RL78, RX Family

R01AN2669EG0100
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Pmod™ Application Board

Battery Charging, Sensor and Pmod Sample Code

Introduction

The Pmod™ Application board is an auxiliary PCB designed to connect to Renesas Starter Kit (RSK) boards using their application headers. It provides additional features not necessarily found on the RSK board, such as 4 Pmod™ interfaces, battery-charge control for USB applications, a temperature sensor, LEDs, buzzer and some extra switches. Further functionality can be provided from sensor peripherals which are not fitted as standard. These are a digital accelerometer and both an analogue and digital gyroscope.
This application note describes the technical details of the sample code designed to demonstrate how to use the Pmod™ Application Board peripherals with the RSK. Each sample has been targeted at a specific RSK to which the Pmod™ Application Board connects. The target device for each sample is shown in the table below.

Sample Code	Target Platform
Battery Charging	RSKRL78G1C
Accelerometer Sensor	RSKRX111
Analogue Gyroscope Sensor	RSKRX111
Digital Gyroscope Sensor	RSKRX111
Temperature Sensor	RSKRX111
Pmod™ Display	RSKRX111

Please refer to the Pmod™ Application Board User's Manual for compatibility with other RSK's.

The following documents apply to the Pmod™ Application board. Make sure to refer to the latest versions of these documents. The newest versions of the documents listed are available from the Renesas Electronics Web site.

Document Type	Description	Document Title	Document No.
User's Manual	Describes the technical details of the RSK hardware.	Pmod™ Application Board User's Manual	R20UT3112EG0100
Quick Start Guide	Provides simple instructions to setup the RSK and run the first sample.	Pmod™ Application Board Quick Start Guide	R20UT3113EG0100
Schematics	Full detail circuit schematics of the RSK.	Pmod™ Application Board Schematics	R20UT3111EG0100
Application Note	Pmod™ Application Board – Sensors, Pmod™ and Battery charging Application Note	Pmod™ Application Board Application Note	R01AN2669EG0100

Contents

1. Overview

This applications note aims to provide the user with information that describes each embedded firmware sample for the Pmod Application Board. Its aim is to describe the operation of the sample code for the various peripherals, to aid in the understanding of how to operate such peripherals with the Renesas microcontrollers on the RSK boards.

1.1 Equipment Required

Listed below is the equipment required to run all the sample code.

- The Pmod Application board
- RSKRX111 Test board with default option links and then configured as in section Figure 3-2.
- RSKRL78G1C Test board with default option links and then configured as in section Figure 3-1.
- Pmod LCD Module.
- E1 Emulator.
- E1 USB cable.
- Regulated Power Supply Unit (PSU). Can be used for supplying 5.0V @ 500mA to the RSK.
- A PC running windows 8/7 with e2 studio version 3.1.0.24
  (Available via web download at http://www.renesas.com/e2studio_download)
- USB type A to mini B cable.
- Option Links: 0Ω resistor RC0603JR-070RL.
- Accelerometer IC: ADXL345BCCZ.
- Analogue Gyroscope : ADXRS652BBGZ.
- Digital Gyroscope: ADXRS450BRGZ.
- Amplifier : MCP6401UT-E/OT.

2. Application Leading Tool (Applilet)

Applilet for RSKL78G1C & RSKRX111 has been used to generate part of the sample code discussed in this document. Applilet is a Windows GUI tool for generating template 'C' source code and project settings for the RSKRRL78G1C & RSKRX111. When using Applilet, the engineer is able to configure various MCU features and operating parameters using intuitive GUI controls, thereby bypassing the need in most cases to refer to sections of the Hardware Manual.

Once the engineer has configured the project, the 'Generate Code' function generates sample C code files for each specific MCU feature selected. These code modules are name 'r_cg_xxx.h', 'r_cg_xxx.c', and 'r_cg_xxx_user.c', where 'xxx' is a three letter acronym for the relevant MCU feature, for example 'adc'. Within these code modules, the engineer is then free to add custom code to meet their specific requirement. Custom code must be added in between the following comment delimiters:

```
/* Start user code for adding. Do not edit comment generated here */
/* End user code. Do not edit comment generated here */
```

Applilet will locate these comment delimiters, and preserve any custom code inside the delimiters on subsequent code generation operations. This is important if after adding custom code, the engineer needs to re-visit Applilet to change any MCU operating parameters.

Applilet is not released with this Pmod Application Board but is available via a web download at:

