

RA2E3 Group RA2E3 HS4001 Low Power Sensor System Example

Introduction

This application note describes an application program which displays the data acquired by the HS400x humidity and temperature sensor operating with an RA Family device on an SSD1306 OLED module.

This program uses Software Standby mode as a low power mode. Compared to the Normal mode, the Software Standby mode minimizes power consumption by stopping the CPU and most peripherals. The MCU spends a long time in Software Standby mode except for the wake-up interrupt handling every 500 milliseconds and the OLED sensor data update processing every 4 seconds. The AGT is used to generate wake-up events.

Target Device

RA2E3

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

Required Resources

The resources required for this application program are as follows.

Hardware

- FPB-RA2E3 Fast Prototyping Board (RTK7FPA2E3S00001BE)
- QCIOT-HS4001POCZ relative humidity sensor Pmod[™] board (QCIOT-HS4001POCZ)
- SSD1306 OLED module
 - Resolution: 128 x 64 dot matrix panel
 - Power supply: 3.3 V
 - Interface: I2C
 - Slave address: 0x3c (7-bit address)
- Four jumper wires (male-to-female type)
- * A separate emulator is not required because on-board J-Link will be used.

Development Tools and Software

- e² studio IDE version 2025-01
- Renesas Flexible Software Package (FSP) version 5.8.0
- GCC ARM Embedded Toolchain version 13.2.1.arm-13-7



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1. Description

1.1 Abstract

This application program is used to display humidity and temperature in the room on the screen of an SSD1306 OLED module by using the RA2E3 Fast Prototyping Board (FPB-RA2E3) with the QCIOT-HS4001POCZ relative humidity sensor Pmod[™] board to acquire the temperature and humidity data. This program runs in Software Standby mode as a low power mode to suppress the operating time of the CPU to a minimum, thus reducing power consumption.

The RA2E3 Fast Prototyping Board comes equipped with an RA2E3 MCU and is an evaluation board specialized for prototype development for a variety of applications. It has a built-in SEGGER J-Link[™] On-Board programmer/debugger 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 MCU, and so on, it has high expandability.

HS4001 is a highly accurate, ultra-low power, and fully calibrated relative humidity and temperature sensor. The MEMS sensor features proprietary sensor-level protection ensuring high reliability and long-term stability. The HS4001 is fully calibrated, and temperature compensated with an I2C digital output.

SSD1306 is a graphics display module controlled by I2C using a 128 * 64 organic light emitting diode (OLED). The display module is a representative IC with many libraries available for use with Arduino-compatible boards, Raspberry Pi, etc.

Power Supply	USB power supply (5 V)
Operating Voltage (MCU)	3.3 V
OLED Display Pattern	14 characters * 4 rows

1.2 Main Technical Parameters



1.3 Specifications

- Detect indoor humidity and temperature with QCIOT-HS4001POCZ.
- The AGT is used as the timer to control the acquisition of temperature and humidity data every 500
 milliseconds and updating of the display of temperature and humidity data on the OLED screen every
 four seconds.
- The Software Standby mode is used as a low power mode to reduce power consumption.

Figure 1.1 shows the MCU states and mode transition events, and Figure 1.2 shows a conceptual diagram of the operation modes and current consumption.



Figure 1.1 MCU Status and Mode Transition Events



Figure 1.2 Conceptual Diagram of Operation Mode and Current Consumption



2. RA2E3 MCU

The RA2E3 group is an entry-line single-chip MCU in the RA family based on the 48 MHz Arm[®] Cortex[®]-M23 core with up to 64KB code flash and 16KB SRAM memory.

RA2E3 MCUs provide an optimized feature set for cost-sensitive applications. Ultra-low power consumption contributes to energy-efficient system design, required for IoT applications and battery-operated systems to achieve longer battery life.

For more details of the RA2E3, please refer to the following link:

http://renesas.com/ra2e3

For more details of specifications, please refer to the following link:

https://www.renesas.com/document/mah/ra2e3-group-users-manual-hardware

RA2E3 User's Manual: Hardware (R01UH0992)

2.1 Block Diagram of the RA2E3

Figure 2.1 shows the block diagram of the RA2E3.

