Application Note

16

RL78 Group

Application Note: RL78/I1B Energy Monitor

16-Bit Single-Chip Microcontrollers

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By using this Renesas RL78/I1B Energy Monitor platform, the user accepts the following terms:

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Electromagnetic Compatibility (EMC)

CAUTION

With reference to Directive 2014/30/EU Article 2, clause 2 (e) this is a custom built evaluation kit destined for professionals to be used solely at research and development facilities for such purposes. This equipment can cause radio frequency noise when used. In such cases, the user/operator of the equipment may be required to take appropriate countermeasures under his responsibility.

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How to Use This Manual

1. Purpose and Target Readers

This application note is designed to help the user understand how to interact safely and effectively with Renesas RL78/I1B Energy Monitor. It is intended to be read by those using the Renesas RL78/I1B Energy Monitor as a guide or starting point for their own applications.

This application note demonstrates a basic guide on how to navigate the on-board menu system and use the accompanying PC application to monitor supply and load characteristics, in order to help familiarize the user with the device operation.

This application note also provides a basic guide to e^2 studio; showing how to develop and debug software for the Renesas RL78/I1B Energy Monitor.

Particular attention should be paid to the precautionary notes when reading this application note. These notes occur within the body of the text, at the end of each section, and in the Usage Notes section.

The revision history summarises 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 Renesas RL78/I1B Energy Monitor. 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 at http://www.renesas.eu/

Document Type	Description	Document Title	Document No.
Quick Start Guide	Quick start guide for the RL78/I1B Energy Monitor	RI78/I1B Energy Monitor Quick Start Guide	R20UT3423EG
Hardware Manual	Provides technical details of the RL78/I1B microcontroller group.	RI78/I1B User's Manual: Hardware	R01UH0407EJ
Schematics	Circuit schematics of the RL78/I1B Energy Monitor	Global Reference PF Schematics	D013964_04

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2. List of Abbreviations and Acronyms

Abbreviation	Full Form
ADC	Analogue-to-Digital Converter
A.C.	Alternating Current
COM	Communication
CSV	Comma Separated Values
DVD	Digital Versitile (Video) Disk
E1	On-chip Debugger
EMC	Electromagnetic Compatibility
GDB	GNU Debug
GUI	Graphical User Interface
IAR	Ingenjörsfirman Anders Rundgren
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro-controller Unit
PC	Personal Computer
PCB	Printed Circuit Board
PGA	Programmable Gain Amplifier
RTC	Real Time Clock
SFR	Special Function Register
UAC	User Access Control
USB	Universal Serial Bus

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Table of Contents

1. Introduction 7
1.1 Purpose 7

2. Introduction to the Energy Monitor 8

3. Connecting the RL78/I1B Energy Monitor 9
3.1 AC Supply Connections 9
3.2 User and Development Interfaces 9

4. Tool Installation 11
4.1 IAR Embedded Workbench (Evaluation) Installation 11
4.2 e^2 studio & Energy Meter GUI Installation 12

5. Connecting E1 Emulator 14
5.1 Obtaining an E1 Debugger & E1_Tool 14
5.2 Loction of Debug Connector P3 14
5.3 Connecting the E1 Debugger 15

6. Importing, Programming and Debug 16
6.1 Importing project in to e^2 studio 16
6.2 Building and Debugging the project 16
6.3 Build Configurations 18

7. Graphical User Interface Operation 19
7.1 Finding the Virtual COM Port Number 19
7.2 Launching the GUI 19
7.3 Meter Configuration 20
7.4 COM Setting 20
7.5 GUI Operation 20
7.6 GUI – Calibration Menu 21
7.7 GUI – EM Config Menu 22
7.8 GUI – Data Record Menu 23
7.9 GUI – Debug Menu 23

8. E1 Tool Schematic Diagram 25

9. Additional Information 26

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1. Introduction

1.1 Purpose

The Renesas RL78/I1B Energy Monitor is an evaluation tool for demonstrating the use of the Renesas RL78/I1B microcontroller in an energy monitoring application.

This document is intended to familiarize the user with interacting with the RL78/I1B Energy Monitor safely. It provides details of debugging / programming the RL78/I1B via the Renesas E1 debugger using the e^2 studio IDE. It also provides details of the Graphical User Interface.

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2. Introduction to the Energy Monitor

The RI78/I1B Energy Monitor provides single input, dual output, high performance, low power consumption Energy Monitor.

The Energy Monitor hardware platform is a derivative of the RL78/I1B Global Reference Meter from Renesas. The Global Reference Meter provides additional features, such as tamper sensors, which are not used in the Energy Monitor.