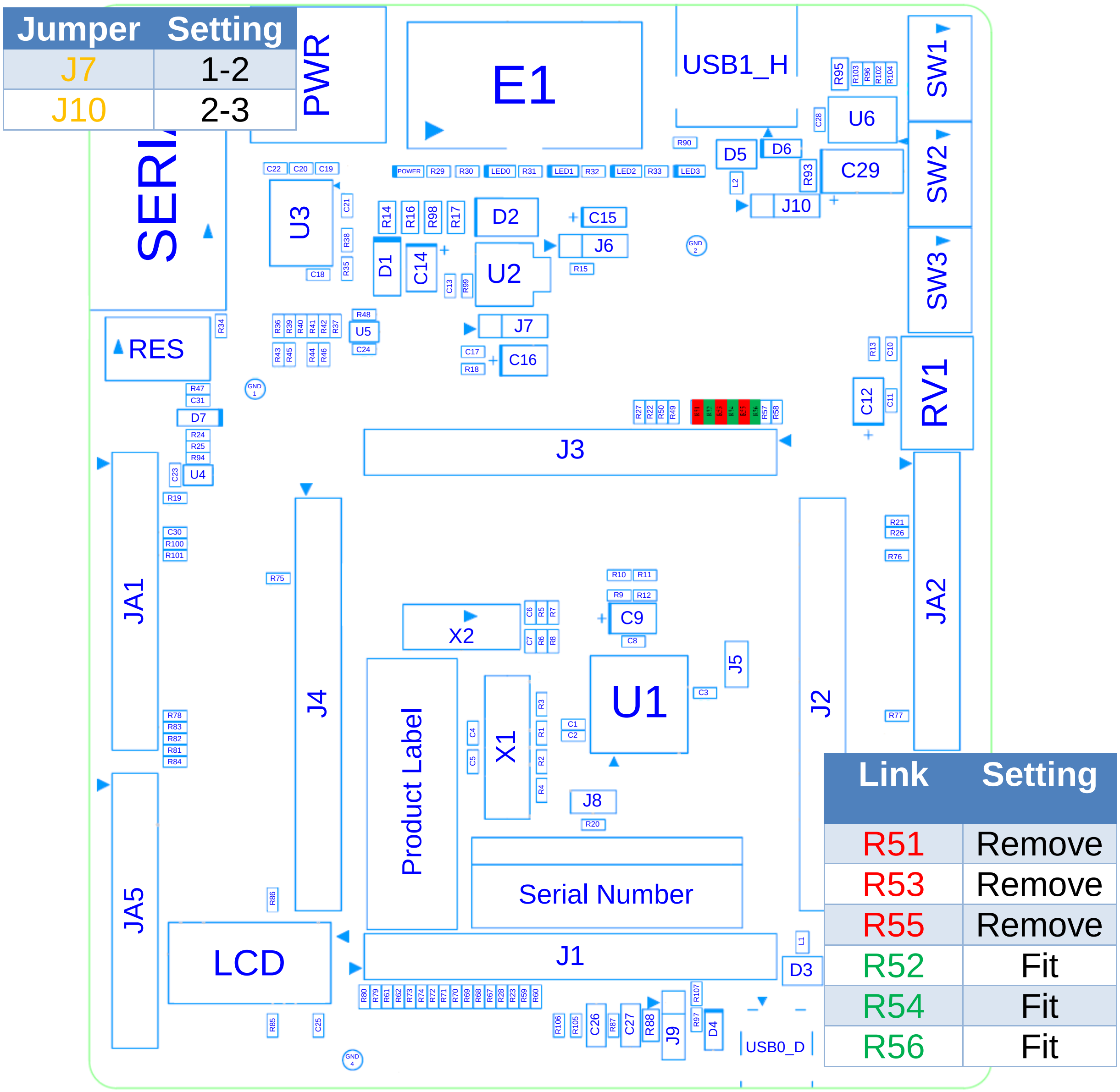
http://www.renesas.com/applilet_download

Note that the Applilet version for the relevant project is mentioned at the top of every code generated source file.

3. Hardware Setup

3.1 RSKRL78G1C Configuration

The jumper settings and option links needed for the 'Battery Charging' sample are shown in Figure 3-1.



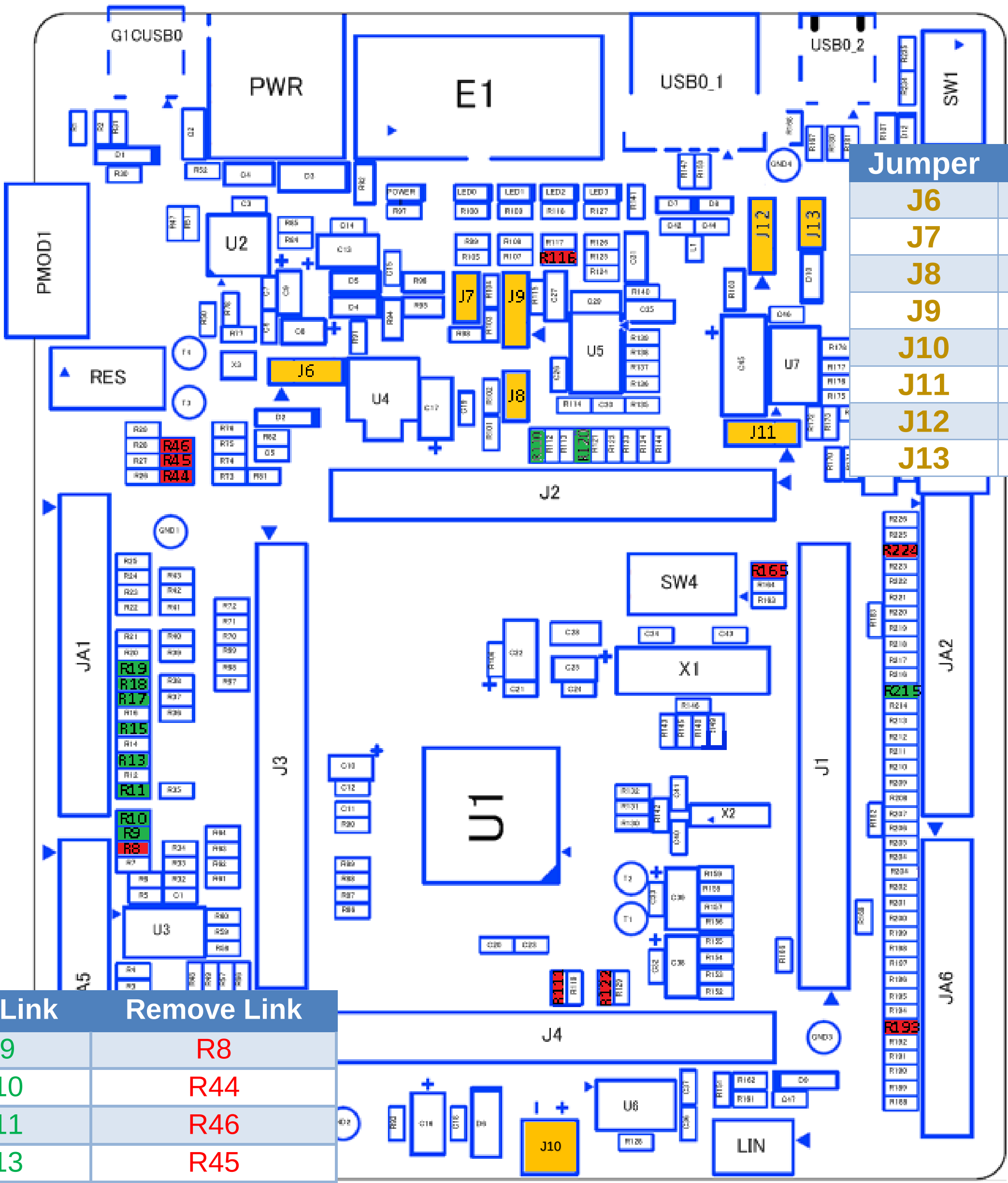
Jumper	Setting
J7	1-2
J10	2-3

Link	Setting
R51	Remove
R53	Remove
R55	Remove
R52	Fit
R54	Fit
R56	Fit

Figure 3-1: Illustration of option links & jumper settings needed to modify the RSKRL78G1C for the 'Battery Charging' sample.

