply and shutting down board components for board current reduction.

Signal Name	MCU		Purpose
	Port	Pin	
P16_CHARGE_EN	P16	18	Drive low to activate charging the supercapacitor.
PE4_IDLE_EN	PE4	47	Drive low to power up the IDLE_VCC rail (LEDs, switches, etc)
P03_POT_EN	P03	1	Drive low to power up the POT_VCC rail (potentiometer bias voltage)
P55_VBUS_EN	P55	25	Drive low to enable IC4 and operate USB host power supply (IC7)
PE2_AN010_VSUP	PE2	49	Measure the board supply voltage using ADC channel AN010.
PE7_AN015_VCAP	PE7	52	Measure the supercapacitor voltage using ADC channel AN015.

Table 2-7 Power supply control pins

Note: Charging the supercapacitor while using it to power the board will rapidly deplete the capacitor.

2.5 On-board Debugger

A SEGGER J-Link OB debugger is fitted on the bottom side of the RPB and can be used to debug the RX111 MCU with e^2 studio. For instructions to use the debugging features in e^2 studio, refer to section 3.

The J-Link debugger is enabled by default (JP2 not fitted). Fitting JP2 will disable the J-Link debugger and is useful for reducing the supply current sourced through the USB connector CN-8.

2.6 Current Measurement

The debugger hardware incorporates a current measurement feature which can measure the current used by the RX111 MCU in various operating modes, which can be accessed and plotted using the ‘GUIDemo’ sample (see section 4).

It is also possible to measure MCU current by removing R64 and fitting a multimeter across JP1. The current measurement circuit on the board will affect current readings taken with a multimeter, so the current measurement circuit should be disabled by setting switch SW3 to the OFF position. In this case the LowPowerDemo sample project should be used to perform the measurements. For detailed instructions please refer to section 2.7.

Note: Ammeter readings taken while running the demo GUI will not be accurate due to interactions between the GUI and the current measurement circuit on the RPBRX111. If Ammeter readings are required disable the current measurement

circuit by setting switch SW3 to the OFF position and use the LowPowerDemo sample project.

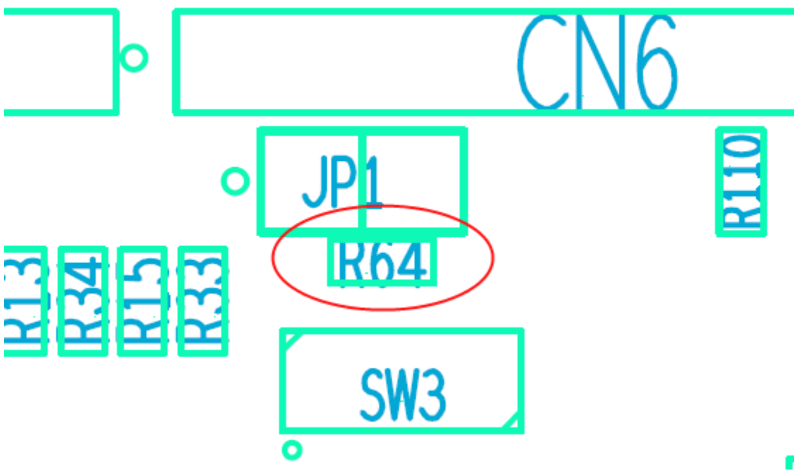
Note: Do not set SW3 to the centre position as this will disconnect the RX111 MCU power supply.

- The different power consumptions were measured under the peripheral states shown in the table below. An Agilent U1241B multi-meter (serial: MY51140128) was used to measure the power.
- The results obtained cannot be guaranteed to be exactly the same for each board; but should not be significantly different. It is good to note that the result can be affected by the test environment and the equipment used.
- Results are shown on the table below.

Clock Mode	Power Consumption			
	NORMAL MODE	**SLEEP MODE**	**DEEP SLEEP MODE**	**SOFTWARE STANDBY MODE**
HIGH SPEED	~4 mA	~1.2mA	~800 uA	0.4 uA
MIDDLE SPEED	~2.3 mA	~600 uA	~500 uA (GUI)	0.4 uA
LOW SPEED	5 uA	2.5 uA	n/a	n/a

2.7 Low Power Current Measurement Instructions

The current consumption in various low power modes can be measured directly using an ammeter connected across JP1 and ensuring that R64 has been removed from the board.



Ensure that SW3 is in the OFF position for this measurement to disable the debugger connections otherwise the lowest power readings will not be possible.

Compile the Low Power Demo sample and download the sample code to the target. Press ‘Resume’ to run the code to ensure that the device is programmed. Stop the debugger, disconnect the target connection and then disconnect the USB cable.

Connect an ammeter across JP1 and select the mA range. Connect a mini-USB cable between CN8 and a PC. The LEDs (LED0 - LED3) will flash several times.

The demo provides a menu which is navigated by the potentiometer RV1 adjusting the illuminated LEDs, and selected by pressing SW1.

Select a menu item based on the following list by adjusting potentiometer RV1 then pressing SW1 to select. The corresponding value will be displayed on LEDs using binary as shown in the table below:

Menu	LED Settings		
User Interface	LED2	LED1	LED0
(0) RTC_MENU *	OFF	OFF	OFF
(1) SUB_32k Clock Mode	OFF	OFF	ON
(2) LOCO_4M Clock Mode	OFF	ON	OFF
(3) HOCO_32M Clock Mode	OFF	ON	ON
(4) SW_SLEEP Clock Mode	ON	OFF	OFF
(5) DP_SLEEP Clock Mode	ON	OFF	ON
(6) SW_STBY Clock Mode	ON	ON	OFF

* The following table is valid only if option “RTC_MENU” was selected. In this case the user should select a value for the RTC options from the table below.

Menu	LED Settings		
RTC_MENU	LED0*	LED1*	LED2*
(1) Output RTC	OFF	OFF	ON
(2) Reset RTC	OFF	ON	OFF
(3) Start RTC	OFF	ON	ON
(4) Stop RTC	ON	OFF	OFF

* Please note the LED Settings in this table are reversed.

