
RX63N Group, RX631 Group

R01AN1067EJ0100

Rev. 1.00

Exiting Software Standby Mode Using the RTCa

June 14, 2013

Abstract

This document describes how to obtain the current time information while intermittently exiting software standby mode using the realtime clock (RTC) in the RX63N Group and RX631 Group.

Products

RX63N Group, 176-Pin and 177-Pin Packages, ROM Capacities: 768 Kbytes to 2 Mbytes

RX63N Group, 144-Pin and 145-Pin Packages, ROM Capacities: 768 Kbytes to 2 Mbytes

RX63N Group, 100-Pin Package, ROM Capacities: 768 Kbytes to 2 Mbytes

RX631 Group, 176-Pin and 177-Pin Packages, ROM Capacities: 256 Kbytes to 2 Mbytes

RX631 Group, 144-Pin and 145-Pin Packages, ROM Capacities: 256 Kbytes to 2 Mbytes

RX631 Group, 100-Pin Package, ROM Capacities: 256 Kbytes to 2 Mbytes

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

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1. Specifications

This document describes how to obtain the time information while intermittently exiting software standby mode using the RTC.

After a reset, if the reset processing is a cold start, the sub-clock oscillator and RTC are initialized. If the reset processing is a warm start, the RTC data is retained so initialization is not performed.

Next, monitor the input level of the interrupt request pin. If the input level is low, the MCU enters software standby mode.

Then when the periodic interrupt occurs every 0.5 seconds, the MCU exits software standby mode, time information is obtained, and the MCU enters software standby mode according to the input level of the interrupt request pin.

- RTC count source: Sub-clock
- VBATT pin: Connect to the VCC pin
- Intermittent period to exit software standby mode: 0.5 seconds

Table 1.1 lists the Peripheral Functions and Their Applications and Figure 1.1 shows the Operation Overview.

In this document, operating states other than software standby mode are referred to as normal mode.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
RTCa	Clock function or exiting from software standby mode
IRQ15	External input for entering software standby mode

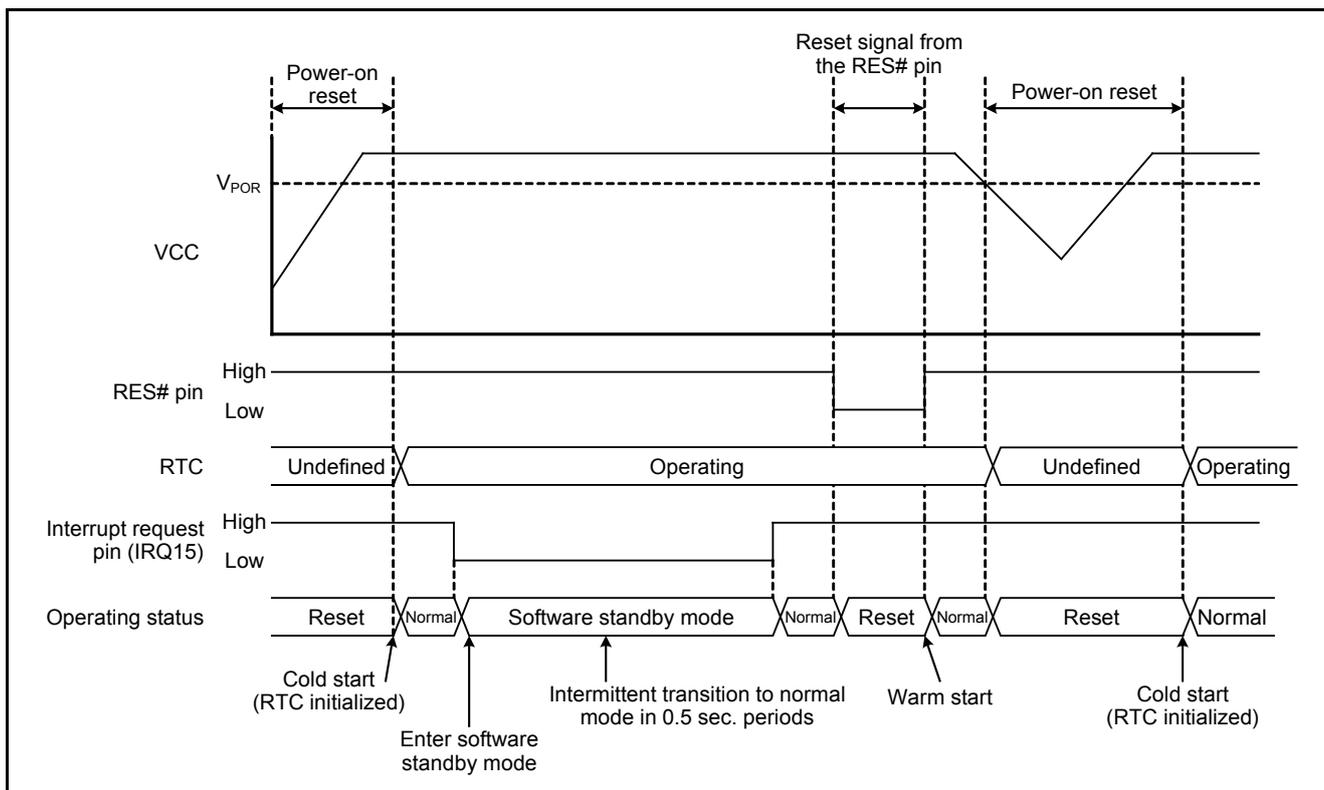


Figure 1.1 Operation Overview

2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

Table 2.1 Operation Confirmation Conditions

Item	Contents
MCU used	R5F563NBDDFC (RX63N Group)
Operating frequencies	<ul style="list-style-type: none"> - Main clock: 12 MHz - Sub-clock: 32.768 kHz - PLL clock: 192 MHz (main clock divided by 1 and multiplied by 16) - LOCO clock: 125 kHz - System clock (ICLK): 96 MHz (PLL clock divided by 2) - Peripheral module clock B (PCLKB): 48 MHz (PLL clock divided by 4)
Operating voltage	3.3 V
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.09.01
C compiler	Renesas Electronics Corporation C/C++ Compiler Package for RX Family V.1.02 Release 01
	Compile options -cpu=rx600 -output=obj="\$(CONFIGDIR)\\$(FILELEAF).obj" -debug -nologo The integrated development environment default settings are used.
iodefine.h version	Version 1.50
Endian	Little endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Device used	Renesas Starter Kit+ for RX63N (product part number: R0K50563NC000BE)

3. Reference Application Note

For additional information associated with this document, refer to the following application note.

- RX63N Group, RX631 Group Initial Setting Rev. 1.00 (R01AN1245EJ0100)

The initial setting functions in the reference application note are used in the sample code in this application note. The revision number of the reference application note is the one when this application note was made. However, the latest version is always recommended. Visit the Renesas Electronics Corporation website to check and download the latest version.

4. Hardware

4.1 Hardware Configuration

Figure 4.1 shows a Connection Example.