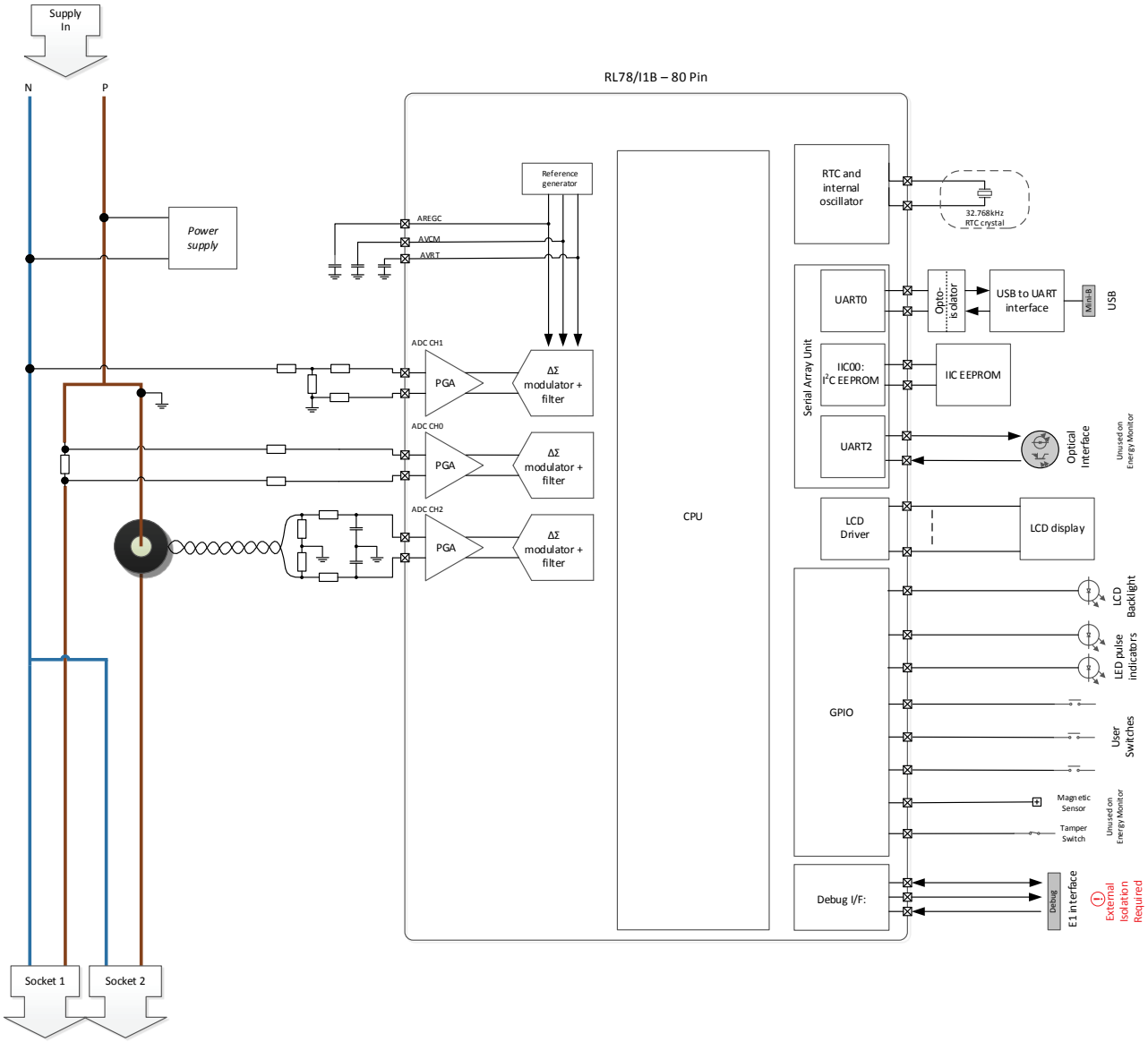


Figure 3-1 RL78/I1B Energy Monitor Block Diagram

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3. Connecting the RL78/I1B Energy Monitor

3.1 AC Supply Connections



The Energy Monitor assembly is isolated from the system earth and therefore can be floating at dangerous potentials. Extreme care must be used when operating the energy monitor when connected to A.C. Line Voltages. Never operate the demonstration system with the covers removed unless suitable isolation and protective equipment is used. This unit is intended to be operated only by suitably qualified personnel.

The electrical connections to the meter are through an IEC C20 (input terminal) and two IEC C13 (load terminals).

The RL78/I1B Energy Monitor is designed to be directly connected, so the current passes from input to output terminals for each socket via the current sensing elements internal to the energy monitor. Refer to Figure 3-1 for connection information.

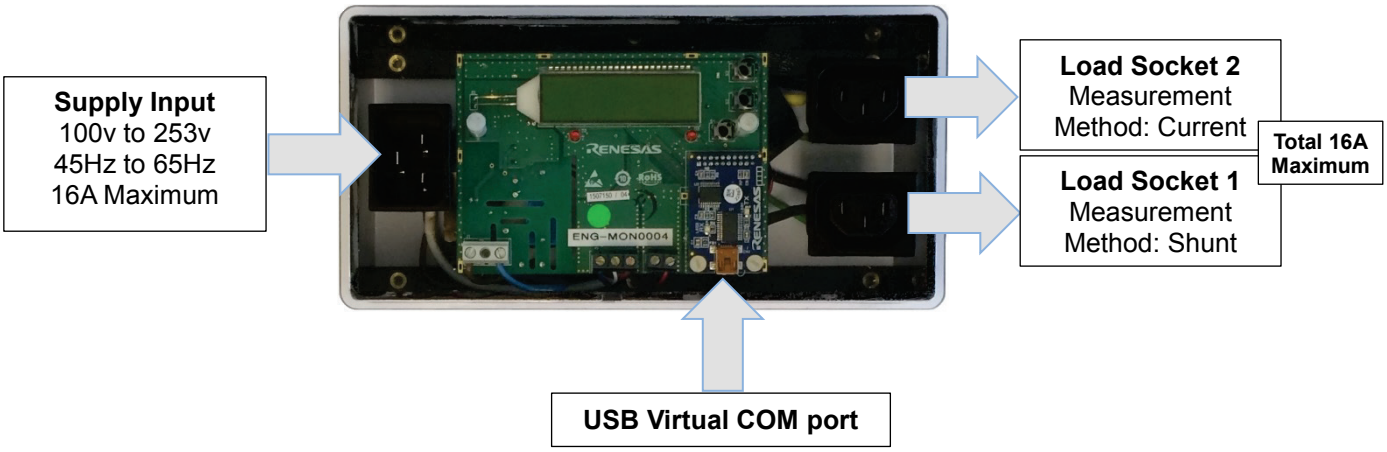


Figure 3-2 RL78/I1B Energy Monitor USB & Power Connections

3.2 User and Development Interfaces

3.2.1 General User Interfces:

The Renesas RL78/I1B Energy Monitor provides the following user-accessible interfaces which can be used with the protective cover closed and can be used safely at all times.

- Menu navigation – Up / Down / Select buttons,
- Isolated USB Virtual COM port.

These interfaces are electrically isolated from the A.C. supply and are safe to use, however the user must be aware that potentially hazardous voltages are present on all the other areas of the exposed PCB which do potentially present a risk of electric shock if touched. This includes items such as the LCD display, MCU, crystal etc.

This system should be operated only with suitable protective equipment and only by appropriately trained and qualified personnel.

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3.2.2 Menu Button Layout

The menu navigation buttons have the following functions:



Figure 3-3 Menu Button Layout

3.2.3 Screen Display loops and Button Functions

Please refer to the Quick Start Guide (R20UT3423EG) for information on the various screen displayed on the RL78/I1B Energy Monitor and the functions of the three menu buttons.

3.2.4 Calibration Reset to Factory Default

In exceptional circumstances, it may be necessary to reset the RL78I1B Energy Monitor to factory default pre-calibration coefficient values.

This procedure will reset to pre-calibration factory defaults. Following this the unit will require calibration with an external reference supply to provide accurate measurements (see section 7.6.1).

To reset the coefficient values to factory defaults: with power off, hold down Select, Down & Up buttons and turn power on. Reset is complete when the display turns on and starts scrolling.

3.2.5 E1 Debugger Interface



The debug connector '**P3'** is **not isolated;** it is at a hazardous voltage when A.C. line power is applied to the Energy Monitor.

