RX Family

Examples of Transitioning to Low Power Consumption Modes

Introduction

This application note describes the use of the low power consumption modes on the target devices listed below. It presents examples of transitioning to the various low power consumption modes. The software described in this application note also provides a simple method of measuring current values after transitioning to one of the low power modes.

Target Devices

- RX Family

Confirmed Devices

- RX130 Group
- RX140 Group
- RX231 Group
- RX65N Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Related Documents

- RX210, RX21A, and RX220 Groups Transition to Low Power Consumption Modes Using the Low Power Consumption Function (R01AN1482)
- RX63N Group, RX631 Group Transition to Low Power Consumption Mode Using Low Power Consumption Function (R01AN1920)
- RX140 Group Snooze Mode Usage Examples (R01AN5914)

Contents

1. Overview

This application note describes the use of functionality for reducing power consumption based on code generated by the Code Generator (CG) function of Smart Configurator (SC) to transition to and to resume from the low power modes.

Table 1.1 shows the supported modes for each device.

Table 1.1 Modes Supported by Devices

Mode	Device (+: Supported, -: Not supported)			
	RX130	RX140	RX231	RX65N
Sleep	+	+	+	+
Deep sleep	+	+	+	-
All-module clock stop	-	-	-	+
Software standby	+	+	+	+
Deep software standby	-	-	-	+
Snooze	-	+	-	-

The conditions applying to the low power mode sample program described in this application note are listed in Table 1.2 and Table 1.3. For details about how to use the snooze mode on the RX140, refer to RX140 Group Snooze Mode Usage Examples (R01AN5914).

Table 1.2 Sample Program Conditions for RX130, RX140, and RX231

Low Power Mode		Module Stop Conditions
Sleep		State in which modules other than DMAC/DTC*1 and RAM0 are stopped
Deep sleep		State in which modules other than DMAC/DTC*1 and RAM0 are stopped*2
Software standby	RTC not used	State in which modules other than DMAC/DTC*1 and RAM0 are stopped
	RTC used	State in which modules other than DMAC/DTC*1 and RAM0 are stopped

Note 1. For the RX130 and RX140, only the DTC is subject to module stop because these devices do not have the DMAC.

Note 2. The DMAC and DTC are put into the module stop state by the functionality for reducing power consumption.

Table 1.3 Sample Program Conditions for RX65N*1

Low Power Mode		Module Stop Conditions
Sleep		State in which only TSIP module is stopped
All-module clock stop		State in which modules other than DMAC/DTC, EXDMAC, RAM, extended RAM, and standby RAM modules are stopped*2
Software standby		State in which modules other than DMAC/DTC, EXDMAC, RAM, extended RAM, and standby RAM modules are stopped
Deep software standby	RTC not used	State in which modules other than DMAC/DTC, EXDMAC, RAM, extended RAM, and standby RAM modules are stopped*3
	RTC used	State in which modules other than DMAC/DTC, EXDMAC, RAM, extended RAM, and standby RAM modules are stopped*3

Note 1. To measure the current consumption of the RX651, use the sample program for the RX65N.
Note 2. The DMAC, DTC, and EXDMAC are put into the module stop state by the functionality for reducing power consumption.
Note 3. The DMAC and DTC are put into the module stop state by the functionality for reducing power consumption.

The sample program described in this application note uses the peripheral functions listed in Table 1.4 to generate low power mode transition triggers. When a transition trigger occurs, the program transitions from the normal operating state to a low power mode, and when another transition trigger occurs while in low power mode, the program resume from the low power mode.

Table 1.4 Peripheral Functions and Their Applications

Peripheral Function	Application
Low power consumption function	Reducing power consumption
External pin interrupt (IRQ)	Transition to low power mode, resuming from low power mode
Realtime clock (RTC)	Current value measurement when using RTC*1, Release triggered by RTC alarm interrupt*2
I/O ports	Switch and LED control

Note 1. Used only in software standby modes that use the RTC.
Note 2. Used only in deep software standby modes that use the RTC.

2. Operation Confirmation Conditions

The operation of the sample program described in this application note has been confirmed under the conditions listed in Table 2.1.

Table 2.1 Operation Confirmation Conditions

Item	Contents
MCU used	R5F51308ADFP (RX130 Group) R5F51406BDFN (RX140 Group) R5F52318ADFP (RX231 Group) R5F565NEDDFC (RX65N Group)
Operating frequency	The operating frequency differs for each project. Refer to 7.1, Operating Frequencies of Each Project, for a listing of the specific operating frequencies.
Operating voltage	3.3 V
Integrated development environment	Renesas Electronics e^2 studio Version 2022-07
C compiler	Renesas Electronics C/C++ Compiler Package for RX Family V.3.04.00
	Compile options –lang = C99
iodefine.h version	Version 2.0 (RX130 Group) Version 1.10C (RX140 Group) Version 1.0I (RX231 Group) Version 2.30 (RX65N Group, RX651 Group)
Emulator*1	E2 Lite
Endian order	Both little endian and big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample program version	Version 1.20
Board used (RSK)	Renesas Starter Kit for RX130-512KB (product No.: RTK5051308SxxxxxBE) Renesas Starter Kit for RX140 (product No.: RTK551406BSxxxxxBE) Renesas Starter Kit for RX231 (product No.: R0K505231SxxxBE) Renesas Starter Kit for RX65N-2MB (product No.: RTK50565NSxxxxxBE)

Note 1. Make sure the emulator is disconnected when measuring the current.

3. Hardware

3.1 Pins Used

Table 3.1 to Table 3.4 list the pins used and their functions.

Table 3.1 Pins Used and Their Functions on the RX130-512KB

Pin Name	I/O	Description
P32/IRQ2	Input	SW2 input (transition to and resume from low power mode)
PD3	Output	LED0 output • After initial settings, on when in normal operating state • Off at transition to low power mode • On after resume from low power mode

Table 3.2 Pins Used and Their Functions on the RX140

Pin Name	I/O	Description
P32/IRQ2	Input	SW2 input (transition to and resume from low power mode)
P21	Output	LED0 output • After initial settings, on when in normal operating state • Off at transition to low power mode • On after resume from low power mode

Table 3.3 Pins Used and Their Functions on the RX231

Pin Name	I/O	Description
P34/IRQ4	Input	SW2 input (transition to and resume from low power mode)
P17	Output	LED0 output • After initial settings, on when in normal operating state • Off at transition to low power mode • On after resume from low power mode

Table 3.4 Pins Used and Their Functions on the RX65N-2MB

Pin Name	I/O	Description
P05/IRQ13	Input	SW2 input (transition to and resume from low power mode*1)
RES#	Input	Resuming from low power mode*1
P73	Output	LED0 output • After initial settings, on when in normal operating state • Off at transition to low power mode • On after resume from low power mode

Note 1. An interrupt (IRQ) applied to the SW pin of the RSK cannot be used to resume from deep software standby. Instead, reset the device using the RES# pin.

3.2 Hardware Configuration

3.2.1 Hardware Modifications

In order to confirm the operation of the functionality for reducing power consumption using the low power modes as described in this application note, modifications have been made to the RSK boards. On the RX231 RSK board jumper J8 is used to measure MCU current consumption, but in its state when shipped from the factory there is no jumper J8 on the board. Resistor R55 is used for the setting “Shorted Pin1-2.” Therefore, the following modifications are necessary:

1. Remove resistor R55.
2. Place jumper J8 on the jumper pins.

Figure 3.1 and Figure 3.2 reproduce the documentation excerpts needed to modify the RSK board.

RSKRX231 6. Configuration

6.3 Power Supply Configuration

Table 6-3 and Table 6-4 below details the function of the option links associated with power supply configuration.

Reference	Configuration	Explanation	Related Ref.
J8 *1	Shorted Pin1-2	Connects Board_VCC to UC_VCC.	R55
	All open	Enables current probe for MCU current consumption.	R55
J9	Shorted Pin1-2	Connects EXT_BATT to 5V power rail.	-
	Shorted Pin2-3	Connects VBUS0 to 5V power rail.	J15
	All open	Disconnects EXT_BATT and VBUS0 from 5V power rail.	-
R244	Fit	Enables 1.8V regulator output.	U6
	DNF	Enables 3.3V regulator output.	U6
J11	Shorted Pin1-2	Connects regulator output to Board_VCC.	U6
	Shorted Pin2-3	Disconnects regulator output from Board_VCC.	U6
	All open	DO NOT USE	U6

Table 6-3: Power Supply Option Links (1)

*1: By default, jumper J8 is not fitted to the RSK. R55 is fitted by default and becomes the same setting as 'J8 Shorted Pin1-2'.

Figure 3.1 Excerpt from RX231 Group: Renesas Starter Kit User’s Manual

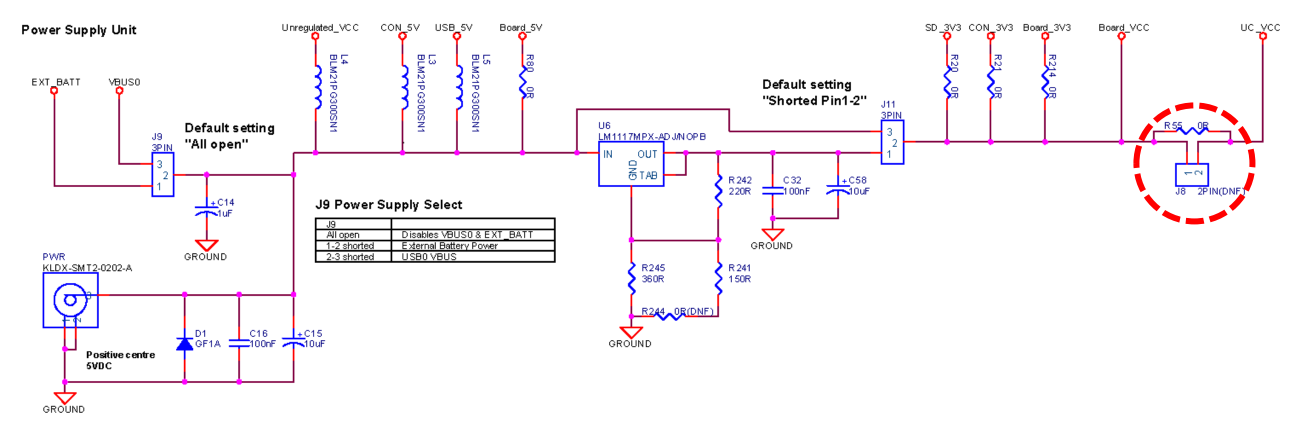

Figure 3.2 Excerpt from Renesas Starter Kit for RX231: CPU Board Schematics

For details, refer to RX231 Group: Renesas Starter Kit User’s Manual (R20UT3027) and Renesas Starter Kit for RX231: CPU Board Schematics (R20UT3026).

4. Software

The sample program described in this application note is divided into separate projects for each low power mode. For details, refer to 4.3, Project Composition. The sample program described in this application note transitions to low power mode when a low power mode transition trigger occurs, and when another low power mode transition trigger occurs while in low power mode, it resumes from low power mode.

IRQ is used as the low power mode transition trigger. Table 4.1 lists the IRQ settings.