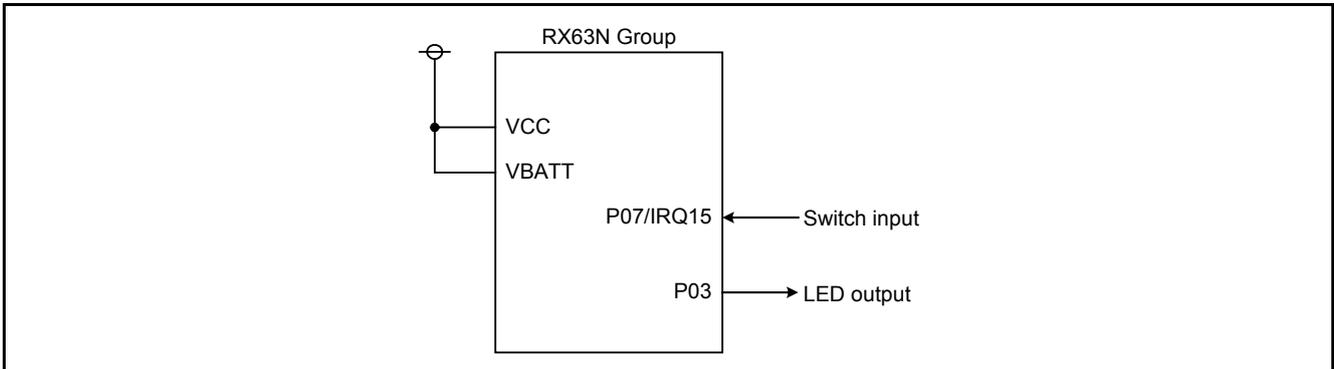


Figure 4.1 Connection Example

4.2 Pins Used

Table 4.1 lists the Pins Used and Their Functions.

This table assumes the 176-pin package is used. When using packages with less than 176 pins, select the pins appropriate to the package used.

Table 4.1 Pins Used and Their Functions

Pin Name	I/O	Function
P07/IRQ15	Input	Switch input for entering modes
P03	Output	LED output

5. Software

In normal mode, time information is updated and the level of the interrupt request pin is monitored. The RTC time information is stored in the time data storage area (global variable). The level of the interrupt request pin is monitored using the IR flag of the IRQ15 interrupt.

When the IR flag of the IRQ15 interrupt is 1, the RTC periodic interrupt (PRD interrupt) is enabled, and the MCU enters software standby mode. The MCU exits software standby mode by a PRD interrupt request, and the PRD interrupt is disabled.

After the MCU exits software standby mode, the RTC time information is updated, the level of the interrupt request pin is monitored, and the above processing is repeated.

Settings for the peripheral functions are listed below.

RTC

Count source: Sub-clock

Initial time setting: 00:00:00, Tuesday, January 1, 2013

Time mode: 24-hour mode

RTCOUT output: Disabled

Error adjustment: Not used

Time capture: Not used

Interrupts used: PRD interrupt is generated in 0.5 sec. periods; Carry interrupt (CUP)

IRQ15 input pin

Detection method: Low level is detected

Digital filter: Enabled (sampling clock: PCLKB/8)

Interrupt used: External pin interrupt (IRQ15 interrupt)

5.1 Operation Overview

(1) Initial setting

After a reset, if the RSTSR1.CWSF bit is 0 (cold start), the sub-clock oscillator and RTC are initialized, and the RSTSR1.CWSF bit is set to 1 (warm start). The LED is turned on, and the RTC time information is read. Also, the IR flag of the IRQ15 interrupt is monitored.

(2) Entering software standby mode

When the IR flag of the IRQ15 interrupt becomes 1, the PRD interrupt request is enabled, and the clock source for the system clock changes from the PLL clock to the LOCO clock. The LED is turned off, the WAIT instruction is executed, and the MCU enters software standby mode.

(3) Exiting software standby mode

The MCU exits software standby mode by the PRD interrupt request generated every 0.5 seconds. The LED is turned on in the PRD interrupt handling. The clock source for the system clock switches from the LOCO clock to the PLL clock, and the PRD interrupt request is disabled. After waiting 1/128th of a second, the RTC time information is read. If the IR flag of the IRQ15 interrupt is 1, perform the processing in step (3) again; if the IR flag is 0, read the RTC time information. Also, the IR flag of the IRQ15 interrupt is monitored.

(4) Warm start

After a reset, if the RSTSR1.CWSF bit is 1, the sub-clock oscillator and RTC are not initialized, and MCU operation continues.

Figure 5.1 shows the Timing Diagram.