RA2E3 48	BMHz 32-Bit Arm [®] Co	rtex [®] -M23 Core	NVIC SWD MTB
Code Flash (64KB, 32KB) SRAM (16KB) Parity Data Flash (2KB)	Analogue 12-bit ADC (13ch) Temperature Sensor	GPT 32-bit (1ch) GPT 16-bit (6ch) AGT 16-bit (2ch) WDT	<u>€</u> нмі
	දිරි System	Safety	Security
I2C x 1 SCI x 4 SPI x 1	Sys Tick DTC Multiple Clocks On-Chip Oscillator HOCO (24,32,48,64MHz),	Memory Protection Unit SRAM Parity Check POE Clock Frequency Accuracy Measurement	128 bit Unique ID
	LOCO (32KHz), ILOCO (15KHz) Low Power Modes ELC Port Function Select RTC	CRC Calculator IWDT Data Operation Circuit Flash Area Protection ADC Self Test	LQFP 32, 48

Figure 2.1 Block Diagram of the RA2E3



2.2 RA2E3 Low Power Modes

The table "Operating conditions of each low power mode" in the RA2E3 (R01UH0992) User's Manual describes the conditions for transitions to low power modes, the states of the CPUs and peripheral modules, and the condition for release from each mode.

The available low power modes are as follows:

- Sleep mode
- Software Standby mode
- Snooze mode

The Software Standby mode minimizes power consumption by stopping the CPU and most peripherals while retaining the contents of SRAM. The MCU can wake up from this mode by an external interrupt, RTC alarm, or AGT underflow event. The following peripherals remain operational in Software Standby mode.

- AGT (Low Power Asynchronous General Purpose Timer): Can continue counting and trigger wakeup.
- RTC: Can generate an alarm-based wake-up.
- IRQ pins: Can wake up the MCU upon receipt of an external signal.
- I2C and other communication peripherals: Remain disabled until a wake-up event occurs.

3. System Outline

3.1 Introduction

The application program uses an RA2E3 MCU, a digital temperature and humidity sensor and OLED display module. After the MCU (RA2E3) has detected the temperature and humidity in the room, the user can check the data on the OLED screen. The AGT is used as the timer to control the acquisition of temperature and humidity data every 500 milliseconds and updating of the display on the OLED every four seconds.

In addition, this program runs in Software Standby mode as a low power mode while CPU operation is not required.

Figure 3.1 shows the system configuration.



Figure 3.1 System Configuration

3.2 Peripheral Functions to be Used

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

Tabla	2 1	Dorinhoral	Eunctions	to	ho	llead
rable	J .1	Peripheral	Functions	ιο	be	Usea

Peripheral Function	Usage
I2C (IIC0)	Get data (temperature and humidity) from the sensors.
	Control the OLED to display temperature and humidity.
AGT1	Count clock cycles every 500 milliseconds.



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
P400/SCL0	Clock signal: Communicate with sensor (HS4001) and OLED through I2C bus
P401/SDA0	Data signal: Communicate with sensor (HS4001) and OLED through I2C bus
VDD	Power-supply voltage
GND	Ground

3.4 Operating Procedure

- 1. Once power is supplied, system initialization begins.
- 2. After initialization, the OLED (SSD1306) displays "RENESAS" and the demonstration title.
- 3. The temperature and humidity data are acquired every 500 milliseconds after an interrupt by the AGT has been accepted.
- 4. After the temperature and humidity data have been acquired, the MCU (RA2E3) operates in Software Standby mode as a low power mode and waits for the next interrupt from the AGT.
- 5. The MCU (RA2E3) sends the temperature and humidity data that have been acquired to the OLED (SSD1306) every four seconds to update the display of the data on the OLED screen.

Display pattern

R	E	Ν	E	S	A	S							
F	Ρ	В	-	R	Α	2	E	3		D	Ε	Μ	0
Т	е	m	р		x	x		x	С				
Н	u	m	i		x	x		x	%				



4. Hardware

This section describes the hardware products and configurations of connections used by the application program.

For details of the QCIOT-HS4001POCZ, please refer to the following link:

https://www.renesas.com/en/products/sensor-products/environmental-sensors/humidity-temperature-sensors/qciot-hs4001pocz-relative-humidity-sensor-pmod-board

For details of the SSD1306, please refer to the following link:

https://www.solomon-systech.com/product/ssd1306/

Figure 4.1 shows the FPB-RA2E3 PMOD Interface. Figure 4.2 shows the connection of FPB-RA2E3, QCIOT-HS4001POCZ and SSD1306.





