# RL78/G14

## Ultrasonic Range Finder (Pmod MAXSONAR) Device Sample

### Introduction

This document describes a Renesas microcontroller RL78/G14 application for Ultrasonic Range Finder (Pmod MAXSONAR).

### Target Device

RL78/G14

When applying the sample program covered in this document to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

## Contents

# 1. Description

## 1.1 Abstract

The Ultrasonic Range Finder Device Sample is au ultrasonic range finder using the RL78/G14 Fast Prototyping Board and the Digilent PMOD MAXSONAR. With an OLED screen, it makes the range information well displayed and shows different levels of range in different colors. The backlight makes it possible to view the screen and every detail from every angle, even in the dark night.

The RL78/G14 Fast Prototyping Board comes equipped with a high-performance RL78/G14 microcontroller and is an evaluation board specialized for prototype development for a variety of applications. It has a built-in emulator circuit that is equivalent to an E2 emulator Lite so you can write/debug programs without additional tools. In addition, with Arduino Uno and Pmod™ interfaces included standard and through-hole access to all pins of the microcontroller, and so on, it has high expandability.

The Pmod MAXSONAR is a single-transducer ultrasonic range finder that uses the MaxBotix® LV-MaxSonar®-EZ1™. Users can measure how far away an object is with an accuracy within 1 inch to over 20 feet away. Information is sent in a variety of ways including UART, PWM, and analog signMAXSONAR.

## 1.2 Specifications and Main Technical Parameters

### Technical Parameters

| | |
|---|---|
| Power Supply | USB power supply (5 V) |
| Operating Voltage (MCU) | 3.3 V |
| Operating Temperature: | Ambient temperature |
| OLED Display Pattern | 12 cha * 4 |

### Specifications

| | |
|---|---|
| Function: | Detect range with the Digilent PMOD MAXSONAR.<br>Display all the reange information on an OLED screen.<br>Information in different colors on the OLED screen correspond to different levels of range. |

# 2. RL78/G14 Microcontroller

## 2.1 RL78/G14 Block Diagram

Figure 2.1 shows the block diagram of RL78/G14 (80-pin products).

