

RA2E1 Group

RA2E1 ZMOD4410 Sensor Device Sample

Introduction

This document describes a Renesas microcontroller RA2E1 application for a ZMOD4410 sensor device using the RA2E1 Fast Prototyping Board.

Target Device

RA2E1

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	3
1.1 Abstract.....	3
1.2 Specifications and Main Technical Parameters.....	3
2. RA2E1 Microcontroller	4
2.1 RA2E1 Block Diagram	4
2.2 Key Features.....	5
2.3 Pin Assignments	7
3. System Outline	8
3.1 Principle Introduction	8
3.2 Peripheral Functions to be Used	10
3.3 Pins to be Used	10
3.4 Operating Instructions.....	11
4. Hardware	12
4.1 Schematics	13
5. Software	14
5.1 Integrated Development Environment	14
5.2 Operation Outline	14
5.3 Flow Chart.....	15
5.4 File Compositions	16
6. How to Add Sensor Middleware using FSP in e2studio	17
7. How to Build the Project and How to Program the Output File	21
7.1 Build in e2studio	21
7.2 Writing srec file using Renesas Flash Programmer	21
8. Sample Code	22
9. Reference Documents	22

1. Description

1.1 Abstract

The ZMOD4410 sensors device sample is a precision digital sensor featuring indoor air quality using the RA2E1 Fast Prototyping Board. With an OLED screen, it makes all the information well displayed and shows different levels of indoor environment quality in different colors, with each color corresponding to a different level of health concern. The backlight makes it possible to view the screen and every detail from every angle, even in the dark night.

The RA2E1 Fast Prototyping Board comes equipped with a high-performance RA2E1 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 US082-ZMOD4410EVZ Gas Sensor Module is designed for detecting total volatile organic compounds (TVOC) and monitoring indoor air quality (IAQ). It is a 12-pin LGA assembly (3.0 x 3.0 x 0.7 mm) that consists of a gas sense element and a CMOS signal conditioning IC. The module's sense element consists of a heater element on a Si-based MEMS structure and a metal oxide (MOx) chemiresistor. The signal conditioner controls the sensor temperature and measures the MOx conductivity, which is a function of the gas concentration. The measurement results can be read via an I2C interface with the user's microprocessor, which processes the data to determine the TVOC concentration, IAQ rating and estimated carbon dioxide (eCO2) level. This flexibility makes the sensors in the US082-ZMOD4410EVZ platform capable of providing a variety of measurement options by varying the method of operation or changing the firmware used to interpret the resistance measurements. Downloadable firmware libraries and source code provided by IDT enables detection of TVOC and odors and supports smart devices measuring IAQ that require low-power operation. The US082-ZMOD4410EVZ is ideal for applications such as thermostats, air purifiers, building controls, smart fans, HVAC equipment, and smart devices.

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 row

Specifications

- Function:
 - Detect indoor air quality with US082-ZMOD4410EVZ.
 - Display the air quality information on an OLED screen.
 - Information in different colors on the OLED screen correspond to different levels of air quality.

2. RA2E1 Microcontroller

2.1 RA2E1 Block Diagram

Figure 2.1 shows the block diagram of RA2E1 (64-pin products).

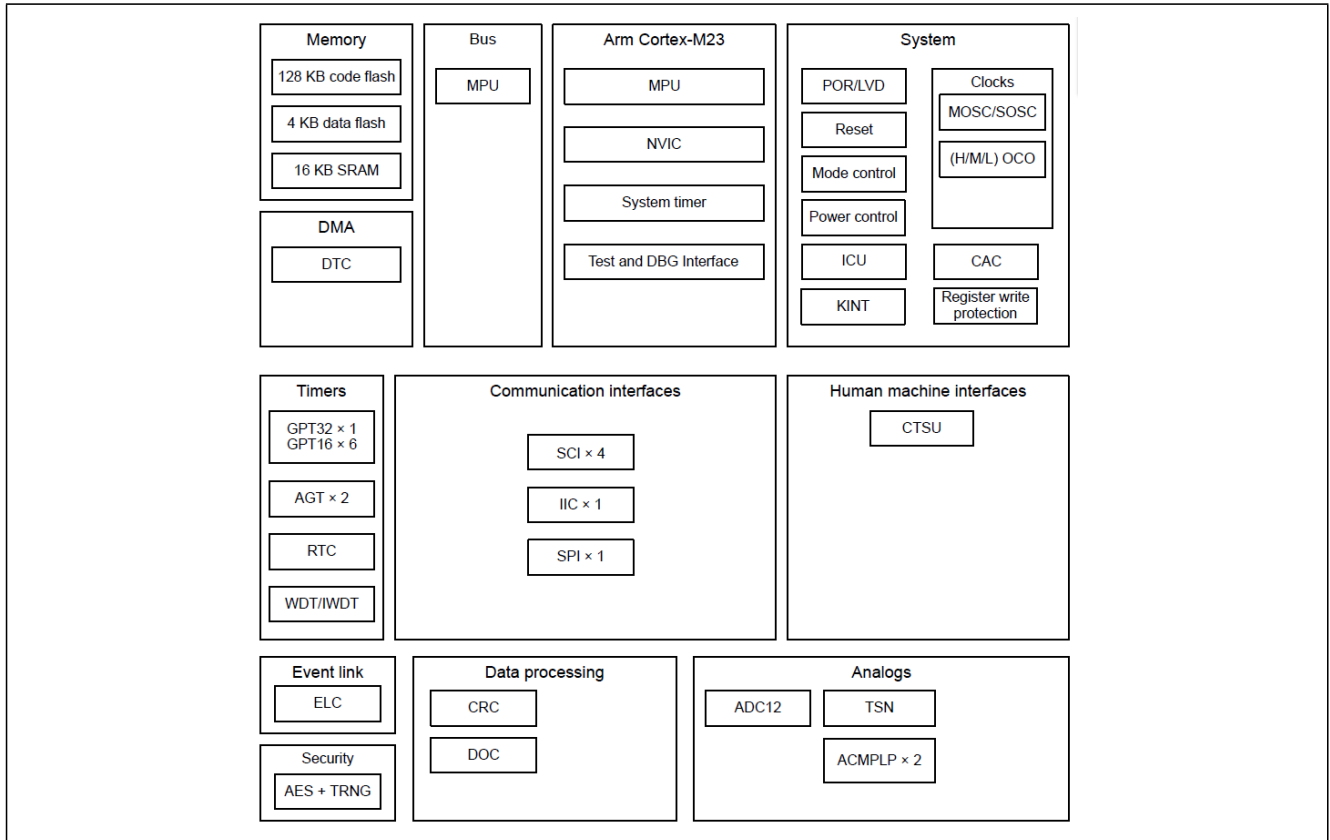


Figure 2.1 RA2E1 Block Diagram

2.2 Key Features

- Arm Cortex-M23 Core
 - Armv8-M architecture
 - Maximum operating frequency: 48 MHz
 - Arm Memory Protection Unit (Arm MPU) with 8 regions
 - Debug and Trace: DWT, FPB, CoreSight™ MTB-M23
 - CoreSight Debug Port: SW-DP

- Memory
 - Up to 128-KB code flash memory
 - 4-KB data flash memory (100,000 program/erase (P/E) cycles)
 - 16-KB SRAM
 - Memory protection units
 - 128-bit unique ID

- Connectivity
 - Serial Communications Interface (SCI) × 4
 - Asynchronous interfaces
 - 8-bit clock synchronous interface
 - Simple IIC
 - Simple SPI
 - Smart card interface
 - Serial Peripheral Interface (SPI) × 1
 - I2C bus interface (IIC) × 1

- Analog
 - 12-bit A/D Converter (ADC12)
 - Low-Power Analog Comparator (ACMPLP) × 2
 - Temperature Sensor (TSN)

- Timers
 - General PWM Timer 32-bit (GPT32) × 1
 - General PWM Timer 16-bit (GPT16) × 6
 - Low Power Asynchronous General Purpose Timer (AGT) × 2
 - Watchdog Timer (WDT)

