RA2E1 Group

RA2E1 HS3001 Sensor Device Sample

Introduction

This document describes a Renesas microcontroller RA2E1 application for an HS3001 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

1.1 Abstract

The HS3001 sensor device sample is a precision digital sensor featuring indoor temperature, humidity using the RA2E1 Fast Prototyping Board. With an OLED screen, it makes all the information well displayed and shows different levels of temperature and humidity in different colors, with each color corresponding to a different level of physical 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 HS3001 is a highly-accurate, fully-calibrated relative humidity and temperature sensor. The high accuracy, fast measurement response time, and long-term stability, along with the small package size, makes the HS3001 ideal for a wide number of applications from portable to harsh environments. An integrated calibration and temperature compensation logic provides fully corrected RH and T values via a standard I²C output. The measured data is internally corrected and compensated for accurate operation over a wide range of temperature and humidity levels–user calibration is not required.

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 * 3 row

Specifications

- Function: Detect indoor humidity and temperature with US082-HS3001EVZ.
  Display the humidity/temperature information on an OLED screen.
  Information in different colors on the OLED screen correspond to different levels of temperature/humidity.

2. RA2E1 Microcontroller

2.1 RA2E1 Block Diagram

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

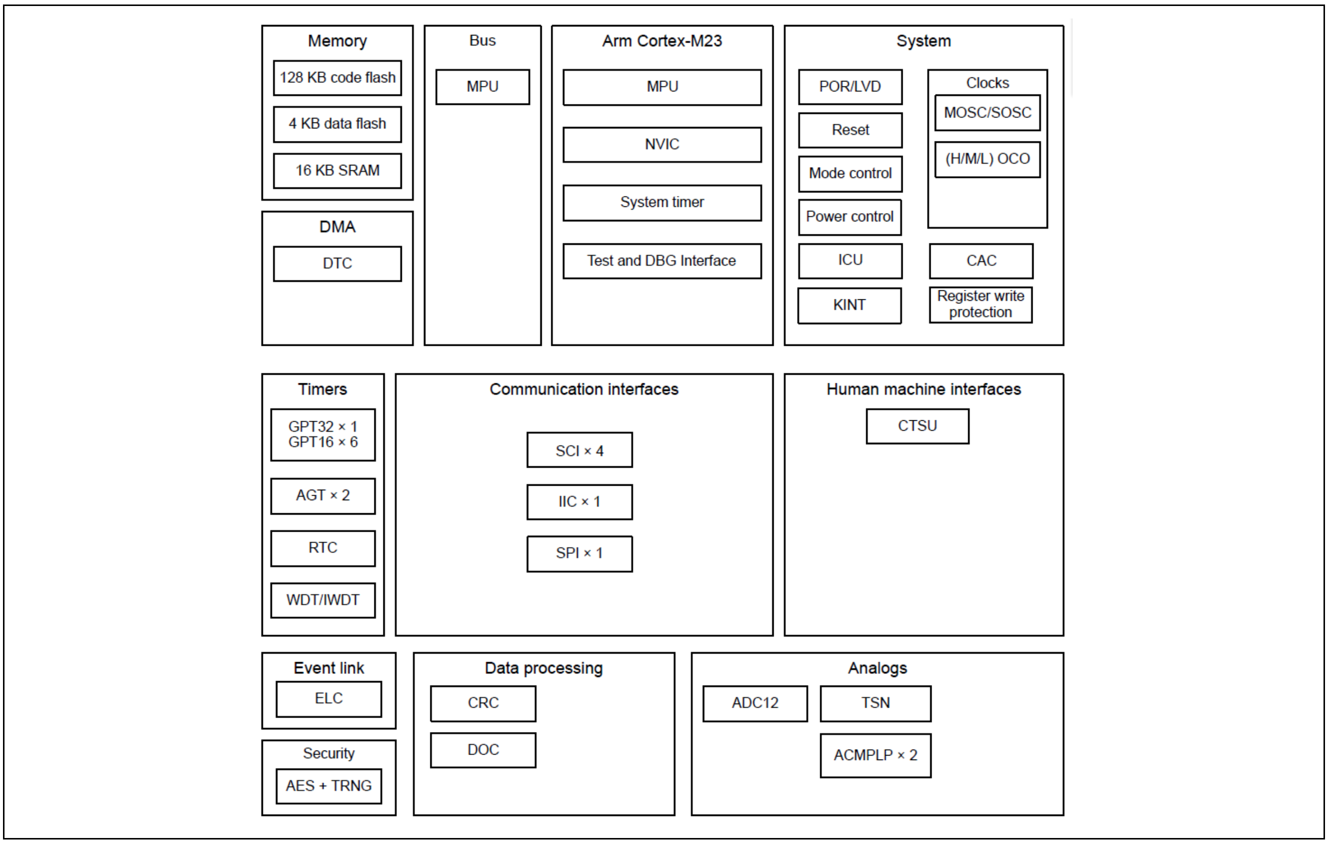

Figure 2.1 RA2E1 Block Diagram

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
- IWDT-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℃ to +85℃
  - 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℃ to +105℃
  - 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)
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  - 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).