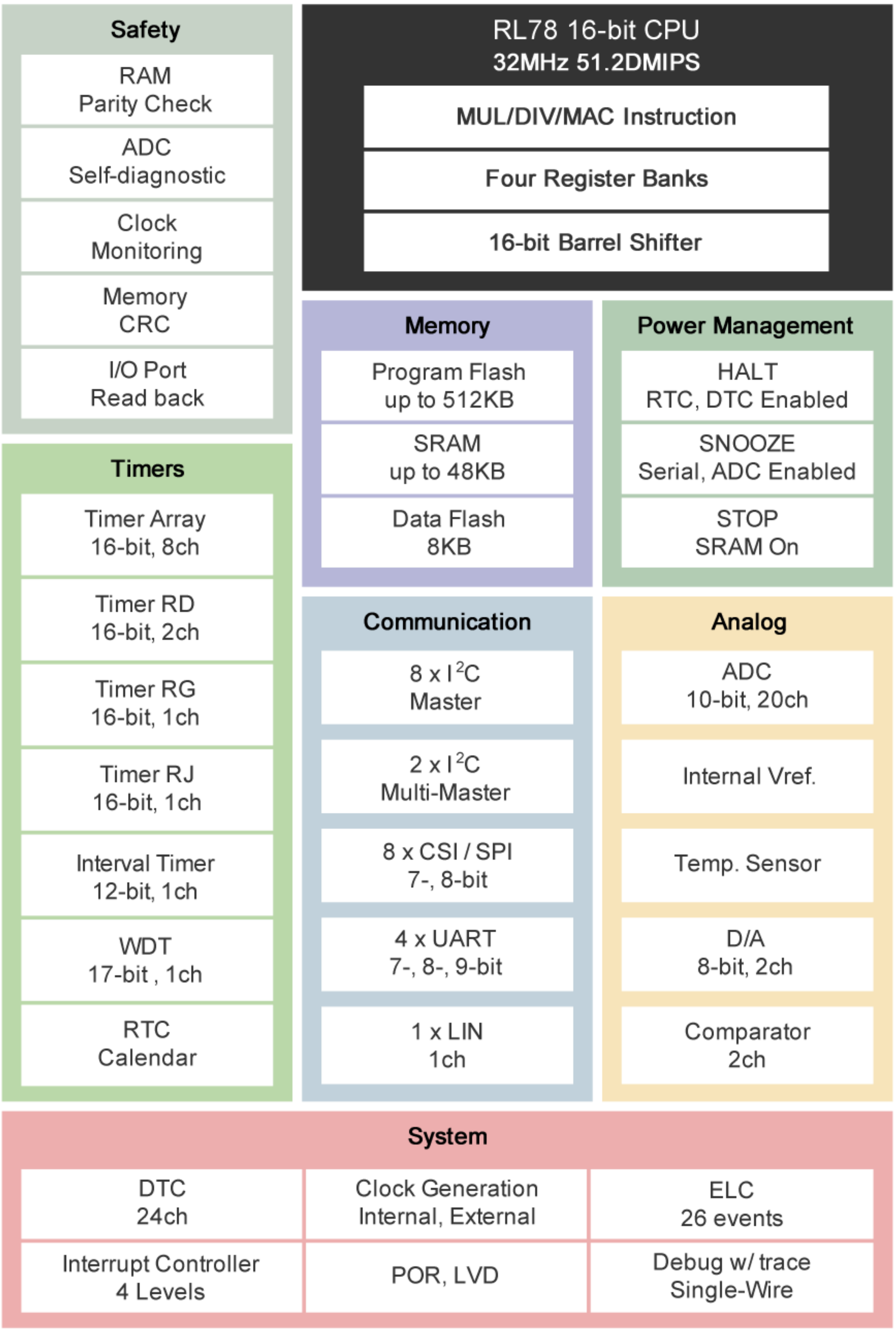


**Figure 2.1 RL78/G14 Block Diagram**

## 2.2 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.03125 μs @ 32 MHz operation with high-speed on-chip oscillator) to ultra-low speed (30.5 μs @ 32.768 kHz operation with subsystem clock)
- General-purpose registers: (8-bit register × 8) × 4 banks
- ROM: 512 KB, RAM: 48 KB, data flash: 8 KB
- Selectable high-speed on-chip oscillator clock: 64/48/32/24/16/12/8/6/4/3/2/1 MHz (TYP.)
- On-chip debug function
- On-chip selectable power-on-reset (POR) circuit
- On-chip voltage detector (LVD)
- On-chip watchdog timer (operable with the dedicated low-speed on-chip oscillator)
- On-chip key interrupt function
- On-chip clock output/buzzer output controller
- On-chip BCD (binary-coded decimal) correction circuit
- I/O port: 52
- Timer
  16-bit timer: 8 channels
  12-bit interval timer: 1 channel
- Serial interface
  CSI: 8 channels
  UART: 4 channels
  Simplified $I^2C$ communication: 8 channels
  Multi-master $I^2C$ communication: 2 channels
- 8/10-bit resolution A/D converter: 17 channels
- 8-bit resolution D/A converter: 2 channels
- Comparator: 2 channels
- Data transfer controller (DTC)
- Event link controller (ELC)
- Standby function: HALT mode or STOP mode or SNOOZE mode
- Power supply voltage: $V_{DD}$ = 1.6 to 5.5 V
- Operating ambient temperature: $T_A$ = -40 to +85°C

RL78/G14 microcontrollers balance the industry's lowest level of consumption current (CPU: 66 µA/MHz, standby (STOP): 240 nA) and a high calculation performance of 51.2 DMIPS (32 MHz). The built-in high-function timer supports three-phase motor control using three-phase complementary PWM output. They have an on-chip oscillator, data flash, A/D and D/A converters, comparator, and more. Built-in safety features (function that detects illegal operation of hardware) enable support for the household appliance safety standard (IEC/UL 60730). With a broad 30 to 100-pin lineup and up to 512 KB on-chip flash memory, these microcontrollers can be used in a wide variety of applications such as motor control and consumer and industrial equipment.

## 2.3 Pin Configuration

Figure 2.2 shows the pin configuration of RL78/G14 (80-pin products).

