R32C/100 Series

Real-Time Clock Operation Using Timer A

R01AN0859EJ0100
Rev. 1.00
Aug. 24, 2012

Abstract

This document describes real-time clock operation using the timer function in the R32C/100 Series MCU.

Products

R32C/116 Group
R32C/117 Group
R32C/118 Group

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

Contents

1. Specifications

This document describes real-time clock operation using timer A0 in timer mode. Enter wait mode after setting the operating mode to low power mode (base clock source is the sub clock). Use the timer A0 interrupt to exit wait mode. The date, day, and time data are updated in the timer A0 interrupt handler.
The date, day, and time data start counting from 00:00:00, Saturday, January 1, 2000.
The count continues until 23:59:59, Saturday, December 31, 2099, and then resets to the initial date and time. The counter takes the leap day into account.

Table 1.1 lists the Peripheral Functions and Their Applications. Figure 1.1 shows the Relationship Between Date, Day, and Time Data. Figure 1.2 shows the Transition Between Operating Modes.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
Timer A0 in timer mode	1 second counter
Timer A1	Generates wait time for sub clock oscillation

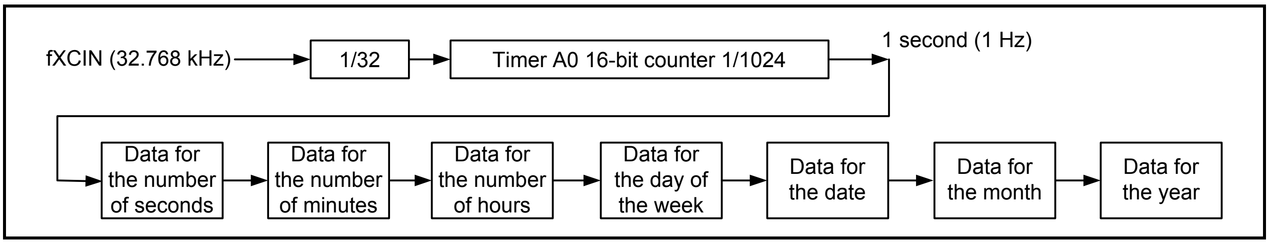


Figure 1.1 Relationship Between Date, Day, and Time Data

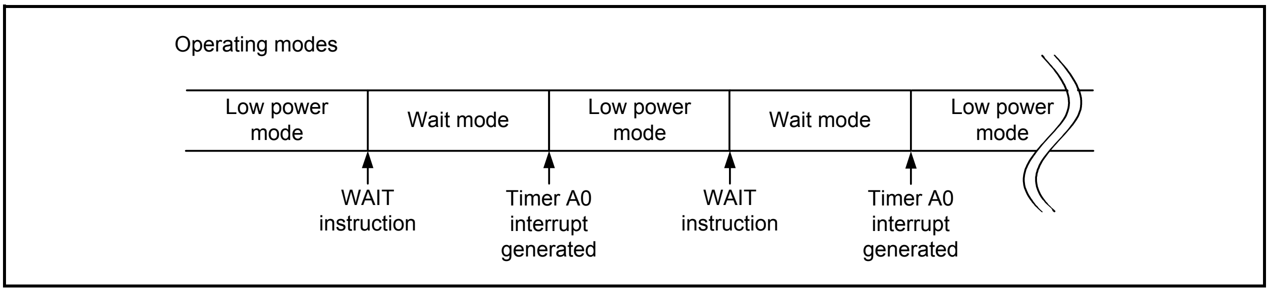


Figure 1.2 Transition Between Operating Modes

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	R5F64189DFD (R32C/118 Group)
Operating frequencies	When in PLL mode • Main clock: 16 MHz • PLL clock: 100 MHz • Base clock: 50 MHz • CPU clock: 50 MHz • Peripheral bus clock: 25 MHz • Peripheral function clock source: 25 MHz When in low power mode • Main clock is stopped • PLL clock is stopped • Base clock: 32.768 kHz (sub clock: 32.768 kHz) • CPU clock: 32.768 kHz • Peripheral bus clock: 16.384 kHz • Peripheral function clock source is stopped
Operating voltage	5 V
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.08
C compiler	Renesas Electronics Corporation R32C/100 Series C Compiler V.1.02 Release 01
	Compile options -D__STACKSIZE__=0X300 -D__ISTACKSIZE__=0X300 -DVECTOR_ADR=0x0FFFFFBDC -c -finfo -dir "$(CONFIGDIR)" (Default setting is used in the integrated development environment.)
Operating mode	Single-chip mode
Sample code version	Version 1.00

3. Reference Application Notes

Application notes associated with this application note are listed below. Refer to these application notes for additional information.

- R32C/100 Series Configuring PLL Mode (REJ05B1221-0100)
- R32C/100 Series Entering Low-speed Mode (REJ05B1222-0100)
- R32C/100 Series Configuring Wait Mode (REJ05B1223-0100)

4. Hardware

4.1 Pin Used

Table 4.1 lists the Pin Used and Its Function.

Table 4.1 Pin Used and Its Function

Pin Name	I/O	Function
P0_0	Output	Confirm period for transition to wait mode

5. Software

5.1 Operation Overview

Enter wait mode after setting the operating mode to low power mode. With timer A0 in timer mode, use a timer A0 interrupt with a 1 second period to exit wait mode. The date, day, and time data are updated in the timer A0 interrupt handler. Leap day determination is performed when the month changes. After the data is updated, a WAIT instruction is used to enter wait mode again.

Settings:

- Timer used: Timer A0
- Mode used: Timer mode
- Timer A0 count source: fC32
- Interrupt used: Timer A0 interrupt
- Gate function: Not used

Formula to calculate a 1 second counter:

1000 ms = (1 ÷ fC32) × (TA0 + 1)
= {1 ÷ (32.768 kHz ÷ 32)} × 1024
= 0.9765625 ms × 1024

(1) Initial setting
Set timer A0 and low power mode as the initial setting.

(2) Timer A0 count start
Set the TA0S bit in the TABSR register to 1 to start the timer A0 count. After the timer A0 count starts, the real-time clock starts counting from 00:00:00, Saturday, January 1, 2000.