P3 interface allows the user to connect an E1 Debugger to the RL78/I1B Energy Monitor via an intermediate adaptor board. Please see Section 5 for further connection details.



The user MUST supply and use suitable isolation between the debug PC and the RL78/I1B Energy Monitor if line power is applied.

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4. Tool Installation

In order to develop and debug the RL78/I1B Energy Monitor embedded project a number of tools need to be installed on the development computer. Please install these tools in the following order.

Installation Disk #1:

- IAR Embedded Workbench – Provides compiler, assembler and linker.

Installation Disk #2:

- Renesas e^2 studio – Integrated Development and Debugging environment, Including the Renesas Energy Monitor Graphical interface.

4.1 IAR Embedded Workbench (Evaluation) Installation

This step with install IAR Embedded Workbench Evaluation copy. This provides a 30-day time limited evaluation license providing a fully functional integrated development environment including project manager, editor, compiler, assembler, linker, librarian, and debugger tools. A complete set of user guides is included in PDF format.

After the 30-day evaluation period has ended, a license must be purchased.

1. Insert the IAR Embedded Workbench DVD into your computer's DVD-ROM drive. The DVD should automatically run the installation program. If the installer does not start, browse to the DVD root folder and double click on 'Autorun'.

2. Click the Install IAR Embedded Workbench® entry on the displayed banner screen.

3. Windows™ 7 / 8 / 8.1 users may see the "User Account Control" dialog box. If applicable, enter the administrator password and click 'Yes'.

4. The installer welcome screen will open. Follow the on-screen instructions to install the RL78 IAR Embedded Workbench. This process will take several minutes.

5. On the 'InstallShield Wizard Complete' dialogue – select 'Launch IAR Embedded Workbench' and click 'Finish'.

6. When IAR Embedded Workbench loads, a 'License Wizard' will be displayed, unless you have an existing license select '◉ Register with IAR Systems to get an evaluation license' and follow the License Wizard steps to obtain a 'Time limited' 30-day evaluation license.

7. Once the license has been verified, the license wizard will show 'Your evaluation license has been activated'. Click 'Done' to complete this step.

Note: When prompted to specify a location for installing any tools, it is recommended that default entries be accepted.

The Windows driver signing or Windows Security dialogs boxes may be displayed. Please accept the driver to continue.

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4.2 e² studio & Energy Meter GUI Installation

1. Insert the e² studio DVD into your computer's DVD-ROM drive. The DVD should automatically run the installation program. If the installer does not start, browse to the DVD root folder, open the e² studio folder then double click on 'setup.exe'.

2. Windows™ 7 / 8 / 8.1 users may see the "User Account Control" dialog box. If applicable, enter the administrator password and click 'Yes'.

3. The installer welcome screen will open. Follow the on-screen instructions to install the RL78/I1B Energy Monitor software. This process will take several minutes.

Note: When prompted to specify a location for installing any tools, it is recommended that default entries be accepted.

The Windows driver signing or Windows Security dialogs boxes may be displayed. Please accept the driver to continue.

4.2.1 Configuring IAR Embedded Workbench Plugin

e² studio now needs to be configured to use the IAR tool chain installed with the IAR Embedded Workbench.

1. Start e² studio (skip this step if already open):
   Windows™ 7: Start Menu > All Programs > Renesas Electronics e2studio > e2 studio
   Windows™ 8 / 8.1: From Apps View, click 'e2studio' icon.

2. In the 'Select a workspace' folder dialogue that appears, browse a suitable location and folder name to save your new workspace to. Click OK to continue.

3. On the 'There are no new toolchains avaiable for integration' dialogue, click 'OK'.

4. In the 'Code Generator Registration' dialog click 'OK'

5. Windows™ 7 / 8 / 8.1 users may see the "User Account Control" dialog box. If applicable, enter the administrator password and click 'Yes'.

6. A 'Code Generator COM component register' dialog will pop-up with the text "Please restart e2 studio to use Code Generator". Click 'OK'.

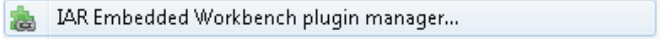
7. In the 'Restart e2 studio' dialog click 'OK'. e² studio will be restarted due to first-time registration of the Code Generator COM component.

8. Once e² studio is restarted the 'Select a workspace' window appears again. Click 'OK'.

9. On the 'There are no new toolchains avaiable for integration' dialogue, click 'OK'.

10. e² studio needs an internet connection to obtain contents from IAR. If required for your network, proxy servers can be setup in the preferences dialogue found here:
    Window > Preferences > General > Network Connections.

11. Launch the IAR Plugin Manager by selecting: Help > IAR Embedded Workbench plugin manager…



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12. Click ‘RL78’ in the list of ‘Supported targets’ and click the checkbox next to the latest version displayed under ‘Available IAR Embedded Work installations’ and click ‘Install’. Installation progress can be seen in the status bar at the bottom of the window, ‘Configuring IAR plugins’ may take a few minutes to complete.

13. An Install dialogue box will be displayed, ensure all named items are selected and click ‘Next’. Click ‘Next’ on the ‘Install Details’ dialogue box.

14. If acceptable, select the ‘I Accept the terms of the license agreement’ and click ‘Finish’. The required support software will now be installed. If a Security Warning dialogue box is shown, accept this by clicking ‘OK’.

15. e^2 studio now needs to be restarted, click ‘Yes’ on the ‘Software Updates’ to confirm the restart.

On the restart is complete, e^2 studio is now configured to use the IAR Embedded Workbench RL78 tool chains.

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5. Connecting E1 Emulator



The debug connector '**P3'** is **not isolated;** it is at a hazardous voltage when A.C. line power is applied to the Energy Monitor.

The user MUST supply and use suitable isolation between the debug PC and the RL78/I1B Energy Monitor if A.C. line power is applied.



The E1 Debugger can power the RL78/I1B Energy Monitor for programming and debugging when line power is not applied. In this case additional isolation is not required.

5.1 Obtaining an E1 Debugger & E1_Tool

To allow the debugging and downloading of firmware an E1 Debugger must be used.
The part number for the E1 debugger required is R0E000010KCE00.

The E1_Tool is a small adaptor board that allows the E1 to connect to the RL78/I1B Energy Monitor. A schematic diagram of this can be found in section 8.

These can be obtained from your local Renesas Sales Office (contact details can be found at the end of this document).