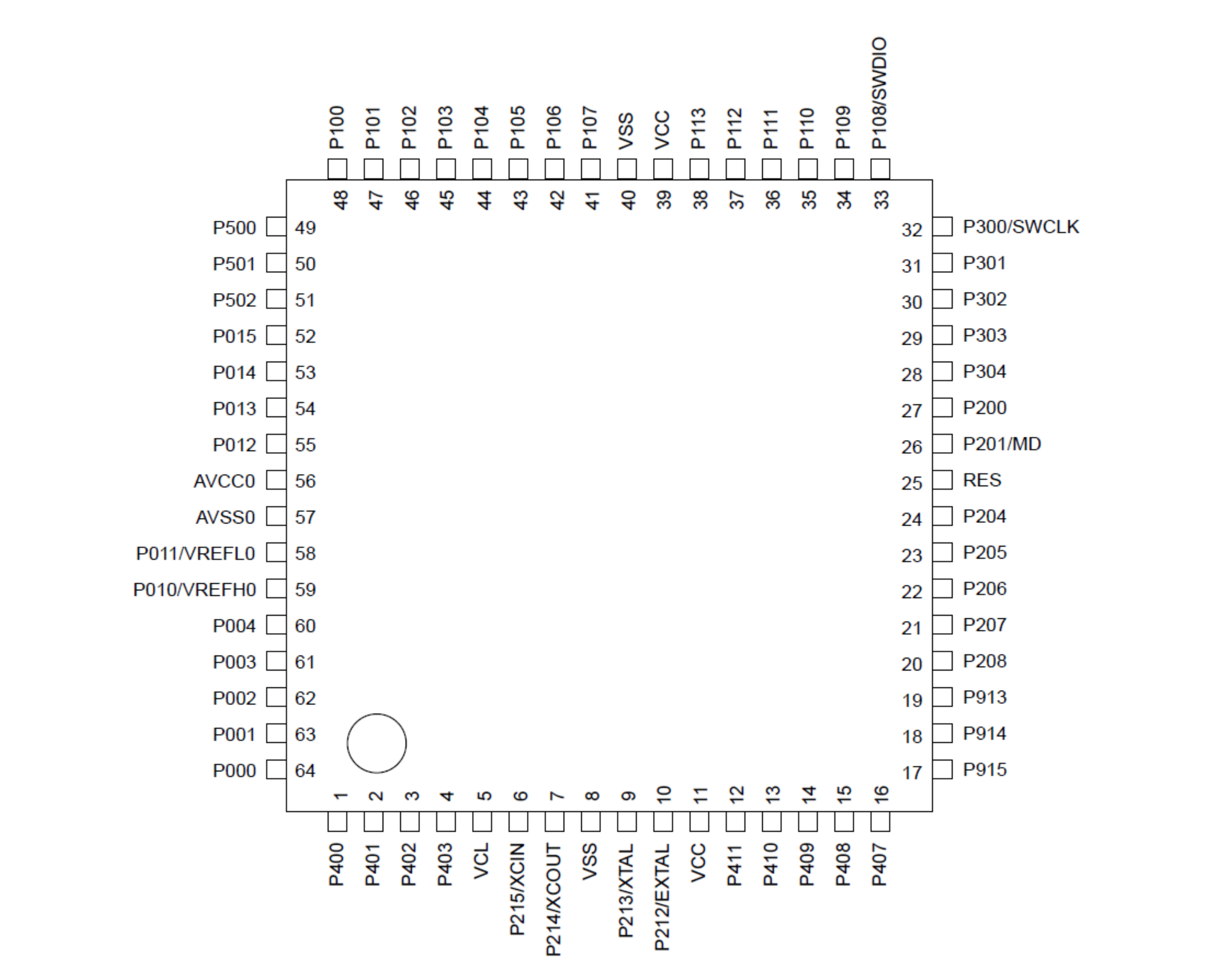


Figure 2.2 RA2E1 (64-pin products) Pin Assignments

3. System Outline

3.1 Principle Introduction

The HS3001 Sensor Device uses an RA2E1 microcontroller and a digital temperature & humidity sensor. After detecting the indoor temperature/humidity, 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 Relative Humidity Sensor Pmod™ Board (US082-HS3001EVZ).