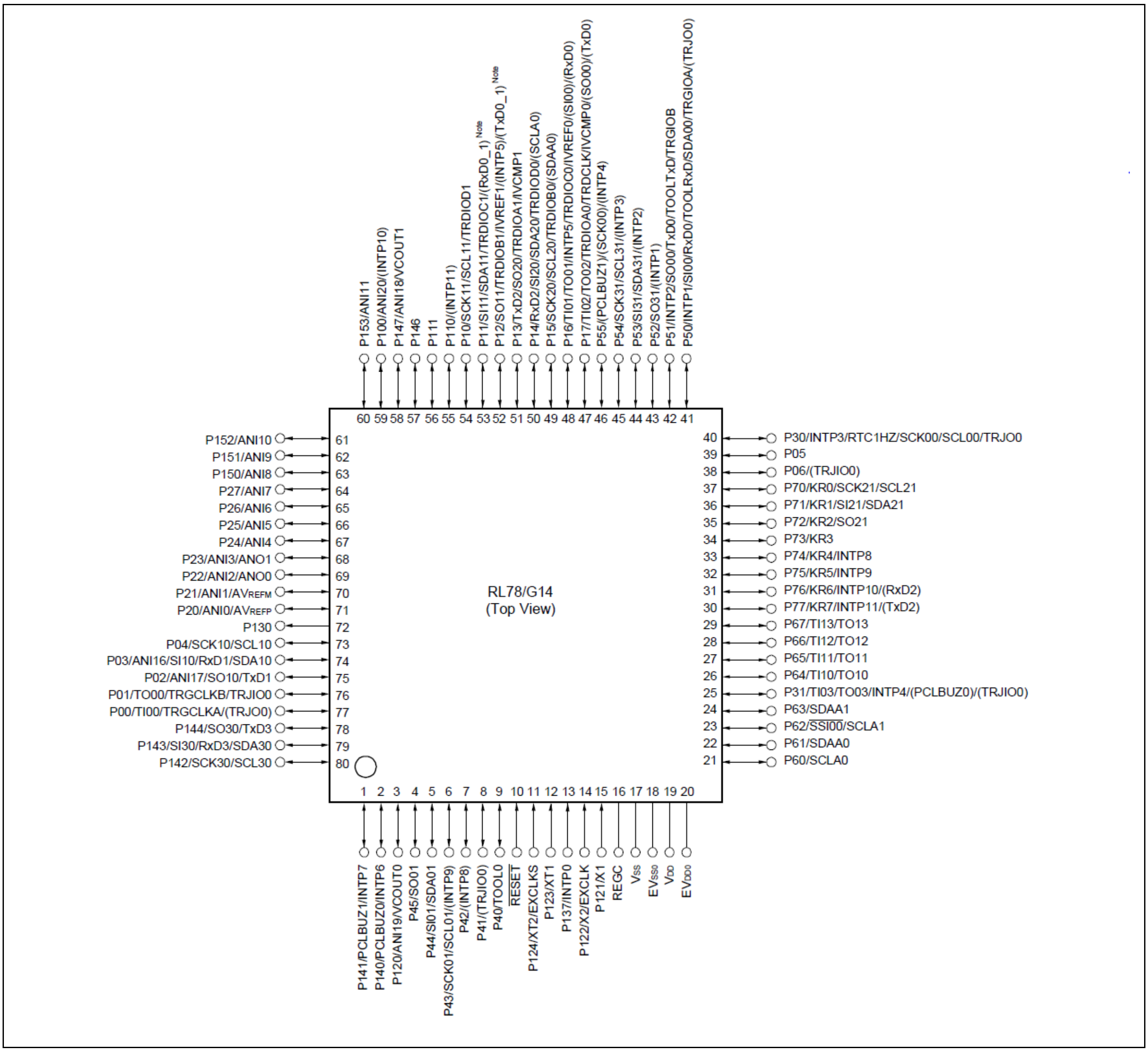


**Figure 2.2 RL78/G14 (80-pin products) Pin Configuration**

Note: Mounted on the 384 KB or more code flash memory products.

# 3. System Outline

## 3.1 Principle Introduction

The Ultrasonic Range Finder Sensor Device Sample uses an RL78/G14 microcontroller and the Digilent PMOD MAXSONAR. After detecting the range, the MCU (RL78/G14) sends the sensing data to the Pmod OLEDrgb module and visualizes the corresponding information on the OLED screen. Figure 3.1 shows the system composition. Figure 3.2 shows the system block diagram. Figure 3.3 shows the connection of RL78/G14 FPB, PMOD OLED RGB and the Digilent PMOD MAXSONAR.