3.2 RSKRX111 Configuration

The jumper settings and option links needed for the Pmod™ Display and Sensor samples are shown in Figure 3-2.



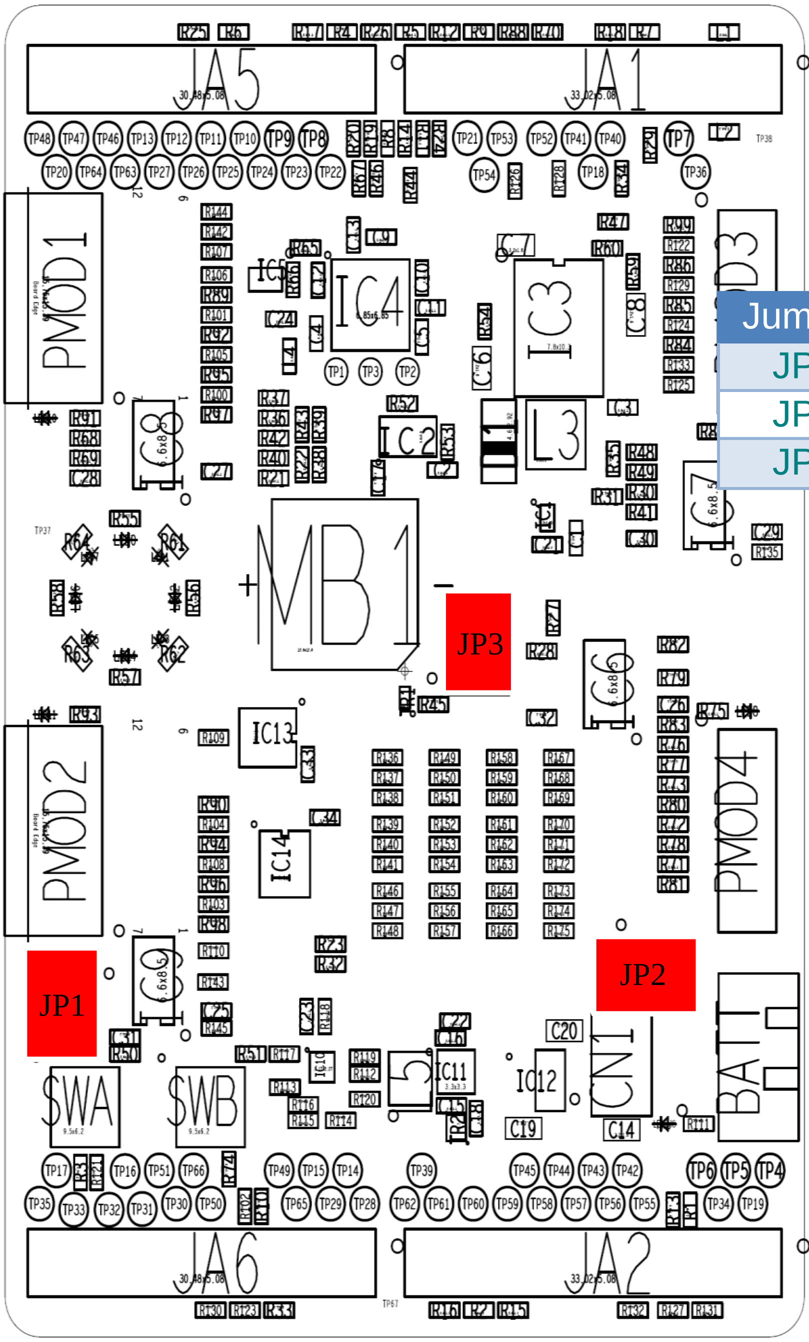
Jumper	Setting
J6	n/c
J7	n/c
J8	n/c
J9	Pin2-3
J10	DNF
J11	Pin1-2
J12	Pin1-2
J13	Pin1-2

Add Link	Remove Link
R9	R8
R10	R44
R11	R46
R13	R45
R15	R111
R17	R116
R18	R122
R19	R165
R215	R193
	R224

Figure 3-2 : Illustration of option links needed to modify the RSKRX111 for the Pmod Display and Sensor samples.

3.3 PmodTM Application Board

The jumper settings needed for the PmodTM Application Board are shown in Figure 3-3 . For option link modifications on the PmodTM Application Board please refer to the relevant sample header in this document.



Jumper	Setting
JP1	Pin1-2
JP2	Pin2-3
JP3	Pin1-2

Figure 3-3: Illustration of jumper settings needed for the Pmod™ Application Board.

* This board will be sold or is sold to publics as Renesas brand

4. Battery Charging Sample

The ‘Battery Charging’ sample has been developed with the RSKRL78G1C platform together with the Pmod™ Application Board. It aims to demonstrate the use of the RSK and Pmod™ Application Board as a USB peripheral device (charging the battery from a Host device) or as a USB host device (when the battery is a source of power to connected USB peripherals). This is in compliance with the USB ‘Battery Charging Specification v1.2’.

4.1 Host Mode

When configured as a Host, the RSK/Pmod™ Application board can be configured to function as a Charging Downstream Port (CDP) or a Dedicated Charging Port (DCP), as defined by the USB battery charging specification. The Pmod™ Application Board supplies regulated power from either the lithium-ion battery or the RSK power source to a USB peripheral device via the Host USB connection on the RSK, with a current limit appropriate to the port configuration.

