User’s Manual

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RL78/I1C

User’s Manual: Isolated Shunt PMOD

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General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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1. Overview

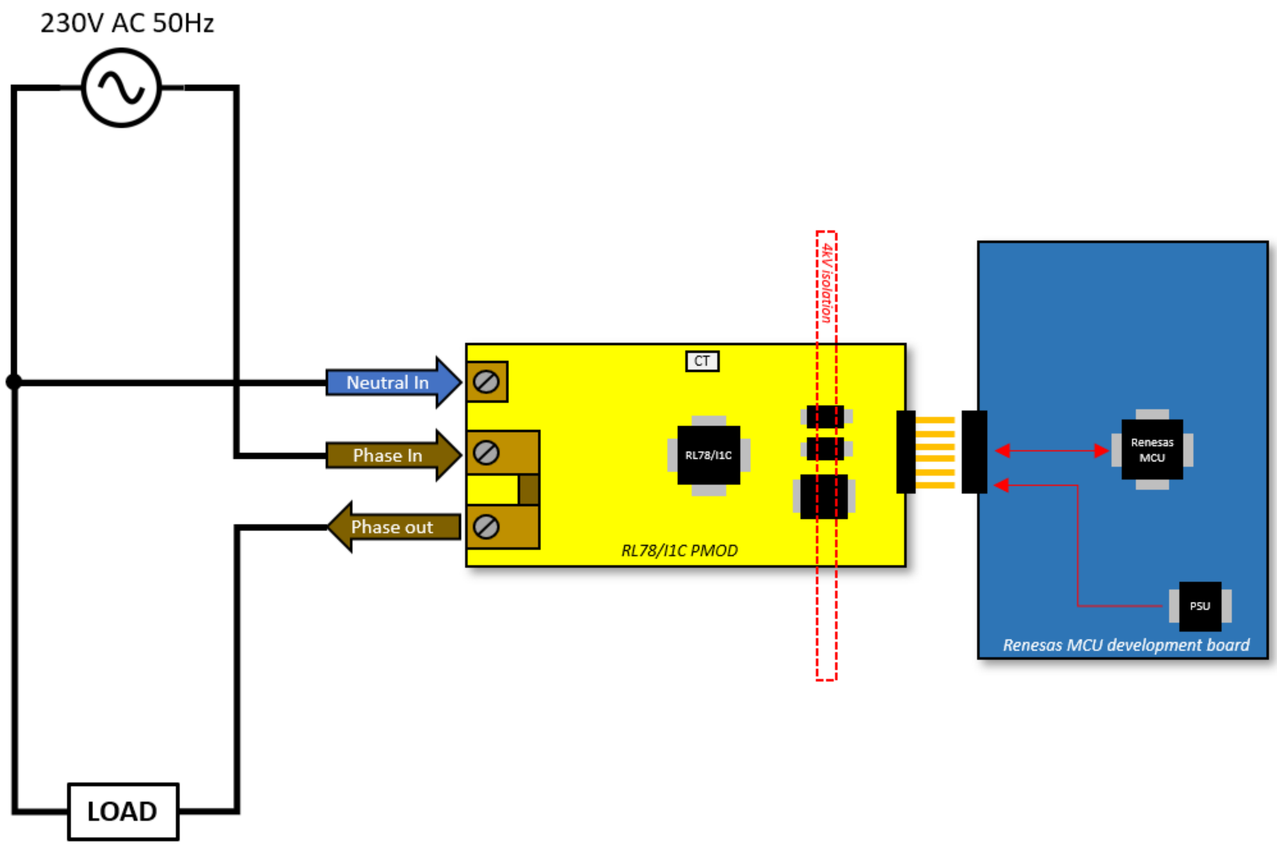
1.1 Purpose

The RL78/I1C Isolated Shunt PMOD is a self-contained single-phase energy measurement system designed for high-current and high-voltage AC systems, such as revenue-grade utility e-meters, utility and industrial submetering, building management systems and appliance monitoring.

1.2 Features

The measured energy data is made available over a PMOD style UART interface, so allowing any general purpose Renesas MCU development board to act as a host and communicate with the measurement system easily. No dedicated metrology functions are required on the host MCU for simple single-phase measurement applications.

