RA4E1 | RA6E1 Group

Low Power Application for FPB-RA4E1 or FPB-RA6E1

Introduction

This application note describes the features of RA4E1 and RA6E1 MCUs that are useful for low-power operation, typically required for logging data for long durations. The FPB-RA4E1 or FPB-RA6E1 kit is used for creating such a low-power data logging system. The functionality demonstrated here is often required in products such as fitness trackers, fleet tracking devices, and so forth. The data logger uses the 12-bit A/D Converter (ADC), Data Transfer Controller (DTC), Asynchronous General Purpose Timer (AGT), Realtime Clock (RTC), Event Link Controller (ELC), Data Operation Circuit (DOC), and Low-power Mode (LPM). Snooze mode and Software Standby mode are used to reduce power consumption by minimizing the CPU operation time. Application projects use the e^2 studio Integrated Development Environment (IDE) and Flexible Software Package (FSP) provided for the RA family.

This application note is based on application note "Low Power Application (Use of ADC, DTC and ELC at Snooze mode) for FPB-RA2E1 and FPB-RA2E2" (R30AN0392), and adapted so that operation can be run on the FPB-RA4E1 and FPB-RA6E1.

Prerequisites

We assume that you have developed projects using the Renesas e^2 studio IDE and FSP. If not, we recommend that you build and run the Blinky project according to section “Tutorial: Your First RA MCU Project – Blinky” in FSP User’s Manual (R11UM0155 or Github link) before trying out this application. You can then become familiar with the e^2 studio IDE and FSP and verify that the debugging connectivity to the boards is working correctly.

Required Resources

This application project is created for Renesas RA Family MCUs RA4E1 and RA6E1. When applying this application note to other MCUs, be sure to change it according to the specifications of the MCU and evaluate it carefully. The resources required for this application project are as follows.

Hardware:

- Renesas RA Kit FPB-RA4E1 or FPB-RA6E1 (FPB-RA6E1, FPB-RA4E1)
- Seeed Grove Base Shield V2.0 for Arduino (https://www.seeedstudio.com/Base-Shield-V2.html)
- Seeed Grove - Luminance Sensor (https://www.seeedstudio.com/Grove-Luminance-Sensor.html)
- Seeed Grove - Temperature Sensor (https://www.seeedstudio.com/Grove-Temperature-Sensor.html)
- USB – TTL Serial connector.

Development Tools and Software:

- e^2 studio IDE version 2025-04.1.
- Renesas Flexible Software Package (FSP) version 6.0.0.
- GCC ARM Embedded Toolchain version 13.2.1.arm-13-7.
- Terminal software (e.g., Tera Term).

Contents

1. Overview 4
1.1 Overview of Specifications 4
1.1.1 Data Acquisition Function/Level Judgment Function 5
1.1.2 Data Output Function 6
1.2 Peripheral Modules of RA4E1 or RA6E1 MCU 7

2. Description of Functions Used 9
2.1 Low Power Modes 9
2.1.1 Available Low Power Modes 9
2.1.2 Low Power Mode Transition Events 10
2.2 12-bit A/D Converter 11
2.2.1 A/D Conversion Channel 11
2.2.2 Conversion Start Event 12
2.2.3 Data Register Automatic Clearing Function 13
2.3 DTC Transfer 14
2.3.1 Transfer Start Event 14
2.3.2 Chain Transfer 15
2.4 DOC Subtraction Mode 17
2.5 ELC Event Connection 18
2.6 Two-channel Connected AGT 20
2.7 RTC Mode Selection 21
2.8 Clock Output 21

3. Low-power Data Logger Application 21
3.1 Functional Specification 21
3.1.1 Data Acquisition Function 22
3.1.2 Data Level Judgement Function 22
3.1.3 Data Output Function 22
3.2 User Interface 23
3.2.1 Connect the Sensor 23
3.2.2 Connect the USB-TTL Connector 24
3.2.3 Data Communication Specifications 24
3.2.3.1 Communication Data Format 24
3.2.4 Input/Output Pins for Debugging 25
3.3 Clock Input 26
3.4 Debugging 27
3.4.1 Canceling the Low Power Mode by Pressing Down the User Switch 27
3.4.2 Checking the Low Power Mode Status 27
3.4.3 Fast Cycle Debug 28
3.5 Flowchart 28

4. Evaluating Applications 32
4.1 Importing and Building a Project 32
4.2 Script Settings for Low Power Mode Debugging 32
4.3 Download and Debug a Project 33
4.4 Procedure for Checking the Operation of the Low-power Data Logger 34
4.5 Evaluating the Current Consumption 35
5. References 35
Revision History 37

1. Overview

1.1 Overview of Specifications

This application project acquires sensor data and compares it against thresholds at regular intervals. These processes are intermittently executed with Snooze mode during Software Standby mode to achieve operation as a low-power data logger.

In this application project, Snooze mode is entered every 30 minutes during Software Standby mode. While operating in Snooze mode, A/D conversion and the level judgment of the result are performed. After judging the level, the system returns to Software Standby mode. However, if the conversion result is greater than or equal to the threshold value, Snooze mode is canceled, and MCU is transitioned to Normal mode. In addition, the low-power mode is canceled every 24 hours, and the measured data accumulated in the buffer is transmitted. After the data transmission, the process repeats. When a user button is pressed, the low power mode is canceled, and the requested data is transmitted. Table 1 explains the details of these processes for each function.

Table 1. List of Functions

Function	Process Description
Data Acquisition Function	A/D conversion is triggered by the AGT count underflow event, and conversion results are stored in the measurement data buffer.
Level Judgement Function	The level of A/D conversion results is judged by the Data Operation Circuit (DOC). If the conversion result is greater than or equal to the threshold value, the interrupt occurs.
Data Output Function	When the RTC alarm interrupt, external IRQ interrupt, or DOC interrupt occurs, the mode shifts to Normal mode and the data is output by UART communication.

Figure 1 shows the MCU states and mode transition events, and Figure 2 shows a conceptual diagram of the operation modes and current consumption.

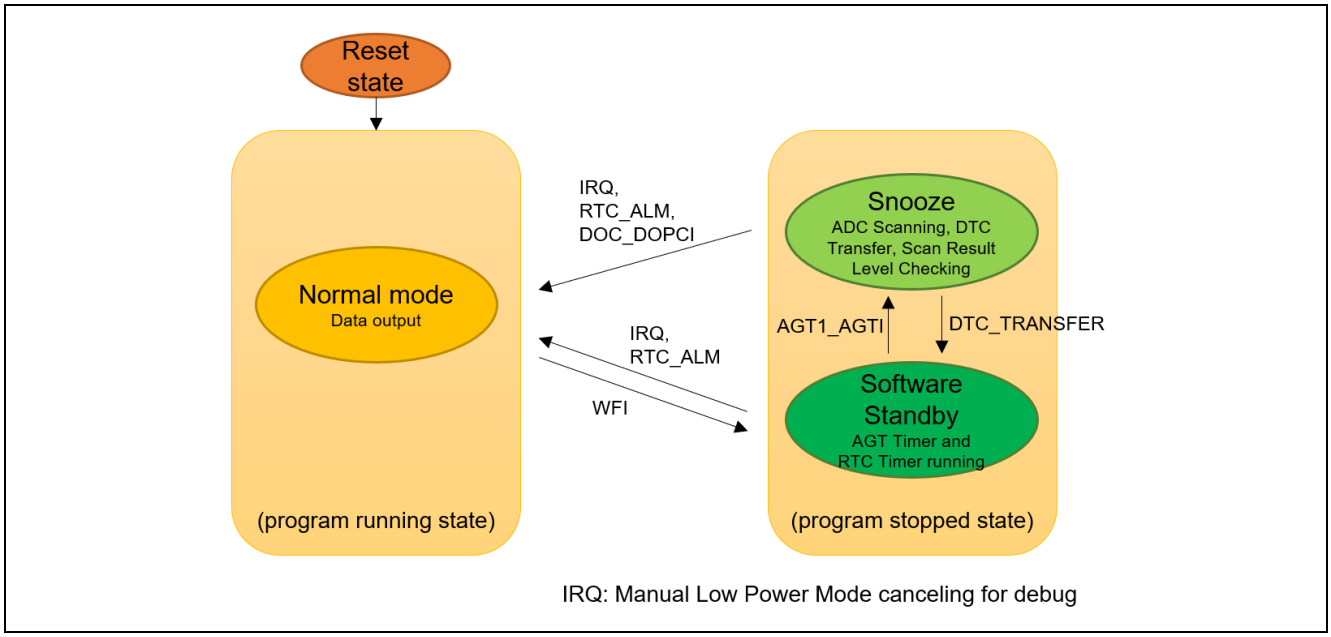
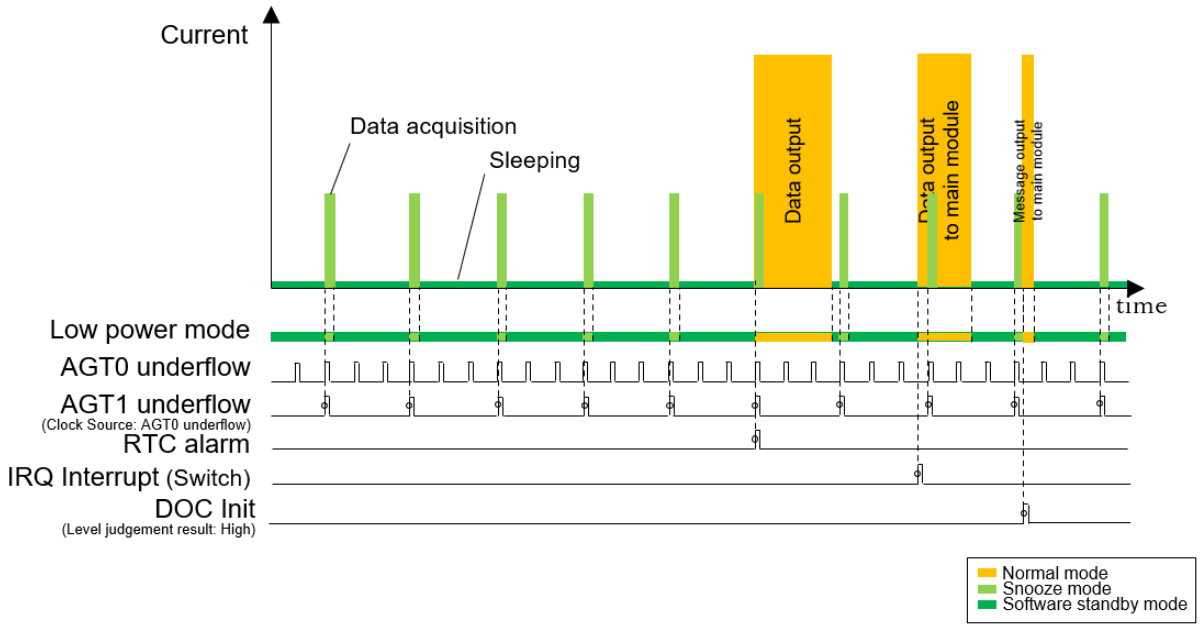


Figure 1. MCU Status and Mode Transition Events



Note: The current consumption and the duration of each process are conceptual.

Figure 2. Conceptual Diagram of Operation Mode and Current Consumption

1.1.1 Data Acquisition Function/Level Judgment Function

In the data acquisition function, the AGT timer interrupt transitions the MCU from Software Standby mode to Snooze mode, and A/D conversion is performed on two channels. The A/D conversion result is stored in the measurement data buffer using the DTC. The system returns to Software Standby mode when the DTC transfer completion event occurs.

The level judgment function judges the level of A/D conversion results using the Data Operation Circuit (DOC). If the conversion result is greater than or equal to the threshold value, the DOC interrupt occurs, and MCU is transitioned to Normal mode.

The processing sequence for the above functions is described using Figure 3:

① AGT0 timer generates an AGT0 underflow signal every minute.

② AGT1 timer uses the AGT0 underflow signal as the count source and creates an AGT1 underflow interrupt at 30 counts (every 30 minutes) of this signal. When AGT1 underflow interrupt occurs, it requests a transition to Snooze mode.

③ The ADC starts A/D conversion by a synchronous trigger from the ELC-linked event from AGT1 or Snooze request event.

④ When an ADC conversion end interrupt is generated, the DTC performs transfer processing in the following order according to the transfer information set for repeat transfer mode and chain transfer:

a. The conversion result of A/D converter channel 0 is transferred to the channel 0 measurement data buffer.

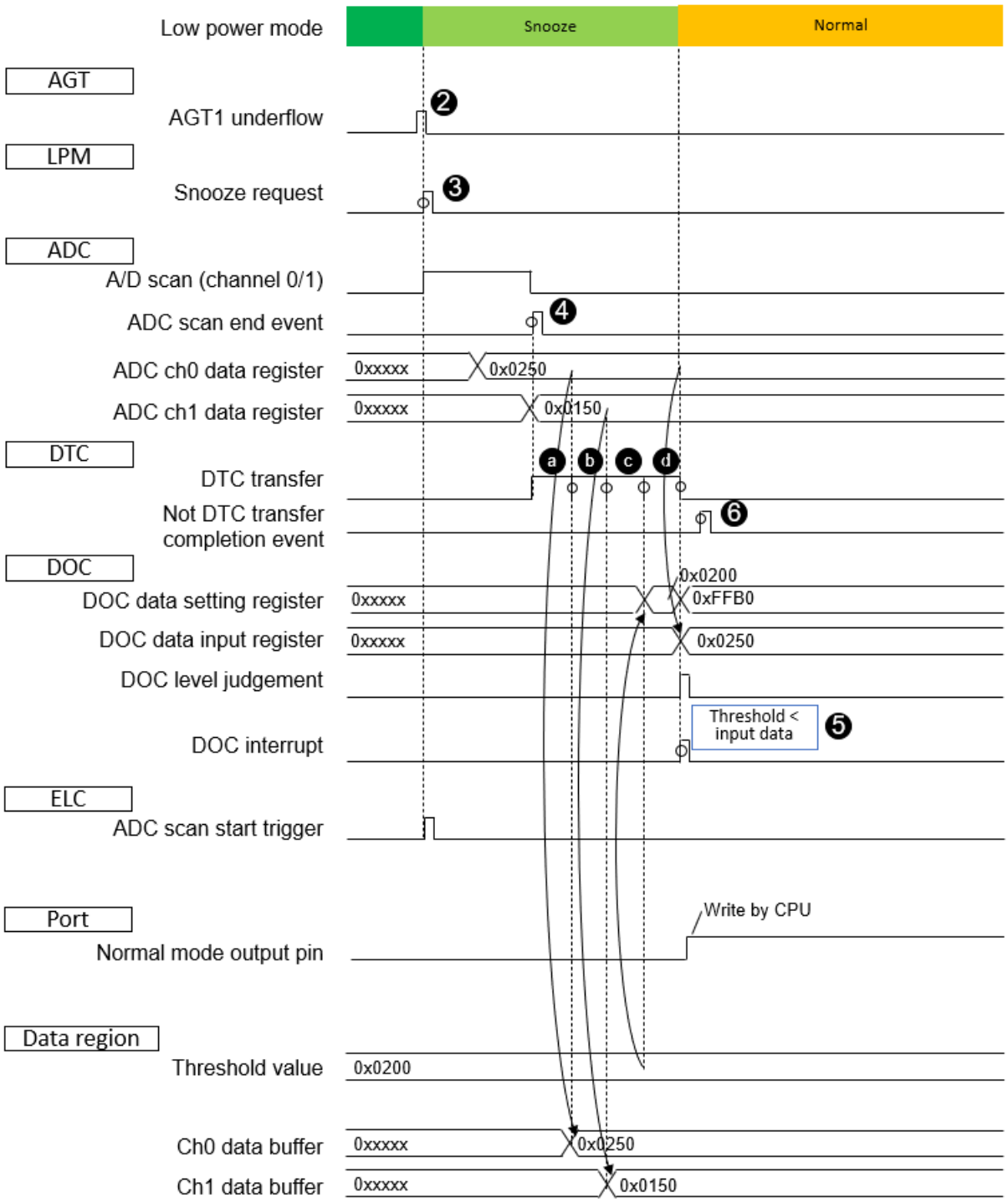
b. The conversion result of A/D converter channel 1 is transferred to the channel 1 measurement data buffer.

c. The value of the level judgment threshold storage variable is transferred to the DOC data setting register.

d. The conversion result of A/D converter channel 1 is transferred to the DOC data input register.

⑤ When the level judgment result event (Data Operation Circuit interrupt) of channel 1 occurs, Snooze mode is canceled.

⑥ When a Not DTC transfer completion interrupt (DTC_TRANSFER) is generated due to the completion of the transfer processing of ④, the system returns to Software Standby mode.



Note: The duration of each processing and event occurrence represents a concept.
Note: The processing sequence ① is omitted. Refer to section 2.6 Two-channel Connected AGT for details.

Figure 3. Timing Chart for Data Acquisition and Level Judgement

1.1.2 Data Output Function

The data output function transitions the MCU from Software Standby mode to Normal mode by RTC alarm interrupt, external IRQ interrupt, or DOC interrupt and outputs data by UART communication. After the data output is completed, the MCU transitions to low-power mode. However, if the transition request event to Normal mode is RTC alarm interrupt, the RTC alarm for the next transition from Software Standby mode to Normal mode is set, and then the mode transitions to the low power mode.

The above functions are described in the processing sequence as follows:

① When RTC alarm interrupt, external IRQ interrupt, or DOC interrupt occurs, the low power mode is canceled.

② After the low power mode is canceled, transmit data is generated, and the SCI outputs the data.

③ The MCU transitions to low power mode after the data output is completed.

1.2 Peripheral Modules of RA4E1 or RA6E1 MCU

Table 2 lists the main peripheral modules of the RA4E1 or RA6E1 MCU used in this application project and their typical uses. These are illustrated in the functional overview of RA4E1 MCU in Figure 4 and RA6E1 MCU in Figure 5.

Table 2. Main Peripheral Modules

Module	Typical Uses
Low Power Modes	Snooze mode and Software Standby mode are used to achieve low power consumption.
12-bit ADC	Converts the analog continuous time signal from the sensor to a discrete digital signal value.
DTC	The analog conversion result of the A/D converter is transferred to the buffer using the DTC in repeat transfer mode. A DTC chain transfer is used to transfer the data from the ADC data register, and from RAM/ROM memory to the DOC register for level judgement.
DOC	Uses subtraction mode to judge the level of the A/D conversion result.
16-bit AGT 0/1	Generates a transition request to Snooze mode and starts data acquisition timing every 30 minutes.
RTC	Measures the time since the power is on. The 24-hour alarm interrupt is used to cancel the low power mode and generate the timing of data output.
SCI	Performs UART communication with the external equipment.
ELC	Connects a Snooze transition request event or an AGT underflow event to the A/D converter start conversion event.