- Safety
 - SRAM parity error check
 - Flash area protection
 - ADC self-diagnosis function
 - Clock Frequency Accuracy Measurement Circuit (CAC)
 - Cyclic Redundancy Check (CRC) calculator
 - Data Operation Circuit (DOC)
 - Port Output Enable for GPT (POEG)
 - Independent Watchdog Timer (IWDT)
 - GPIO readback level detection
 - Register write protection
 - Main oscillator stop detection
 - Illegal memory access detection

- Security and Encryption
 - AES128/256
 - True Random Number Generator (TRNG)

■ System and Power Management

- Low power modes
- Switching regulator
- Realtime Clock (RTC)
- Event Link Controller (ELC)
- Data Transfer Controller (DTC)
- Key Interrupt Function (KINT)
- Power-on reset
- Low Voltage Detection (LVD) with voltage settings

■ Human Machine Interface (HMI)

- AES128/256
- True Random Number Generator (TRNG)

■ Multiple Clock Sources

- Low power modes
- Main clock oscillator (MOSC) (1 to 20 MHz)
- Sub-clock oscillator (SOSC) (32.768 kHz)
- High-speed on-chip oscillator (HOCO) (24/32/48/64 MHz)
- Middle-speed on-chip oscillator (MOCO) (8 MHz)
- Low-speed on-chip oscillator (LOCO) (32.768 kHz)
- Clock trim function for HOCO/MOCO/LOCO
- IWDG-dedicated on-chip oscillator (15 kHz)
- Clock out support

■ Up to 56 pins for general I/O ports

- 5-V tolerance, open drain, input pull-up, switchable driving ability

■ Operating Voltage

- VCC: 1.6 to 5.5 V

■ Operating Temperature and Packages

- Ta = -40°C to +85°C
 - 64-pin LQFP (14 mm × 14 mm, 0.8 mm pitch)
 - 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)
 - 64-pin BGA (4 mm × 4 mm, 0.4 mm pitch)
 - 48-pin LQFP (7 mm × 7 mm, 0.5 mm pitch)
 - 48-pin HWQFN (7 mm × 7 mm, 0.5 mm pitch)
 - 36-pin LGA (4 mm × 4 mm, 0.5 mm pitch)
 - 32-pin LQFP (7 mm × 7 mm, 0.8 mm pitch)
 - 32-pin HWQFN (5 mm × 5 mm, 0.5 mm pitch)
 - 25-pin WLCSP (2.14 mm × 2.27 mm, 0.4 mm pitch)
- Ta = -40°C to +105°C
 - 64-pin LQFP (14 mm × 14 mm, 0.8 mm pitch)
 - 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)
 - 64-pin BGA (4 mm × 4 mm, 0.4 mm pitch)
 - 48-pin LQFP (7 mm × 7 mm, 0.5 mm pitch)
 - 48-pin HWQFN (7 mm × 7 mm, 0.5 mm pitch)
 - 36-pin LGA (4 mm × 4 mm, 0.5 mm pitch)
 - 32-pin LQFP (7 mm × 7 mm, 0.8 mm pitch)
 - 32-pin HWQFN (5 mm × 5 mm, 0.5 mm pitch)
 - 25-pin WLCSP (2.14 mm × 2.27 mm, 0.4 mm pitch)

2.3 Pin Assignments

Figure 2.2 shows the pin assignments of RA2E1 (64-pin products).

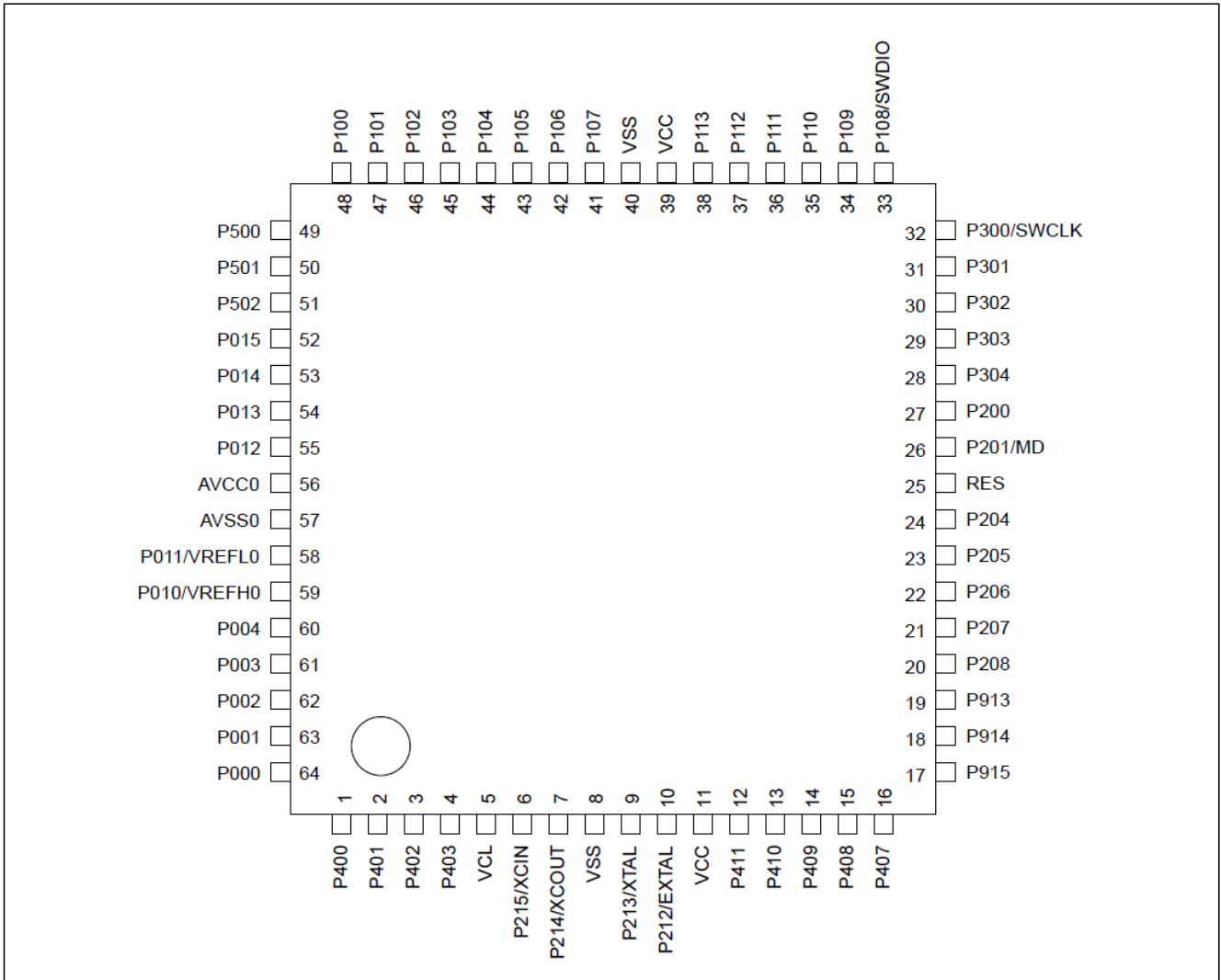


Figure 2.2 RA2E1 (64-pin products) Pin Assignments

3. System Outline

3.1 Principle Introduction

The ZMOD4410 Sensor Device uses an RA2E1 microcontroller and a digital gas sensor. After detecting the indoor air quality, the MCU (RA2E1) 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 RA2E1 FPB PMOD Interface. Figure 3.3 shows the connection of RA2E1 FPB, PMOD OLED RGB and TVOC and Indoor Air Quality Sensor Pmod™ Board (US082-ZMOD4410EVZ).