In Host Mode, the battery charge controller IC, R2A20056BM (IC10 on page 5 of the schematics) is used to select the power source for supplying power to the connected peripheral device, and to limit the discharge current of the lithium-ion battery, according to the charging mode selected. The output of the R2A20056BM is then fed to a 5V switched-mode regulator to provide a stable supply for the USB connection.

The RSK/ Pmod™ Application Board, operating as a Host can be configured to operate in the following modes:

(a) Charging Downstream Port (CDP)

A Charging Downstream Port is a USB Port in which enumerates. As such it does support data as well. It is identified by manipulation of the data lines, as defined by the USB Battery Charging Specification. The current limit set is 1.5A.

(b) Dedicated Charging Port (DCP)

A Dedicated Charging Port is a USB port that does not enumerate. As such there is no data support. It is identified by both USB data lines D+ and D- being connected together by a resistance not exceeding 200 Ohms. The current limit set is 1.5A.

4.1.2 Configuration

To configure the RSK/ Pmod™ Application board alterations to the source file ‘r_cg_userdefine.h’ must be made. To configure it to be a Host, Pmod_CONFIG must be defined as Pmod_HOST_MODE.

For the RSK/ Pmod™ Application Board to be configured as a CDP, Pmod_USB_BATT_CONFIG must be defined as Pmod_CDP_MODE.

```
#define PMOD_CONFIG   (PMOD_HOST_MODE)

#define PMOD_USB_BATT_CONFIG (PMOD_CDP_MODE)
```

For the RSK/ Pmod™ Application Board to be configured as a DCP, Pmod_USB_BATT_CONFIG must be defined as Pmod_DCP_MODE

```
#define PMOD_CONFIG   (PMOD_HOST_MODE)

#define PMOD_USB_BATT_CONFIG (PMOD_DCP_MODE)
```

To power the RSK/ Pmod™ Application Board ensure that the Jumper J6 is fitted on pins 2-3 as well as the configuration showed in Figure 3-1.

For safety reasons note that to only power the board from the battery after the battery_source_settings() function has been executed.

4.2 Peripheral Mode

In Peripheral Mode, the Pmod™ Application Board provides the means to charge a connected lithium-ion battery from a USB host via the Peripheral USB connection on the RSK. The RSK microcontroller will detect the Host charger status, either SDP, CDP or DCP, and then communicate with the battery charge controller R2A20056BM IC10 via I2C to control the charging current of the battery accordingly.

4.2.1 Configuration

To configure the RSK/Pmod™ Application Board, alterations to the source file ‘r_cg_userdefine.h’ must be made. To configure it as a Peripheral Device, the define Pmod_CONFIG must be defined as Pmod_PERI_MODE.

```
#define PMOD_CONFIG  (PMOD_PERI_MODE)

#define PMOD_USB_BATT_CONFIG (0)
```

4.3 Running Battery Charging Sample

Ensure that the RSKRL78G1C option links are modified from the default configuration to the configuration shown in Figure 3-1. The default link configuration for the Pmod™ Application Board is correct for the battery charging application. Connect the Pmod™ Application Board to the RSK.

1. Ensure that the jumper links on the Pmod™ Application Board are as figure 4-3.

2. Open e2 studio and the USB battery charging sample project. Make the appropriate selections in ‘r_cg_userdefine.c’ in order to define Peripheral or the required Host mode. Build the code.

3. Connect the Pmod™ Application Board to the RSK on the Application Headers. Connect the display to the Pmod1 connector on the Pmod™ Application Board. Connect the E1 debugger to the PC with a USB cable and then to the RSK. Connect a power supply to the RSK.

4. Run the code in debug mode.

5. For the RSK / Pmod™ Application Board configured as a Peripheral, connect to the Host device using the mini-B socket on the RSK (usually called USB0-2).

6. For the RSK / Pmod™ Application Board configured as a Host, connect the peripheral to the USB-A Socket, usually called USB0-1 on the RSK PCB.

4.4 User Interface

In either mode, there will be certain features upon the Pmod™ LCD Screen available for the user. After the user-pressing switch 1 denoted SW1 upon the RSKRX111, the user will enter the menu. Using the variable resistor denoted RV1 the user will be able to highlight an option in the menu. To select the option the user must press SW1, and to escape to the menu the user must press SW2.

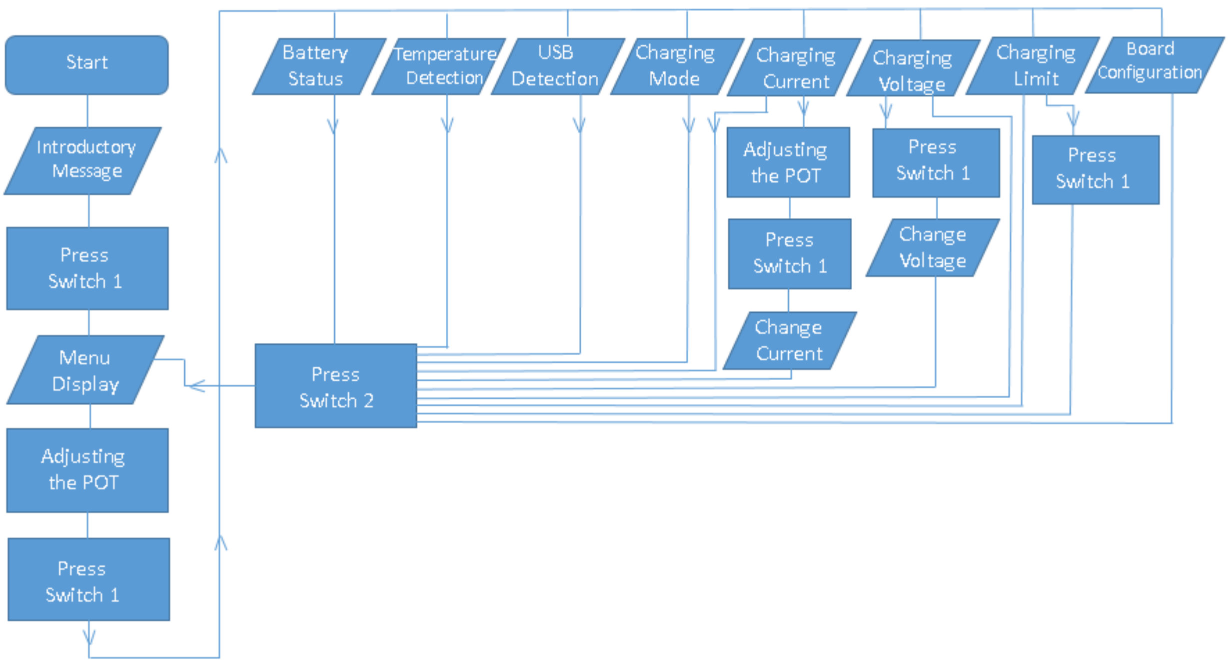


Figure 4-1 A flow chart to show user interface operation.