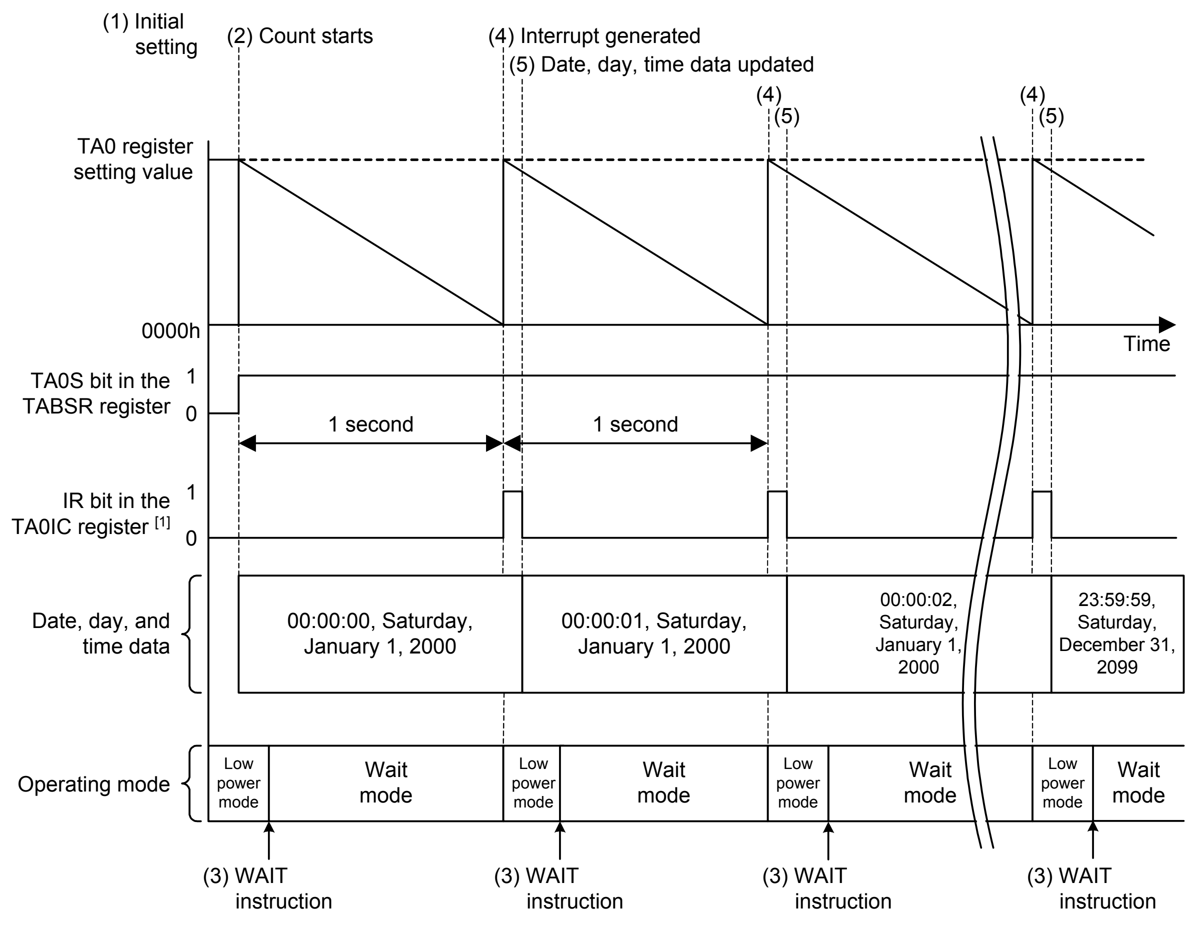
(3) WAIT instruction execution
Execute the WAIT instruction to enter wait mode.

(4) Timer A0 interrupt generation
When timer A0 underflows, the timer A0 interrupt is generated and the MCU exits wait mode.

(5) Timer A0 interrupt handling
Date, day, and time data are updated in the timer A0 interrupt handler. However, the values are stored in the variable in hexadecimal.

(6) Date, day, and time data initialization
The count continues until 23:59:59, Saturday, December 31, 2099, and then resets to the initial date and time.

Figure 5.1 shows an Example of Real-Time Clock Operation.



Note:
1. This bit becomes 0 when an interrupt request is accepted.

Figure 5.1 Example of Real-Time Clock Operation

5.2 Constants

Table 5.1 lists the Constants Used in the Sample Code.

Table 5.1 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
YEAR_MAX	2099	Data for the maximum number of years
MONTH_MAX	12	Data for the maximum number of months
WEEK_MAX	6	Data for the maximum number of weeks in a month
HOUR_MAX	23	Data for the maximum number of hours
MIN_MAX	59	Data for the maximum number of minutes
SEC_MAX	59	Data for the maximum number of seconds

5.3 Variables

Table 5.2 lists the Global Variables, and Table 5.3 lists the const Variable.

Table 5.2 Global Variables

Type	Variable Name	Contents	Function Used
unsigned short	year_cnt	Store data for number of years (2000 to 2099)	date_set, leap_day_check
unsigned char	month_cnt	Store data for number of months (1 to 12)	date_set, leap_day_check
unsigned char	day_cnt	Store data for number of days (1 to 31)	time_set, date_set, leap_day_check
unsigned char	week_cnt	Store data for day of the week 0: Sunday 1: Monday 2: Tuesday 3: Wednesday 4: Thursday 5: Friday 6: Saturday	time_set, date_set
unsigned char	hour_cnt	Store data for number of hours (00 to 23)	time_set
unsigned char	min_cnt	Store data for number of minutes (00 to 59)	time_set
unsigned char	sec_cnt	Store data for number of seconds (00 to 59)	time_set

Table 5.3 const Variable

Type	Variable Name	Contents	Function Used
const unsigned char	day_max_tbl[12]	Data table for the maximum number of days per month	date_set

5.4 Functions

Table 5.4 lists the Functions.