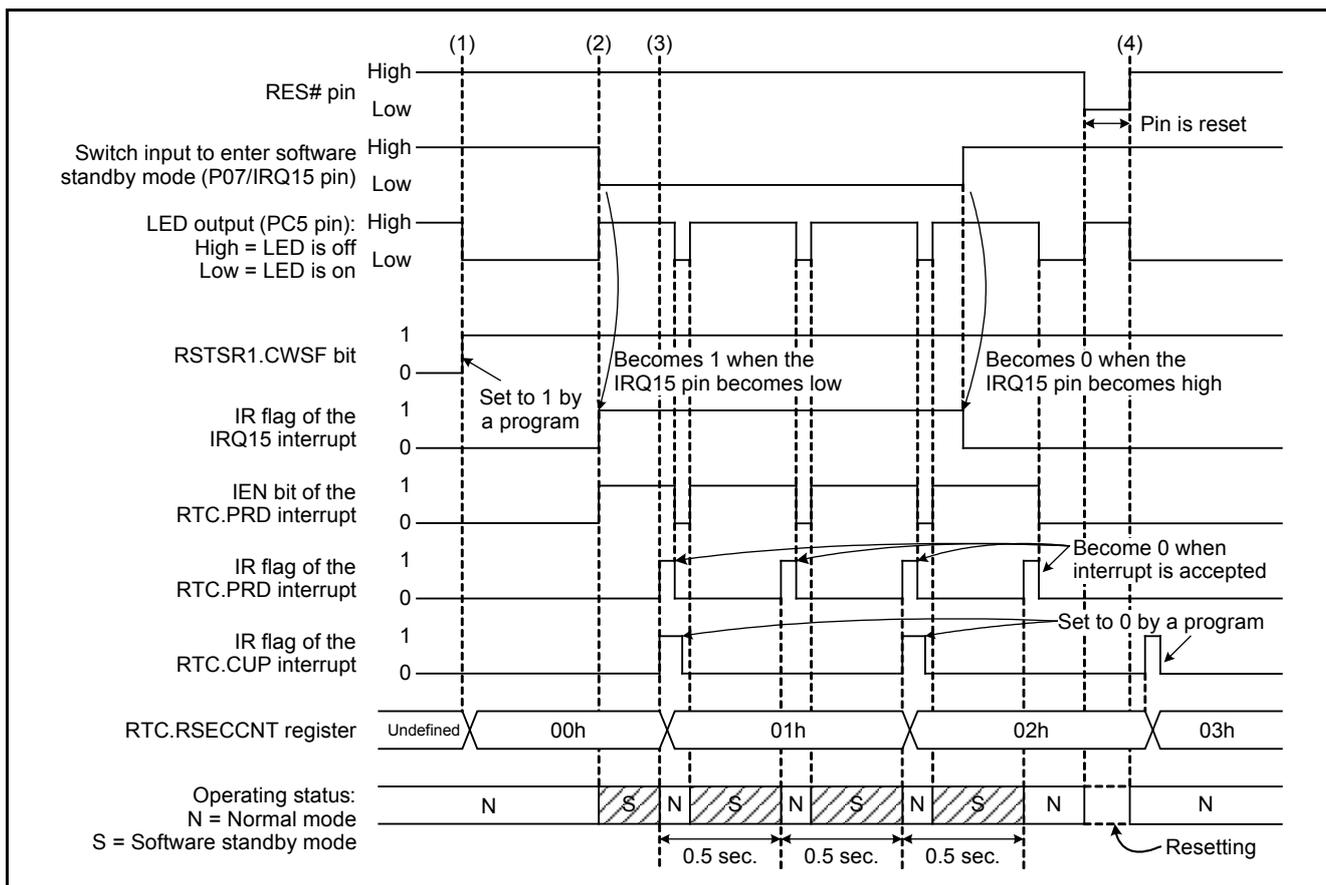


Figure 5.1 Timing Diagram

5.2 File Composition

Table 5.1 lists the Files Used in the Sample Code. Files generated by the integrated development environment are not included in this table.

Table 5.1 Files Used in the Sample Code

File Name	Outline	Remarks
main.c	Main processing	
r_init_stop_module.c	Stop processing for active peripheral functions after a reset	
r_init_stop_module.h	Header file for r_init_stop_module.c	
r_init_non_existent_port.c	Nonexistent port initialization	
r_init_non_existent_port.h	Header file for r_init_non_existent_port.c	
r_init_clock.c	Clock initialization	
r_init_clock.h	Header file for r_init_clock.c	

5.3 Option-Setting Memory

Table 5.2 lists the Option-Setting Memory Configured in the Sample Code. When necessary, set a value suited to the user system.

Table 5.2 Option-Setting Memory Configured in the Sample Code

Symbol	Address	Setting Value	Contents
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	The IWDT is stopped after a reset. The WDT is stopped after a reset.
OFS1	FFFF FF8Bh to FFFF FF88h	FFFF FFFFh	The voltage monitor 0 reset is disabled after a reset. HOCO oscillation is disabled after a reset.
MDES	FFFF FF83h to FFFF FF80h	FFFF FFFFh	Little endian

5.4 Constants

Table 5.3 lists the Constants Used in the Sample Code.

Table 5.3 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
SW_STANDBY	IR(ICU,IRQ15)	IRQ15 interrupt status flag: Switch to enter software standby mode
SW_ON	1	Switch on
SW_OFF	0	Switch off
LED_RUN	PORT0.PODR.BIT.B3	P03 output data storage bit: LED
LED_ON	0	LED on
LED_OFF	1	LED off
LOOP_COUNT	96,000,000L/128	Loop counter: Wait at least 1/128th of a second (ICLK = 96 MHz)

5.5 Structure/Union List

Figure 5.2 shows the Structure/Union Used in the Sample Code.

```

/* **** Time Data **** */
typedef struct
{
    uint8_t    second;        /* Second */
    uint8_t    minute;       /* Minute */
    uint8_t    hour;         /* Hour */
    uint8_t    dayweek;     /* Day of the week */
    uint8_t    day;         /* Day */
    uint8_t    month;       /* Month */
    uint16_t   year;        /* Year */
} time_bcd_t;
    
```

Figure 5.2 Structure/Union Used in the Sample Code

5.6 Variable

Table 5.4 lists the Global Variable.

Table 5.4 Global Variable

Type	Variable Name	Contents	Function Used
time_bcd_t	time	Time data storage area	rtc_time_read

5.7 Functions

Table 5.5 lists the Functions.

Table 5.5 Functions

Function Name	Outline
main	Main processing
port_init	Port initialization
R_INIT_StopModule	Stop processing for active peripheral functions after a reset
R_INIT_NonExistentPort	Nonexistent port initialization
R_INIT_Clock	Clock initialization
peripheral_init	Peripheral function initialization
irq_init	IRQ initialization
rtc_init	RTC initialization
rtc_time_read	Reading RTC time information
run_to_standby	Preparation to enter software standby mode
standby_to_run	Exiting software standby mode
Excep_RTC_PRD	RTC period interrupt handling

5.8 Function Specifications

The following tables list the sample code function specifications.

main	
Outline	Main processing
Header	None
Declaration	void main(void)
Description	After the initial setting, the LED is turned on, the RTC time information is read, and if switch input for entering software standby mode indicates on, the MCU enters software standby mode.
Arguments	None
Return Value	None
port_init	
Outline	Port initialization
Header	None
Declaration	void port_init(void)
Description	Initializes the ports.
Arguments	None
Return Value	None
R_INIT_StopModule	
Outline	Stop processing for active peripheral functions after a reset
Header	r_init_stop_module.h
Declaration	void R_INIT_StopModule(void)
Description	Performs settings to enter the module-stop state.
Arguments	None
Return Value	None
Remark	Transition to the module-stop state is not performed in the sample code. For more information on this function, refer to the RX63N Group, RX631 Group Initial Setting Rev. 1.00 application note.
R_INIT_NonExistentPort	
Outline	Nonexistent port initialization
Header	r_init_non_existent_port.h
Declaration	void R_INIT_NonExistentPort(void)
Description	Initializes port direction registers for ports that do not exist in products with less than 176 pins.
Arguments	None
Return Value	None
Remark	The number of pins in the sample code is set for the 176-pin package (PIN_SIZE=176). After this function is called, when writing in byte units to the PDR and PODR registers which have nonexistent ports, set the corresponding bits for nonexistent ports as follows: set the I/O select bits in the PDR registers to 1 and set the output data store bits in the PODR registers to 0. For more information on this function, refer to the RX63N Group, RX631 Group Initial Setting Rev. 1.00 application note.

R_INIT_Clock	
Outline	Clock initialization
Header	r_init_clock.h
Declaration	void R_INIT_Clock(void)
Description	Initializes clocks. Determines if the reset processing is a cold start or a warm start. The sub-clock is only initialized when the reset processing is a cold start.
Arguments	None
Return Value	None
Remark	In the sample code, the PLL clock is selected as the system clock, and the sub-clock is selected as the count source of the RTC (pattern D). For more information on this function, refer to the RX63N Group, RX631 Group Initial Setting Rev. 1.00 application note.

peripheral_init	
Outline	Peripheral function initialization
Header	None
Declaration	void peripheral_init(void)
Description	Initializes the peripheral functions being used.
Arguments	None
Return Value	None

irq_init	
Outline	IRQ initialization
Header	None
Declaration	void irq_init(void)
Description	Initializes the IRQ.
Arguments	None
Return Value	None

rtc_init	
Outline	RTC initialization
Header	None
Declaration	void rtc_init(void)
Description	Initializes the RTC.
Arguments	None
Return Value	None

rtc_time_read	
Outline	Reading RTC time information
Header	None
Declaration	void rtc_time_read(void)
Description	Reads the RTC time information and stores it in the time data storage area.
Arguments	None
Return Value	None

run_to_standby

Outline	Preparation to enter software standby mode
Header	None
Declaration	void run_to_standby(void)
Description	Performs processing required before entering software standby mode.
Arguments	None
Return Value	None

standby_to_run

Outline	Exiting software standby mode
Header	None
Declaration	void standby_to_run(void)
Description	Performs processing after exiting software standby mode.
Arguments	None
Return Value	None

Excep_RTC_PRD

Outline	RTC period interrupt handling
Header	None
Declaration	void Excep_RTC_PRD(void)
Description	Turns on the LED.
Arguments	None
Return Value	None

5.9 Flowcharts

5.9.1 Main Processing

Figure 5.3 shows the Main Processing.