Figure 4.1 FPB-RA2E3 PMOD Interface



Figure 4.2 Connection of FPB-RA2E3, QCIOT-HS4001POCZ and SSD1306

Figure 4.3 shows the hardware configuration.



Figure 4.3 Hardware Configuration



5. Software

5.1 Integrated Development Environment

The sample code described in this chapter has been checked under the conditions listed in Table 5.1.

Item	Description
Board	FPB-RA2E3
Device	RA2E3 (R7FA2E3073CFL)
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
Integrated development environment	e ² studio 2025-01
(e ² studio)	
FSP	5.8.0 from Renesas Electronics Corp.
Toolchain (GCC ARM Embedded)	13.2.1.arm-13-7
HS4001 Library	HS400X Temperature/Humidity Sensor (rm_hs400x)
Low Power Modes driver	Low Power Modes (r_lpm)
Timer driver	Timer, Low-Power (r_agt)

5.2 Operation Outline

(1) Reset / Initialization

When power is supplied to the system, it will enter the processing for initialization. Power is supplied to the OLED and the display is cleared. After that, it displays "Renesas Electronics" and other characters by default. HS4001 is initialized. IIC0 and I/O pins are also initialized.



Figure 5.1 Initialized OLED Screen

(2) Measurement mode

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

(3) Display mode

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



Figure 5.2 Screen Displaying the Temperature and Humidity Data



5.3 Flowcharts

5.3.1 Main Processing

Figure 5.3 shows the flowchart of the main processing.



Figure 5.3 Main Processing



5.3.2 Timer Interrupt Handling

Figure 5.4 shows the flowchart of the timer interrupt handling.



Figure 5.4 Timer Interrupt Handling



5.4 File Structure

The file structure is shown below.



Figure 5.5 File Structure

6. How to Add Middleware and Driver by Using the FSP in e^2 studio

This section introduces how to add the middleware and HAL driver stacks in the configurator. The introduced stacks are required for the application program. The application program can be used by importing the project. Refer to chapter 7, How to Import and Build the Project, for the procedure of importing.

6.1 HS400X Temperature/Humidity Sensor

- 1. Launch e² studio.
- 2. Create a new project.

Select RA > RA2E3 > FPB-RA2E3 from [...] for [Board].

Renesas RA C/C++ Project				×			
Renesas RA C/C++ Project							
Device and Tools Selection							
Device Selection							
FSP Version: 5.8.0	~	Board Description					
Board: FPB-RA2E3	~	Fast Prototyping E	soard for RA2E3 MCU Group				
Device: R7FA2E3073CFL		manual, quick star	rt guide, errata, design package, example				
Core: CM23	~	projects, etc.					
Language: OC OC++							
		Device Details					
		TrustZone	No				
		Pins	48 072/F005Ests7UEXUN	N)			
		Processor	Cortex-M23				
IDE Project Type		Debugger					
e ² studio managed build	~	J-Link ARM		~			
Toolchains							
GNU ARM Embedded							
13.2.1.arm-13-7 ~	Manage Toolchains						
٢							
\odot		< Back	Next > Finish Ca	ancel			

Figure 6.1 Creating a New Project

3. Add HS4001 sensor middleware to the [Stacks] tabbed page.

New Stack > Sensor > HS400X Temperature/Humidity Sensor (rm_hs400x)

Threads 🐑 New Thread 🛍 Remove 📄	HAL/Common Stacks	New Stack	AL	SP	emove	
V 🖉 HAL/Common			Analog	ŝ		333 33585
g_ioport I/O Port (r_ioport)	g_ioport I/O Port		Audio	,		
	(r_ioport)		Bootloader	,		
	(T)		Connectivity	>		
	U		DSP	>		
			Input	>		The second secon
			Monitoring	>		
			Motor	>		
			Networking	>		FIGELARD FREE FREE FREE FREE FREE FREE FREE FR
			Power	>		ANDUNE ANDUNE
1			Security	>		PACELLIN ARE IT AT A MARK AND A
Objects New Object > Remove			Sensor	> +	FS101	5 Flow Sensor (rm_fs1015)
			Storage	> •	₱ FS2012	2 Flow Sensor (rm_fs2012) [Deprecated]
			System	>	₱ FS300	0 Flow Sensor (rm_fs3000)
			Timers	> ,	HS300	X Temperature/Humidity Sensor (rm_hs300x)
			Transfer	>		X Temperature/Humidity Sensor (rm_hs400x)
			Search	-		3 Light/Proximity/PPG Sensor (rm_ob1203) [Deprecated]
Summany BSD Clocks Dins Interrupts Event L	inke Stacke Components			-	RRH4	5410 Gas Sensor Module (rm rrh46410)
summary our clocks Pins interrupts Event Li	TIKS STOCKS COMPONENTS					

