RL78/G13

Real-Time Clock CC-RL

R01AN2590EJ0200
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Introduction

This application note describes the real-time clock (RTC). It shows example settings for using the constant-period interrupt function and alarm interrupt function of the real-time clock.

Target Device

RL78/G13

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

Contents

1. Specifications

This application note shows example settings for using the constant-period interrupt function and alarm interrupt function of the real-time clock (RTC). The constant-period interrupt function provides an inverted output to the external output pin by using interrupts. The alarm interrupt function generates an alarm interrupt upon the elapse of five seconds after the date and time specified with the clock.

Table 1.1 lists the peripheral functions to be used and their uses. Figure 1.1 presents an overview of sample code operation.

Table 1.1 Peripheral Functions to be Used and Their Uses

Peripheral Function	Use
Real-time clock	Used to generate RTC interrupts (INTRTC).
P10	Set to a port output (inverted output) by constant-period interrupt processing.
P11	Set to a port output (high-level output) by alarm interrupt processing.

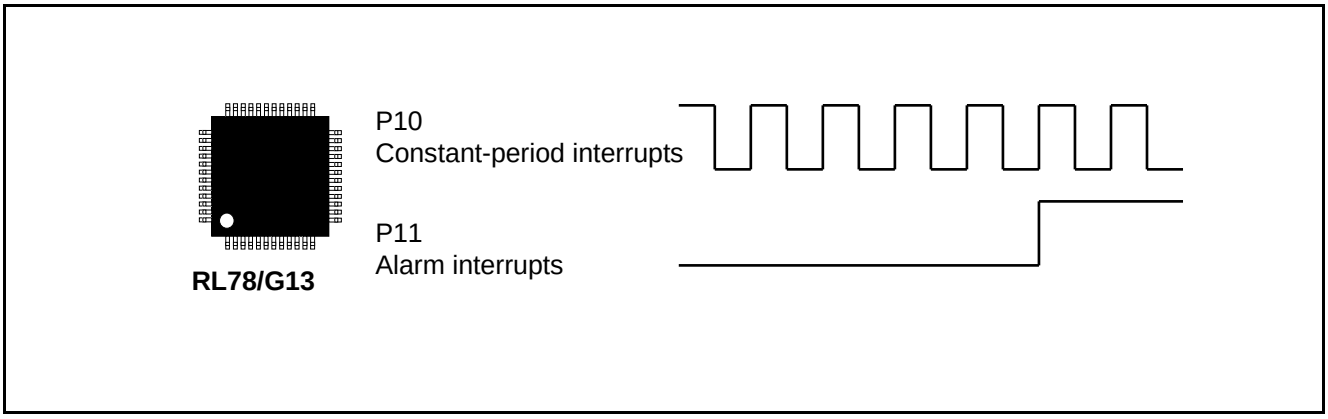

Figure 1.1 Overview of Sample Code Operation

2. Operation Check Conditions

The sample code described in this application note has been checked under the conditions listed in the table below.

Table 2.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/G13 (R5F100LEA)
Operating frequency	• High-speed on-chip oscillator (HOCO) clock: 32 MHz • CPU/peripheral hardware clock: 32 MHz
Operating voltage	5.0 V (Operation is possible over a voltage range of 2.9 V to 5.5 V.) LVD operation (V_{LVD}): Reset mode which uses 2.81 V (2.76 V to 2.87 V)
Integrated development environment (CS+)	CS+ for CC V3.01.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.01.00 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio V4.0.0.26 from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.01.00 from Renesas Electronics Corp.

3. Related Application Note

The application note that is related to this application note is listed below for reference.

- RL78/G13 Initialization (R01AN2575E) Application Note

4. Description of the Hardware

4.1 Hardware Configuration Example

Figure 4.1 shows an example of hardware configuration that is used for this application note.

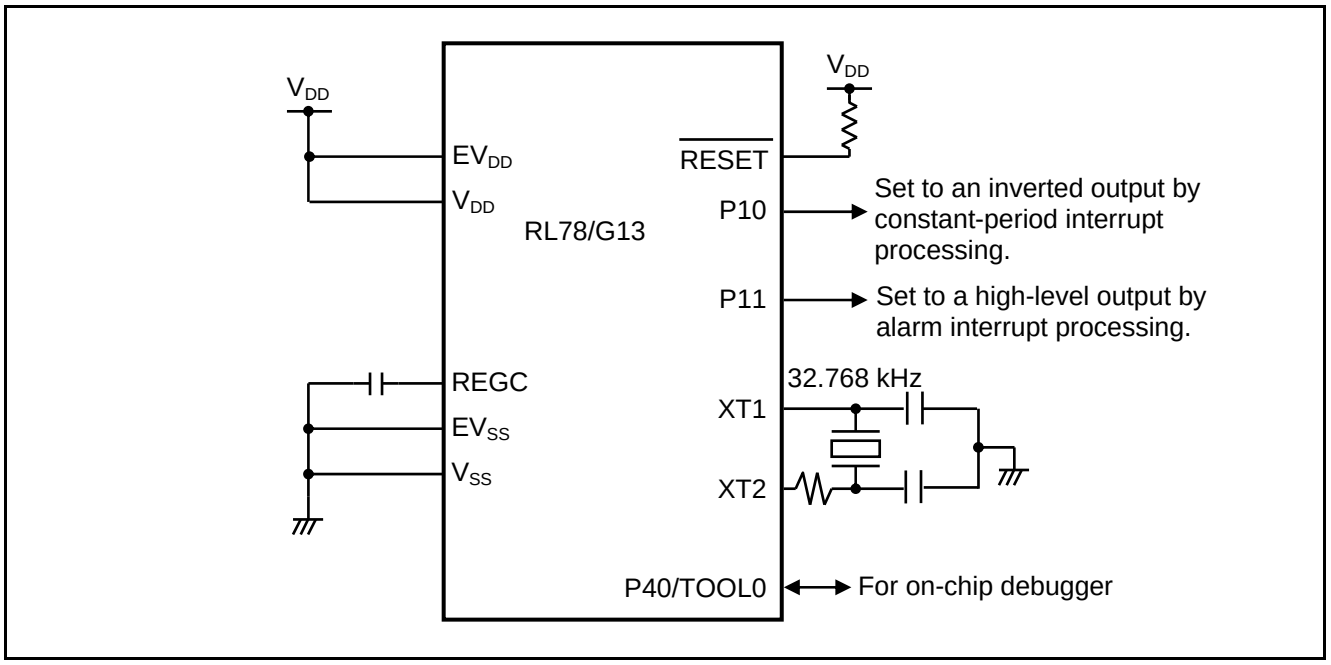

Figure 4.1 Hardware Configuration

Cautions: 1. The purpose of this circuit is only to provide the connection outline and the circuit is simplified accordingly. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met (connect the input-only ports separately to V_{DD} or V_{SS} via a resistor).
2. Connect any pins whose name begins with EV_{SS} to V_{SS} and any pins whose name begins with EV_{DD} to V_{DD}, respectively.
3. V_{DD} must be held at not lower than the reset release voltage (V_{LVD}) that is specified as LVD.

4.2 List of Pins to be Used

Table 4.1 lists the pins to be used and their functions.

Table 4.1 Pins to be Used and Their Functions

Pin Name	I/O	Description
P10	Output	Set to an inverted output by constant-period interrupt processing.
P11	Output	Set to a high-level output by alarm interrupt processing.

5. Description of the Software

5.1 Operation Outline

After initialization, the current date and time of the clock are set to “2010/4/1 (THU) 15:59:55” and the alarm date and time to “16:00:00 each day” for the operations described in this application note. Also, the following interrupt processing is performed:

- Constant-period interrupt processing for setting P10 to an inverted output
- Alarm interrupt processing for setting P11 to a high-level output

(1) Initialize the real-time clock (RTC).
< Conditions for setting>

- Select the subsystem clock (f_{SUB}) as the RTC operation clock.
- Disable the RTC1HZ pin output.
- Present the time in 24-hour system.
- Enable RTC constant-period interrupts and set their cycle time to 0.5 second.
- Initialize the current date and time to 2001/1/1 (Monday) 00:00:00.
- Enable INTRTC interrupts.

(2) Configure the I/O ports.

- Configure P10 as an output port (initial value: high level) for constant-period interrupt processing.
- Configure P11 as an output port (initial value: low level) for alarm interrupt processing.

Caution: For precautions in using the device, refer to RL78/G13 User's Manual: Hardware.

5.2 List of Option Byte Settings

Table 5.1 summarizes the settings of the option bytes.

Table 5.1 Option Byte Settings

Address	Value	Description
000C0H/010C0H	01101110B	Disables the watchdog timer. (Stops counting after the release from the reset state.)
000C1H/010C1H	01111111B	LVD reset mode, 2.81 V (2.76 V to 2.87 V)
000C2H/010C2H	11101000B	HS mode, HOCO: 32 MHz
000C3H/010C3H	10000101B	Enables the on-chip debugger.

5.3 List of Constants

Table 5.2 lists the constants that are used in this sample program.

Table 5.2 Constants for the Sample Program

Constant	Setting	Description
HALFSEC	1U	Specifies the cycle time (0.5 s) for constant-period interrupts.
MD_OK	0x00U	Setup status (setup completed)
MD_ARGERROR	0x81U	Setup status (setup unsuccessful due to an invalid argument)
MD_BUSY1	0x03U	Setup status (setup unsuccessful due to a counter deactivation failure)
MD_BUSY2	0x04U	Setup status (setup unsuccessful due to a counter activation failure)
_01_RTC_COUNTER_PAUSE	0x01U	Specifies whether to activate or deactivate the real-time clock counter. Setting: Activates the counter.
RTC_WAITTIME	320U	Specifies the wait time (about 10 μs) after switching between activation and deactivation of the real-time clock counter.
_80_RTC_ALARM_ENABLE	0x80U	Specifies whether to enable or disable alarm operation. Setting: Enables alarm operation.
_40_RTC_ALARM_INT_ENABLE	0x40U	Specifies whether to enable or disable interrupts due to alarm matching. Setting: Enables interrupts.
_10_RTC_ALARM_MATCH	0x10U	Clears the alarm detection status flag.
_08_RTC_INTC_GENERATE_FLAG	0x08U	Clears the constant-period interrupt status flag.