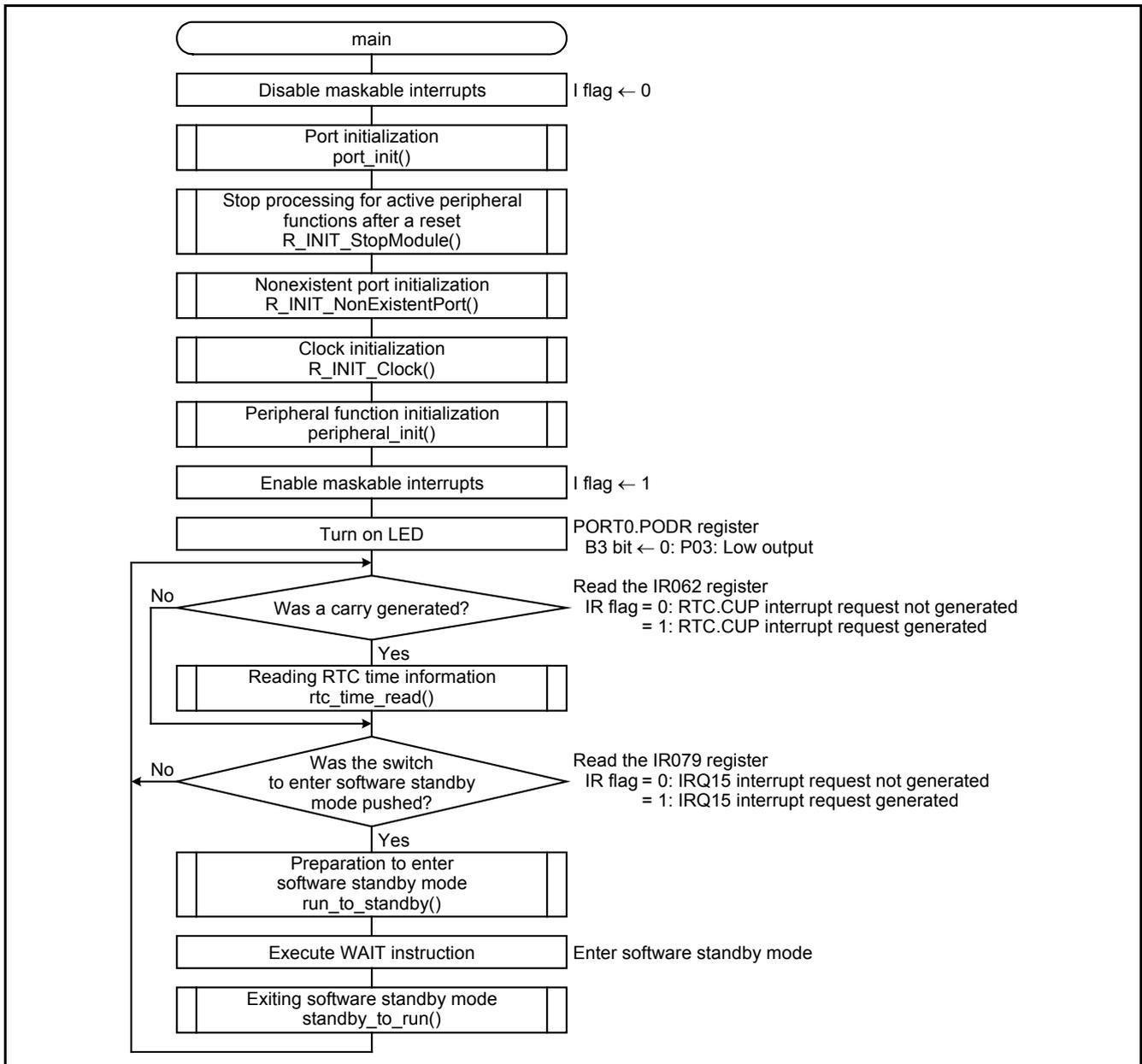


Figure 5.3 Main Processing

5.9.2 Port Initialization

Figure 5.4 shows Port Initialization.

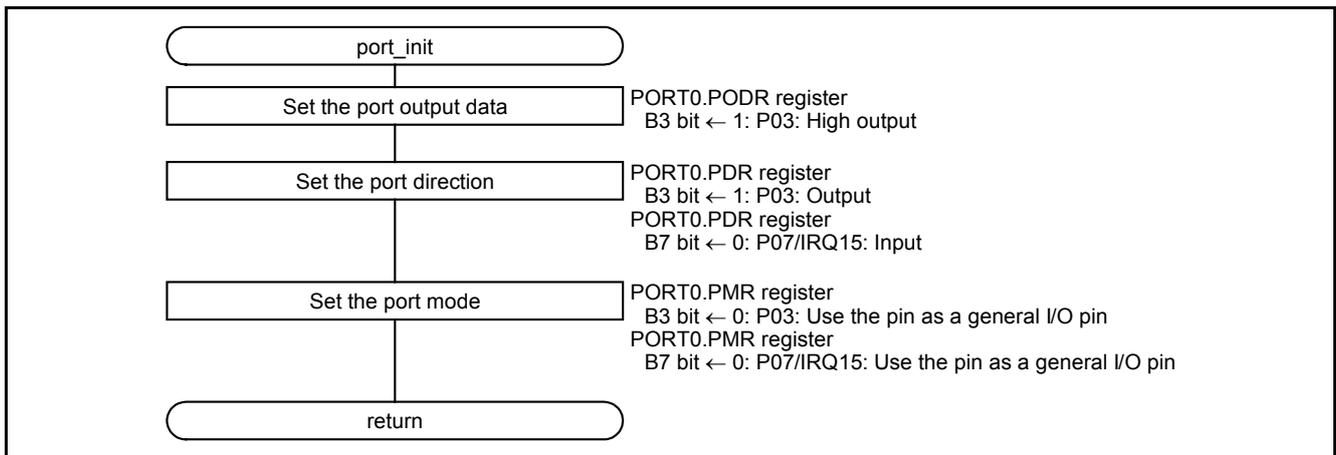


Figure 5.4 Port Initialization

5.9.3 Clock Initialization

Figure 5.5 shows Clock Initialization.