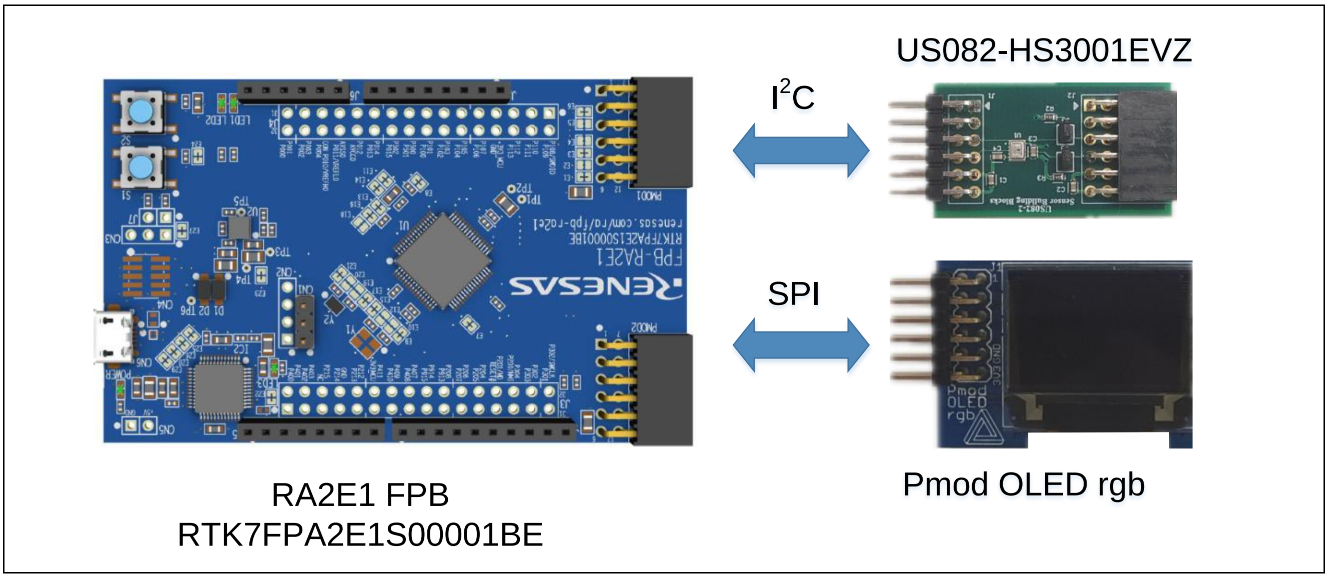


Figure 3.1 System Composition

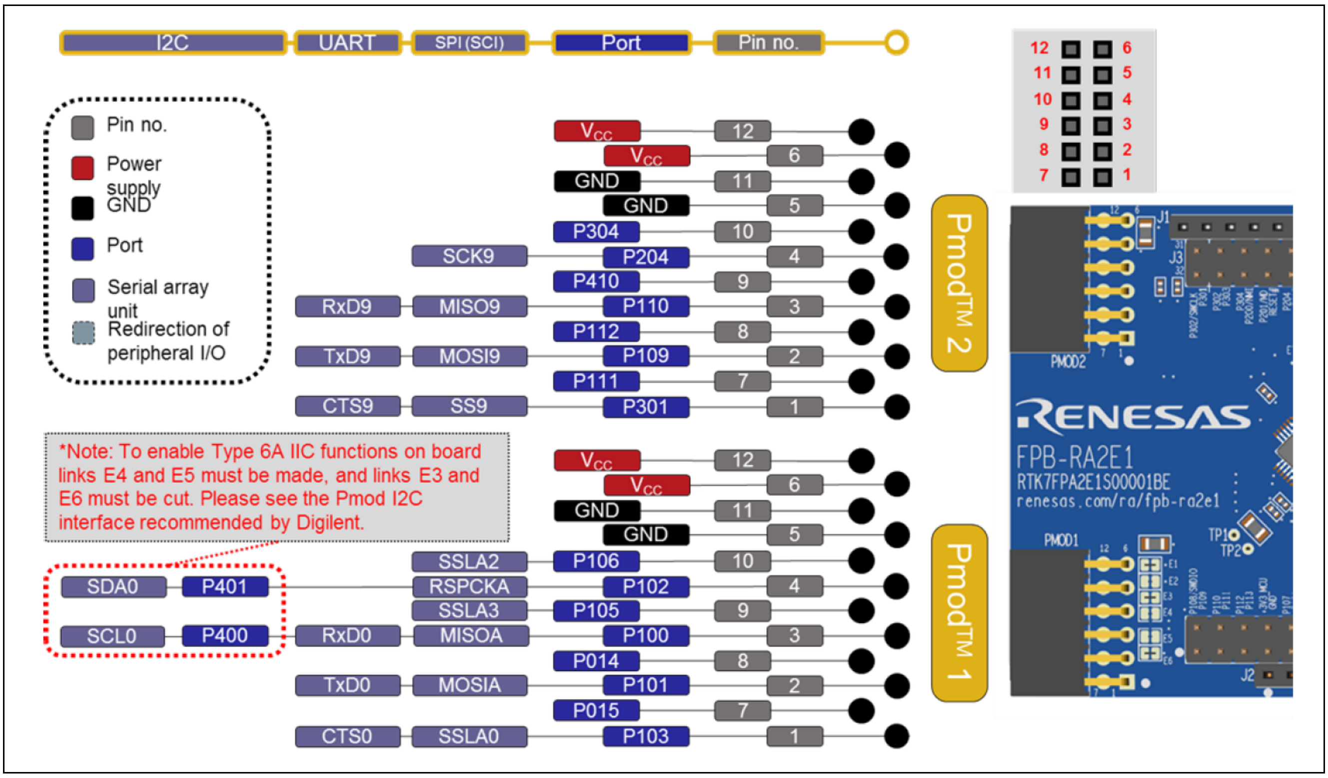
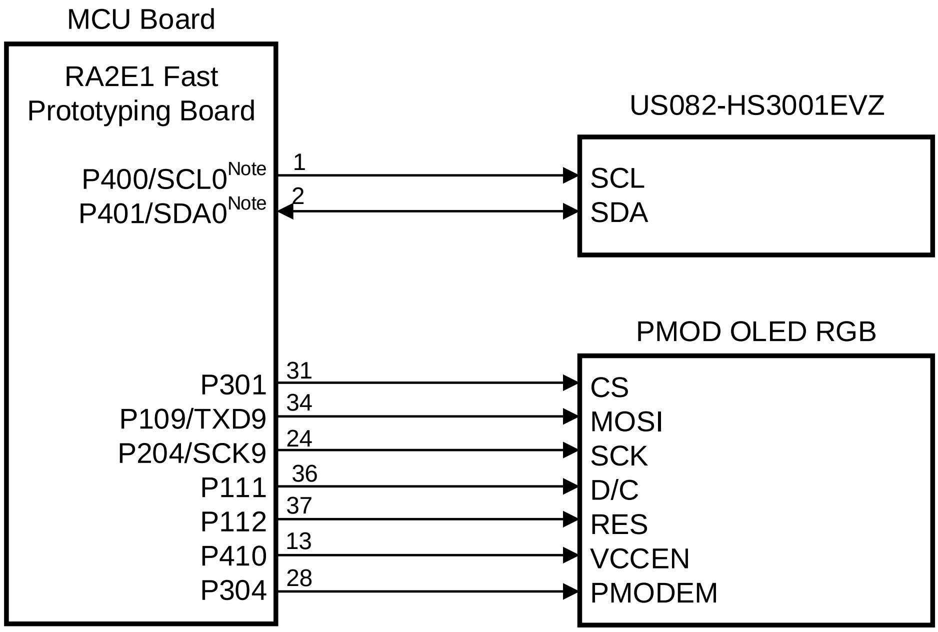


Figure 3.2 RA2E1 FPB PMOD Interface



Note: As P400 and P401 are used as I2C interface which communicates with US082-HS3001EVZ, it is needed to enable Type 6A IIC functions on the FPB-RA2E1 board. Please ensure that the on board links of E4 and E5 are closed and links of E3 and E6 are open.