5.2 Loction of Debug Connector P3

The Debug connector P3 is found on the reverse side of the Energy Monitor adjacent to the output sockets as illustrated below.

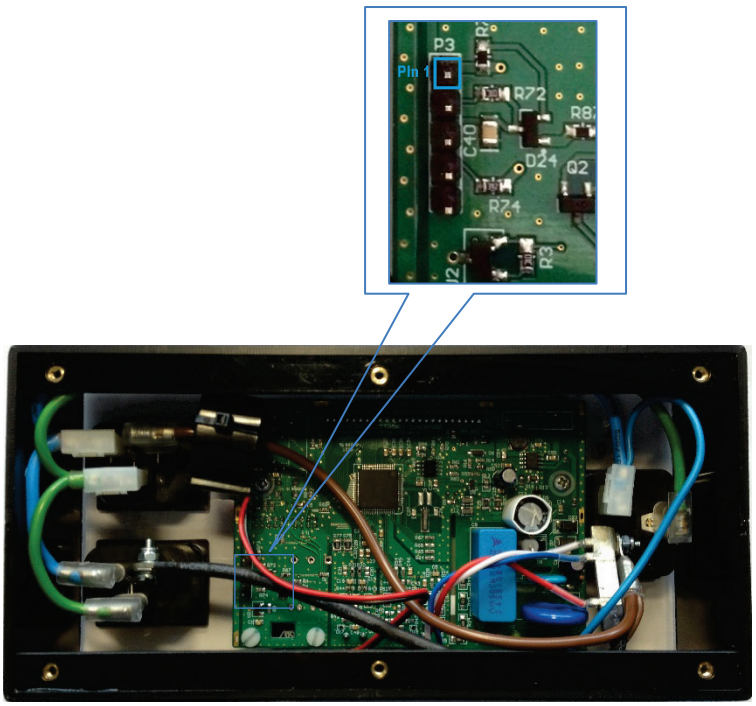


Figure 3-4 RL78/I1B E1 Interface 'P3'

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5.3 Connecting the E1 Debugger

1. Ensure A.C. line power to the RL78/I1B Energy Monitor is OFF.

2. Connect the E1 debugger module to the interface board ‘E1_Tool’.

3. Connect the ribbon cable from the ‘E1_Tool’ interface board to P3 of the RL78/I1B Energy Monitor, noting Pin 1 orientation.

4. Connecting the E1 to the PC depends if A.C. Line Power will be applied to the RL78/I1B Energy Monitor:

   a. **Debugging when A.C. Line power may be applied**: Connect the E1 debugger to a suitable USB to USB isolator and connect the USB to USB isolator to a spare USB port of your PC.

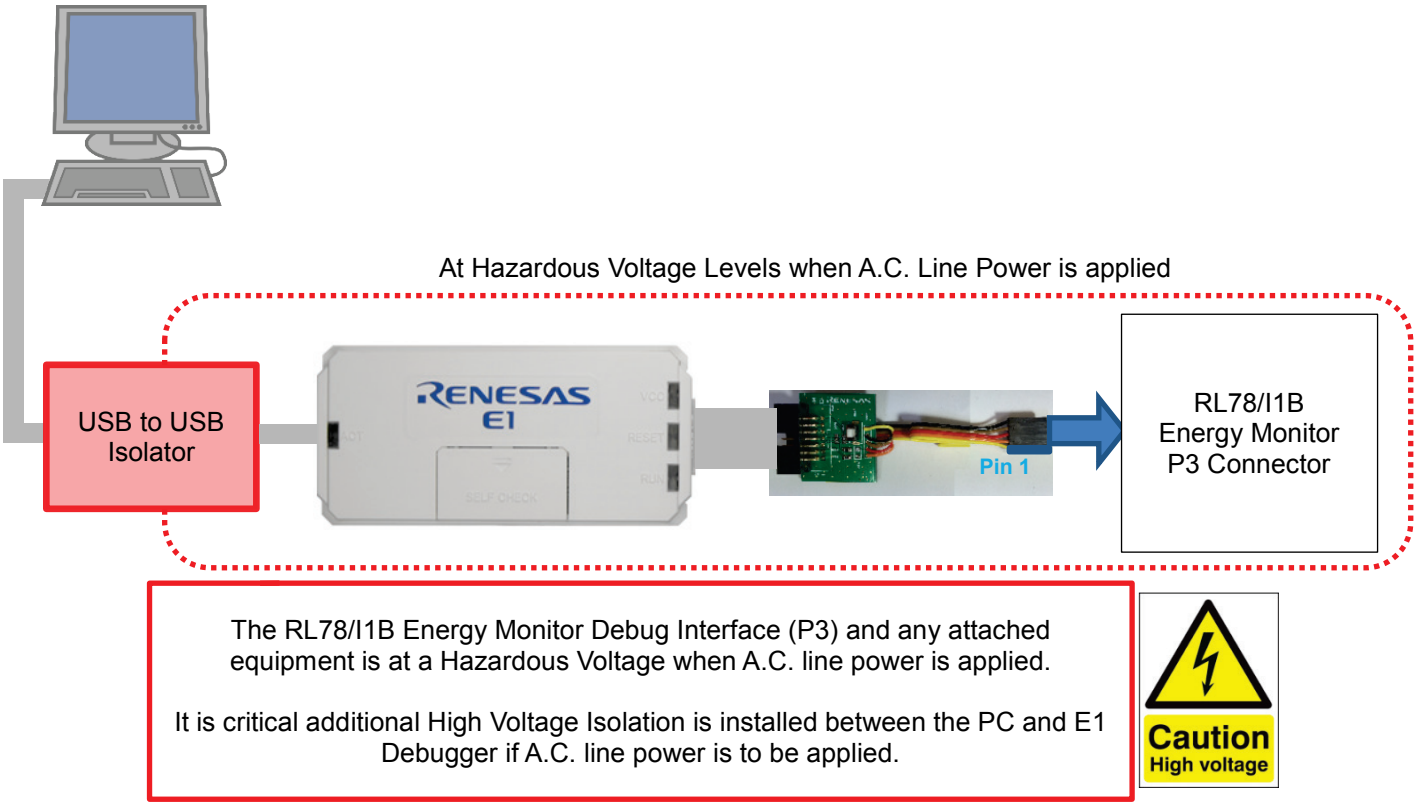
   b. **Debugging when A.C. Line power will <u>never</u> be applied**: If debugging in a setup where A.C. line power will not be applied to the RL78/I1B Energy Monitor, the USB to USB isolator is not required - Connect the E1 debugger to a spare USB port of your PC.