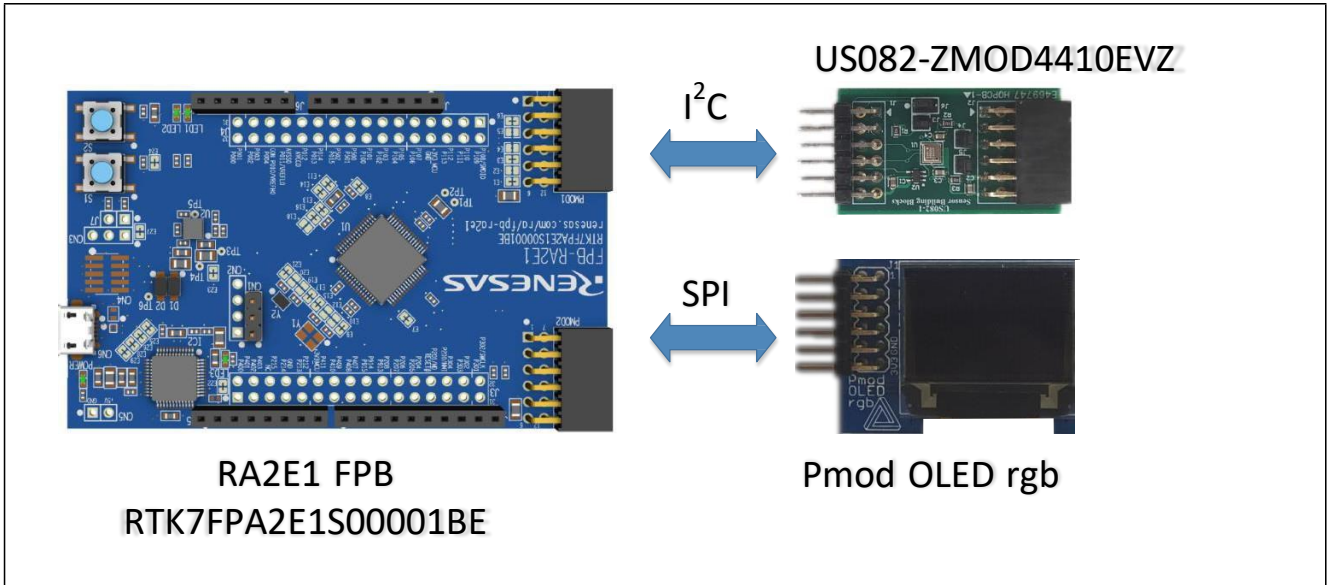


Figure 3.1 System Composition

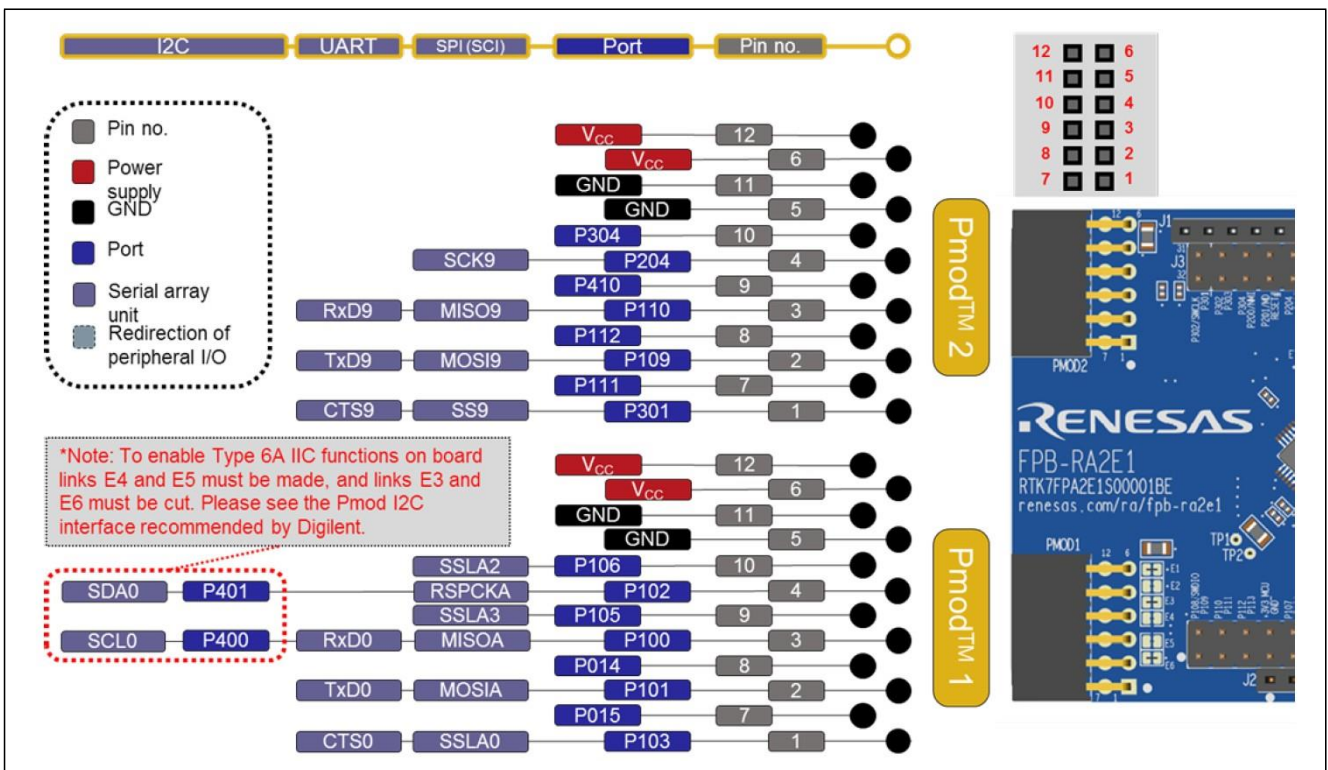


Figure 3.2 RA2E1 FPB PMOD Interface

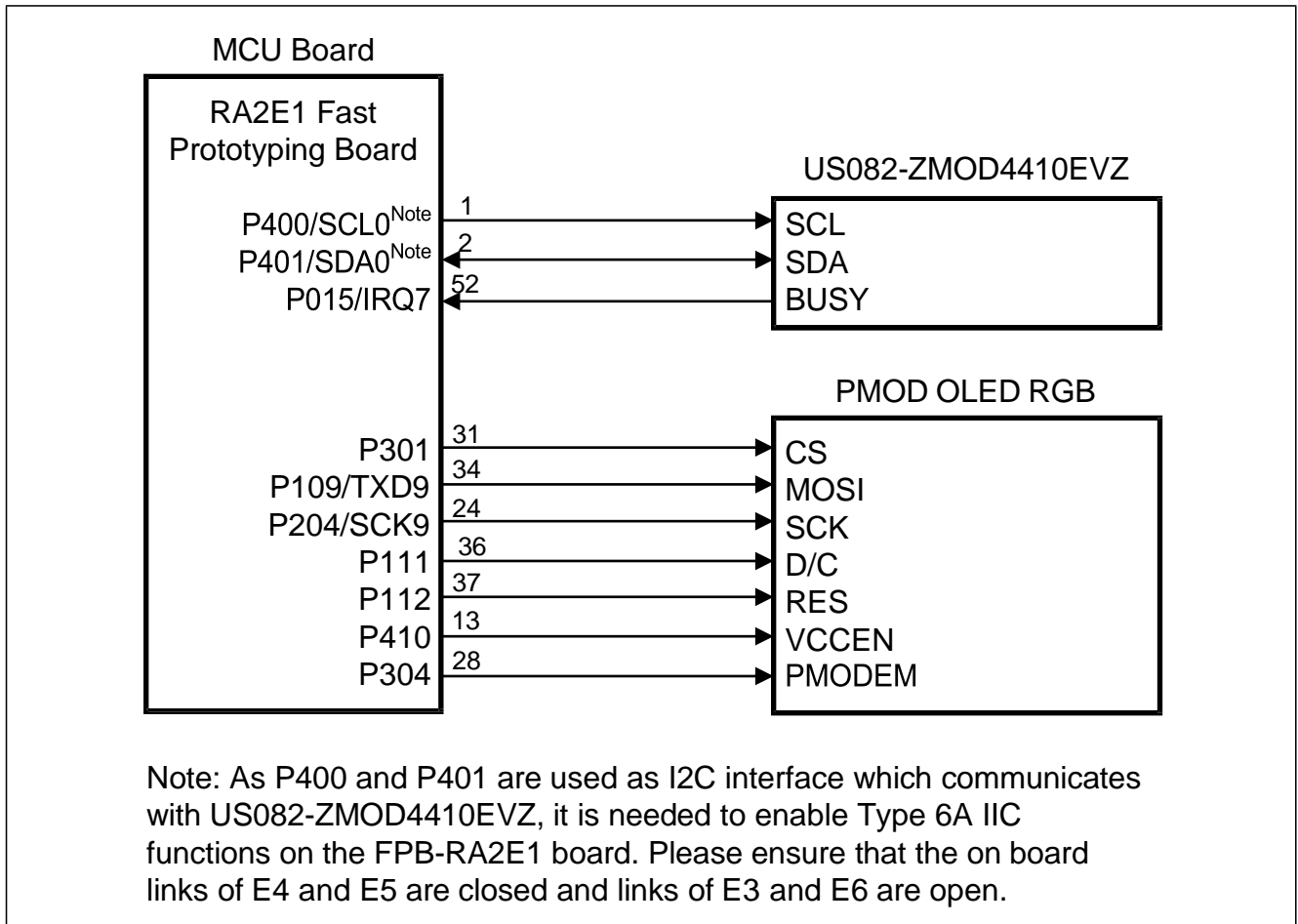


Figure 3.3 Connection of RA2E1 FPB, PMOD OLED RGB and US082-ZMOD4410EVZ

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
3-wire Serial I/O (SCI9)	Control OLED to display IAQ, ECO2 and TVOC.
I2C (IIC0)	Get data (IAQ, ECO2 and TVOC) from the sensors.
Timer (GPT0)	Insert delay in the initialization, writing and reading operation of US082-ZMOD4410EVZ.

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
P301	Control CS (Chip Select) pin of PMOD OLED RGB
P109/TXD9	Communicate with PMOD OLED RGB through TXD (Master-Out-Slave-In) pin
P204/SCK9	Communicate with PMOD OLED RGB through SCK (Serial Clock) pin
P111	Control D/C (Data/Command) pin of PMOD OLED RGB
P112	Control RES pin of PMOD OLED RGB
P410	Control VCCEN pin of PMOD OLED RGB
P304	Control PMODEN pin of PMOD OLED RGB
P400/SCL0	Clock signal: Communicate with sensors (ZMOD4410) through IIC-bus
P401/SDA0	Data signal: Communicate with sensors (ZMOD4410) through IIC-bus
P015/IRQ7	Judge the status of ZMOD4410 through BUSY pin of ZMOD4410
VDD	Power supply voltage
GND	Ground

3.4 Operating Instructions

- (1) Once powered on, the system begins to initialize.
- (2) After initialization, the MCU (RA2E1) starts to get the sensor measurement result, and send it to the OLED to visualize.
- (3) Finishing to visualize, and the MCU (RA2E1) starts the next measurement.

Display pattern: (12 char * 4 row)

Use different colors to display the sensor data

		R	E	N	E	S	A	S			
T	e	m	p	:		x	x	.	x		C
H	u	m	d	:		x	x	.	x		%

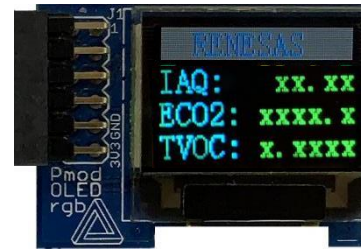


Table 3.3 OLED Display Color

Item	Range	OLED Display Color
IAQ ^{Note}	0.00 – 1.99	Green char
	2.00 – 2.99	Grass char
	3.00 – 3.99	Yellow char