5.4 List of Functions

Table 5.3 lists the functions that are used in this sample program.

Table 5.3 Functions for the Sample Program

Function Name	Outline
R_RTC_Set_ConstPeriodInterruptOn	Enables constant-period interrupts.
R_RTC_Start	Enables the RTC.
R_RTC_Set_CounterValue	Changes the RTC counter value.
R_RTC_Set_AlarmValue	Configures the alarm output.
r_rtc_interrupt	Processes RTC interrupts (INTRTC).
r_rtc_callback_alarm	Processes alarm interrupts.
r_rtc_callback_constperiod	Processes constant-period interrupts.
r_alarm_proc	Event processes when the alarm interrupt occurs.

5.5 Function Specifications

This section describes the specifications for the functions that are used in this sample program.

[Function Name] R_RTC_Set_ConstPeriodInterruptOn	
Synopsis	Constant-period interrupt enable
Header	r_cg_rtc.h
Declaration	MD_STATUS R_RTC_Set_ConstPeriodInterruptOn(rtc_int_period_t period)
Explanation	This function configures the constant-period interrupt.
Arguments	rtc_int_period_t period : [Constant-period interrupt period]
Return value	MD_ARGERROR: Argument invalid MD_OK: Setup completed and operation started
Remarks	None

[Function Name] R_RTC_Start	
Synopsis	RTC enable
Header	r_cg_rtc.h
Declaration	void R_RTC_Start(void)
Explanation	This function enables the RTC.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_RTC_Set_CounterValue	
Synopsis	RTC counter value change
Header	r_cg_rtc.h
Declaration	MD_STATUS R_RTC_Set_CounterValue(rtc_counter_value_t counter_write_val)
Explanation	This function sets RTC counter values.
Arguments	rtc_counter_value_t counter_write_val : [Storing count register values]
Return value	MD_OK: Setup completed Others: Setup incomplete or unsuccessful
Remarks	None

[Function Name] R_RTC_Set_AlarmValue	
Synopsis	Alarm output setup
Header	r_cg_rtc.h
Declaration	void R_RTC_Set_AlarmValue(rtc_alarm_value_t alarm_val)
Explanation	This function configures the alarm interrupt.
Arguments	rtc_alarm_value_t alarm_val : [Alarm output conditions]
Return value	None
Remarks	None

[Function Name] r_rtc_interrupt	
Synopsis	RTC interrupt (INTRTC) processing
Header	r_cg_rtc.h
Declaration	static void __near r_rtc_interrupt(void)
Explanation	Constant-period interrupts and alarm interrupts arise from the same interrupt source (INTRTC). This function makes a distinction between the two types of interrupts. An alarm interrupt triggers alarm interrupt processing. A constant-period interrupt triggers constant-period interrupt processing.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_rtc_callback_alarm	
Synopsis	Alarm interrupt processing
Header	r_cg_rtc.h
Declaration	static void r_rtc_callback_alarm(void)
Explanation	This function sets P11 to a high-level output.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_rtc_callback_constperiod	
Synopsis	Constant-period interrupt processing
Header	r_cg_rtc.h
Declaration	static void r_rtc_callback_constperiod(void)
Explanation	This function inverts the P10 output.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_alarm_proc	
Synopsis	Event processing when the alarm interrupt occurs
Header	r_cg_rtc.h
Declaration	static void r_alarm_proc(void)
Explanation	Executed when an alarm interrupt occurs.
Arguments	None
Return value	None
Remarks	None

5.6 Flowcharts

Figure 5.1 shows the overall flow of the sample program described in this application note.

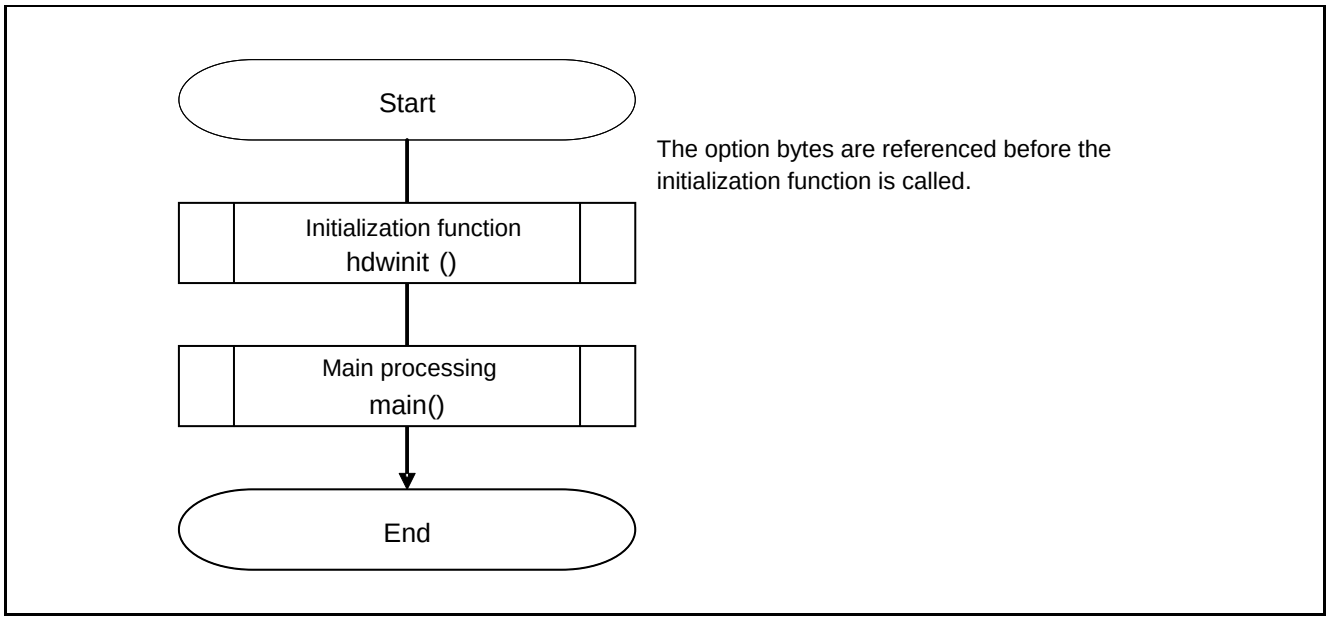

Figure 5.1 Overall Flow

Note: Startup routine is executed before and after the initialization function.

5.6.1 Initialization Function

Figure 5.2 shows the flowchart for the initialization function.

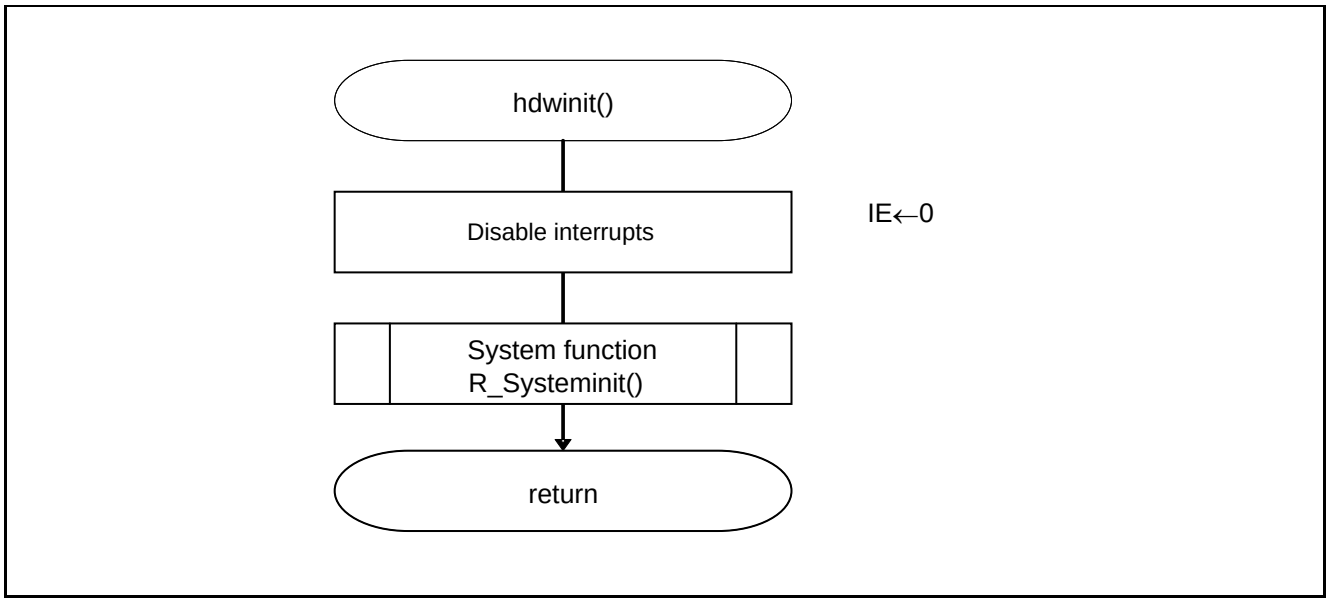

Figure 5.2 Initialization Function

5.6.2 System Function

Figure 5.3 shows the flowchart for the system function.