Table 5.4 Functions

Function Name	Outline
timer_a0_int	Timer A0 initial setting
time_set	Time setting
date_set	Date setting
leap_day_check	Leap day determination
subclock_set	Sub clock oscillation setting
before_wait_mode_set	Wait mode preset processing
power_control	Power control processing
_timer_a0	Timer A0 interrupt handling

5.5 Function Specifications

The following tables list the sample code function specifications.

timer_a0_int	
Outline	Timer A0 initial setting
Header	None
Declaration	void timer_a0_init(void)
Description	Initial settings to use timer A0 in timer mode.
Argument	None
Returned value	None
Remark	

time_set	
Outline	Time setting
Header	None
Declaration	void time_set(void)
Description	After setting the data for the seconds, minutes, hours, date, and day of the week, the date setting function is called.
Argument	None
Returned value	None
Remark	

date_set	
Outline	Date setting
Header	None
Declaration	void date_set(void)
Description	The leap day determination function is called, and depending on the result, the date, month, and year data is set.
Argument	None
Returned value	None
Remark	

leap_day_check	
Outline	Leap day determination
Header	None
Declaration	unsigned char leap_day_check(void)
Description	• Leap day is determined. • Years that can be evenly divided by 4 are determined to have the leap day (February 29). However, years that can be divided by 4 or divided by 100, but cannot be divided by 400 are determined to not have a leap day.
Argument	None
Returned value	• Leap day: 1 • Not a leap day: 0
Remark	

subclock_set	
Outline	Sub clock oscillation setting
Header	None
Declaration	void subclock_set(void)
Description	After setting both bits PD8_6 and PD8_7 in the PD8 register to 0 (input mode) and the PU25 bit in the PUR2 register to 0 (pull-up resistor unused), set the CM04 bit in the CM0 register to 1 (XIN-XCIN oscillator).
Argument	None
Returned value	None
Remark	Set the oscillation stabilization time according to the manufacturer’s recommendation.

before_wait_mode_set	
Outline	Wait mode preset processing
Header	None
Declaration	void before_wait_mode_set(void)
Description	• Change the base clock source from the PLL clock to the sub clock and enter low speed mode. • Stop the main clock and PLL clock, and transition from low speed mode to low power mode.
Argument	None
Returned value	None
Remark	

power_control	
Outline	Power control processing
Header	None
Declaration	void power_control(void)
Description	Set the interrupt priority level for wake-up, execute the WAIT instruction, and enter wait mode.
Argument	None
Returned value	None
Remark	

_timer_a0	
Outline	Timer A0 interrupt handling
Header	None
Declaration	void _timer_a0(void)
Description	Call the timer_set function in the interrupt handler.
Argument	None
Returned value	None
Remark	

5.6 Flowcharts

5.6.1 Main Processing

Figure 5.2 shows the Main Processing.

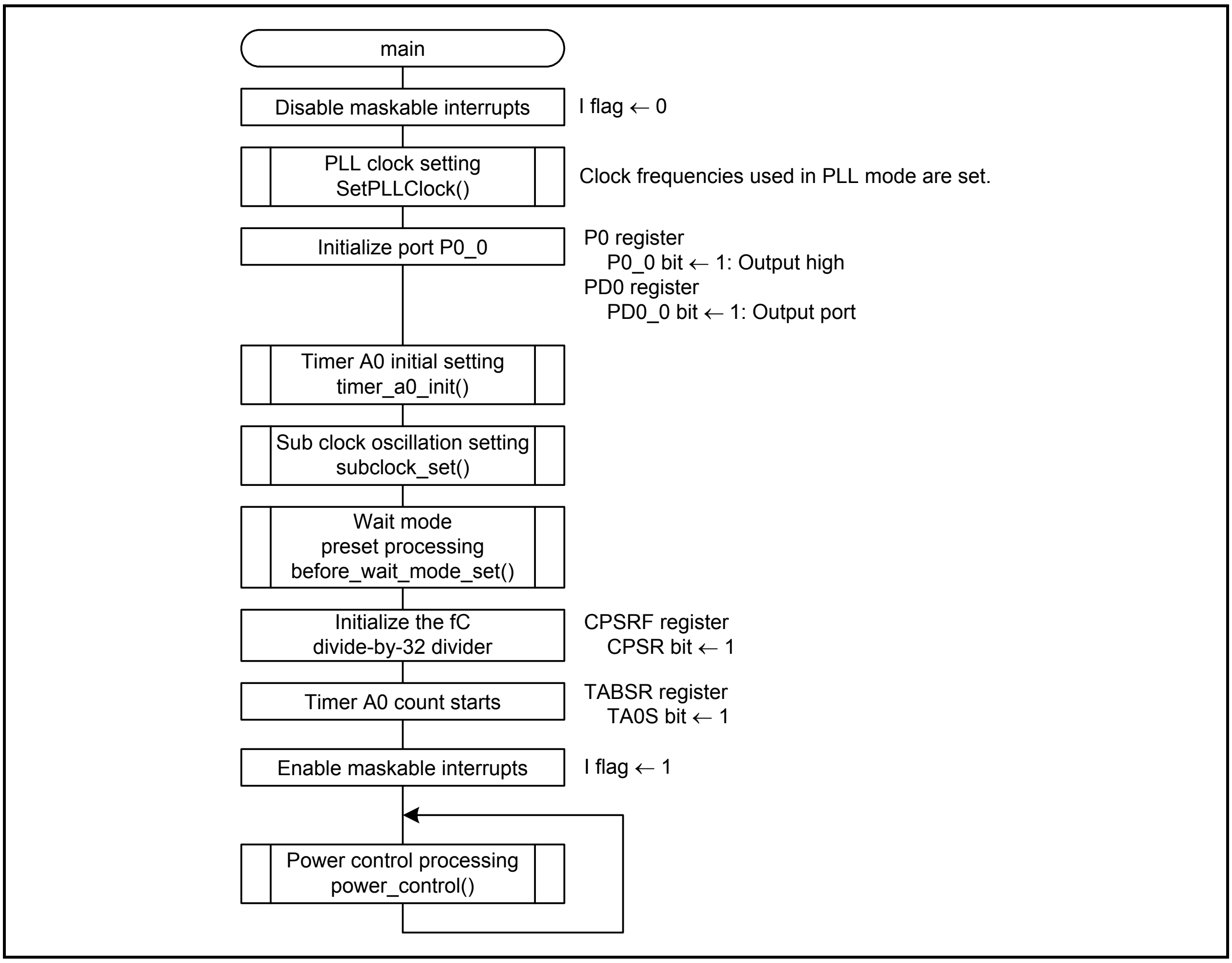


Figure 5.2 Main Processing

5.6.2 Timer A0 Initial Setting

Figure 5.3 shows the Timer A0 Initial Setting.