Table 4.1 IRQ Settings

Setting Item	Setting Description
Detection type	Falling edge
Digital filter	Disabled
Priority	Level 15 (highest)

4.1 Operation Overview

4.1.1 Sleep Mode

After initial settings, the program turns on the LED and waits for a low power mode transition trigger to occur. On the RX65N, after initial settings, the module stop state is released for all modules except the TSIP. When a low power mode transition trigger occurs, the program turns off the LED and transitions to sleep mode. When another low power mode transition trigger occurs while in sleep mode, the program resumes from sleep mode and turns on the LED.

Figure 4.1 shows an overview of sleep mode operation.

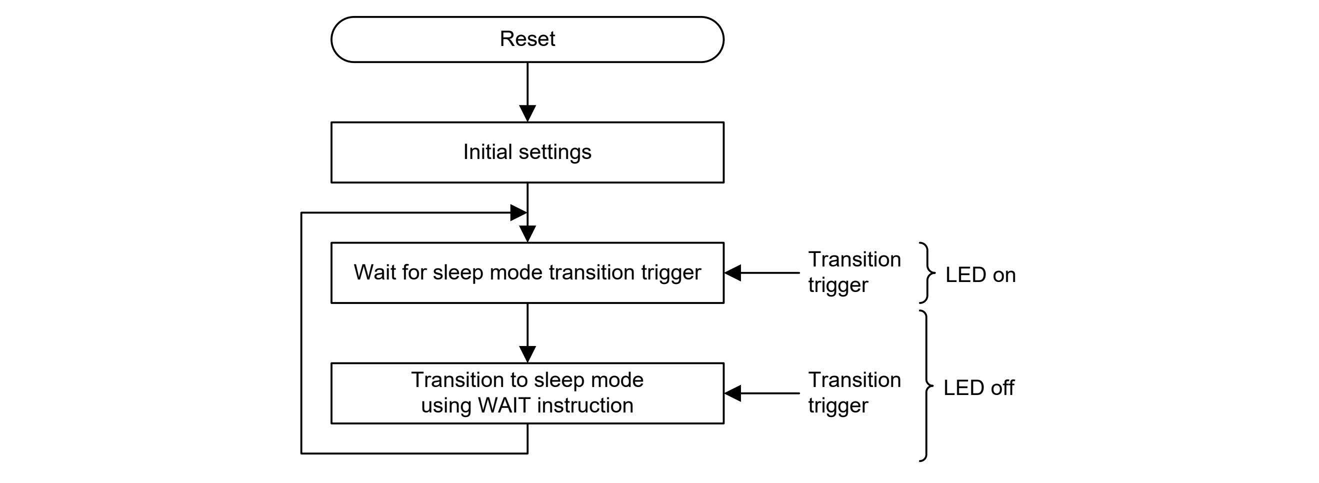

Figure 4.1 Overview of Sleep Mode Operation

4.1.2 Deep Sleep Mode

After initial settings, the program turns on the LED and waits for a low power mode transition trigger to occur. When a low power mode transition trigger occurs, the program turns off the LED and transitions to deep sleep mode. When another low power mode transition trigger occurs while in deep sleep mode, the program resumes from deep sleep mode and turns on the LED.

Figure 4.2 shows an overview of deep sleep mode operation.

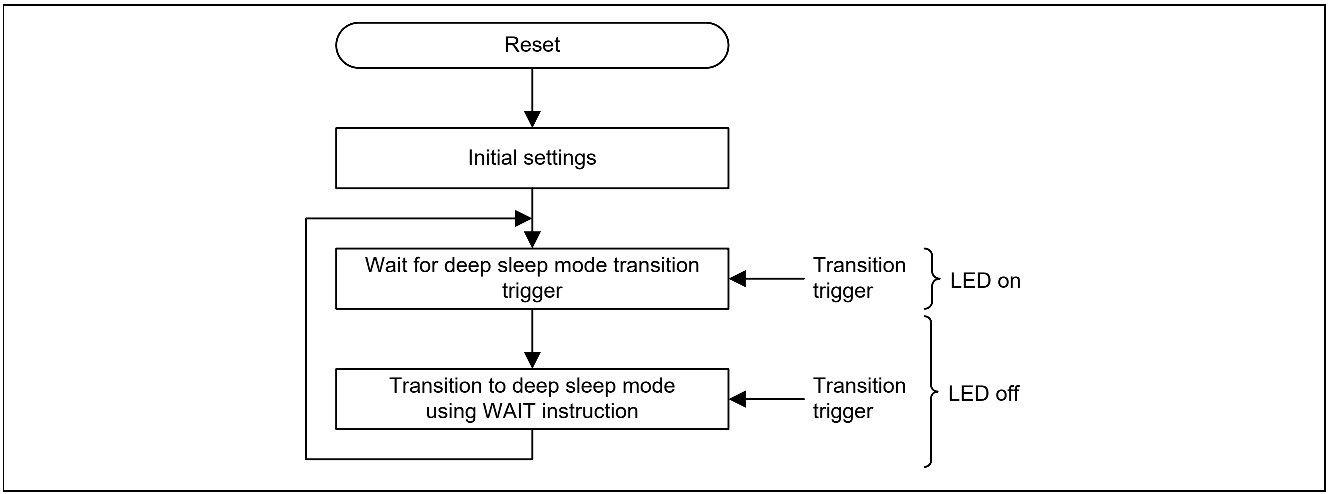

Figure 4.2 Overview of Deep Sleep Mode Operation

4.1.3 All-Module Clock Stop Mode

After initial settings, the program turns on the LED and waits for a low power mode transition trigger to occur. When a low power mode transition trigger occurs, the program turns off the LED and transitions to all-module clock stop mode. When another low power mode transition trigger occurs while in all-module clock stop mode, the program resumes from all-module clock stop mode and turns on the LED.

Figure 4.3 shows an overview of all-module clock stop mode operation.

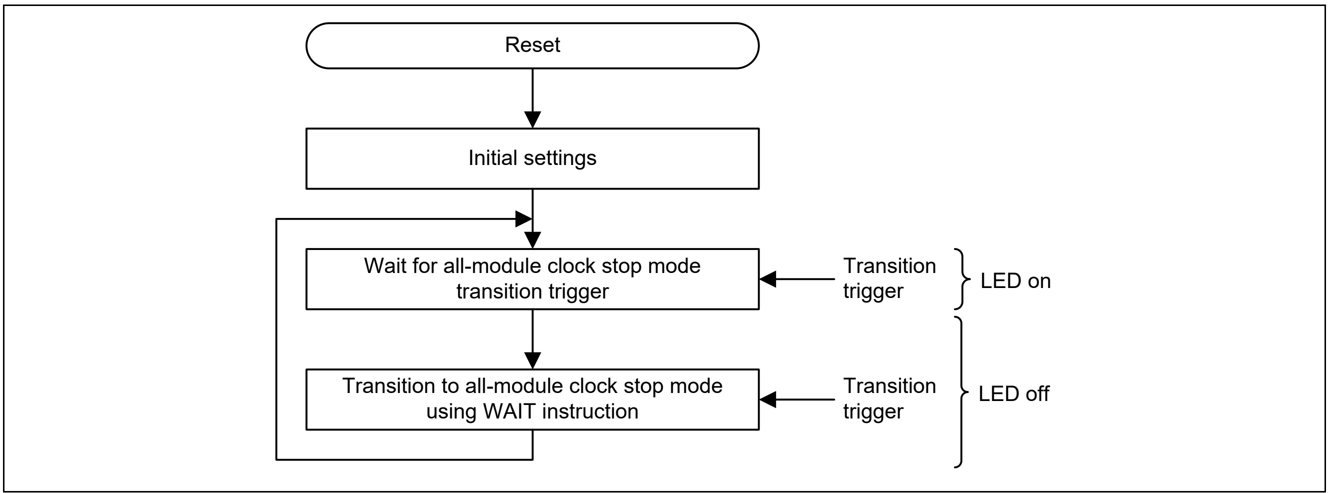

Figure 4.3 Overview of All-Module Clock Stop Mode Operation

4.1.4 Software Standby Mode

After initial settings, the program turns on the LED and waits for a low power mode transition trigger to occur. When a low power mode transition trigger occurs, the program turns off the LED and transitions to software standby mode. When another low power mode transition trigger occurs while in software standby mode, the program resumes from software standby mode and turns on the LED.

Figure 4.4 shows an overview of software standby mode operation.

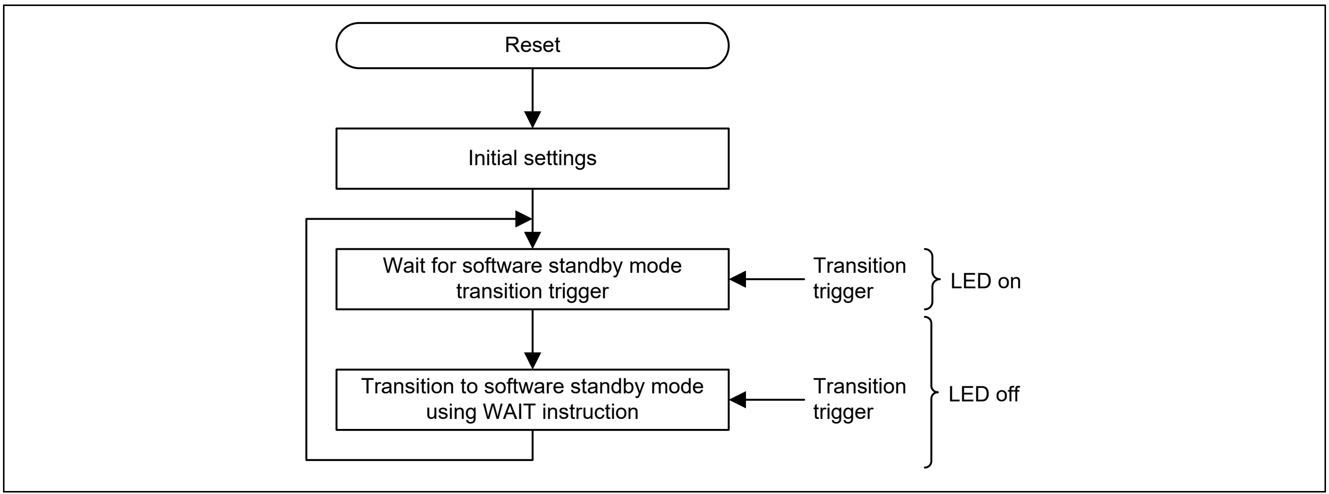

Figure 4.4 Overview of Software Standby Mode Operation

4.1.5 Deep Software Standby Mode

After initial settings, the program turns on the LED and waits for a low power mode transition trigger to occur. When a low power mode transition trigger occurs, the program turns off the LED and transitions to deep software standby mode. When a reset is applied using the RES# pin or RTC alarm interrupt occurs while in deep software standby mode, operation resumes from deep software standby mode.

Figure 4.5 and Figure 4.6 show an overview of deep software standby mode operation.

