SH7231 Group

Example of Application for Connecting the Optical Sensor

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Abstract

This document describes an application example to connect the SH7231 with an optical sensor.

Products

SH7231

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 sample code measures light quantity of each RGB color by using the optical sensor connected to the SH7231. It adjusts LED blinking speed, which corresponds to each color according to the measured value.

When all the measurement values of each color for the optical sensor fall below the threshold value, the optical sensor transits to the deep software standby mode, and returns from the mode by NMI.

Table 1.1 lists the Peripheral Functions and Their Applications and Figure 1.1 shows the System Configuration.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
I/O port	Controls photometry of optical sensor Reads RGB measurement data
Compare match timer (CMT)	Controls LED blinking
Interrupt controller (INTC)	Sets interrupt priority level of the CMT
Control of power-down mode	Transits/Cancels the deep software standby mode

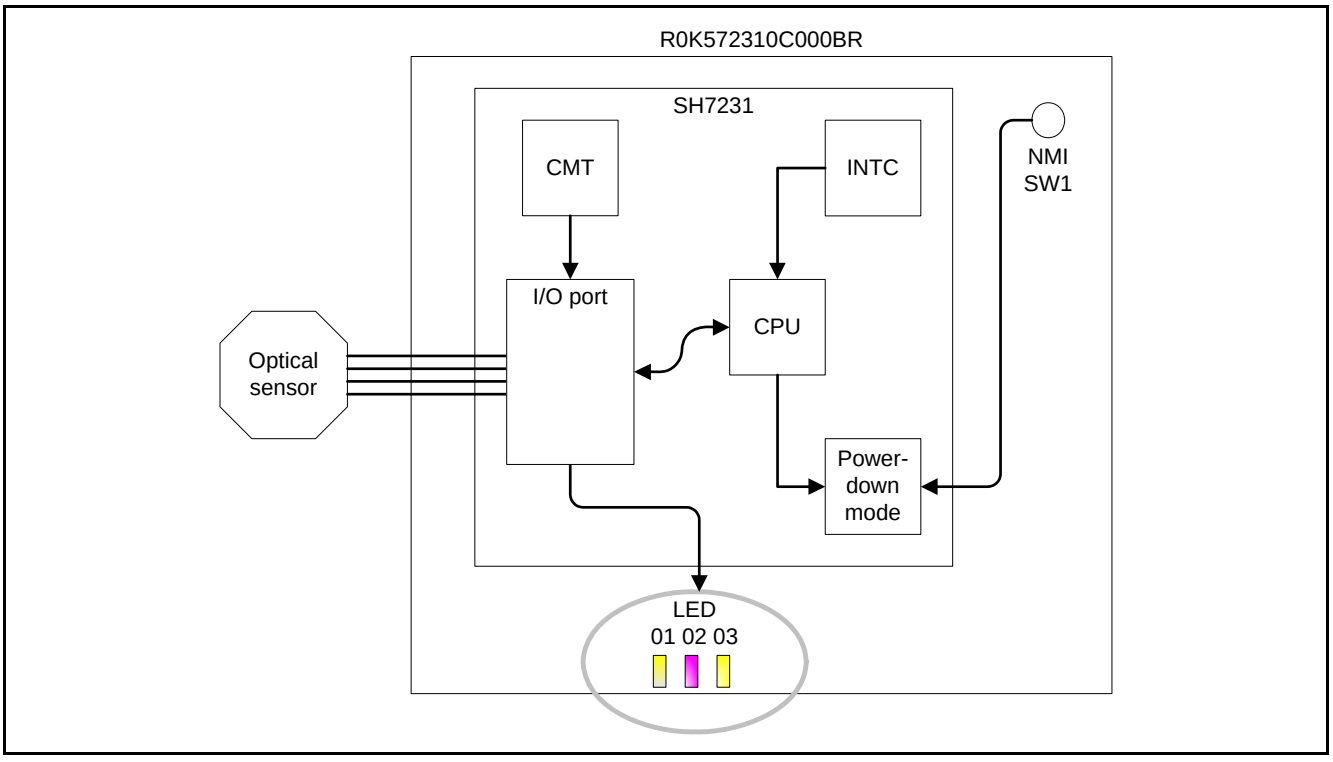

Figure 1.1 System Configuration

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	SH7231
Operating frequency	Main clock: 100MHz Bus clock: 50MHz Peripheral clock: 50MHz
Operating voltage	Vcc: 3.3V
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Ver.4.08.00
C compiler	Renesas Electronics Corporation SuperH RISC engine family C/C++ compiler package Ver.9.04 Release 00
	Compile options: -cpu=sh2afpu -fpu=single -include="$(WORKSPDIR)\inc","$(WORKSPDIR)\src\common" -object="$(CONFIGDIR)\$(FILELEAF).obj" -debug -gbr=auto -chgincpath -errorpath -global_volatile=0 -opt_range=all -infinite_loop=0 -del_vacant_loop=0 -struct_alloc=1 -nologo
Operating mode	Single chip mode
Sample code version	1.00
Board used	R0K572310C000BR
Device used	Optical sensor *1

Note: *1 The optical sensor is connected to the port H to be used.

3. Reference Application Notes

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

- SH7231 Group Example of Initialization (R01AN0322EJ)
- SH7231 Group Using Deep Software Standby Mode (R01AN0822EJ)

4. Hardware

4.1 Hardware Configuration

In this sample code, the digital color sensor is adopted for the optical sensor for illuminance detection. The digital color sensor can make the three RGB colors a simultaneous photometry.

PH9 to PH6 are used to control the optical sensor, and they are connected as shown in Figure 4.1.

PG11 to PG9 are connected to the LED3 to 1 which blink the light based on the measurement data of the three RGB colors obtained.

Figure 4.1 shows the Connection Example.

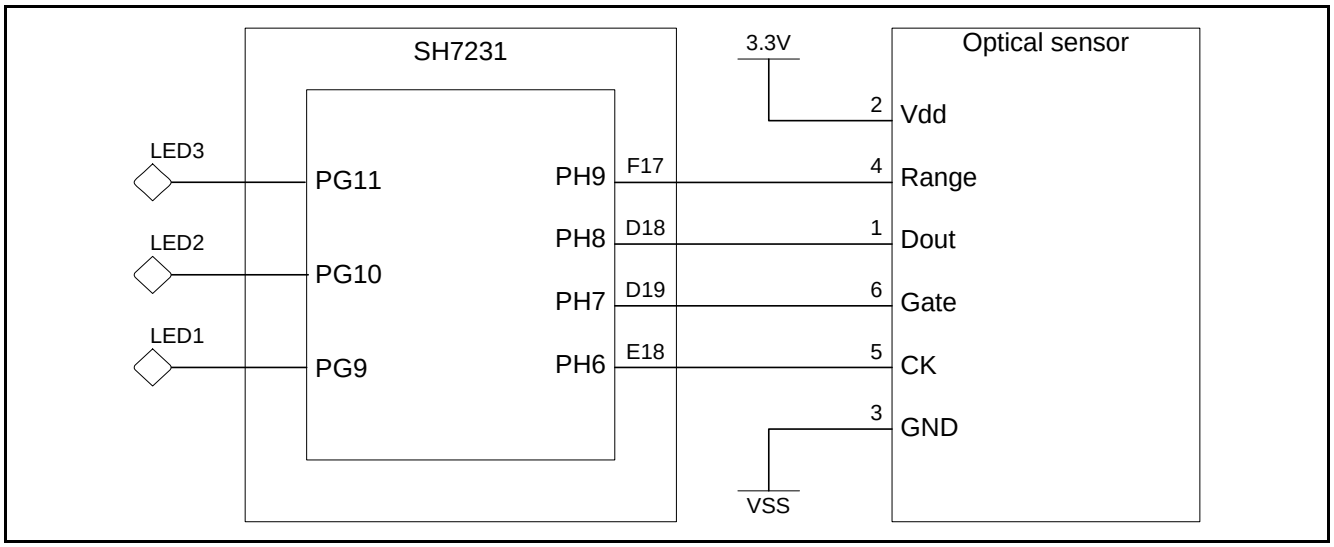

Figure 4.1 Connection Example

4.2 Pins Used

Table 4.1 lists the Pins Used and Their Functions.