All other selections are for a clock mode. LED0 will flash the selected number of times to confirm the selection. The menu operation will return to the main menu for the selection of a clock mode.

After selection of a clock mode select the CPU load option in the same way by making a selection from the table below

Menu	LED Settings		
RTC_MENU	LED2	LED1	LED0
(1) CPU_MIN	OFF	OFF	ON
(2) CPU_TYP	OFF	ON	OFF
(3) CPU_MAX	OFF	ON	ON

LED1 will flash the selected number of times to confirm the selection.

At this point the CPU enters a full power loop in the selected mode. LED2 will be lit. At this point observe the MCU current to show what the operational current is.

Press SW1 to put the CPU into the selected low power mode and again observe the MCU current measurement. At this point the low power mode has been activated.

For the SUB_32k and SW_STBY modes the current will be in the order of micro Amps so it may be necessary at this point to switch the ammeter into the uA range.

Caution: In most Ammeters selection a very low current range introduces a larger series resistance which will produce a significant voltage drop once the current returns to the mA range. Some low cost meters may disconnect the processor current while changing modes. This can cause the CPU to be reset and prevent the correct measurement.
In this case you can fit a jumper link across JP1 while changing range on the multi-meter.

To exit the low power mode and restart, return the Ammeter to the mA range to avoid any possible overload of the meter and press the reset switch.

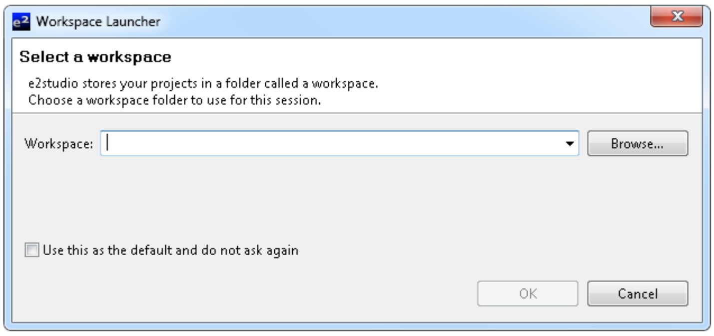
3. Debugging with e2 studio

3.1 Introduction

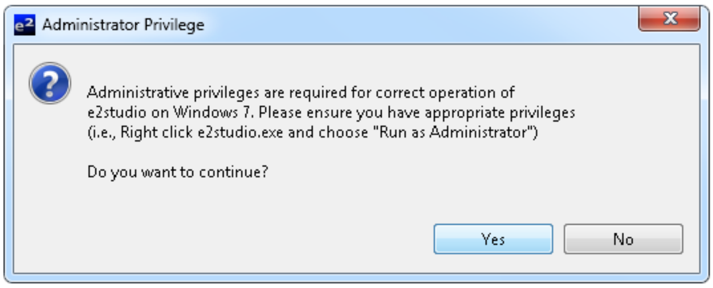
e2 studio is an open source integrated development tool that allows the user to write, compile, program and debug a software product on many of the Renesas microcontrollers.

3.2 Starting e2 studio and Importing Sample Code

- Start e2 studio by selecting it from the Start Menu. The first dialog box to appear will be the Workspace Launcher.
- Click 'Browse' and select a suitable location to store your workspace, using the 'Create New Folder' option as necessary. Click 'OK'

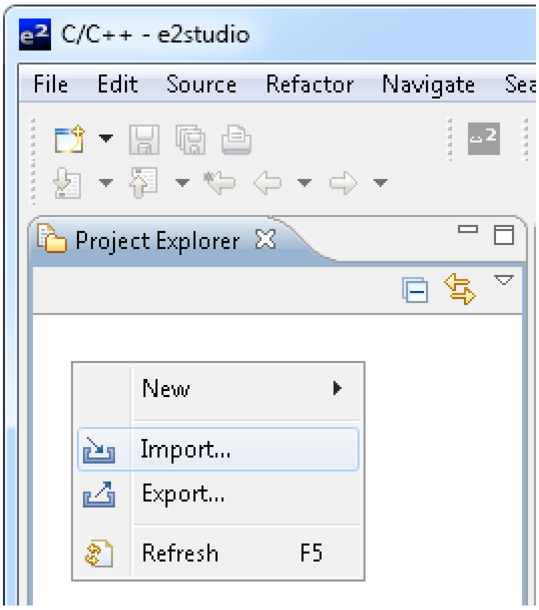


- Click 'Yes' when presented with the 'Administrator Privilege' dialog box.

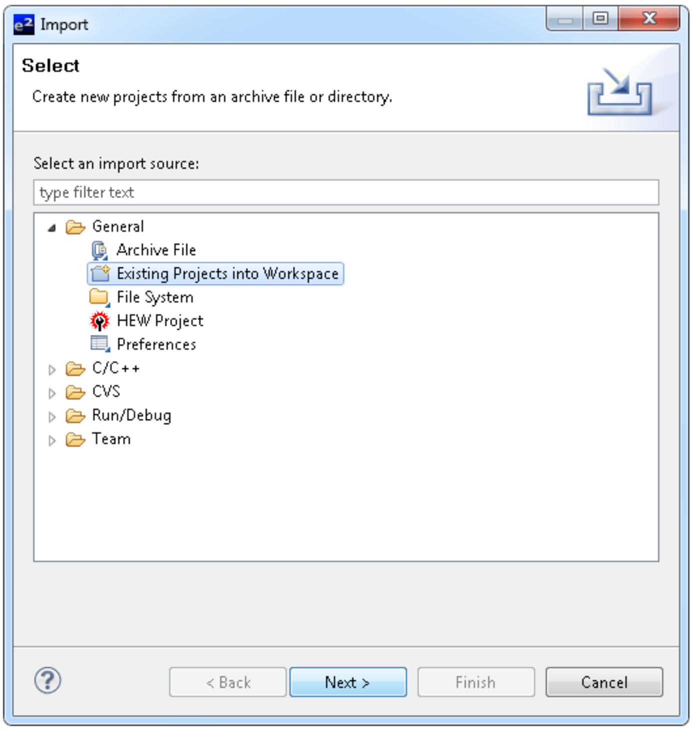


- The e2 studio welcome splash screen will appear. Click the 'Go to the workbench' arrow button on the far right (circled in the screenshot opposite).