5. The green ‘ACT’ LED on the E1 debugger will flash.

6. The E1 debugger drivers will now be installed. Note that, this may take up to a minute and administrator privileges will be required.

Windows™ 7	**Windows™ 8 / 8.1**
“Device driver software installed successfully” pop-up will appear in the Windows™ toolbar and installation will complete.	An icon will appear in the Windows™ toolbar and installation will complete.

7. The green ‘ACT’ LED on the E1 debugger will illuminate constantly.



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6. Importing, Programming and Debug

This section provides a guide to importing, programming and debugging the project for the RL78/I1B Energy Monitor.

6.1 Importing project in to e^2 studio

1. Start e^2 studio (skip this step if already open):
   Windows™ 7: Start Menu > All Programs > Renesas Electronics e2studio > e2 studio
   Windows™ 8 / 8.1: From Apps View, click 'e2 studio' icon.

2. In the 'Select a workspace' folder that appears, browse a suitable location and enter a folder name to save your new workspace to. Click OK to continue.

3. On the 'There are no new toolchains available for integration' dialogue Click 'OK'.

4. In the e^2 studio welcome screen, click the 'Go to the workbench' arrow icon, on the far right.

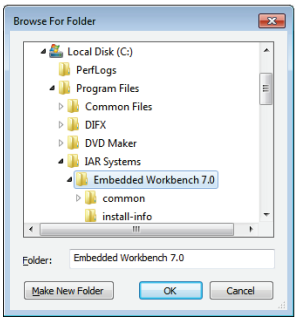
5. Right-click in the project explorer window, and select 'Import'.

6. Under 'Select an Import Source' select General > Existing Projects into Workspace, and click 'Next'.

7. Click the 'Browse' button, and locate the following project directory and click 'OK':
   C:\Renesas\Workspace\RL78I1B_EnergyMonitor'

8. Ensure the 'Copy projects into workspace' option is ticked and then click 'Finish'.

9. A 'Preferences' dialogue will be displayed. Click 'Browse' and locate the folder in which IAR Embedded Workbench was installed and click 'OK'. A Windows™ 7 32-bit example is shown below:



10. Click 'OK' to close the 'Preferences' dialogue.

6.2 Building and Debugging the project

The RL78/I1B Energy Monitor can be powered and debugged via the E1 Debugger if A.C. Line Voltage will never be applied. In this configuration, the LED Backlight does not operate and ADC measurements are not representative; this is a useful development configuration when A.C. Line Voltages presents an unacceptable hazard.

With suitable isolation and precautions, (see section 5) the RL78/I1B Energy Monitor can be powered from the A.C. Line Voltage and debugged by the E1 Debugger.

1. Select the "RL78I1B_EnergyMonitor" project by left clicking on it, then click the arrow next to build button (hammer icon), and select 'Debug' from the drop down menu.

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2. e^2 studio will now build the project. Once this is finished, debugging can be started by clicking the arrow next to debug button (bug icon), and selecting 'Debug Configurations…'.

3. Click the entry 'Renesas GDB Hardware Debugging' and click to create a new configuration.

4. Click 'Search Project…'. In the 'Program Selection' window, select 'RL78I1B_EnergyMonitor.d87' and click 'OK'.

5. Click the 'Debugger' tab, then the 'Connection Settings' secondary tab. Change the highlighted items and ensure all other entries match the screenshot below.

   a. If the RL78/I1B Energy Monitor is being debugged with A.C. Line Voltage applied select:
   'Power Target From The Emulator (MAX 200mA)' to **NO**

   b. If the RL78/I1B Energy Monitor is being debugged stand alone with A.C. Line Voltage NOT applied select:
   'Power Target From The Emulator (MAX 200mA)' to **YES**

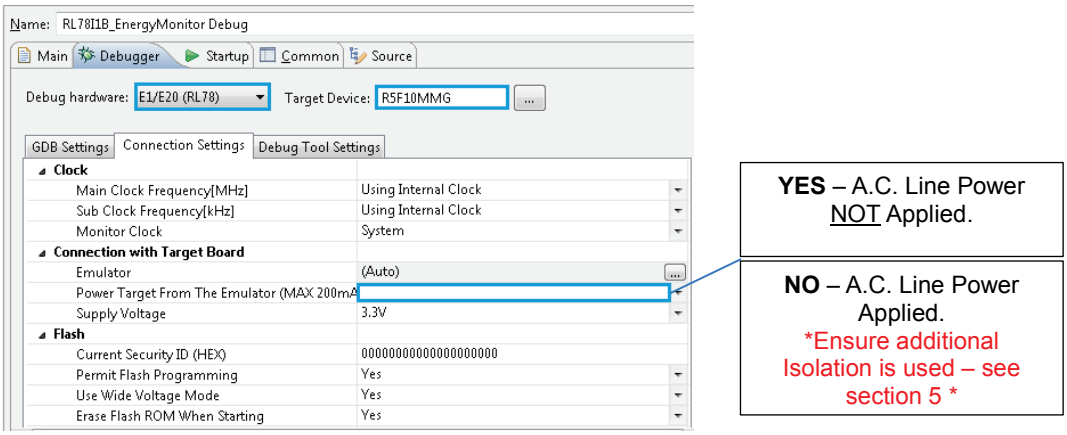


Figure 3-5 Debug Configuration Settings

8. Click the 'Debug' button to download the code to the target, and begin debugging.

9. A firewall warning may be displayed for 'e2-server-gdb.exe'. Select the check-box for 'Private networks, such as my home or work network', and click 'Allow access'.

10. A User Account Control (UAC) dialog may be displayed. Enter the administrator password and click 'Yes'.

11. e^2 studio may ask you to 'Confirm Perspective Switch', click 'Yes'.

12. Once the code has been downloaded, click the 'Resume' button to run the code up to the first line of the main function, main().
    Click 'Resume' again to start execution of the main code.

13. Click the 'Suspend' button. The program will stop and the source code will be opened at the current program counter. Note: the application uses many library functions, 'No source available' warnings may be displayed if the program is suspended while executing library functions.

14. To disconnect from the target board, click the 'Disconnect' button on the toolbar:

15. Select the C/C++ perspective (at the top right) to return to the editor view.

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6.3 Build Configurations

The e^2 studio workspace has two build configurations: ‘Debug’ 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.

Debug

This default 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.