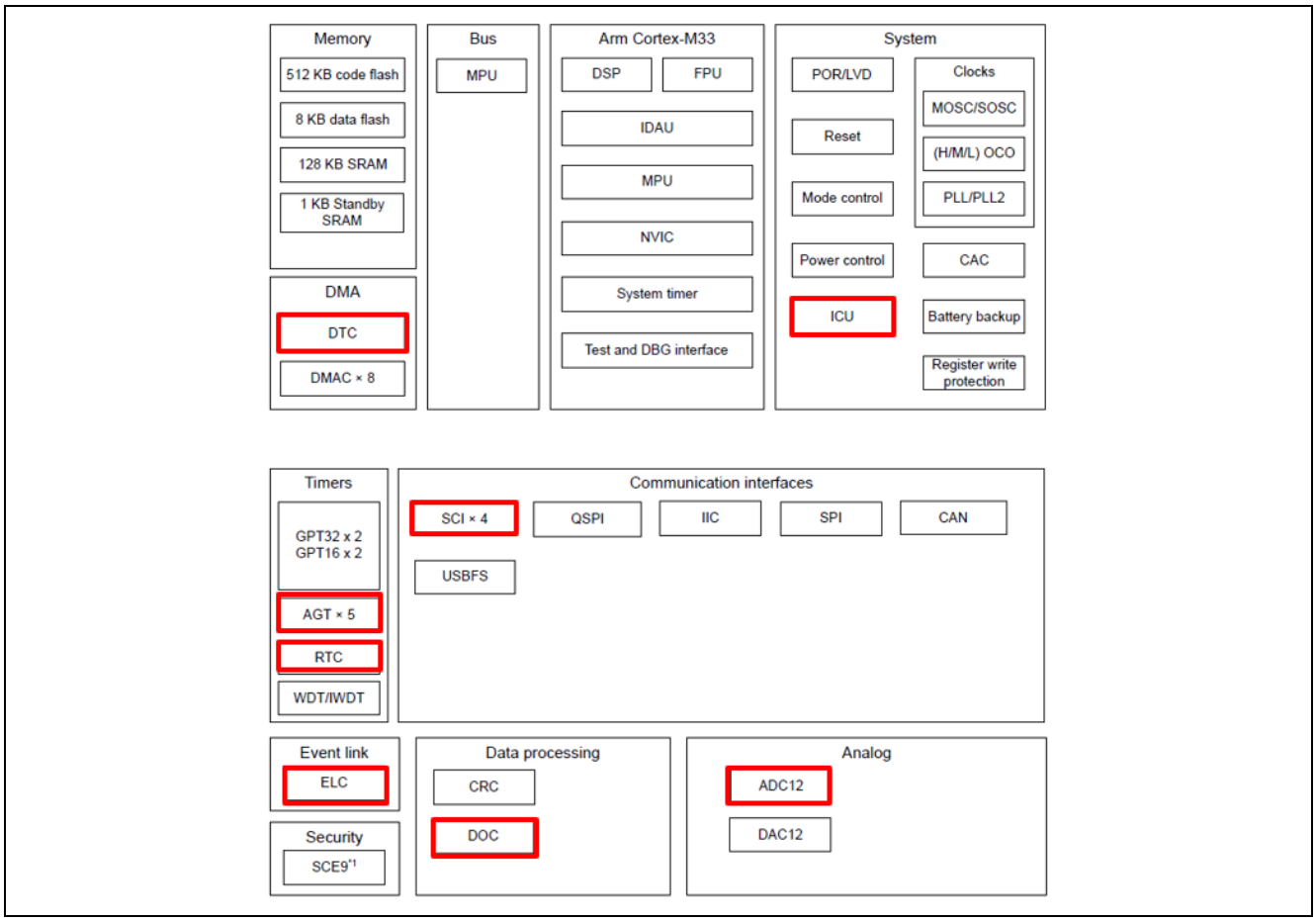


Figure 4. Outline of RA4E1 MCU Function

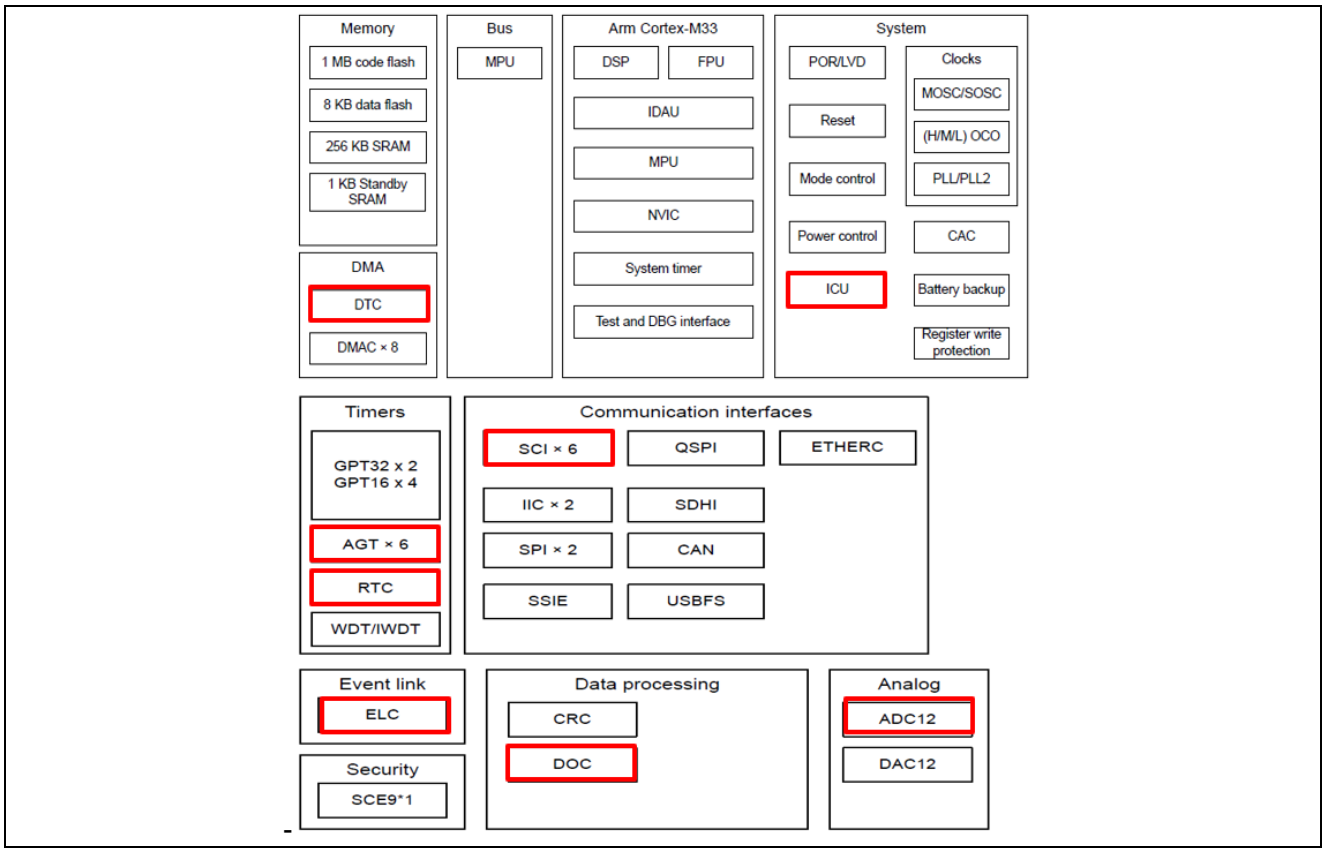


Figure 5. Outline of RA6E1 MCU Function

2. Description of Functions Used

This section describes the functions of the LPM, ADC, DTC, ELC, AGT, and RTC modules of RA4E1 or RA6E1 MCU and explains how to set them to achieve the expected operation.

2.1 Low Power Modes

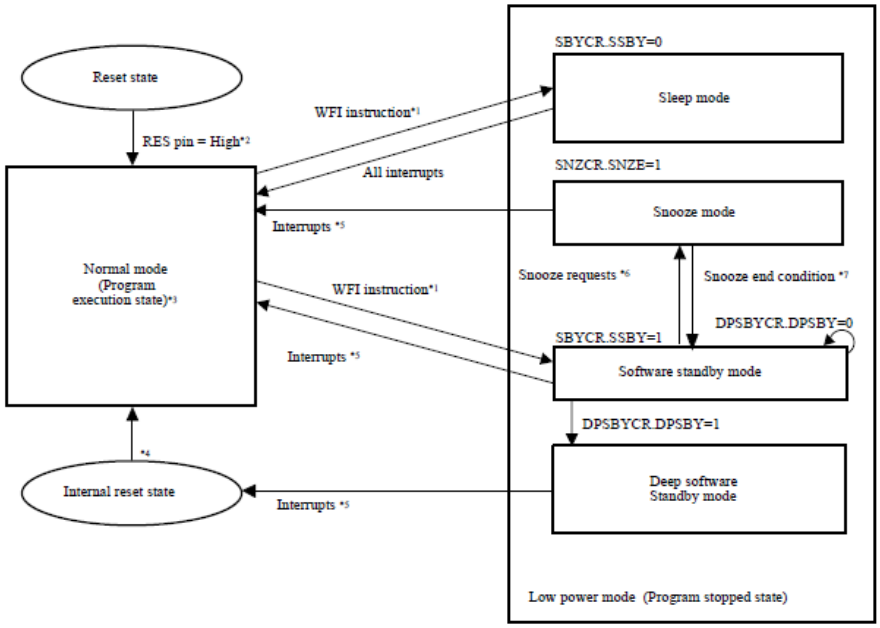
2.1.1 Available Low Power Modes

Table “Operating conditions of each low power mode” in RA4E1 User's Manual (R01UH0929) or RA6E1 User’s Manual (R01UH0930) describes the conditions to transition to low power modes, the states of the CPUs and peripheral modules, and the condition to cancel each mode.

The available low-power modes are:

- Sleep mode
- Software Standby mode
- Snooze mode
- Deep Software Standby mode

Figure 6 shows a schematic diagram of the low-power mode transitions.



Note 1. When an interrupt that acts as a trigger for cancel is received during a transition to the program-stopped state after the execution of a WFI instruction, the MCU executes interrupt exception handling instead of transitioning to low power mode.
Note 2. The MOCO clock is the source of the operating clock following a transition from the reset state to Normal mode.
Note 3. The transition to Normal mode is made because of an interrupt from Sleep mode, Snooze mode, or Software Standby mode. The clock source is the same as before entering the low power mode.
Note 4. When an available interrupt request is generated, an internal reset (Deep Software Standby reset) is generated over a fixed period. Canceling of Deep Software Standby mode accompanies release from the internal reset state, and then the MCU transitions to Normal mode and executes reset exception processing with the MOCO clock as the source of the operating clock.
Note 5. See Table 10.3
Note 6. See Table 10.7
Note 7. See Table 10.9

Figure 6. Schematic Diagram of Low Power Mode Transitions

(1) Sleep Mode

Generally, CPU operation is the most significant factor for the increase in power consumption. In Sleep mode, the MCU halts operation but retains the value of the CPU's internal registers. Peripheral functions other than the CPU are not stopped. Sleep mode is canceled when an available reset or interrupt occurs. All interrupt sources are available. When using interrupts to cancel Sleep mode, the corresponding IELSRn register must be set prior to executing the WFI instruction.

(2) Software Standby Mode

Software Standby mode dramatically reduces power consumption by stopping the CPU, most on-chip peripheral functions, and oscillators. However, the CPU's internal registers, SRAM data, the on-chip peripheral functions, and I/O port status are retained.

(3) Snooze Mode

Snooze mode is an extension of Software Standby mode that allows limited peripheral modules to operate when the CPU is halted. This reduces current consumption by flexible operation of peripheral modules required by the application. Snooze mode can be entered from Software Standby mode by a specified interrupt request. Interrupt requests available in Snooze mode can also transition from Snooze mode to Normal mode or Software Standby mode.

(4) Deep Software Standby Mode

In Deep Software Standby mode, the CPU and on-chip peripheral functions, except for some internal modules, are stopped. Current consumption is reduced since the internal power supply to these modules is stopped prior to entering Deep Software Standby mode. The contents of all CPU registers and internal peripheral modules, except for the RTC alarm, RTC interval, and USB suspend/resume detecting unit, become undefined.

2.1.2 Low Power Mode Transition Events

For details on the available low-power mode transitions, refer to the relevant sections in RA4E1 User's Manual (R01UH0929) or RA6E1 User's Manual (R01UH0930):

- Table: Available Snooze requests to switch to Snooze mode.
- Table: Available Snooze end requests (triggers to return to Software Standby mode).
- Table: Available Interrupt Source for canceling Snooze, Software Standby, and Deep Software Standby Modes.

Table 3 lists the mode transition events used in this application project. Figure 7 also shows the low power transition event settings on the FSP configurator.

Table 3. Mode Transition Events Used in this Application Project

Transition Request	Event
Request for transition to Snooze mode	AGT1_AGTI
Snooze mode end request	DTC_TRANSFER
Request for transition to Normal mode from Snooze mode or Software Standby mode	PORT_IRQ RTC_ALM DOC_DOPCI

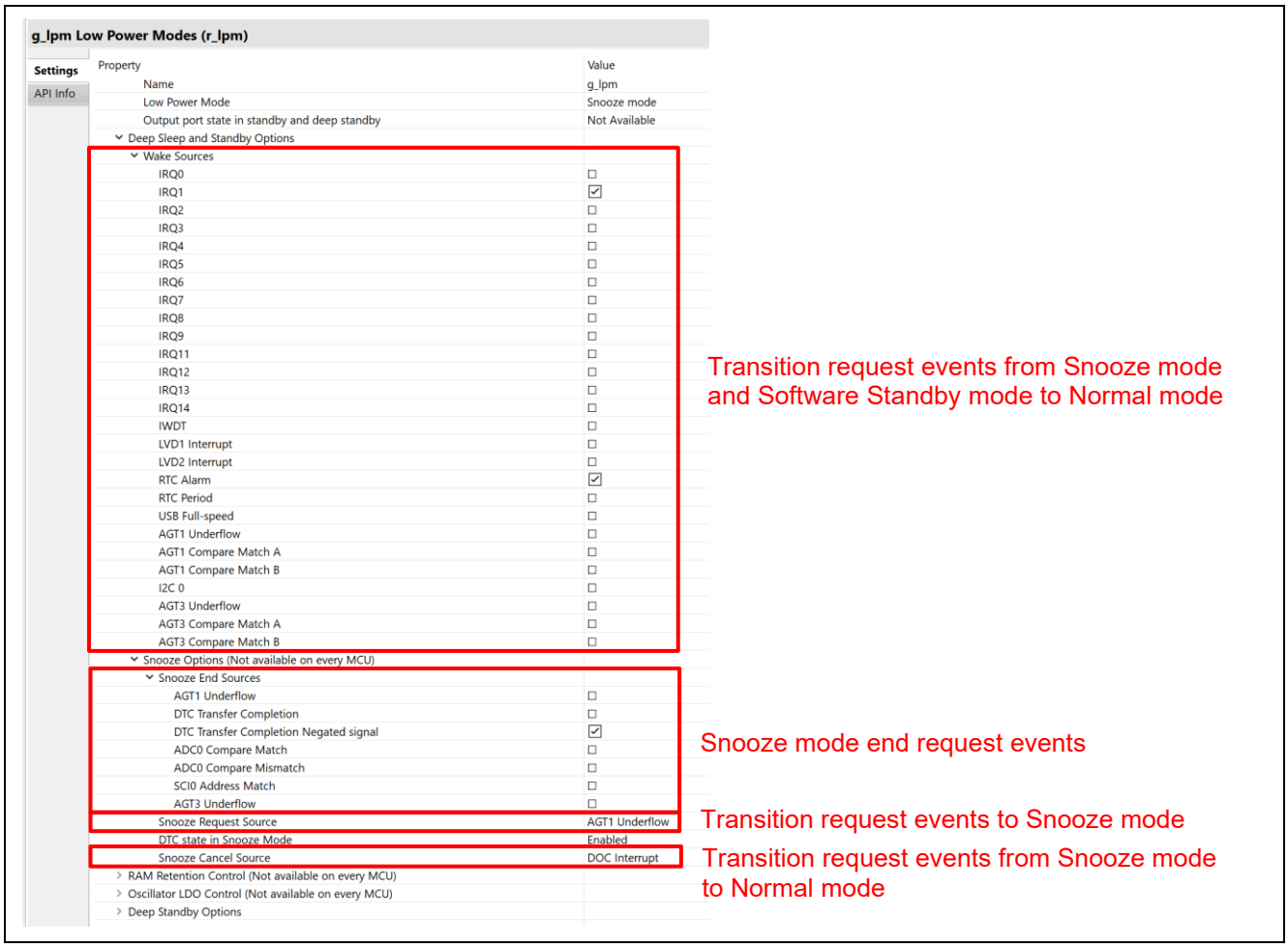


Figure 7. Low Power Mode Transition Event Settings on FSP Configurator

2.2 12-bit A/D Converter

The RA4E1 or RA6E1 MCU includes a 12-bit successive approximation A/D converter (ADC12) unit. There are three types of scan conversion operation modes:

- Single scan mode: Executes the scan of the specified channel once.
- Continuous scan mode: Scanning of the specified channels is repeated until ADCSR.ADST bit is set to 0 by the software.
- Group scan mode: The scan of the channel selected in Groups A and B is executed once by the synchronous trigger.

2.2.1 A/D Conversion Channel

The RA4E1 or RA6E1 MCU 12-bit A/D converter unit (ADC12) can select up to 9 channels (AN000 to AN004, AN011 to AN013, and AN016) or 11 channels (AN000 to AN008, AN012, and AN013) respectively of analog input or internal reference voltage. The available input channels depend on the package type.

This application project uses Seeed's Grove Base Shield V2.0 for Arduino to connect the sensor through the Arduino compatible connector of the FPB-RA4E1 or FPB-RA6E1 kit. J6-1 and J6-2 of Arduino compatible connector of the FPB-RA4E1 or FPB-RA6E1 are connected to analog channels 0 (AN000) and 1 (AN001) of the RA4E1 or RA6E1 MCU and can be read by selecting channels 0 and 1. Figure 8 shows the analog signal pin connections for Arduino compatible connectors in the FPB-RA4E1 or FPB-RA6E1 kit. Figure 9 shows the ADC scan channels settings in the FSP configurator.

The A/D conversion channel is selected through the ADANSA0/ADANSA1 registers. A/D conversion is started from the smallest channel number according to the conversion sequence for the analog input channel (ANn). The A/D conversion result is stored in the corresponding A/D data register n (ADDRn).