Figure 3.3 Connection of RA2E1 FPB, PMOD OLED RGB and US082-HS3001EVZ

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 (SCI9)	Control OLED to display temperature, humidity.
I2C (IIC0)	Get data (temperature, humidity) from the sensors.

3.3 ins 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 sensor (HS3001) through IIC-bus
P401/SDA0	Data signal: Communicate with sensor (HS3001) through IIC-bus
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 * 3 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		%

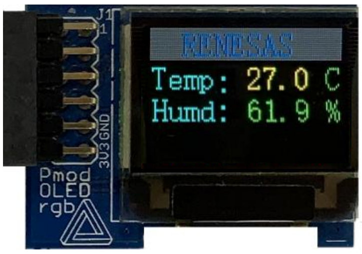


Table 3.3 OLED Display Color

Item	Range	OLED Display Color
Temperature	14.9 or low ˚C	Blue char
	15.0 – 24.9˚C	Green char
	25.0 – 39.9˚C	Yellow char
	40.0 or more ˚C	Red char
Humidity	0.0 – 14.9%	Red char
	15.0 – 39.9%	Yellow char
	40.0 – 69.9%	Green char
	70.0 – 100%	Blue char

4. Hardware

This section describes how the RA2E1 Fast Prototyping Board measures the temperature and humidity via US082-HS3001EVZ. And the sensing data (temperature, humidity) are displayed on pmod OLED rgb.

About the details of pmod OLED rgb and US082-HS3001EVZ, please refer to the following linkages.

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

https://www.renesas.com/jp/en/products/sensor-products/humidity-sensors/us082-hs3001evz-relative-humidity-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).

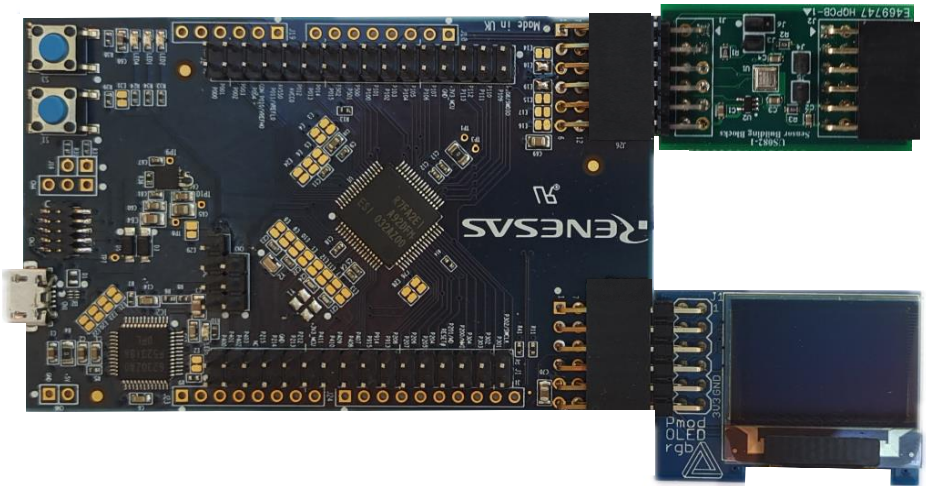


Figure 4.1 Hardware Composition

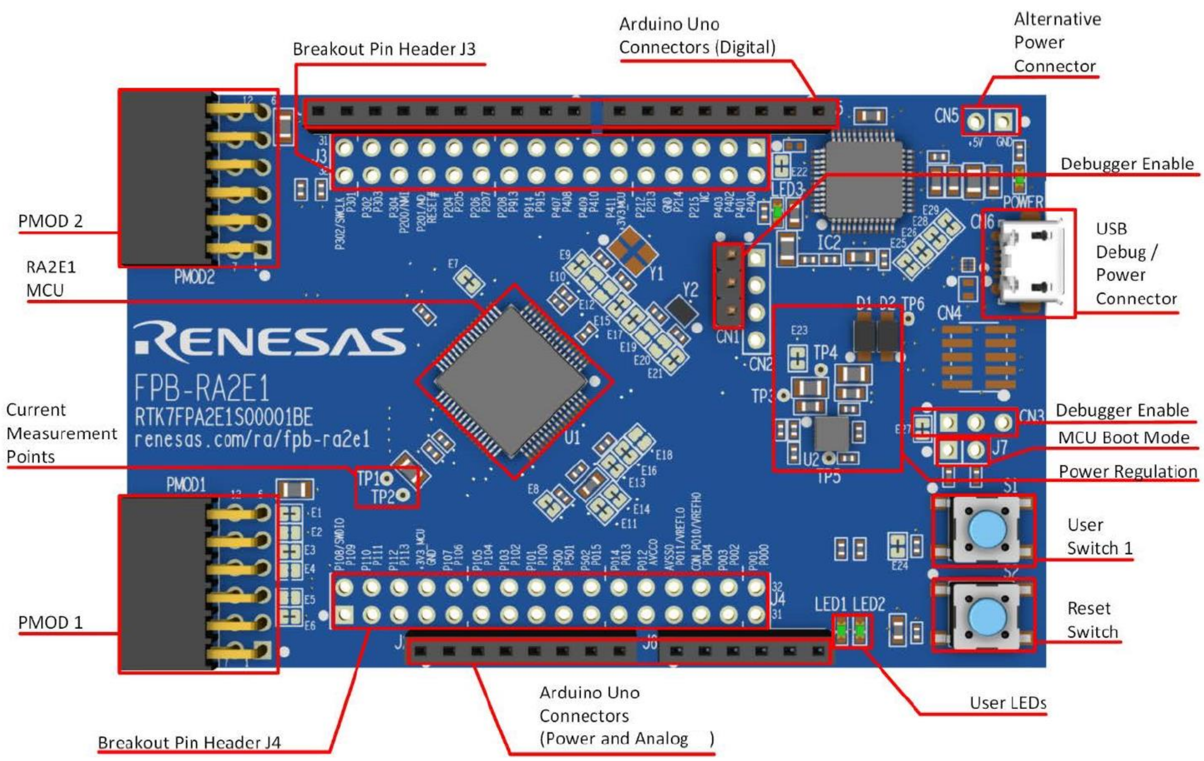


Figure 4.2 RA2E1 FPB Board Layout (Top Side)

4.1 Schematics

Figure 4.3 shows the schematic of US082-HS3001EVZ via RA2E1 FPB Pmod2 connector.