The PMOD module contains high-voltage isolation on both the data and power interface, so allowing the host



MCU development board to maintain its safe voltage range, with no special handling precautions required.

Figure 1-1: Overview of connections to the RL78/I1C Isolated shunt PMOD module

1.3 Safety notice

1.3.1 Intended use

The Renesas RL78/I1C PMOD module is intended for **ELECTRICAL LABORATARY USE ONLY.**

The demonstration system should be operated within a temperature and humidity-controlled environment only.

1.3.2 Recommended operating conditions

Power source: Provided by USB host, or by MCU development board, regulated 3.3V DC, <100mA

Operating temperature: Tamb = 0°C to 40°C

Relative humidity: 0°C to 40°C, 0-80% relative humidity, non-condensing

Altitude: Operating, up to 2000m

Pollution degree: PD2

AC cable insulation rating: voltage rating = 300/500V, temperature = 90°C or greater

1.3.3 Equipment installation

The demonstration system is intended for short-term **EVALUATION AND DEVELOPMENT USE ONLY**.

The demonstration system is not intended for use within a permanently connected environment.

1.3.4 Service

NO USER SERVICEABLE PARTS ARE INCLUDED WITHIN THE EQUIPMENT.

If the demonstration systems protective enclosure becomes damaged in any way that can expose the high voltage terminals within, or signs of overheating of any component are observed, immediately disconnect the equipment, and take the unit out of service.

In the event of a malfunction or unexpected operation, the demonstration system must be returned to Renesas for service and repair. Please return faulty equipment to:

Renesas Electronics Europe GmbH, Arcadiastrasse 10, 40472 Dusseldorf, Germany

For technical support please contact your local sales representative. See www.renesas.com for details.

1.3.5 Symbols used

Warning – Dangerous high voltages are present within the RL78/I1C PMOD module.

2.Connectivity

Connections to the PMOD module are through a 12-pin UART enabled PMOD interface (conforming to Digilent type 4A). In addition to the UART Tx and Rx pins for data transmission to and from the host MCU, two additional I/O pin connections (MTU1 and MTU2) are required for power generation (see section 2.1).

Table 2-1. PMOD header pin functions

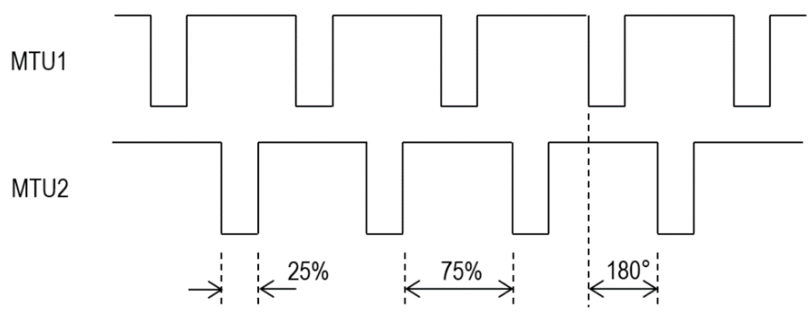
Pin	Signal	Direction	Function
1	MTU1	Input	PWM signal form the host MCU
2	TX_HOST	Input	UART signal input from the host MCU
3	RX_HOST	Output	UART signal output to the host MCU
4	N/C	-	No connection
5	GND_HOST	Power	GND connection to the host MCU board
6	3V3_HOST	Power	3V3 supply from the host MCU board
7	MTU2	Input	PWM signal from the host MCU
8	N/C	-	No connection
9	N/C	-	No connection
10	N/C	-	No connection
11	GND_HOST	Power	GND connection to the host MCU board
12	3V3_HOST	Power	3V3 supply from the host MCU board

2.1 Power supply and PWM signals

Power is delivered to the RL78/I1C PMOD module at 3V3 through the PMOD header. The module contains an isolation transformer which provides galvanic isolation between the host MCU development boards power supply and the RL78/I1C PSU circuit, that is referenced to the AC line.

In order to pass power over the isolation transformer, the 3V3 DC supply from the MCU development board is modulated with a complimentary PWM signal generated by the host MCU to create a pseudo sinewave. The frequency should be 500kHz, the duty cycle should be 75%, and the phase alignment should be 180°.