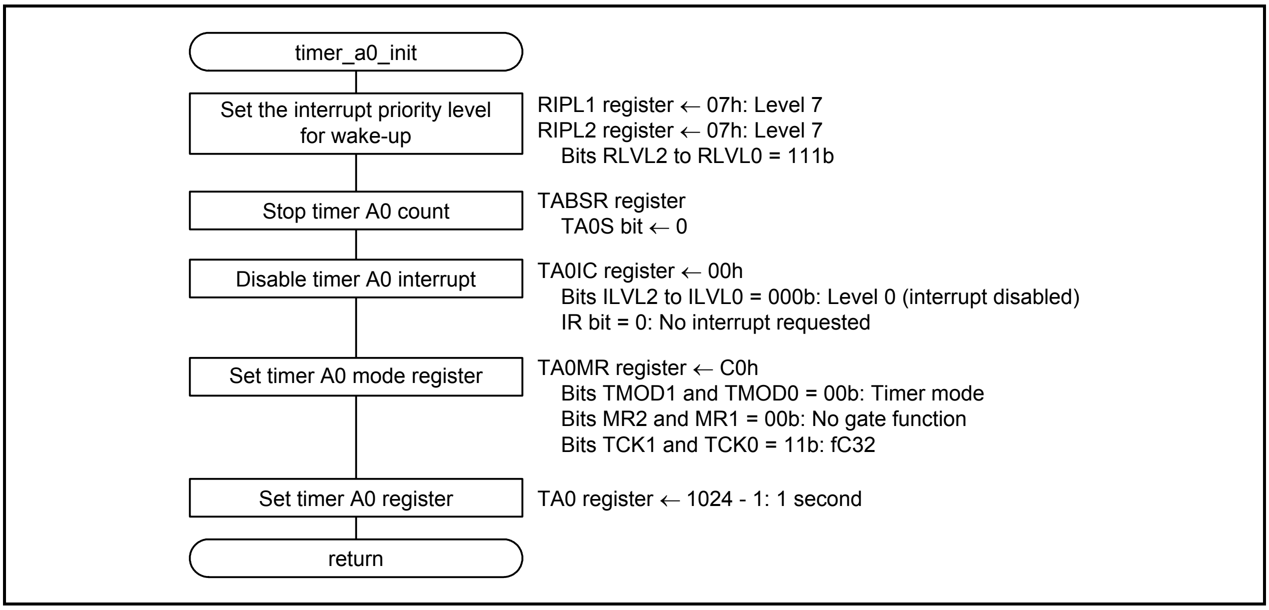


Figure 5.3 Timer A0 Initial Setting

5.6.3 Time Setting

Figure 5.4 shows the Time Setting.

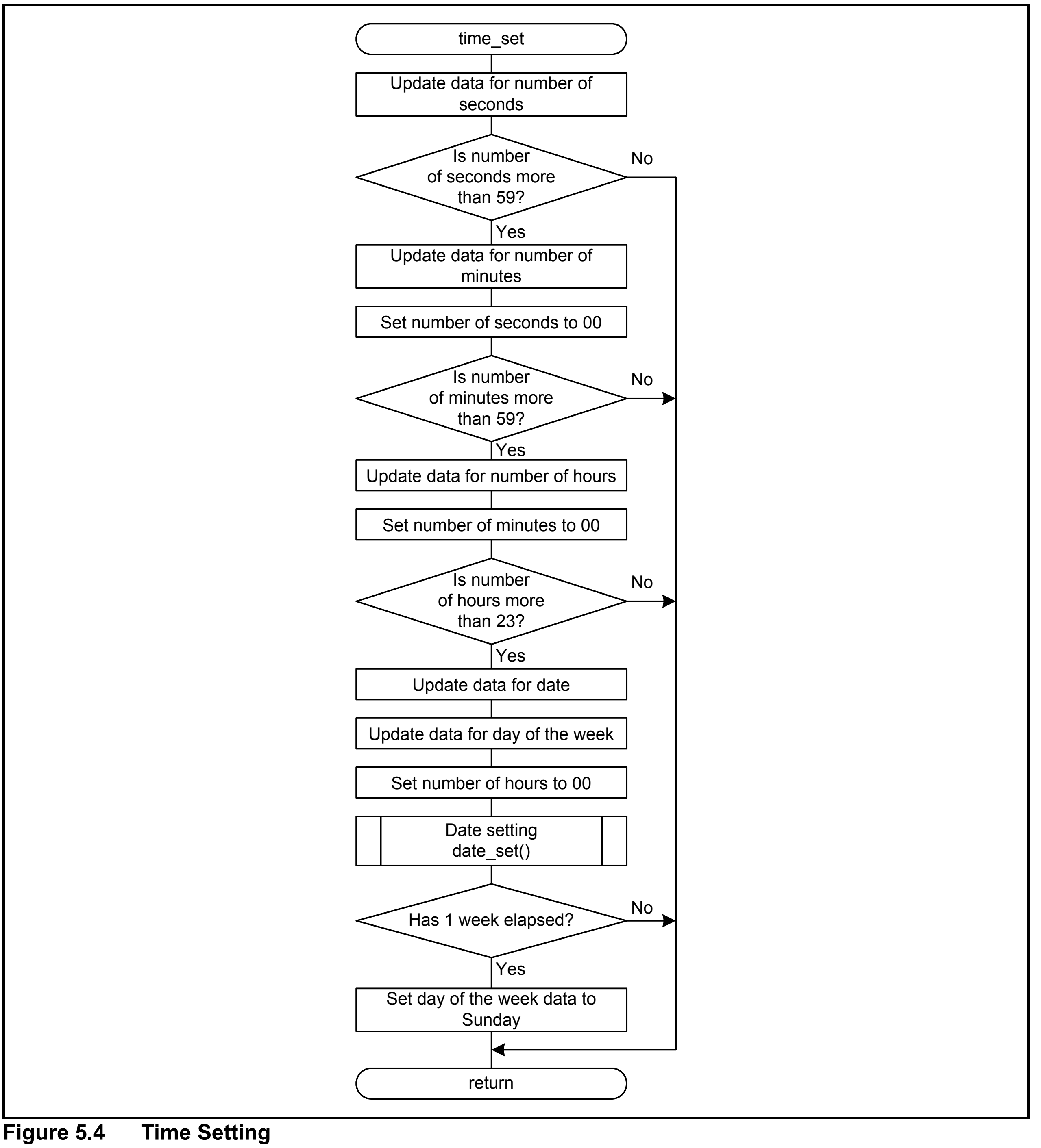


Figure 5.4 Time Setting

5.6.4 Date Setting

Figure 5.5 shows the Date Setting.