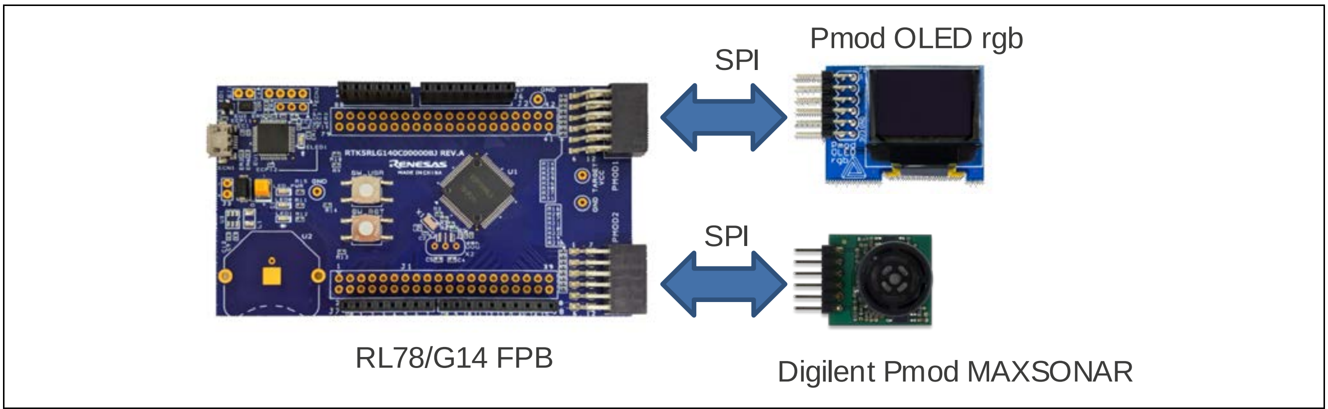


**Figure 3.1 System Composition**

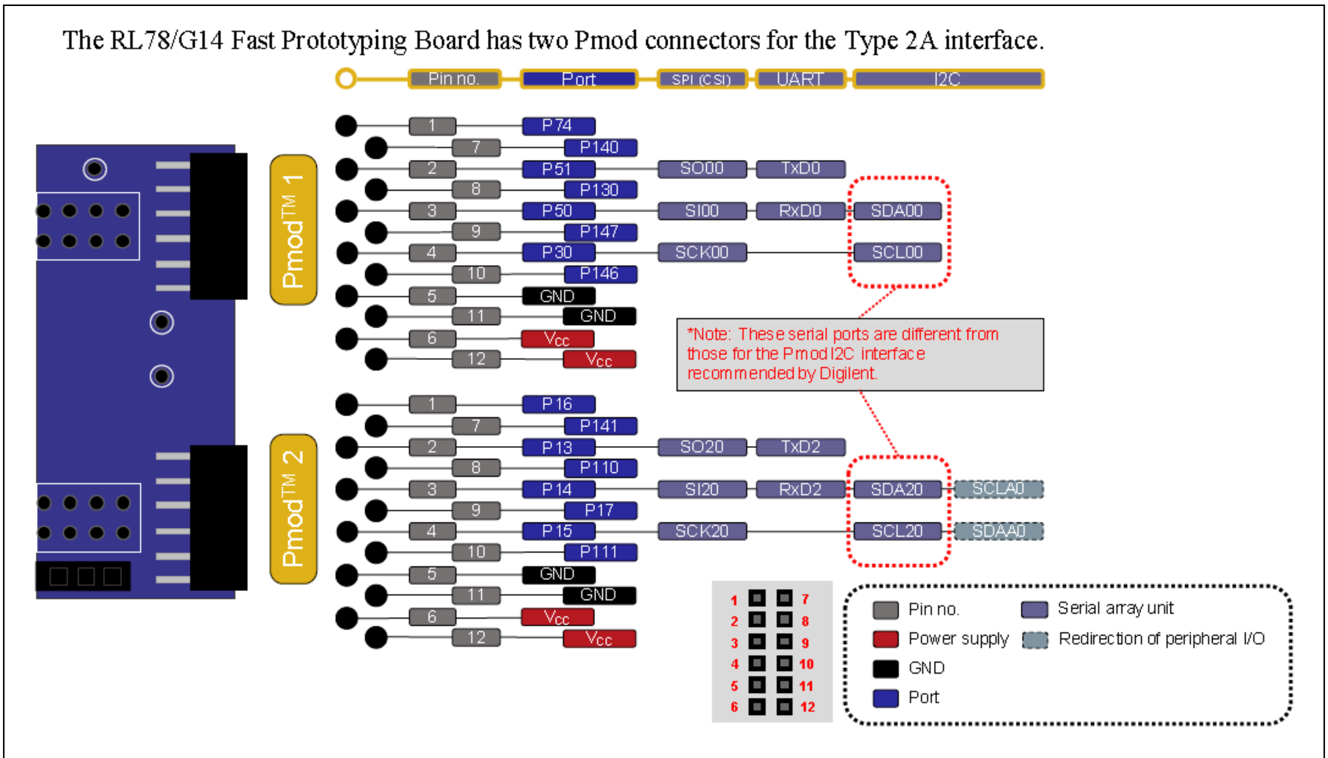


**Figure 3.2 RL78/G14 FPB PMOD Interface**

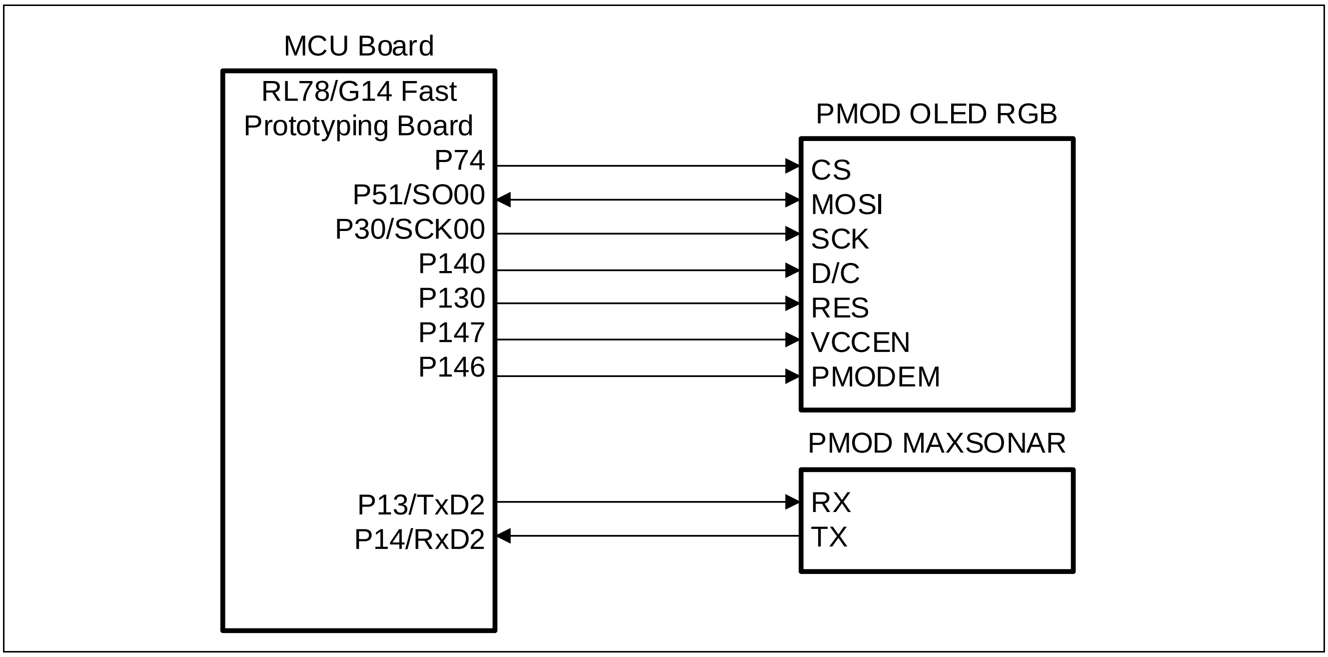


**Figure 3.3 Connection of RL78/G14 FPB, PMOD OLED RGB and the Digilent PMOD MAXSONAR**

## 3.2 Peripheral Functions to be Used

Table 3.1 lists the peripheral functions to be used and their usage.

**Table 3.1 Peripheral Functions to be Used**

| Peripheral Function | Usage |
|---|---|
| Real-time Clock | Count real-time clock and generate interrupts of 1s. |
| TAU0 Channel0 | Count 1us interval using interval timer mode. |
| 3-wire serial (CSI00) | Control OLED to display range. |
| UART serial (UART2) | Get the range data from the sensor. |

## 3.3 Pins to be Used

Table 3.2 lists the pins to be used and their function.

**Table 3.2 Pins to be Used**

| Pin Name | Description |
|---|---|
| P74 | Control CS (Chip Select) pin of PMOD OLED RGB |
| P51/SO00 | Communicate with PMOD OLED RGB through MOSI (Master-Out-Slave-In) pin |
| P30/SCK00 | Communicate with PMOD OLED RGB through SCK (Serial Clock) pin |
| P140 | Control D/C (Data/Command) pin of PMOD OLED RGB |
| P130 | Control RES pin of PMOD OLED RGB |
| P147 | Control VCCEN pin of PMOD OLED RGB |
| P146 | Control PMODEN pin of PMOD OLED RGB |
| P13/TxD2 | Transmit pin: left floating or held at a logic level high voltage |
| P14/RxD2 | Receive pin: Get the data of the sensor |
| VDD | Power supply voltage |
| GND | Ground |