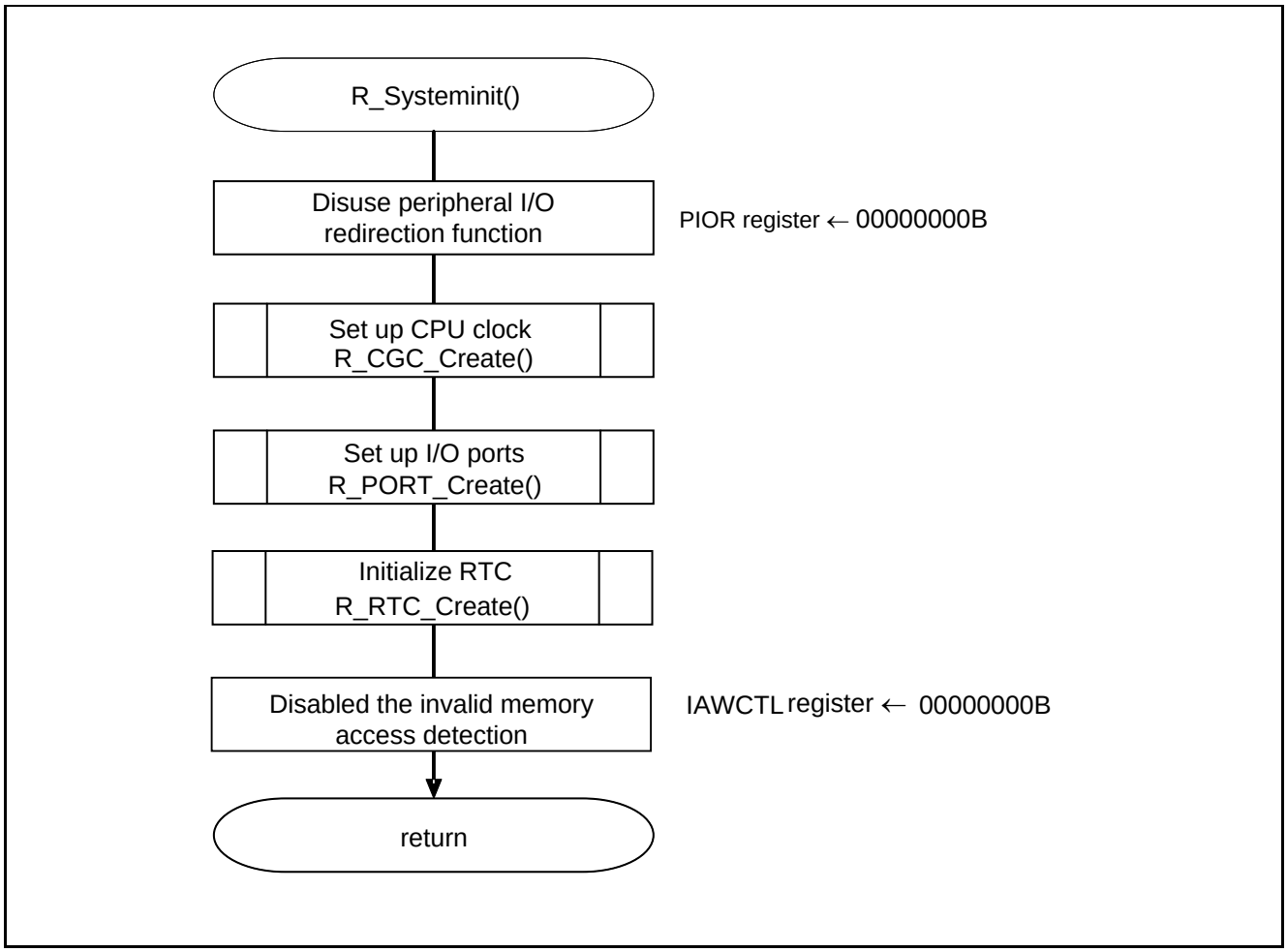

Figure 5.3 System Function

5.6.3 I/O Port Setup

Figure 5.4 shows the flowchart for setting up the I/O ports.

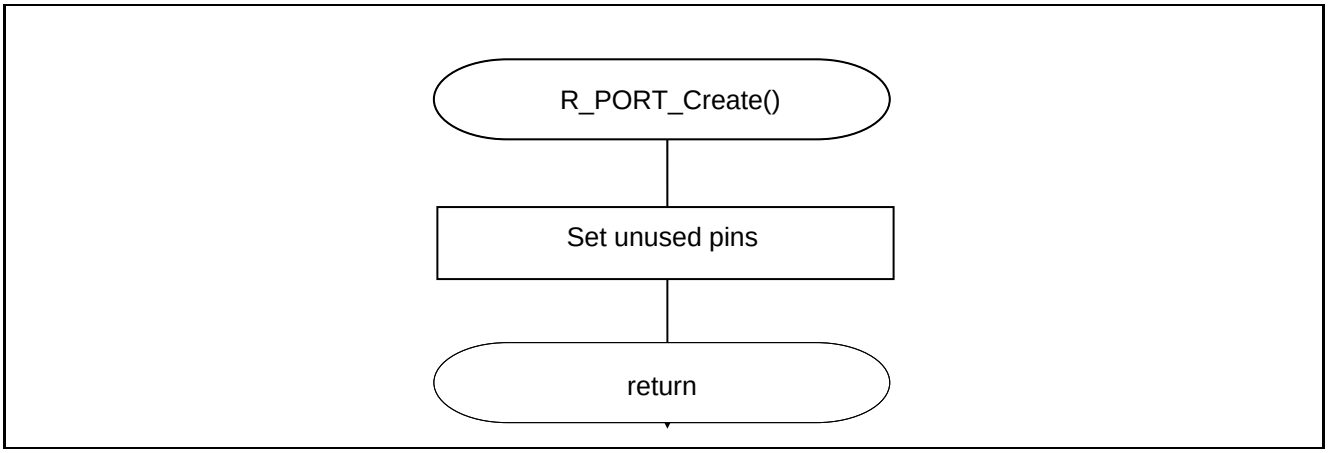

Figure 5.4 I/O Port Setup

Note: Refer to the section entitled "Flowcharts" in RL78/G13 Initialization Application Note (R01AN2575E) for the configuration of the unused ports.

Caution: Provide proper treatment for unused pins so that their electrical specifications are observed. Connect each of any unused input-only ports to V_{DD} or V_{SS} via a separate resistor.

Setting up the output pin by using real-time clock interrupts (INTRTC)

Symbol: PM1

7	6	5	4	3	2	1	0
PM17	PM16	PM15	PM14	PM13	PM12	PM11	PM10
x	x	x	x	x	x	**0**	**0**

Bits 1 and 0

PM1n	PMIn I/O mode selection (n = 0, 1)
0	**Output mode (output buffer on)**
1	Input mode (output buffer off)

Caution: For details on the register setup procedures, refer to RL78/G13 User's Manual: Hardware.

5.6.4 CPU Clock Setup

Figure 5.5 shows the flowchart for setting up the CPU clock.

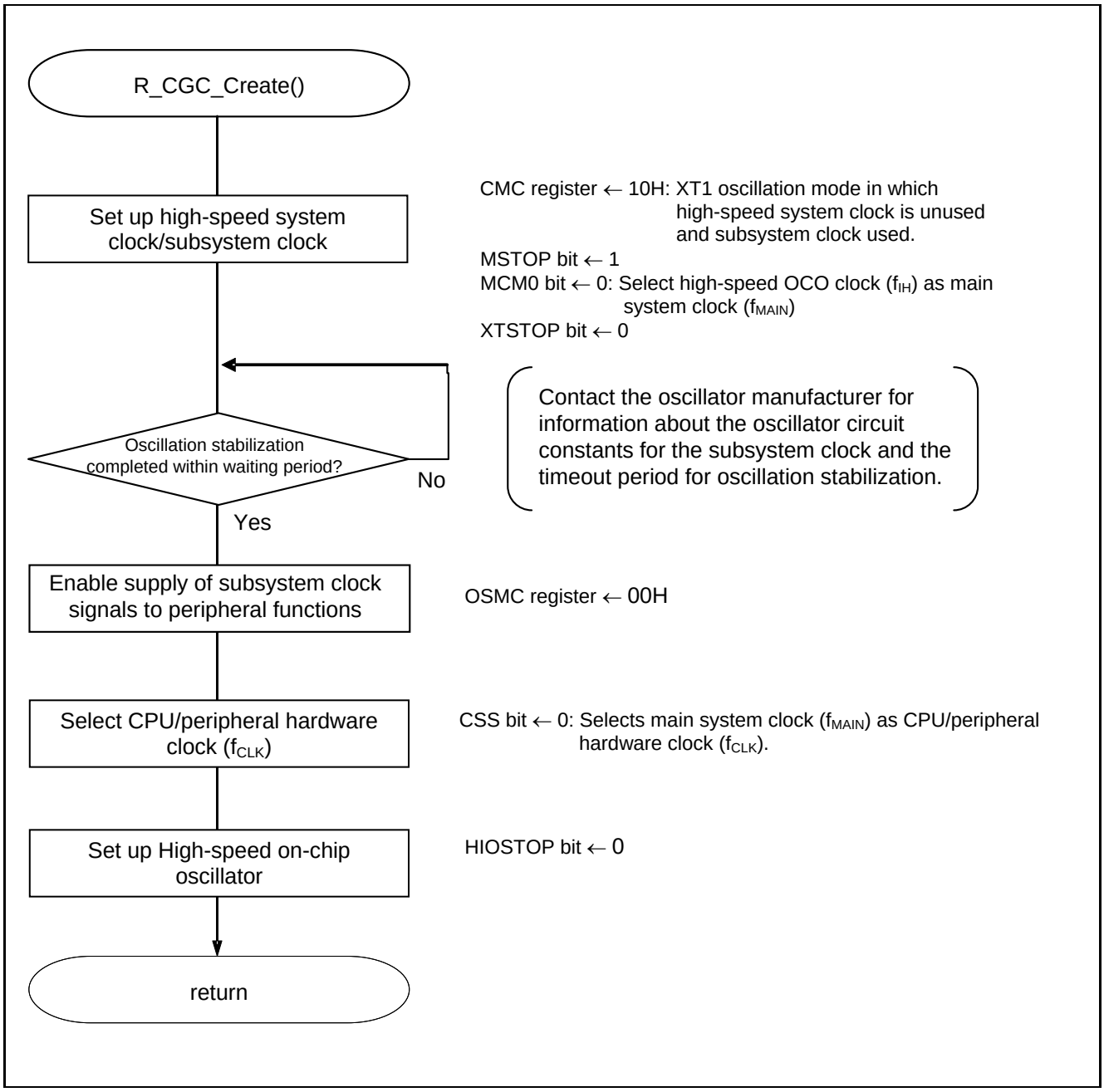

Figure 5.5 CPU Clock Setup

Remarks: CPU clock setup (R_CGC_Create()) determines whether stabilization of subsystem clock oscillation is completed within a waiting period (about 1 second). This period is specified with constant CGC_SUBWAITTIME in r_cg_cgc.h.