Figure 2-1: Dual complimentary PWM signals applied to PMOD pins MTU1 and MTU2



Note - The host MCU signals must <u>not</u> be allowed to be at a static logic 0 level otherwise the PMOD module will be damaged.

2.2 UART signals

The PMOD module communicates with the host MCU development board through a UART interface. Data isolation is provided with opto-couplers. The baud rate utilized is 9600, with a format of 7-bits, 1 stop bit, even parity and no flow control.

2.3 Programming header J1

Header J1 is the programming and debugging connection to the RL78/I1C MCU. This header contains all connections required to program and debug the RL78 family device from a Renesas E2 or E2Lite debugger.

Table 2-2. RL78/I1C programming/debug header pin functions

Pin	Signal	Direction	Function
1	VCC	Power	VCC connection to the RL78/I1C
2	TRST	Input	
3	JRESET	Input	
4	TOOL0	Input	
5	GND	Power	GND connection to the RL78/I1C

In order to interface the 5-pin header on the PMOD module to the 14-pin header on the E2/E2Lite debugger, an adaptor cable must be fabricated. See Figure **2-2** below.

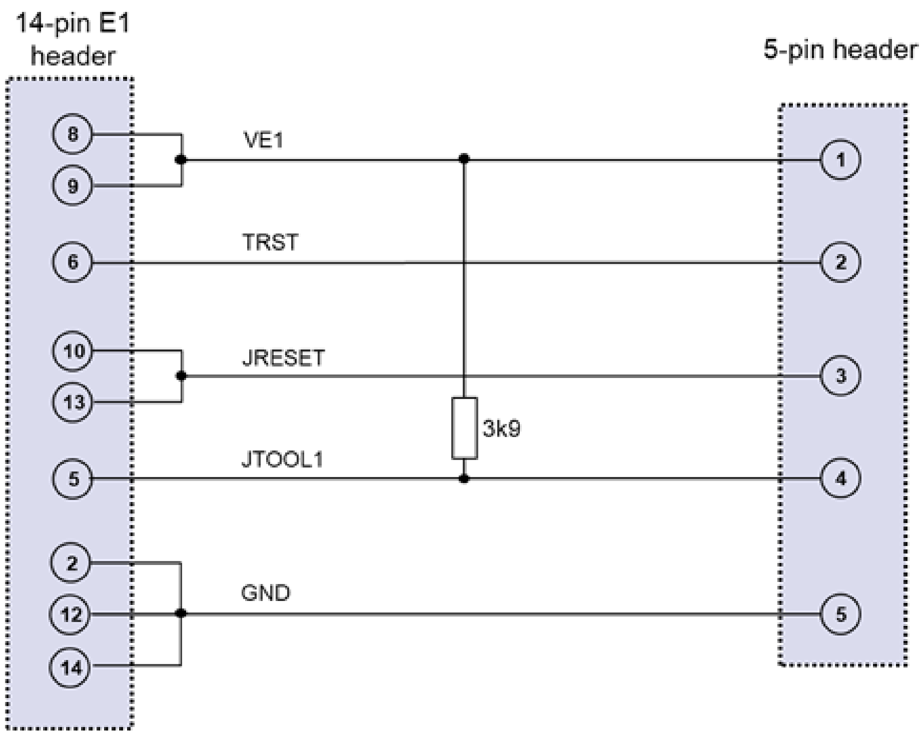


Figure 2-2**: 14-pin E2/E2Lite to 5-pin PMOD module adaptor cable connections**

Note – The programming header J1 is <u>not</u> protected with any high-voltage isolation components. <u>DO NOT</u> connect the E2/E2Lite debugger when the PMOD module is connected to the AC line without additional external protective equipment (not supplied with this kit).

2.4 AC Line

Connect the AC power cables to the PMOD module through the three screw terminals.

Table 2-3. AC line connections

Terminal marking	Enclosure marking	Function
NEUTRAL_IN	N	**Neutral connection terminal** Used for voltage measurement reference
LIVE_IN	L1	**Phase/Live input connection terminal** Used for voltage and current measurements – **high current path**
LIVE_OUT	L2	**Phase/Live output connection terminal** Used for current measurements – **high current path**

The AC connection terminals are labelled on the PCB silkscreen and molded into the enclosure.