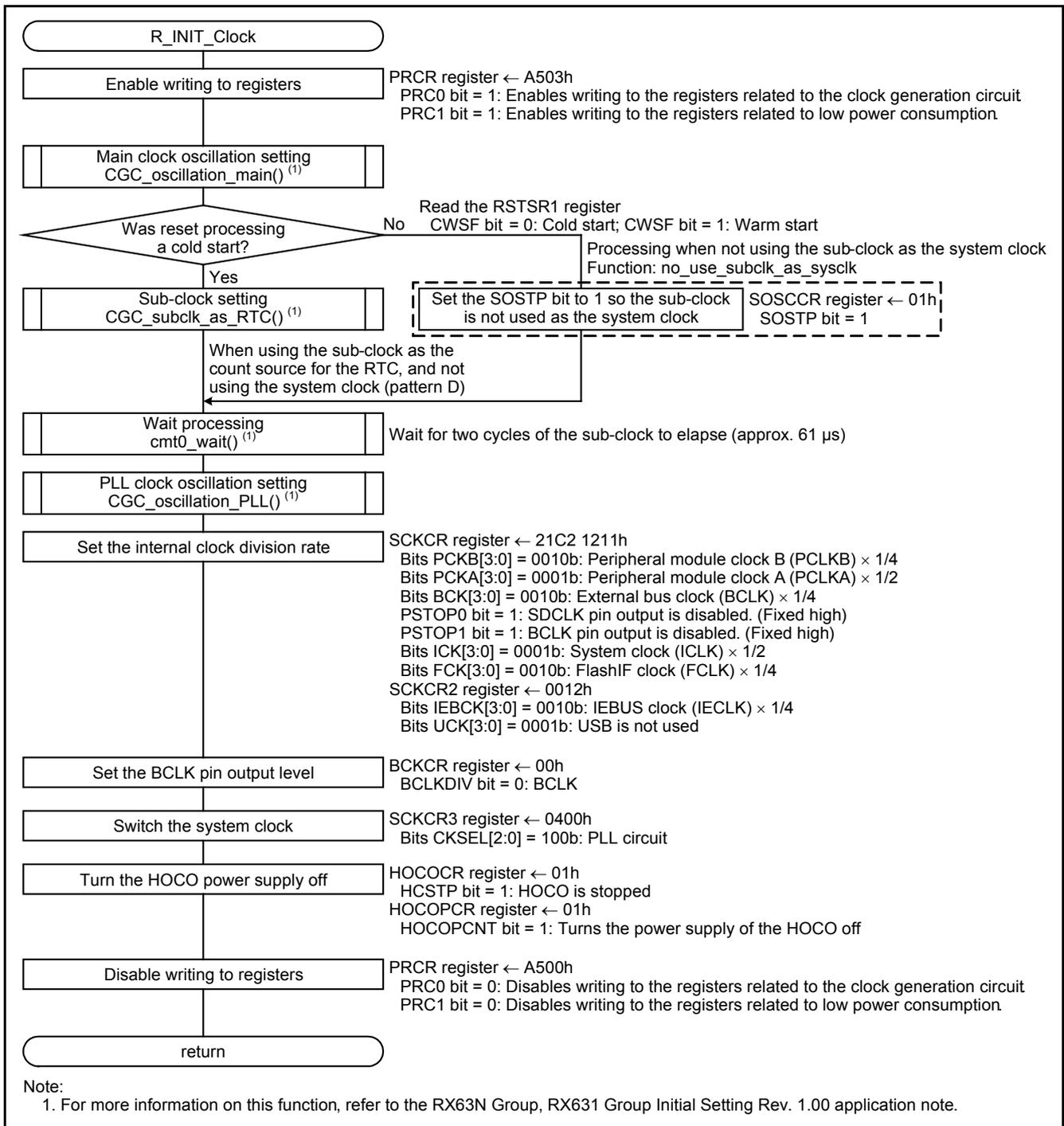


Figure 5.5 Clock Initialization

5.9.4 Peripheral Function Initialization

Figure 5.6 shows Peripheral Function Initialization.

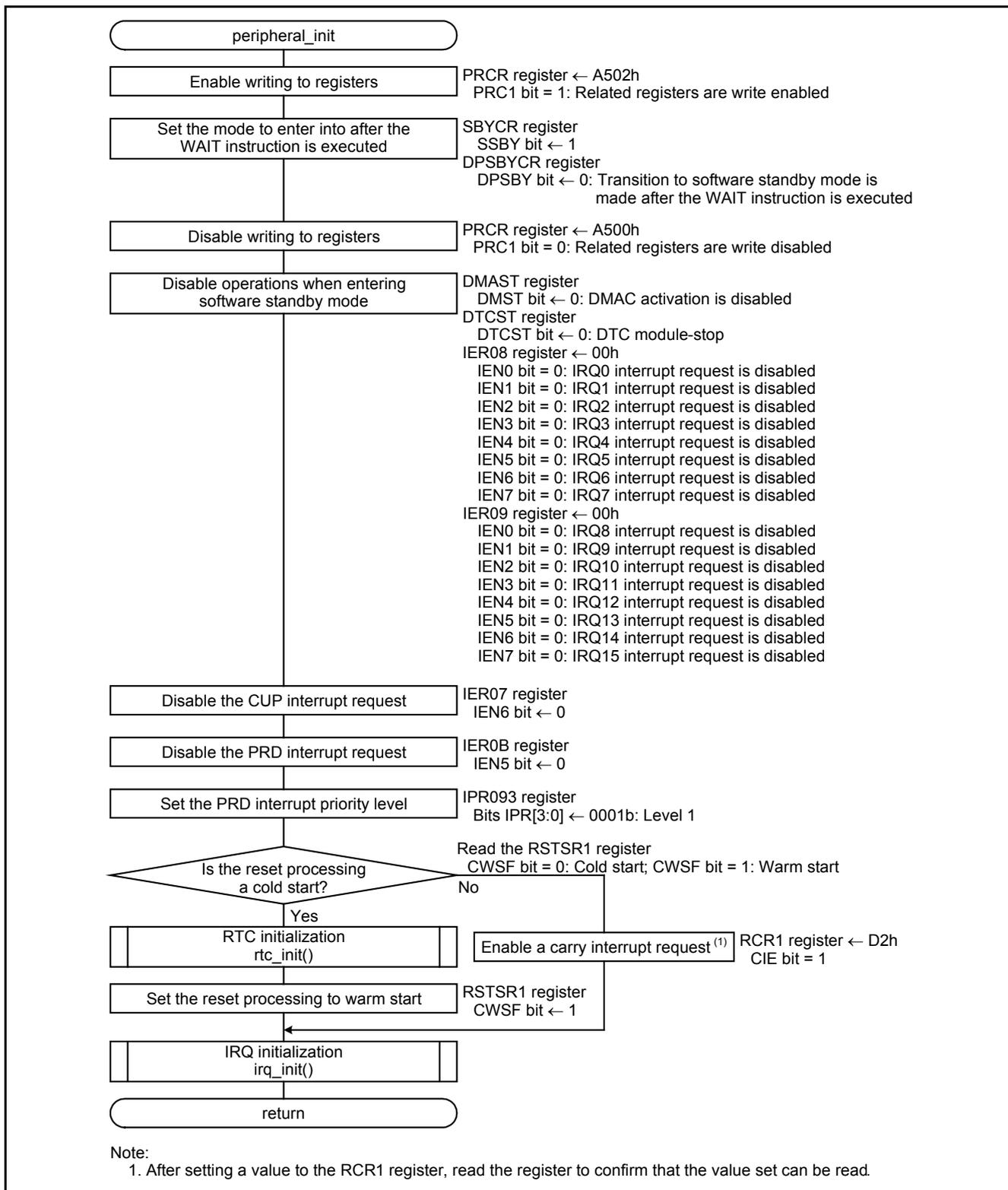


Figure 5.6 Peripheral Function Initialization

5.9.5 IRQ Initialization

Figure 5.7 shows IRQ Initialization.