Caution: For details on the procedure for setting up the CPU clock (R_CGC_Create ()), refer to the section entitled "Flowcharts" in RL78/G13 Initialization Application Note (R01AN2575E).

5.6.5 RTC Initialization

Figure 5.6 shows the flowchart for RTC initialization.

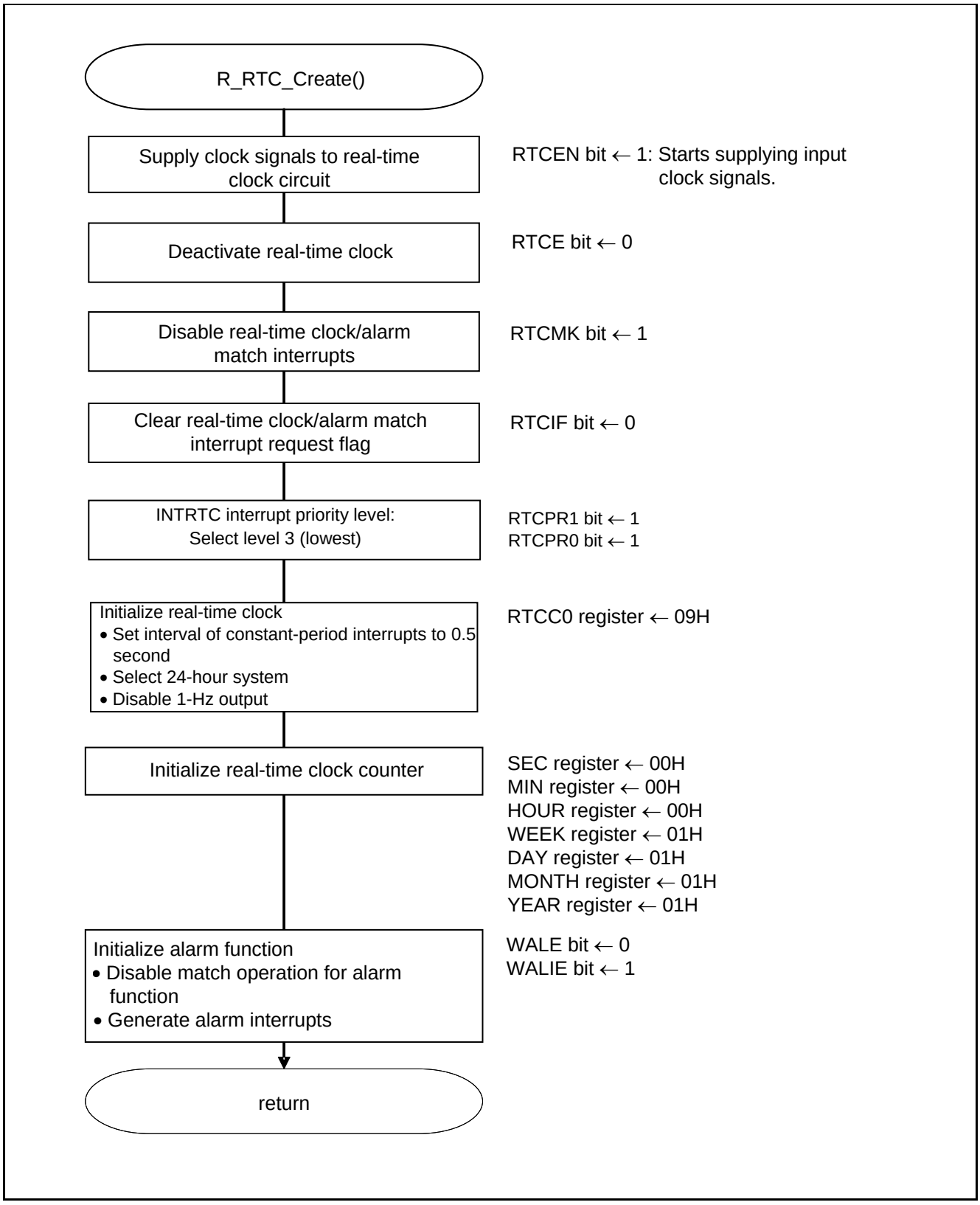

Figure 5.6 RTC Initialization

Enabling supply of clock signals to the RTC

- Peripheral enable register 0 (PER0)
  Enable supply of clock signals to the real-time clock.

Symbol: PER0

7	6	5	4	3	2	1	0
RTCEN	IICA1EN	ADCEN	IICA0EN	SAU1EN	SAU0EN	TAU1EN	TAU0EN
1	0	x	x	x	x	0	x

Bit 7

RTCEN	Control of input clock signals to the real-time clock
0	Stops input clock supply.
1	**Enables input clock supply.**

RTC operation control

- Real-time clock control register 0 (RTCC0)
  Select a time format.
  Set the interval of constant-period interrupts.

Symbol: RTCC0

7	6	5	4	3	2	1	0
RTCE	0	RCLOE1	0	AMPM	CT2	CT1	CT0
0	0	**0**	0	**1**	**0**	**0**	**1**

Bit 7

RTCE	Real-time clock operation control
0	**Stops the counter operation.**
1	Starts the counter operation.

Bit 3

AMPM	Selection of 12-/24-hour system
0	12-hour system (a.m. and p.m. are displayed.)
1	**24-hour system**

Bits 2 to 0

CT2	CT1	CT0	Constant-period interrupt (INTRTC) selection
0	0	0	Does not use constant-period interrupt function.
0	**0**	**1**	**Once per 0.5 s (synchronized with second count up)**
0	1	0	Once per 1 s (same time as second count up)
0	1	1	Once per 1 m (second 00 of every minute)
1	0	0	Once per 1 hour (minute 00 and second 00 of every hour)
1	0	1	Once per 1 day (hour 00, minute 00, and second 00 of every day)
1	1	x	Once per 1 month (Day 1, hour 00 a.m., minute 00, and second 00 of every month)

Caution: For details on the register setup procedures, refer to RL78/G13 User's Manual: Hardware.

Specifying the date and time in the format of year, month, day, week, hour, minute and second.

- Count registers (YEAR, MONTH, DAY, WEEK, HOUR, MIN and SEC)
  Specify the date and time.

Symbol: YEAR

7	6	5	4	3	2	1	0
00 to 99 (BCD code)							

Symbol: MONTH

7	6	5	4	3	2	1	0
0	0	0	01 to 12 (BCD code)				

Symbol: DAY

7	6	5	4	3	2	1	0
0	0	01 to 31 (BCD code)					

Symbol: WEEK

7	6	5	4	3	2	1	0
0	0	0	0	0	0 to 6		

Symbol: HOUR

7	6	5	4	3	2	1	0
0	0	0 to 23 or 1 to 12, 21 to 32 (BCD code)					

Symbol: MIN

7	6	5	4	3	2	1	0
0	0 to 59 (BCD code)						

Symbol: SEC

7	6	5	4	3	2	1	0
0	0 to 59 (BCD code)						

Caution: For details on the register setup procedures, refer to RL78/G13 User's Manual: Hardware.

Configuring the alarm interrupt generated by the real-time clock

- Real-time clock control register 1 (RTCC1)
  Configure the alarm match operation.
  Configure the alarm match interrupt.

Symbol: RTCC1

7	6	5	4	3	2	1	0
WALE	WALIE	0	WAFG	RIFG	0	RWST	RWAIT
0	**1**	0	x	x	0	x	x

Bit 7

WALE	Alarm operation control
0	**Disables match operation.**
1	Enables match operation.

Bit 6

WALIE	Alarm interrupt (INTRTC) function control
0	Does not generate interrupts due to an alarm match.
1	**Generates interrupts due to an alarm match.**

Caution: For details on the register setup procedures, refer to RL78/G13 User's Manual: Hardware.

5.6.6 Main Processing

Figures 5.7 and 5.8 show the flowcharts for main processing.