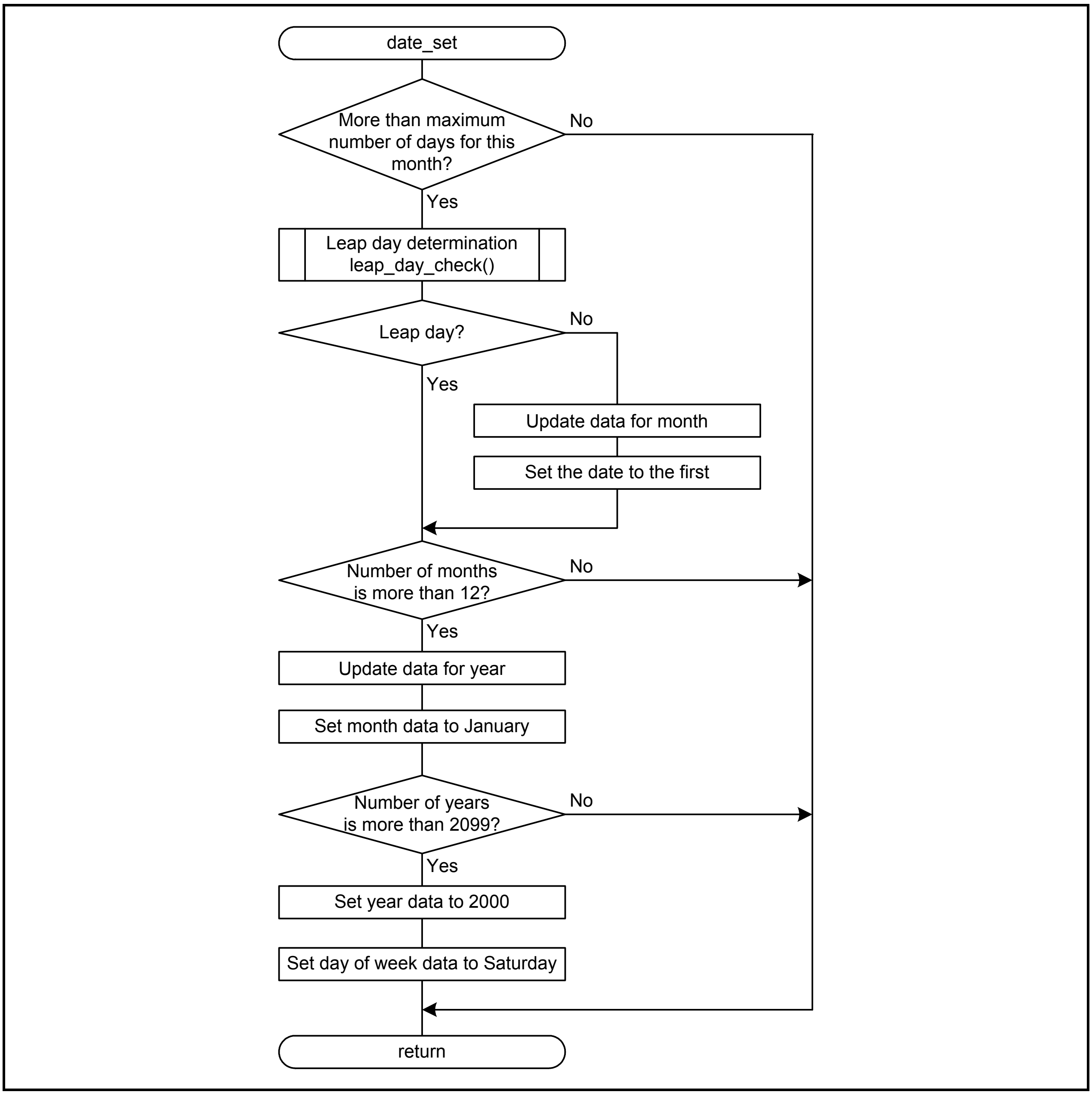


Figure 5.5 Date Setting

5.6.5 Leap Day Determination

Figure 5.6 shows the Leap Day Determination.