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



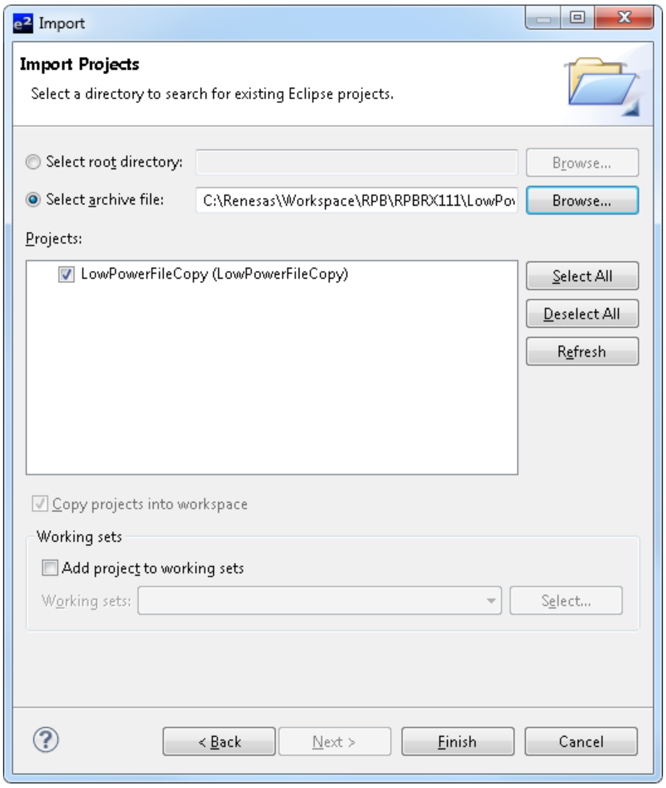
- The Import dialog box will now show. Expand the 'General' folder icon, and select 'Existing Projects into Workspace', then click 'Next'.



- Choose ‘Select archive file’ and browse to the following file:

  C:\Renesas\Workspace\RPB\RX111\
  Sample Projects\LowPowerFileCopy.zip

- Click ‘Finish’ on the import dialog box to import the project.



3.3 Build Configurations and Debug Sessions

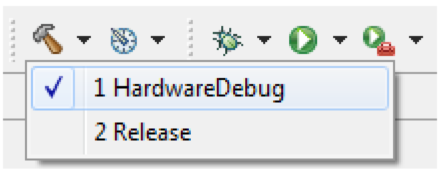
3.3.1 Build Configuration

The e[2] studio workspace will be created with two build configurations: ‘HardwareDebug’ and ‘Release’.

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

HardwareDebug
This 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.

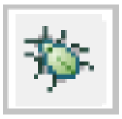
- Click the top level ‘LowPowerFileCopy’ folder and then go to the arrow next to the build button (hammer icon), and select the ‘HardwareDebug’ option. 

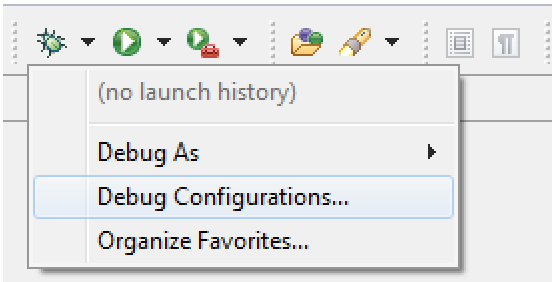


- e[2] studio will now build the code.

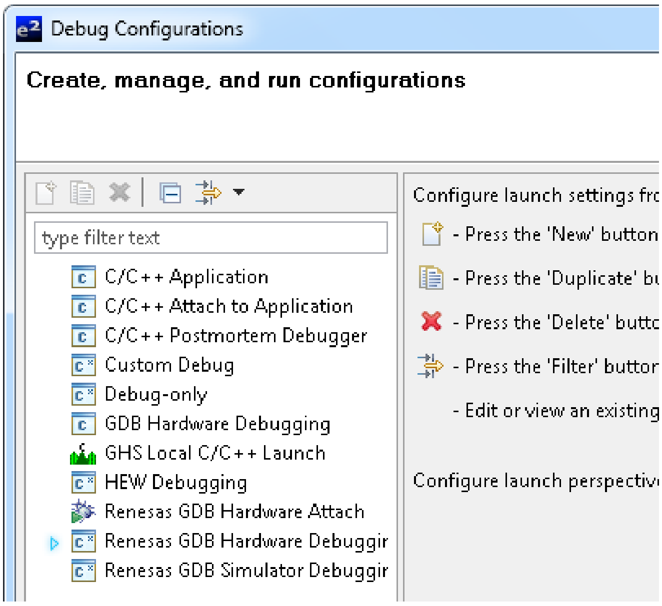
3.3.2 Debug Configuration

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

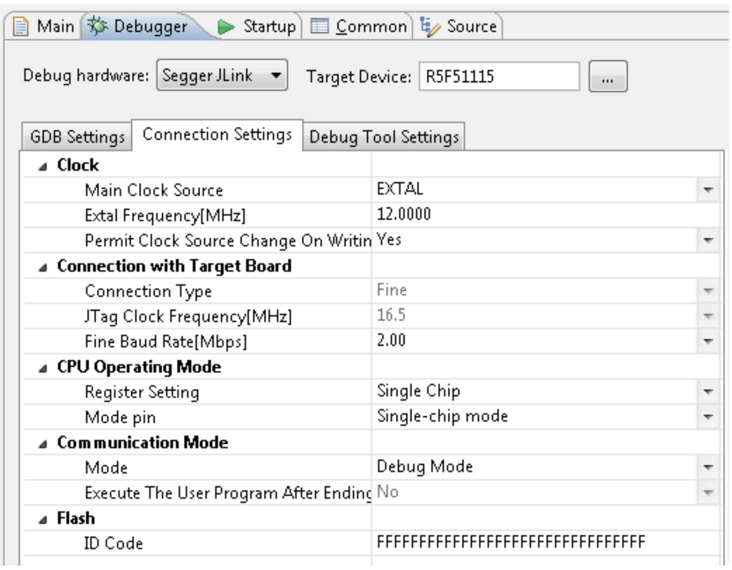




- The 'Debug Configurations' dialog box will appear. Click the small arrow next to the 'Renesas GDB Hardware Debugging' option.
- The debug configurations for each project will appear. Select the entry for the 'LowPowerFileCopy' project.