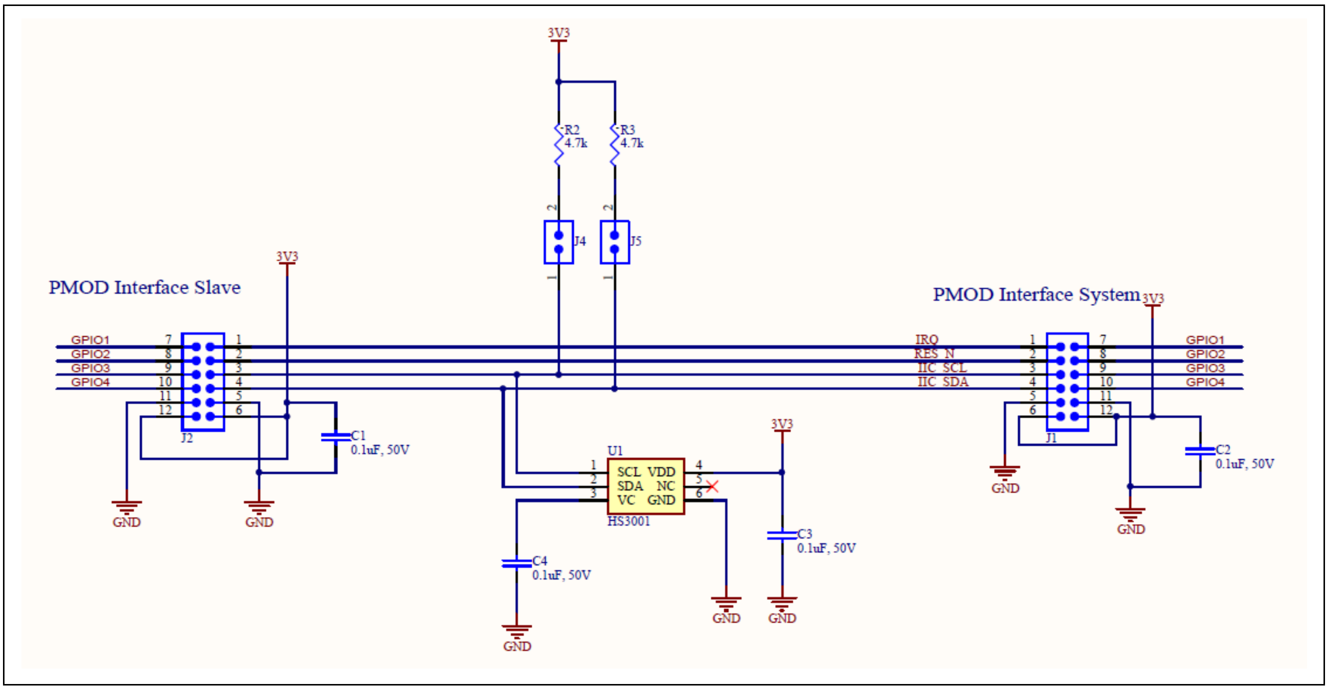


Figure 4.3 US082-HS3001EVZ Circuit

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
HS3001 Lib	Middleware - HS3000X on rm_hs300x

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.

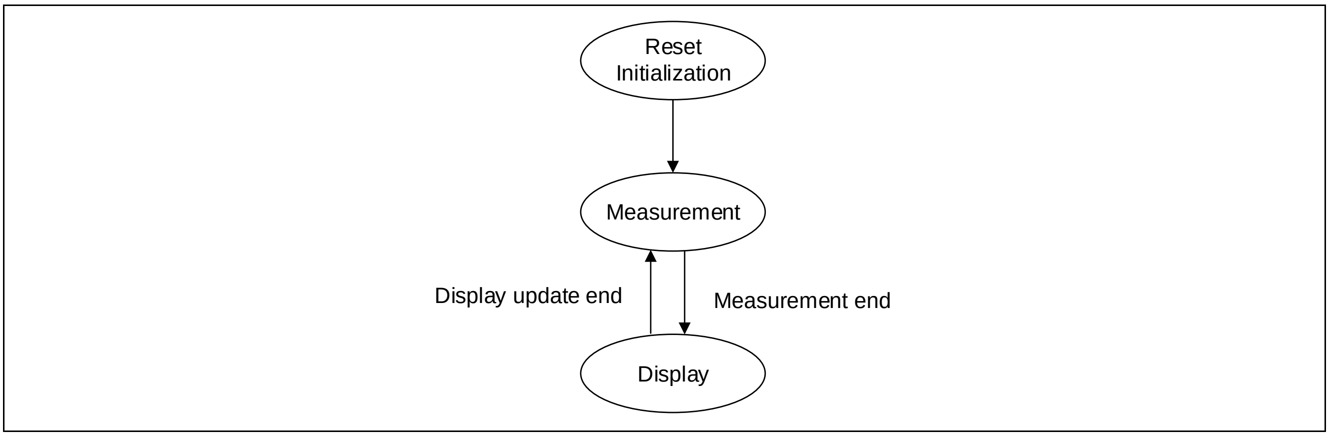


Figure 5.1 Tasks Transition Block Diagram

(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. HS3001 is initialized. SCI9, IIC0 and I/O pins will be initialized.