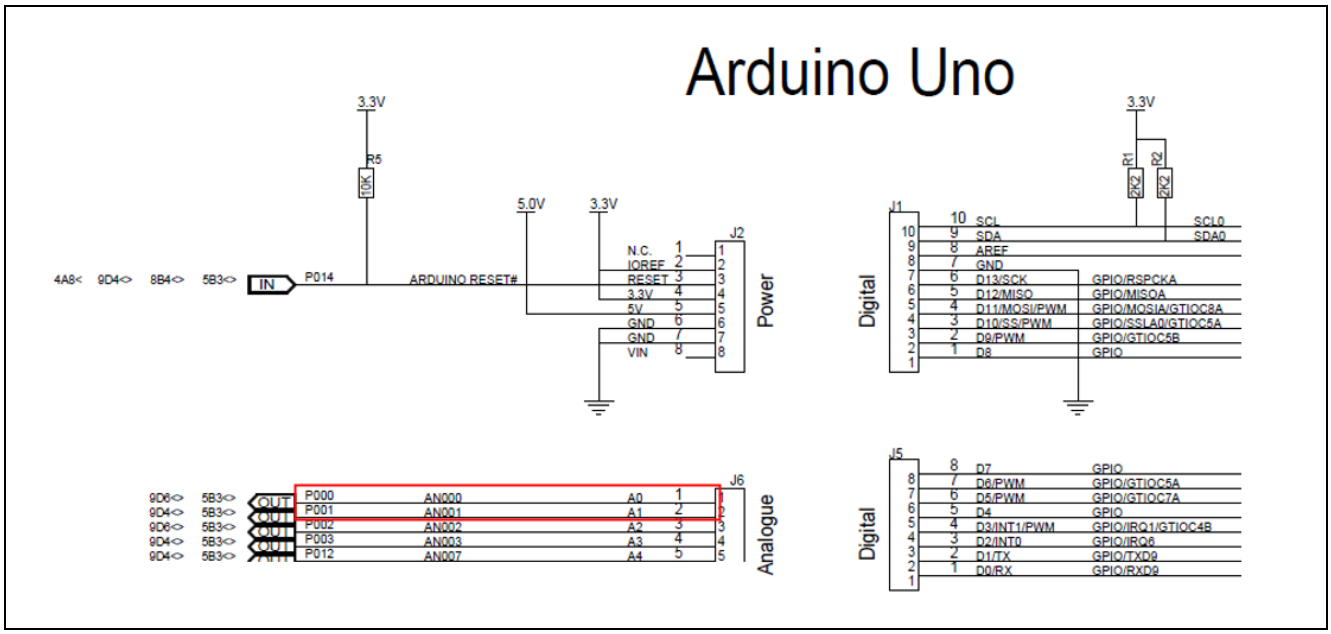


Figure 8. FPB-RA4E1 or FPB-RA6E1 Kit Arduino Compatible Connector Analog Signal Pin Connection

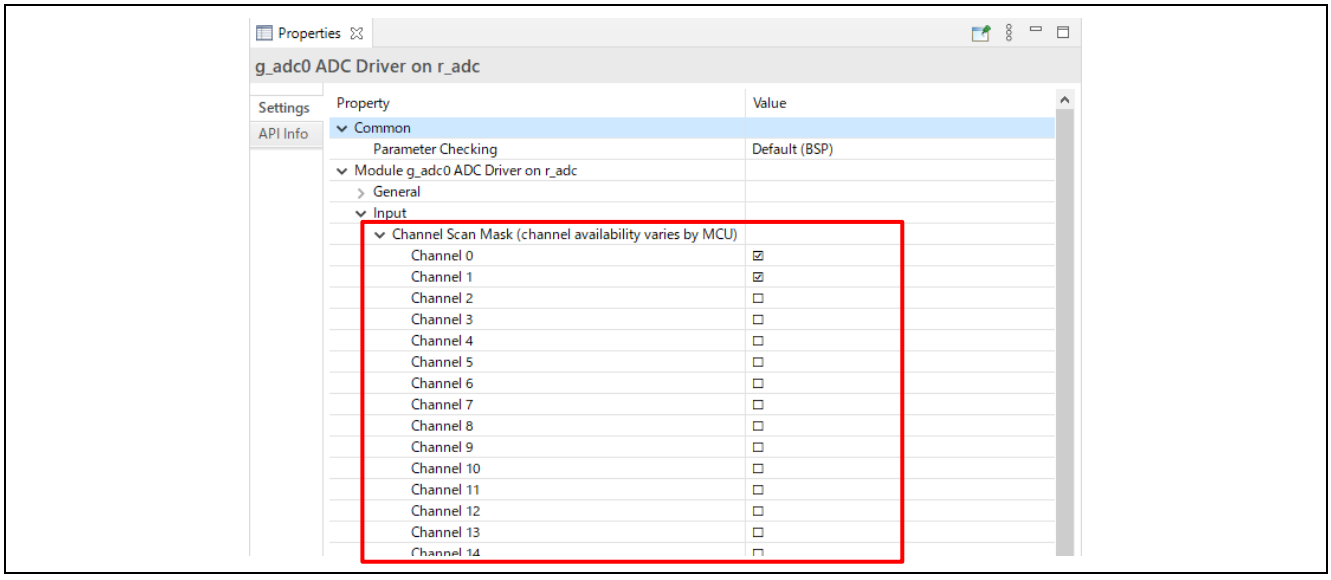


Figure 9. ADC Scan Channels Settings on FSP Configurator

2.2.2 Conversion Start Event

Figure 10 shows ADC12 Input/Output events. The ADC12 conversion start condition can be selected from three triggers: software trigger, synchronous trigger from ELC, and asynchronous trigger by external trigger ADTRG0 pin. In this application project, the synchronous trigger from the ELC is selected as the conversion start condition. Figure 11 shows the A/D conversion start trigger event settings in the FSP configurator.

A/D conversion by a synchronous trigger from the ELC can be started by the preset event of the ELC specified by ELSRn register as shown below. Set ADCSR.TRGE bit to 1 and ADCSR.EXTRG bit to 0 and select the corresponding source in ADSTRGR.TRSA[5:0] and ADSTRGR.TRSB[5:0] bits:

- Select ELC_AD00 in the ELC.ELSR8 register.
- Select ELC_AD01 in the ELC.ELSR9 register.

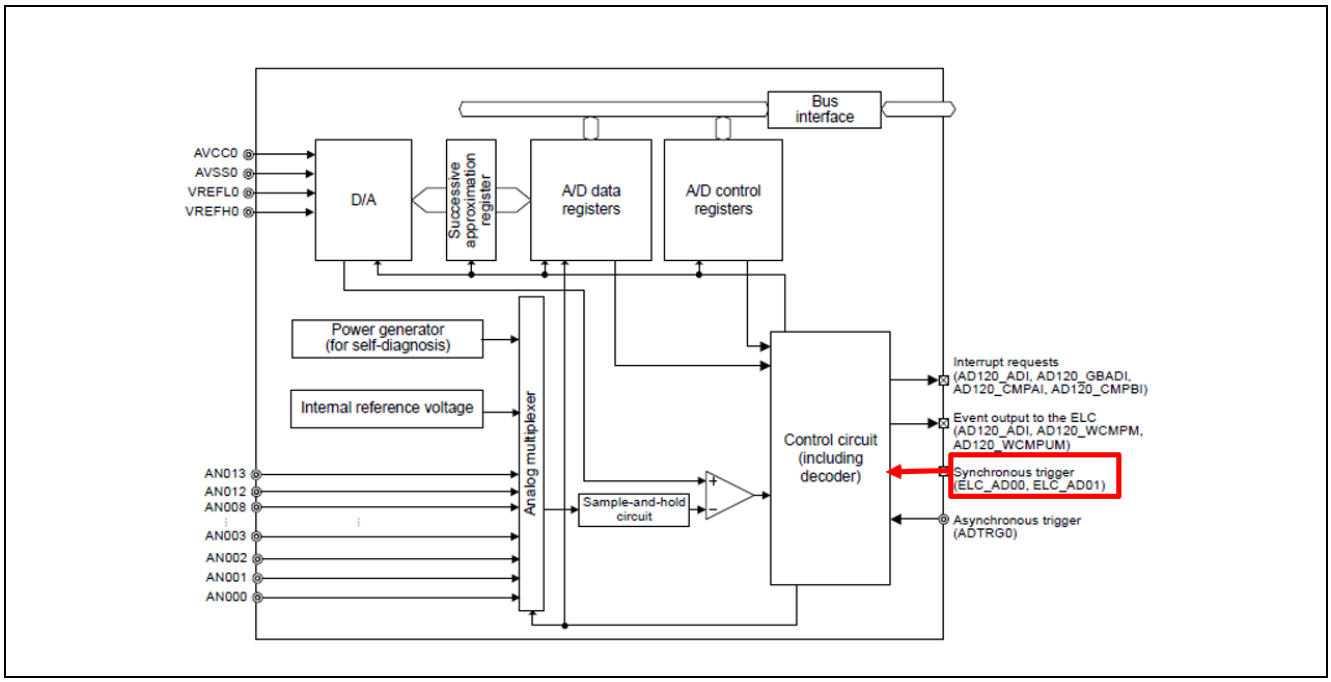


Figure 10. ADC12 Input/Output Events

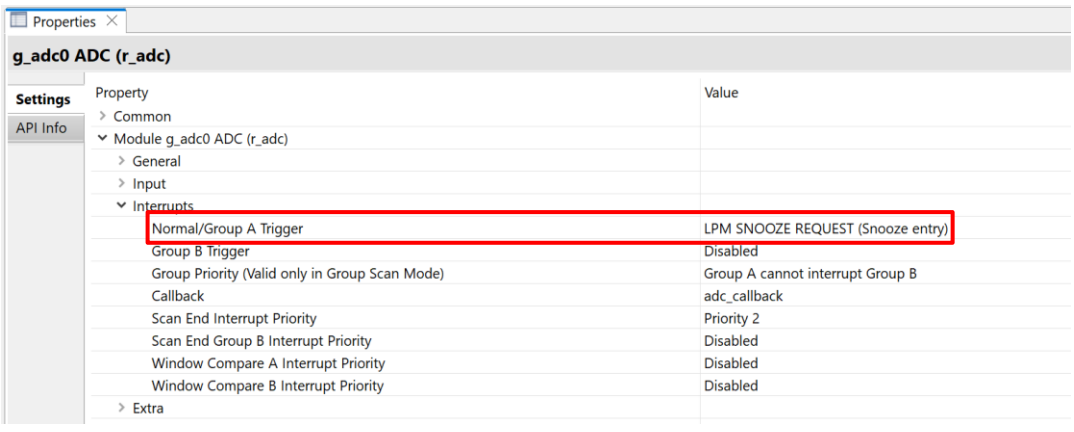


Figure 11. A/D Convert Start Trigger Event Settings in FSP Configurator

2.2.3 Data Register Automatic Clearing Function

When an A/D data register is read by the CPU or DTC, the A/D data register (ADDRn, ADRD, ADDBLDR, ADDBLDRA, ADDBLDRB, ADTSDR, ADOCDR) can be automatically cleared to 0x0000 by setting ADCER.ACE bit to 1 in Figure 12. In this application project, the value of the data register (ADDR0) must be read twice in order to transfer the conversion result of A/D converter channel 0 to the two data areas. Therefore, the data register automatic clearing function is disabled (set the ACE bit in ADCER to 0).

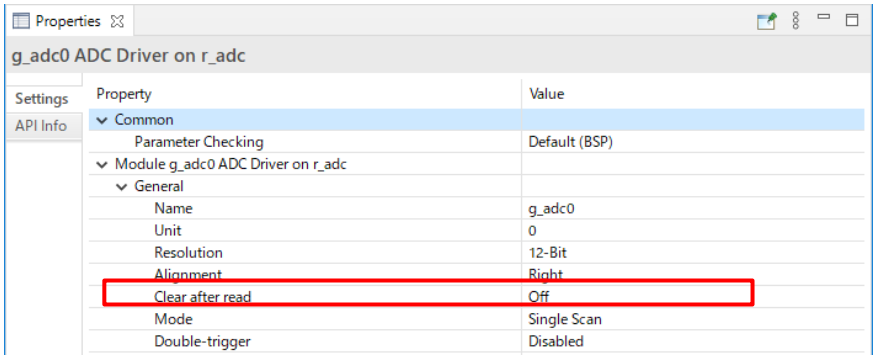


Figure 12. ADC Data Register Auto Clearing Function Settings in FSP Configurator

2.3 DTC Transfer

When the Data Transfer Controller (DTC) is activated by an interrupt request, it transfers data according to the transfer information. To operate DTC, the data to be transferred must be stored in SRAM in advance.

The following three transfer modes are available:

- Normal transfer mode: One data transfer is performed by one activation.
- Repeat transfer mode: One data transfer is performed by one activation. When data of repeat size is transferred, it returns to the address at the start of the transfer.
- Block transfer mode: One block is transferred at one activation.

2.3.1 Transfer Start Event

The DTC can be activated by an interrupt request. When the IELSRn.DTCE bit in the ICU is set to 1, the DTC is activated by the corresponding interrupt. The selector output number n (n = 0 to 95) set in the IELSRn register in the ICU is defined as the interrupt vector number. For the enabled interrupt, a particular DTC interrupt source corresponding to each interrupt vector number n is selected by the IELSRn.IELS[8:0] (n = 0 to 95) bits in the ICU.

Figure 13 shows DTC activation by an interrupt request from a peripheral module. Figure 14 also shows the DTC transfer start event settings in the FSP configurator.

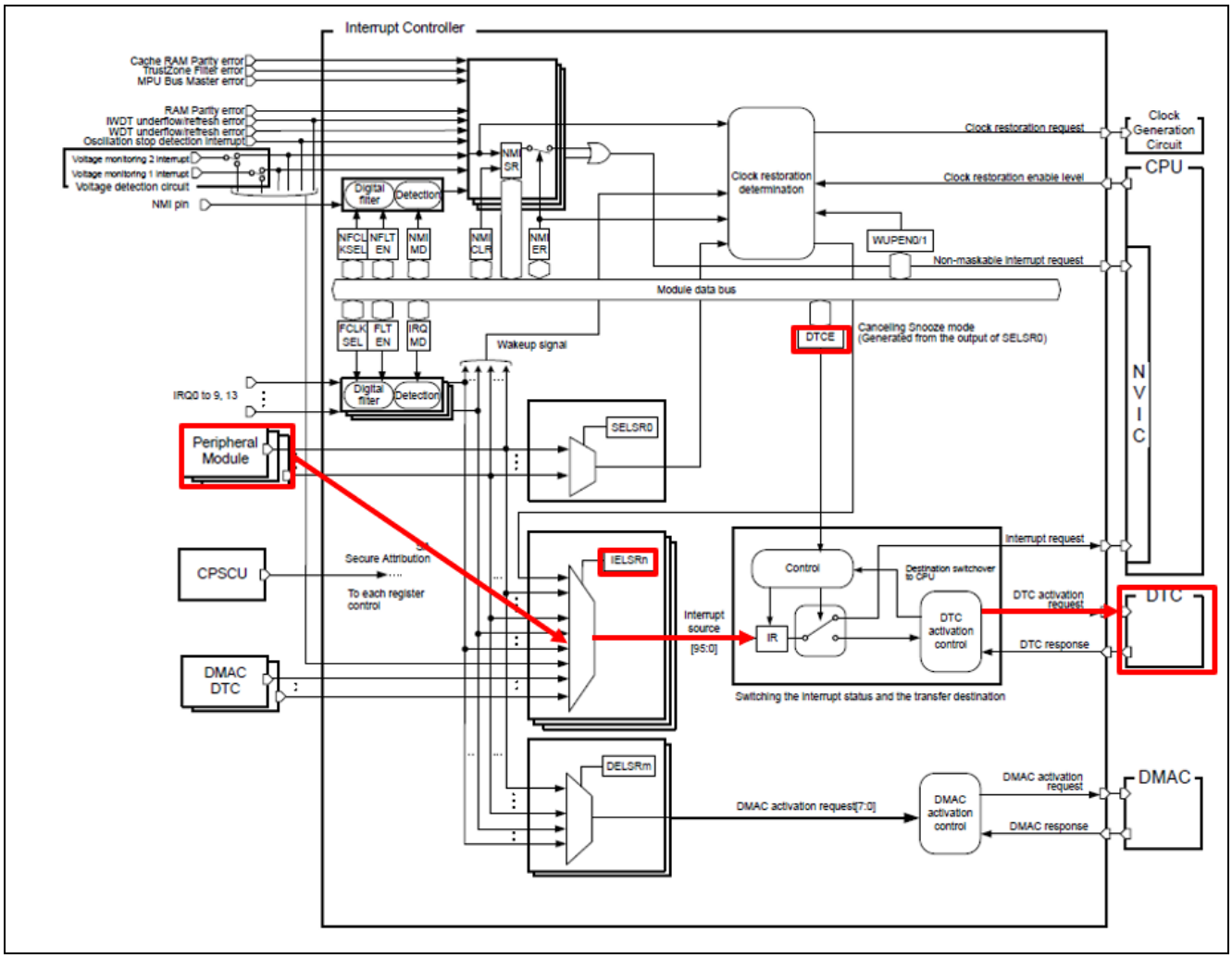


Figure 13. DTC Activation by an Interrupt Request from a Peripheral Module

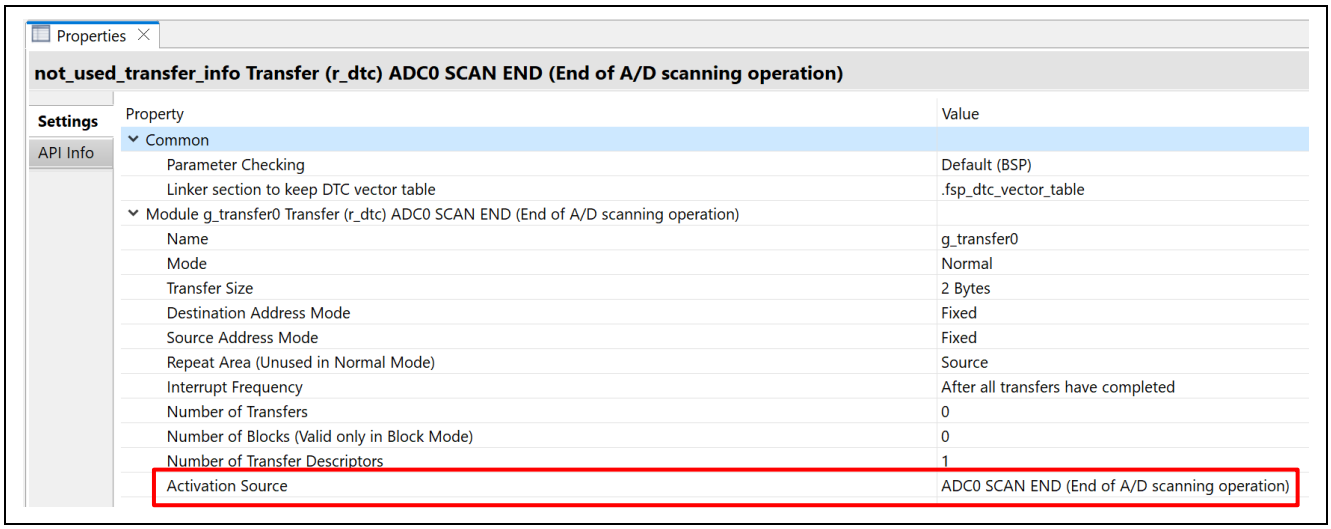


Figure 14. DTC Transfer Start Event Settings in FSP Configurator

2.3.2 Chain Transfer

The DTC can perform chain transfers in which multiple data transfers are performed continuously for a single activation source. When the CHNE bit in the MRB register is set to 1, chain transfer is enabled.