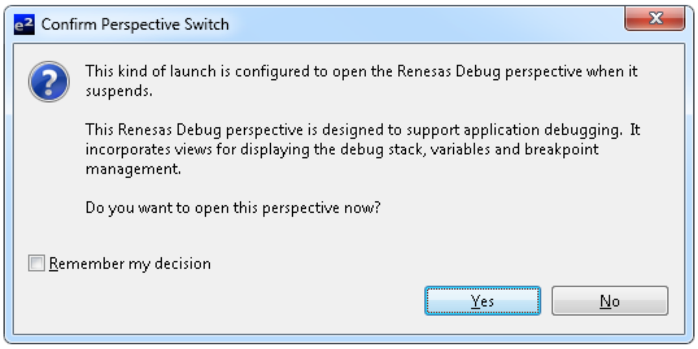


- The debug configurations control page will then show for the project. Change the main tab to 'Debugger' and then select 'Connection Settings' on the secondary tab bar that appears.
- There is no need to change the debugger settings as they are preconfigured with the project, however feel free to review the settings provided.

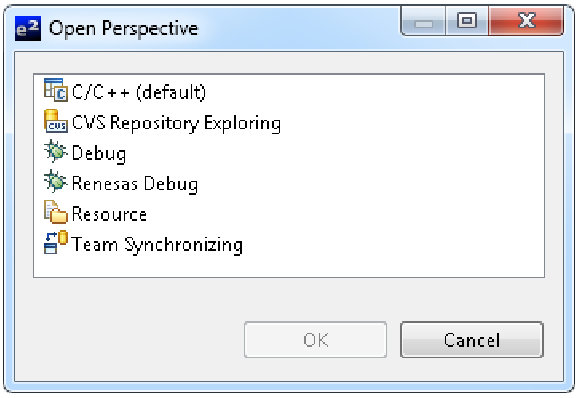


- Click the 'Debug' button to continue. e2 studio will now connect to the debugger and download the code to the target.

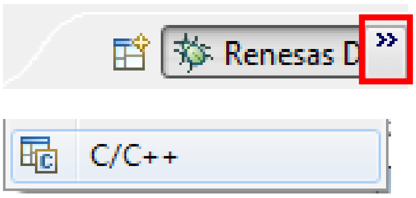
- After downloading the code a dialog box will appear asking if you would like to switch to the 'Debug perspective'. Click 'Remember my decision' to prevent this dialog box from appearing in future, then click 'Yes'
- e[2] studio will load the new perspective, which is optimised for debugging.



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



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



3.3.3 Running the Demo

- Each sample includes a Description.txt file detailing the sample's operation and any configuration required.
- Once the code has been downloaded, click 'Resume' to run the code to the main function, then click the 'Resume' button again to run the rest of the code.
- It is recommended that you run the sample once before continuing with this tutorial. Detailed instructions for operation of the sample are given in the Description.txt file. Note however that the USB cable should not be unplugged from CN8 as this will disable the debugger.

3.4 Reviewing the Sample Code

This section will give a brief overview of some of the demo code and describe basic debugging functionality using e[2] studio. For more information on the USB Host library that the demo is built around, review the USB HMSC application note (R01AN0624EJ) available from the Renesas website.

3.4.1 Program Initialisation

Before the main program can run, the microcontroller must be configured. The following parts of the tutorial program are used for initialising the RPB 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.

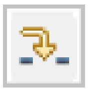
- Intially the microcontroller will start in the PowerON_Reset_PC() function, from which the initialisation and main functions are called.
- Click the 'Step Over' button (or press [F6] twice) to step to the usb_cpu_mcu_initialize() line.

```
void PowerON_Reset_PC(void)
{
    set_intb(__sectop("C$VECT"));

    /* MCU initialized */
    usb_cpu_mcu_initialize();

    _INITSCT();                 // Initialize Sections
```

- Click the 'Step Into' button (or press [F5]) to enter the function.



- This function configures the oscillators and clock dividers. A summary of the clock speeds may be found in the function comments.
- The user can step through this initialisation code by clicking the 'Step Over' icon, but for the purpose of this manual it will be skipped.
- Click the 'Resume' button (or press [F8]), to run the code up to the main function.

```
/***************************************************************
Function Name   : usb_cpu_mcu_initialize
Description     : MCU Initialize
Arguments       : void
Return value    : void
***************************************************************
void usb_cpu_mcu_initialize(void)
{
    /* Protect register */
    SYSTEM.PRCR.WORD = 0xA503;          /* Protect off */

    /* Main clock Oscillator control register */
    SYSTEM.MOSCCR.BIT.MOSTP = 0;        /* Main clock oscil

    /* Main clock Oscillator wait control register */
    SYSTEM.MOSCWTCR.BIT.MSTS = 0x06;    /* 32768 state */

    /* Sub clock Oscillator control register */
    SYSTEM.SOSCCR.BIT.SOSTP = 1;        /* Sub clock Oscill

    /* Start PLL Controler */
    /* PLL control register */
    SYSTEM.PLLCR.BIT.PLIDIV = 1;        /* 1/2(6MHz) */
    SYSTEM.PLLCR.BIT.STC = 0x0f;        /* x8(6MHz*8 = 48MH

    /* PLL control register2 */
    SYSTEM.PLLCR2.BIT.PLLEN = 1;        /* PLL enable */

    /* Clock select ICLK=24MHz/PCLKB=24MHz/PCLKD=24MHz/FCLK
    SYSTEM.SCKCR.LONG = 0x21000101;
```

For further details regarding hardware configuration, please refer to 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.