	4.00 – 4.99	Orange char
	5.00 or more	Red char
ECO2	0.0 – 799.0	Green char
	800.0 – 999.0	Yellow char
	1000.0 – 4999.0	Orange char
	5000.0 or more	Red char
TVOC ^{Note}	0.0000 – 0.3000	Green char
	0.3000 – 1.0000	Grass char
	1.0000 – 3.0000	Yellow char
	3.0000 – 10.0000	Orange char
	10.0000 or more	Red char

Note: The US082-ZMOD4410EVZ Gas Sensor Module is designed for detecting total volatile organic compounds (TVOC) and monitoring indoor air quality (IAQ) in different use cases. IDT has adopted the definition of TVOCs and their impact on user health and comfort proposed by the UBA; see Table 3.4.

Table 3.4 Level of Air Quality Based on TVOC Levels Described by the UBA

IDT IAQ Rating	Reference Level	Air Information	TVOC (mg/m3)	Air Quality
≤ 1.99	Level 1	Clean Hygienic Air (target value)	< 0.3	Very Good
2.00 to 2.99	Level 2	Good Air Quality (if no threshold value is exceeded)	0.3 to 1.0	Good
3.00 to 3.99	Level 3	Noticeable Comfort Concerns (not recommended for exposure > 12 months)	1.0 to 3.0	Medium
4.00 to 4.99	Level 4	Significant Comfort Issues (not recommended for exposure > 1 month)	3.0 to 10.0	Poor
≥ 5.00	Level 5	Unacceptable Conditions (not recommended)	> 10.0	Bad

4. Hardware

This section describes how the RA2E1 Fast Prototyping Board measures the indoor air quality via US082-ZMOD4410EVZ. And the sensing data (indoor air quality) are displayed on pmod OLED rgb.

About the details of pmod OLED rgb and US082-ZMOD4410EVZ, please refer to the following linkages.

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

<https://www.renesas.com/jp/en/products/sensor-products/environmental-sensors/digital-gas-sensors/us082-zmod4410evz-tvoc-and-indoor-air-quality-sensor-pmod-board-renesas-quick-connect-iot>

Figure 4.1 shows the hardware composition. Figure 4.2 shows the RA2E1 FPB Board Layout (Top Side).