All three terminals utilize M4 x10mm pan head machine screws with captive nuts. The AC line cables must be terminated with suitable ring terminals.

Ensure that the conductor diameter (cross sectional area) is suitable for the load connected.

Note - If the metrology module is to be operated at its maximum rated current of 80A rms, the conductor should be sized to provide adequate heat transfer from the internal shunt to maintain a low operating temperature for optimum accuracy. A conductor of 16mm^2 or greater is recommended.

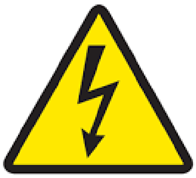
The AC line cables require insulation rated at 90°C or greater.

Figure 2-3: Example AC line connection to the RL78/I1C PMOD module (low current usage)

2.5 Optional Current Transformer (CT)

An external Current Transformer (CT) can be fitted to provide a secondary current monitoring channel. This CT would typically be installed on the neutral conductor to provide tamper detection for 1-ph 2-wire meter applications.

The CT is not provided in the RL78/I1C PMOD kit. A suitable CT with a turn's ratio of approx. 1:2500 should be sourced, such as an AmoTech ASM-120L. Connect the CT to header J2. The burden resistor is already fitted to the RL78/I1C PMOD PCB.



Warning – Dangerous high voltages are present within the RL78/I1C PMOD module. Ensure that all protective covers are replaced before connection to the AC supply, and that all conductors used are insulated where they exit the PMOD enclosure.

All components, including the RL78/I1C MCU, on the AC line side of the isolation components are referenced to the AC line LIVE-IN terminal. Do not attempt to probe or measure any signals when the AC line is energized without additional external protective equipment.

3.Getting started using the PMOD module

3.1 With a PC

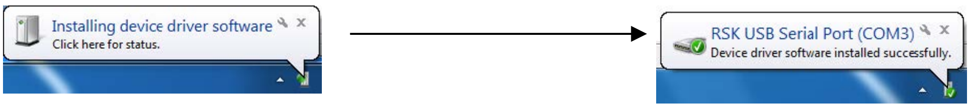
The RL78/I1C PMOD module is supplied with a USB-to-PMOD interface adaptor that allows the PMOD module to be used out-of-the-box with a PC for immediate evaluation.

The USB-to-PMOD adaptor includes a USB-UART interface that provides a virtual COM port on the host PC, and it supplies the dual complementary PWM signals and 3V3 power to the module.

3.1.1 Connect and install the USB driver

When the USB-to-PMOD adaptor is first connected to a PC running Windows™ the PC will look for a driver. This driver is usually preinstalled with the Windows™ OS, so the PC should be able to find it. The PC will report that it is installing a driver and then report that a driver has been installed successfully, as shown in **Figure 3-1**. The exact messages may vary depending upon operating system.

Figure 3-1: USB-Serial Windows™ Installation message



If you do not have the driver, please download the driver installer from the FTDI website:

https://www.ftdichip.com/Drivers/VCP.htm

Once the driver is installed, the interface will be available as a COM port. The exact COM port numbers allocated will vary but will appear in Device Manager.

Note – if the USB device fails to enumerate correctly it is recommended to use a powered USB hub.