3.4.2 Main Functions

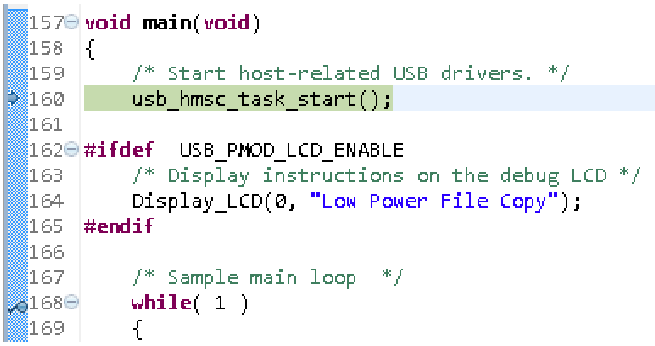
This section will look at the program code called from within the main() function, and how it works.

- Double-click in the left-hand column to set a breakpoint on the 'while (1)' line inside the main function. This will be used later in the tutorial.

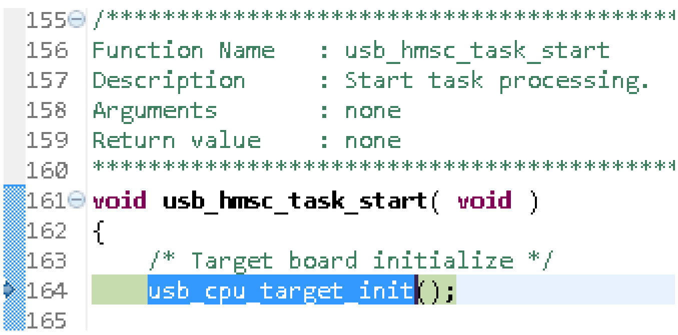
Note: The alternative to the above method requires reverting back to the default 'C/C++' perspective.

Whilst in the C/C++ perspective, set the mouse cursor on the instruction, then from the menu bar select Run > Toggle Breakpoint.

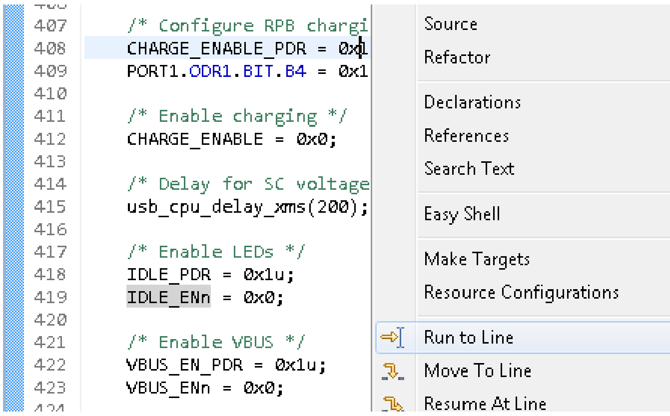
- Click 'Step Into' (or press [F5]) to enter the usb_hmsc_task_start() function.



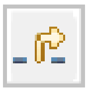
- Select the usb_cpu_target_init() function call and press [F3] (or right-click and select 'Open Declaration'. The usb_cpu_target_init() function will open.



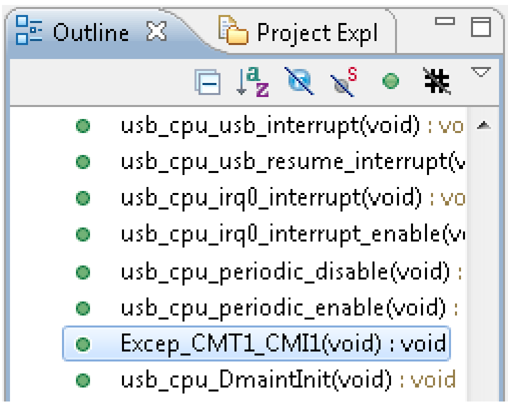
- First select and then right-click on the line 'CHARGE_ENABLE_PDR = 0x1u' and select 'Run to Line' to execute the program up to this point. The board LEDs and voltage measurement ADC inputs will be configured.
- The following lines set the supercapacitor charge enable pin into open-drain mode and drives it low to charge the capacitor. The LEDs and USB bus switch are also activated. For more information on hardware configuration, see section 2.



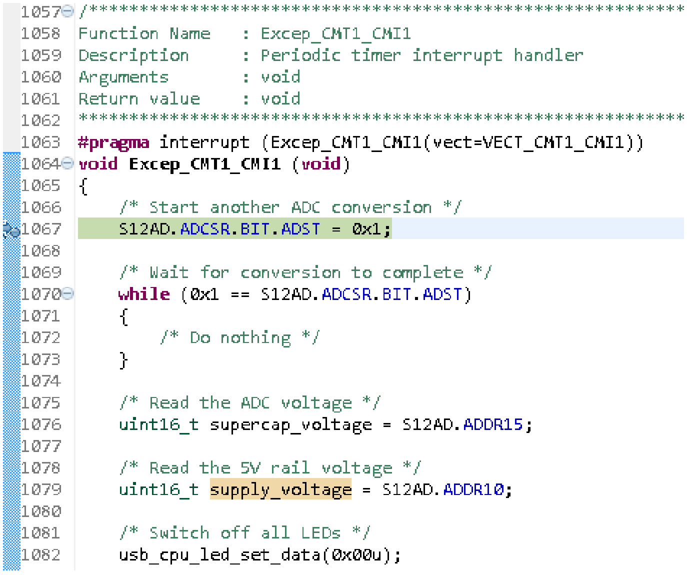
- In the 'Outline' view on the right-hand-side, click on the function 'Excep_CMT1_CMI1'
- Set a breakpoint on the first line in the function.
- Click the 'Step Return' button (or press [F7]) to run to the end of the current function and return to the caller.