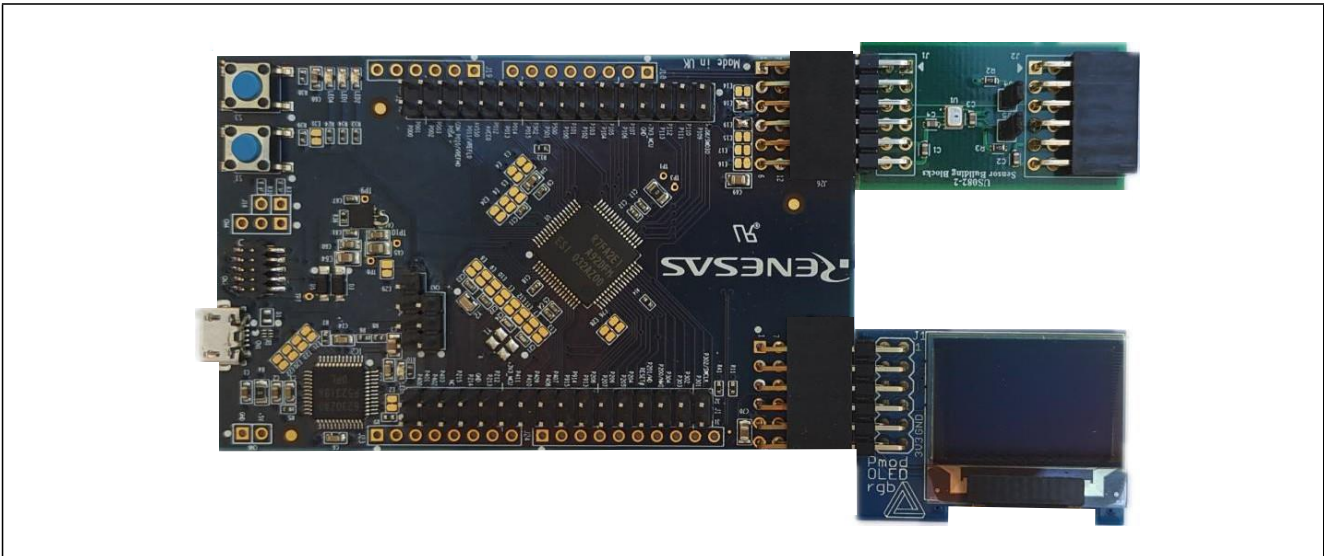


Figure 4.1 Hardware Composition

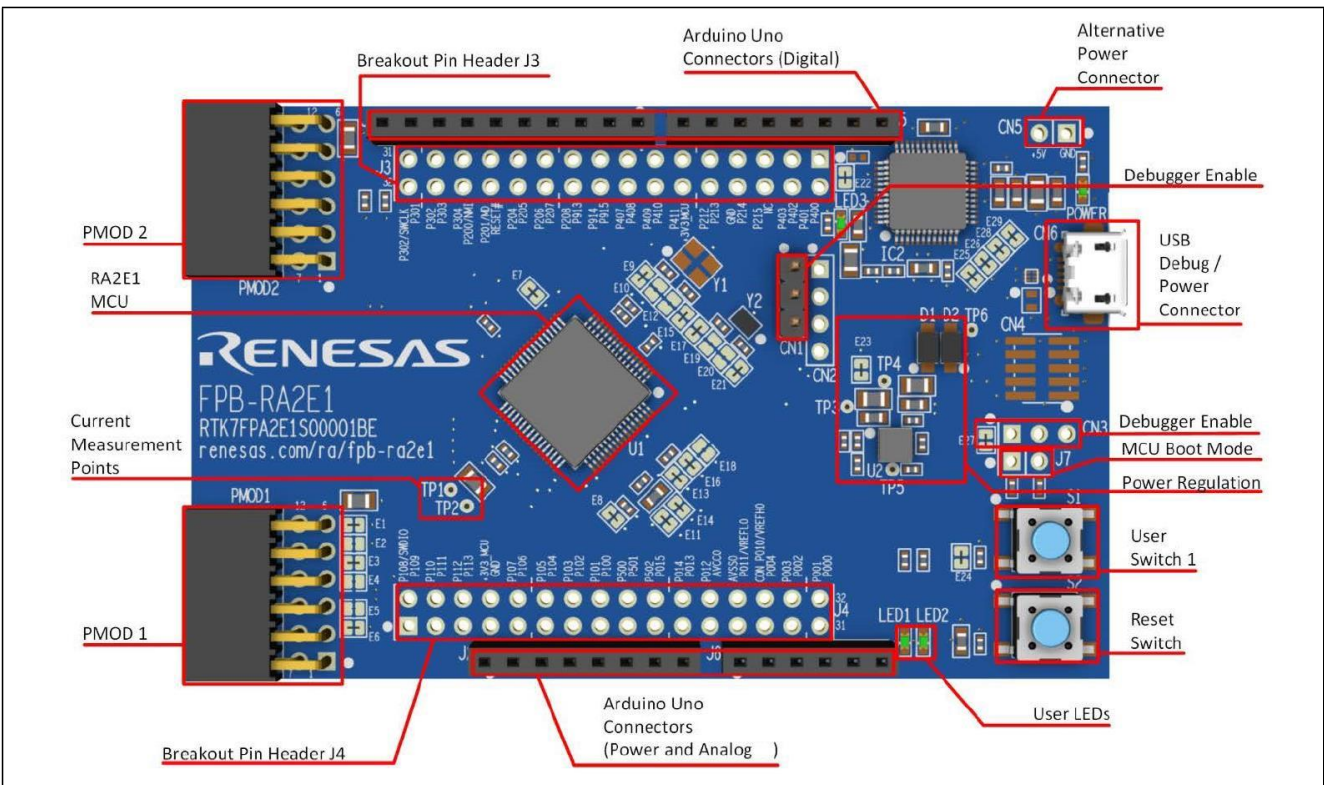


Figure 4.2 RA2E1 FPB Board Layout (Top Side)

4.1 Schematics

Figure 4.3 shows the schematic of US082-ZMOD4410EVZ via RA2E1 FPB Pmod2 connector.

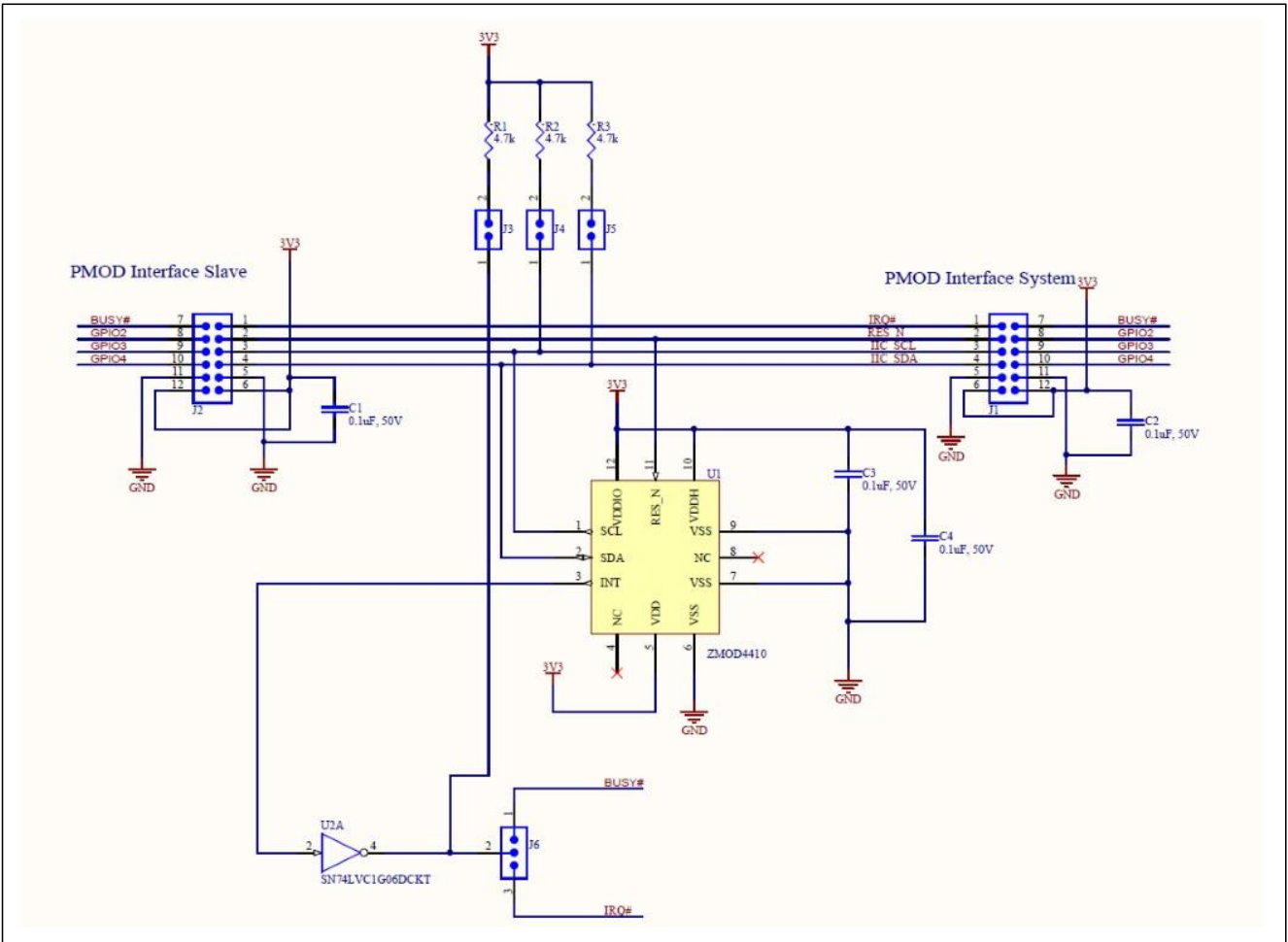


Figure 4.3 US082-ZMOD4410EVZ Circuit

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
Board	FPB-RA2E1
Device	RA2E1(R7FA2E1A92DFM)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 48 MHz System clock (ICLK): 48 MHz Peripheral module clock B (PCLKB): 24 MHz Peripheral module clock D (PCLKD): 48 MHz
Operating voltage	3.3 V (can run on a voltage range of 1.6 V to 5.5 V)
Integrated development environment (e ² studio)	e ² studio 2021-07
FSP	3.4.0 from Renesas Electronics Corp.
Toolchain (GCC ARM Embedded)	10.2.1.20201103
Project type	Flat
ZMOD4410 Lib	Middleware - ZMOD4XXX on rm_zmod4xxx

5.2 Operation Outline

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

Figure 5.1 shows the block diagram for the tasks transition.