Figure 6.2 Adding to the [Stacks] Tabbed Page



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

tacks Configuration		Generate Project Content
Investigation Image: Contract Contract Contract Image: Contract Contract Contract Image: Contract Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Contract Contract Contract Image: Contract Contract Image: Contract Contract Image: Contract Image: Contract Contreact <t< td=""><td>HAL/Common Stacks</td><td>New Stack > ♣ Extend Stack > ♠ Remove 2C Master (r_iic_master) 2C Master (r_sci_j2c)</td></t<>	HAL/Common Stacks	New Stack > ♣ Extend Stack > ♠ Remove 2C Master (r_iic_master) 2C Master (r_sci_j2c)

Figure 6.3 Adding r_iic_master or _r_sci_i2c

5. Set the properties of the I2C master driver according to the specifications of the target board.

Clicking on [I2C master driver] on the [Stacks] tabbed page displays the properties in the [Properties] window.

Objects	🚯 New Object > 💼 Remove	🚸 g_i2c_master0 I2C Master (r_iic_master)		
		0		
		· · · · · · · · · · · · · · · · · · ·		
		S Add DTC Driver for Add DTC Driver for		
		Transmission [Optional] Reception [Optional]		
	<			
Summary	BSP Clocks Pins Interrupts Event Links Stacks Com	nponents		
Propertie	es × Problems スマート・ブラウザー			
a i2c ma	aster0 I2C Master (r iic master)			
9				
Settings	Property	Value		
API Info	✓ Common			
7411110	Parameter Checking	Default (BSP)		
	DTC on Transmission and Reception	Disabled		
	10-bit slave addressing	Disabled		
	 Module g_i2c_master0 I2C Master (r_iic_master) 			
	Name	g_i2c_master0		
	Channel	U Standard		
	Kate	i Standard		
	Custom Kate (bps)	0		
	Fall Time (ns)	120		
	Puth Ovela (%)	120		
	Slave Address	50		
	Address Mede	0x00 7. pit		
	Timeout Mode	7-Bit Short Mode		
	Timeout during SCL Low	Short Mode		
	Callback	farm comms i2c callback		
	Interrupt Priority Level	Priority 2		
	✓ Pins			
	SCLO	P400		
	SDA0	P401		

Figure 6.4 Setting Properties of the I2C Master Driver



6. Set the pins to be used. The pins to be used can be checked on the [Pins] tabbed page.

Type filter text	Name	Value	Lock	Link	
A Paripharals	Pin Group Selection	_A only			
AnalogiADC	Operation Mode	Enabled			
	✓ Input/Output				
	SCL0	✓ P400			
Connectivity:IIC	SDA0	💙 P401		4	
Connectivity:SCI Connectivity:SCI Connectivity:SPI Pebug:JTAG/SWD Interrupt:ICU Interrupt:KINT System:CGC System:SYSTEM TRG:ADC(Digital) TRG:ADC(Digital)	K Module name: IIC0 Usage: For IIC, us -Please re	e same Pin Group for SDA/SC fer to the MCU User's Manua	CL signals I.		>
> 🗸 Timers:AGT 🗸 🗸					

Figure 6.5 Checking Pins to be Used

6.2 Low Power Modes

1. Add the driver for the LPM peripheral to the [Stacks] tabbed page.

New Stack > Power > Low Power Modes (r_lpm)

2. Set details of Low Power Modes.

At this time, select [Software Standby mode] for [Low Power Mode] and [AGT1 Underflow] under [Wake Sources].