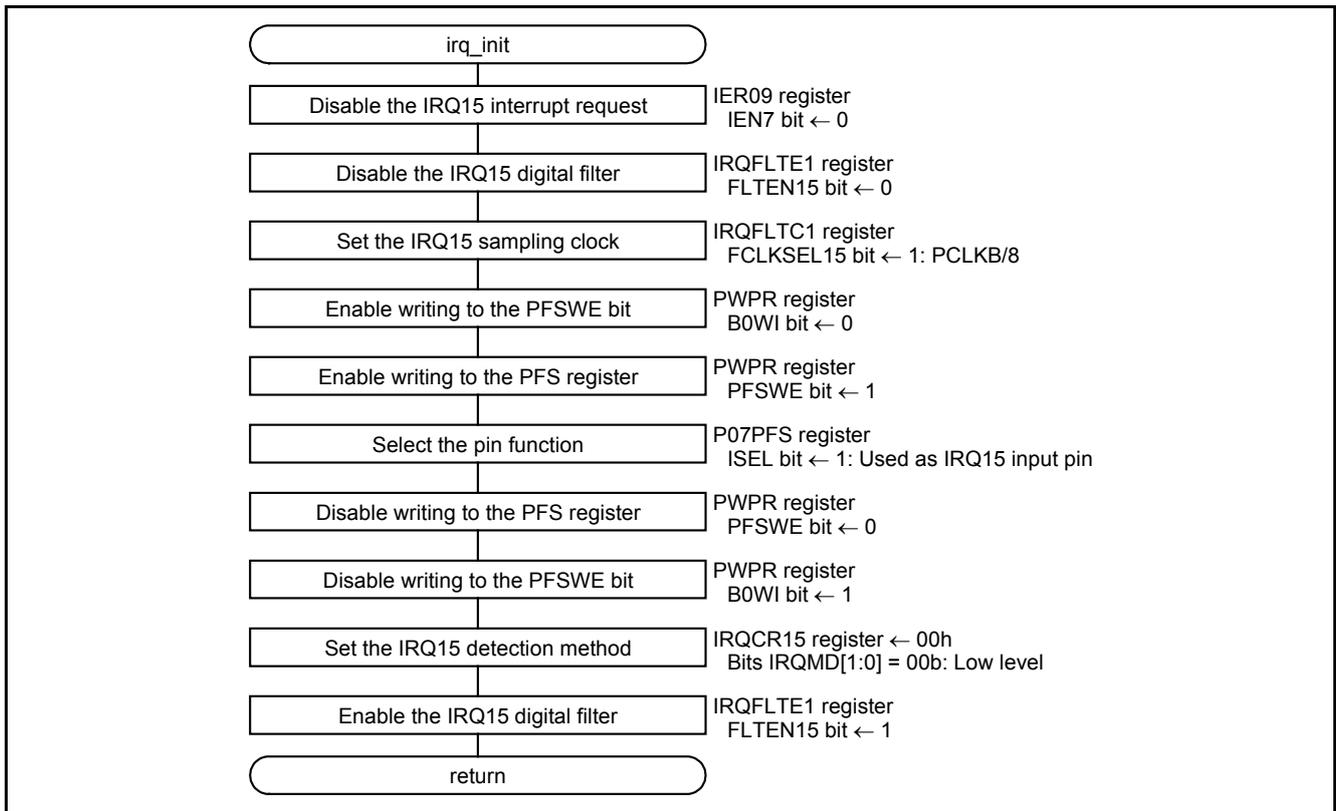


Figure 5.7 IRQ Initialization

5.9.6 RTC Initialization

Figure 5.8 shows RTC Initialization.