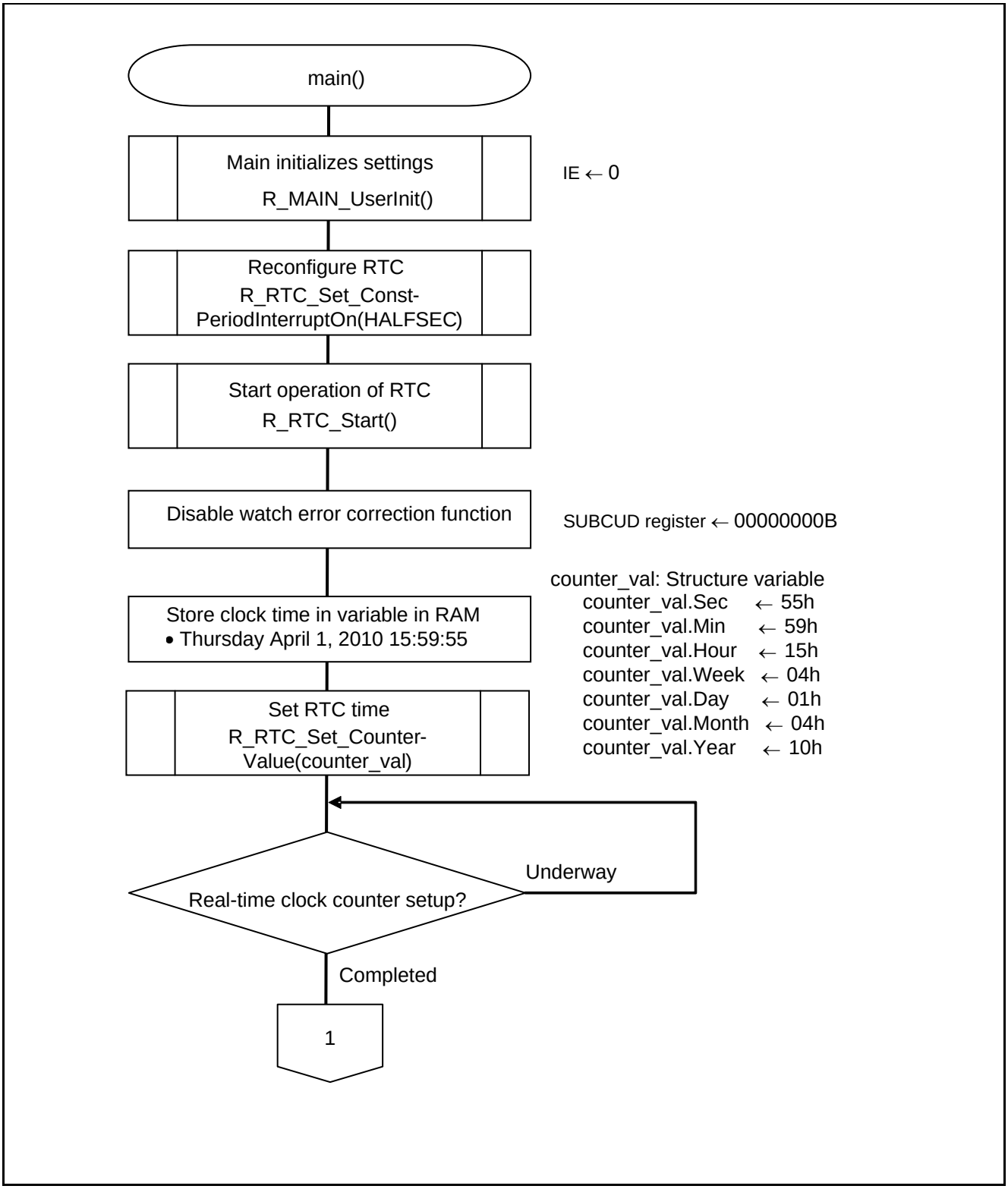

Figure 5.7 Main Processing (1/2)

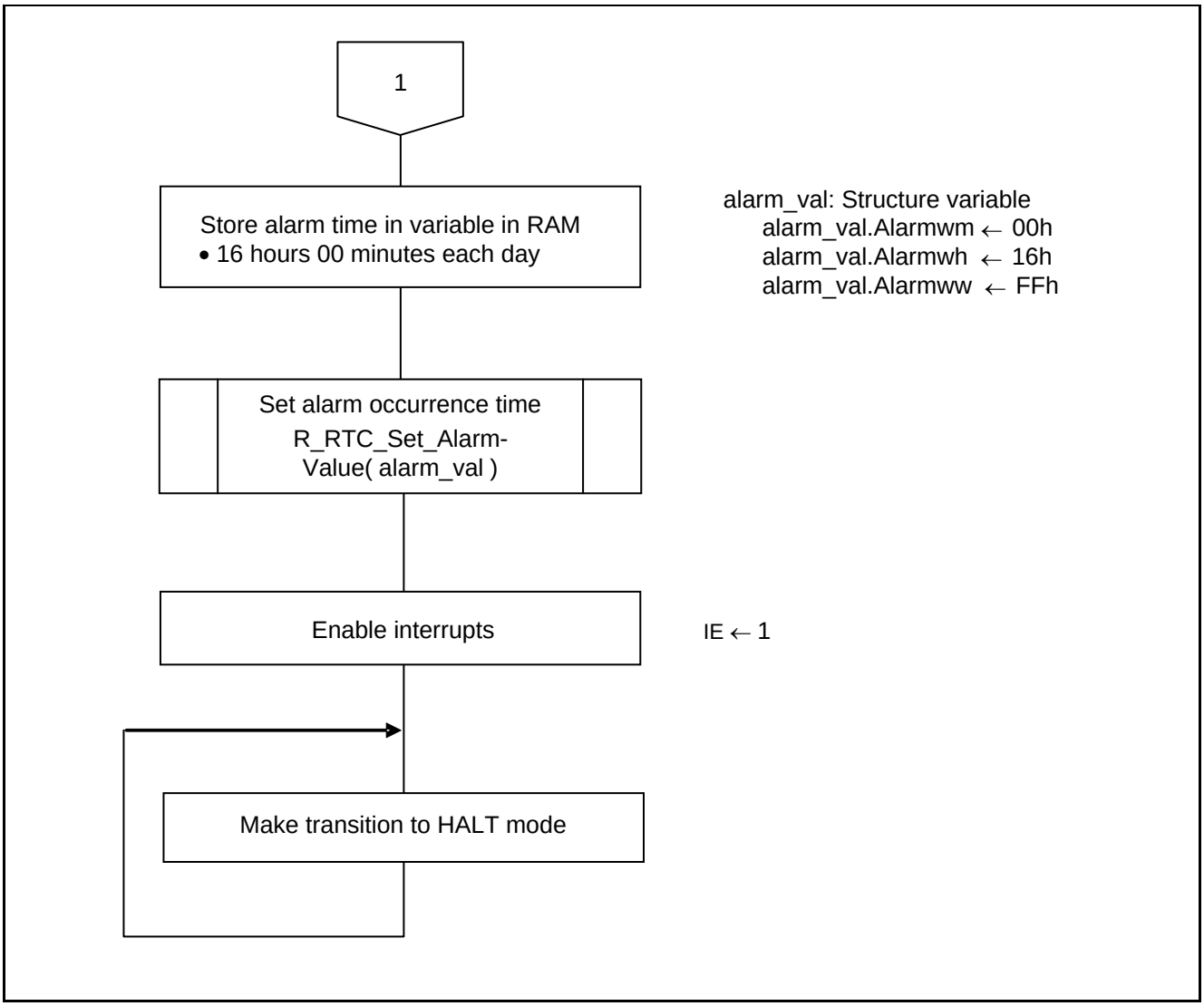

Figure 5.8 Main Processing (2/2)

Correcting the watch error

- Watch error correction register (SUBCUD)
  Correct the watch error by incrementing or decrementing it.

Symbol: SUBCUD

7	6	5	4	3	2	1	0
DEV	F6	F5	F4	F3	F2	F1	F0
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Bit 7

DEV	Setting of watch error correction timing
0	**Corrects watch error when the second digits are at 00, 20, or 40 (every 20 seconds).**
1	Corrects watch error only when the second digits are at 00 (every 60 seconds).

Bit 6

F6	Setting of watch error correction value
0	**Increases by {(F5, F4, F3, F2, F1, F0) – 1} × 2.**
1	**Decreases by {(/F5, /F4, /F3, /F2, /F1, /F0) + 1} × 2.**

Caution: For details on the register setup procedures, refer to RL78/G13 User's Manual: Hardware.

5.6.7 Main initializes settings

Figure 5.9 shows the flowchart for the main initializes settings.

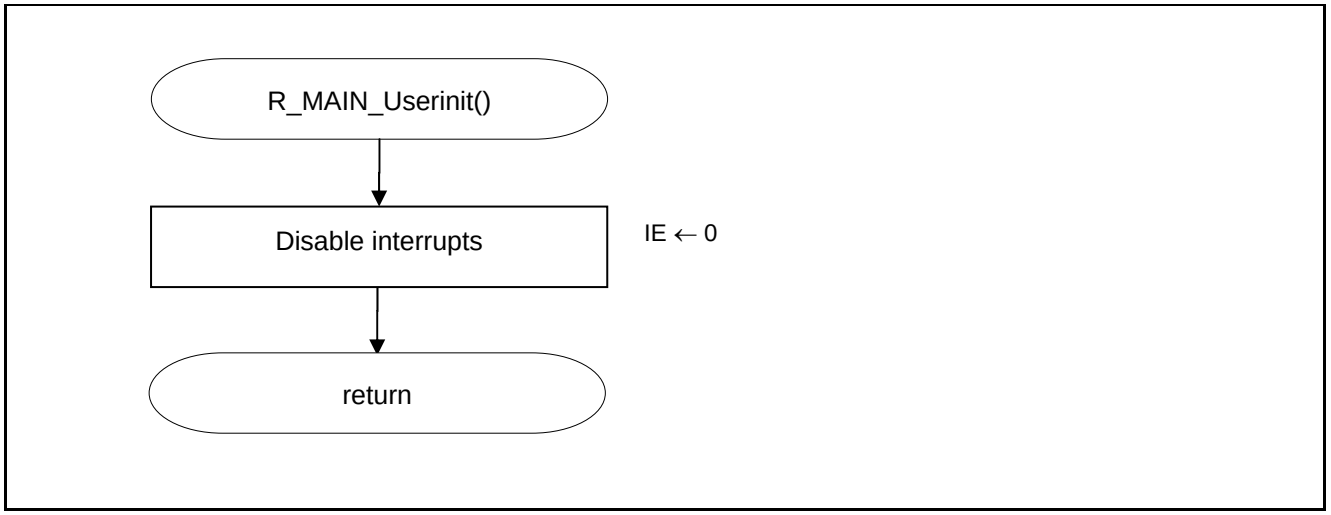

Figure 5.9 Main initializes settings

5.6.8 RTC Reconfiguration

Figure 5.10 shows the flowchart for main processing.