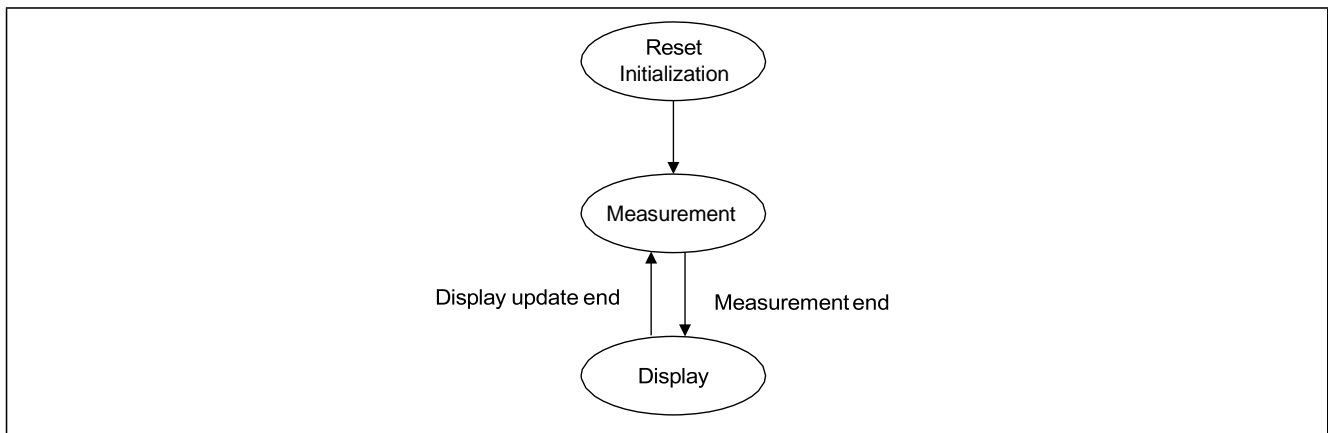


Figure 5.1 Tasks Transition Block Diagram

(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. ZMOD4410 is reset and initialized. SCI9, IIC0, GPT0 and I/O pins will be initialized.

(2) Measurement mode

After initialization, the MCU starts to get the sensor measurement results. Sensor ZMOD4410 needs to wait 1.99 seconds before starting the next measurement.

(3) Display mode

After measurement, the MCU sends the information to the OLED to display.

5.3 Flow Chart

5.3.1 Main Processing

Figure 5.2 shows the flowchart for main processing routine.

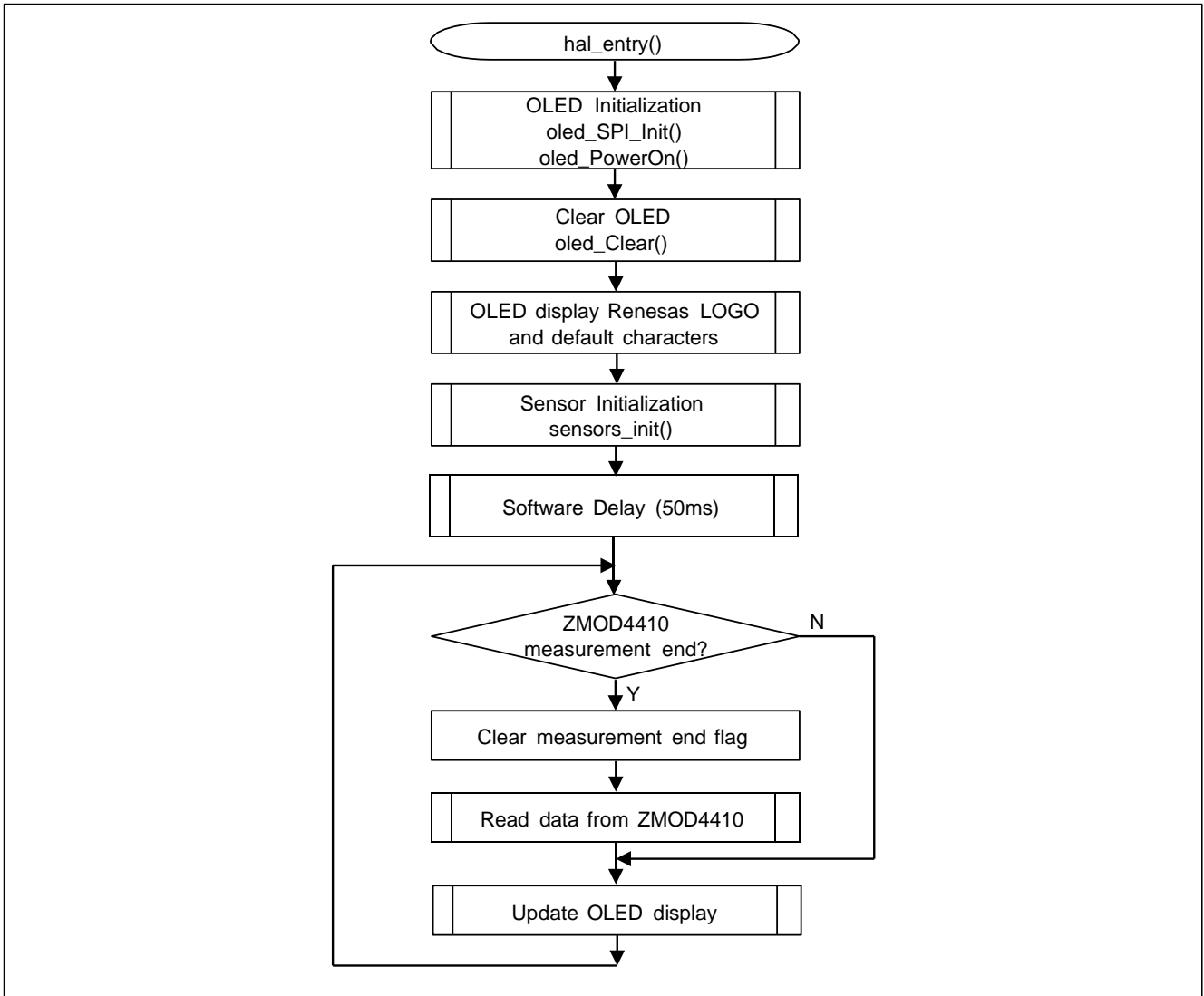
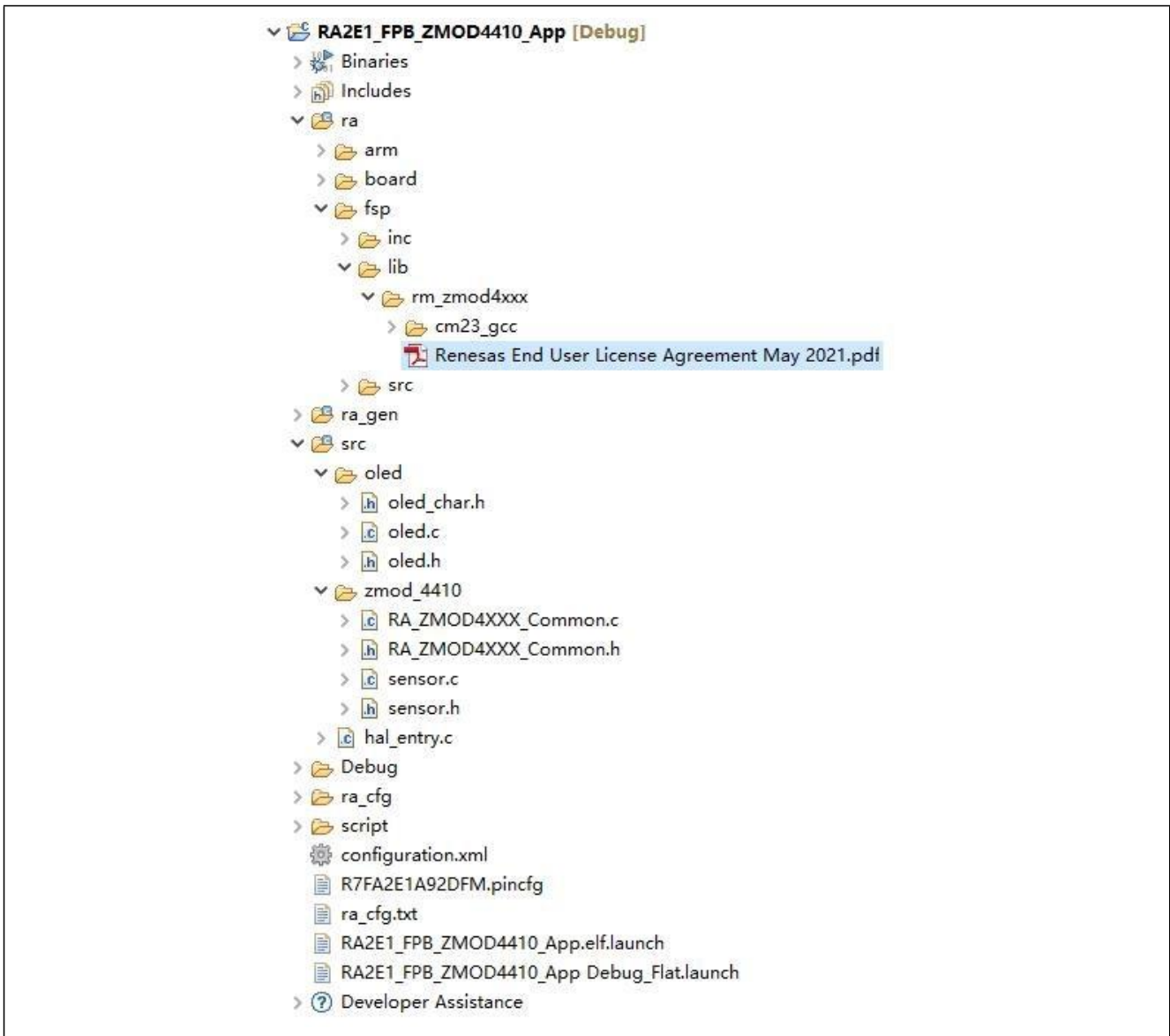