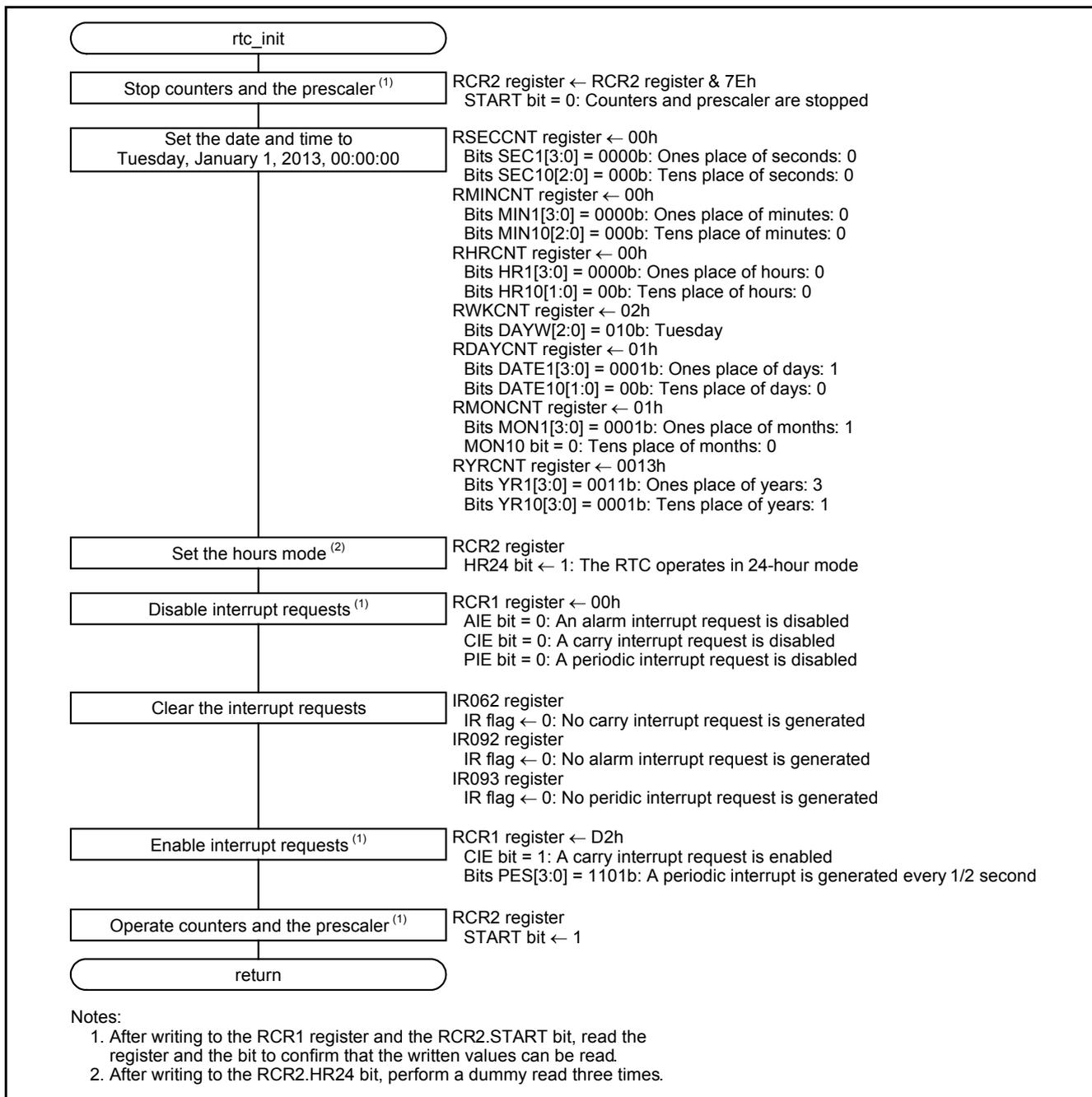


Figure 5.8 RTC Initialization

5.9.7 Reading RTC Time Information

Figure 5.9 shows the Reading RTC Time Information.

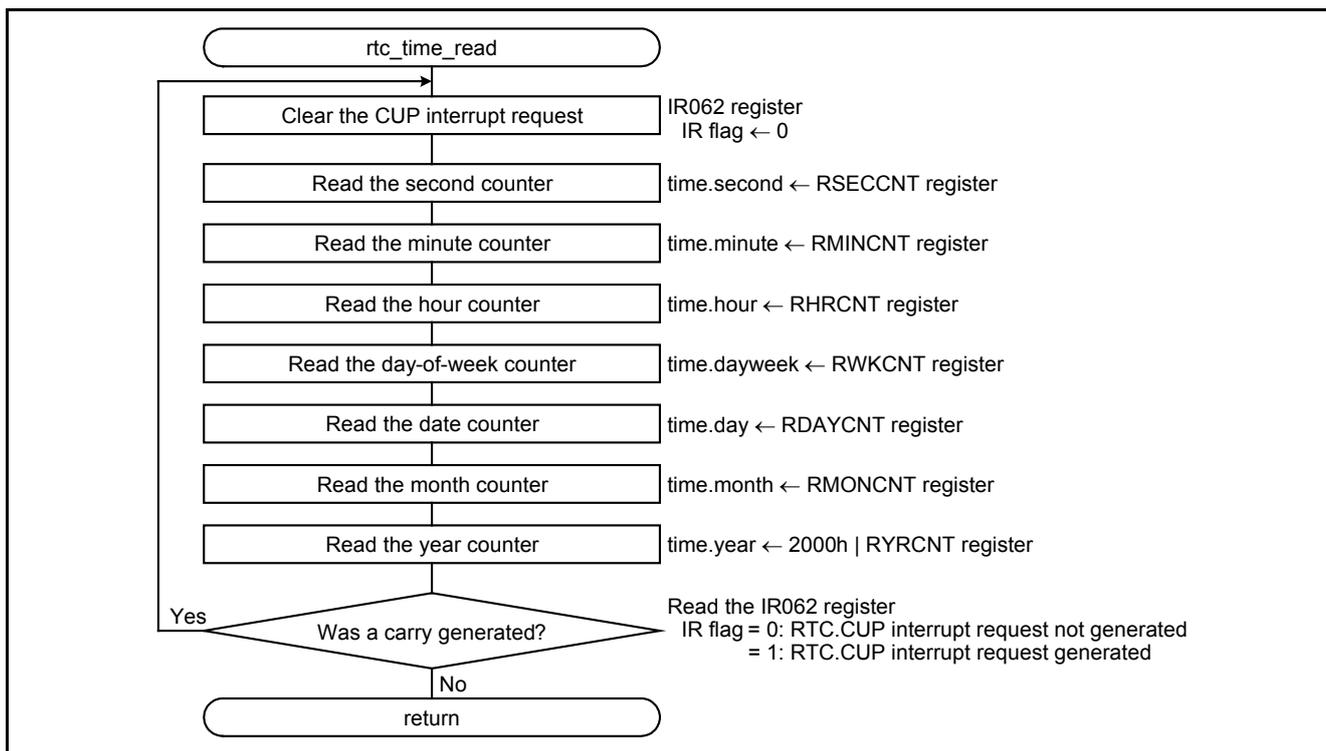


Figure 5.9 Reading RTC Time Information

5.9.8 Preparation to Enter Software Standby Mode

Figure 5.10 shows Preparation to Enter Software Standby Mode.