 Objects 	g_hs400x_sensor0 HS400X Temperat ^ g_Jpm0 Low Power Modes (r_Jpm) ↓	g_hs400x_sen HS400X Temperature/ Sensor (rm_hs	sor0		
Summary	BSP Clocks Pins Interrupts Event Links Stacks Component	5			
Proble	ms Console Properties X Smart Browser	Smart Manual			
1100101		Structure			
g_lpm0	Low Power Modes (r_lpm)				
Catting	Property		Value		
Settings	✓ Common				
API Info	Parameter Checking		Default (BSP)		
	Standby Limit		Disabled		
	 Module g_lpm0 Low Power Modes (r_lpm) 				
	✓ General				
	Name		g_lpm0		
	Low Power Mode		Software Standby mode		
	Output port state in standby and deep standby	Not Supported			
	Supply of SOSC clock to peripheral function in stand	Not Supported			
	Startup speed of the HOCO in Standby and Snooze	Not Supported			
	Flash mode in sleep or snooze	Not Supported			
	 Deep Sleep and Standby Options 				
	✓ Wake Sources				
	IRQ0				
	IRQ1				
	IRQ2				
	IRQ3				
	IRQ4				
	IRQ5				
	IRQ6				
	IRQ7				
	IWDT				
	Key Interrupt				
	LVD1 Interrupt				
	LVD2 Interrupt				
	RTC Alarm				
	RTC Period				
	AGT1 Underflow				
	AGT1 Compare Match A				
	AGI1 Compare Match B		U		

Figure 6.6 Properties of Low Power Modes



3. Add the driver for the AGT peripheral to the [Stacks] tabbed page.

New Stack > Timers > Low-Power (r_agt)

4. Set details of the AGT.

Set the timer period, clock source, etc. Here, select a sub-clock as the clock source.

*In RA2E3, the LOCO can also be selected as the clock source for the AGT to reduce the BOM and save the I/O ports. In such cases, check the accuracy of the LOCO.

< Objects	q_hs400x_sensor0 HS400X ♦ New Object > R Remove	ensor0 'e/Humidity _hs400x)	g_lpm0 Low Power Modes (r_lpm)	 g_timer1 Timer, Low-Power (r_agt) > 	
Summary	BSP Clocks Pins Interrupts Even	t Links Stacks C	omponents		
Propertie	s × Problems Smart Bro	owser Cons	sole Search IO Regi	sters Debug	
				📑 🖬 🗹	
g_timer1	Timer, Low-Power (r_agt)				
	Dranasty			Value	
Settings	Property			value	
API Info	Common			Default (RSD)	
	Pin Output Support			Enabled	
	Pin Input Support			Disabled	
	 Module a timer1 Timer, Low-F 	Power (r_aqt)			
	✓ General	3-7			
	Name			g_timer1	
	Counter Bit Width			AGT 16-bit	
	Channel			1	
	Mode			Periodic	
	Period			500	
	Period Unit			Milliseconds	
	Count Source			SUBCLOCK	
	> Output				
	> Input				
	> Interrupts				
	✓ Pins				

Figure 6.7 Properties of the AGT

- 6.3 I2C Communication Device
- 1. Add the middleware for OLED to the [Stacks] tabbed page.

New Stack > Connectivity > I2C Communication Device (rm_comms_i2c)

2. Add the I2C Shared Bus

Make the "I2C Shared Bus" selection for use since the temperature and humidity sensor and the OLED are connected in a multi-slave configuration.

Use > g_comms_i2c_bus0 I2C Shared Bus (rm_comms_i2c)

g_comms_i2c_device1 I2C Communication Device (rm_comms_i2c)
Add I2C Shared Bus
New Image: Second sec

Figure 6.8 Adding the I2C Shared Bus



3. Configure the property of the I2C Communication Device.

At this time, set the properties to the following.