Table 4.1 Pins Used and Their Functions

Pin Name	I/O	Function
PH9	Output	Switches sensitivity of the optical sensor (Range)
PH8	Input	Input measurement data of the optical sensor (Dout)
PH7	Output	Operates Gate pin of the optical sensor
PH6	Output	Pulse output to read data of the optical sensor (CK)
PG11 to 9	Output	Blink LED3 to 1 on the board in use

5. Software

5.1 Operation Overview

When the SH7231 is started, it determines whether or not the start is a return from the deep software standby mode. It cancels the deep software standby mode only when the start is a return from the mode, then initializes each function and enters into the main loop.

Generates the CMT0 compare match interrupt with 50ms cycle, and reads the optical sensor value in the process of this exception handling.

When the measurement data of the three RGB colors is more than the threshold value, the measurement data and the counter value for blinking control an output to the port G and blink the LED.

When all of the measurement data does not exceed the threshold value, transmits to the deep software standby mode. The NMI switch is used to return from the deep software standby mode.

Figure 5.1 shows the Operation Overview.

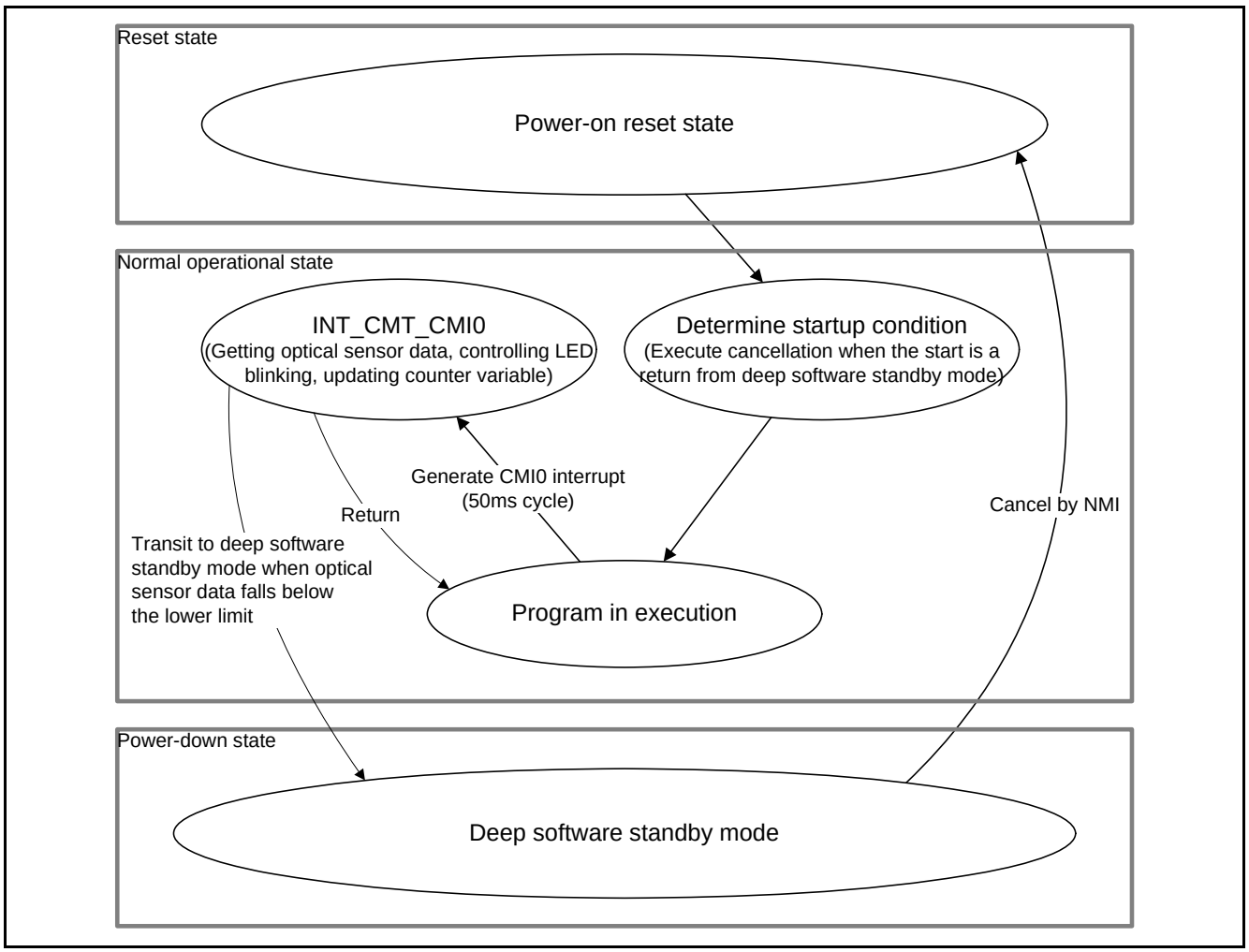

Figure 5.1 Operation Overview

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
OPT_DATA_BIT	12	Number of bits of the optical sensor data
OPT_WAIT_TG	20	Integration time (20ms)*1
OPT_WAIT_T1	5	Waiting time until the pulse output is started after integration (5us)*1
OPT_WAIT_T2	5	Waiting time until the pulse is generated between each RGB color data (5us)*1
OPT_WAIT_T4	2	Waiting time until the photometry is started after changing the sensitivity (2ms)*1
OPT_WAIT_TW	-1	Pulse width for reading (500ns)*1
OPT_CARRY_HIGH	H'0800	Optical sensor received bit with High
OPT_CARRY_LOW	0	Optical sensor received bit with Low
OPT_DATA_MAX	H'0FFF	Optical sensor received data with maximum value
OPT_DATA_THRESHOLD	H'0040	Threshold value for transmitting to the optical sensor received deep software standby mode (When the Range is High)
BLINK_MAX	840	Maximum counter value used to blink the LED (the least common multiple of 1 to 8)

Note: *1 Waiting time for photometric timing of the optical sensor.

5.3 Variables

Table 5.2 lists the Global Variables.

Table 5.2 Global Variables

Type	Variable Name	Contents	Function Used
uint16_t	g_opt_data_R	Sensor data (Red)	get_opt_sensor INT_CMT_CMI0
uint16_t	g_opt_data_G	Sensor data (Green)	get_opt_sensor INT_CMT_CMI0
uint16_t	g_opt_data_B	Sensor data (Blue)	get_opt_sensor INT_CMT_CMI0
uint16_t	g_blink_mem	Counter for LED blinking	INT_CMT_CMI0

5.4 Functions

Table 5.3 lists the Functions.