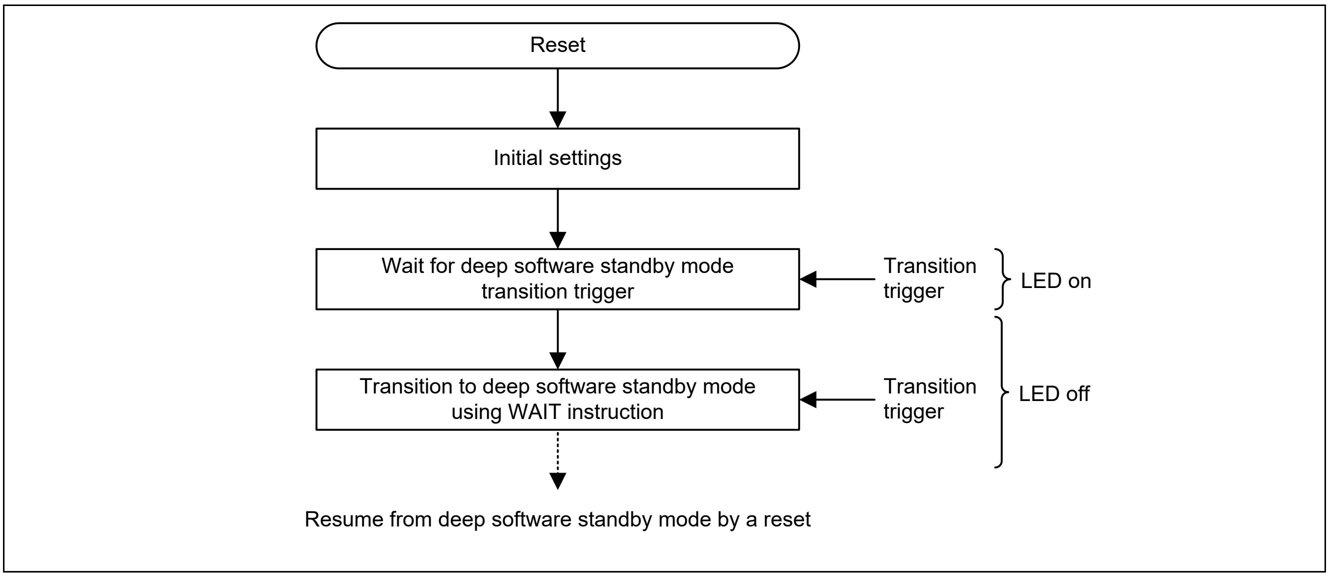

Figure 4.5 Overview of Deep Software Standby Mode Operation (Mode release by reset)

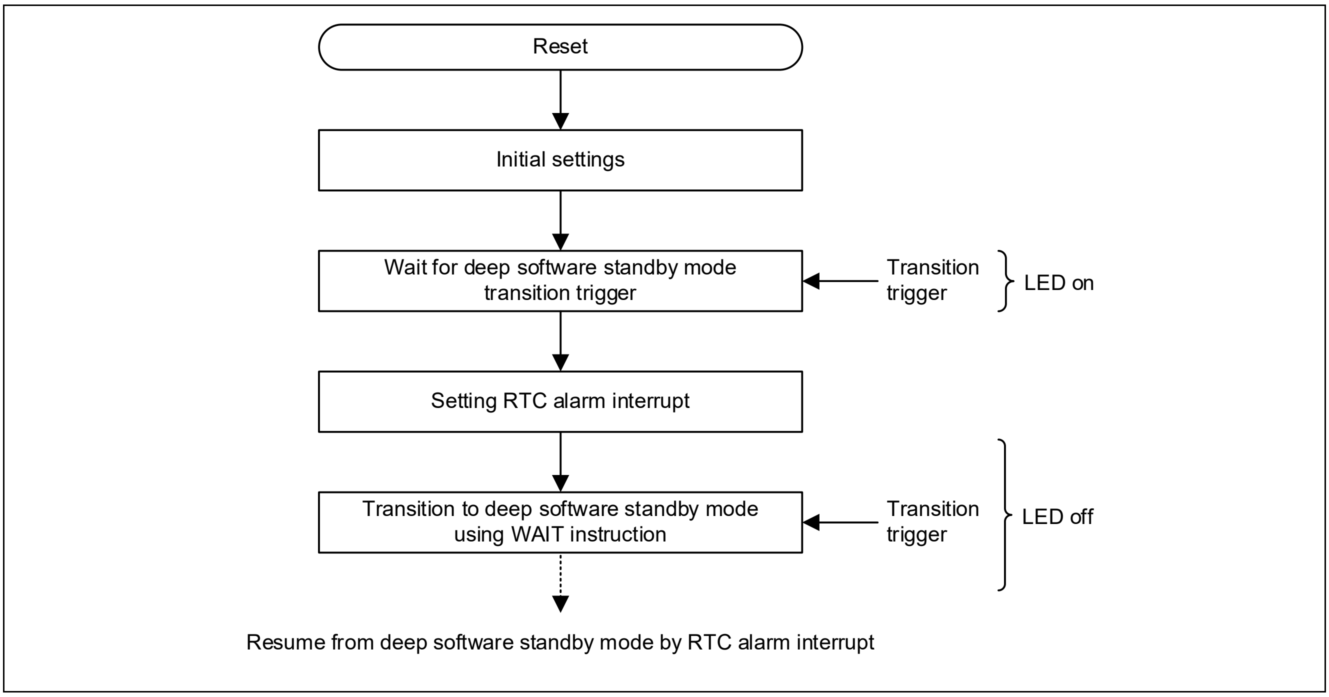

Figure 4.6 Overview of Deep Software Standby Mode Operation (Mode release by alarm interrupt)

4.2 Module Composition

The sample program described in this application note utilizes source code related to the components listed in Table 4.2, generated by the Code Generator function of Smart Configurator, in combination.

Figure 4.7 shows the module composition of the sample program described in this application note.

Table 4.2 List of Components

Component	Version	Resource
Board support package (BSP)	7.20	—
Realtime clock	1.8.0	RTC
Low power consumption	2.3.0	LPC
Interrupt controller	2.3.0	ICU

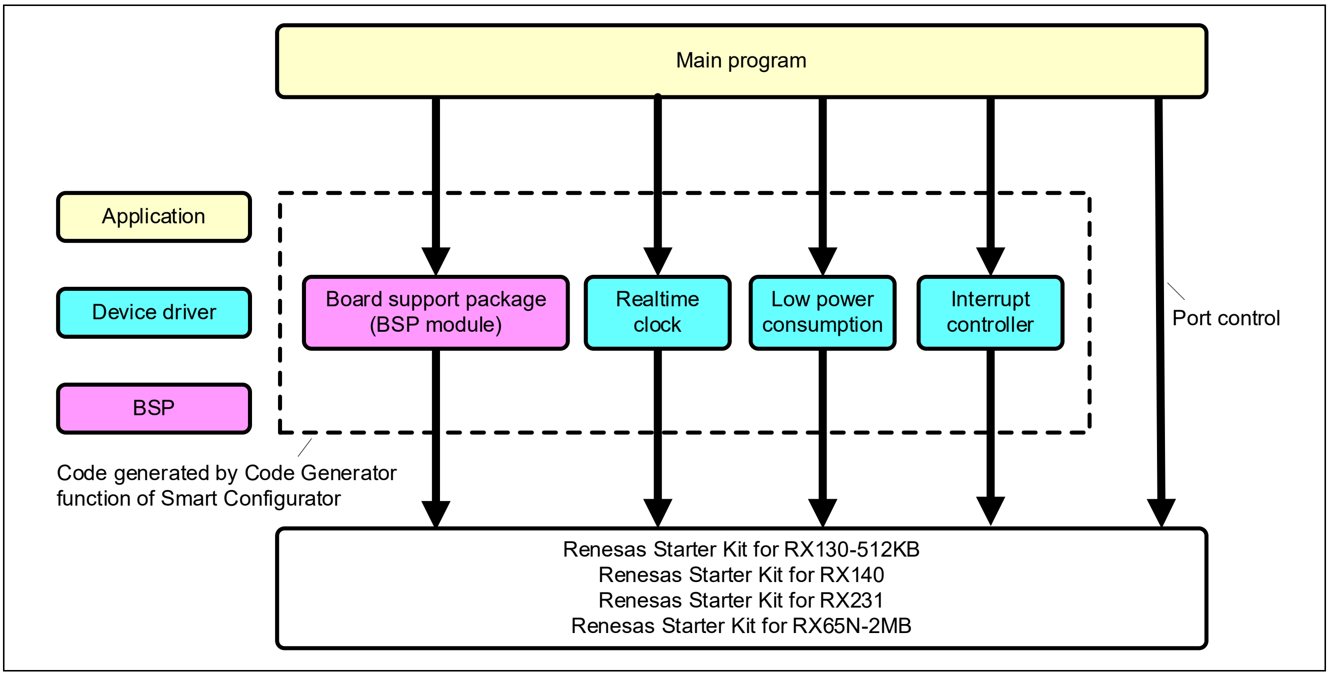

Figure 4.7 Module Composition

4.3 Project Composition

Table 4.3 and Table 4.4 list the project composition described in this application note, and Figure 4.7 shows the project composition.

Table 4.3 List of Project Composition (1/2)

Target Device	Project Name	Contents
RX130	power_save_sleep_rx130	Project for confirming sleep mode on RX130-512KB
	power_save_deep_sleep_rx130	Project for confirming deep sleep mode on RX130-512KB
	power_save_software_standby_rx130	Project for confirming software standby mode on RX130-512KB
	power_save_software_standby_rtc_operation_rx130	Project for confirming software standby mode on RX130-512KB with RTC operating
RX140	power_save_sleep_rx140	Project for confirming sleep mode on RX140
	power_save_deep_sleep_rx140	Project for confirming deep sleep mode on RX140
	power_save_software_standby_rx140	Project for confirming software standby mode on RX140
	power_save_software_standby_rtc_operation_rx140	Project for confirming software standby mode on RX140 with RTC operating
RX231	power_save_sleep_rx231	Project for confirming sleep mode on RX231
	power_save_deep_sleep_rx231	Project for confirming deep sleep mode on RX231
	power_save_software_standby_rx231	Project for confirming software standby mode on RX231
	power_save_software_standby_rtc_operation_rx231	Project for confirming software standby mode on RX231 with RTC operating

Table 4.4 List of Project Composition (2/2)

Target Device	Project Name	Contents
RX65N	power_save_sleep_rx65n	Project for confirming sleep mode on RX65N-2MB
	power_save_all_module_clock_stop_rx65n	Project for confirming all-module clock stop mode on RX65N-2MB
	power_save_software_standby_rx65n	Project for confirming software standby mode on RX65N-2MB
	power_save_deep_software_standby_rx65n	Project for confirming deep software standby mode on RX65N-2MB
	power_save_deep_software_standby_rtc_operation_rx65n	Project for confirming deep software standby mode on RX65N-2MB with RTC operating (Release deep software standby mode by reset)
	power_save_deep_software_standby_rtc2_operation_rx65n	Project for confirming deep software standby mode on RX65N-2MB with RTC operating (Release deep software standby mode by alarm interrupt)