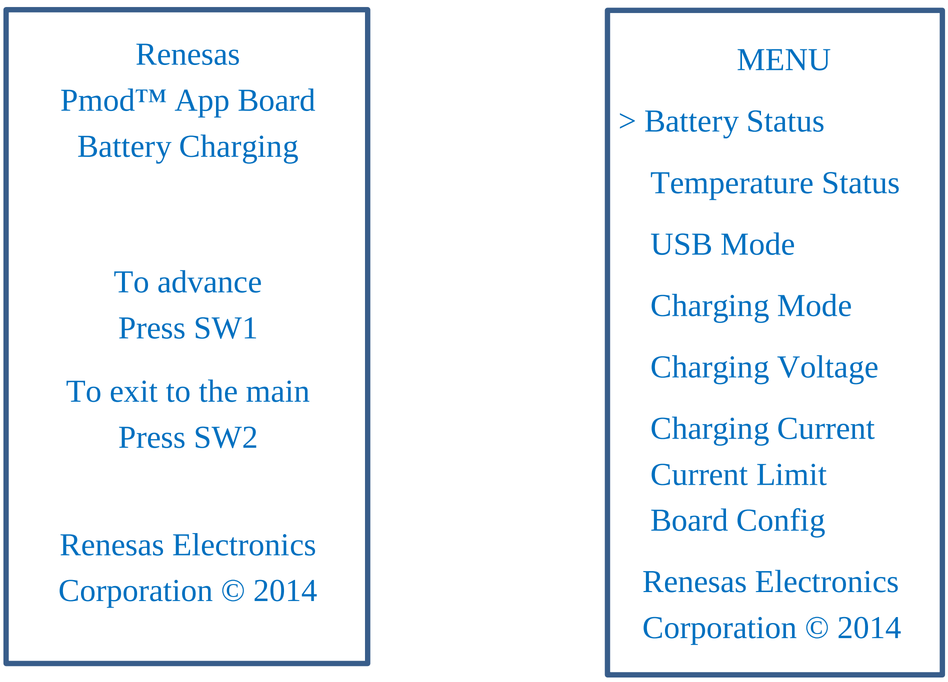


Figure 4-2 : A diagram to show the ‘Introductory Message’ and ‘Menu’ respectively.

4.4.1 Battery Status

In Battery Status, the battery charge controller R2A20056BM IC10 is interrogated and the battery state summarised on the Pmod™ display. The possibilities are "Battery Not Detected", "Weak Battery", "Full Battery", "Battery Detected" or "Good Battery". For more information upon these possibilities or on the detection method, please refer to the R2A20056BM data sheet.

4.4.2 Temperature Detection

Temperature Detection is a feature only for batteries with a thermistor connected to them, i.e. a battery with three wires. The battery charge controller R2A20056BM IC10 is read to determine the temperature status. The Pmod™ display will display one of the following possibilities "Temperature protection (LOW)","Low rate charge (LOW)","Normal charge", "Low rate charge(HIGH)", "Temperature protection (HIGH)", or "No thermistor".

4.4.3 USB Detection

In this mode, the Pmod™ screen will display the state of the USB. The possibilities are "PERIPHERAL-DCP","PERIPHERAL-CDP","PERIPHERAL-SDP", "HOST-DCP" or "HOST-CDP".

4.4.4 Charging Mode

Charging Mode will again read the battery charge controller R2A20056BM IC10 and display the detected charging state. The possibilities are "DEFAULT", "Forced Charge", "Trickle Charge", "Quick Charge", "High temp.charge-1","High temp.charge-2", "and Charge completion detection “,” Battery non-connection, Error-1 “,” Error-2” or “Error-3”. For more information upon these possibilities or on the detection method, please refer to the R2A20056BM data sheet.

4.4.5 Charging Voltage

In this submenu, the user will be able to choose the voltage the battery charge controller R2A20056BM IC10 sets to charge the battery. Pressing SW1 cycles through 4.00V, 4.05V, 4.10V, 4.15V and 4.20V.

4.4.6 Charging Current

In this submenu, the user will be able to choose the different current settings for different modes of charging; quick charge, completion charge and trickle charge. For quick charge current, the options are 0.5c or 1.0C. For completion current, the options are 0.05C, 0.1C or 0.2C and for trickle charge current, the options are 0.1C or 0.2C. For more information on the current values and conditions, please refer to the R2A20056BM data sheet.

4.4.7 Current Limit

Choosing the Current Limit will allow the user to control the current limit. The options available are “100mA”, “500mA”, “1000mA”, “1500mA”, “1800mA”, “Limitless”, “No Use ”, “SUSPEND”. The options can be achieved by pressing switch 1 to cycle through the options.

4.4.7 Board Configuration

In board configuration, the Pmod™ LCD Screen will display either ‘Host’ or ‘Peripheral’.