In this application project, the following transfer is executed by one activation factor. Figure 15 shows the chain transfer operation in this case:

- The conversion result of A/D converter channel 0 is stored in the channel 0 measurement data buffer.
- The conversion result of A/D converter channel 1 is stored in the channel 1 measurement data buffer.
- The value of the level judgment threshold storage variable is stored in the DOC data setting register.
- The conversion result of A/D converter channel 1 is stored in the DOC data input register.

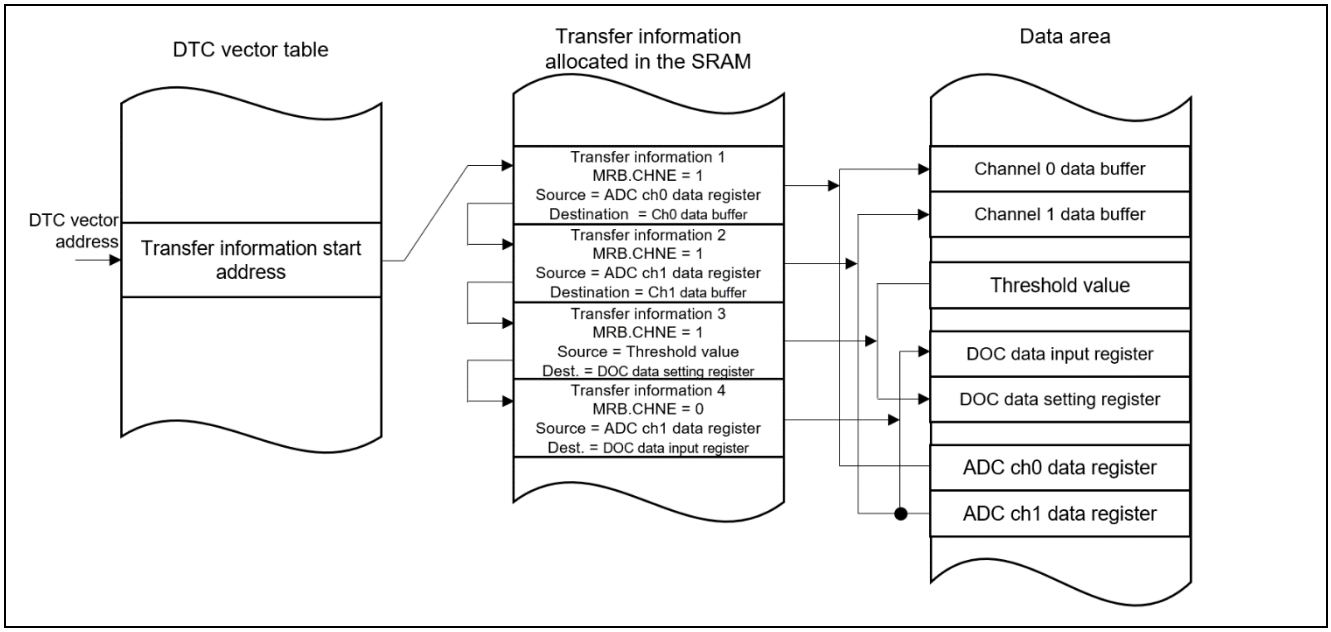


Figure 15. Chain Transfer Operation

When chain transfer is set using the DTC driver of the FSP, the transfer information can be declared as an array of transfer_info_t structures, and the pointer of the first transfer information can be passed to the driver. At this time, the chain_mode member of all transfer_info_t structures, except for the last transfer, must be set to TRANSFER_CHAIN_MODE_EACH or TRANSFER_CHAIN_MODE_END and configured for chain mode. Set chain_mode of the last transfer to TRANSFER_CHAIN_MODE_DISABLED.

Since the FSP Configurator does not allow creation of chained Transfer Control Blocks, the R_DTC_Reconfigure function should be used to override the FSP defined transfer_info_t data passed through the transfer_cfg_t data structure instance.

The chain transfer shown in Figure 15 is set as follows:

```
transfer_info_t g_dtc_data_transfer_info[4] = {
{
        .transfer_settings_word_b.dest_addr_mode = TRANSFER_ADDR_MODE_INCREMENTED,
        .transfer_settings_word_b.repeat_area = TRANSFER_REPEAT_AREA_DESTINATION,
        .transfer_settings_word_b.irq = TRANSFER_IRQ_END,
        .transfer_settings_word_b.chain_mode = TRANSFER_CHAIN_MODE_EACH,
        .transfer_settings_word_b.src_addr_mode = TRANSFER_ADDR_MODE_FIXED,
        .transfer_settings_word_b.size = TRANSFER_SIZE_2_BYTE,
        .transfer_settings_word_b.mode = TRANSFER_MODE_REPEAT,
        .p_dest = address of the channel 0 data buffer,
        .p_src = address of ADC channel 0 data register,
        .num_blocks = 0,
        .length = size of the channel 0 data buffer,
},
{
        .transfer_settings_word_b.dest_addr_mode = TRANSFER_ADDR_MODE_INCREMENTED,
        .transfer_settings_word_b.repeat_area = TRANSFER_REPEAT_AREA_DESTINATION,
        .transfer_settings_word_b.irq = TRANSFER_IRQ_END,
        .transfer_settings_word_b.chain_mode = TRANSFER_CHAIN_MODE_EACH,
        .transfer_settings_word_b.src_addr_mode = TRANSFER_ADDR_MODE_FIXED,
        .transfer_settings_word_b.size = TRANSFER_SIZE_2_BYTE,
        .transfer_settings_word_b.mode = TRANSFER_MODE_REPEAT,
        .p_dest = address of the channel 1 data buffer,
        .p_src = address of ADC channel 1 data register,
        .num_blocks = 0,
        .length = size of the channel 1 data buffer,
},
{
        .transfer_settings_word_b.dest_addr_mode = TRANSFER_ADDR_MODE_FIXED,
        .transfer_settings_word_b.repeat_area = TRANSFER_REPEAT_AREA_DESTINATION,
        .transfer_settings_word_b.irq = TRANSFER_IRQ_END,
        .transfer_settings_word_b.chain_mode = TRANSFER_CHAIN_MODE_EACH,
        .transfer_settings_word_b.src_addr_mode = TRANSFER_ADDR_MODE_FIXED,
        .transfer_settings_word_b.size = TRANSFER_SIZE_2_BYTE,
        .transfer_settings_word_b.mode = TRANSFER_MODE_REPEAT,
        .p_dest = address of the DOC data setting register,
```

```
        .p_src = address of the level judgment threshold storage variable,
        .num_blocks = 0,
        .length = 1,
},
{
        .transfer_settings_word_b.dest_addr_mode = TRANSFER_ADDR_MODE_FIXED,
        .transfer_settings_word_b.repeat_area = TRANSFER_REPEAT_AREA_DESTINATION,
        .transfer_settings_word_b.irq = TRANSFER_IRQ_END,
        .transfer_settings_word_b.chain_mode = TRANSFER_CHAIN_MODE_DISABLED,
        .transfer_settings_word_b.src_addr_mode = TRANSFER_ADDR_MODE_FIXED,
        .transfer_settings_word_b.size = TRANSFER_SIZE_2_BYTE,
        .transfer_settings_word_b.mode = TRANSFER_MODE_REPEAT,
        .p_dest = address of the DOC data input register,
        .p_src = address of ADC channel 0 data register,
        .num_blocks = 0,
        .length = 1,
}
};
```

2.4 DOC Subtraction Mode

The Data Operation Circuit (DOC) compares, adds, or subtracts 16-bit data. If the selected condition is met, an interrupt request is generated. There are three types of interrupt occurrence conditions that can be selected:

- The compared values either match or mismatch.
- The result of data addition is greater than 0xFFFF.
- The result of data subtraction is less than 0x0000.

Figure 16 shows the DOC function settings in the FSP configurator.

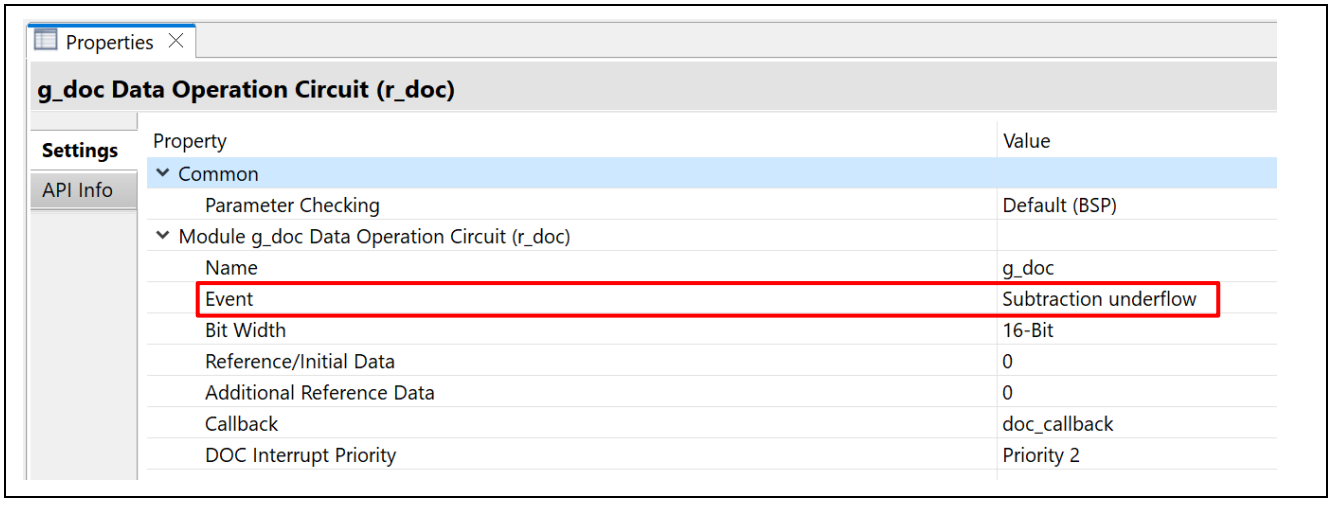


Figure 16. DOC Function Settings on FSP Configurator

In this application project, when the measured data is greater than or equal to the threshold value, the level judgment operation to generate an event is realized by the DOC subtraction mode. The procedure for determining the level using the DOC subtraction mode is shown below. Figure 17 shows the states of the registers at that time.

Procedure for the level judgment using DOC subtraction mode:

① The threshold of the level judgment is stored in the data setting register (DODSR).

② The conversion result of A/D converter channel 1 is stored in the data input register (DODIR).

③ If the subtraction is less than 0x0000, DOCR.DOPCF flag is set to 1.

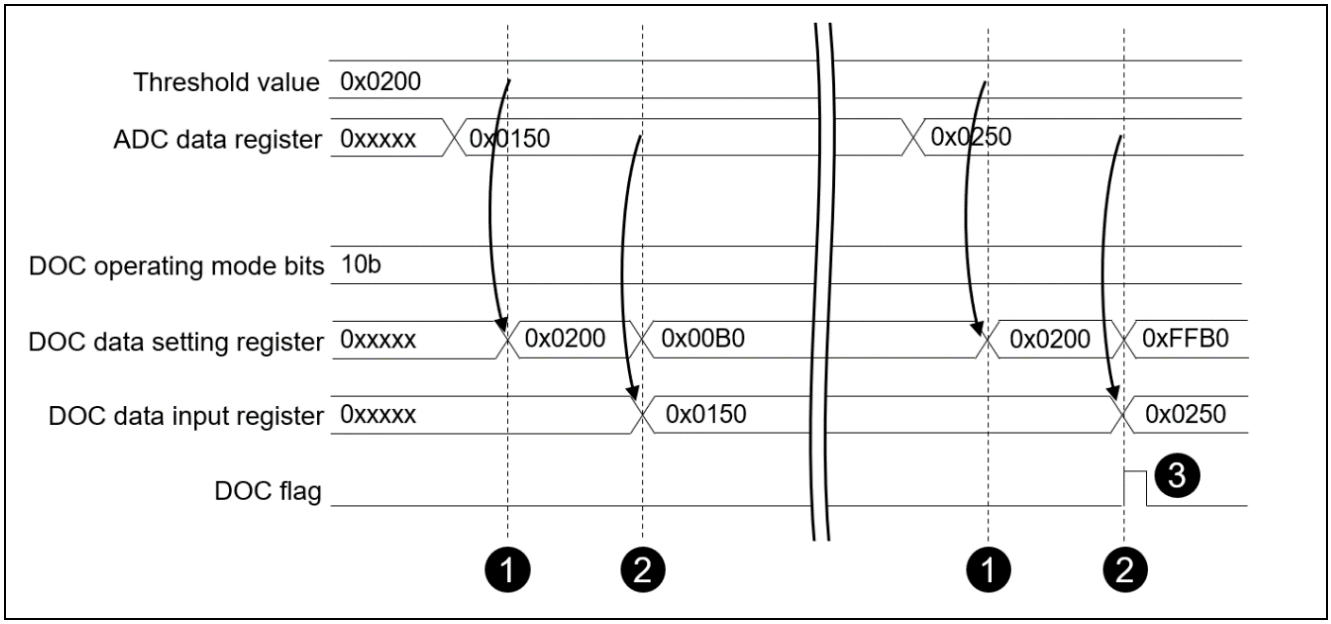


Figure 17. Level Judgement Using DOC Subtraction Mode

2.5 ELC Event Connection

The ELC uses event signals/indications generated by peripheral modules as source signals and passes them to other modules to provide direct linkage between modules without interrupting the CPU operation. As a result, Interrupt Service Routines to the CPU from the event generating module are not required.

When event linking is used, set the ELS[8:0] bits in the ELSRn register for the module to which the event is linked — also, ELCR.ELCON bits are set to 1 to enable all event links. Refer to Table “Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers” in the RA4E1 User's Manual (R01UH0929) or RA6E1 User’s Manual (R01UH0930) for the event number to be set in the ELSRn register.

As described above, this application project uses a synchronous trigger from the ELC as the A/D conversion start trigger. And, in this application project, the event that triggers the ADC conversion start is changed according to the state of the low power mode. In Snooze or Software Standby mode, connect the Snooze request event to ADC12. Otherwise, connect AGT1 underflow interrupt to ADC12. Figure 18 shows the event connection in the ELC module at that time.

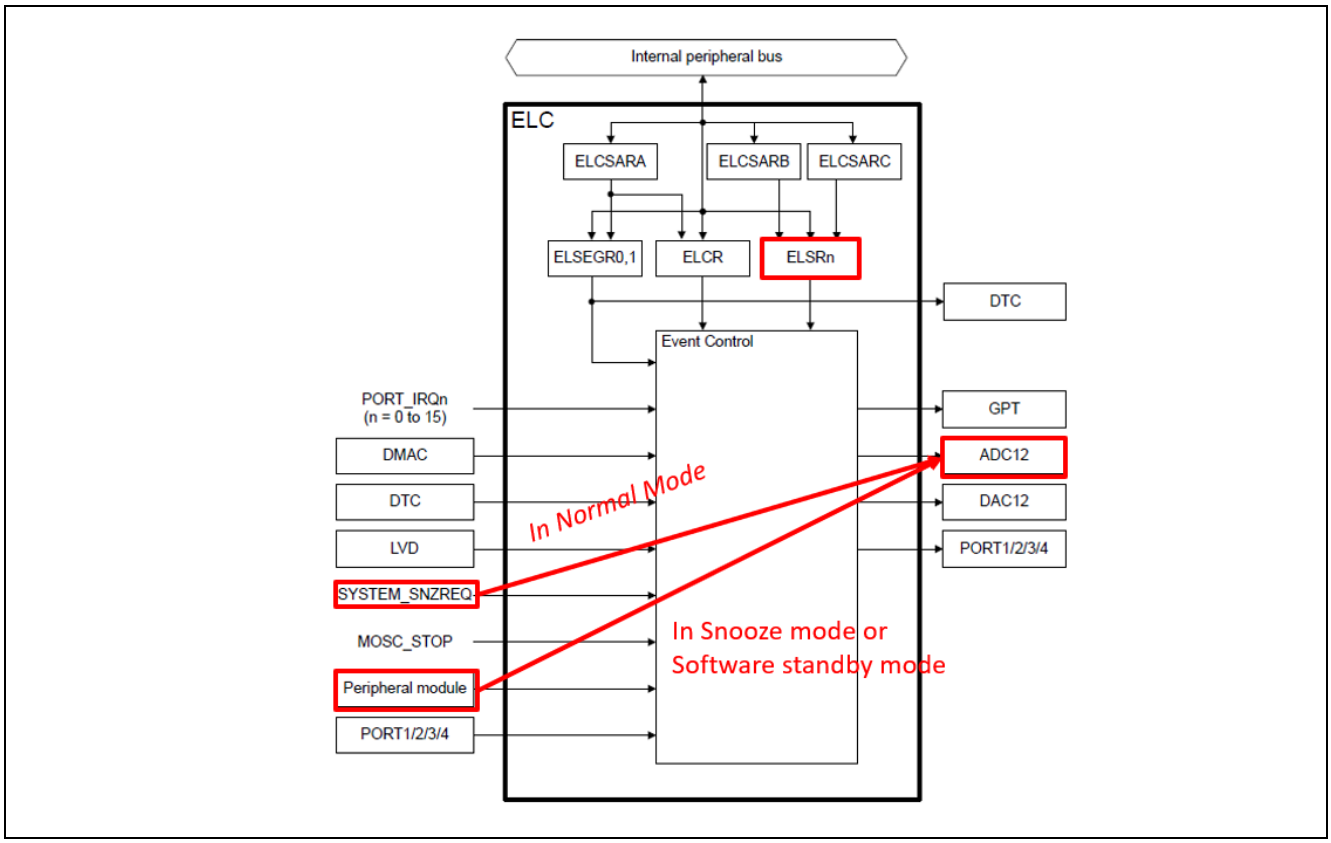


Figure 18. ELC Event Connection for ADC Start Conversion

The ELC event connection can be configured in the FSP Configurator. Some ELC event connections (Example: ADC12 scan start event) can be conveniently configured from the Properties View, which is visible upon selecting the module seen on the Stacks tab. The ELC Allocation setting status can be checked with Allocations by opening Event Links as shown in Figure 19. To set additional links, set them from **User Events Consumed** > **New User Event**. As shown in Figure 19, we have added settings for port-out that cannot be set on **Stacks** tab.