(2) Measurement mode

After initialization, the MCU starts to get the sensor measurement results.

(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.

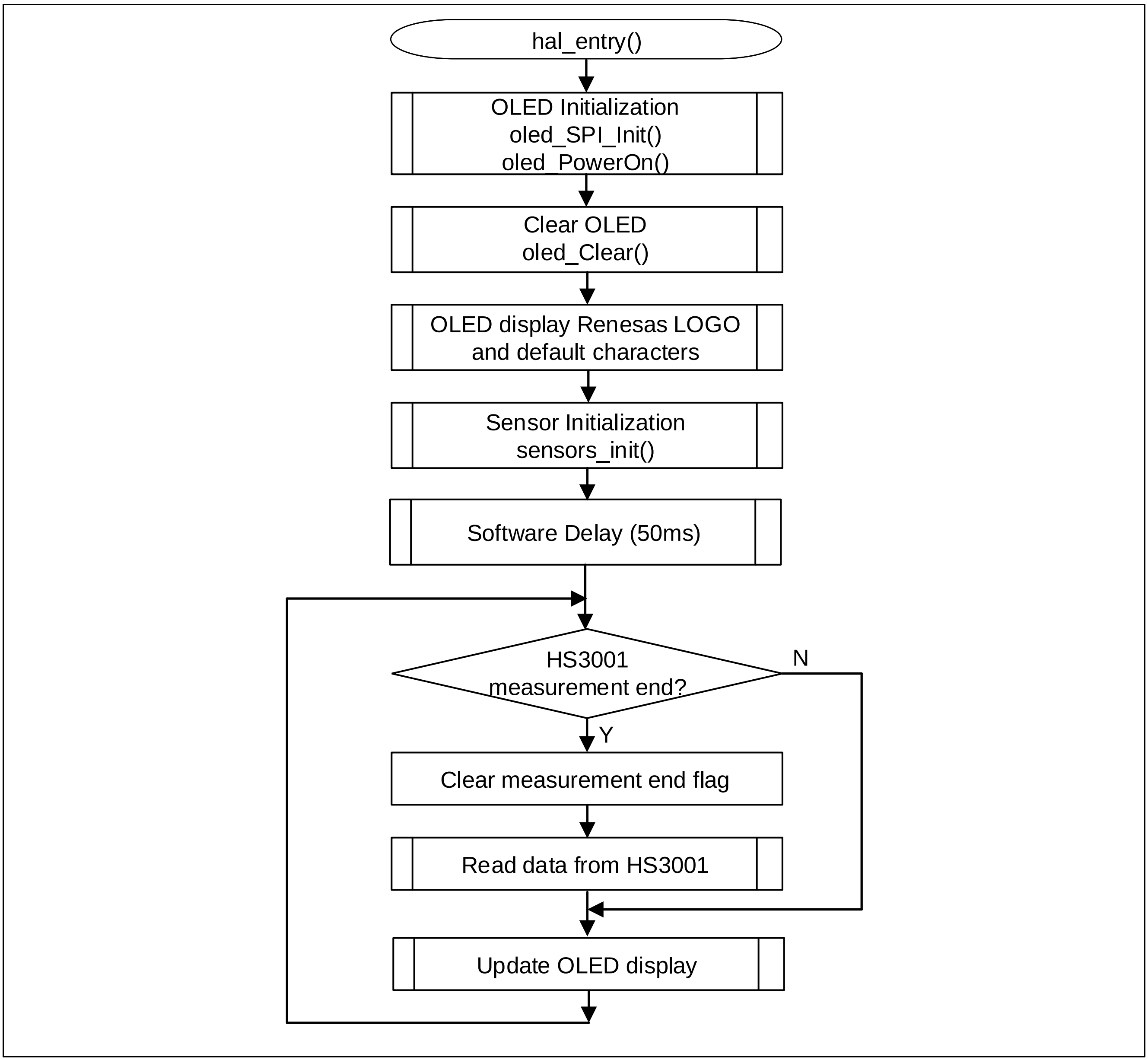
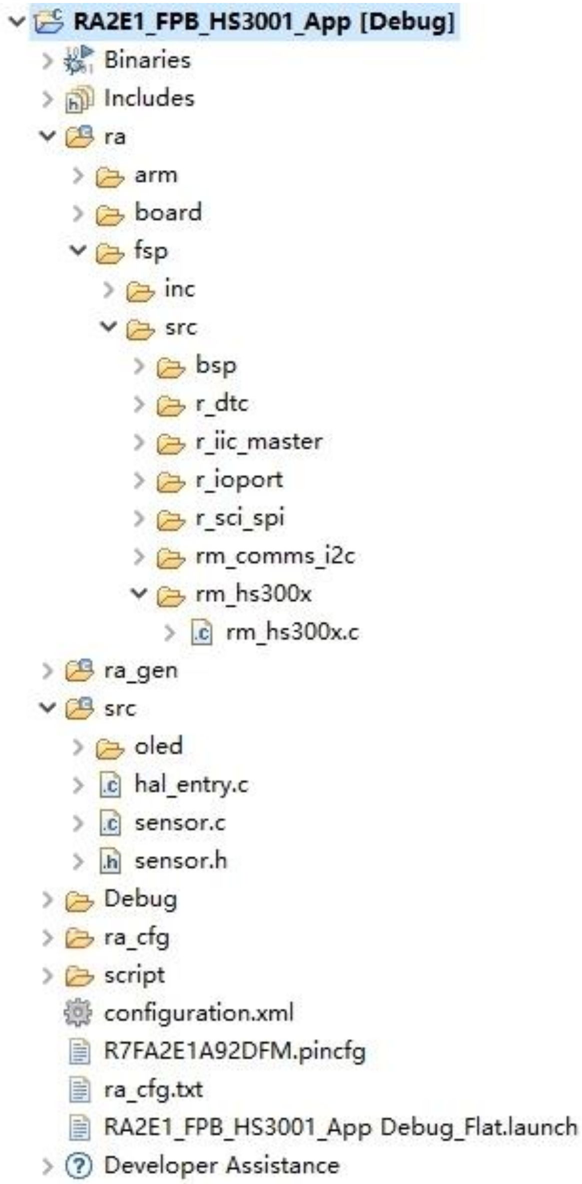