## 3.4 Operating Instructions

(1) Once powered on, the system begins to initialize.

(2) After initialization, the MCU (RL78/G14) enters the STOP mode.

(3) The application controls the MCU (RL78/G14) to wake up from STOP mode by interrupt RTC.

(4) After waking up, the MCU (RL78/G14) starts to get the sensor measurement result, and sends it to the OLED to visualize.

(5) Finishing to visualize, and the MCU (RL78/G14) enters STOP mode again, waiting for interrupts.

Display pattern: (12char *4 row)
Use different colors to display the sensor data

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R | E | N | E | S | A | S | | | |
| D | i | s | t | a | n | c | e | : | | | |
| | | x | x | x | | c | m | | | | |

**Table 3.3 OLED Display Color**

| Item | Range | OLED Display Color: |
|---|---|---|
| Range | 10 or low cm | Green char |
| | 10 – 200 cm | Yellow char |
| | 200 or more cm | Red char |

# 4. Hardware

This section describes how the RL78/G14 Fast Prototyping Board measures the range via the Digilent PMOD MAXSONAR. And the range sensing data is displayed on pmod OLED rgb.

About the details of pmod OLED rgb, please refer to the following linkage.

https://reference.digilentinc.com/reference/pmod/pmodoledrgb/start

About the details of Digilent pmod MAXSONAR, please refer to the following linkage.

https://store.digilentinc.com/pmodmaxsonar-maxbotix-ultrasonic-range-finder/

Figure 4.1 shows the hardware composition. Figure 4.2 shows the RL78/G14 FPB Board Layout (Top Side).