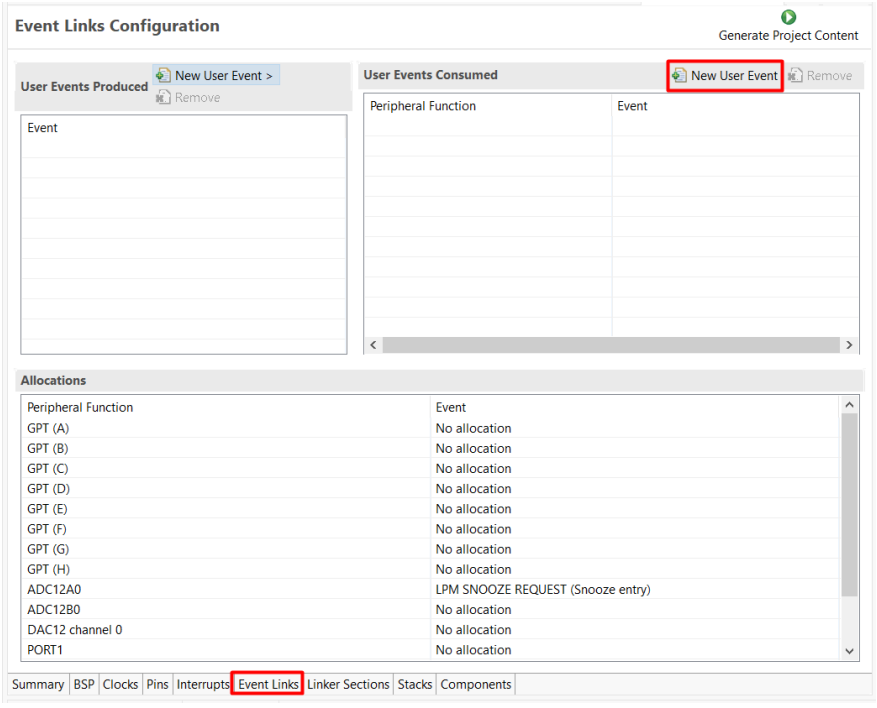


Figure 19. ELC Connection Settings on the Configurator

2.6 Two-channel Connected AGT

The RA4E1 or RA6E1 MCU implements 16-bit Asynchronous General Purpose Timers (AGTn), n = 0 to 3, 5 for RA4E1, and n = 0 to 5 for RA6E1. The AGT can be used over a two-channel connection to generate a long-period interrupt (Figure 20). To connect to two channels, select the underflow event signal from AGTn as the count source in the ATGn.AGTMR1.TCK bit. However, the only combinations that can be selected are as follows:

RA4E1 MCU:
- The AGT0 underflow event signal as the count source of AGT1.
- The AGT2 underflow event signal as the count source of AGT3.

RA6E1 MCU:
- The AGT0 underflow event signal as the count source of AGT1.
- The AGT2 underflow event signal as the count source of AGT3.
- The AGT4 underflow event signal as the count source of AGT5.

Refer to the relevant part of the RA4E1 User's Manual (R01UH0929) or RA6E1 User's Manual (R01UH0930) for more information. Figure 21 also shows AGT count source settings in the FSP configurator.

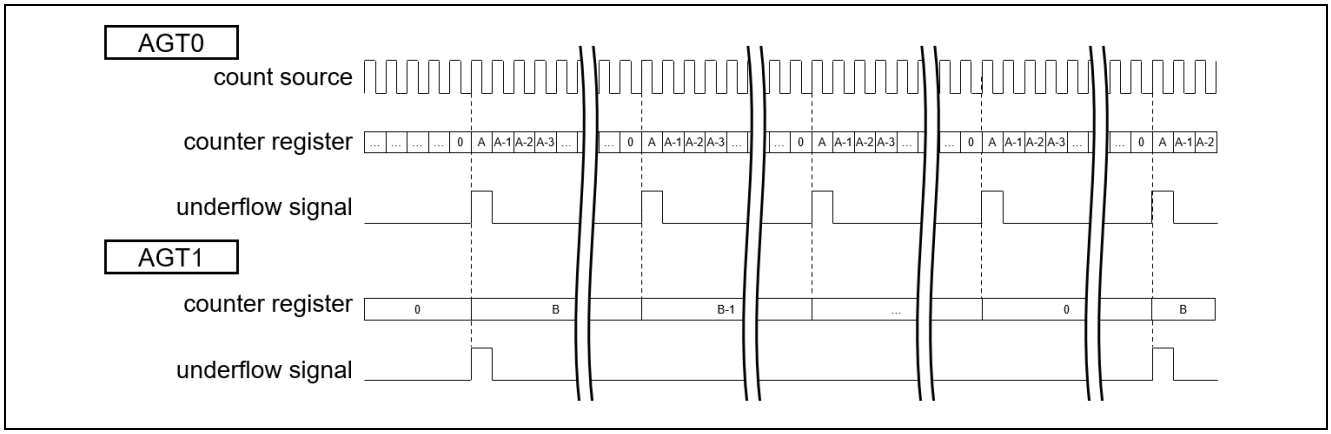


Figure 20. Two-Channel Connected AGT

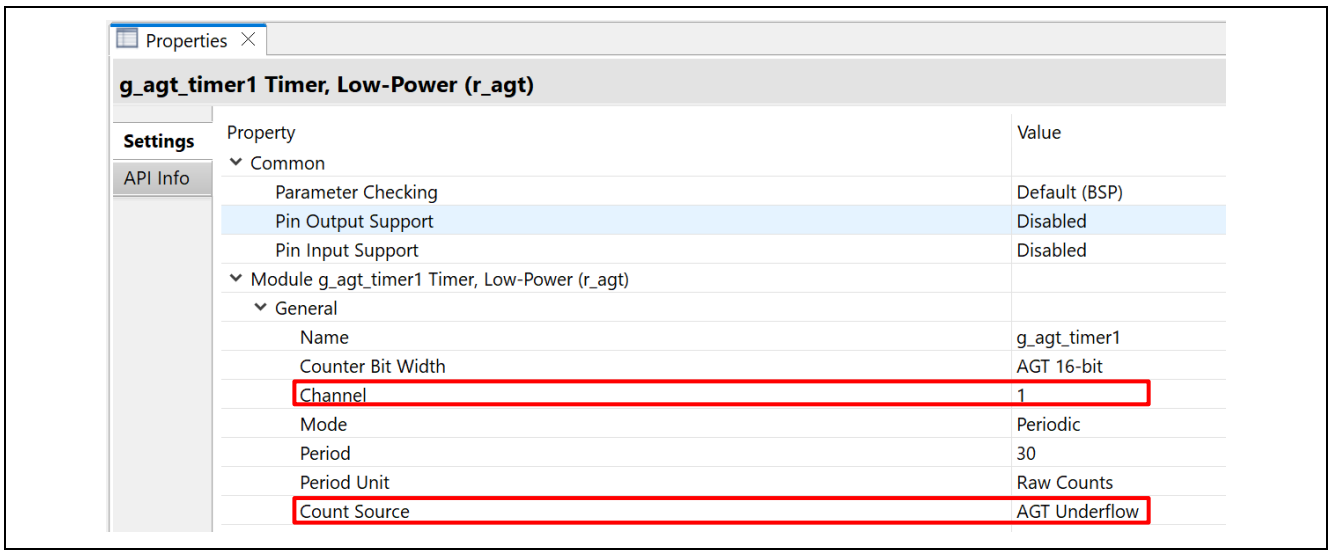


Figure 21. AGT Count Source Settings in FSP Configurator

The maximum period with a single-channel AGT during Software Standby mode is 256 seconds (approximately 4.3 minutes) when selecting AGTLCLK or AGTSCLK as the count source and 1/128 as the clock frequency division ratio. If using a two-channel AGT, the maximum period is approximately 16,777,216 seconds (approximately 194 days).

In this application project, a two-channel AGT is used because it is necessary to generate a periodic interrupt every 30 minutes as a transition request to Snooze mode and the timing of data acquisition.

2.7 RTC Mode Selection

The RTC has two count modes: calendar count mode and binary count mode. Calendar count mode retains the 100-year calendar from 2000 to 2099 and automatically corrects the leap year date. In binary count mode, seconds are counted, and the information is saved as a serial value. In this application project, binary count mode is selected to measure the time (elapsed seconds) since startup.

The count mode can be selected by using the RCR2.CNTMD bit. When this bit is rewritten, the next processing is performed after confirming that the value has been rewritten. If the count mode is set again, the RTC software reset is executed, and the initial settings are re-applied. This bit is updated synchronously with the count source, but the count mode is switched after an RTC software reset.

2.8 Clock Output

This application project allows checking the status of the low power mode by outputting the clock externally. This is possible because some oscillators stop in Software Standby mode.

The clock sources output from CLKOUT pins and their division factors are set by the following registers:

- CKOCR.CKODIV[2:0], or CKOCR.CKOSEL [2:0]
- OFS1.HOCOFRQ1[2:0]

To enable outputting from CLKOUT pin, set CKOCR.CKOEN to 1. The FSP configurator sets the clock output from Clocks tab, as shown in Figure 22.

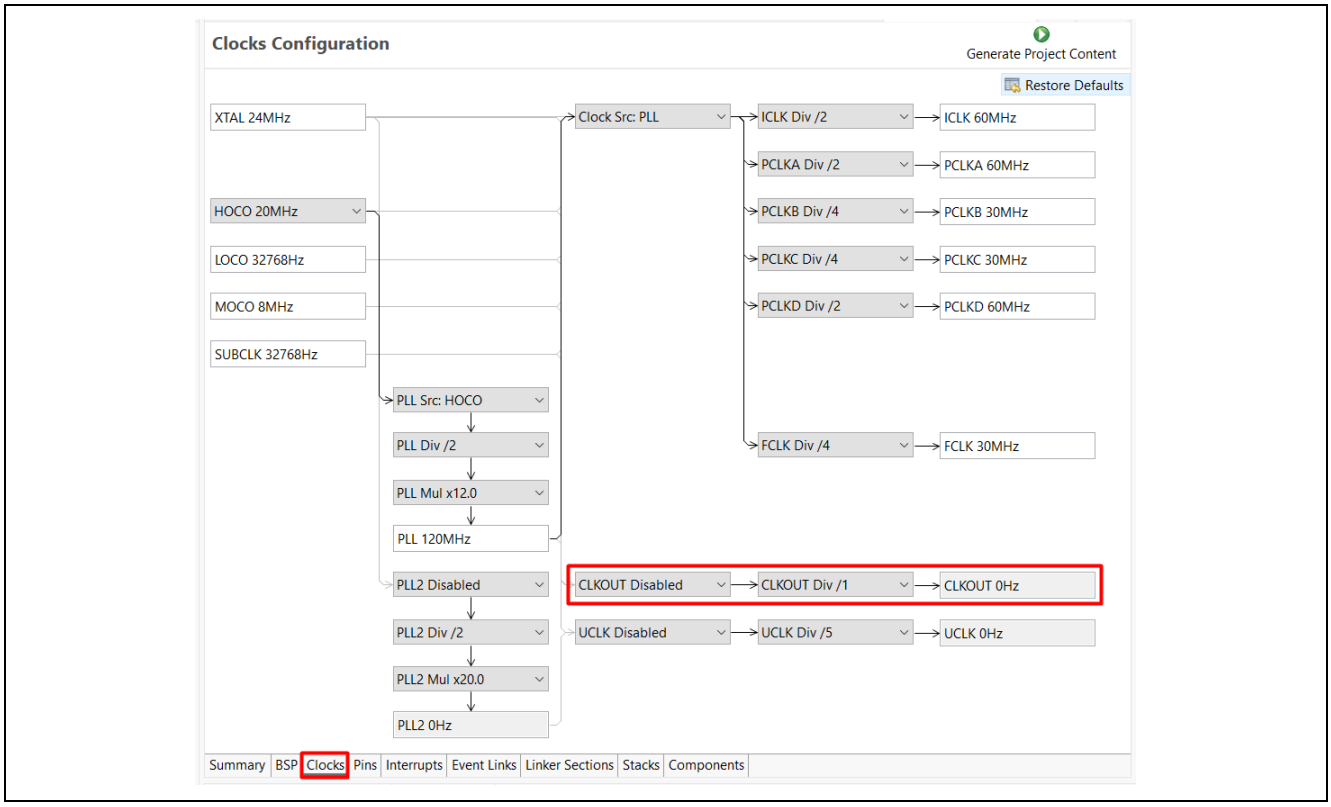


Figure 22. Clock Output Settings in FSP Configurator

3. Low-power Data Logger Application

This chapter describes the detailed design of the low-power data logger application using the module features described in the previous chapter.

3.1 Functional Specification

This application project is implemented based on the following specifications. Figure 23 also shows the overall algorithm for the low-power data logger.

3.1.1 Data Acquisition Function

- Analog signals of two sensors (Luminance sensor Seeed Grove-Luminance Sensor, Temperature sensor Seeed Grove-Temperature Sensor) connected to external pins are acquired by A/D converters.
- Analog signal input values are between the low-potential reference voltage (VREFL and VSS) and the high-potential reference voltage (VREFH and VCC) set between 0 V and 3.3 V, respectively.
- Acquisition of data from each sensor is performed every 30 minutes regardless of the low power mode status (using Snooze request event or AGT1 underflow interrupt).
- The size of the measurement data buffer is 96 samples (48 hours of sampling every 30 minutes).

3.1.2 Data Level Judgement Function

- After acquiring the data, the analog signal pin AN001 level is judged by the DOC.
- When AN001 is equal to or greater than the threshold (30.00°C), the low power mode is canceled, and data is output.

3.1.3 Data Output Function

- Perform data output every 24 hours triggered by RTC alarm interrupt or as triggered by external IRQ interrupt or DOC interrupt.
- UART communication format is 115,200 bps baud rate, 8-bit data length, no parity, 1 stop bit.

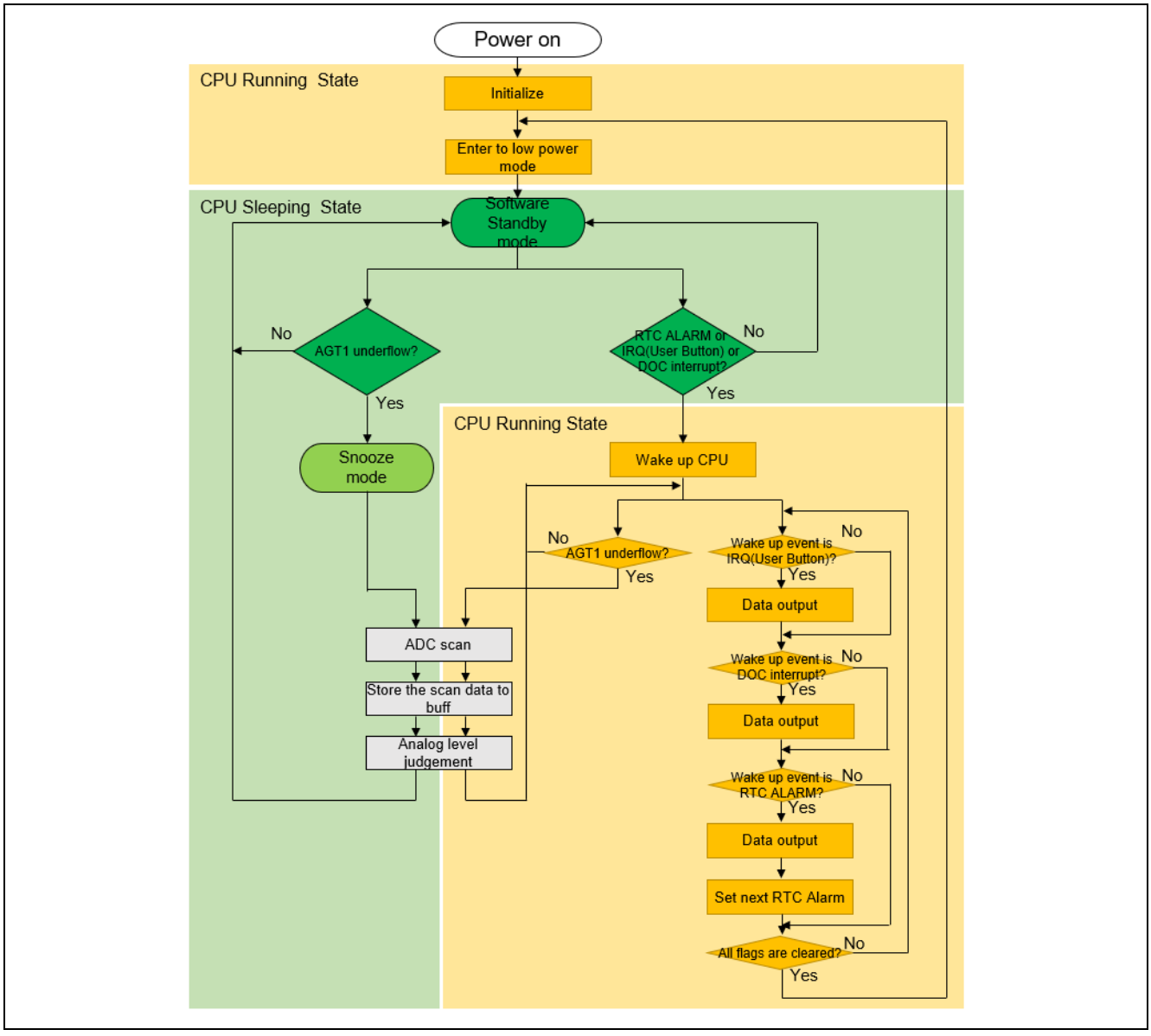


Figure 23. Overall Algorithm of the Low-power Data Logger

3.2 User Interface

This chapter describes the user interface for the Low-power Data Logger Application. See section 4.4 "Procedure for Checking the Operation of the Low-power Data Logger" for more information on checking operation using the main module.

Figure 24 shows the system overview of this application project.