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7. Graphical User Interface Operation

7.1 Finding the Virtual COM Port Number

The installation of the RL78/I1B Energy Monitor software automatically installs driver software onto the PC to allow communication with the energy monitor via USB, acting as a virtual serial port.

Ensure that the RL78/I1B Energy Monitor is disconnected from the incoming A.C. Line Voltage. Connect the PC to the Energy Monitor USB port, this will power the Energy Monitor's USB circuitry.

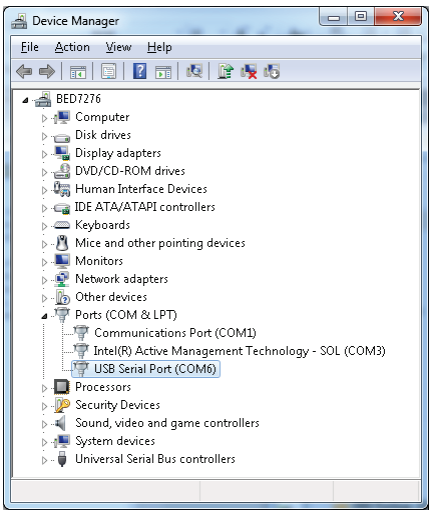
The USB Serial Converter drivers will now be installed. Note that, this may take up to a minute and administrator privileges will be required.

Windows™ 7	Windows™ 8 / 8.1
"Device driver software installed successfully" pop-up will appear in the Windows™ toolbar and installation will complete.	An icon will appear in the Windows™ toolbar and installation will complete.

In order to connect with the RL78/I1B Energy Monitor, the allocated COM port number must be determined.

On the PC, open Windows™ 'Device Manager'. Expand the "Ports (COM & LPT)" section and the COM port will listed as 'USB Serial Port (COMxx)'.

In the example below the serial port is identified as COM6.



7.2 Launching the GUI

The Energy Meter GUI is installed during the RL78/I1B Energy Monitor Software installation and provides an intuitive way to view and modify many parameters of the RL78/I1B Energy Monitor.

Ensure the RL78/I1B Energy Monitor is running (see section 6).

Start the Energy Monitor GUI:

Windows™ 7: Start Menu > All Programs > EnergyMeterGUIvxxx (where xxx is a version number)

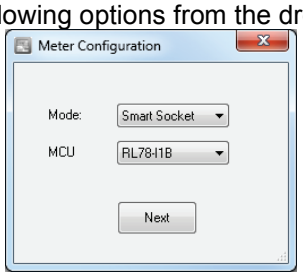
Windows™ 8 / 8.1: From Apps View, click EnergyMeterGUIvxxx icon (where xxx is a version number)



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7.3 Meter Configuration

After starting the application, select the following options from the drop down list:



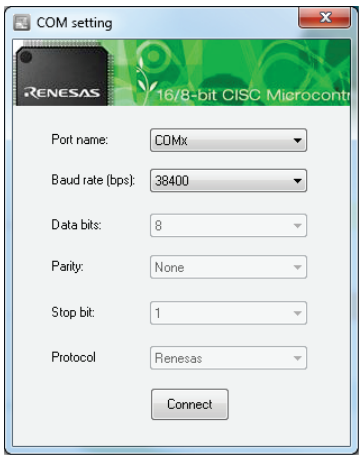
7.4 COM Setting

In the ‘COM Setting’ Dialogue, use the drop down menu change the ‘Port name:’ to the COM port identified in Section 7.1.

Note, the RL78/I1B Energy Monitor virtual COM port must be connected before launching the GUI, or the Port name will not appear in the list.

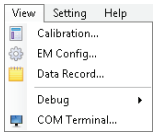
‘Baud rate (bps):’ must be set to 38400.

Click Connect.



7.5 GUI Operation

The main functions of the GUI can be accessed through the ‘View’ menu. These functions are duplicated with buttons on the right of the GUI’s main window.



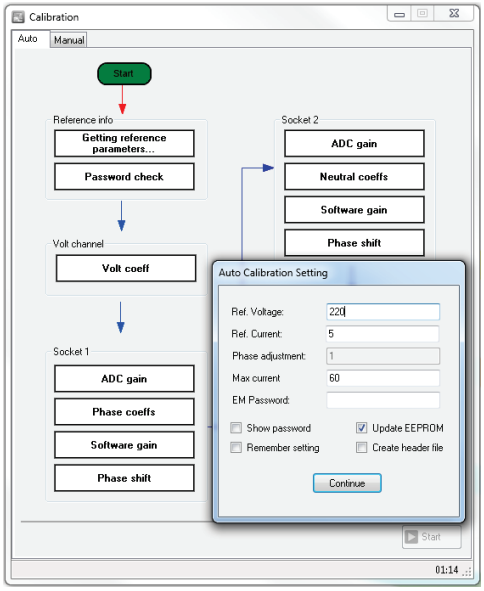
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7.6 GUI – Calibration Menu

Please note: Auto calibration requires a precision external reference supply. Attempts to calibrate without a suitable supply will result in poor accuracy and/or incorrect measurement values.

7.6.1 Auto Calibration

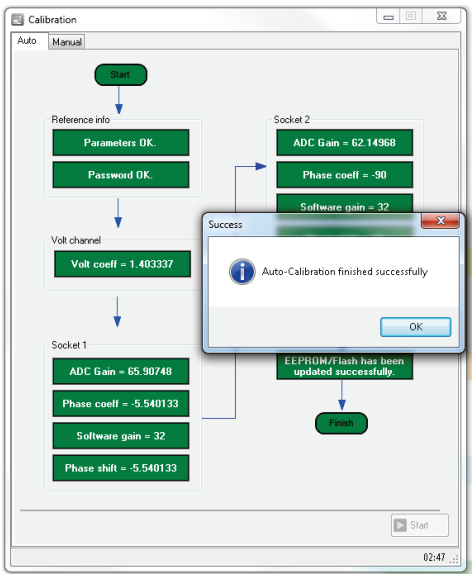
This provides automatic calibration of the RL78/I1B Energy Monitor against a known external reference supply.



Clicking ‘Start’ on the Auto Calibration tab will bring up the ‘Auto Calibration Setting’ window.

Ref. Voltage - Enter the value of the external reference supply output voltage. Suggested value 230.
Ref. Current - Enter the value of the external reference supply load current (per socket). Suggested value 5.
Max. Current - Enter ‘60’ . This value is used in the Metrology Code internal to the RL78/I1B and is not related to the limits imposed by connectors and wiring.
EM Password – this is not used on the RL78/I1B Energy Monitor.