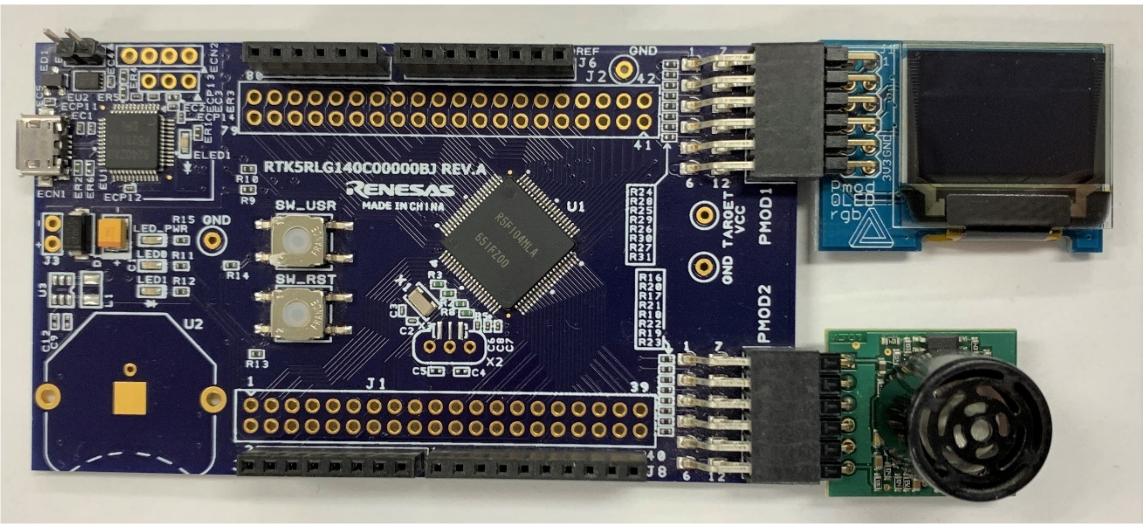

**Figure 4.1 Hardware Composition**

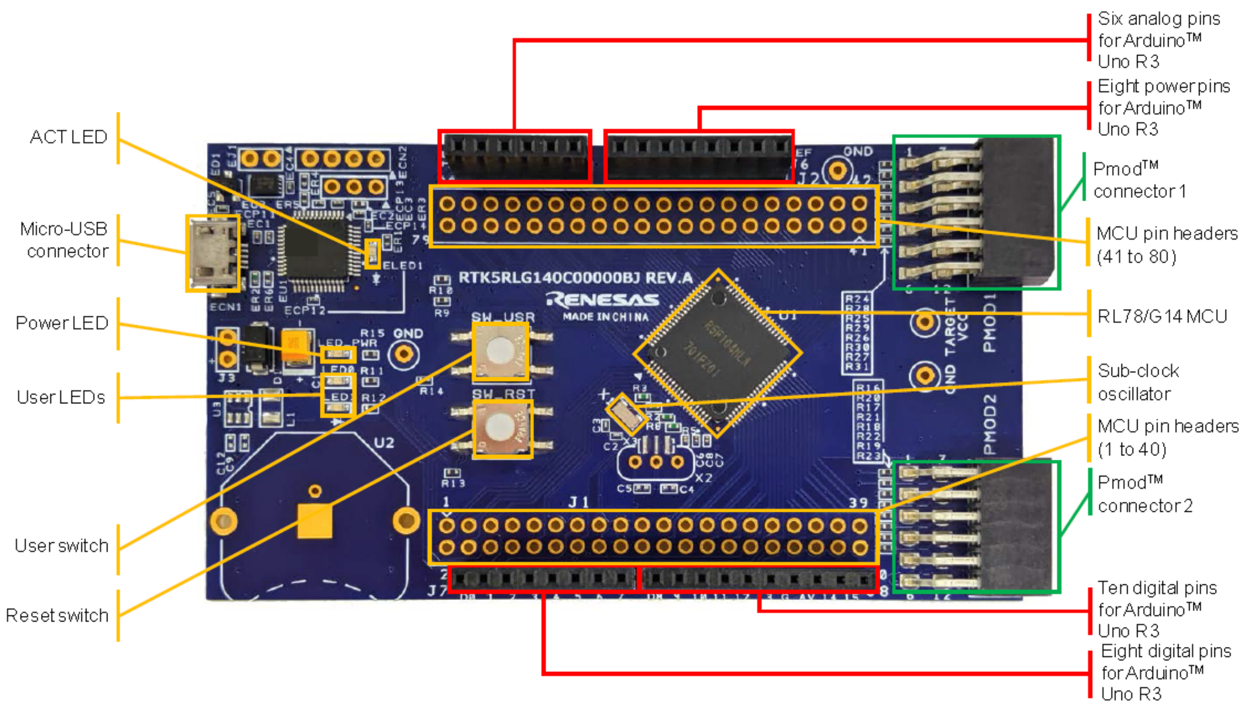


**Figure 4.2 RL78/G14 FPB Board Layout (Top Side)**

# 5. Software

## 5.1 Integrated Development Environment

The sample code described in this chapter has been checked under the conditions listed in the table below.

**Table 5.1 Operation Check Conditions**

| Item | Description |
|---|---|
| Microcontroller used | RL78/G14 (R5F104ML) |
| Operating frequency | High-speed on-chip oscillator (HOCO) clock: 32 MHz<br>CPU/peripheral hardware clock: 32 MHz<br>Low-speed on-chip oscillator clock: 15 kHz |
| Operating voltage | 3.3 V (can run on a voltage range of 2.7 V to 5.5 V)<br>LVD: Interrupt & reset mode<br>Reset generation level ($V_{LVDL}$): 1.63 V<br>Interrupt generation level ($V_{LVDH}$): 1.73 V |
| Integrated development environment (CS+) | CS+ for CC (RL78, RX, RH850) V8.04.00 from Renesas Electronics Corp. |
| C compiler (CS+) | Renesas CCRL v1.09.00 |
| Integrated development environment (e$^2$ studio) | e$^2$ studio V7.7.0 from Renesas Electronics Corp. |
| C compiler (e$^2$ studio) | Renesas CCRL v1.09.00 |

## 5.2 Option Byte

Table 5.2 summarizes the settings of the option bytes.