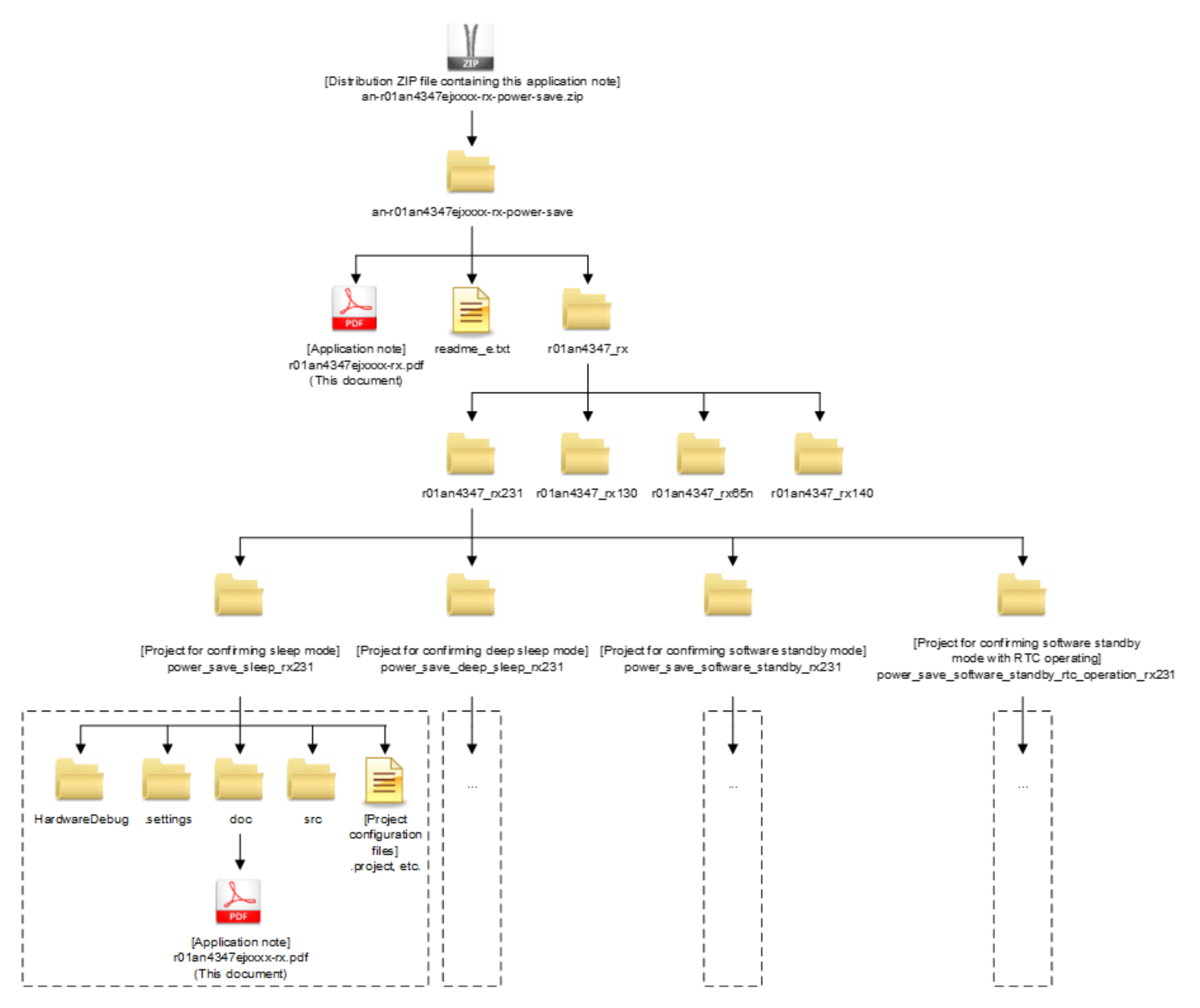

Figure 4.8 Project Composition

Unzipping the ZIP archive in which this application note is distributed creates a folder of the same name that contains the folders and files shown above.

The “r01an4347_rx” folder contains separate folders for each target device, and each of these folders contain projects corresponding to the various low power modes. Each project can be imported into the e^2 studio workspace and then run.

4.4 File Structure

The file structure used by the sample program is shown below. The main program is generated in the folder “project folder\src\”.

Example: Project for confirming sleep mode on RX231
“power_save_sleep_rx231¥src¥main.c”

Table 4.5 lists the file related to the main program of the project for confirming the low power mode.

Table 4.5 File Related to Main Program

File Name	Description
main.c	Main processing routine for confirming low power mode

The source code is generated in the folder “project folder\src\smc_gen” by the Code Generator function of Smart Configurator.

Example: Project for confirming sleep mode on RX231
“power_save_sleep_rx231¥src¥smc_gen”

Table 4.6 lists a file generated by the Code Generator function of Smart Configurator in which the source code has been modified. The folder name “project folder\src\smc_gen” is omitted.

Table 4.6 File Generated by Code Generator Function of Smart Configurator with Modified Source Code

Folder Name	File Name	Description	Remarks
Config_ICU	Config_ICU_user.c	Interrupt handler implemented by user	Processing added to r_Config_ICU_irq4_interrupt() function. For details, refer to 4.10.5, IRQ4 Interrupt Handler.

Files containing unmodified source code generated by the Code Generator function of Smart Configurator have been omitted.

4.5 Option Setting Memory

Table 4.7 and Table 4.8 list the option setting memory configuration used by the sample program. Change the settings to the optimum values for your system as needed.

Table 4.7 Option Setting Memory Configuration of Sample Program for RX130-512KB, RX140 and RX231

Symbol	Address	Setting Value	Description
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	After a reset, IWDT and WDT*[1] are stopped.
OFS1	FFFF FF8Bh to FFFF FF88h	FFFF FFFFh	Fast startup time is disabled. After a reset, voltage monitoring 0 reset is disabled. After a reset, HOCO oscillation is disabled.
MDE	FFFF FF83h to FFFF FF80h	FFFF FFFFh	Little-endian

Note 1. WDT applies to the RX231 Groups only.

Table 4.8 Option Setting Memory Configuration of Sample Program for RX65N-2MB

Symbol	Address	Setting Value	Description
OFS0	FE7F 5D04h to FE7F 5D07h	FFFF FFFFh	After a reset, IWDT and WDT are stopped.
OFS1	FE7F 5D08h to FE7F 5D0Bh	FFFF FFFFh	After a reset, voltage monitoring 0 reset is disabled. After a reset, HOCO oscillation is disabled.
MDE	FE7F 5D00h to FE7F 5D03h	FFFF FFFFh	Little-endian

4.6 Constants

Table 4.9 lists the constants used by the sample program.

Table 4.9 Constants Used by Sample Program

Constant Name	Setting Value	Description
LED_ON	(0)	LED is on
LED_OFF	(1)	LED is off
LED0	(PORTD.PODR.BIT.B3)	LED0 (PD3) PODR register bit (used by sample program for RX130-512KB)
	(PORT2.PODR.BIT.B1)	LED0 (P21) PODR register bit (used by sample program for RX140)
	(PORT1.PODR.BIT.B7)	LED0 (P17) PODR register bit (used by sample program for RX231)
	(PORT7.PODR.BIT.B3)	LED0 (P73) PODR register bit (used by sample program for RX65N-2MB)
ALARMSET	(30)	Number of seconds from transition to deep software standby mode to mode release by RTC alarm interrupt (used by sample program for RX65N-2MB)

4.7 Variables

Table 4.10 lists the global variables.

Table 4.10 Global Variables

Type	Variable Name	Description
extern volatile bool	g_sw_pressed	State indicating whether or not switch is depressed False: Not depressed True: Depressed

4.8 Functions

Table 4.11 lists the functions used by the sample program.

Table 4.11 Functions Used by Sample Program

Function Name	Description
main	Main processing routine
save_power_port_init	Initial port settings
save_power_peripheral_init	Initial peripheral function settings
save_power_wait_trigger	Wait for low power mode transition trigger
alarm_setting	Setting RTC alarm interrupt (used by sample program for RX65N-2MB)
convert_to_dec	Conversion process to decimal number (used by sample program for RX65N-2MB)
r_Config_ICU_irq2_interrupt*[1]	IRQ2 interrupt handler (used by sample program for RX130-512KB and RX140)
r_Config_ICU_irq4_interrupt*[1]	IRQ4 interrupt handler (used by sample program for RX231)
r_Config_ICU_irq13_interrupt*[1]	IRQ13 interrupt handler (used by sample program for RX65N-2MB)

Note 1. Of the functions generated by the Code Generator function of Smart Configurator, only those whose source code has been modified are listed. Functions consisting of unmodified source code generated by the Code Generator function of Smart Configurator have been omitted.

4.9 Function Specifications

The specifications of sample program functions are presented below.

main	
Outline	Main processing routine
Header	None
Declaration	void main (void)
Description	After initial settings, transitions to and then resumes from low power mode.
Arguments	None
Return Value	None

save_power_port_init	
Outline	Initial port settings
Header	None
Declaration	void save_power_port_init (void)
Description	Makes initial port settings.
Arguments	None
Return Value	None

save_power_peripheral_init	
Outline	Initial peripheral function settings
Header	None
Declaration	void save_power_peripheral_init (void)
Description	Makes initial peripheral function settings.
Arguments	None
Return Value	None

save_power_wait_trigger	
Outline	Wait for low power mode transition trigger
Header	None
Declaration	void save_power_wait_trigger (void)
Description	Waits for the low power mode transition trigger (IRQ) to occur.
Arguments	None
Return Value	None

alarm_setting	
Outline	Setting RTC alarm interrupt
Header	None
Declaration	void alarm_setting(void)
Description	Sets the time to release deep software standby mode by an RTC alarm interrupt. The sample program only supports minutes and seconds. (used by sample program for RX65N-2MB)
Arguments	None
Return Value	None

convert_to_dec	
Outline	Conversion process to decimal number
Header	None
Declaration	uint8_t convert_to_dec(uint8_t time)
Description	Convert the value obtained from the minute and second counter bits to decimal. (used by sample program for RX65N-2MB)
Arguments	uint8_t time
Return Value	uint8_t time_dec

r_Config_ICU_irq2_interrupt	
Outline	IRQ2 interrupt handler
Header	Config_ICU.h
Declaration	static void r_Config_ICU_irq2_interrupt (void)
Description	Processes the IRQ2 interrupt. The IRQ2 interrupt handler sets the switch-depressed state (g_sw_pressed) to true. (used by sample program for RX130-512KB and RX140)
Arguments	None
Return Value	None
Notes	This function is generated by the Code Generator function of Smart Configurator.

r_Config_ICU_irq4_interrupt	
Outline	IRQ4 interrupt handler
Header	Config_ICU.h
Declaration	static void r_Config_ICU_irq4_interrupt (void)
Description	Processes the IRQ4 interrupt. The IRQ4 interrupt handler sets the switch-depressed state (g_sw_pressed) to true. (used by sample program for RX231)
Arguments	None
Return Value	None
Outline	This function is generated by the Code Generator function of Smart Configurator.

r_Config_ICU_irq13_interrupt	
Outline	IRQ13 interrupt handler
Header	Config_ICU.h
Declaration	static void r_Config_ICU_irq13_interrupt (void)
Description	Processes the IRQ13 interrupt. The IRQ13 interrupt handler sets the switch-depressed state (g_sw_pressed) to true. (used by sample program for RX65N-2MB)
Arguments	None
Return Value	None
Notes	This function is generated by the Code Generator function of Smart Configurator.

4.10 Flowcharts

As an example, a flowchart of the sample program for the RX231 is shown below. In addition, the RX65N is used as an example of the main processing routine of the sample program when transitioning to deep software standby mode.

The sample program described in this application note includes code generated by the Code Generator function of Smart Configurator. Refer to 4.10.5, IRQ4 Interrupt Handler, regarding the modified portions of the source code generated by the Code Generator function of Smart Configurator. Flowcharts have been omitted for unmodified source code generated by the Code Generator function of Smart Configurator.

4.10.1 Main Processing Routine

Figure 4.9 is a flowchart of the main processing routine.