- Slave Address: 0x3c
- Callback: oled_comms_i2c_callback

	a hs400x sensor0 HS400X Temperature ^	g_comms_i2c_device1 I2C Communication Device (rm_comms_i2c)			
4	g_lpm0 Low Power Modes (r_lpm) g_timer1 Timer, Low-Power (r_agt)				
4	g_comms_i2c_device1 I2C Communicat	0			
1	Ň				
`					
Objects	🐑 New Object > 💼 Remove	g_comms_12c_bus0 12C Shared Bus (rm_comms_12c)			
		()			
		g_i2c_master0 I2C Master (r_iic_master)			
		1			
		Add DTC Driver for			
		Iransmission [Optional] Reception [Optional]			
Summary	RSP Clocks Pins Interrunts Event Links Sta	icks Components			
Summary	BSP Clocks Pins Interrupts Event Links St	acks Components			
Summary Propertie	I BSP Clocks Pins Interrupts Event Links <u>Sta</u> s × Problems スマート・ブラウザー	3cks Components			
Summary Propertie	I BSP Clocks Pins Interrupts Event Links <u>Sta</u> s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De	vice (rm_comms_i2c)			
Summary Propertie g_comm	I BSP Clocks Pins Interrupts Event Links <u>Sta</u> s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property	vice (rm_comms_i2c)			
Summary Propertie g_comm Settings	I BSP Clocks Pins Interrupts Event Links <u>Sta</u> s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property	ecks Components evice (rm_comms_i2c) Value			
Summary Propertie g_comm Settings API Info	I BSP Clocks Pins Interrupts Event Links <u>Sta</u> s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property	ecks Components evice (rm_comms_i2c) Value Default (BSP)			
Summary Propertie g_comm Settings API Info	BSP Clocks Pins Interrupts Event Links St. s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property Common Parameter Checking V Module g_comms_i2c_device1 I2C Comm	acks Components vice (rm_comms_i2c) Value Default (BSP) nunication			
Summary Propertie g_comm Settings API Info	I BSP Clocks Pins Interrupts Event Links St. s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property Common Parameter Checking Module g_comms_i2c_device1 I2C Comm Name	acks Components vice (rm_comms_i2c) Value Default (BSP) nunication g_comms_i2c_device1			
Summary Propertie g_comm Settings API Info	I BSP Clocks Pins Interrupts Event Links <u>St</u> s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property Common Parameter Checking Module g_comms_i2c_device1 I2C Comm Name Semaphore Timeout (RTOS only)	acks Components vice (rm_comms_i2c) Value Default (BSP) nunication g_comms_i2c_device1 0xFFFFFFF			
Summary Propertie g_comm Settings API Info	BSP Clocks Pins Interrupts Event Links <u>St</u> s × Problems スマート・ブラウザー s_i2c_device1 I2C Communication De Property ✓ Common Parameter Checking ✓ Module g_comms_i2c_device1 I2C Comm Name Semaphore Timeout (RTOS only) Slave Address	acks Components vice (rm_comms_i2c) Value Value Default (BSP) nunication g_comms_i2c_device1 0xFFFFFFF 0x3c			
Summary Propertie g_comm Settings API Info	BSP Clocks Pins Interrupts Event Links <u>St</u> s × Problems スマート・ブラウザー s_i2c_device1 12C Communication De Property ✓ Common Parameter Checking ✓ Module g_comms_i2c_device1 12C Comm Name Semaphore Timeout (RTOS only) Slave Address Address Mode	exice (rm_comms_i2c) Value Value Default (BSP) nunication g_comms_i2c_device1 0xFFFFFFF 0x3c 7-Bit			

Figure 6.9 Properties of the I2C Communication Device

- 7. How to Import and Build the Project
- 1. Launch e² studio.
- 2. Click on [File] in the display menu and select [Import].
- 3. The [Import] window is displayed. Open the [General] category, select [Existing Projects into Workplace], and click on [Next].
- 4. In the [Select archive file] form, select the project file. After selection, confirm that the specified project "RA2E3_HS4001LowPowerSensorSystemExample" is displayed in [Project] and click on [Finish]. The [Import] window is then closed.
- 5. Open [configuration.xml] and click on [Generate Project Content] in the [Configurator] window.
- 6. In Project Explorer, click on the project name to bring it focus.
- 7. Select [Build Project] in the [Project] menu to start building.



8. How to Debug the Project for Low Power

- 1. Click on [Run] in the display menu and select [Debug Configurations].
- 2. Under the [Debugger] tab, go to the [Connection Settings] sub-tab to configure the following
 - J-link

Script File: CM_low_power_debug.JLinkScript

Low Power Handling: Yes

The script file is included with this application project and can be used by specifying it in the debug settings.