Click ‘Continue’, the Auto Calibration will commence. Once finished the window will display the calculated calibration values or details of any problems found.

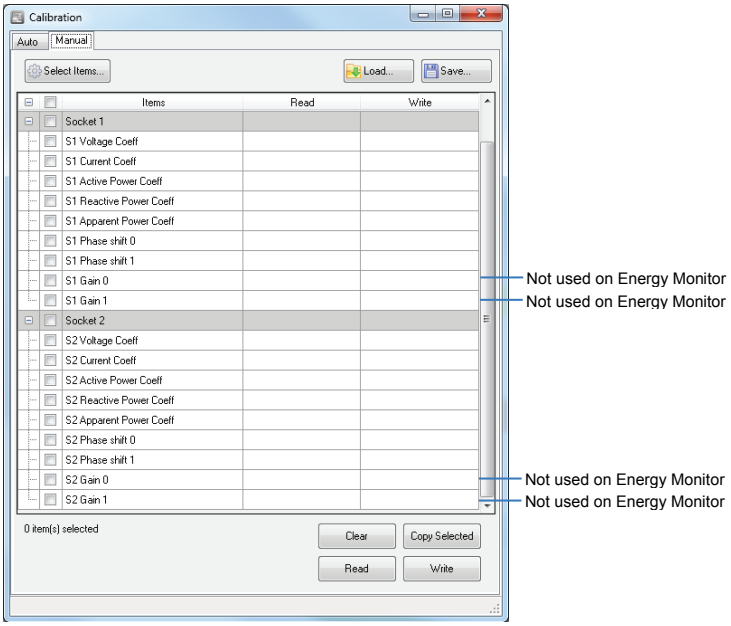


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7.6.2 Manual Calibration

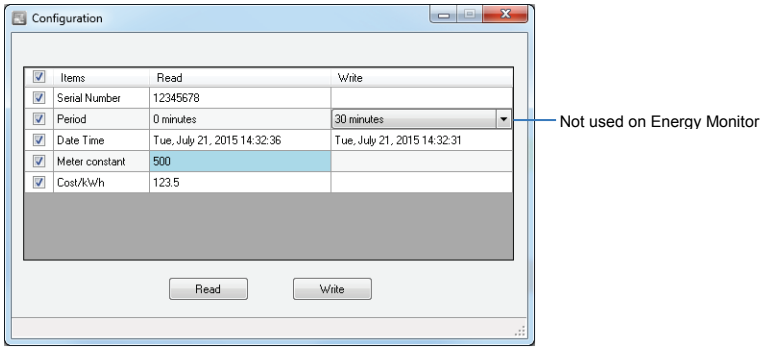
Please note: Manual calibration allows the modification of values used in the metrology calculations, which will affect the accuracy of measurements. Autocalibration should be used as the primary calibration method.

This tab allows the direct reading and writing of the RL78/I1B Energy Monitor calibration values.



7.7 GUI – EM Config Menu

This 'Configuration' window allows the reading and writing of various parameters of the RL78/I1B Energy Monitor:

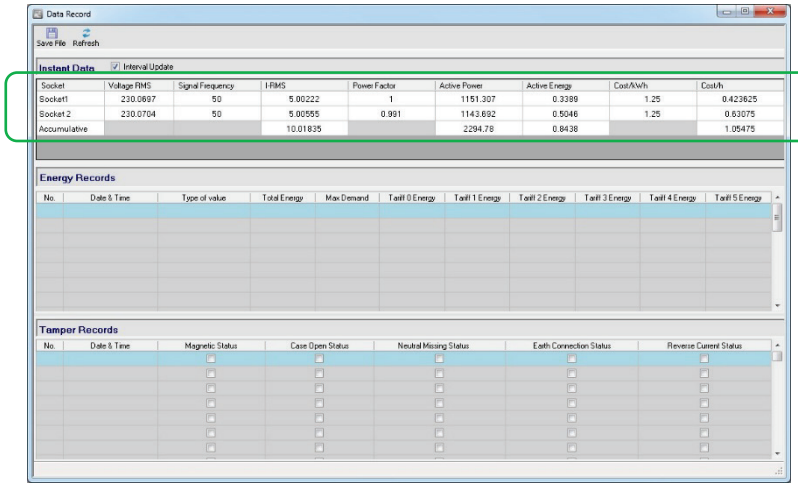


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7.8 GUI – Data Record Menu

The Data Record window presents details of the supply and loads measured by the RL78/I1B Energy Monitor.

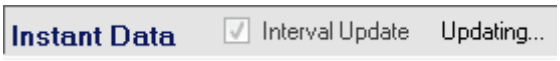
The Energy Records and Tamper Records are not currently used on the RL78/I1B Energy Monitor.



Units Displayed

	V	Hz	A		W	kWh		
Socket	Voltage RMS	Signal Frequency	I-RMS	Power Factor	Active Power	Active Energy	Cost/kWh	Cost/h
Socket1	230.0697	50	5.00222	1	1151.307	0.3389	1.25	0.423625
Socket 2	230.0704	50	5.00555	0.991	1143.692	0.5046	1.25	0.63075
Accumulative			10.01835		2294.78	0.8438		1.05475

Automatic Interval Update



This tick box enables automatic updating of the values. This is triggered 5-seconds after the previous update has completed.

Note the Data Record window cannot be closed when an update is in progress. Please wait until the update has finished and then close the window.

7.9 GUI – Debug Menu

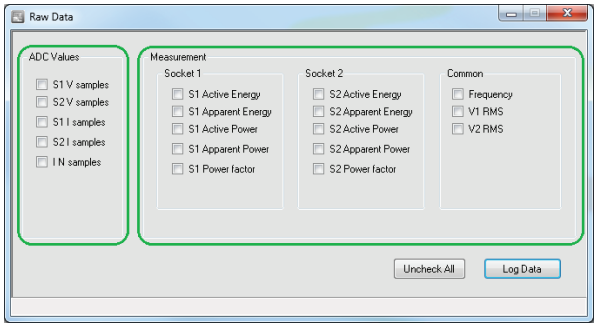
7.9.1 SFR…

The SFR window provides a convenient way to read and write Special Function Registers within the RL78/I1B microcontroller while the RL78/I1B Energy Monitor firmware is running.

For details of the SFRs please refer to the RL78/I1B user's Manual: hardware.