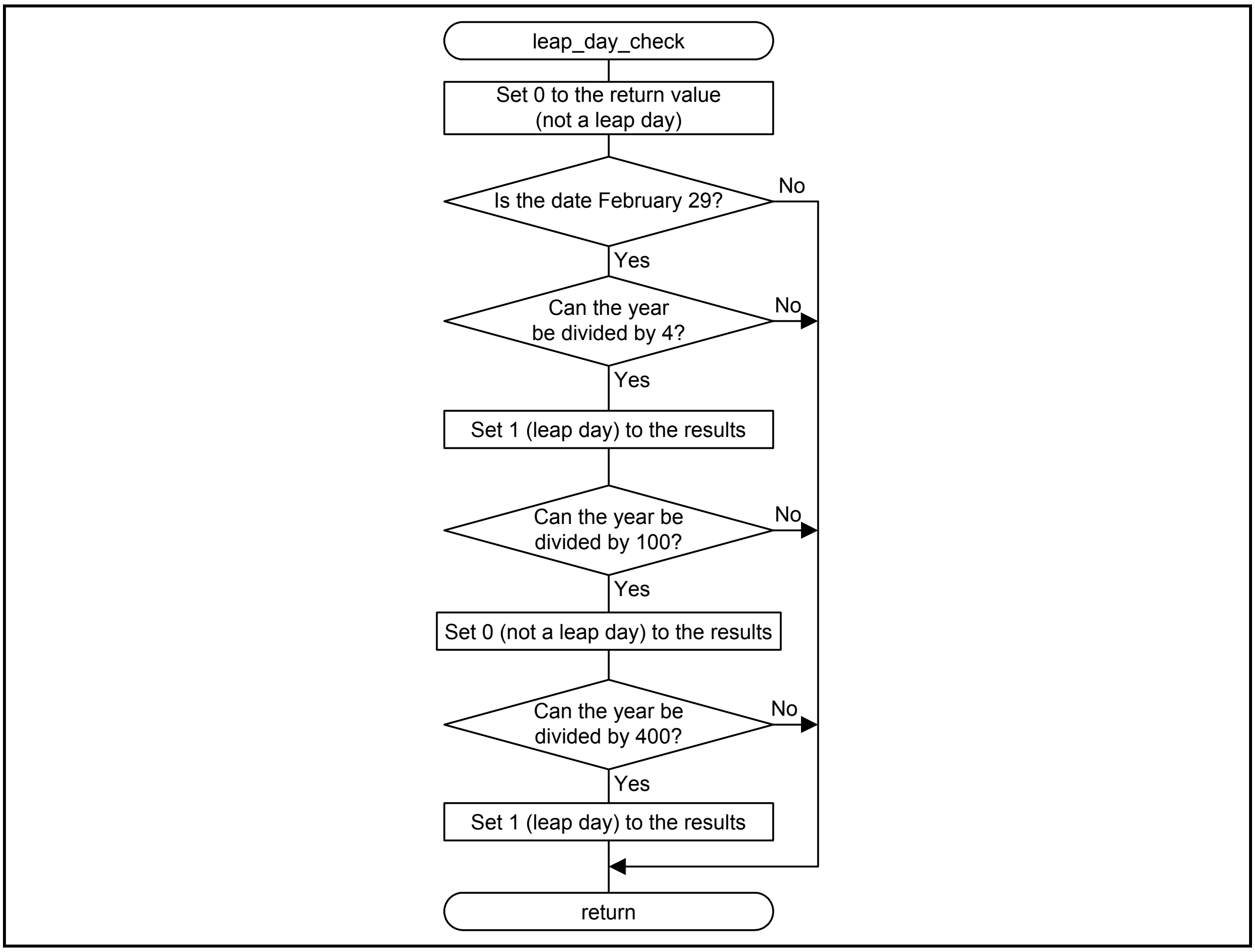


Figure 5.6 Leap Day Determination

5.6.6 Sub Clock Oscillation Setting

Figure 5.7 and Figure 5.8 show the sub clock oscillation setting.

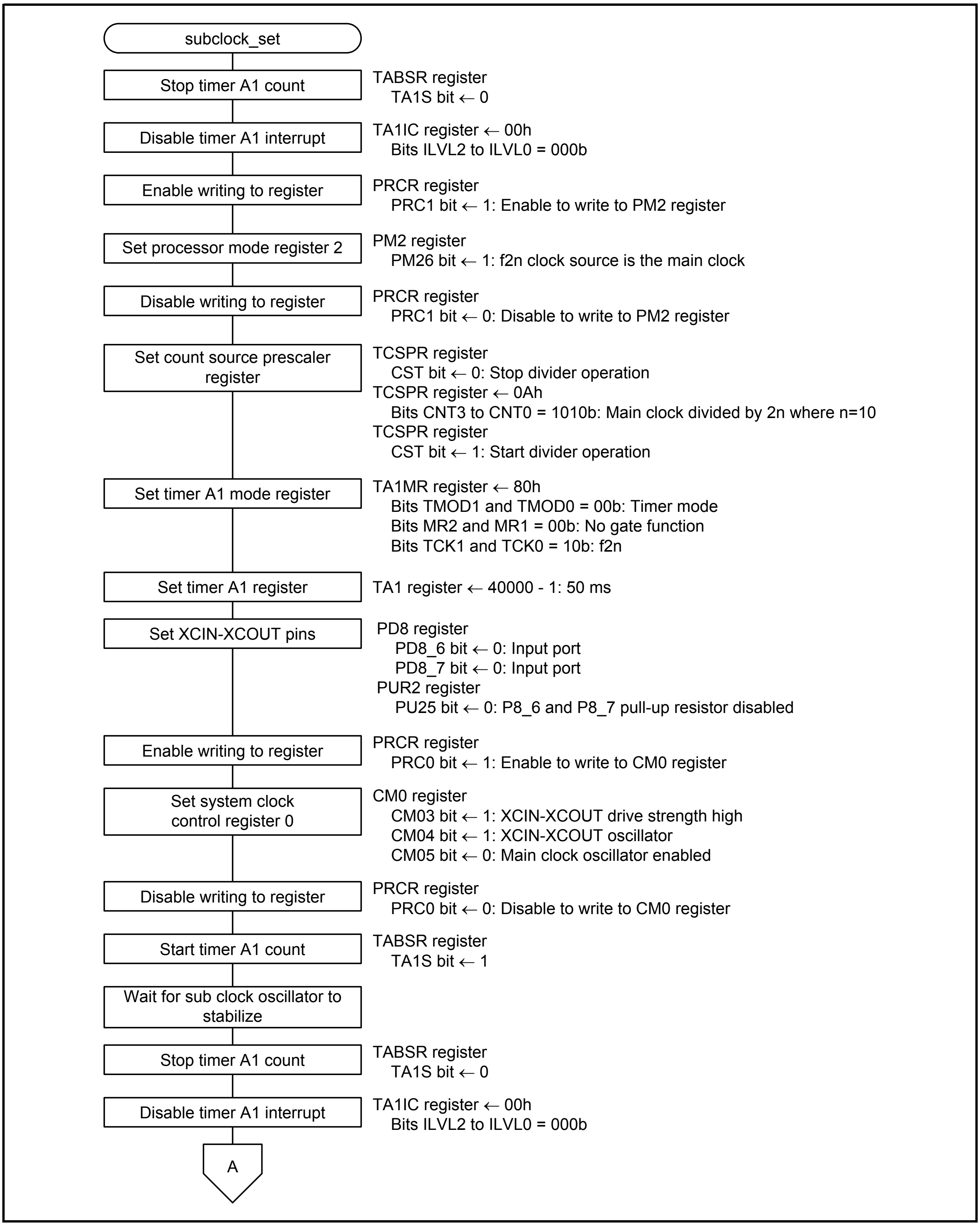


Figure 5.7 Sub Clock Oscillation Setting (1/2)