* The script file is not applied to the project by default. If a debug connection is made without setting up a script file, the MCU may not correctly make the transition to LPM. Even if it does, the power consumption may be higher than expected.

roject Explorer × E S 7 8 =							
> > >	1 2 9 10 🗙 🖻 7 -	Name: HS4001_displayOLED_multi_I2C Debug_Flat					
	type filter text	filter text					
	C C/C++ Application C C/C++ Remote Application	Debug hardware: J-Link ARM V	arget Device: R7FA2E307				
> Ge build	✓ C GDB Hardware Debugging	GDB Settings Connection Settings Debug Tool Settings					
	* HS4001_displayOLED_multi_I2C Debug	✓ J-Link		^			
> Contraction	GDB Simulator Debugging (RH850)	Туре	USB	~			
	🗸 Launch Group	J-Link Serial	(Auto)				
CM_low_power_debugJLinkScript	✓ C Renesas GDB Hardware Debugging	Settings File	{workspace_loc:/{ProjName}}/{LaunchConfigName},jlink				
configuration.xml	E HS4001_displayOLED_multi_I2C Debug_F	Script File	\${workspace_loc;/\${ProjName}}/CM_low_power_debugJLinkScrip	pt			
HS4001_displayOLED_multi_I2C Debug_Flat.jlink	test_hs4001 Debug_Flat	Log File	\${workspace_loc:/\${ProjName}}/JLinkLog.log				
KS4001_displayOLED_multi_I2C Debug_Flat.launch	Renesas Simulator Debugging (RX, RL78)	Low Power Handling	Yes	~			
JLinkLog.log		✓ IP Connection					
D		Connection Method	ID via LAN	~			

Figure 8.1 Specifying the Script File

9. Tips on e^2 studio for Debugging

9.1 Displaying IO Registers

Select the [Window] menu > [Show View] > [Other...] to open the [Show View] window, and then select Debug > IO Registers.

When you enter the name of a register for reference in the search box, you can easily find the given register.



Window Help						
New Window					Q	😰 🔤 C/C++ 🛭 🎄 Debug
Editor >	c X R main c		Variables Breaknoints	Project Explorer	IO Pegisters	», – –
Appearance > entry.		•	valiables bleakpoints			,
Show View > 🔍 B	reakpoints Alt+Shift+Q, B	~	AGI	Y	V 🖽 🖻 🍝 🧐	🌠 🔍 🚍 🔲 💷 🛯 🎖
Perspective > 🗉 o	onsole Alt+Shift+O. C		Name	Value (Hex)	Address	Description ^
Navigation > 🎋 🖸	Debug		> 💑 AGTO		0x40084000	Low Power Asynchronou
	ebugger Console		✓ 器 AGT1		0x40084100	Low Power Asynchronou
Preferences State	Salar Console		AGT	0x12db	0x40084100	AGT Counter Register
. 55	vebug sources		AGTCMA	0x2000	0x40084102	AGT Compare Match A F
L	lisassembly		AGTCMB	0x2000	0x40084104	AGT Compare Match B R
1990 E	rror Log Alt+Shift+Q, L		> IT AGICR	0x03	0x40084108	AGI Control Register
🚺 E	xecutables		> WW AGIMR1	0x61	0x40084109	AGI Mode Register 1
ର୍ଜୁ E	xpressions		> IN AGIMR2	0x00	0x4008410a	AGT Mode Register 2
N	/lemory		> IN AGTICC	0x05	0x40084100	AGT I/O Control Register
0 N	Nemory Browser		> 1010 ACTOMER	0x00	0x40084100	AGT Event Pin Select Rec
	Adules	_		0x00	0x40084108	AGT Compare Match Fur
9= 0	Outline Alt+Shift+O_O	_	> PIIC	0x00	0x40004101	RUS Control
(e) p	roblems Alt Shift O X	Alta Shifta O Y	> = 603		0x40003000	Clock Fraguency Accurac
			> The CRC		0x40074000	Cyclic Redundancy Check
	logiess				0x4001b000	Debug Function
P P	roject Explorer		> B DOC		0x40054100	Data Operation Circuit
offor R	legisters		> Z DTC		0x40005400	Data Transfer Controller
	ignals		> 🛃 ELC		0x40041000	Event Link Controller
🤬 S	mart Browser		> 🛃 FLCN		0x407ec000	Flash I/O Registers
🖓 s	mart Manual		> 🚼 GPT164		0x40078400	General PWM 16-bit Tim
🔁 T	emplates		> 🚼 GPT165		0x40078500	General PWM 16-bit Tim
(×)= V	ariables Alt+Shift+Q, V		> 🚼 GPT166		0x40078600	General PWM 16-bit Tim
C	Other Alt+Shift+Q, Q		< - CDT1C7		0-40070700	Conorol DMAA 16 bit Tim

Figure 9.1 Displaying IO Registers



9.2 Customizing the [IO Registers] View

Right-click on the name of a register and select [Add to Selected Registers]. You can confirm that only the specified registers have been selected on the [Selected Registers] tabbed page.