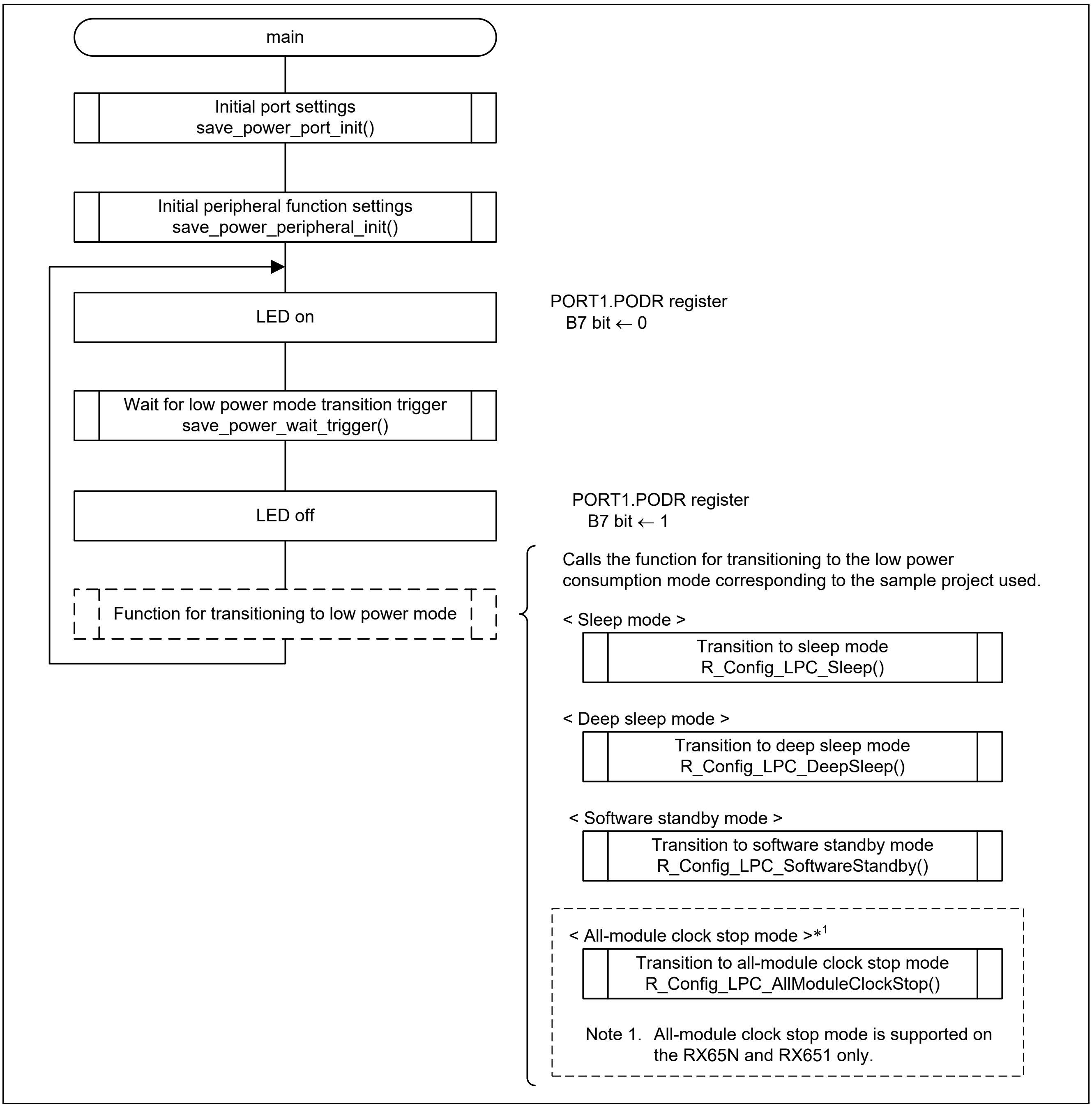

Figure 4.9 Main Processing Routine

Figure 4.10 is a flowchart of the main processing routine of the sample program when transitioning to deep software standby mode.

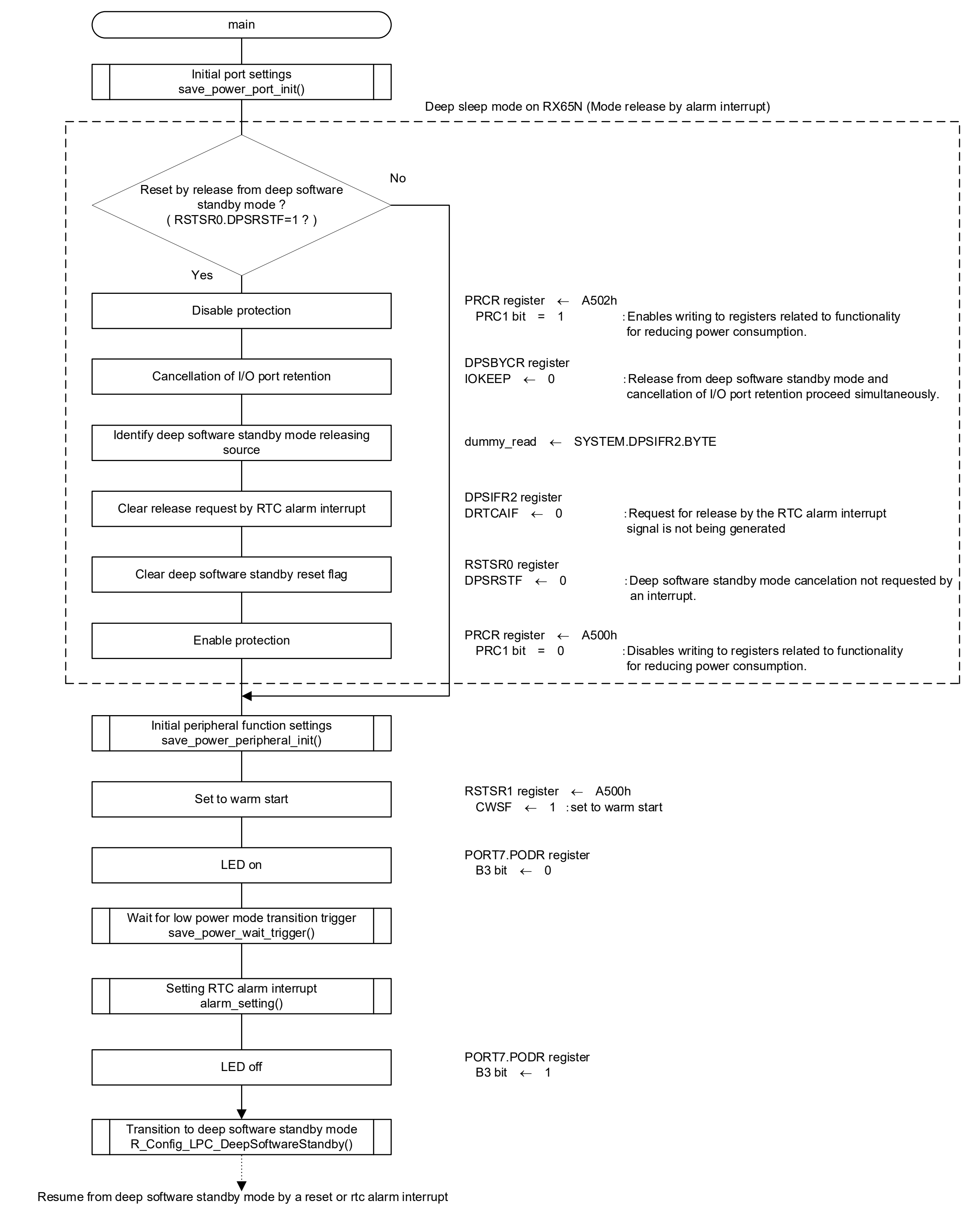

Figure 4.10 Main Processing Routine of Sample Program when Transitioning to Deep Software Standby Mode

4.10.2 Initial Port Settings

Figure 4.11 is a flowchart of the initial port settings.

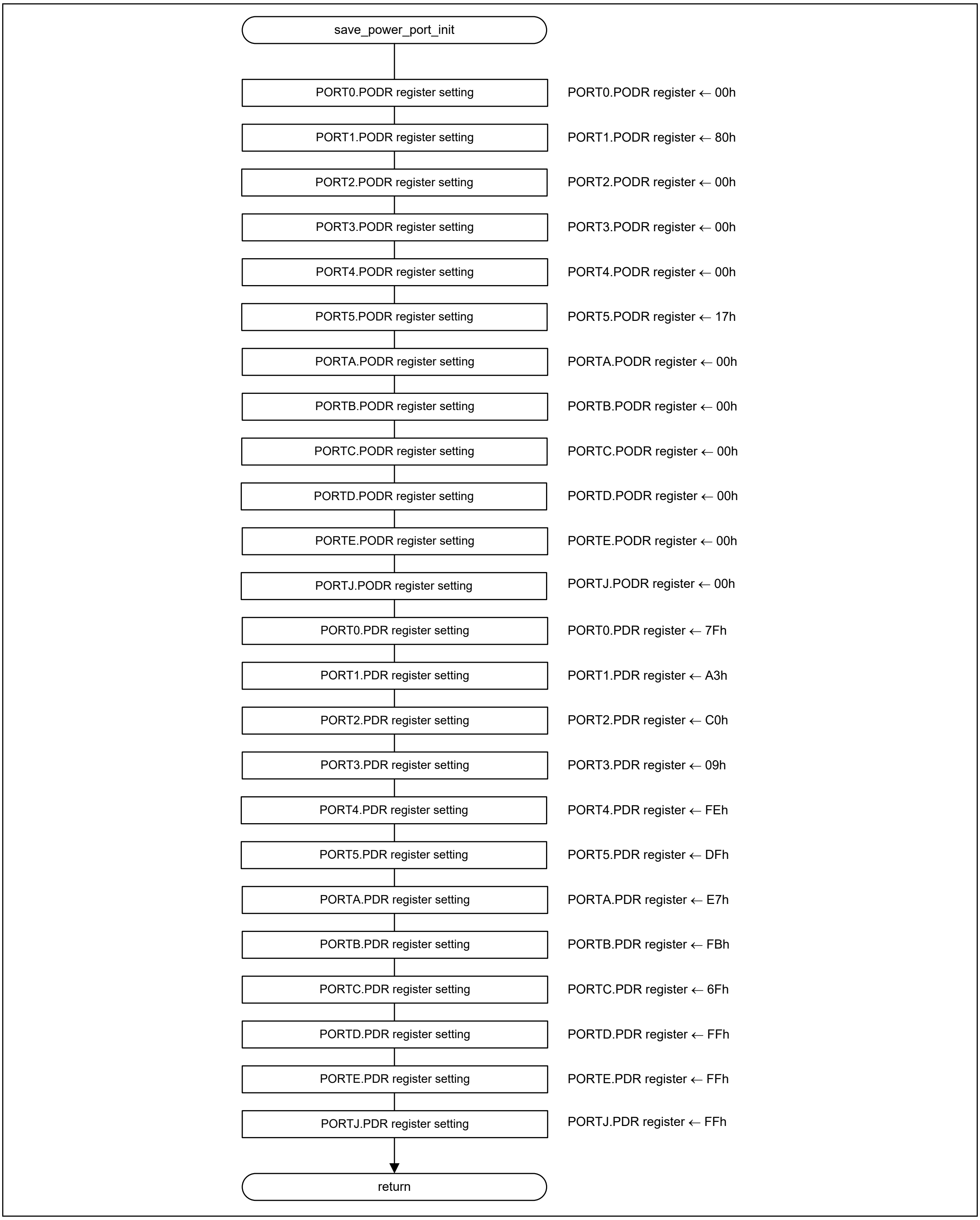

Figure 4.11 Initial Port Settings

4.10.3 Initial Peripheral Function Settings

Figure 4.12 is a flowchart of the initial peripheral function settings.