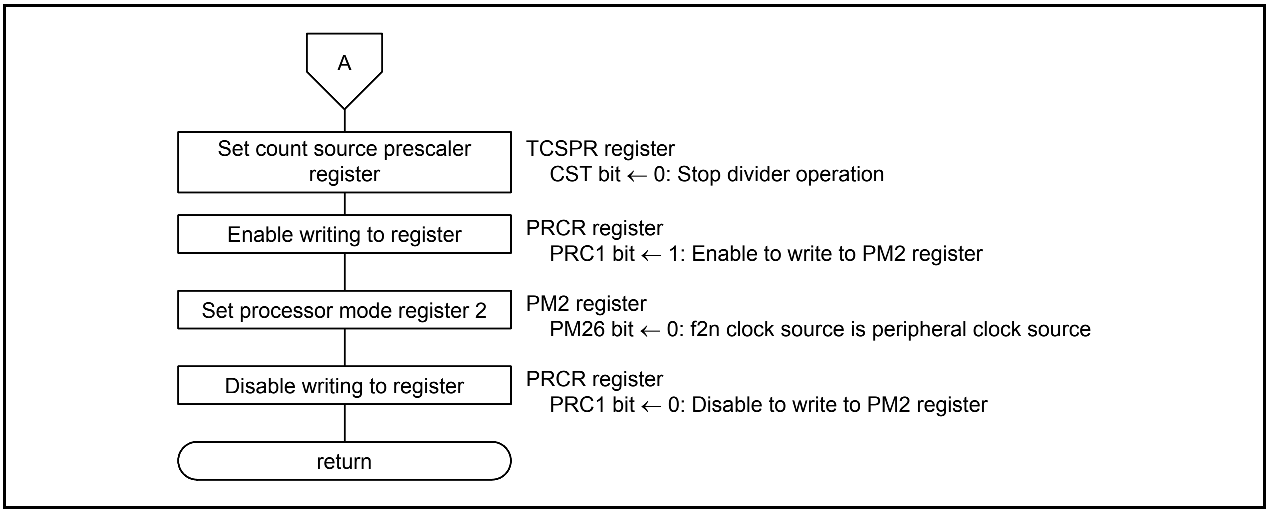
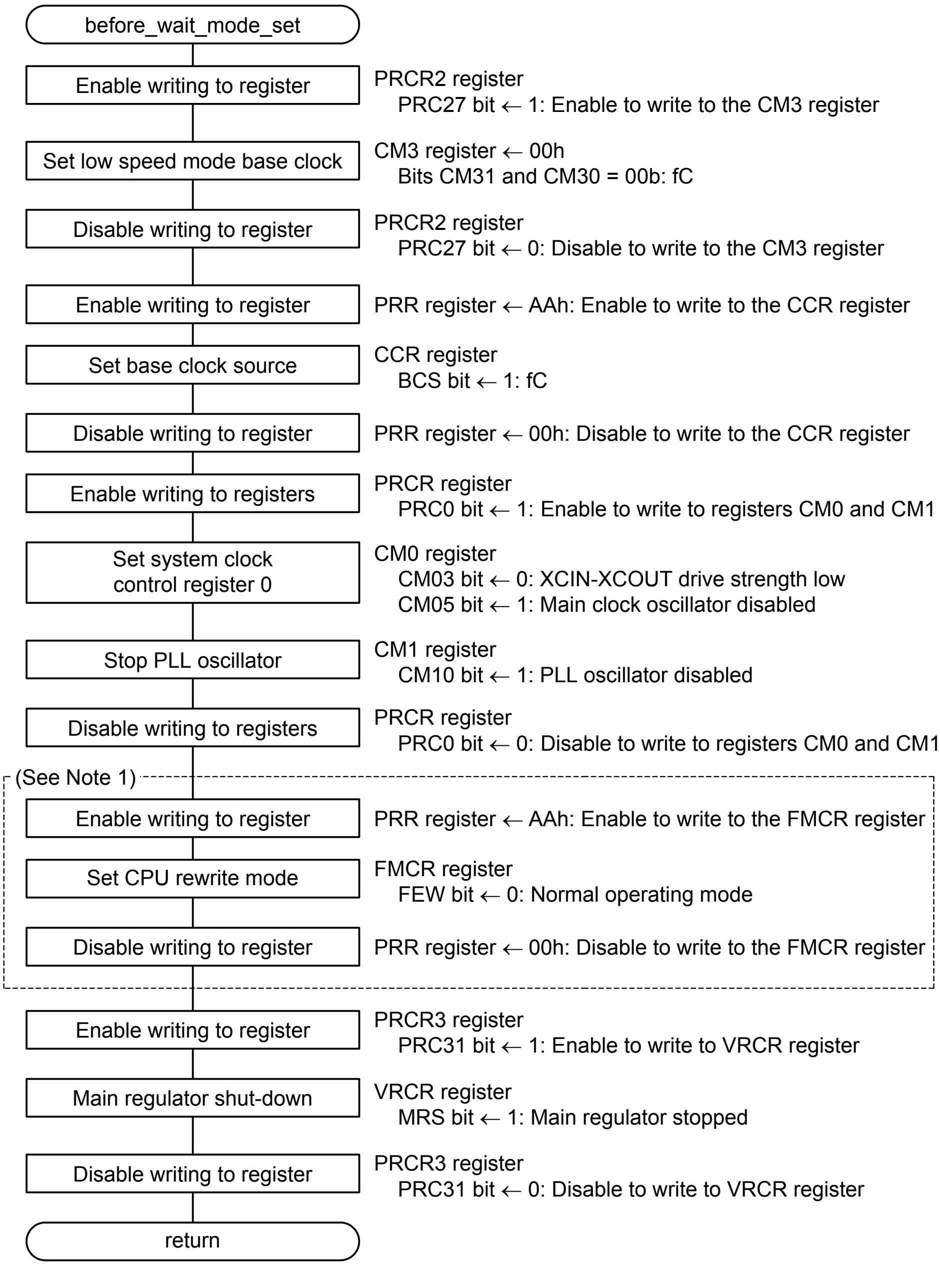


Figure 5.8 Sub Clock Oscillation Setting (2/2)

5.6.7 Wait Mode Preset Processing

Figure 5.9 shows Wait Mode Preset Processing.



Note:
1. Perform this processing when using an embedded CPU rewrite program.

Figure 5.9 Wait Mode Preset Processing

5.6.8 Power Control Processing

Figure 5.10 shows the Power Control Processing.