Table 5.3 Functions

Function Name	Outline
main	Main processing
io_init_pfc	Initialization of pin function controller
io_init_intc	Initialization of interrupt controller
io_init_cmt	Initialization of compare match timer
software_wait_ms	Software wait (in ms)
software_wait_us	Software wait (in us)
get_opt_sensor	Getting optical sensor data
goto_deep_standby	Transition to the deep software standby mode
cancel_deep_standby	Cancellation of the deep software standby mode
judgment_deep_standby	Judgment of return from the deep software standby mode
INT_CMT_CMI0	Exception handling of the CMT0 compare match timer interrupt (CMI0)

5.5 Function Specifications

The following tables list the sample code function specifications.

main	
Outline	Main processing
Header	
Declaration	void main(void)
Description	Makes a judgment on whether or not the start is a return from the deep software standby mode. Cancels the deep software standby mode when it is a return. Initializes each function and enters into the main loop.
Arguments	None
Return Value	None

io_init_pfc	
Outline	Initialization of pin function controller
Header	
Declaration	void io_init_pfc(void)
Description	Sets the pin function of the port G 11 to 9 to the I/O port, also sets the pin function of the port H 9 to 6 for external device. Enables general input function and sets the input range of the optical sensor to High.
Arguments	None
Return Value	None

io_init_intc	
Outline	Initialization of interrupt controller
Header	
Declaration	void io_init_intc(void)
Description	Sets interrupt priority level of the CMT0.
Arguments	None
Return Value	None

io_init_cmt	
Outline	Initialization of compare match timer
Header	
Declaration	void io_init_cmt(void)
Description	Sets to generate the CMI0 interrupt request with 50ms cycle.
Arguments	None
Return Value	None

software_wait_ms		
Outline	Software timer (in ms)	
Header		
Declaration	int32_t software_wait_ms(uint32_t ms)	
Description	Executes the NOP instruction repeatedly at the specified time (in ms) by the argument.	
Arguments	uint32_t ms	: Waiting time (in ms)
Return Value	0	: Normal
	-1	: Setting value error

software_wait_us		
Outline	Software timer (in us)	
Header		
Declaration	int32_t software_wait_us(int32_t us)	
Description	Executes the NOP instruction repeatedly at specified time (in us) by the argument. When -1 is specified for the argument, the NOP instruction is executed repeatedly for 500ns.	
Arguments	int32_t us	More than 1 : Waiting time (in us)
		-1 : 500ns
Return Value	0	: Normal
	-1	: Setting value error

get_opt_sensor	
Outline	Getting optical sensor data
Header	
Declaration	void get_opt_sensor(void)
Description	Reads the RGB measurement data from the optical sensor, and substitutes the results to each variable.
Arguments	None
Return Value	None

goto_deep_standby	
Outline	Transition to the deep software standby mode
Header	
Declaration	void goto_deep_standby(void)
Description	Sets each register to transit to the deep software standby mode. Transits to the deep software standby mode by executing the sleep instruction.
Arguments	None
Return Value	None

cancel_deep_standby	
Outline	Cancellation of the deep software standby mode
Header	
Declaration	void cancel_deep_standby(void)
Description	Clears the deep software standby mode setting flag and the cancellation source flag.
Arguments	None
Return Value	None

judgment_deep_standby	
Outline	Judgment of return from the deep software standby mode
Header	
Declaration	void cancel_deep_standby(void)
Description	Makes a judgment on whether or not the start is a return from the deep software standby mode, and executes cancellation.
Arguments	None
Return Value	None

INT_CMT_CMI0	
Outline	Exception handling of the CMT0 compare match timer interrupt (CMI0)
Header	
Declaration	void INT_CMT_CMI0(void)
Description	Read by the compare match with 50ms cycle and gets the optical sensor data. When the measurement data of three RGB colors is less than the threshold value, transits to the deep software standby mode. If it's not, the port G output is controlled by the counter value and each measurement data to blink the LED. Then the counter variables are updated.
Arguments	None
Return Value	None

5.6 Flowcharts

5.6.1 Main Processing

Figure 5.2 shows the Main Processing.

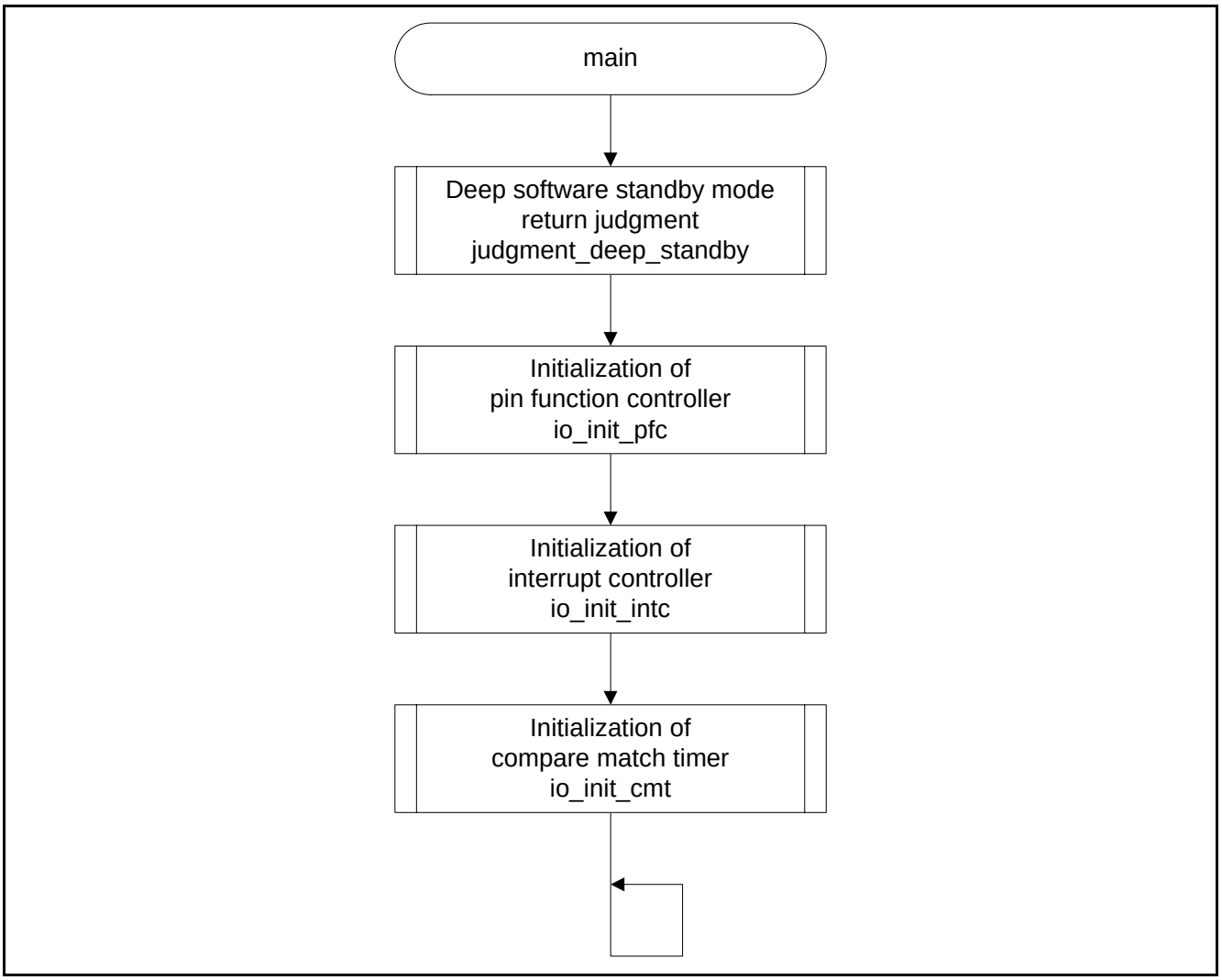

Figure 5.2 Main Processing

5.6.2 Initialization of Pin Function Controller

Figure 5.3 shows the Initialization of Pin Function Controller.