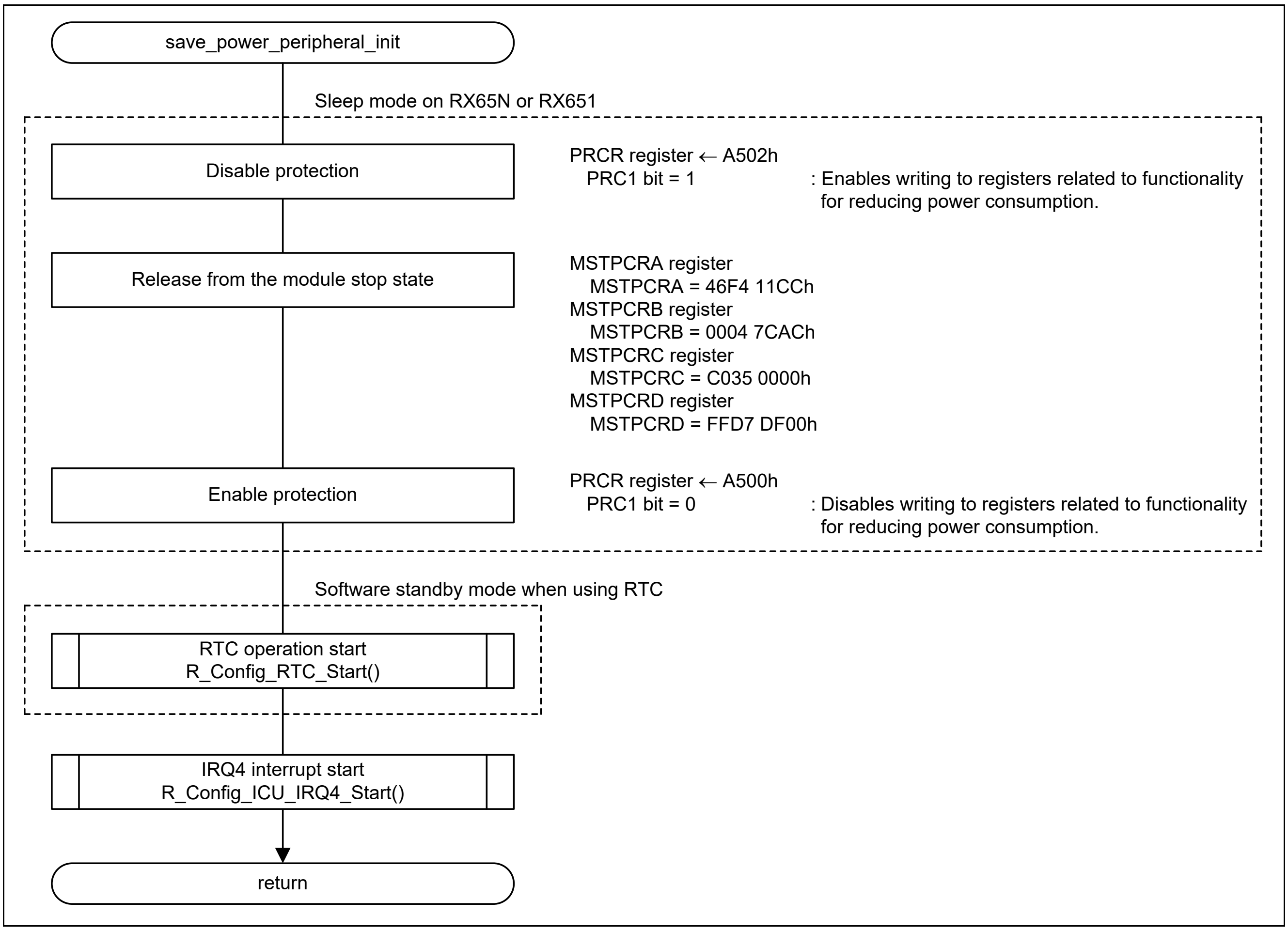

Figure 4.12 Initial Peripheral Function Settings

4.10.4 Wait for Low Power Mode Transition Trigger

Figure 4.13 is a flowchart of the wait for low power mode transition trigger.

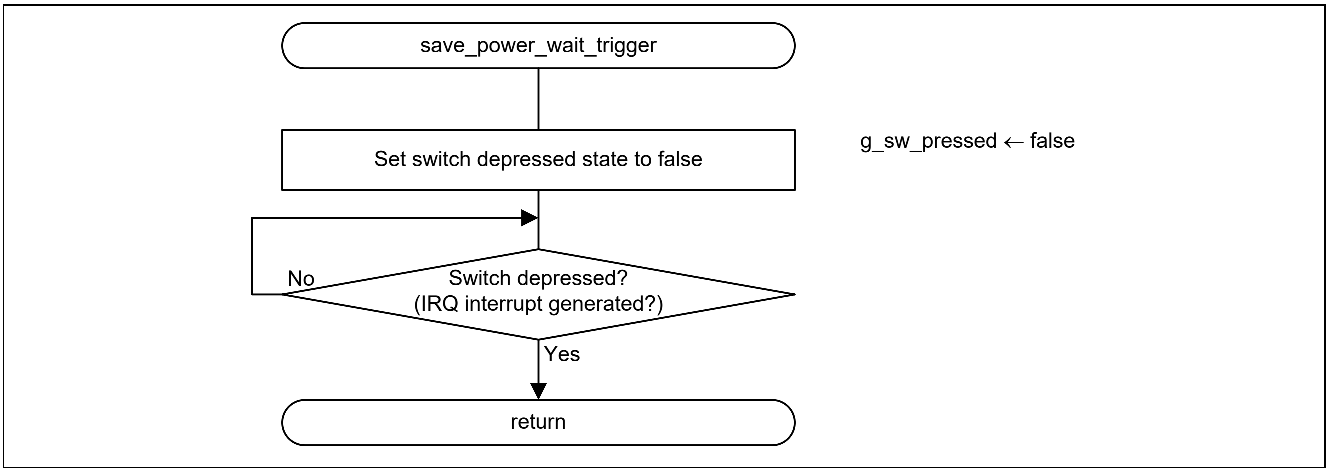

Figure 4.13 Wait for Low Power Mode Transition Trigger

4.10.5 Setting RTC alarm interrupt

Figure 4.14 is a flowchart of setting RTC alarm interrupt.

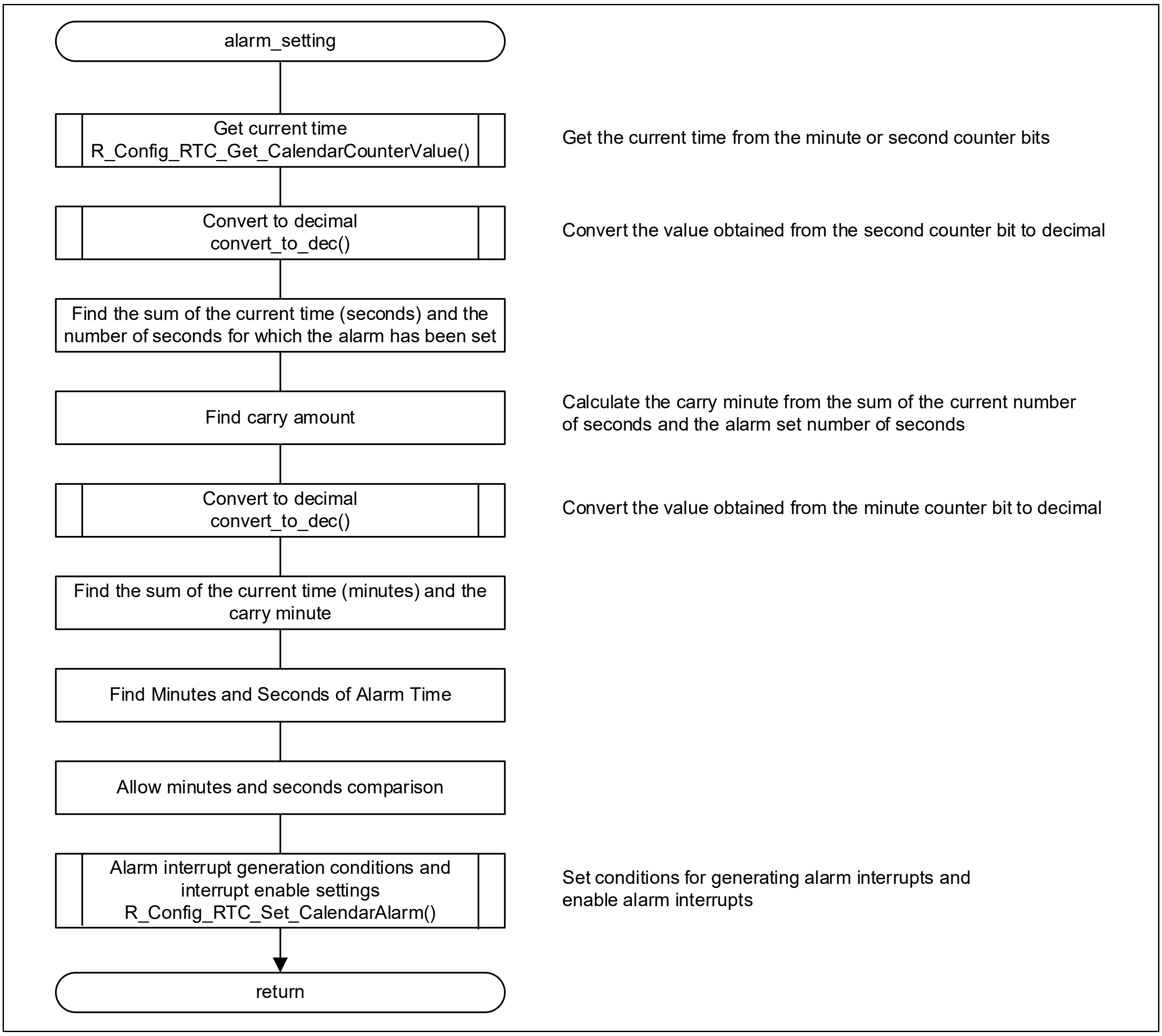

Figure 4.14 Setting RTC alarm interrupt

4.10.6 Conversion process to decimal number

Figure 4.15 is a flowchart of conversion process to decimal number.