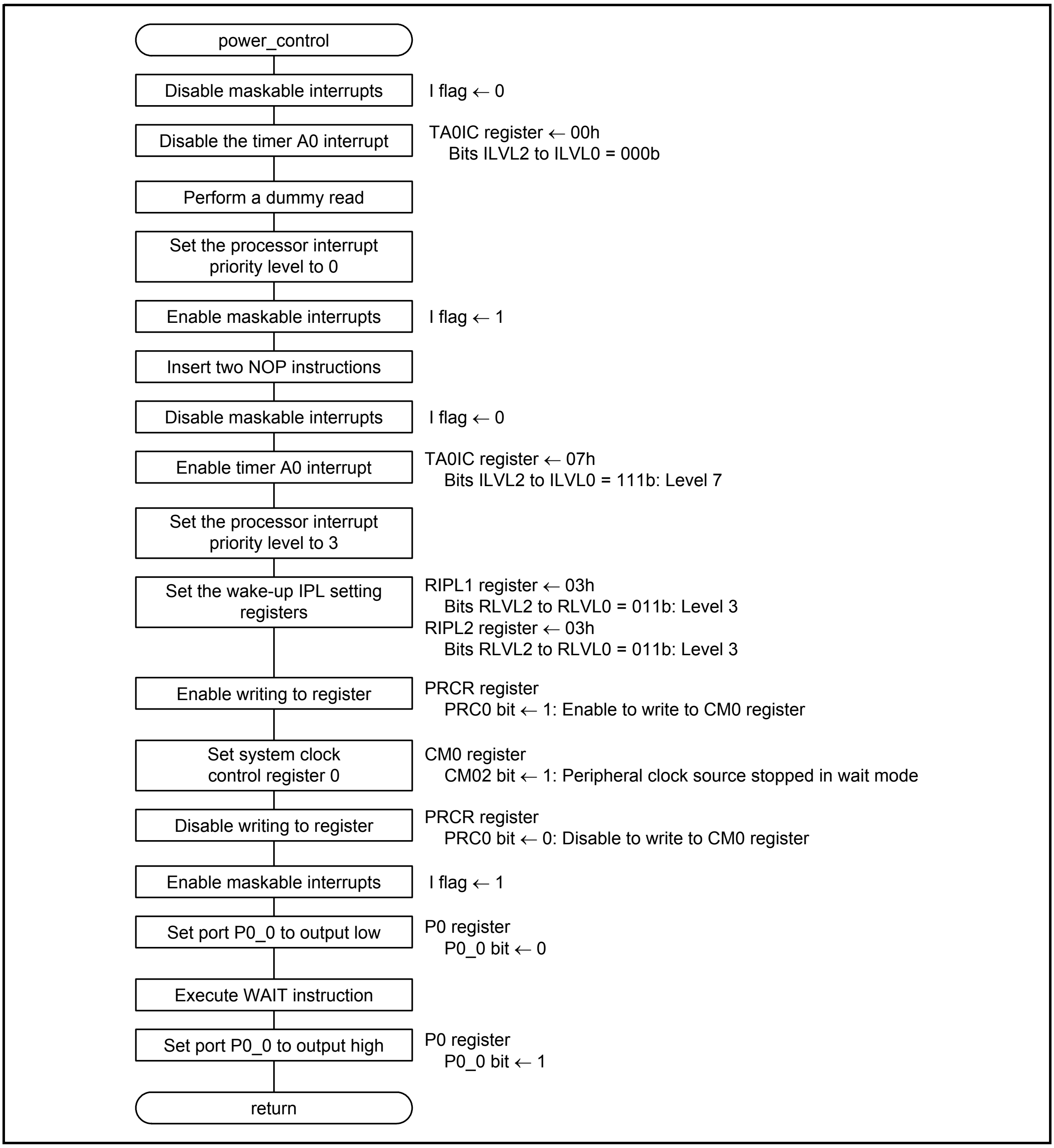


Figure 5.10 Power Control Processing

5.6.9 Timer A0 Interrupt Handling

Figure 5.11 shows the Timer A0 Interrupt Handling.

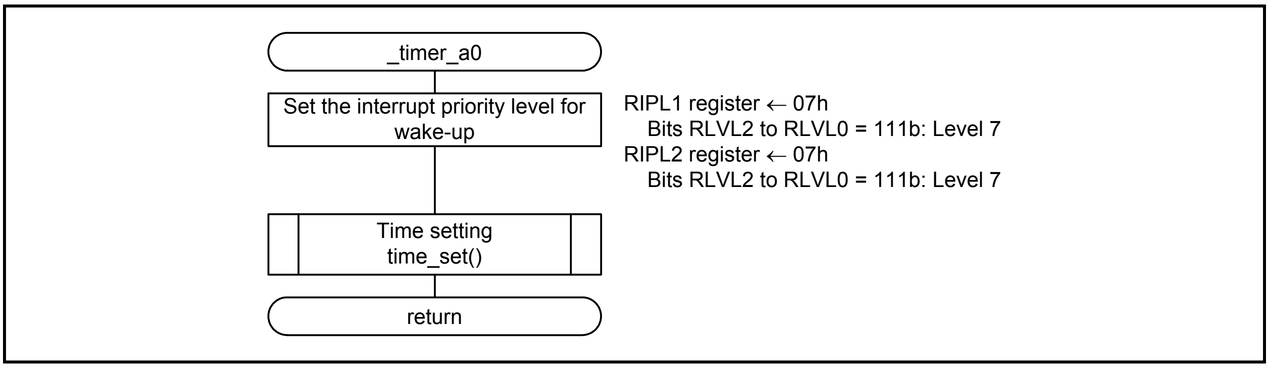


Figure 5.11 Timer A0 Interrupt Handling

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

R32C/116 Group User's Manual: Hardware Rev.1.10
R32C/117 Group User's Manual: Hardware Rev.1.10
R32C/118 Group User's Manual: Hardware Rev.1.10
The latest versions can be downloaded from the Renesas Electronics website.

Technical Update/Technical News
The latest information can be downloaded from the Renesas Electronics website.

C Compiler Manual
R32C/100 Series C Compiler Package V.1.02
C Compiler User's Manual Rev.2.00
The latest version can be downloaded from the Renesas Electronics website.

Website and Support

Renesas Electronics website
http://www.renesas.com/

Inquiries
http://www.renesas.com/contact/

Revision History	R32C/100 Series Real-Time Clock Operation Using Timer A

Rev.	Date	Description	
		Page	Summary
1.00	Aug. 24, 2012	—	First edition issued

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 manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

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.
   — The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
2880 Scott Boulevard Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-65030, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898

Renesas Electronics Hong Kong Limited
Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2886-9318, Fax: +852 2886-9022/9044

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei, 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 906, 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 Korea Co., Ltd.
11F., Samik Lavied' or Bldg., 720-2 Yeoksam-Dong, Kangnam-Ku, Seoul 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 2.2