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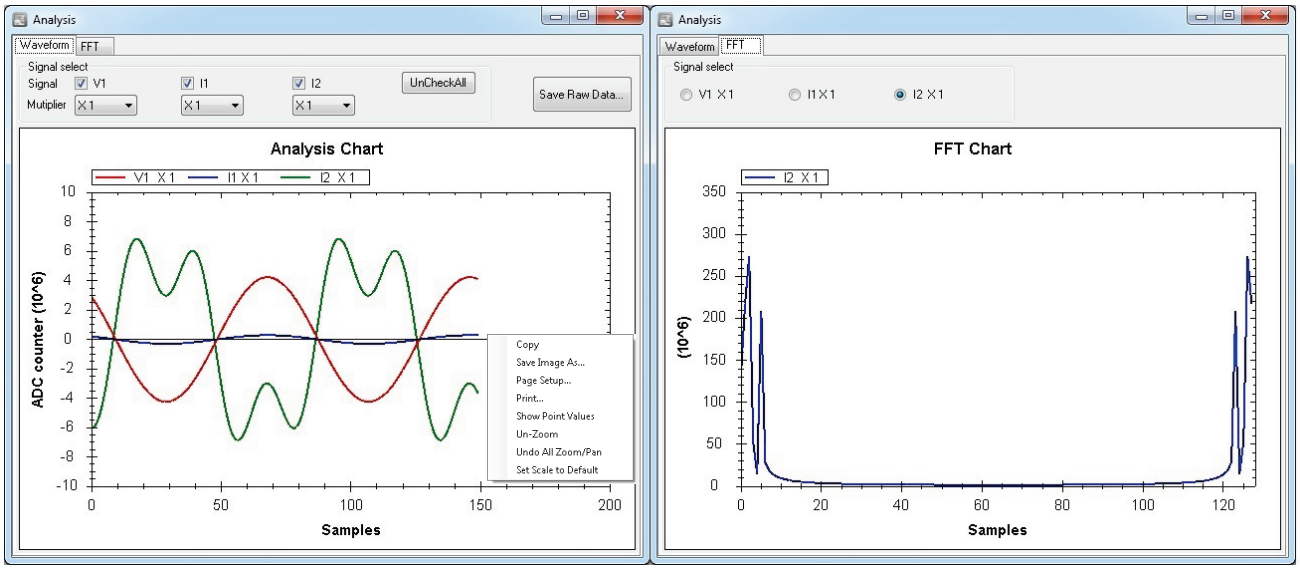
7.9.2 Raw Data



The Raw Data window is split in to two sections: ADC Values and Measurement.

ADC Values
This feature logs 150 samples of each selected item directly from the RL78/I1B ADC. These samples are taken prior to the application of any calibration or correction factors.
These values are presented as a graph and FFT plot of the frequency content.
A maximum of three items can be selected simultaneously.

Example below shows Voltage, Socket 1 Current and Socket 2 Current (with a harmonic content).

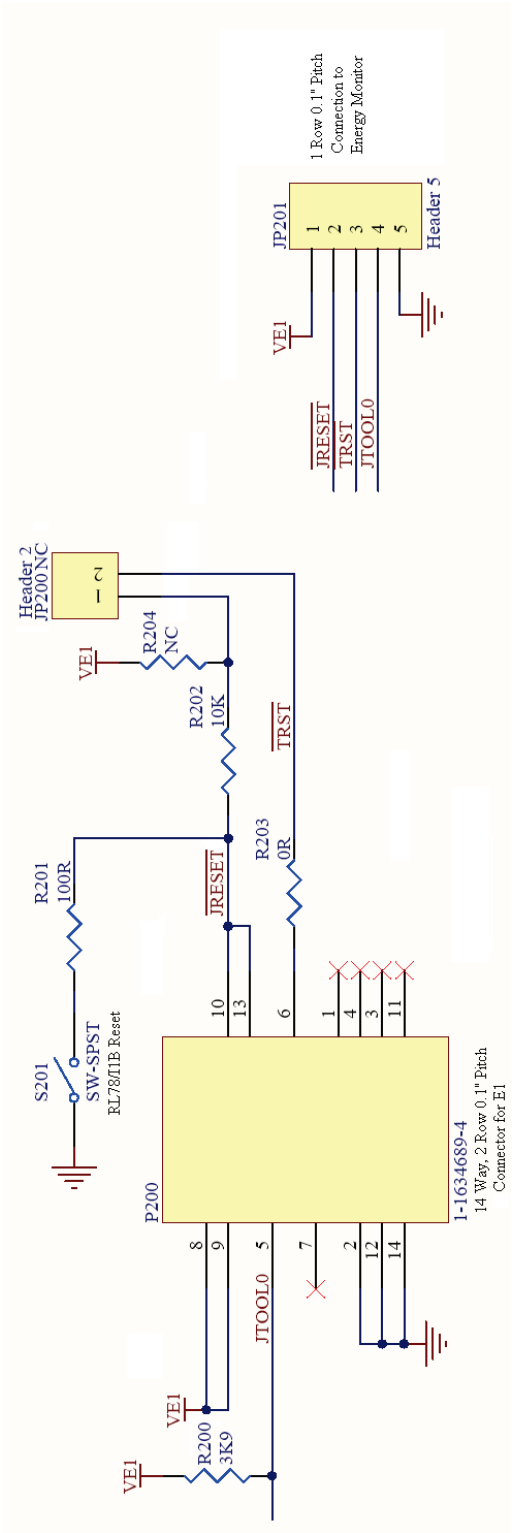


Several features are available to manipulate the Analysis Chart view such as drag to zoom and export features available by right clicking on the trace area.

Measurement
The measurement section captures sequential measurements from the RL78/I1B Energy Monitor and exports them as a CSV file. This file can easily be imported in to popular spreadsheet programs.

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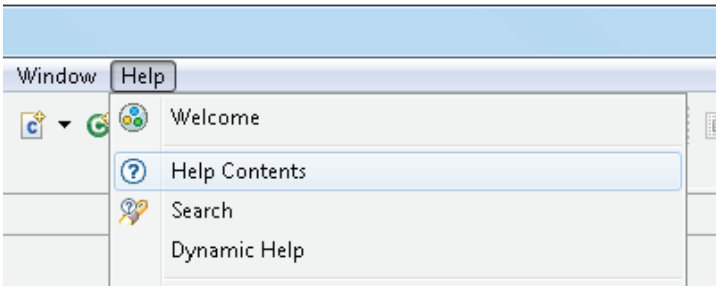
8. E1 Tool Schematic Diagram



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9. 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.



For information about the RL78/I1B microcontrollers refer to the RL78/I1B User's Manual: Hardware.

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

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