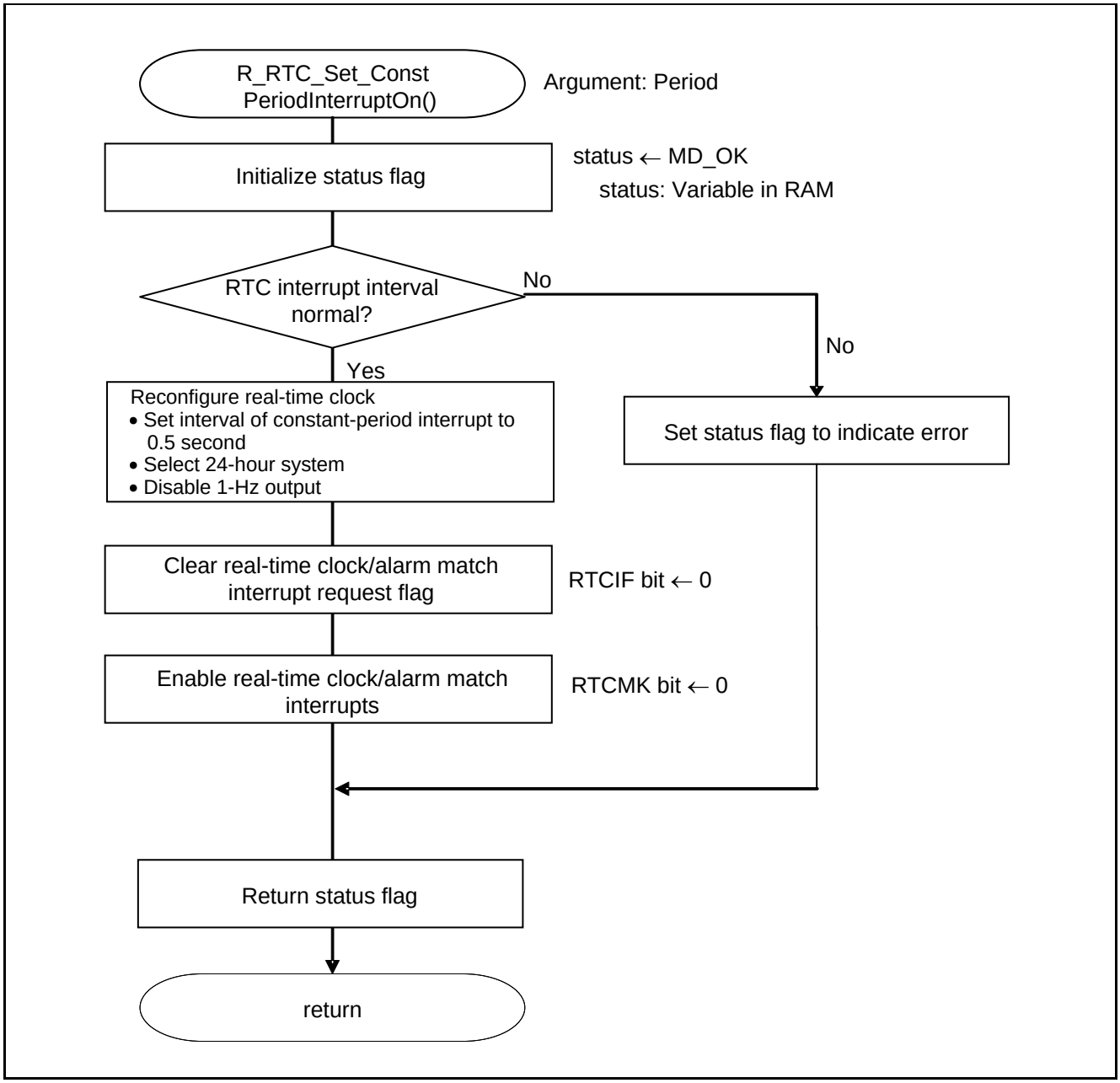

Figure 5.10 RTC Reconfiguration

5.6.9 RTS Startup

Figure 5.11 shows the flowchart for starting the operation of the RTC.

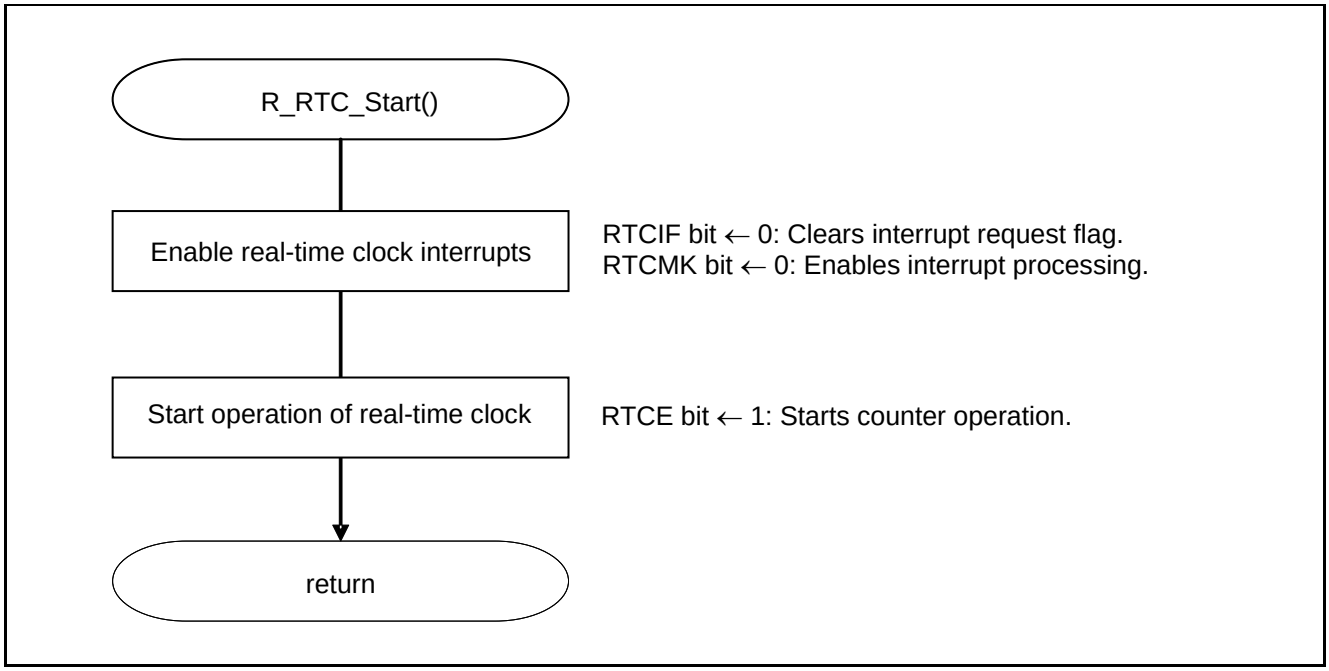

Figure 5.11 RTC Startup

Configuring the RTC interrupt (INTRTC)

- Interrupt request flag register (IF1H)
  Clear the RTCIF interrupt source flag.
- Interrupt mask flag register (MK1H)
  Mask RTCMK interrupts.

Symbol: IF1H

7	6	5	4	3	2	1	0
TMIF04	TMIF13	SRIF3 CSIIF31 IICIF31	STIF3 CSIIF30 IICIF30	KRIF	ITIF	**RTCIF**	ADIF
x	x	x	x	x	x	**0**	x

Bit 1

RTCIF	Interrupt request flag
0	**No interrupt request signal is generated**
1	Interrupt request is generated, interrupt request status

Symbol: MK1H

7	6	5	4	3	2	1	0
TMMK04	TMMK13	SRMK3 CSIMK31 IICMK31	STMK3 CSIMK30 IICMK30	KRMK	ITMK	**RTCMK**	ADMK
x	x	x	x	x	x	**0**	x

Bit 1

RTCMK	Interrupt processing control
0	**Enables interrupt processing.**
1	Disables interrupt processing.

Caution: For details on the register setup procedures, refer to RL78/G13 User's Manual: Hardware.

5.6.10 RTC Time Setup

Figures 5.12 and 5.13 show the flowcharts for setting the RTC time.