4.5 Sample Code Information

4.5.1 RSKRL78G1C Interface

Task	Module	MCU Pins Used	Application Header Pins Used	Function
Interfacing with IC10 R2A20056BM Charge Controller IC	MCU - IIC	SCLA0-P60 SDAA0-P61	JA1 – 25 JA1 – 26	Communicating with IC10 R2A20056BM battery charge controller.
Interfacing with Pmod™ Screen	MCU – SCI0 MCU – I/O MCU – IIC	SO00TX – P51 SCLK00 – P30 P21 – (Pmod1 SS) P23 – (Pmod1 PIN9) SCLA0-P60 SDAA0-P61	JA2 – 6 JA2 – 10 JA1 – 10 JA1 – 12 JA1 – 25 JA1 – 26	Data Transfer on Pmod channel 1 Driving Port Expander IC14 for Pmod RST and PIN10 lines
USB power supply / charging	EXT_CHG EXT_BATT EXT_VBUS	N/A N/A N/A	JA6 – 21 JA6 – 19 JA6 – 17	- Function Battery Charge Supply - Host supply from battery to RSK - Host supply to USB

Table 4-1: Peripherals used for the Battery Charging Sample.

4.6 Operation

1. After initialisation, The sample application name, copyright and instructions will be displayed on the Pmod™ LCD screen.
2. In Host mode the USB power supply is configured to be derived from either the RSK power supply, or the battery, by enabling the output of the charge controller IC10 to the 5V power supply on the Pmod™ Application Board in the enable_5V() function.
3. Depending on the defined USB port type the Host USB will be configured to either be a CDP or DCP. These port configurations are executed in the usb_dcp_configuration() & usb_cdp_configuration() functions respectively.
4. In Peripheral mode the port type connected to the function USB port on the RSKRL78G1C is detected, in the usb_port_detection() function.
5. Following this the function user_interface() is entered.
6. The sample will then wait for switch 1 on the RSKRL78G1C to be pressed, before entering the main loop.
7. Following this the user interface is set up in an infinite while loop to handle the menu features. A menu is displayed and a selection adjusted using the pot on the RSK, in the function main_menu_selector() (along with the display update). Pressing SW1 on the RSK makes the selection, and the appropriate function is called from the submenu_display() function.
8. The submenu includes 8 functions:
   i. battery_detection_state() - Achieved by reading register 0x03 of the battery-charging IC and will display according to the data received.
   ii. temperature_detection() - Achieved by reading the TEMP bits of register 0x04 of the battery charging IC and display accordingly.
   iii. usb_state() - In Host mode, this is a consequence of the defined operation of the Battery Charging Sample. In Peripheral mode the display shows the connected USB Host type, the stored result from the function mentioned in step 4.
   iv. charging_mode() - Achieved by reading the USB bits of register 0x04 of the battery charging IC and displaying the result.
   v. charging_voltage() - In this subheading the sample allows the user with an interrupt driven switch to select and see the charging by reading and writing to the VCHG bits of register 0x00.
   vi. charging_current() – Similar to Charging Voltage switch 1 is used to change current values as described in 5.4.6 . This is accomplished by reading and writing to the 0x00 address of the battery-charging chip.
   vii. board_configuration() – This is displayed as a consequence of the defined operation.
   viii. error() – Uses the SPI protocol to display “Error”.
9. The sample then waits until SW2 is pressed and repeats the loop from step 6.

5. Sensor Samples

The sensor samples have been developed on the RSKRX111 platform connected to the Pmod™ Application Board.

5.1 Accelerometer Sensor

The aim of this sample is to use the accelerometer to display acceleration in the 3 X, Y and Z planes.

The Pmod™ Application Board is not fitted with an accelerometer as default. An Analog Devices ADXL345 IC must be mounted on the Pmod™ Application Board in order for the sample code to work, fitted in position IC2.

The sample reads the relevant registers from the ADXL345 via the IIC bus connection and outputs the raw data for the X, Y and Z axes raw data to the display.

5.1.1 Connections

The accelerometer is to be soldered at position IC2 of the Pmod™ Application Board.
The RSKRX111 must be configured as detailed in Figure 3-2, for the Accelerometer Sensor Sample to work correctly.
Connect the Pmod™ Application Board to the RSKRX111 on the Application Headers.
Ensure the Pmod™ LCD display is attached to the Pmod1 Connector before power up.

5.1.2 RSK RX111 Interface

Task	Module	MCU Pins Used	Application Header Pins Used	Function
Communicating with IC2 ADXL345 accelerometer	MCU - IIC	SCL-PB0 SDA-PA6	JA1 – 26 JA1 – 25	Communicating with IC2 ADXL345 accelerometer
Interfacing with Pmod™ Screen	MCU – SCI0 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 P41 – (Pmod1 SS) P43 – (Pmod1 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 10 JA1 – 12 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 1 Driving Port Expander IC14 for Pmod RST and PIN10 lines

Table 5-1: Peripherals used for the 'Accelerometer Sensor' Sample.

5.1.3 Operation

1. The sample first initialises Pmod™ display on Pmod™ channel 1. The IIC MCU peripheral is set as a master to configure the port expander IC14 controlling the reset and pin10 lines for Pmod1 as well as the accelerometer. To communicate with the Pmod™ display, the SCI1 MCU peripheral is configured as 'Simple SPI bus' (Master transmit only).
2. It then uses the SPI protocol to display the name of the sample & copyright information.
3. The sample then loops repeatedly, reading the accelerometer device id for validation purposes then reading the acceleration values for the X, Y and Z axes.
4. Then it displays the results, unscaled onto the display connected to Pmod1.

5.2 Analogue Gyroscope Sensor

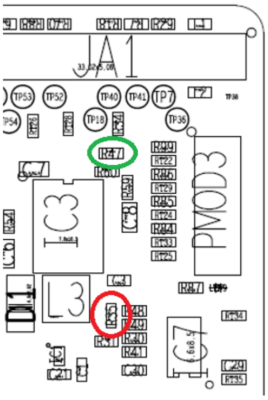
The aim for this sample is to use the analogue gyroscope to display the z-axis (yaw) angular rate of the PmodTM Application Board.

The PmodTM Application Board is not fitted with an Analogue Gyroscope or an associated Operational Amplifier by default. An Analogue Devices ADXRS652 IC and a Microchip MCP6401U must be mounted on the PmodTM Application Board in order for this sample to operate correctly, in positions IC4 and IC5 respectively.