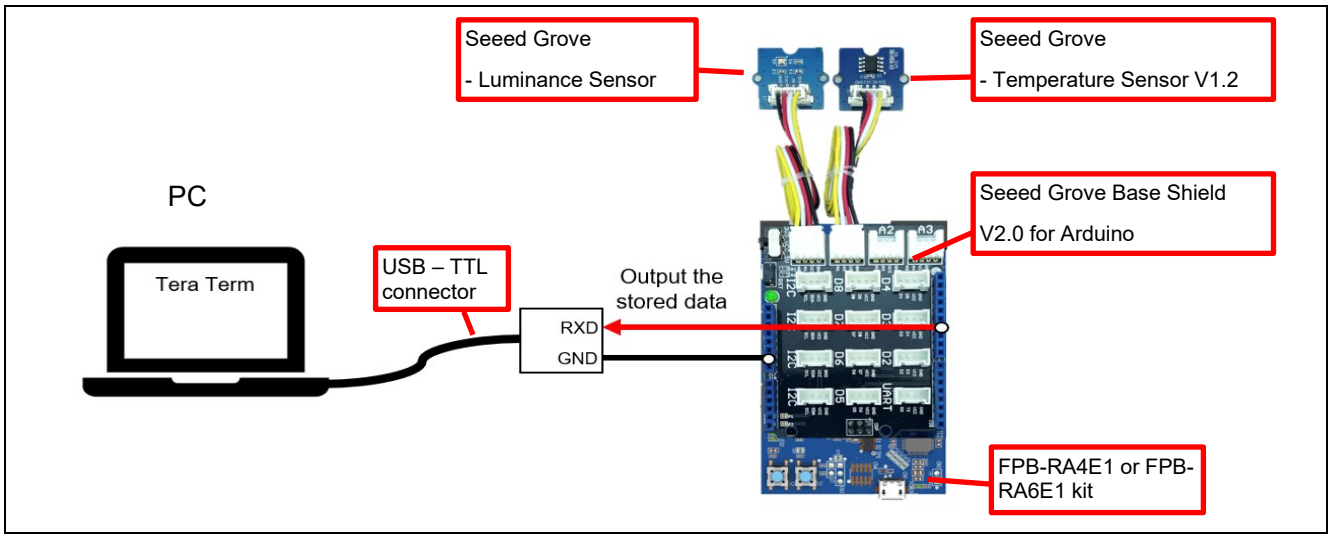


Figure 24. System Overview

3.2.1 Connect the Sensor

Figure 25 shows the connection diagram with the sensor. In this application project, attach Seeed's Grove Base Shield V2.0 for Arduino to the Arduino compatible connector of the FPB-RA4E1 or FPB-RA6E1 kit. Attach the sensor module to the A0 and A1 connectors of this Base Shield with Grove cable. This connects the analog signal pins (AN000 and AN001) of the RA4E1 or RA6E1 MCU with the analog output pins of the two sensors.

- Light Sensor Module: Seeed Grove – Luminance Sensor
  - Equipped with illuminance sensor APDS-9002, Operating voltage: 2.4 to 5V, Measurement range: 0 to 1000 Lux.
- Temperature Sensor Module: Seeed Grove – Temperature Sensor
  - Equipped with NTC thermistor NCP18WF104F03RC, Operating voltage: 3.3 to 5V, Operating temperature range: -40 °C to 125 °C.

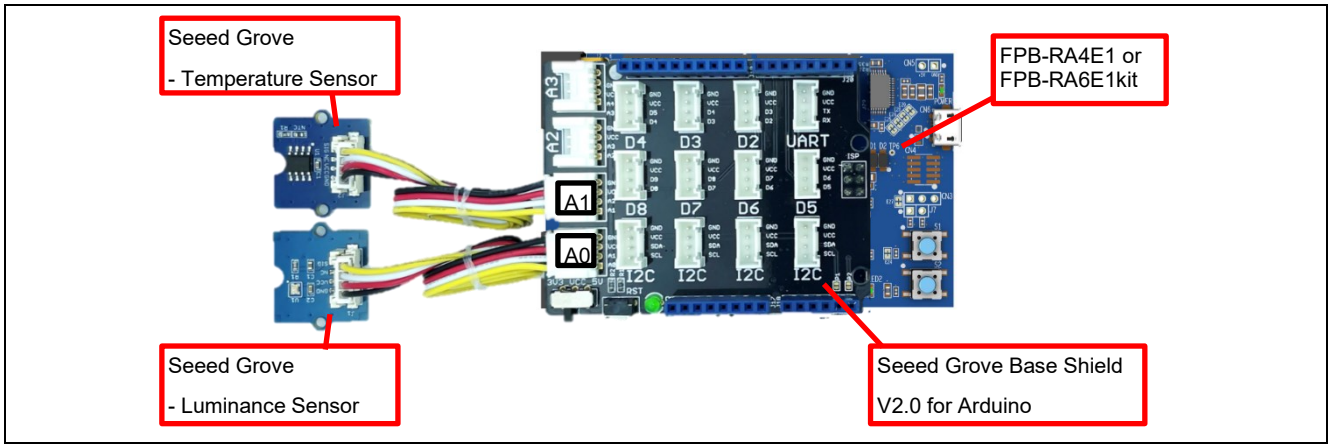


Figure 25. Sensor Connection

3.2.2 Connect the USB-TTL Connector

Table 4 and Figure 26 shows the connection pins to the USB-TTL connector. Connect the Arduino compatible connector of the FPB-RA4E1 or FPB-RA6E1 kit using jumper wires.

Table 4. Pins to be Connected to the USB-TTL Connector (FPB-RA4E1 or FPB-RA6E1 kit)

RA4E1 or RA6E1 Pin	FPB-RA4E1 or FPB-RA6E1 Pin	Typical Uses
P101/TxD0	J1-4	Serial communication (transmission). Connect to the RXD pin of the USB-TTL connector.
VSS	GND	Ground. Connect to the GND pin of the USB-TTL connector.

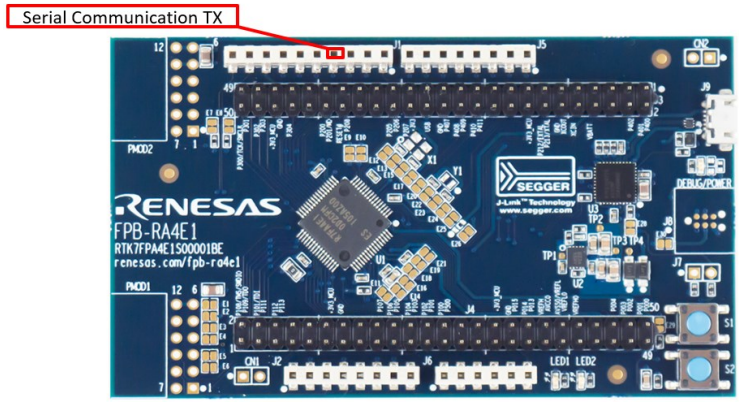


Figure 26. Connecting to the External Equipment

3.2.3 Data Communication Specifications

This application project performs data communication according to the following procedure and format.

3.2.3.1 Communication Data Format

Following is the packet format/protocol of data transmitted by the FPB-RA4E1 or FPB-RA6E1:

- Packet format:

(a) Start code	(b) Attribute code	(c) Delimiter code	(d) Data length code	(c) Delimiter code	(e) Data	(f) End code	(g) Linefeed code

Description	Code	Length	Function
(a) Start code	'^'	1 byte	Start of the packet
(b) Attribute code	ASCII Code	1 byte	Represent a data output occurrence event: '1': RTC alarm event '2': External IRQ event '3': DOC interrupt event
(c) Delimiter code	‘,’	1 byte	Code delimiting code
(d) Data length code	ASCII Code	4 bytes	Indicates the length of the data section.
(e) Data	ASCII Code	Number of bytes specified in (d)	See the following Data Format
(f) End code	'$'	1 byte	End of the packet
(g) Linefeed code	‘\n’	1 byte	Linefeed

- (e) Data format
  The format of the data part varies depending on the attribute code, as shown below:
  — Attribute code 1/2 (output data by RTC alarm and external IRQ interrupt)
  Format of data part:

Time data	‘,’	Number of data	','	First data	','	Second data	','	・・・	','	Last data

Light Data	'/'	Temperature Data

  — Attribute code 3 (output data by DOC interrupt)
  Format of data part:

Time data	','	Light data	'/'	Temperature data

The data comprising the format of attribute codes 1 to 3 is generated as follows:

- The data count consists of 0 to 9 ASCII codes. The length is 2 bytes.
  - Example: When the system transmits 10 data, it sets 0x31, 0x30.
- The time/light/temperature data consists of 0 to 9 ASCII codes.
  - Example: When the system transmits a time value “1234”, it sets 0x31, 0x32, 0x33, 0x34.
- The time data is composed of 10-digit decimal numbers representing elapsed time.
- The light and temperature data are composed of 4-digit decimal number representing ADC read value. When the system transmits data “2000”, it sets 0x32, 0x30, 0x30, 0x30.
- The delimiter between the code is ',', the delimiter between the time and light data is '/'.

3.2.4 Input/Output Pins for Debugging

Table 5 and Figure 27 show the I/O pins for debugging this application project. The debug pins can be observed and toggled as shown below to cancel the low power modes and check the status of the modes.

Table 5. Debugging I/O Pins (FPB-RA4E1 or FPB-RA6E1 kit)

RA4E1 or RA6E1 Pin	FPB-RA4E1 or FPB-RA6E1 Pins or Connecting Components	Typical Uses
P109/CLKOUT	J5-2	Clock output
P408	LED1	Turn on in Error Condition
P407	LED2	Turn on in Normal mode
P205/IRQ1	User switch S1	Manual cancellation of low-power mode

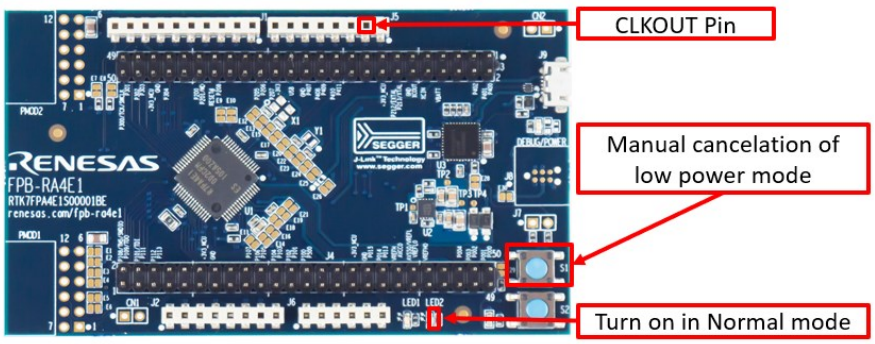


Figure 27. Debugging I/O Pins (FPB-RA4E1 or FPB-RA6E1 kit)

3.3 Clock Input

The clock from the external oscillator must be input for the RTC or AGT to perform an accurate time count. The FPB-RA4E1 or FPB-RA6E1 kit implements a 32.768 KHz clock crystal, but by default, it is not connected to RA4E1 or RA6E1 MCU by solder jumpers (E22, E23 for FPB-RA4E1 and E25, E26 for FPB-RA6E1). Therefore, the project attached with this application note selects an internal clock (LOCO) as the count source for AGT0 and RTC.

When accurate time counting is required, connect the external oscillator using solder bridges.

Also, the following settings should be changed:

- Change the sub-clock populating setting to “Populated” in the **BSP** tab in the FSP configurator.
- Change the count source for AGT0 to “SUBCLOCK” in the **Stacks** tab in the FSP configurator.
- Change the count source for RTC to the sub-clock in `rtc_initialize()` in `app_common.c`.

Figure 28 and Figure 29 show the positions of the solder jumpers for external oscillator connections in FPB-RA4E1.

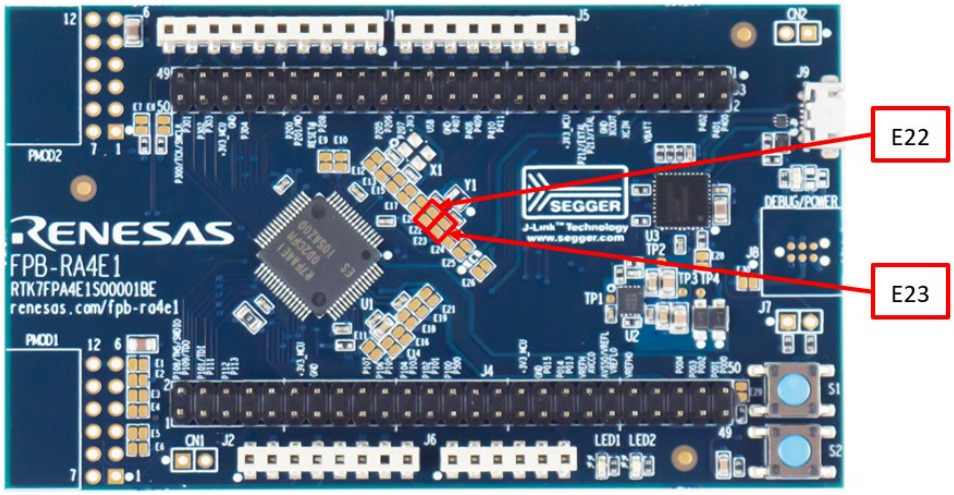


Figure 28. Solder Jumper for External Oscillator Connection in FPB-RA4E1

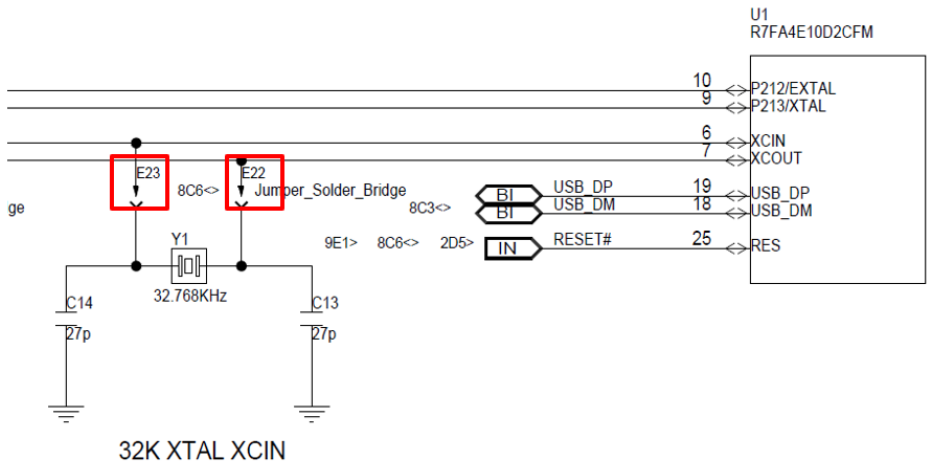


Figure 29. Solder Jumper for External Oscillator Connection in FPB-RA4E1 (Circuit Diagram)

Figure 30 and Figure 31 show the positions of the solder jumpers for external oscillator connections in FPB-RA4E1.

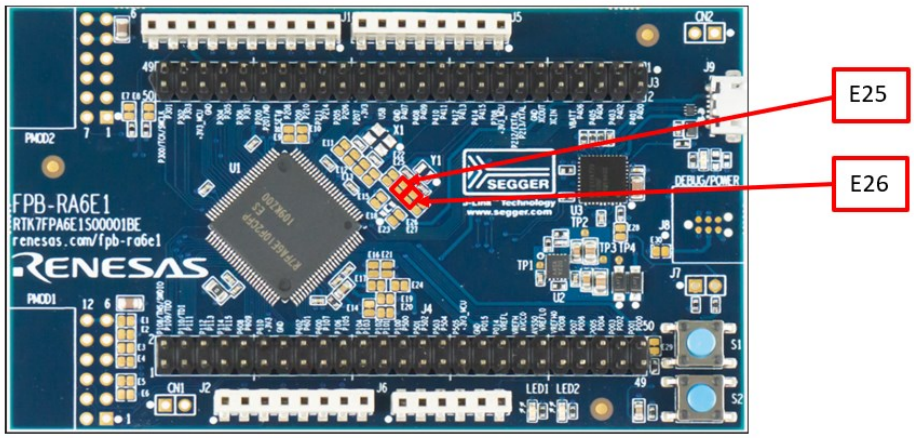


Figure 30. Solder Jumper for External Oscillator Connection in FPB-RA6E1

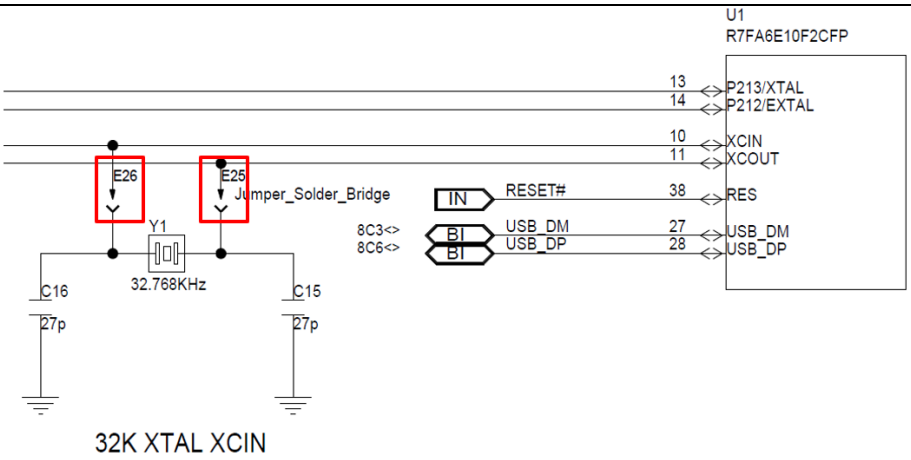


Figure 31. Solder Jumper for External Oscillator Connection in FPB-RA6E1 (Circuit Diagram)

3.4 Debugging

This application project implements pin input/output function for checking the low power mode status, fast cycle debug function, and disable sensor dependent process function.

3.4.1 Canceling the Low Power Mode by Pressing Down the User Switch

The user switch S1 of FPB-RA4E1 or FPB-RA6E1 can be pressed to generate IRQ1 interrupt and cancel the low power mode. By setting a breakpoint after canceling, the program being executed is stopped, and each register and data can be checked.

3.4.2 Checking the Low Power Mode Status

The low power mode status can be checked by observing LED2 and CLKOUT pin.

When LED2 is turned on, the mode is Normal. In Software Standby mode, HOCO, MOCO, and MOSC clocks are stopped. Therefore, when these clocks are set as the clock output source, CLKOUT pin retains either High or Low state. When toggling out, the mode is changed to Normal or low power mode other than the Software Standby mode. **When the debugger is connected, the clock does not stop even if Software Standby mode is entered. Disconnecting the debugger is required to check the mode status.**

Table 6 lists the pin output states in each low-power mode and Figure 32 and Figure 33 show examples of pin outputs in each low-power mode.