3.1.2 Read data from the RL78/I1C

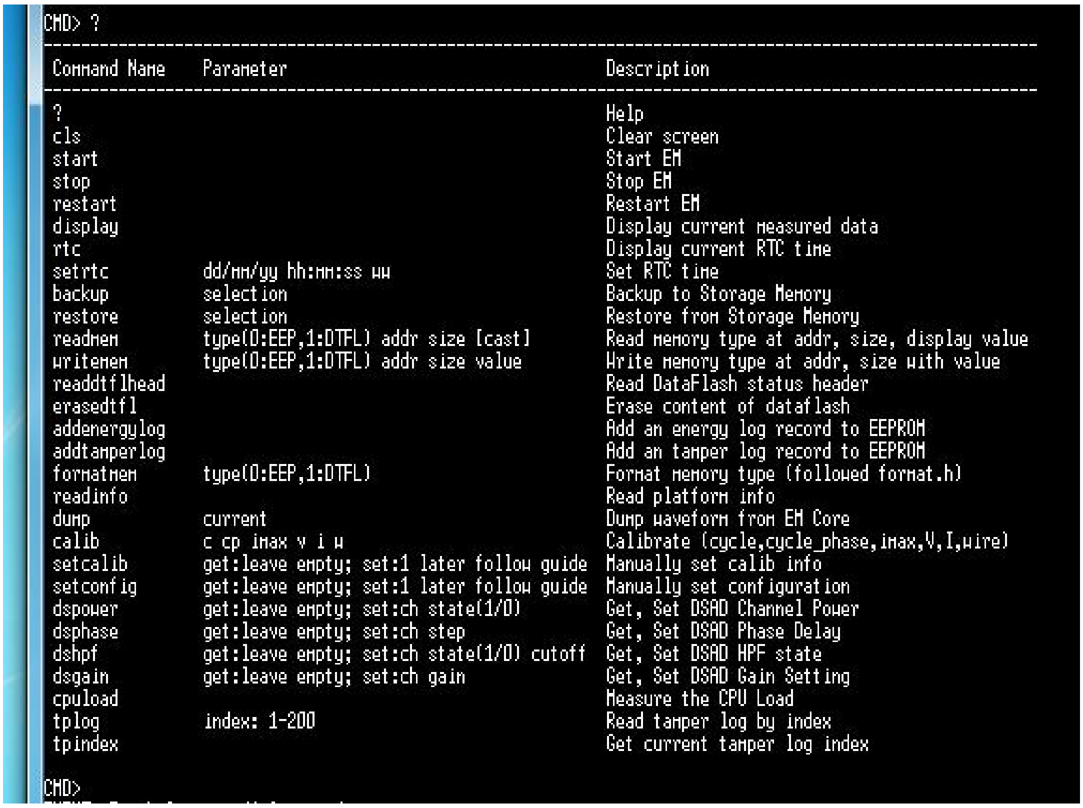
Open a terminal program such as TeraTerm and connect to the previously identified COM port with UART settings 9600 baud, 7-bit, 1-stop bit, even parity.

Connect the PMOD module to the USB-to-PMOD adaptor. The RL78/I1C metrology application should now transmit start-up statistical data, as seen in Figure 3-2 below.

```
+--------------------------------------------------------------------------+
|                           Energy Meter Start-up                          |
+--------------------------------------------------------------------------+
|
|    All peripherals has been initialized by hdwinit()
|    CMD Prompt has been started (__DEBUG mode)
|  1. Check Reset Flag                                       [          OK] |
|  2. Initialize meter data storage                          [          OK] |
|  3. Initialize MCU Configuration Page                      [          OK] |
|  4. Initialize EM Core by default information on MCU       [          OK] |
|  5. Register event callback                                [          OK] |
|  6. Start all other peripheral modules
|     . Start RTC module      01/01/2000 00:00:00            [          OK] |
|  7. Load Meter Data:
|     . Check meter data format:                             [   FORMATTED] |
|     . Restore library data from EEPROM:                    [          OK] |
|  8. Load MCU Configuration Data:
|     . Check MCU Configuration Page                         [   FORMATTED] |
|     . Restore configuration from MCU Configuration Page    [          OK] |
|     . Restore calibration from MCU Configuration Page      [          OK] |
|  9. Start EM Core                                          [          OK] |
| 10. Read platform information from EEPROM                  [          OK] |
| 11. Update number of reset to EEPROM                       [          OK] |
+--------------------------------------------------------------------------+
| 12. Platform detail information
|      . Unit Code          :
|      . Firmware Version   :
|      . Type of meter      :
|      . Manufacture Date   : 00/00/2000
|      . Number of reset    : 1
|      . LCD Scroll Period  : 0
+--------------------------------------------------------------------------+
```