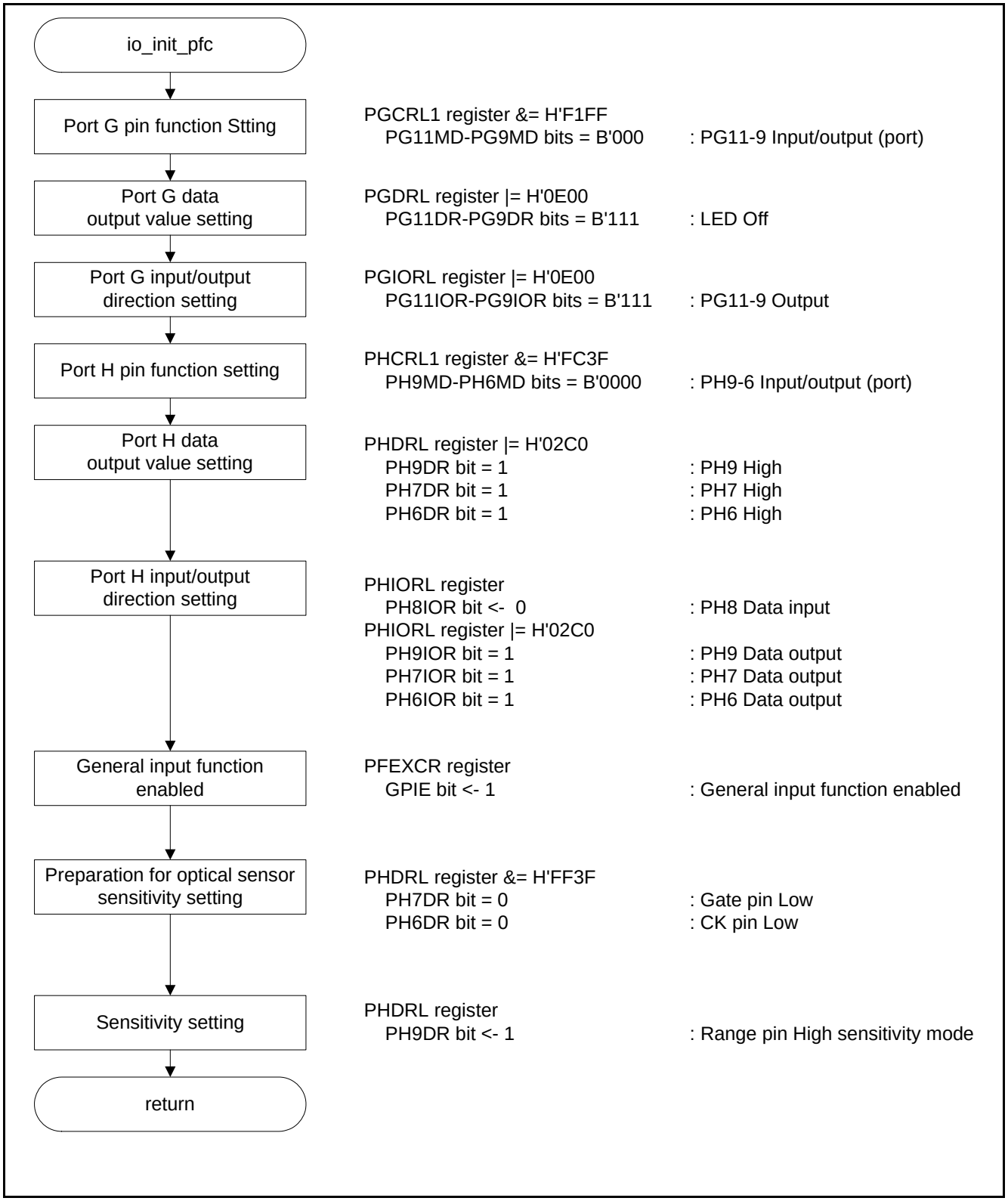

Figure 5.3 Initialization of Pin Function Controller

5.6.3 Initialization of Interrupt Controller

Figure 5.4 shows the Initialization of interrupt Controller.

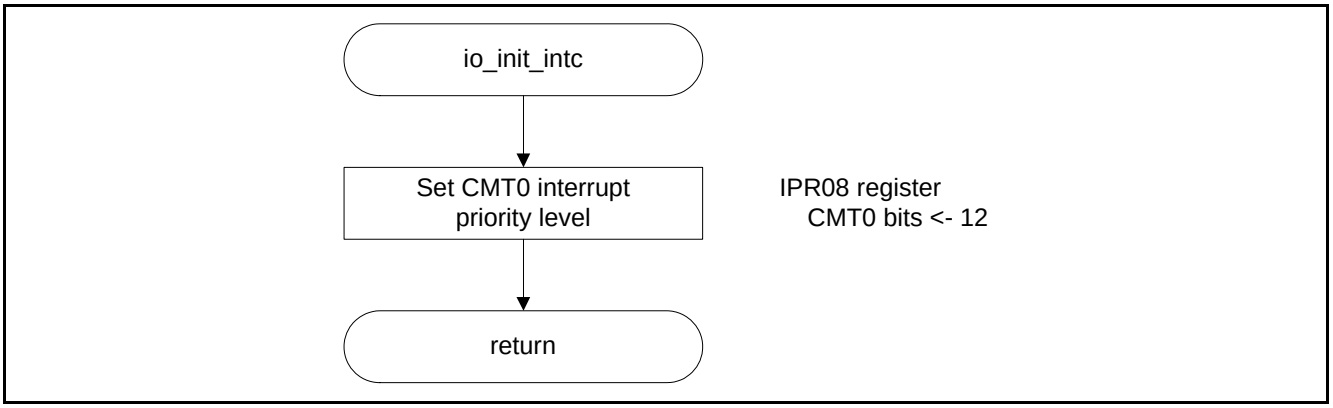

Figure 5.4 Initialization of interrupt Controller

5.6.4 Initialization of Compare Match Timer

Figure 5.5 shows the Initialization of Compare Match Timer.