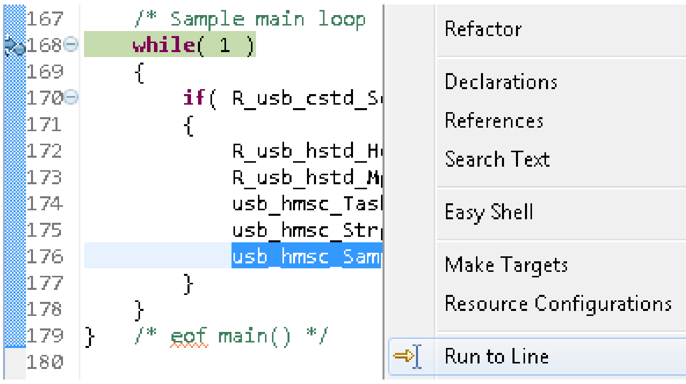
- Click the 'Resume' button to continue running the code.



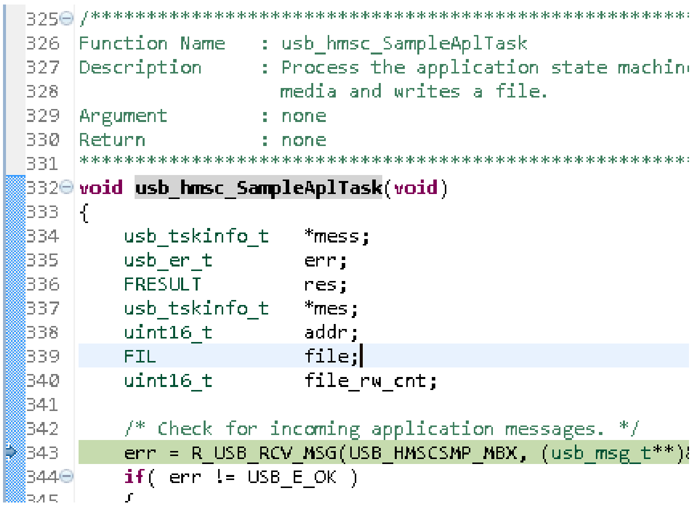
- Execution will stop on the breakpoint at the start of 'Excep_CMT1_CMI1()'. This is an interrupt handler for a periodic timer started in the 'usb_cpu_target_init()' function.
- This function reads the power supply and supercapacitor voltages, and uses these values to enable/disable charging when the external power supply is connected/disconnected, and to operate the LEDs and display the current charge state.
- Remove the breakpoint by double-clicking the blue circle in the left-hand column.
- Click the 'Resume' button to continue running the code. The microcontroller will enter a low power sleep state.



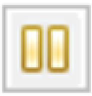
- Plug in a USB memory stick. An interrupt will wake the microcontroller and execution will stop at the breakpoint in the main function.
- Select and then right-click on the function 'usb_hmsc_SampleAplTask()' and click the 'Run to Line' menu option. Click 'Step In' to enter the function.



- This function checks for incoming application messages, and processes them to mount the USB memory stick, copy a file and then unmount it, before entering software standby mode.
- Click 'Resume' to copy the file and complete the sample.



- Click the 'Suspend' button to halt program execution. This is the extent of the tutorial code.



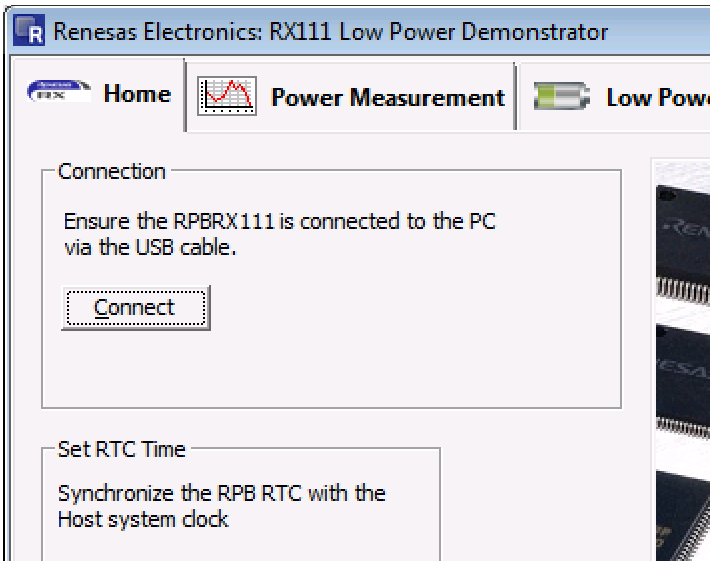
4. Demonstration GUI

A 'GUIDemo' sample is included in the sample set, and connects to an application running on a PC to control the RX111 operating mode and measure power usage of the device. This section will describe how to use the GUI to demonstrate the low-power characteristics of the microcontroller.

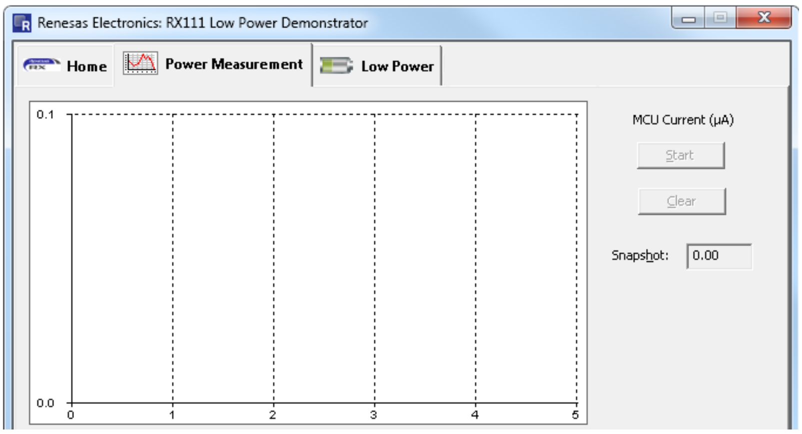
- First, follow the steps in sections 3.2 and 3.3, substituting 'GUIDemo' for 'LowPowerFileCopy' to prepare the sample code in e^2 studio and download it to the board.
- Once this process has completed, stop the debugger in e^2 studio and power cycle the board.