Figure 5.2 Main Processing

5.4 File Compositions

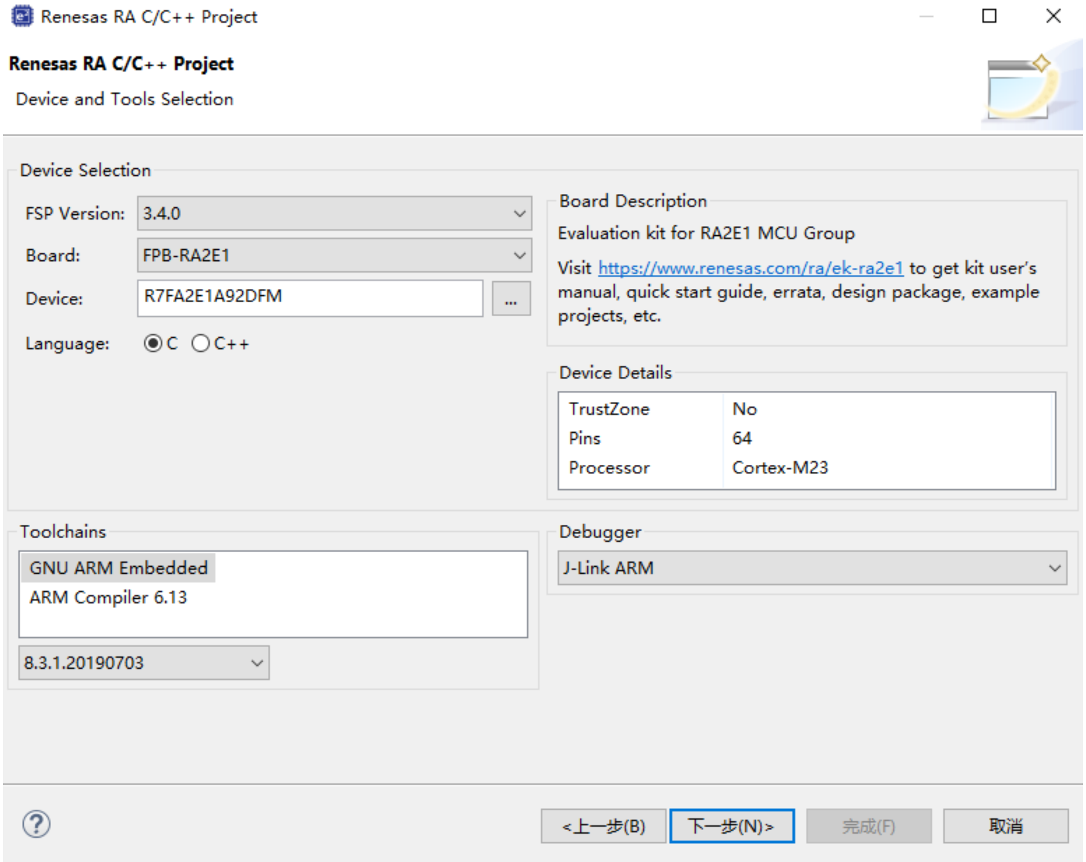
The file composition is shown below.



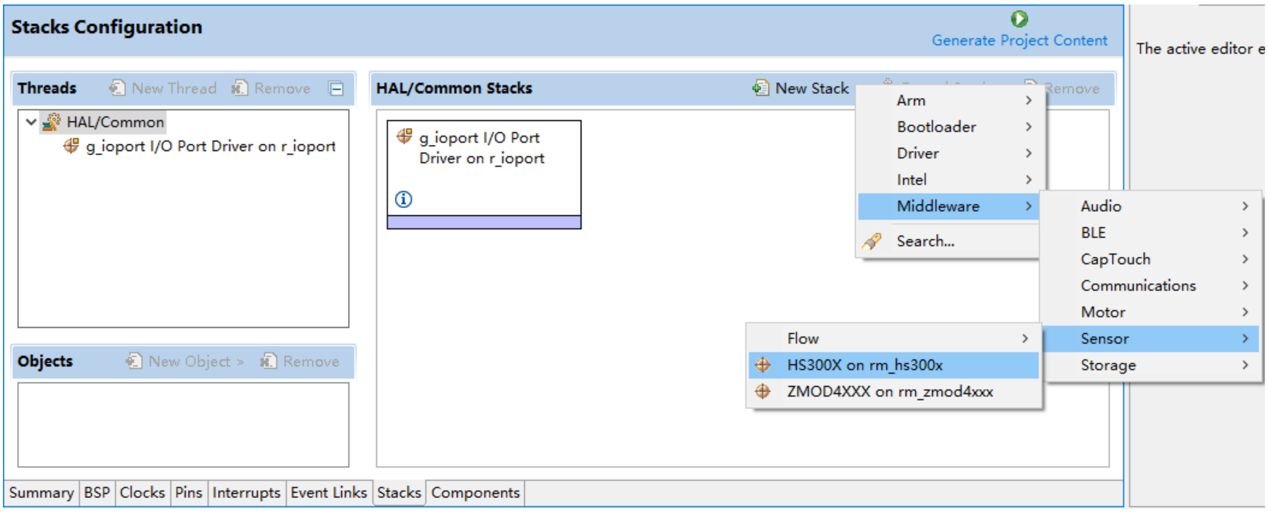
6. How to Add Sensor Middleware using FSP in e2studio