Figure 5.2 Main Processing

5.4 File Compositions

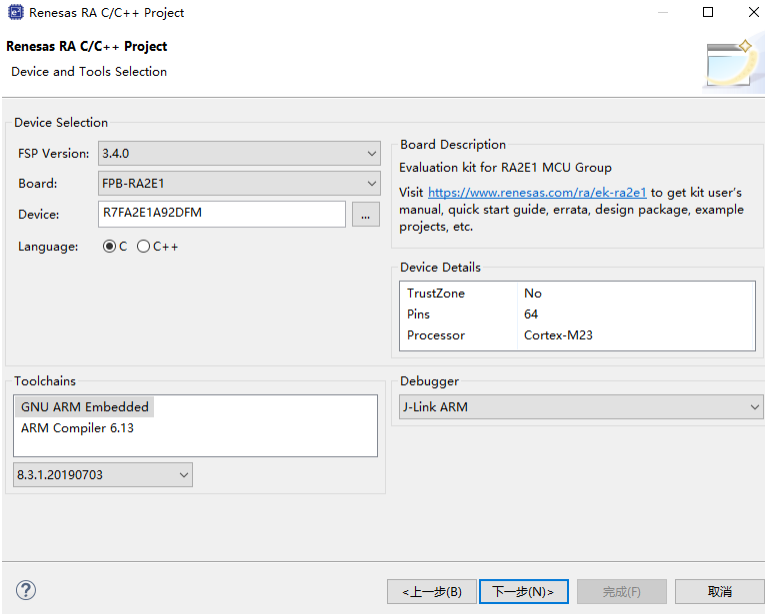
The file composition is shown below.



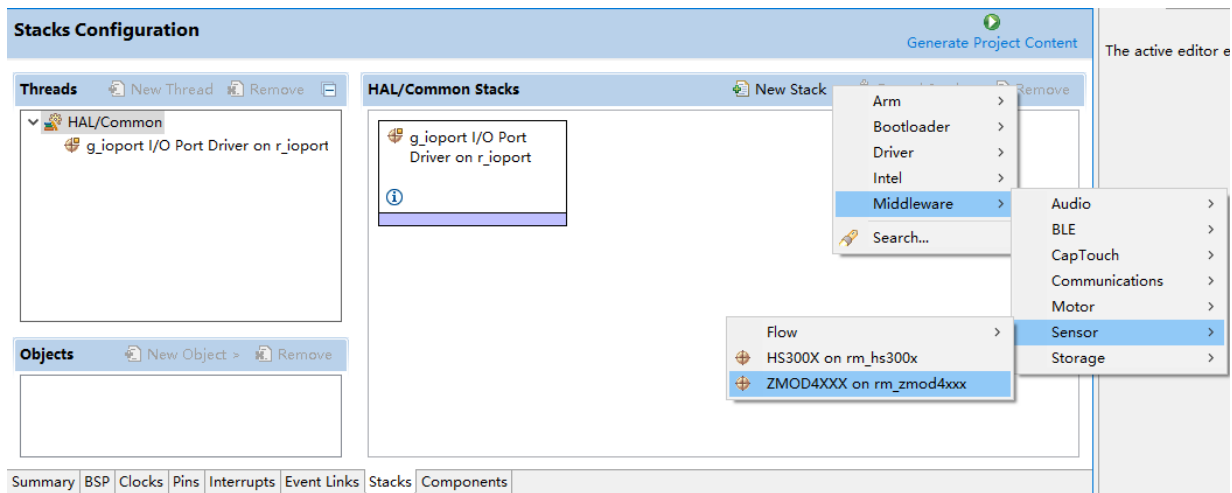
6. How to Add Sensor Middleware using FSP in e2studio

I. Launch e2 studio.

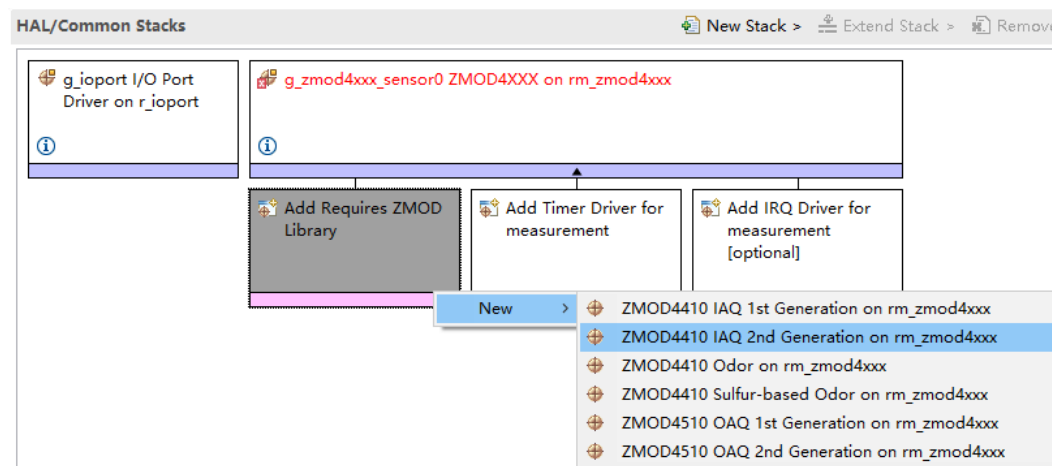
II. Create a new project.