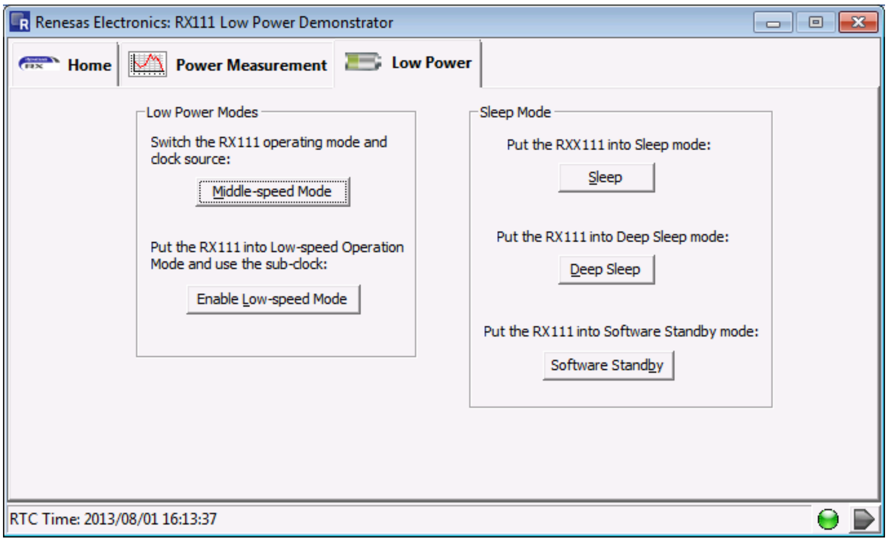
- Launch the demo GUI, either by double-clicking the 'YRPBRX111 Demo' desktop shortcut or using the Start menu.

- The demo GUI should start with the 'Home' tab active as shown oppsoite. Click 'Connect' to connect with the RPB.
- After a few seconds the message in the status bar at the bottom of the window will change to show the RTC time reading from the RPB and the red circle in the bottom-right corner will go green.
- Use the 'Sync' button to set the RPBRX111 RTC with the host computer system time.
- A monitoring console to show communication between the PC and the RPB can be opened by clicking the arrow in the window corner.



- Click on the 'Power Measurement' tab.
- This tab accesses the current measurement circuit on the RPB, and displays current measurements taken from the MCU.
- Click the 'Start' button to begin taking measurements. Data will appear on the graph, with time on the horizontal axis and current (in µA) on the vertical. The axis will scale automatically.





- Click on the 'Low Power' tab.
- This tab provides controls to change the speed mode (and clock source) of the RX111 MCU, along with access to sleep modes.
- By default, the system clock uses the 12MHz crystal oscillator and the PLL circuit.
- In middle-speed mode the high-speed on-chip oscillator (HOCO) will be selected as the clock source and the crystal oscillator shut down.
- In low-speed mode the 32.768kHz subclock will be selected as the clock source and all other clocks will be disabled. Note that when low-speed mode is selected, it is not possible to put the RX111 into any of the sleep modes.
- Switch back to the 'Power Measurement' tab after changing clock source to observe the effect on the MCU current. It may be necessary to stop, clear, and restart the graph when using sleep modes, as the reduction in current is significant.

5. Code Development

5.1 Overview

For all code debugging using Renesas software tools, the RPB board must be connected to a PC via a USB cable plugged in to the on-board debugger (connector CN8).

The on-board debugger can only be used with the RX111 on the RPB, and is not designed for user system development. A Renesas Starter Kit is available for this device which contains an E1 debugger for use with user hardware.

5.2 Compiler Restrictions

The compiler supplied with this RPB is fully functional for a period of 60 days from first use. After the first 60 days of use have expired, the compiler will default to a maximum of 128k code and data. To use the compiler with programs greater than this size you need to purchase the full tools from your distributor.

5.3 Mode Support

The RX111 microcontroller only supports single-chip operating mode.

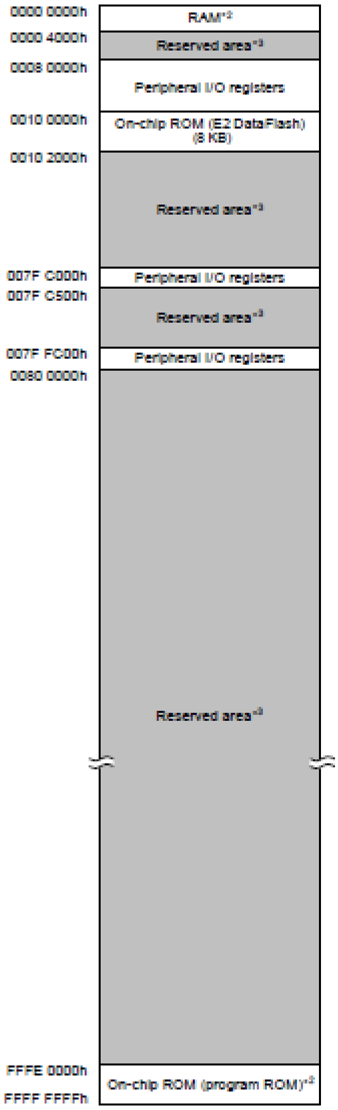
5.4 Debugging Support

The on-board J-Link debugger supports a variety of debugging features, some of which are described in the 'AdvancedDebugDemo' sample provided. Further documentation is available from the SEGGER Microcontroller website.

It is also possible to debug the RX111 using a Renesas E1 Emulator, by fitting a 14-pin shrouded box header to the connector labelled 'E1' on the underside of the RPB. No other modification is necessary however the J-Link OB and E1 should not be used at the same time.

5.5 Address Space

Figure 8-1 below details the address space of the MCU. This diagram is taken from the Hardware Manual version 0.2. The MCU fitted to the RPB has 32KB of ROM. For further details, refer to the RX111 Group Hardware Manual.



Note 1. The address space in boot mode is the same as the address space in single-chip mode.
Note 2. The capacity of ROM/RAM differs depending on the products.