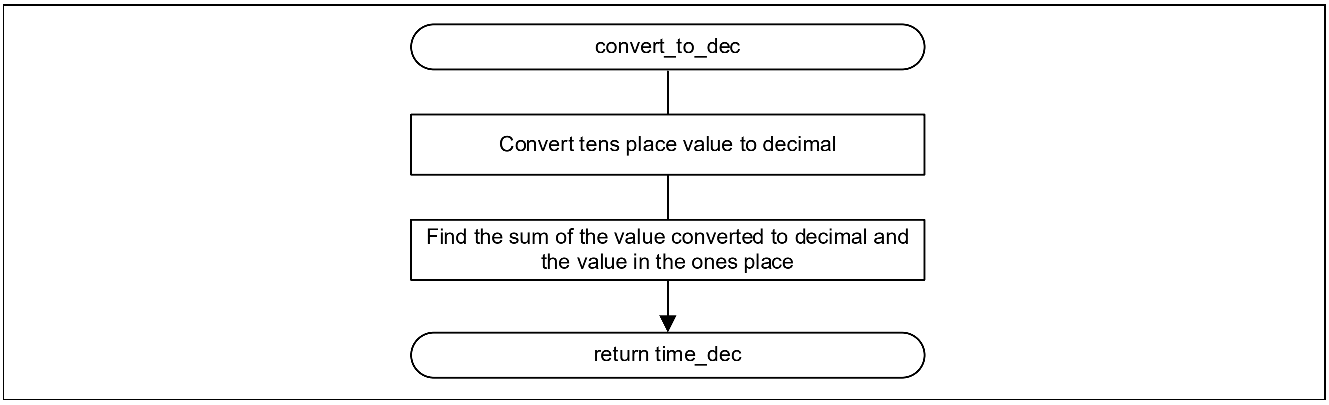

Figure 4.15 Conversion process to decimal number

4.10.7 IRQ4 Interrupt Handler

Figure 4.16 is a flowchart of the IRQ4 interrupt handler.

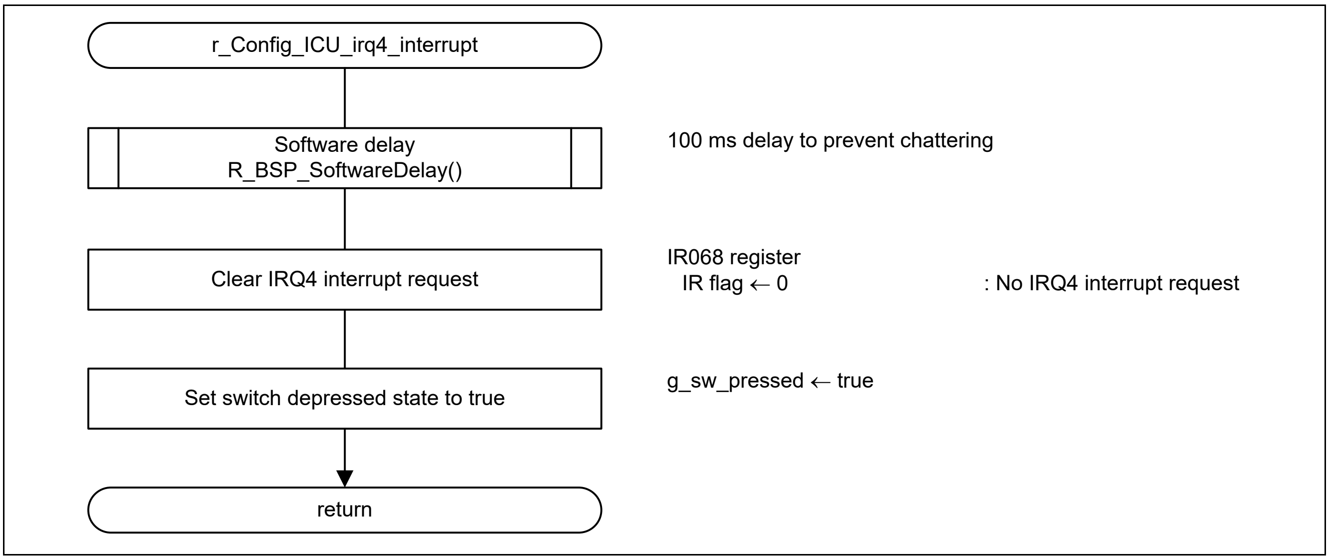

Figure 4.16 IRQ4 Interrupt Handler

5. Using the Smart Configurator to Perform Configuration

When configuring the sample projects using Smart Configurator, the relevant settings for each sample project are maintained in the Configuration menu of Smart Configurator. For documentation on how to use Smart Configurator, refer to Renesas e^2 studio Smart Configurator User's Guide (R20AN0451).

6. Notes on Transition to a Low Power Consumption Mode

(1) Clocks operate in some low power consumption modes such as sleep mode. To reduce current consumption, stop unnecessary clocks or lower their frequencies by changing the division ratio.

(2) Function-specific notes might apply to some peripheral functions when the operating state changes to the module stop state or when the operating mode changes to a low power consumption mode. For the notes that apply to a specific peripheral function, refer to the documentation for the peripheral function.

(3) In some low power consumption modes such as software standby mode, operation of the I/O ports cannot be changed. Therefore, make sure that the appropriate I/O settings are specified before the operating mode changes to such a low power consumption mode.
Table 6.1 shows Setting example of I/O port.

Table 6.1 Setting example of I/O port

State of the I/O port	Port settings to reduce current consumption
Input setting	Fix the input level (High or Low). There are many pins that become high impedance during standby mode by setting them to input.
Output setting	Output a level that does not create a potential difference in external pull-up/pull-down resistors. If a pin of connected device is in an input state and there is no external/internal pull-up/pull-down resistor, output low.

(4) A board consumes more current if an emulator is connected to the board. Therefore, when you measure the current consumption of a board, make sure that no emulator is connected to the board.

(5) A current consumption measurement program cannot correctly measure the current consumption if the program is written from e^2 studio in debug mode. Use Renesas Flash Programmer or another flash memory programming software tool to write the program.

7. Appendix

7.1 Operating Frequencies of Each Project

Table 7.1 to Table 7.11 list the operating frequencies used when confirming the operation of the program described in this application note.

Table 7.1 Operating Frequencies of Project for Confirmation of Sleep Mode and Deep Sleep Mode on RX130-512KB

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	32 MHz	Main clock	2	8
System clock (ICLK)	32 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	0.5 MHz	PLL	64	—
Peripheral module clock D (PCLKD)	0.5 MHz	PLL	64	—
FlashIF clock (FCLK)	0.5 MHz	PLL	64	—

Table 7.2 Operating Frequencies of Project for Confirmation of Software Standby Mode on RX130-512KB

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	32 MHz	Main clock	2	8
System clock (ICLK)	32 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	32 MHz	PLL	1	—
Peripheral module clock D (PCLKD)	32 MHz	PLL	1	—
FlashIF clock (FCLK)	32 MHz	PLL	1	—

Table 7.3 Operating Frequencies of Project for Confirmation of Software Standby Mode on RX130-512KB with RTC Operating

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	32.768 kHz	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	32 MHz	Main clock	2	8
System clock (ICLK)	32 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	32 MHz	PLL	1	—
Peripheral module clock D (PCLKD)	32 MHz	PLL	1	—
FlashIF clock (FCLK)	32 MHz	PLL	1	—

Table 7.4 Operating Frequencies of Project for Confirmation of Sleep Mode and Deep Sleep Mode on RX140

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	32 MHz	Main clock	2	8
System clock (ICLK)	32 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	0.5 MHz	PLL	64	—
Peripheral module clock D (PCLKD)	0.5 MHz	PLL	64	—
FlashIF clock (FCLK)	0.5 MHz	PLL	64	—

Table 7.5 Operating Frequencies of Project for Confirmation of Software Standby Mode on RX140

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	32 MHz	Main clock	2	8
System clock (ICLK)	32 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	32 MHz	PLL	1	—
Peripheral module clock D (PCLKD)	32 MHz	PLL	1	—
FlashIF clock (FCLK)	32 MHz	PLL	1	—

Table 7.6 Operating Frequencies of Project for Confirmation of Software Standby Mode on RX140 with RTC Operating

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	32.768 kHz	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	32 MHz	Main clock	2	8
System clock (ICLK)	32 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	32 MHz	PLL	1	—
Peripheral module clock D (PCLKD)	32 MHz	PLL	1	—
FlashIF clock (FCLK)	32 MHz	PLL	1	—

Table 7.7 Operating Frequencies of Project for Confirmation of Sleep Mode and Deep Sleep Mode on RX231

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	54 MHz	Main clock	2	13.5
USB dedicated PLL	Stopped	—	—	—
System clock (ICLK)	54 MHz	PLL	1	—
Peripheral module clock A (PCLKA)	0.84375 MHz	PLL	64	—
Peripheral module clock B (PCLKB)	0.84375 MHz	PLL	64	—
Peripheral module clock D (PCLKD)	0.84375 MHz	PLL	64	—
FlashIF clock (FCLK)	0.84375 MHz	PLL	64	—
External bus clock (BCK)	0.84375 MHz	PLL	64	—

Table 7.8 Operating Frequencies of Project for Confirmation of Software Standby Mode on RX231

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	54 MHz	Main clock	2	13.5
USB dedicated PLL	Stopped	—	—	—
System clock (ICLK)	54 MHz	PLL	1	—
Peripheral module clock A (PCLKA)	54 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	27 MHz	PLL	2	—
Peripheral module clock D (PCLKD)	27 MHz	PLL	2	—
FlashIF clock (FCLK)	27 MHz	PLL	2	—
External bus clock (BCK)	27 MHz	PLL	2	—

Table 7.9 Operating Frequencies of Project for Confirmation of Software Standby Mode on RX231 with RTC Operating

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	8 MHz	—	—	—
Sub-clock	32.768 kHz	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	54 MHz	Main clock	2	13.5
USB dedicated PLL	Stopped	—	—	—
System clock (ICLK)	54 MHz	PLL	1	—
Peripheral module clock A (PCLKA)	54 MHz	PLL	1	—
Peripheral module clock B (PCLKB)	27 MHz	PLL	2	—
Peripheral module clock D (PCLKD)	27 MHz	PLL	2	—
FlashIF clock (FCLK)	27 MHz	PLL	2	—
External bus clock (BCK)	27 MHz	PLL	2	—

Table 7.10 Operating Frequencies of Project for Confirmation of Sleep Mode, Software Standby Mode, Deep Software Standby Mode, and All-Module Clock Stop Mode on RX65N-2MB

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	24 MHz	—	—	—
Sub-clock	Stopped	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	240 MHz	Main clock	1	10
System clock (ICLK)	120 MHz	PLL	2	—
Peripheral module clock A (PCLKA)	120 MHz	PLL	2	—
Peripheral module clock B (PCLKB)	60 MHz	PLL	4	—
Peripheral module clock C (PCLKC)	60 MHz	PLL	4	—
Peripheral module clock D (PCLKD)	60 MHz	PLL	4	—
FlashIF clock (FCLK)	60 MHz	PLL	4	—
External bus clock (BCK)	120 MHz	PLL	2	—
USB clock (UCK)	48 MHz	PLL	5	—

Table 7.11 Operating Frequencies of Project for Confirmation of Deep Software Standby Mode on RX65N-2MB with RTC Operating

Name	Operating Frequency	Clock Source	Division Ratio	Multiplication Ratio
Main clock	24 MHz	—	—	—
Sub-clock	32.768 kHz	—	—	—
High-speed on-chip oscillator (HOCO)	Stopped	—	—	—
Low-speed on-chip oscillator (LOCO)	Stopped	—	—	—
IWDT dedicated on-chip oscillator	Stopped	—	—	—
PLL	240 MHz	Main clock	1	10
System clock (ICLK)	120 MHz	PLL	2	—
Peripheral module clock A (PCLKA)	120 MHz	PLL	2	—
Peripheral module clock B (PCLKB)	60 MHz	PLL	4	—
Peripheral module clock C (PCLKC)	60 MHz	PLL	4	—
Peripheral module clock D (PCLKD)	60 MHz	PLL	4	—
FlashIF clock (FCLK)	60 MHz	PLL	4	—
External bus clock (BCK)	120 MHz	PLL	2	—
USB clock (UCK)	48 MHz	PLL	5	—

8. Importing a Project

The sample code is provided as the e² studio project. This section describes importing a project into the e² studio. After importing a project, confirm that the build settings and the debug settings are correct.