Figure 3-2: RL78/I1C metrology application start-up message

To obtain a full set of commands for the metrology application type "?" followed by a carriage return. The command set will be returned as shown in **Figure 3-3** below.



```
CMD> ?
------------------------------------------------------------------------------------------------
 Command Name    Parameter                                  Description
------------------------------------------------------------------------------------------------
 ?                                                          Help
 cls                                                        Clear screen
 start                                                      Start EM
 stop                                                       Stop EM
 restart                                                    Restart EM
 display                                                    Display current measured data
 rtc                                                        Display current RTC time
 setrtc          dd/mm/yy hh:mm:ss ww                       Set RTC time
 backup          selection                                  Backup to Storage Memory
 restore         selection                                  Restore from Storage Memory
 readmem         type(0:EEP,1:DTFL) addr size [cast]        Read memory type at addr, size, display value
 writemem        type(0:EEP,1:DTFL) addr size value         Write memory type at addr, size with value
 readdtflhead                                               Read DataFlash status header
 erasedtfl                                                  Erase content of dataflash
 addenergylog                                               Add an energy log record to EEPROM
 addtamperlog                                               Add an tamper log record to EEPROM
 formatmem       type(0:EEP,1:DTFL)                         Format memory type (followed format.h)
 readinfo                                                   Read platform info
 dump            current                                    Dump waveform from EM Core
 calib           c cp imax v i w                            Calibrate (cycle,cycle_phase,imax,V,I,wire)
 setcalib        get:leave empty; set:1 later follow guide  Manually set calib info
 setconfig       get:leave empty; set:1 later follow guide  Manually set configuration
 dspower         get:leave empty; set:ch state(1/0)         Get, Set DSAD Channel Power
 dsphase         get:leave empty; set:ch step               Get, Set DSAD Phase Delay
 dshpf           get:leave empty; set:ch state(1/0) cutoff  Get, Set DSAD HPF state
 dsgain          get:leave empty; set:ch gain               Get, Set DSAD Gain Setting
 cpuload                                                    Measure the CPU Load
 tplog           index: 1-200                               Read tamper log by index
 tpindex                                                    Get current tamper log index

CMD>
```

Figure 3-3: RL78/I1C metrology application command set

To obtain the present energy measurement data type "display" followed by carriage return. Data will be returned as shown in **Figure 3-4** below.

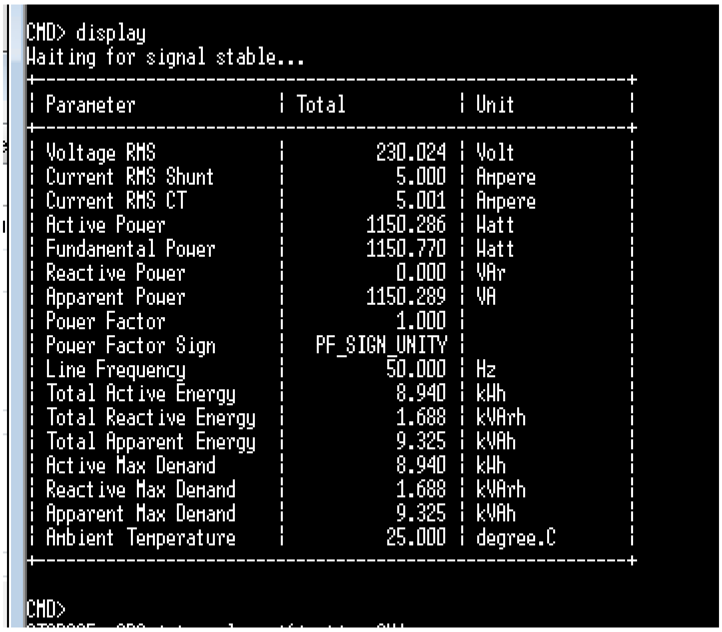


Figure 3-4: RL78/I1C metrology application energy measurement data

3.1.3 Calibration

The RL78/I1C metrology application is pre-calibrated, so should not require additional calibration before use. However, if subsequent calibration is required then the following two steps shall be followed.

Step 1: For the CT channel (ch0), send the command following the format below:

- **calib 100 100 [max I] [V] [I] [ch]**

The conditions applied are 230V, 5A, max current 60A, so the command is "calib 100 100 60 230 5 0"

Calibration confirmation data will be returned as shown in **Figure 3-5** below.