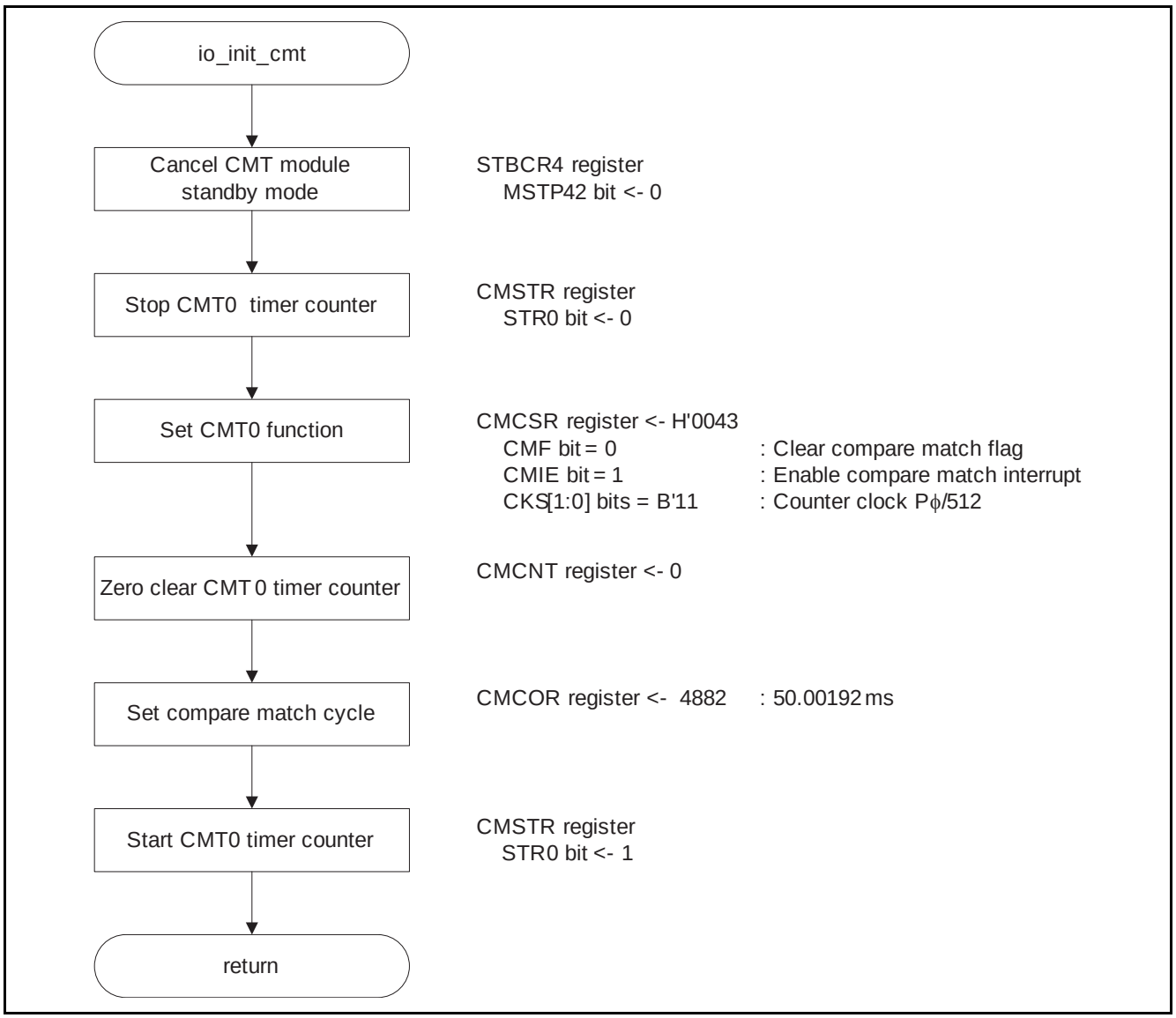

Figure 5.5 Initialization of Compare Match Timer

5.6.5 Software Wait (in ms)

Figure 5.6 shows the Software Wait (in ms).

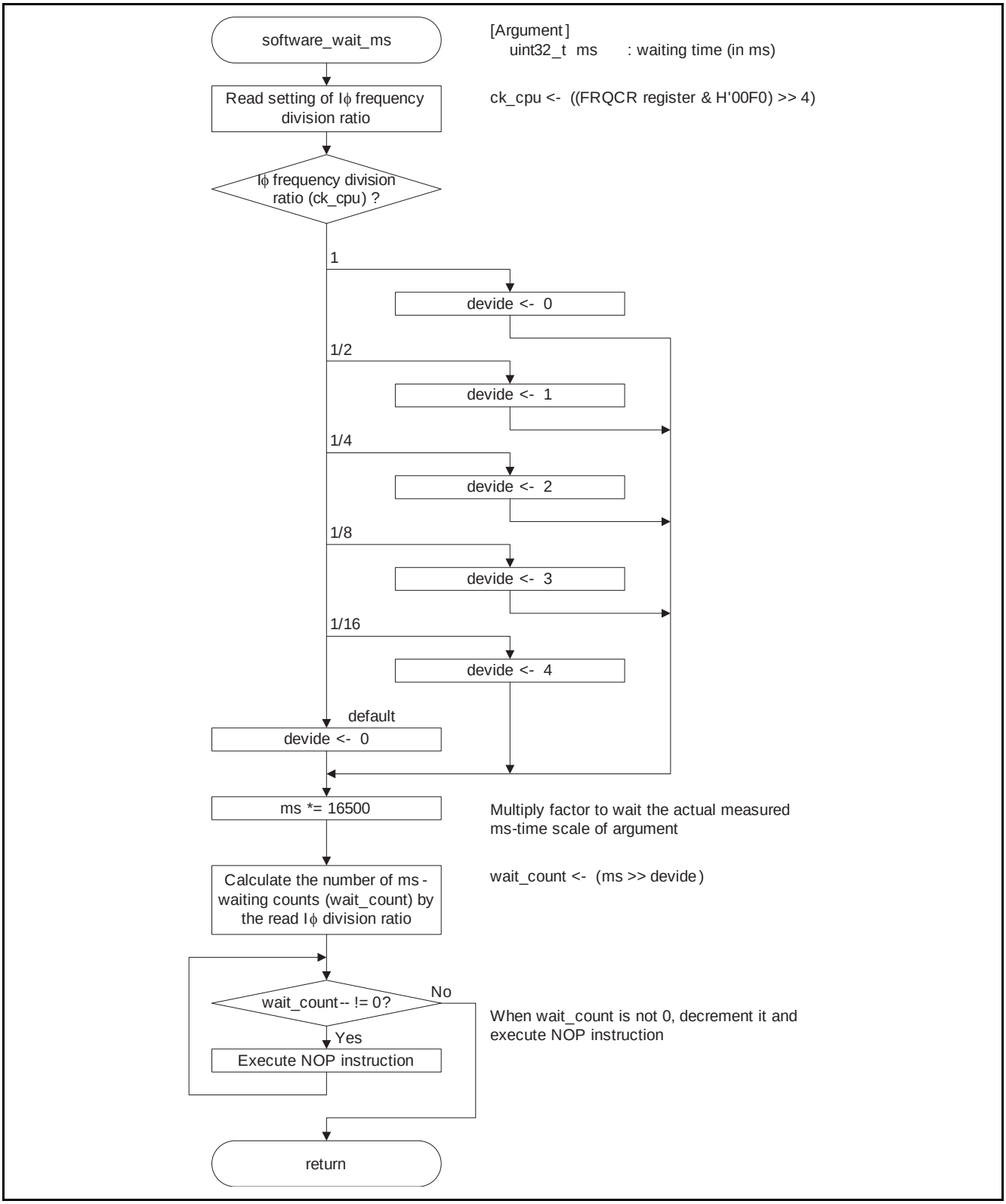

Figure 5.6 Software Wait (in ms)

5.6.6 Software Wait (in us)

Figure 5.7 shows the Software Wait (in us).