Example: AGT1 registers

Variables Breakpoint	Project Explorer	Expressions	Eventpoints IO Registers Y "1 D
variables bleakpoint	FIOJECI EXPIDIEI	Expressions	
		AGI	Y ↓ ↓ ↓ □ ₹ 30 🙀 ♀ ■ □ □ □ □ 10 1
Name	Value (Hex)	Address	Description ^
> 🛃 ADC120		0x4005c000	12-bit A/D Converter
> 🚼 AGT0		0x40084000	Low Power Asynchronous General Purpose Timer 0
✓ 3 AGT1		0~40004100	Low Power Asynchronous General Purpose Timer 1
1919 AGT	Add to Selected Reg	gisters	AGT Counter Register
1010 AGTCMA	hemove from Select	ted Registers	AGT Compare Match A Register
1010 AGTCMB	E Collapse all other g	roups	AGT Compare Match B Register
> 1000 AGTCR	Pofrach		AGT Control Register
> IIII AGTMR1	 Refresh 		AGT Mode Register 1
> 1010 AGTMR2	Lock Refresh		AGT Mode Register 2
> III AGTIOC	Expand All Groups		AGT I/O Control Register
> IIII AGTISR	Collapse All		AGT Event Pin Select Register
> 1919 AGTCMSR	Find		AGT Compare Match Function Select Register
> IIII AGTIOSEL	Manage Selected Re	enisters	AGT Pin Select Register
> 🛃 BUS	Drint Expanded Group	upc	BUS Control
> 🛃 CAC		uha	Clock Frequency Accuracy Measurement Circuit
	Save		
All Registers Selected Regist	Сору		
An Registers Selected Regist	Chow Value (Pip) co	lumm	

Figure 9.2 [Add to Selected Registers]

Variables	Breakpoints	Project Explorer	Expressions	Eventpoints IO Registers X 🔭 🗖
			AGT	
Name		Value (Hex)	Address	Description
🗸 🛼 AGT1			0x40084100	Low Power Asynchronous General Purpose Timer 1
ଜ라 AGT		0x199c	0x40084100	AGT Counter Register
ଜ라 AGTC	CMA	0x2000	0x40084102	AGT Compare Match A Register
🕌 AGTO	СМВ	0x2000	0x40084104	AGT Compare Match B Register
> 湯許 AGTC	CR	0x03	0x40084108	AGT Control Register
> 淵智 AGTN	MR1	0x61	0x40084109	AGT Mode Register 1
> 渦 AGTN	MR2	0x00	0x4008410a	AGT Mode Register 2
> 潟읡 AGTI	OC	0x05	0x4008410c	AGT I/O Control Register
> 🎆 AGTI	SR	0x00	0x4008410d	AGT Event Pin Select Register
> 潟鉛 AGTC	CMSR	0x00	0x4008410e	AGT Compare Match Function Select Register
> 🕍 AGTI	OSEL	0x00	0x4008410f	AGT Pin Select Register
<				>
All Registers	elected Registers			

Figure 9.3 Selected Registers

9.3 Setting Breakpoints

When the debugger is started, double-clicking on a line in the area where the addresses of the editor are displayed sets a breakpoint.

If you right-click on a line in that area, you can directly select the type of breakpoints by selecting [Toggle Software Breakpoint] or [Toggle Hardware Breakpoint].





RA2E3 HS4001 Low Power Sensor System Example



Figure 9.4 Setting a Breakpoint



Figure 9.5 Selecting the Type of Breakpoints

10. Sample Program

The sample program is available on the Renesas Electronics Website.

11. Reference Documents

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

- RA2E3 Fast Prototyping Board (R20UT5128)
 https://www.renesas.com/document/mat/fpb-ra2e3-v1-users-manual
- RA2E3 User's Manual: Hardware (R01UH0992) https://www.renesas.com/document/mah/ra2e3-group-users-manual-hardware
- RA Family, RX Family, RL78 Family, RZ Family HS400x Sample Application (R01AN6333)



Revision History

		Description		
Rev.	Date	Page	Summary	
Rev.1.00	May.07.25	-	First release	



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 is supplied until the 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

6.

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. 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 systemevaluation test for the given product.

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