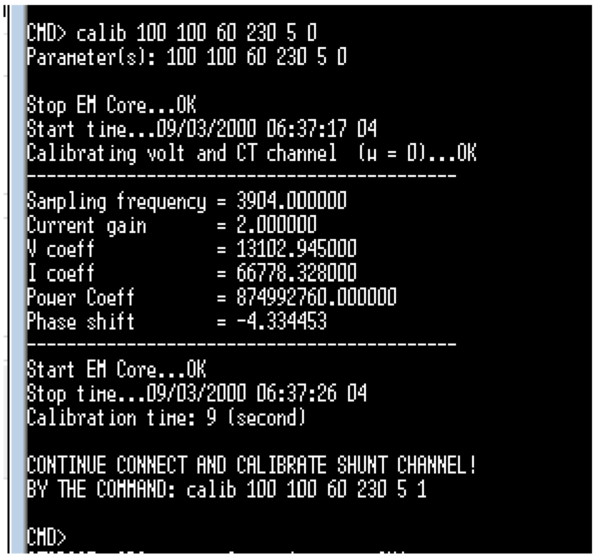
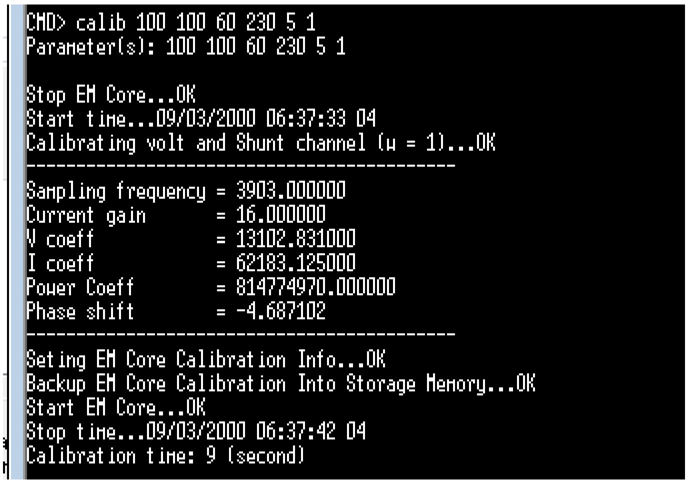


Figure 3-5: RL78/I1C metrology application calibration confirmation data (step 1)

Step 2: For the Shunt channel (ch1), follow the on screen instruction and send the command shown:

"calib 100 100 60 230 5 1"

Again, the calibration confirmation data will be returned as shown in **Figure 3-6** below.



```
CMD> calib 100 100 60 230 5 1
Parameter(s): 100 100 60 230 5 1

Stop EM Core...OK
Start time...09/03/2000 06:37:33 04
Calibrating volt and Shunt channel (w = 1)...OK
------------------------------------------
Sampling frequency = 3903.000000
Current gain       = 16.000000
V coeff            = 13102.831000
I coeff            = 62183.125000
Power Coeff        = 814774970.000000
Phase shift        = -4.687102
------------------------------------------
Seting EM Core Calibration Info...OK
Backup EM Core Calibration Into Storage Memory...OK
Start EM Core...OK
Stop time...09/03/2000 06:37:42 04
Calibration time: 9 (second)
```

Figure 3-6: RL78/I1C metrology application calibration confirmation data (step 2)

3.1.4 Power impulse LED

LED D1 is the power impulse LED. It is pre-configured for 1200imp/kWh.

3.2 With a host MCU development board

Connect the PMOD module to a suitable Type 4A PMOD interface on the host MCU development board, as defined in section 2, and configure the host MCU to provide the dual complementary PWM signals as defined in section 2.1.

Establish a serial UART connection with the RL78/I1C metrology application as defined in section 2.2, with the same command set as seen in section 3.1.2.

When debugging the host MCU, be careful to avoid ANY condition that will allow the host MCUs MTU1 and MTU2 signals to be at a static logic 0 level, otherwise the PMOD module will be damaged.

Revision History	RL78/I1C User’s Manual: Isolated Shunt PMOD

Rev.	Date	Description	
		Page	**Summary**
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