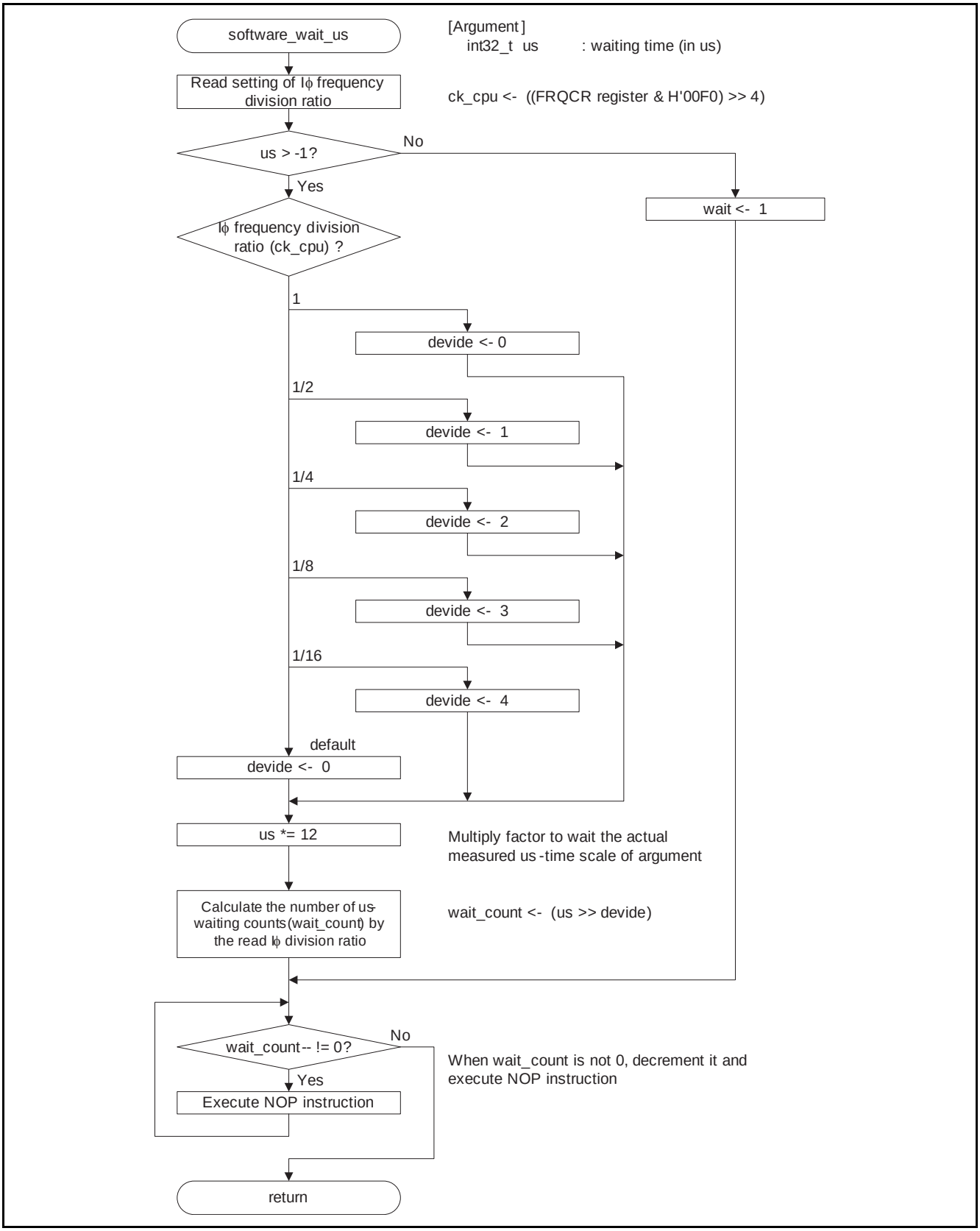

Figure 5.7 Software Wait (in us)

5.6.7 Getting Optical Sensor Data

Figure 5.8 shows the Getting Optical Sensor Data.