Table 6. Pin Output States in each Low Power Mode

Low Power Modes	P109/CLKOUT	P407/LED2
Normal mode	Toggle	High
Software Standby mode	High or Low	Low
Snooze mode	Toggle	Low

Figure 32. Example of Pin Output in Snooze Mode

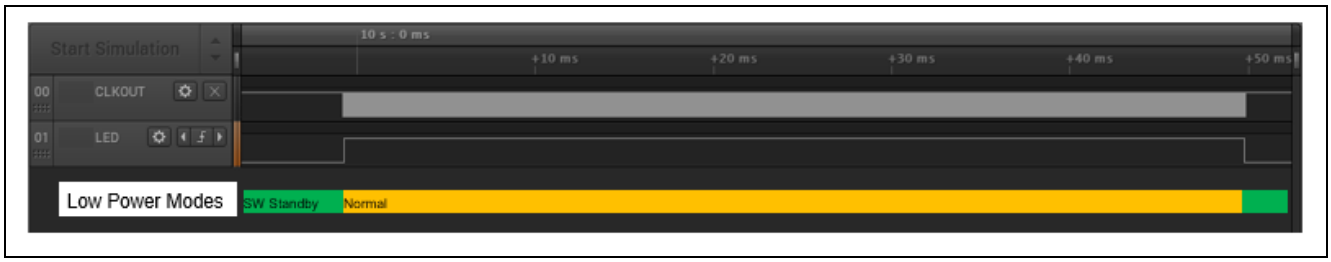


Figure 33. Example of Pin Output in Normal Mode

3.4.3 Fast Cycle Debug

This sample project implements a function to speed up the execution cycle of data acquisition and data processing in order to check the operation in a short time. To enable this feature, define `DEBUG_FAST_CYCLE` macro in `app_common.h`. When the `DEBUG_FAST_CYCLE` macro is defined, the following process is enabled, the data acquisition period is set every 30 seconds, and the data processing period is set every 24 minutes:

- Resetting the AGT0 timer count (AGT).
- Changing the Added Value of the RTC Alarm Setting.

3.5 Flowchart

Figure 34 shows the overall flow of the application project.

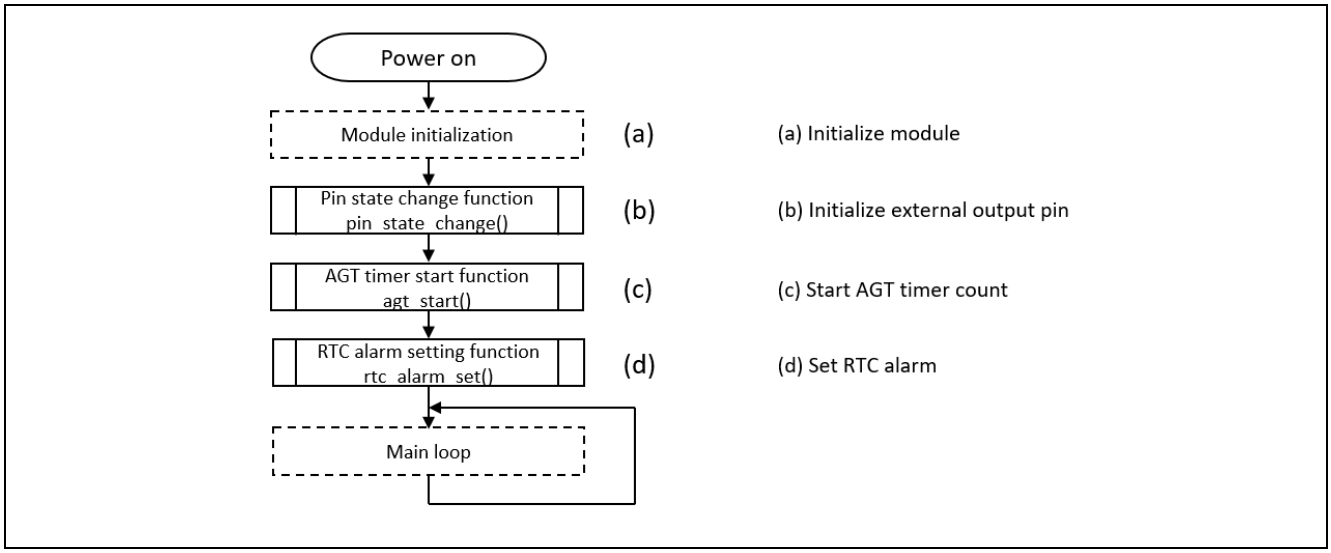


Figure 34. Overall Flow

Figure 35 shows the module initialization processing flow.

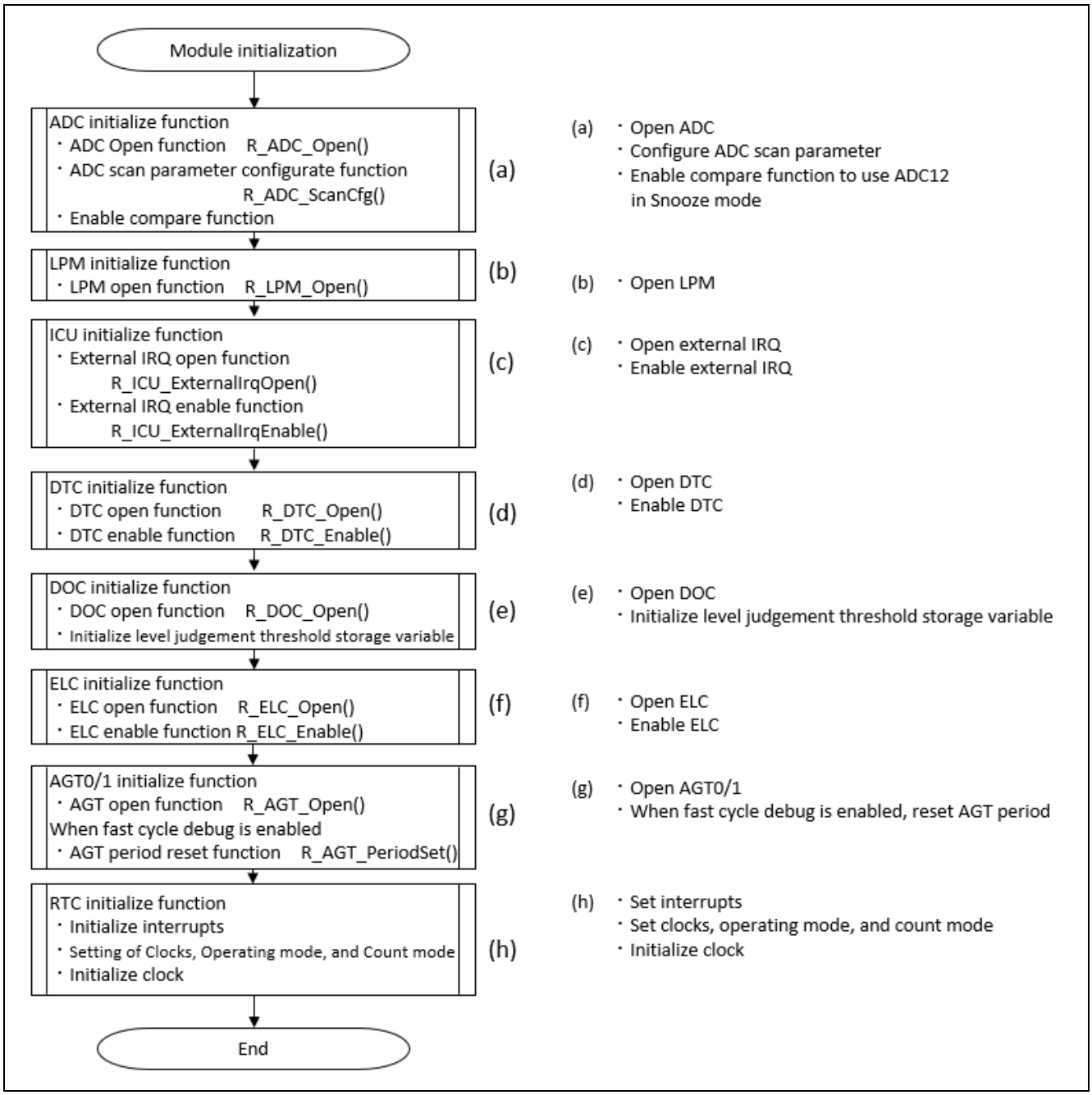


Figure 35. Module Initialization Processing

Figure 36 shows the main loop processing flow.

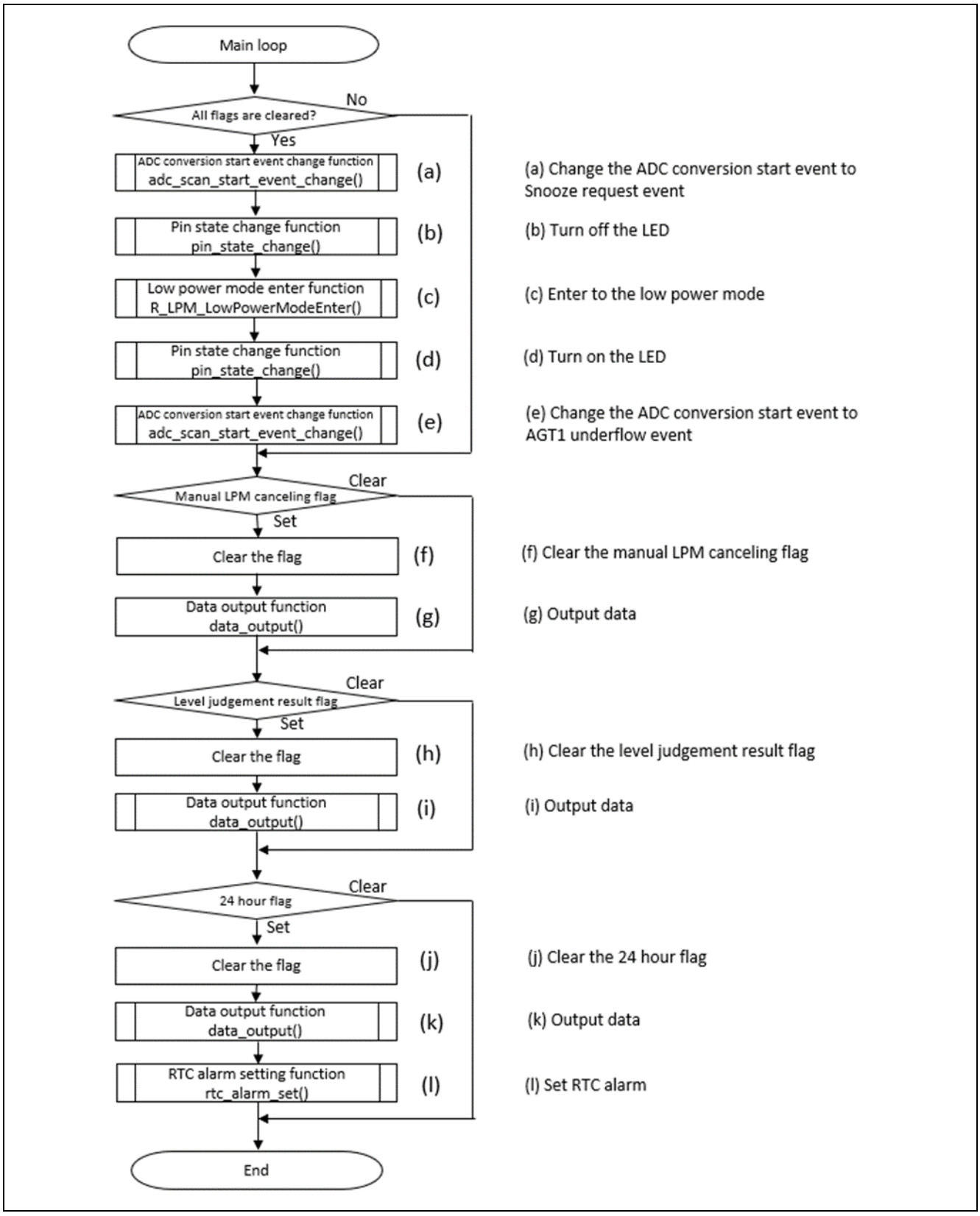


Figure 36. Main Loop Processing

Figure 37 shows the flow of RTC alarm interrupt processing.

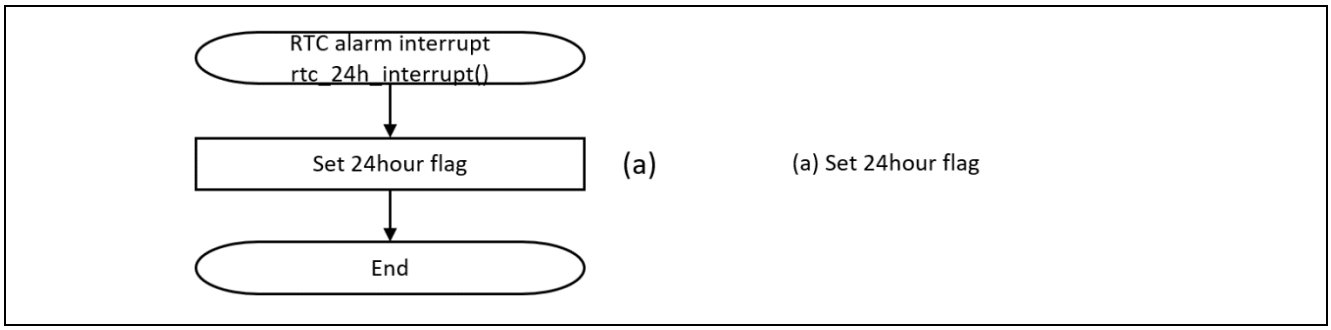


Figure 37. RTC Alarm Interrupt Processing

Figure 38 shows the flowchart for IRQ interrupt processing.

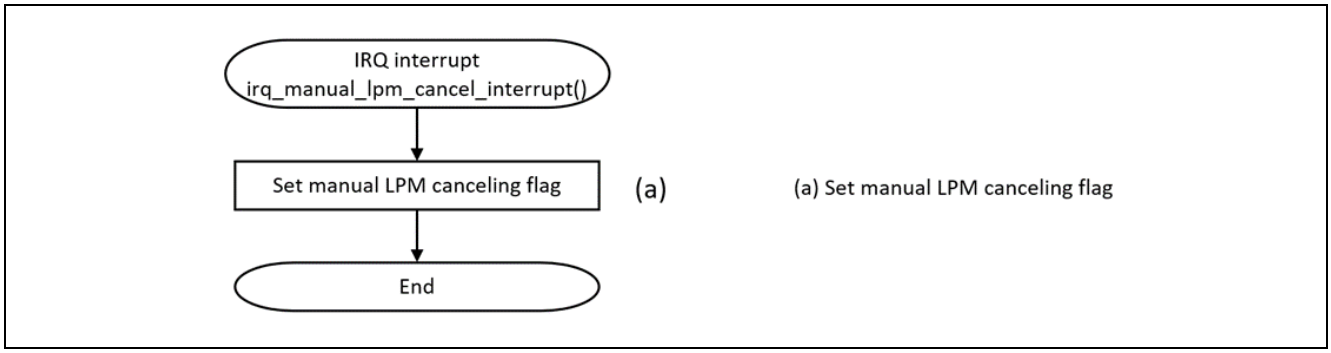


Figure 38. IRQ Interrupt Processing

Figure 39 shows the flowchart for DOC interrupt processing.

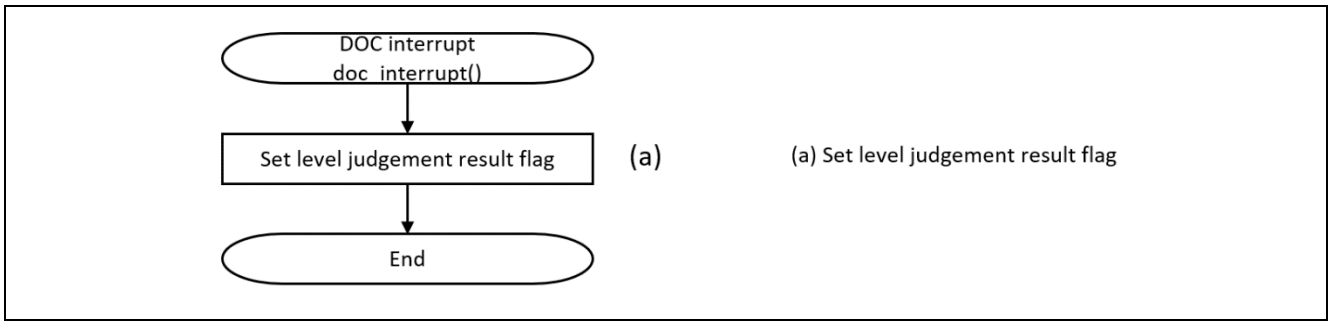


Figure 39. DOC Interrupt Processing

Figure 40 shows the SCI interrupt processing flow.

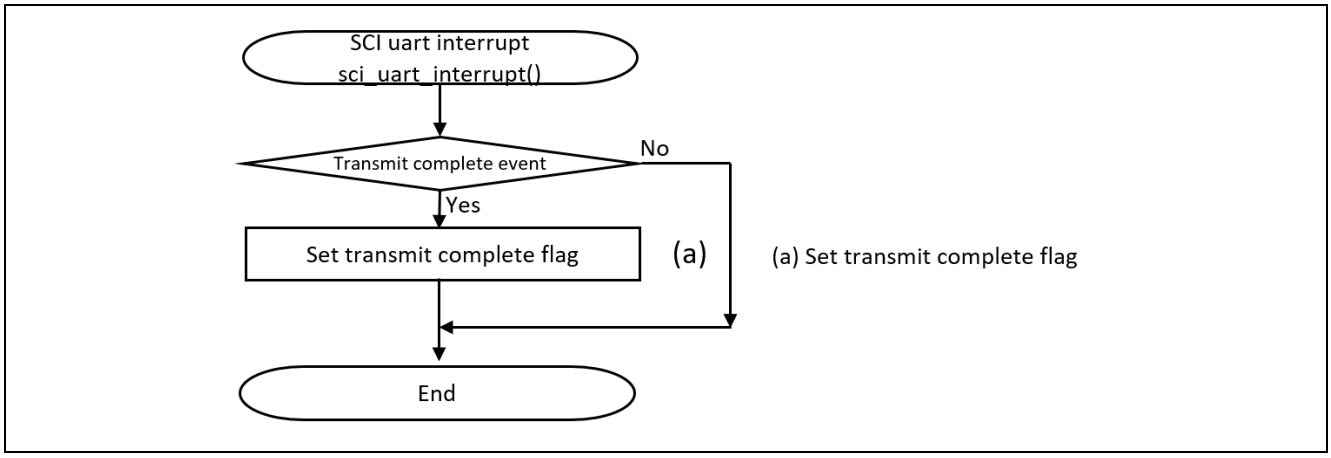


Figure 40. SCI Interrupt Processing

Figure 41 shows the flow of data processing.