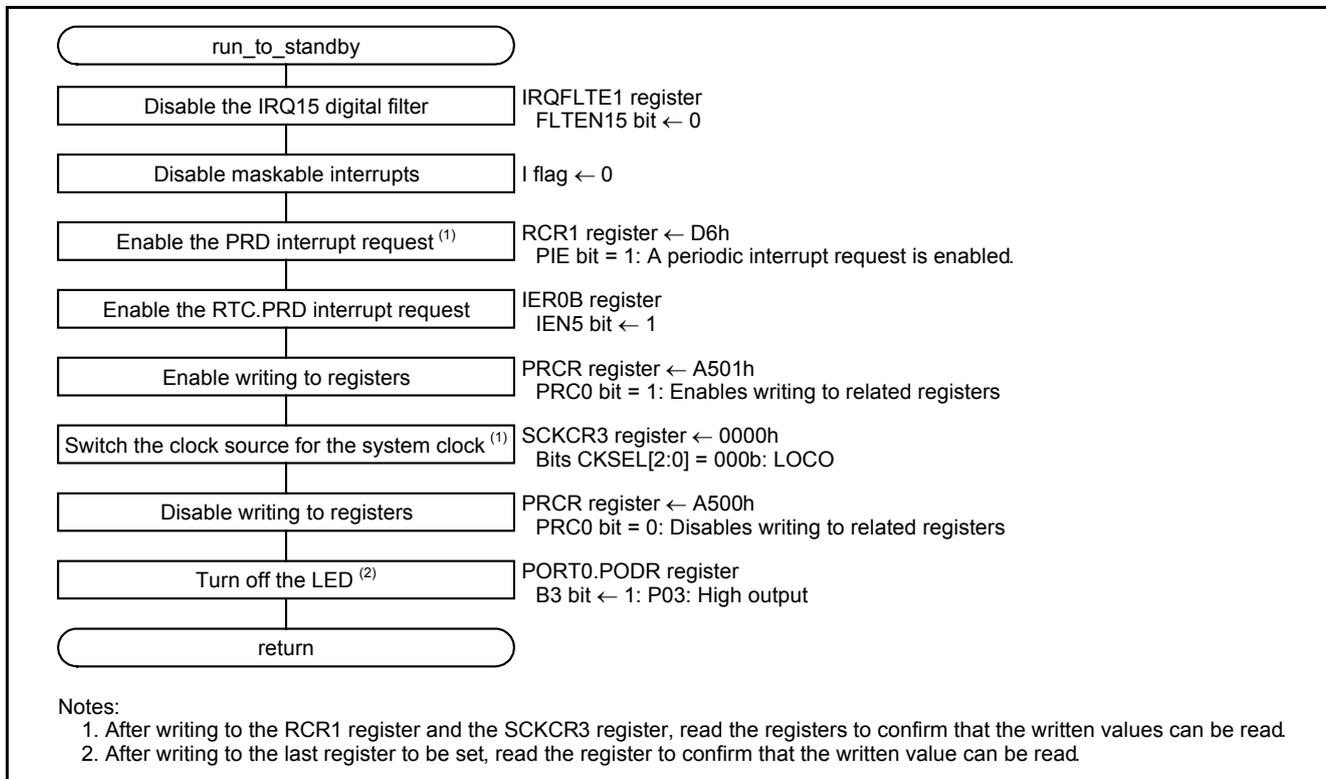


Figure 5.10 Preparation to Enter Software Standby Mode

5.9.9 Exiting Software Standby Mode

Figure 5.11 shows Exiting Software Standby Mode.

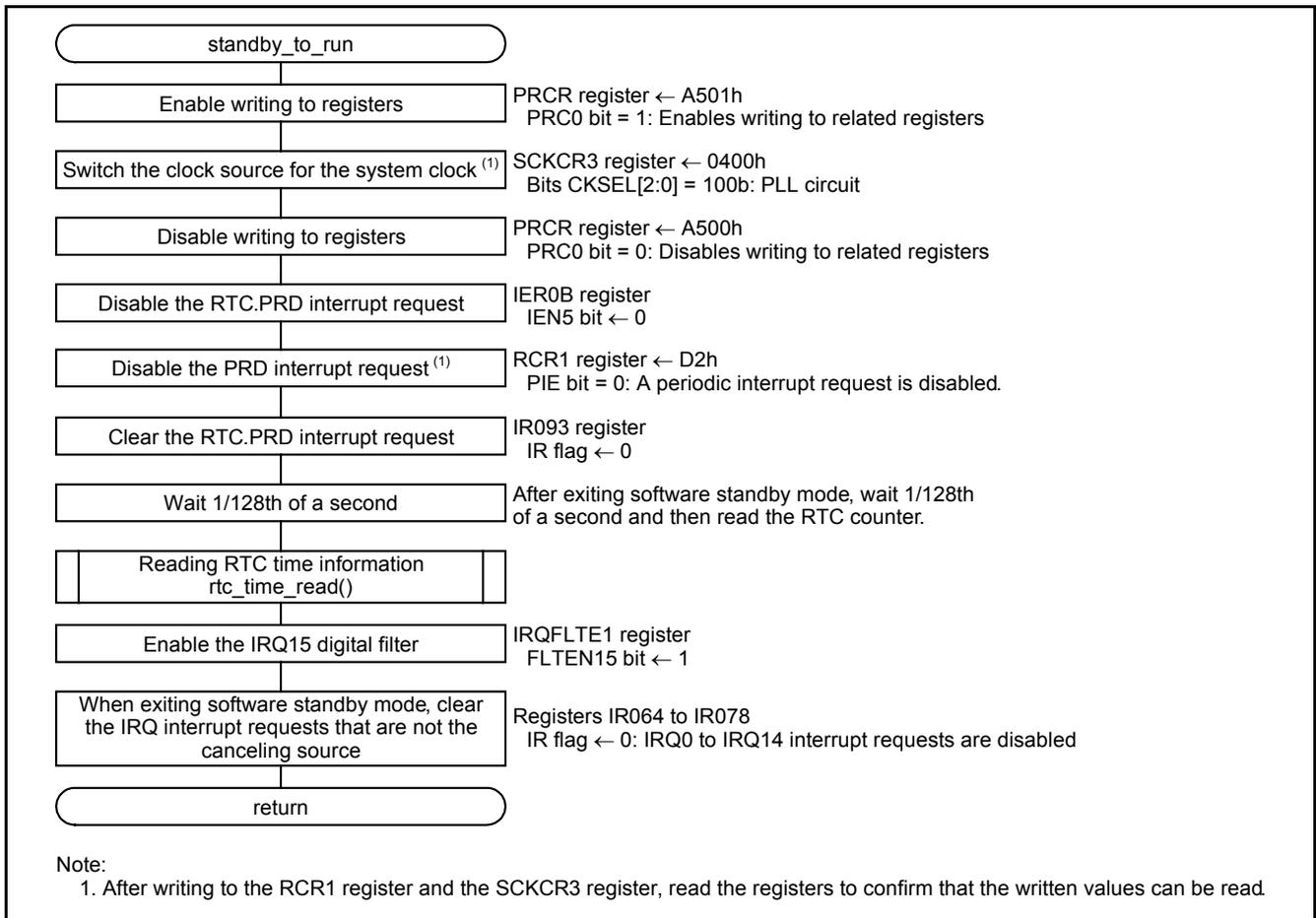


Figure 5.11 Exiting Software Standby Mode

5.9.10 RTC Period Interrupt Handling

Figure 5.12 shows RTC Period Interrupt Handling.

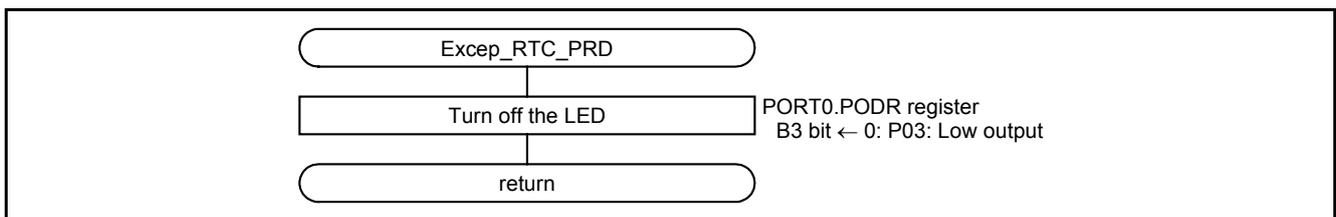


Figure 5.12 RTC Period Interrupt Handling

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

User's Manual: Hardware

RX63N Group, RX631 Group User's Manual: Hardware Rev.1.50 (R01UH0041EJ)

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 C/C++ Compiler Package V.1.01 User's Manual Rev.1.00 (R20UT0570EJ)

The latest version can be downloaded from the Renesas Electronics website.

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REVISION HISTORY	RX63N Group, RX631 Group Application Note Exiting Software Standby Mode Using the RTCa
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Rev.	Date	Description	
		Page	Summary
1.00	June 14, 2013	—	First edition issued

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General Precautions in the Handling of MPU/MCU Products

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1. Handling of Unused Pins

Handle unused pins in accord 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

Access to reserved addresses is prohibited.

- The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

After applying a reset, only release the reset line after the operating clock signal has become stable.

When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

Before changing from one product to another, i.e. to one with a different part number, confirm that the change will not lead to problems.

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