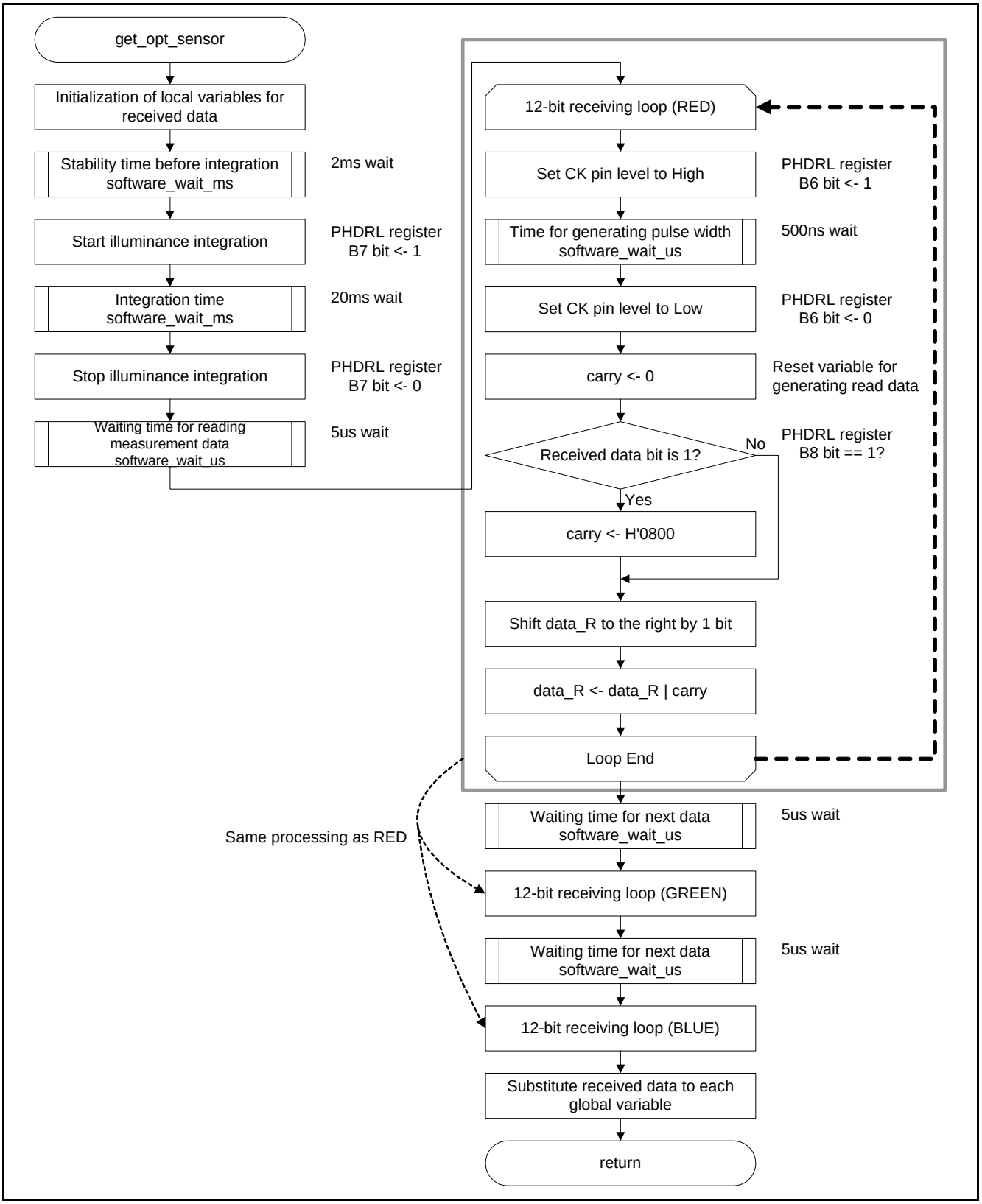

Figure 5.8 Getting Optical Sensor Data

5.6.8 Transition to Deep Software Standby Mode

Figure 5.9 shows the Transition to Deep Software Standby Mode.

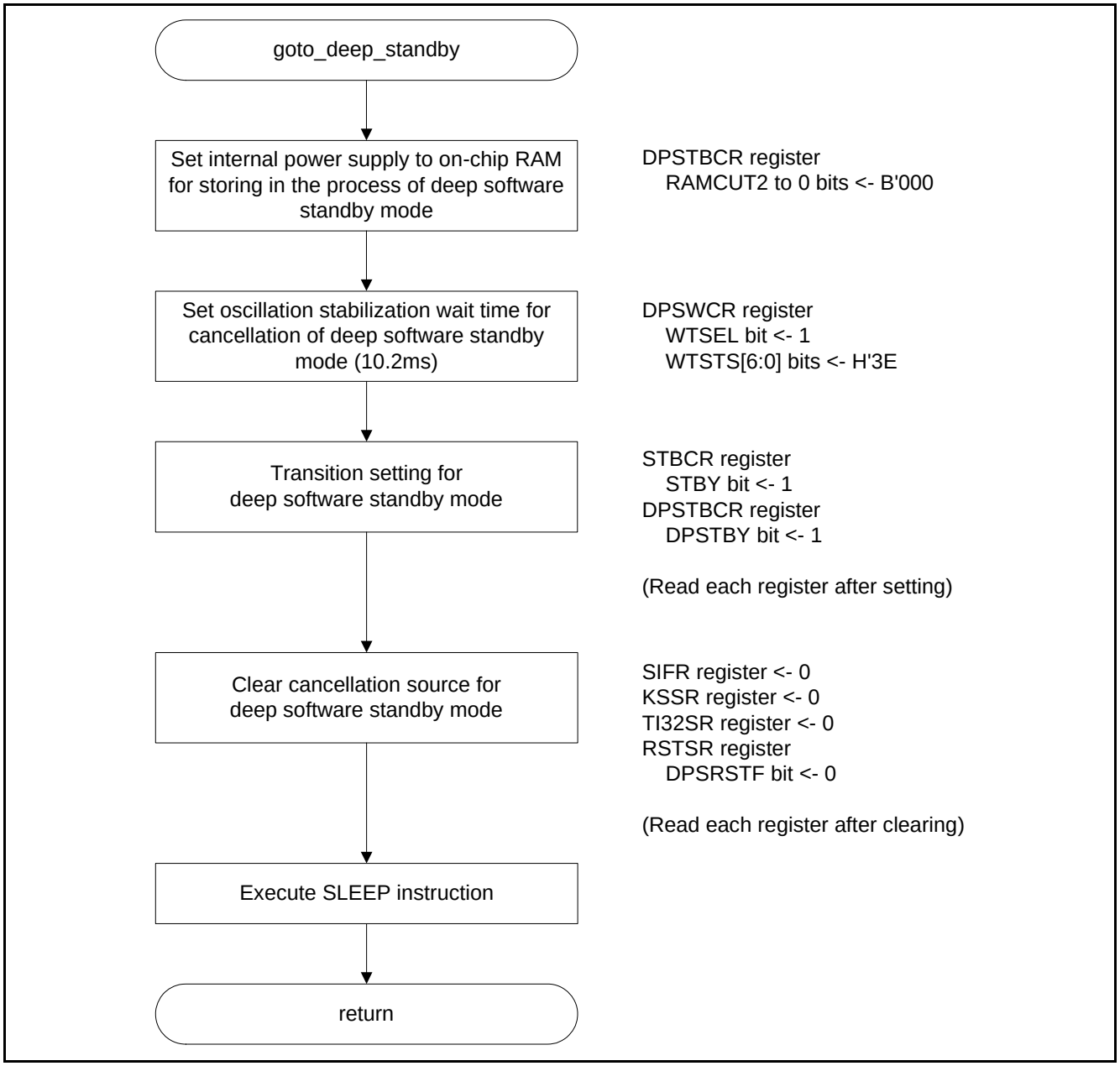

Figure 5.9 Transition to Deep Software Standby Mode

5.6.9 Cancellation of Deep Software Standby Mode

Figure 5.10 shows the Cancellation of Deep Software Standby Mode.

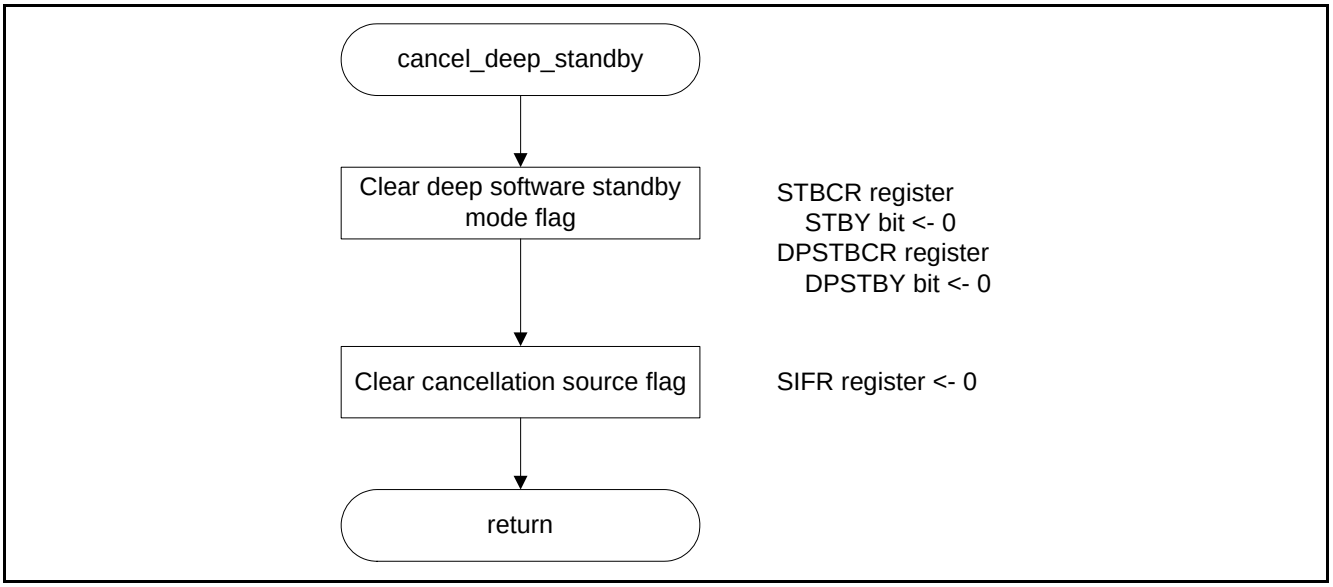

Figure 5.10 Cancellation of Deep Software Standby Mode

5.6.10 Judgment of Return From Deep Software Standby Mode

Figure 5.11 shows the Judgment of Return From Deep Software Standby Mode.