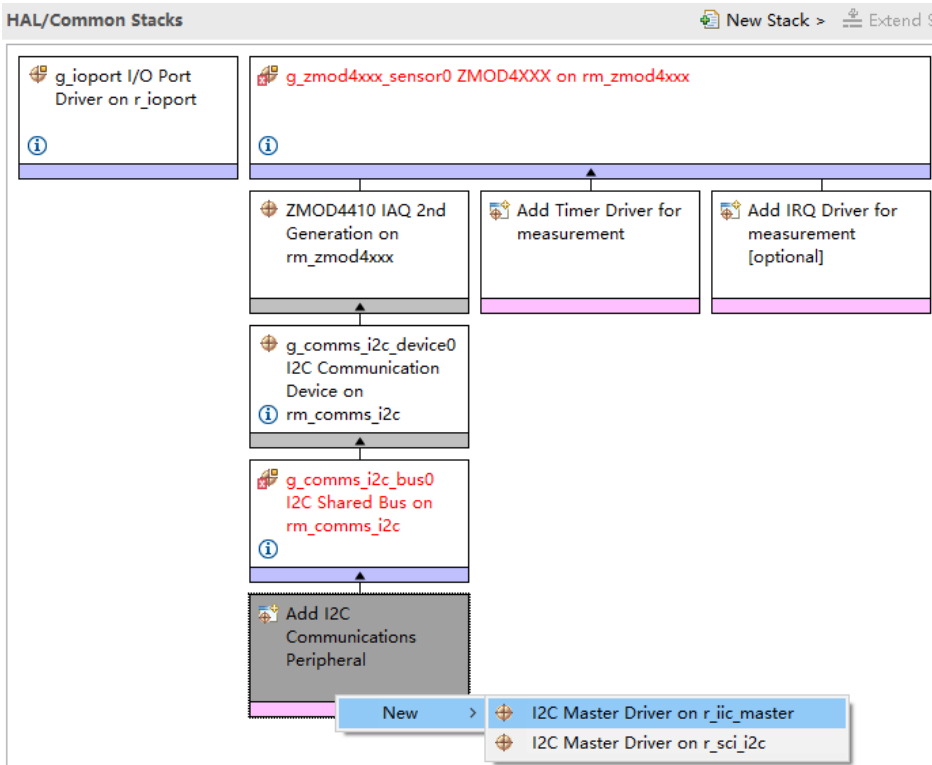
III. Add ZMOD4410 sensor middleware in the "Stacks" tabbed page.



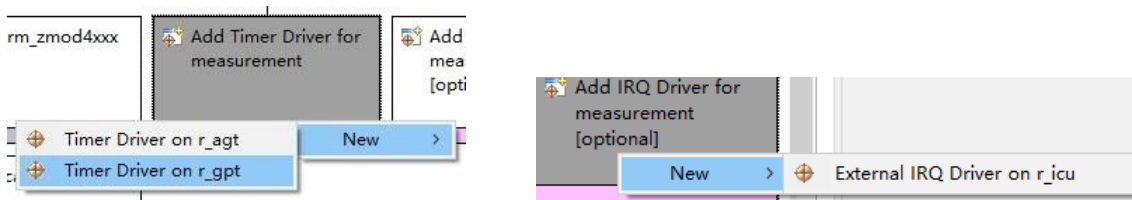
IV. Add requires ZMOD library. In this application, add "ZMOD4410 IAQ 2nd Generation on rm_zmod4xxx".



V. Add the r_iic_master or r_sci_i2c according to the specifications of the target board.



VI. Add Timer Driver and IRQ driver for measurement. Timer can select GPT or AGT.



VII. Set the used pins.

Pin Selection

Type filter text

- ✓ Connectivity:IIC
 - ✓ IIC0
- ✓ Connectivity:SCI
 - SCI0
 - SCI1
 - SCI2
 - ✓ SCI9
- > Connectivity:SPI
- > Input:CTSU
- > ✓ Input:ICU
- > Input:KINT
- > Monitoring:CAC
- > System:CGC
- > ✓ System:DEBUG
- > ✓ System:SYSTEM
- > Timers:AGT
- > Timers:GPT
- > Timers:RTC

Pin Configuration

Name	Value	Lock	Link
Pin Group Selection	_A only		
Operation Mode	Enabled		
Input/Output			
SDA	✓ P401		
SCL	✓ P400		

Module name: IIC0
 Usage: For IIC, use same Pin Group for SDA/SCL signals
 -Please refer to the MCU User's Manual.

Pin Function	Pin Number
summary	BSP Clocks Pins Interrupts Event Links Stacks Components

Pin Selection

Type filter text

- ✓ IIC0
- ✓ Connectivity:SCI
 - SCI0
 - SCI1
 - SCI2
 - ✓ SCI9
- > Connectivity:SPI
- > Input:CTSU
- ✓ Input:ICU
 - ✓ ICU0
 - > Input:KINT
 - > Monitoring:CAC
 - > System:CGC
 - > ✓ System:DEBUG
 - > ✓ System:SYSTEM
 - > Timers:AGT
 - > Timers:GPT
 - > Timers:RTC

Pin Configuration

Name	Value	Lock	Link
Operation Mode	Enabled		
▼ Input/Output			
NMI	None		
IRQ00	None		
IRQ01	✓ P205		
IRQ02	None		
IRQ03	None		
IRQ04	None		
IRQ05	None		
IRQ06	None		
IRQ07	✓ P015		

Module name: ICU0
Usage: To use IRQ function with output or peripheral modes, change directly in port dialog

Pin Function | Pin Number

Summary | BSP | Clocks | Pins | Interrupts | Event Links | Stacks | Components

VIII. Set the properties of I2C Master Driver, Timer Driver and IRQ Driver according to the specifications of the target board.

g_i2c_master0 I2C Master Driver on r_iic_master

Settings	Property	Value
API Info	▼ Common	
	Parameter Checking	Default (BSP)
	DTC on Transmission and Reception	Disabled
	10-bit slave addressing	Disabled
	▼ Module g_i2c_master0 I2C Master Driver on r_iic_master	
	Name	g_i2c_master0
	Channel	0
	Rate	Standard
	Rise Time (ns)	120
	Fall Time (ns)	120
	Duty Cycle (%)	50
	Slave Address	0x00
	Address Mode	7-Bit
	Timeout Mode	Short Mode
	Timeout during SCL Low	Enabled
Callback	rm_comms_i2c_callback	
Interrupt Priority Level	Priority 1	
▼ Pins		
SDA	P401	
SCL	P400	

g_timer0 Timer Driver on r_gpt		
Settings	Property	Value
API Info	▼ Common	
	Parameter Checking	Default (BSP)
	Pin Output Support	Disabled
	Write Protect Enable	Disabled
	▼ Module g_timer0 Timer Driver on r_gpt	
	▼ General	
	Name	g_timer0
	Channel	0
	Mode	🔒 Periodic
	Period	🔒 1
	Period Unit	🔒 Milliseconds
	> Output	
	> Input	
	▼ Interrupts	
	Callback	🔒 rm_zmod4xxx_timer_callback
	Overflow/Crest Interrupt Priority	Priority 3
	Capture A Interrupt Priority	Disabled
	Capture B Interrupt Priority	Disabled
	Underflow/Trough Interrupt Priority	Disabled
	> Extra Features	
	▼ Pins	
	GTIOCA	<unavailable>
	GTIOCB	<unavailable>

g_external_irq0 External IRQ Driver on r_icu		
Settings	Property	Value
API Info	▼ Common	
	Parameter Checking	Default (BSP)
	▼ Module g_external_irq0 External IRQ Driver on r_icu	
	Name	g_external_irq0
	Channel	7
	Trigger	Rising
	Digital Filtering	Enabled
	Digital Filtering Sample Clock (Only valid when Digital Filter	PCLK / 64
	Callback	🔒 rm_zmod4xxx_irq_callback
	Pin Interrupt Priority	Priority 2
	▼ Pins	
	IRQ07	P015

7. How to Build the Project and How to Program the Output File

7.1 Build in 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 "RA2E1_FPB_ZMOD4410_App" 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 building.
- VI. A Motorola S-record file "RA2E1_FPB_ZMOD4410_App.srec" is generated in the path shown in the Debug folder of e2 studio.

7.2 Writing srec 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 "RA2E1 Fast Prototyping Board User's Manual" (R20UT4956).

- I. Launch Renesas Flash Programmer.
- II. Select "File"->"New Project..." from the menu to create a new project of RA2E1 using E2 lite. About connection setting, "Interface" select "2 wire UART", "Power" select "None".
- III. Press the "Browse ..." button in "Program File" on the "Operation" tab to open the srec File "RA2E1_FPB_ZMOD4410_App.srec".
- IV. Press the "Start" button to start writing.

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

8. Sample Code

The sample code is available on the Renesas Electronics Website.

9. Reference Documents

RA2E1 Fast Prototyping Board (R20UT4956)

RA2E1 User's Manual: Hardware (R01UH0852)

RA Family ZMOD4xxx Sample Application (R01AN5899)

(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/>

Forum

<https://japan.renesasrulz.com/>

All trademarks and registered trademarks are the property of their respective owners.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.10, 21	-	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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

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/.