**Table 5.2 Option Byte Settings**

| Address | Value | Description |
|---|---|---|
| 000C0H/010C0H | 11101111B | Watchdog timer counter operation disabled (counting stopped after reset) |
| 000C1H/010C1H | 00011010B | LVD: Interrupt & reset mode<br>$V_{LVDH}$: Rising edge: 1.77 V, Falling edge: 1.73 V<br>$V_{LVDL}$: Falling edge: 1.63 V |
| 000C2H/010C2H | 11111000B | HS mode, $f_{HOCO}$: 32 MHz<br>CPU clock $f_{CLK}$: 32 MHz |
| 000C3H/010C3H | 10000100B | Enables on-chip debugging |

## 5.3 Operation Outline

The tasks of the entire system are listed as below: Reset/Initialization,STOP mode, Measurement and Display mode.

Figure 5.1 shows the block diagram for the tasks transition.

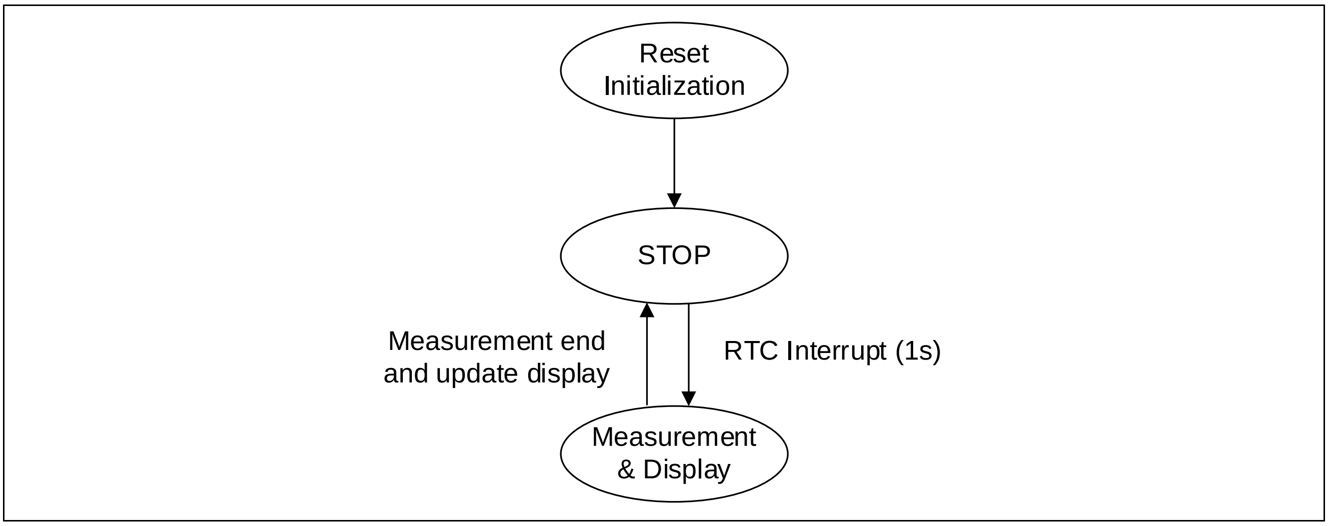


**Figure 5.1 Tasks Transition Block Diagram**

(1) Reset / Initialization

When the system is powered on, it will enter the initialization operation. The OLED is powered on and cleared. Then it displays Renesas logo and other default characters.The Digilent PMOD MAXSONAR is initialized. CSI00, UART2, TAU00, RTC and I/O pins will be initialized.

(2) STOP mode

After initialization, the MCU enters the STOP mode and waits for an RTC interrupt to wake up.

(3) Measurement and Display mode

After waking up, the MCU starts to get the sensor measurement result and sends the information to the OLED to display.

## 5.4 Flow Chart

### 5.4.1 Main Processing

Figure 5.2 shows the flowchart for main processing routine.