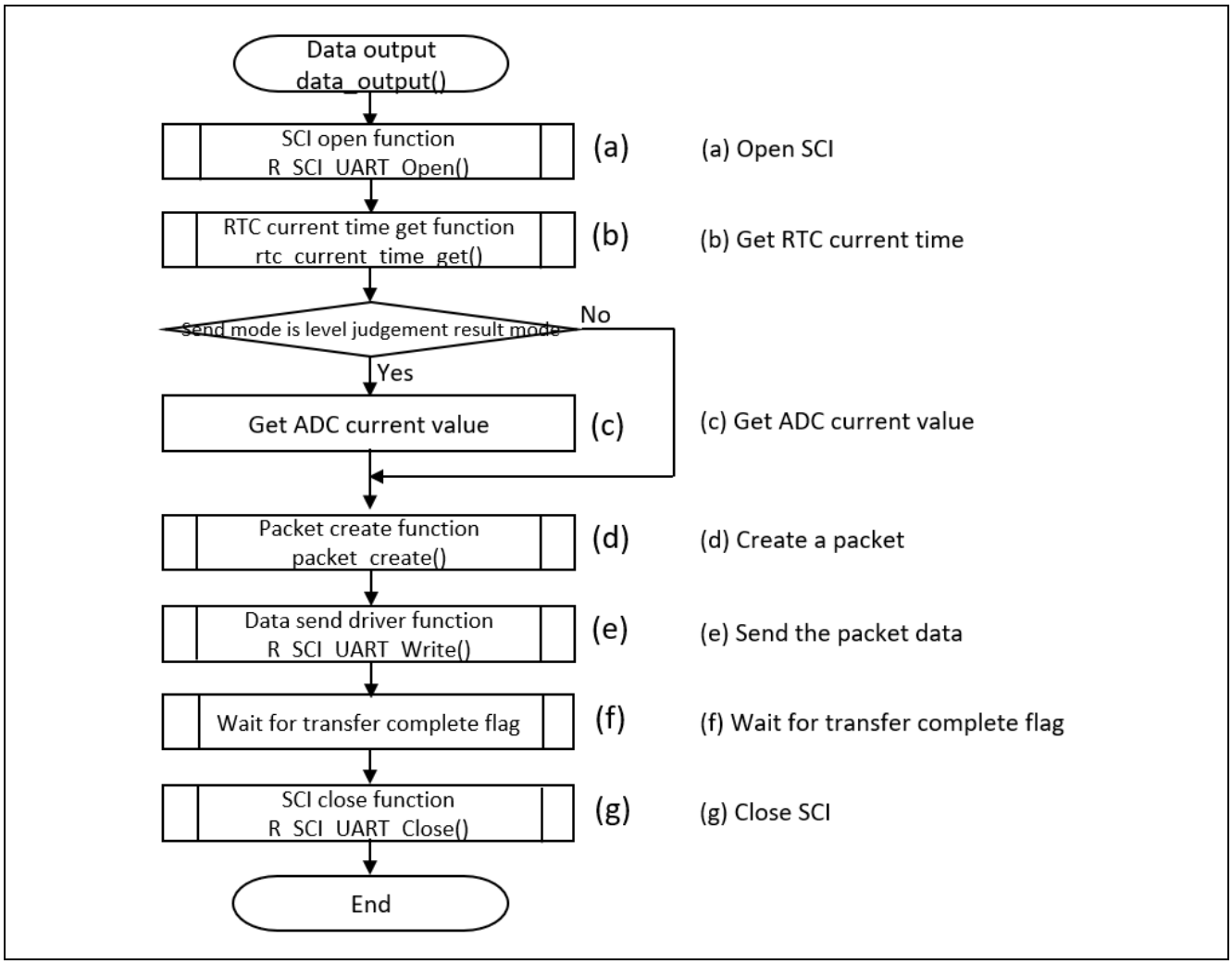


Figure 41. Data Processing

4. Evaluating Applications

4.1 Importing and Building a Project

To build an application project with the e^2 studio IDE:

1. Launch e^2 studio.
2. Select any workspace in the **Workspace launcher**.
3. Close the **Welcome** window.
4. Select **File** > **Import**.
5. Select **Existing Projects into Workspace** from the **Import** dialog box.
6. Select the archive file.
7. Select the project you want to import and click **Finish**.
8. Open configuration.xml and click **Generate Project Content** in the **Configurator** window.
9. Select **Project** > **Build Project**.

4.2 Script Settings for Low Power Mode Debugging

Change the debug settings to debug applications using low-power modes. If you use J-Link to debug low-power modes for RA devices, the default debug configuration does not allow debugging. If the application tries to enter Software Standby mode, the connection between the CPU and the IDE is disconnected, and the IDE debug session is terminated. You can continue to debug in low-power modes by specifying a debug script and configuring the low-power handling option, as shown in Figure 42.

This debug script is provided to develop applications. Therefore, **note that accurate Icc values cannot be measured when measuring the current consumption Icc**. Disable OCD when measuring.

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

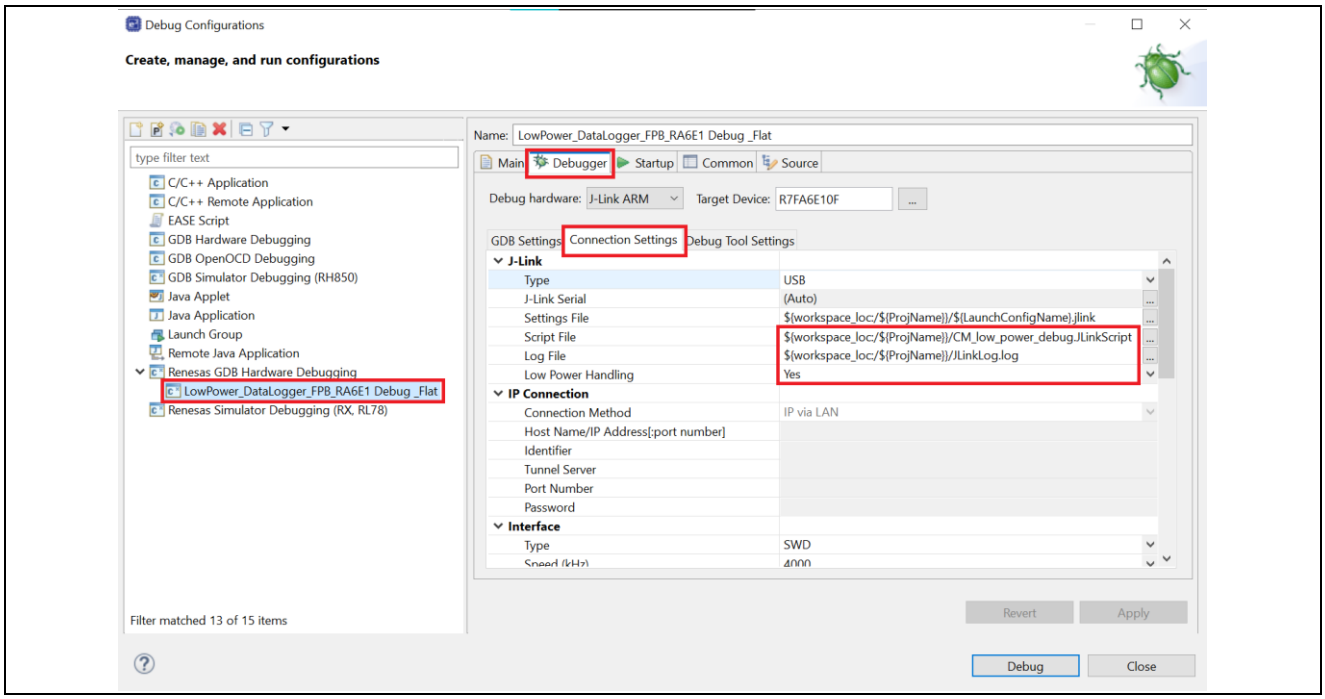


Figure 42. Debugging Settings for LPM Application Debugging

4.3 Download and Debug a Project

To download and debug an application project using e^2 studio and onboard E2 emulator:

1. Connect the connector J9 of the FPB-RA4E1 or FPB-RA6E1 to the PC using a USB cable.
2. Open **Debug Configuration** window.
3. Change settings as follows and as shown in Figure 43:
   - Debug hardware: Select [J-Link (ARM)]
   - Target Device: Select [R7FA6E10F]
4. Click **Debug**.

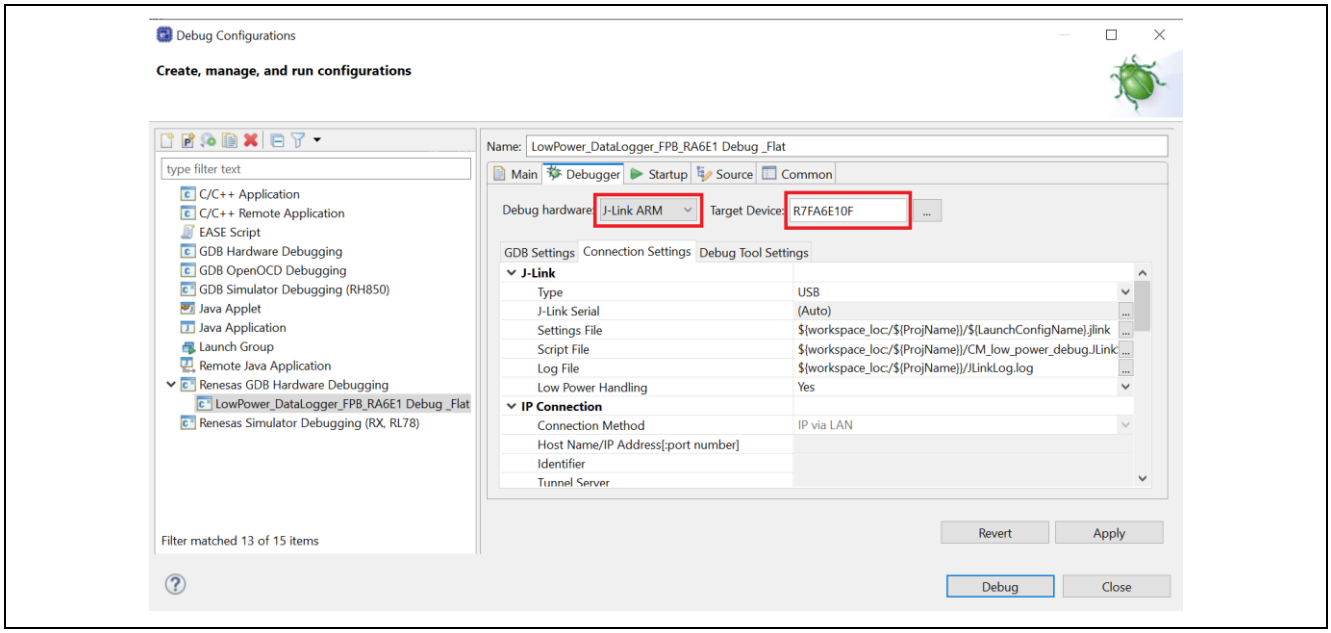


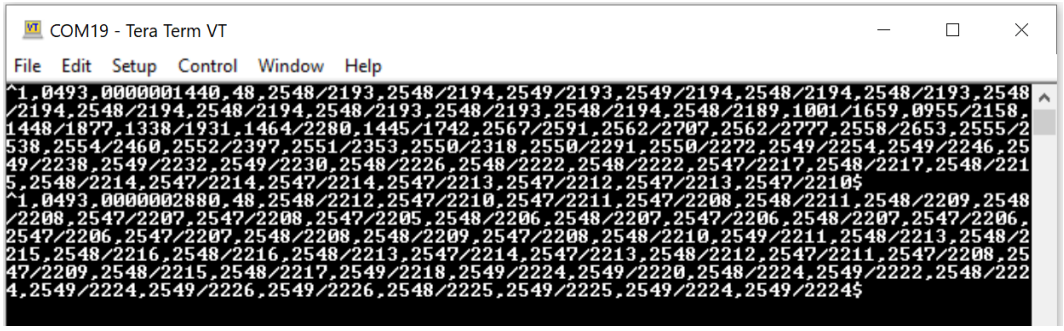
Figure 43. Debug Configuration

4.4 Procedure for Checking the Operation of the Low-power Data Logger

To check the operation of the low-power data logger:

1. Connect the FPB-RA4E1 or FPB-RA6E1 to the PC using USB - TTL connector and jumper wires. Refer to Table 4 for detailed connections.
2. Launch a terminal software on the PC and change the settings as follows:
   - Transfer speed: 115,200 bps
   - Data length: 8 bits
   - Parity: None
   - Stop-bit length: 1 bit
3. Power on the kit.
4. Confirm the operation.

This application project performs data output every 24 hours (every 24 minutes if fast cycle debug is enabled) (See Figure 44). In addition, data output is executed when the values of the light sensor and temperature sensor exceed the threshold value (See Figure 45). The output data can be viewed on terminal software on a PC. Furthermore, by pressing the user switch S1 of the FPB-RA4E1 or FPB-RA6E1 kit, the progress of accumulated measurement data can be output at any time (See Figure 46).

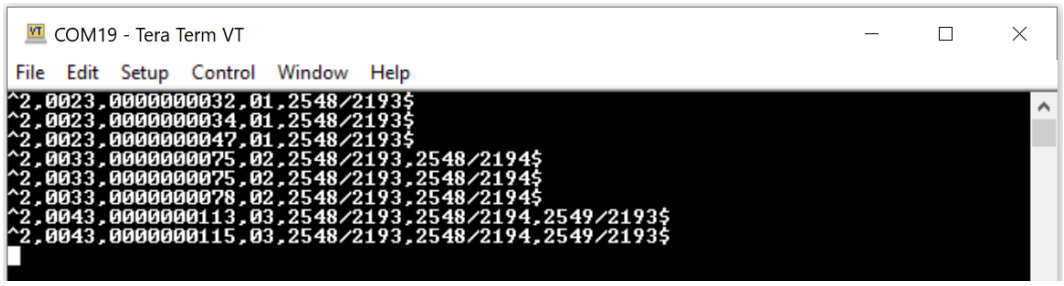


Note: A fast cycle debug is enabled

Figure 44. Example of Data Output Triggered by 24 Hours Pass

Note: A fast cycle debug is enabled

Figure 45. Example of Data Output Triggered by Analog Level Judgment Result



Note: A fast cycle debug is enabled

Figure 46. Example of Data Output Triggered by Pressing the User Switch

4.5 Evaluating the Current Consumption

FPB-RA4E1 or FPB-RA6E1 implements a resistor (R3) and CN1 for measuring the current of the MCU VCC power of 3.3V. When measuring the current amount of the MCU, remove resistor R3 and connect the measuring equipment to the test points.

See Figure 47 and Figure 48 for the location of R3 and CN1.

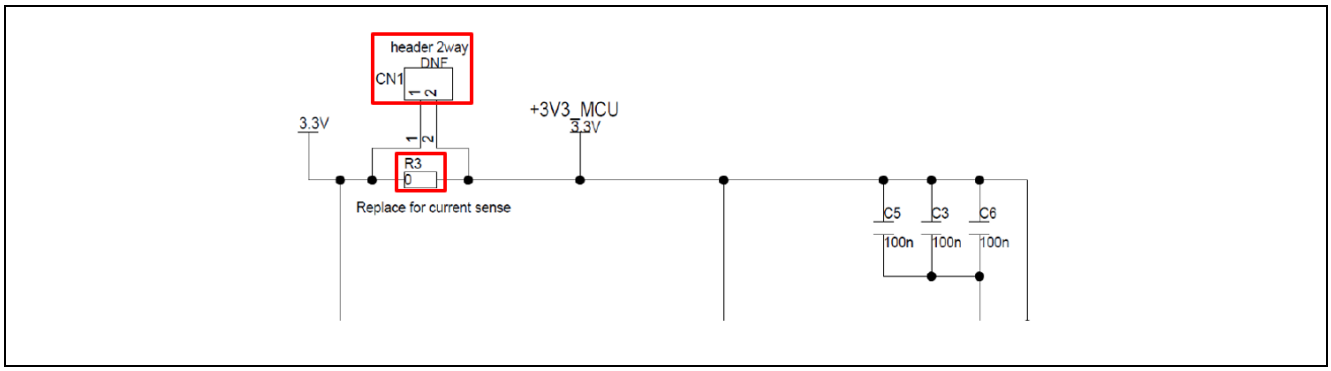


Figure 47. MCU Current Measuring Points (Circuit Diagram)

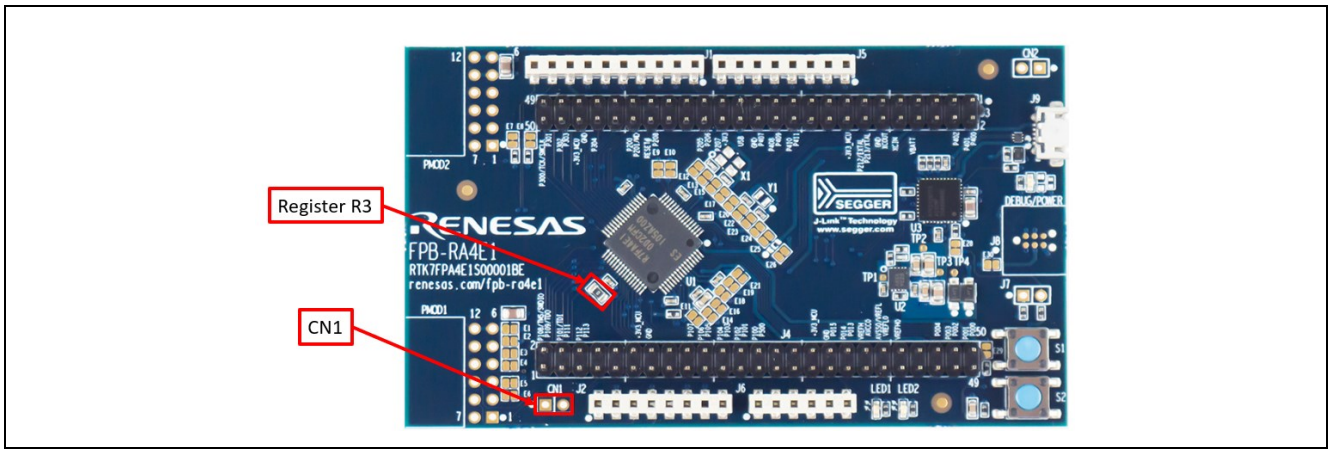


Figure 48. MCU Current Measuring Points

5. References

- Renesas FSP User's Manual: renesas.github.io/fsp
- Renesas RA Family RA4E1 User's Manual: Hardware (R01UH0929)
- Renesas RA Family RA6E1 User's Manual (R01UH0930)
- Example Projects github.com/renesas/ra-fsp-examples
- Application Note: Low Power Application (Use of ADC, DTC, and ELC at Snooze mode) for FPB-RA2E1 and FPB-RA2E2 (R30AN0392)

Website and Support

Visit the following URLs to learn about key elements of the RA family, download tools and documentation, and get support.

RA Product Information	www.renesas.com/ra
Flexible Software Package (FSP)	www.renesas.com/ra/fsp
RA Product Support Forum	www.renesas.com/ra/forum
Renesas Support	www.renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.08.22	-	Initial version
1.10	Jul.17.24	-	Update to FSP v5.2.0
1.20	Jul.10.25	-	Update to FSP v6.0.0

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/.