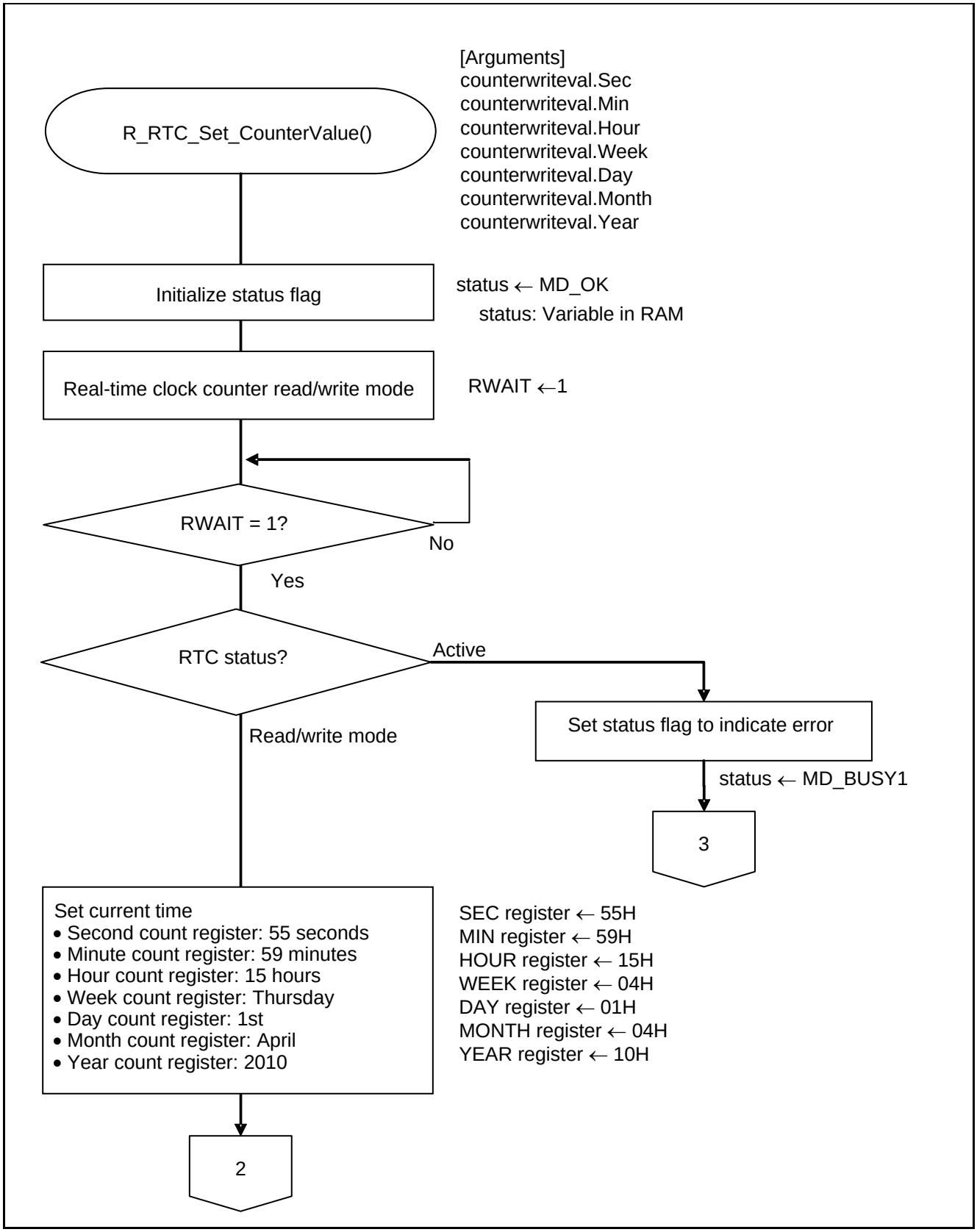

Figure 5.12 RTC Time Setup (1/2)

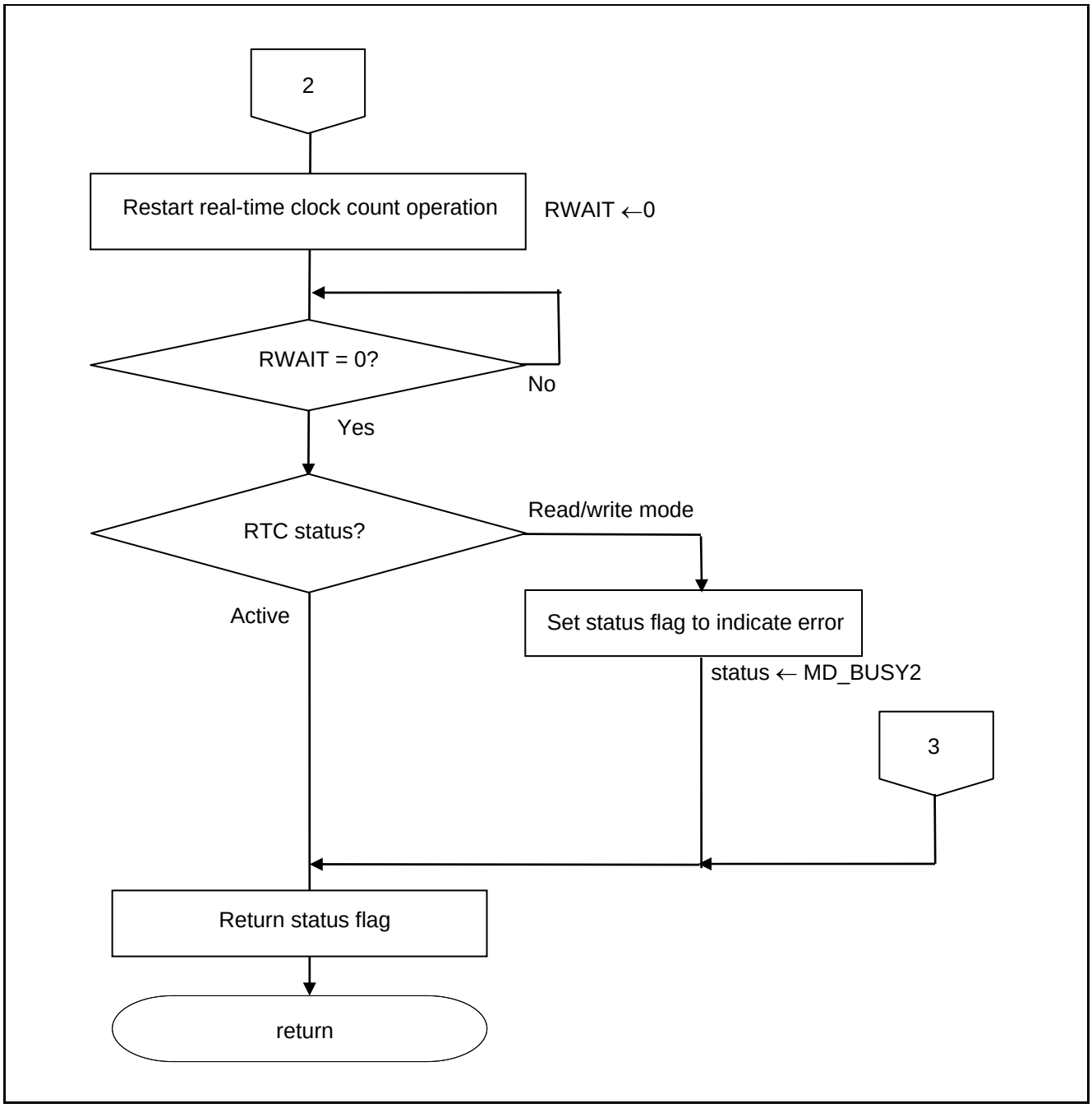

Figure 5.13 RTC Time Setup (2/2)

5.6.11 Alarm Generation Time Setup

Figure 5.14 shows the flowchart for setting the alarm generation time.

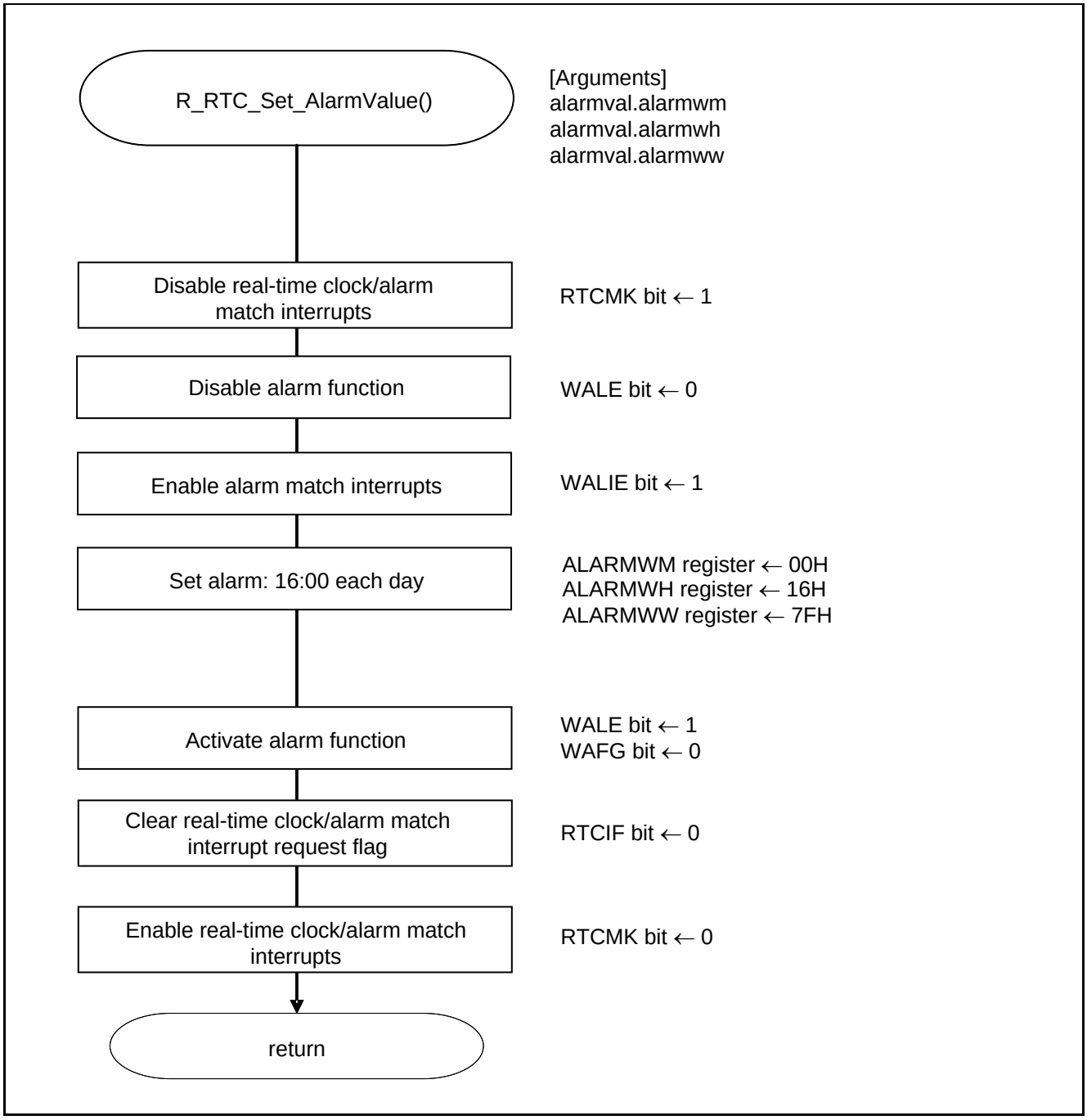

Figure 5.14 Alarm Generation Time Setup

5.6.12 RTC Interrupt (INTRTC) Processing

Figure 5.15 shows the flowchart for processing RTC interrupts (INTRTC).