The sample demonstrates the use of the Analogue Gyroscope, reading the output with the ADC and displaying the angular rate to the Pmod™ Screen.

5.2.1 Connections

The analogue gyroscope IC ADXRS652 and op-amp IC MCP6401U must be fitted in position IC4 and IC5 on the PmodTM Application Board respectively. Resistor 0Ω link R47 must be fitted and R35 must be removed. The locations are shown in Figure 5-1. This modification is required to route the analogue signal from the gyroscope (signal AGYRO) to the correct ADC port on the RSKRX111 (AN014).



Fit 0Ω Link	Remove Link
R47	R35

Figure 5-1: PmodTM Application Board Link Configuration for Analogue Gyroscope Sample

The RSKRX111 must be configured as detailed in Figure 3-2 for the Analogue Gyroscope Sensor Sample to work correctly.
Connect the Pmod™ Application Board to the RSKRX111 on the Application Headers.
Ensure the Pmod™ LCD display is attached to the Pmod1 Connector before power up.

5.2.2 RSKRX111 Interface

Task	Module	MCU Pins Used	Application Header Pins Used	Function
Gyroscope output (after MCP6401U op-amp buffer)	MCU - ADC	AN014 – PE6	JA5 – 3 (ADC6)	Analogue output of gyroscope
Interfacing with Pmod™ Screen	MCU – SCI0 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 P41 – (Pmod1 SS) P43 – (Pmod1 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 10 JA1 – 12 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 1 Control of port expander IC14 for Pmod RST & PIN10 lines

Table 5-2: Connections and MCU Peripherals used for the Analogue Gyroscope Sensor Sample.

5.2.3 Operation

1. The sample first initialises the display on Pmod1. In initiating the display, the IIC MCU peripheral is configured in I2C Mode (Master) to drive port expander IC14 that controls the RST and PIN10 lines of the Pmod™ interface. To communicate with the display, the SCI MCU peripheral is configured as 'Simple SPI bus' (Master transmit only).
2. The sample then sets the ADC MCU peripheral to operate in single-scan mode to read the analogue gyroscope's amplified output.
3. The sample then displays the name of the sample, instructions and copyright information.
4. The sample then enters an infinite while loop, first reading channel 14 of the ADC and waiting for the ADC conversion to complete.
5. It then converts the unsigned 12-bit ADC reading from the gyroscope to a string for it to be displayed on the display.

5.3 Digital Gyroscope Sensor

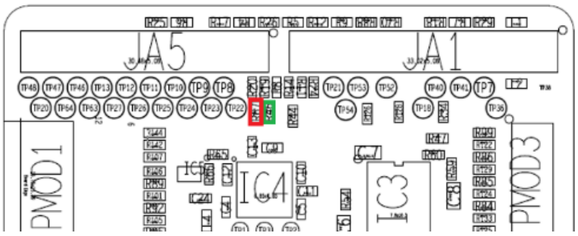
The aim for this sample is to use the digital gyroscope to display the z-axis (yaw) angular rate of the Pmod™ Application Board.

As supplied the Pmod™ Application Board is not fitted with a digital gyroscope. An Analogue Devices ADXRS450 IC will be needed to be sourced separately and soldered to the Pmod™ Application Board, in position IC3.

The sample demonstrates communication with the digital gyroscope, reading the output and displaying the acquired 'RTE' registers on the Pmod™ LCD display.

5.3.1 Connections

The RSKRX111 must be modified as detailed in Figure 3-2. The Digital Gyroscope IC ADXRS450 must be fitted at position IC3 of the Pmod™ Application Board. Resistor 0Ω link R46 must be fitted and R67 must be removed. The locations are shown in Figure 5-2. This modification is required to route the chip select line for the Gyroscope SPI communications but to the correct port on the RX111.



Fit 0Ω Link	Remove Link
R46	R67

Figure 5-2: Pmod™ Application Board Link Configuration for Digital Gyroscope Sample

The Pmod™ LCD display should be connected to the Pmod1 Connector before power up.

5.3.2 RSKRX111 Interface

Task	Module	MCU Pins Used	Application Header Pins Used	Function
Gyroscope Communications	MCU – SCI1* MCU – I/O	TXD1 – P16 SCK1 – P17 PE7 – (DGYRO_SS)	JA2 – 6 JA2 – 10 JA5 – 4	Communication with Digital Gyroscope via SCI in SPI mode.
Interfacing with Pmod™ Display	MCU – SCI1 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 P41 – (Pmod1 SS) P43 – (Pmod1 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 10 JA1 – 12 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 1 Control of port expander IC14 for Pmod RST & PIN10 lines

Table 5-3: Connections and MCU Peripherals used for the Digital Gyroscope Sensor Sample.

*** Note that this is not reproducible by Applilet as it uses a non-applilet function.**

5.3.3 Operation

1. The sample first initialises the display on Pmod1. In initiating the display, the IIC MCU peripheral is configured in I2C Mode (Master) to configure port expander IC14 to control the RST and PIN10 lines to Pmod1. For data transfer to the Pmod™ display, and to/from the gyroscope the SCI MCU peripheral is configured as 'Simple SPI bus' (Master transmit/receive).
2. The Digital gyroscope is then checked for errors by sending an initialisation sequence, as described in the gyroscope datasheet.
3. The sample then displays the name of the sample and copyright information on display.
4. The sample then enters an infinite while loop, reading yaw rate information found in the 'RTE' registers of the Gyroscope. The result is then scaled and converted to a decimal number, and output to the display. There is then a 100ms delay before the cycle repeats.

5.4 Temperature Sensor

The aim for this sample is to use the temperature sensor to display the temperature on a display connected to Pmod1. The Pmod™ Application Board is fitted with a Microchip MCP9700AT Temperature Sensor by default.

The sample will demonstrate reading the output of the temperature sensor IC and displaying the temperature in degree Celsius on the display.

5.4.1 Connections

The temperature sensor is fitted in position IC1 of the Pmod™ Application Board.

Please ensure the Pmod™ LCD Screen is placed in the Pmod1 Connector before power up.