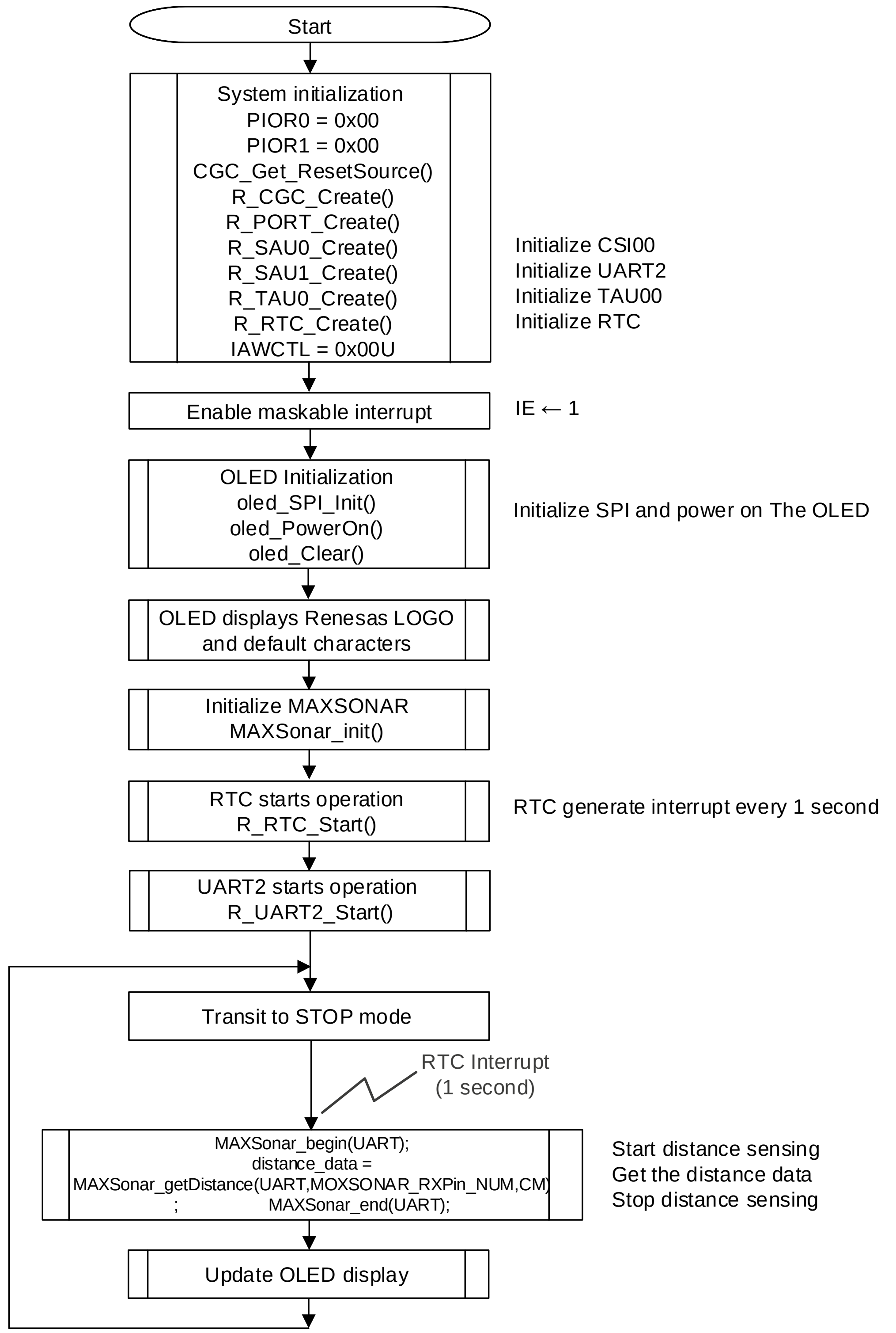


**Figure 5.2 Main Processing**

# 6. How to Build

## 6.1 CS+

I. Launch CS+ for CC (RL78, RX, RH850).

II. Right click on the "File" and select "Open" from the displayed menu.

III. The "Open File" window will be displayed, select the MTPJ file in the Project Folder "RL78G14_FPB_PmodMAXSONAR", and click "Open". Then the "Open File " window is closed.

IV. Right click on the project displayed on the "Project Tree" and select "Build" to start building.

V. A mot file "RL78G14_FPB_ PmodMAXSONAR.mot" is generated in the path shown in the mot File.

## 6.2 e2studio

I. Launch e2 studio.

II. Right click on the "Project Explorer" and select "Import" from the displayed menu.

III. The "Import" window will be displayed. Select "Existing project to workspace" and click "Next".

IV. In the "Select root directory" form, select the project folder shown in the Project Folder "RL78G14_FPB_PmodMAXSONAR" of e2 studio. After selection, confirm that the specified project is displayed in "Project" and click "Finish". Then the "Import" window is closed.

V. Right click on the project displayed on the "Project Explorer" and select "Build Project" to start the building.

VI. A mot file "RL78G14_FPB_PmodMAXSONAR.mot" is generated in the path shown in the mot File of e2 studio.

## 6.3 Writing mot file using Renesas Flash Programmer

This section describes how to write the pre-built mot file attached to this application note.

To write the pre-built mot file, it is necessary to mount a header component so that the Fast Prototyping Board can operate stand-alone. For details, refer to " 5.12 Emulator Reset Header" in "RL78/G14 Fast Prototyping Board User's Manual" (R20UT4573).

I. Launch Renesas Flash Programmer V3.05.

II. Click "New Project… " in "File". About Microcontroller, select "RL78". About Communication Tool, select "E2 Lite". Customer can customize Project Name and choose Project Folder.

III. Press the "Browse…" in "Program File" to open the mot File " RL78G14_FPB_PmodMAXSONAR.mot".

IV. Press "Start" to start writing.

Note: For Flash Programming or Debugging with IDE(CS+/e2studio), EJ1 pin header should be OPEN.
After Flash Programming, standalone operation w/o IDE can be enabled by setting EJ1 to SHORT.

## 7. Sample Code

The sample code is available on the Renesas Electronics Website.

## 8. Reference Documents

RL78/G14 Fast Prototyping Board (R20UT4573)

RL78/G14 User's Manual: Hardware (R01UH0186)

RL78 Family User's Manual: Software (R01US0015)

(The latest versions of the documents are available on the Renesas Electronics Website.)

Technical Updates/Technical News

(The latest information can be downloaded from the Renesas Electronics Website.)

## Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/contact/

## Revision History

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.00 | Sep. 30, 2020 | | First edition issued |
| | | | |

# 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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## Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit: www.renesas.com/contact/.

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