ROM (bytes)		RAM (bytes)	
Capacity	Address	Capacity	Address
128 K	FFFE 0000h to FFFF FFFFh	16 K	0000 0000h to 0000 3FFFh
96 K	FFFE 8000h to FFFF FFFFh		
64 K	FFFF 0000h to FFFF FFFFh	10 K	0000 0000h to 0000 27FFh
32 K	FFFF 8000h to FFFF FFFFh		
16 K	FFFF C000h to FFFF FFFFh	8 K	0000 0000h to 0000 1FFFh

Note: • See Table 1.3, List of Products, for the product type name.

Note 3. Reserved areas should not be accessed.

Figure 5-1: MCU Address Space Diagram

6. Troubleshooting

Can’t Connect the J-Link Debugger to the RX111

Driving PA0_LDOEN low will turn off the Power Supply to the RX111. If this is done without supplying power through VCC_HARVEST on CN7 pin 5, then there will be no power applied to the RX111 and the J-Link debugger will not be able to communicate with the RX111.

To recover a board in this state either:

1. Supply 3.6V through VCC_HARVEST on CN7 pin 5, or
2. Remove R61 from the reverse side of the board as indicated below.

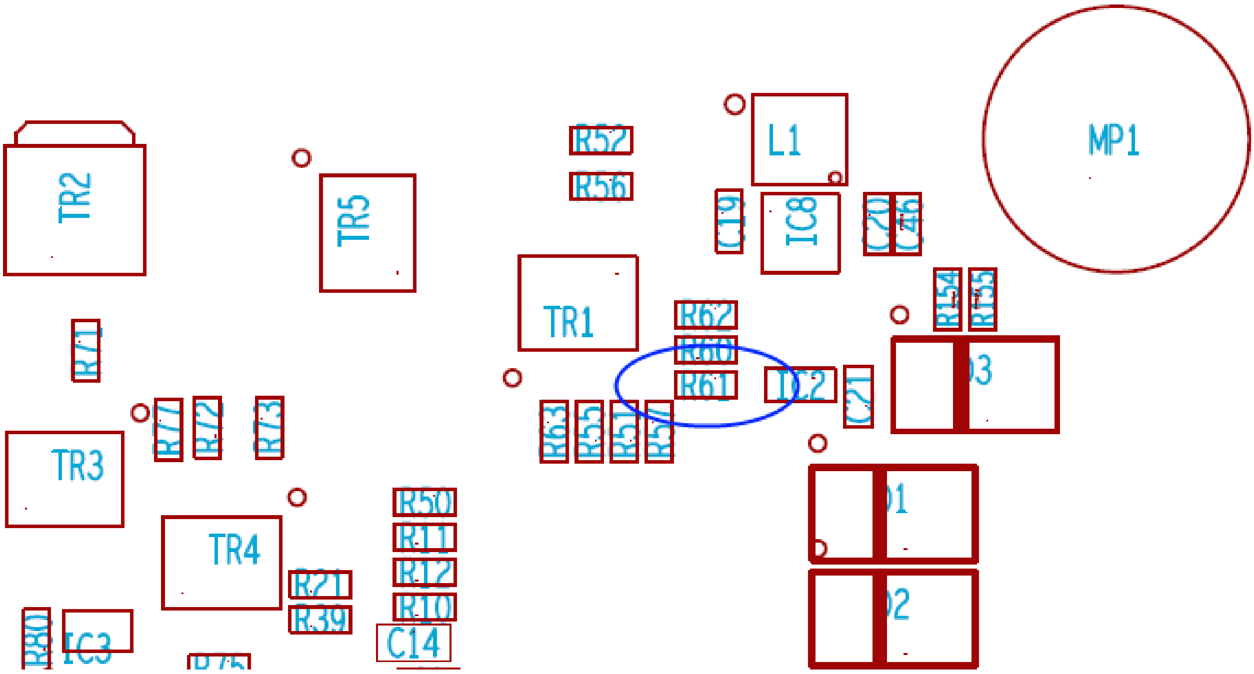
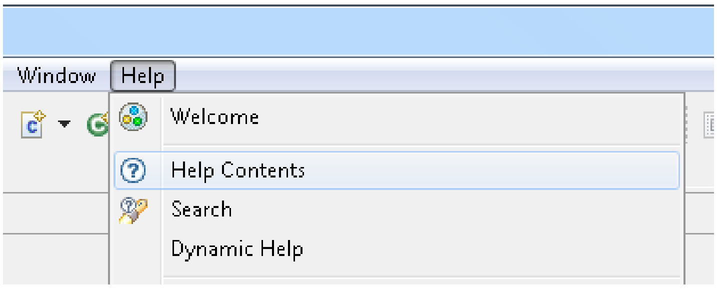


Figure 6-1: Location of R61

7. 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 RPBRX111 can be reproduced using the 'Application Leading Tool' (Applilet) code generator tool. Applilet4 is included on the DVD.
Source files and functions generated by Applilet4 are prefixed with 'r_' and 'R_', respectively.

Applilet4 for the RX111 is a code generation tools to assist you in creating a template for a project that will assist you in initial configuration of the microcontroller. Applilet4 will be integrated into e2 studio with version 2.1. User's working with IAR tools will still need to you the stand-alone application to generate the base code project as the e2 studio built-in version will not generate code for IAR.

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 10 of the "Quick Start Guide"

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

Trademarks

All brand or product names used in this manual are trademarks or registered trademarks of their respective companies or organisations.

REVISION HISTORY	RPB RX111 Tutorial Manual

Rev.	Date	Description	
		Page	Summary
1.00	Jul 09, 2013	—	First Edition issued

Renesas Promotional Board Manual: Tutorial Manual

Publication Date: Rev. 1.00 Jul 09, 2013

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.
2880 Scott Boulevard Santa Clara, CA 95050-2554, 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: +44-1628-651-700, Fax: +44-1628-651-804
Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-65030, Fax: +49-211-6503-1327
Renesas Electronics (China) Co., Ltd.
7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679
Renesas Electronics (Shanghai) Co., Ltd.
Unit 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898
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: +852-2886-9318, Fax: +852 2886-9022/9044
Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei, 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.
11F., Samik Lavied' or Bldg., 720-2 Yeoksam-Dong, Kangnam-Ku, Seoul 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 1.3

RX111 Group

Renesas Electronics Corporation

R20UT2699EG0100