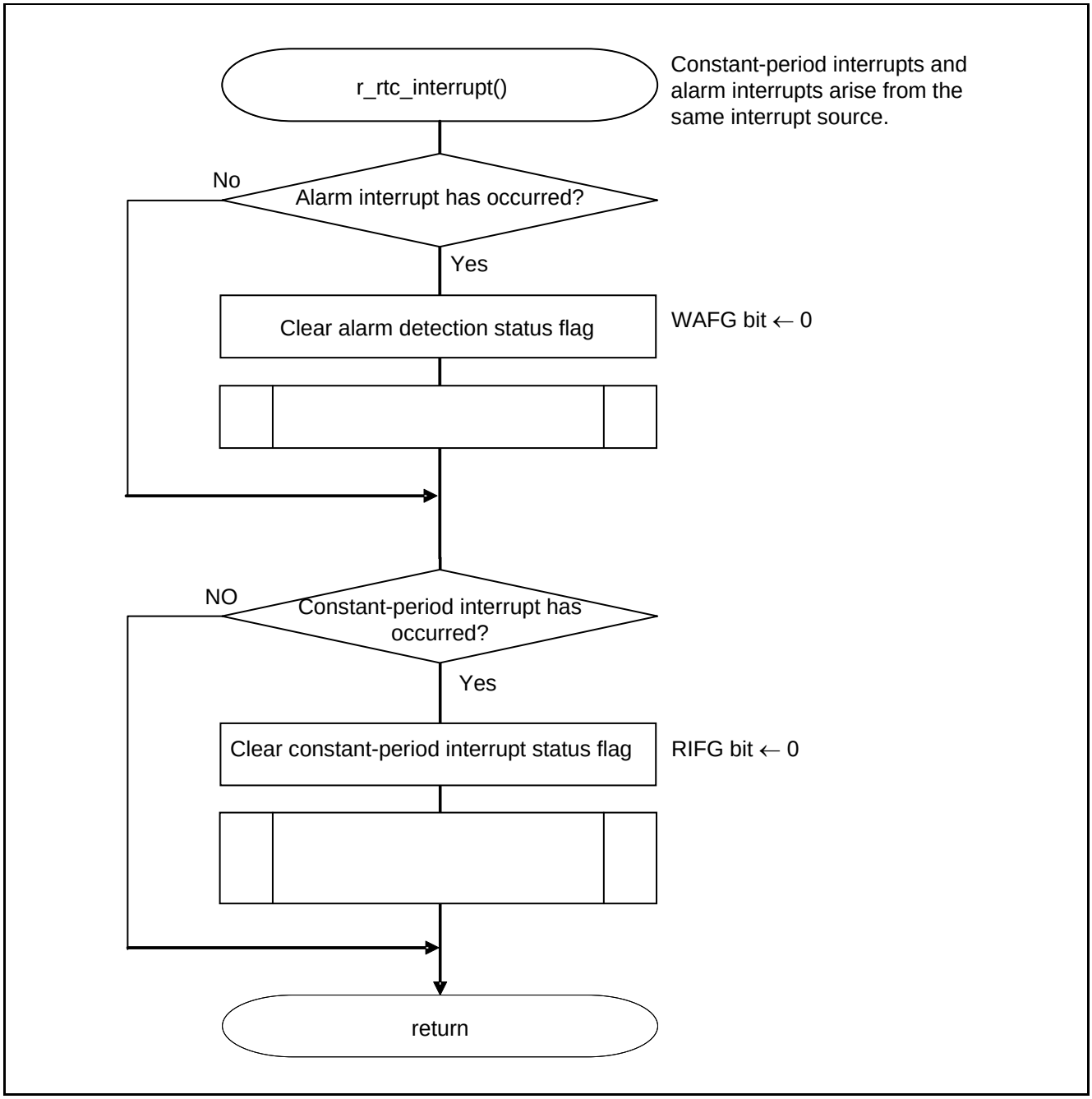

Figure 5.15 RTC Interrupt (INTRTC) Processing

5.6.13 Alarm Interrupt Processing

Figure 5.16 shows the flowchart for processing Alarm interrupts.

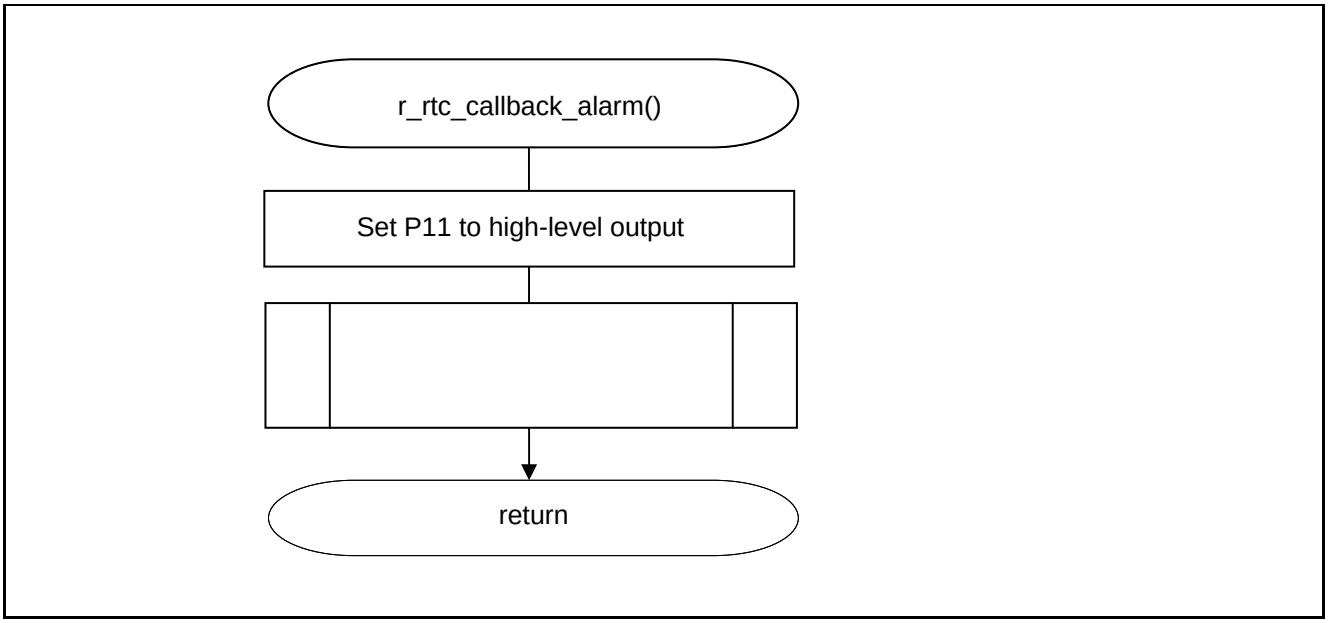

Figure 5.16 Alarm Interrupt Processing

5.6.14 Constant-period Interrupt Processing

Figure 5.17 shows the flowchart for processing Constant-period interrupts.

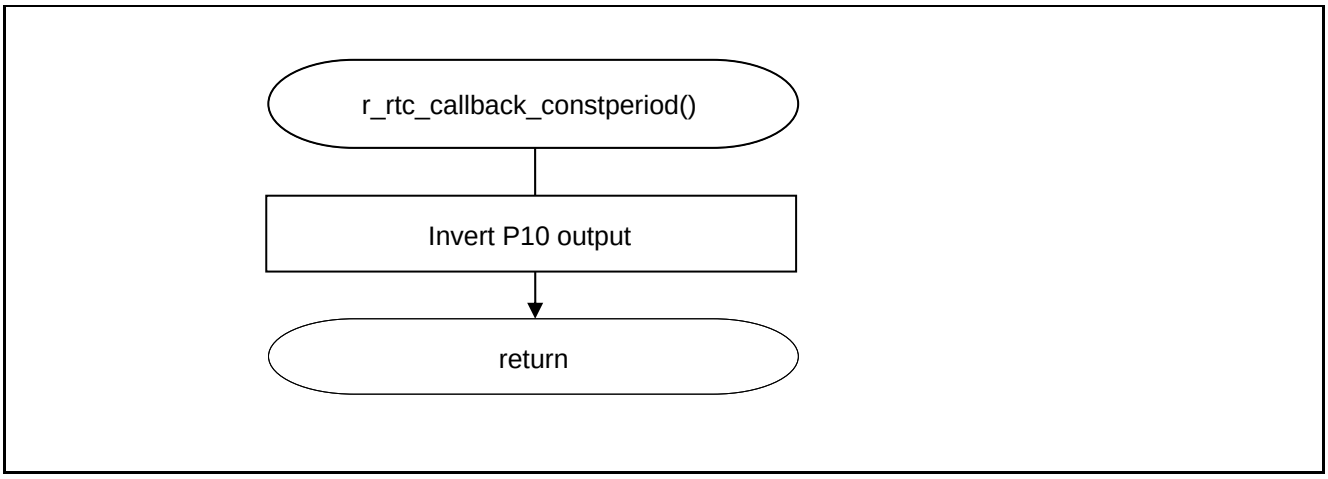

Figure 5.17 Constant-period Interrupt Processing

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Documents for Reference

User's Manual:

RL78/G13 User's Manual: Hardware (R01UH0146E)
RL78 Family User's Manual: Software (R01US0015E)
The latest version can be downloaded from the Renesas Electronics website.

Technical Updates/Technical News

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

Website and Support

Renesas Electronics Website

http://www.renesas.com/index.jsp

Inquiries

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REVISION HISTORY	RL78/G13 Real-Time Clock CC-RL

Rev.	Date	Description	
		Page	Summary
1.00	Jun. 01, 2015	—	First edition issued
2.00	July 01, 2015	4	Table2.1: Added e^2 studio

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU 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. 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 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 a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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