I. Launch e2 studio.

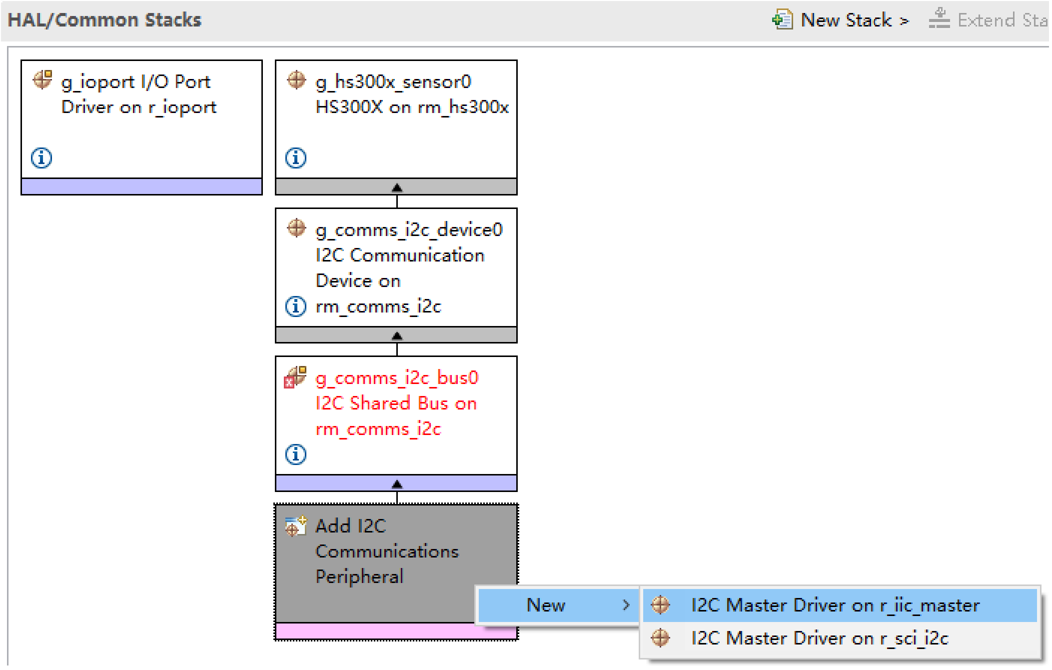
II. Create a new project.



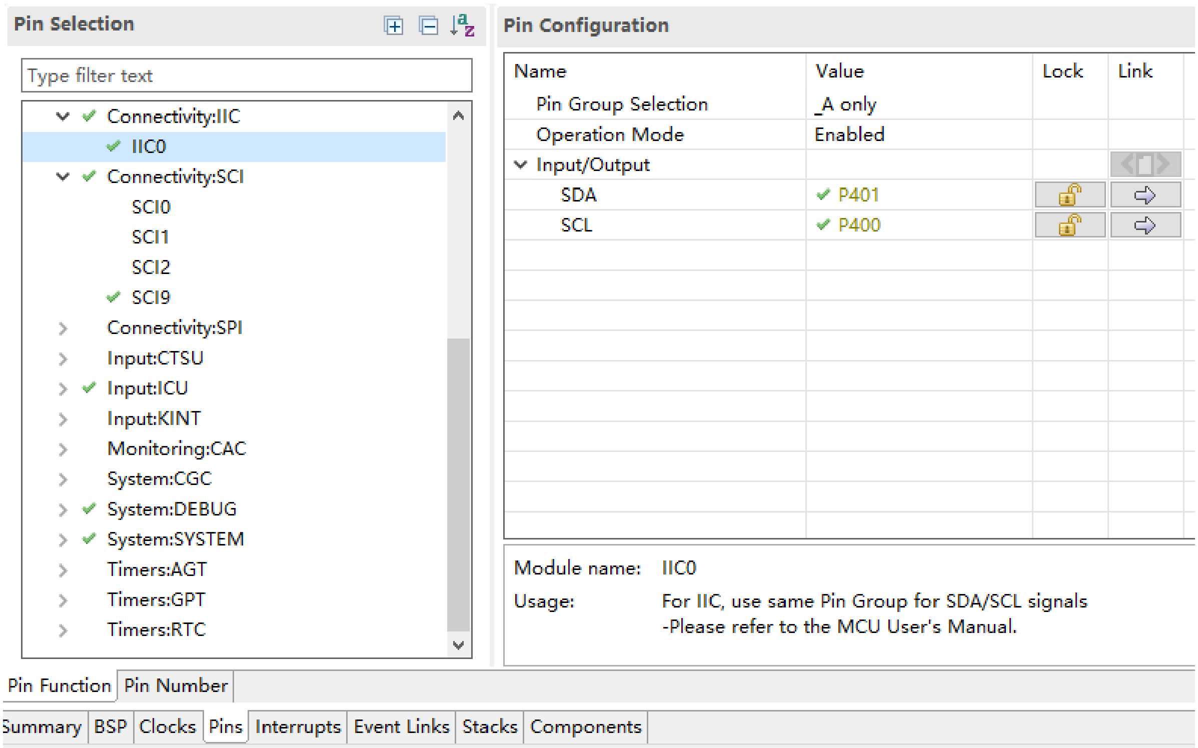
III. Add HS3001 sensor middleware in the "Stacks" tabbed page



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



V. Set the used pins.



VI. Set the properties of I2C Master Driver according to the specifications of the target board.

g_i2c_master0 I2C Master Driver on r_iic_master

Settings | API Info

Property	Value
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

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_HS3001_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_HS3001_App.srec" is generated in the path shown in the Debug folder of e2 studio.

7.2 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 " 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_HS3001_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 HS300x Sample Application (R01AN5897)

(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/

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.

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Contact information

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