8.1 Importing a Project into e² studio

Follow the steps below to import your project into the e² studio.
(Windows/dialogs may differ depending on the e² studio version used.)

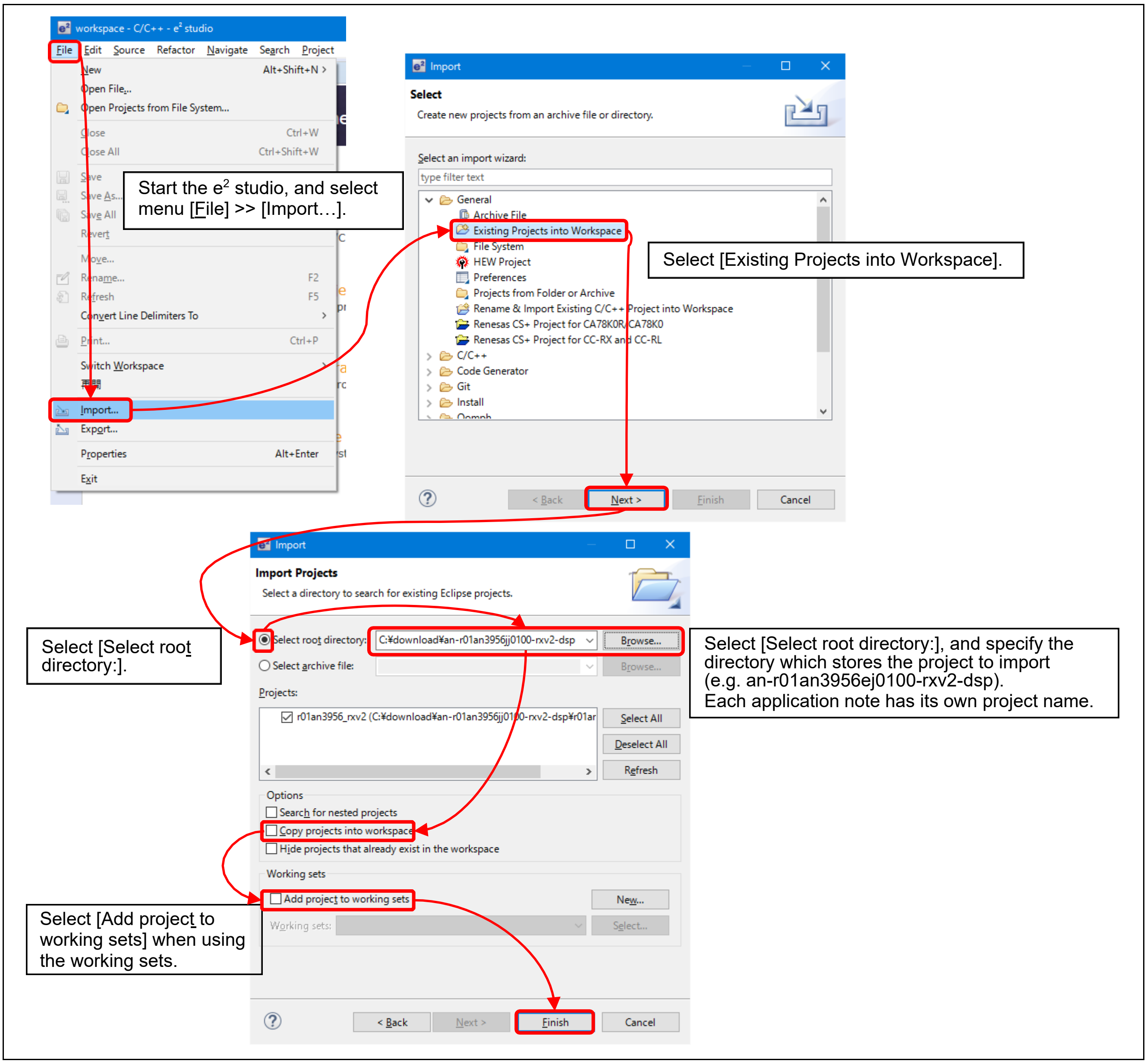

Figure 8.1 Importing a Project into e² studio

8.2 Importing a Project into CS+

If you use CS+, import your project into CS+ by using the procedure described below.

(The windows indicated might slightly differ depending on the version of CS+ you use.)

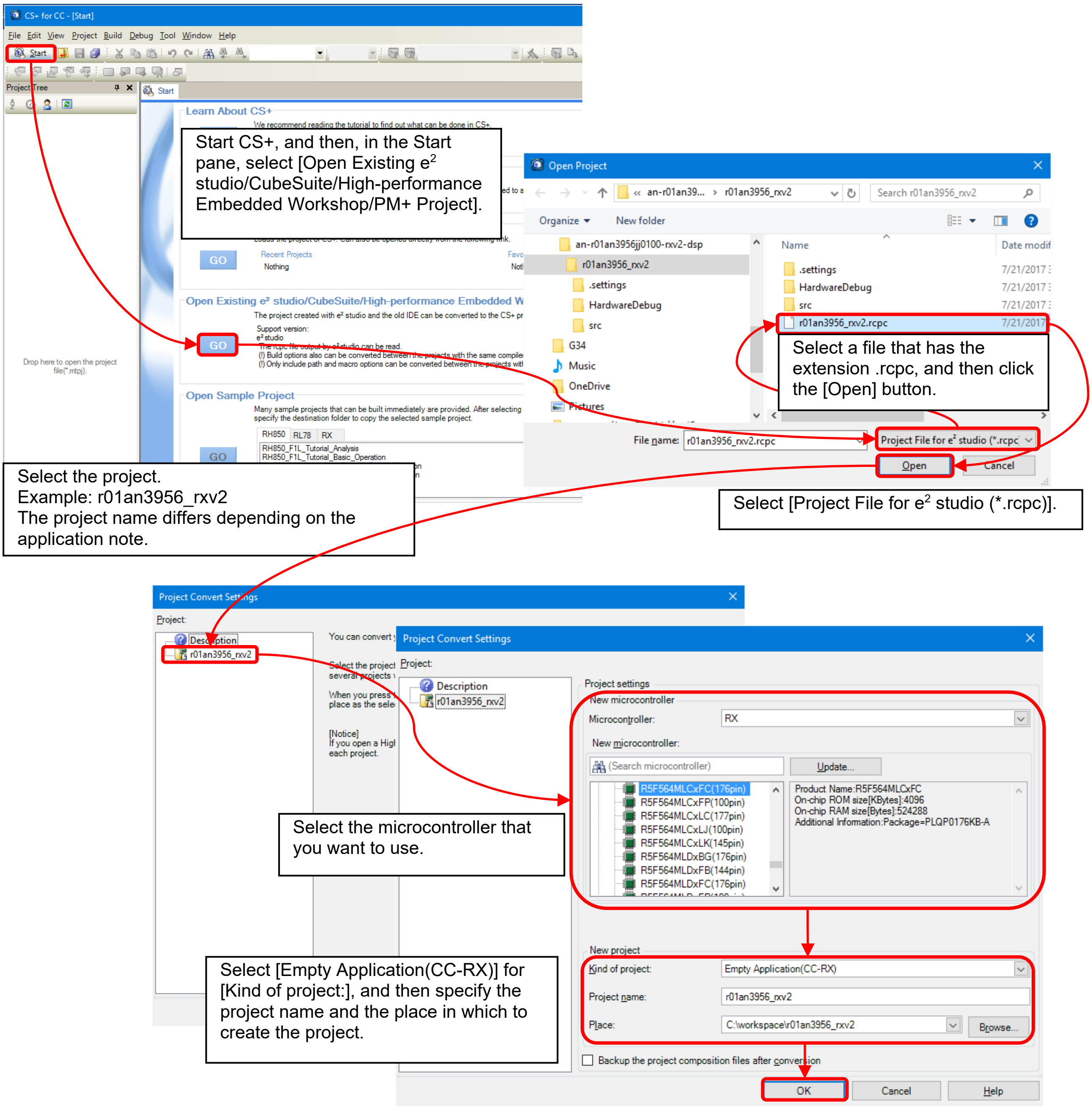

Figure 8.2 Importing a project into CS+

9. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

10. Reference Documents

User's Manual: Hardware

RX130 Group User's Manual: Hardware (R01UH0560)
RX140 Group User's Manual: Hardware (R01UH0905)
RX230 Group, RX231 Group User's Manual: Hardware (R01UH0496)
RX65N Group, RX651 Group User's Manual: Hardware (R01UH0590)
(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual: Firmware Integration Technology

Firmware Integration Technology User's Manual (R01AN1833)
RX Family Board Support Package Module Using Firmware Integration Technology (R01AN1685)
RX Family Adding Firmware Integration Technology Modules to Projects (R01AN1723)
(The latest version can be downloaded from the Renesas Electronics website.)

Technical Update/Technical News

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

User's Manual: Development Tools

RX Family CC-RX Compiler User's Manual (R20UT3248)
Renesas e2 studio Smart Configurator User Guide (R20AN0451)
(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual: Renesas Starter Kit

RX231 Group Renesas Starter Kit User's Manual (R20UT3027)
Renesas Starter Kit for RX231 CPU Board Schematics (R20UT3026)
(The latest version can be downloaded from the Renesas Electronics website.)

Application Note

RX210, RX21A, and RX220 Groups Transition to Low Power Consumption Modes Using the Low Power Consumption Function (R01AN1482)
RX63N Group, RX631 Group Transition to Low Power Consumption Mode Using Low Power Consumption Function (R01AN1920)
RX140 Group Snooze Mode Usage Examples (R01AN5914)
(The latest version can be downloaded from the Renesas Electronics website.)

Revision History

Rev.	Date	Description	
		Page	Summary
1.10	Sep. 14, 2018	—	First edition issued
1.20	Jun. 06, 2022	-	Added target devices (RX140 group).
		-	Deleted sample program for the RX230.
		4	Added a list of modes supported by devices.
		4	Added the RX140 to the devices applicable to the sample program conditions.
		6	Updated the conditions under which operation was verified.
		7	Added a list of pins used on the RX140.
		14	Updated the version information of components.
		15	Added projects for the RX140 in the list of projects.
		16	Added a new project for the RX65N in the list of projects.
		19	Added constant information about the RX140 to the table of constants used by the sample program.
		19	Added ALARMSET to the table of constants used by the sample program.
		20	Added alarm_setting and convert_to_dec to the table of functions used by the sample program.
		21, 22	Added alarm_setting and convert_to_dec to the table of function specifications used by the sample program.
		23	Updated flowchart of main function.
		28	Added flowchart of alarm_setting function
		29	Added flowchart of convert_to_dec function
		30	Added a chapter on the notes on transition to a low power consumption mode.
		30	Delete the chapter on troubleshooting.
		32, 33	Added a table of operating frequencies used for confirmation of program operation on the RX140.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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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.
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