5.4.2 RSKRX111 Interface

Task	**Module**	**MCU Pins Used**	**Application Header Pins Used**	**Function**
Temperature sensor	MCU – ADC	AN002 – P42	JA1 – 11	Analogue output from temperature sensor
Interfacing with Pmod™ Display	MCU – SCI1 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 P41 – (Pmod1 SS) P43 – (Pmod1 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 10 JA1 – 12 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 1 Control of port expander IC14 for Pmod RST & PIN10 lines

Table 5-4: Connections and MCU Peripherals used for the Temperature Sensor Sample.

5.4.3 Operation

1. The sample first initialises Pmod™ display and the MCU 12-bit Analogue to Digital converter in single shot mode. In initiating the display, the IIC MCU peripheral is configured in Master Mode to configure port expander IC14, which controls the RST and PIN10 lines of the Pmod™ connector. The SCI MCU peripheral is configured as a ‘Simple SPI bus’ (Master transmit only) for the data transfer to the display.
2. The sample then displays the name of the sample & copyright information on the Pmod™ display.
3. The sample then enters an infinite while loop and reads channel AN002 of the ADC, then waiting for the ADC conversion to complete.
4. Then the sample converts the 12 bit ADC reading into Degree Celsius scale.
5. It then converts this result to an ASCII string for it to be displayed on Pmod1.

6. Pmod Display sample

The aim of this sample is to demonstrate the display of text and pictures on a display connected to any of the Pmod™ connectors Pmod1 – Pmod4.

6.1.1 Connections

The RSKRX111 must initially be modified as detailed in Figure 3-2. Further required modifications are detailed in Table 6-1. The locations are shown in

Figure 6-1: PmodTM Application Board Link Configuration for Pmod Connectors

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Channel	Fit 0Ω Link	Remove	Signal
Pmod1	Default configuration as per Figure 3-2 works without modification		
Pmod2	R19	R209	Pmod2_SS
Pmod3	R18	R111	Pmod3_PIN9
	R17	R122	Pmod3_SS
Pmod4	R15	R203	Pmod4_SS
	R13	R8	Pmod4_PIN9

Table 6-1 : RSKRX111 Pmod™ Channel Resistor Configuration

Add Link	Remove Link
R19	R209
R18	R111
R17	R122
R15	R203
R13	R8

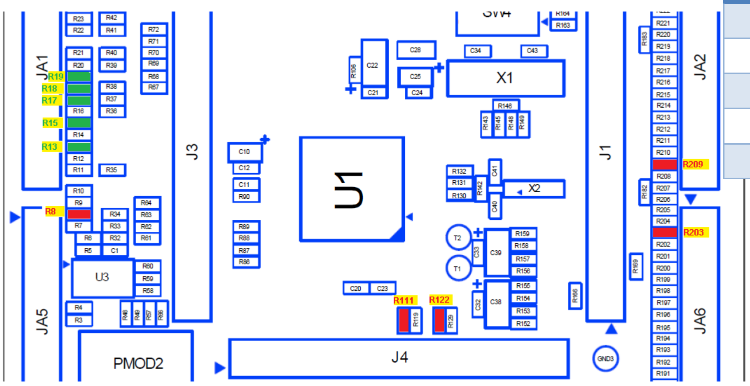

Figure 6-1: Pmod™ Application Board Link Configuration for Pmod Connectors

The desired Pmod™ connector for the display can be selected in software in the source file 'r_cg_userdefine.c'. The default is Pmod1.

Ensure the Pmod™ LCD display is placed in the selected Pmod connector before power up.

6.1.2 RSKRX111 Interface

Task	Module	MCU Pins Used	Application Header Pins Used	Function
Interfacing with Pmod™ Display on Pmod1	MCU – SCI1 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 P41 – (Pmod1 SS) P43 – (Pmod1 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 10 JA1 – 12 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 1 Control of port expander IC14 for Pmod RST & PIN10 lines
Interfacing with Pmod™ Display on Pmod2	MCU – SCI1 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 PE0 – (Pmod2 SS) PB5 – (Pmod2 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 15 JA2 – 21 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 2 Control of port expander IC14 for Pmod RST & PIN10 lines
Interfacing with Pmod™ Display on Pmod3	MCU – SCI1 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 PE2 – (Pmod3 SS) PE1 – (Pmod3 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 17 JA1 – 16 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 3 Control of port expander IC14 for Pmod RST & PIN10 lines
Interfacing with Pmod™ Display on Pmod4	MCU – SCI1 MCU – I/O MCU – IIC	TXD1 – P16 SCK1 – P17 PE4 – (Pmod4 SS) PE6 – (Pmod4 PIN9) SCL-PB0 SDA-PA6	JA2 – 6 JA2 – 10 JA1 – 19 JA1 – 21 JA1 – 26 JA1 – 25	Data Transfer on Pmod channel 4 Control of port expander IC14 for Pmod RST & PIN10 lines

Table 6-2: Peripherals used for the 'PmodDisplay' sample.

6.1.3 Operation

1. The sample will initiate the Pmod™ channel as defined in the 'r_cg_userdefine.h' file and the RTC with counting mode being set to Calendar Mode. In initiating the display, the IIC MCU peripheral is configured in Master Mode to configure port expander IC14, which controls the RST and PIN10 lines of the Pmod™ connector. The SCI MCU peripheral is configured as a 'Simple SPI bus' (Master transmit only) for the data transfer to the display.
2. Following this the Pmod™ will display the sample and copyright information.
3. The sample then waits until the interrupt driven switch (SWA) is pressed in the swa_press() function.
4. The sample then initialises the RTC and enters the main loop.
5. In the RTC interrupt the RTC time is read and stored in array as well as setting a variable to three states depending on the number of times the interrupt has been called. The variable is processed in the main loop (mentioned in step 4) to either display a picture, text or clear the screen.
6. The Pmod™ will also display the time since the RTC was initiated.

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar 20 2015	All	Created.

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU 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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the 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.

Renesas Electronics Corporation

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Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, 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 India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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