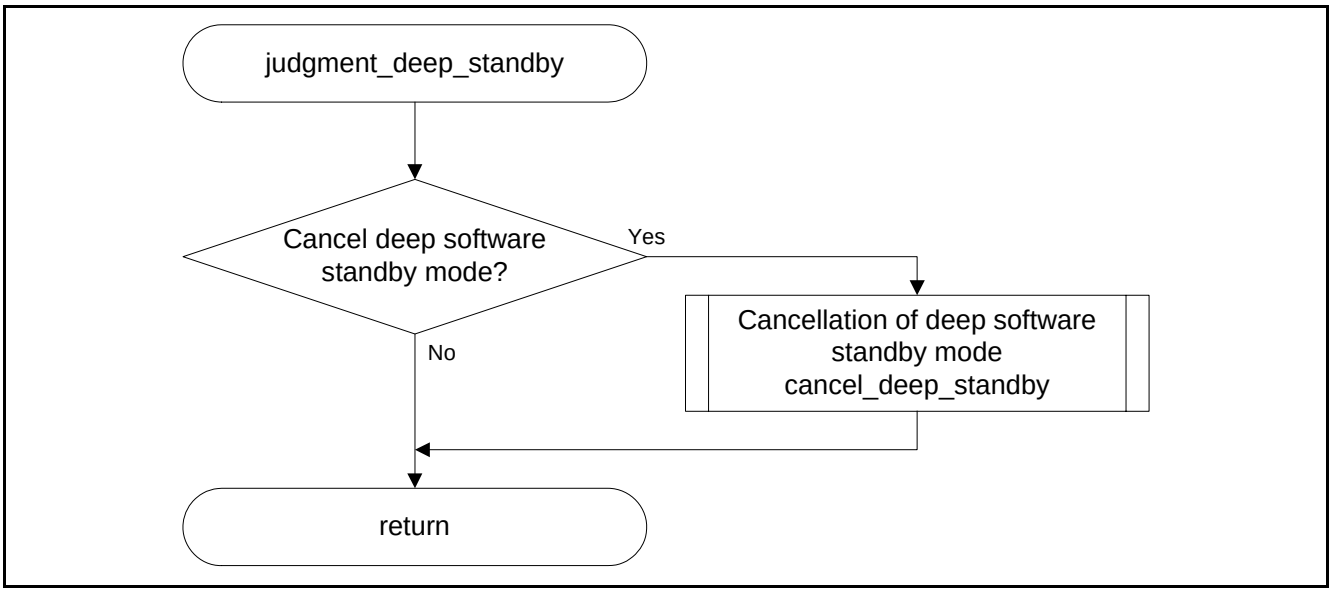

Figure 5.11 Judgment of Return From Deep Software Standby Mode

5.6.11 Exception Handling of Compare Match Timer Interrupt 0

Figure 5.12 show the Exception Handling of Compare Match Timer 0.

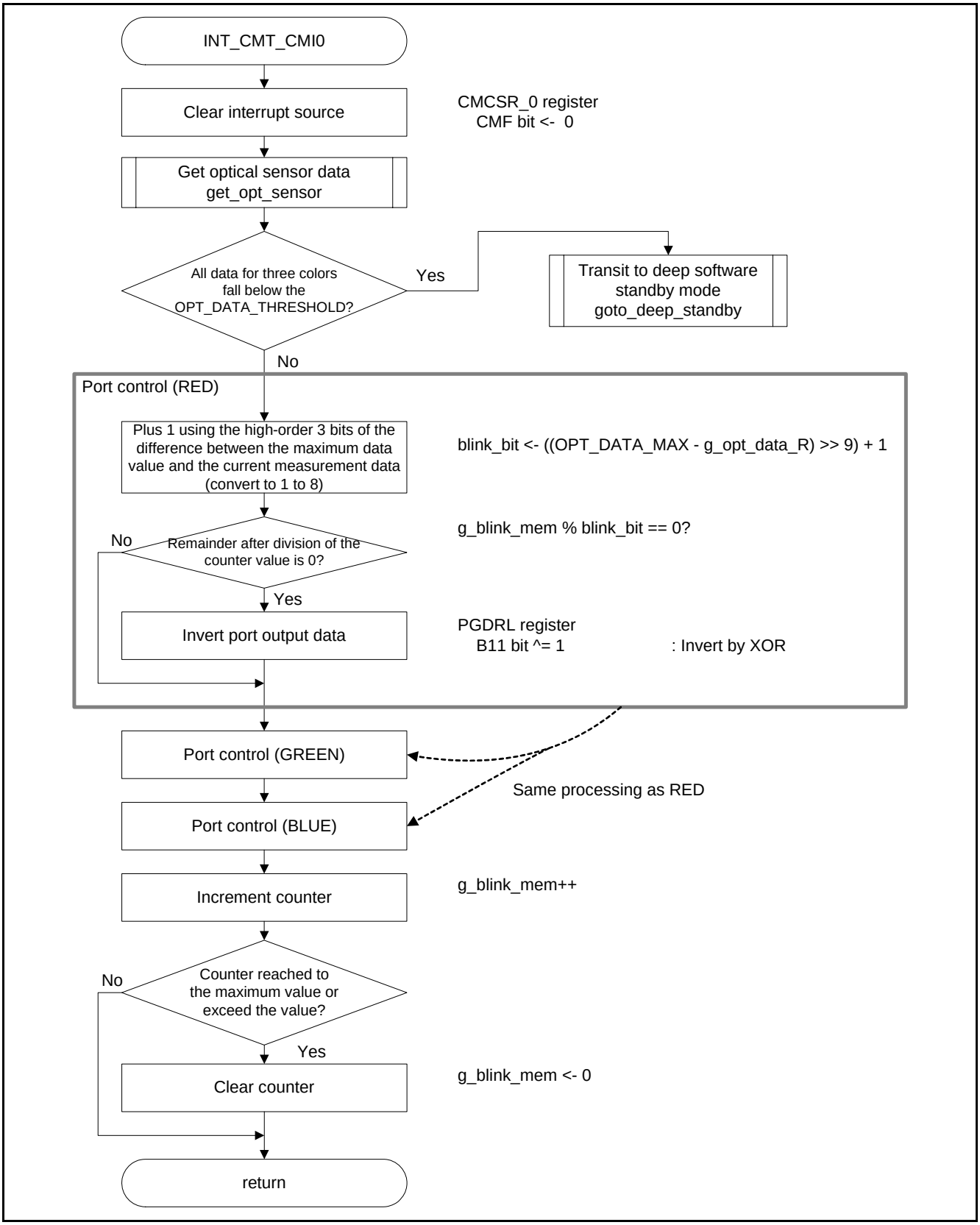

Figure 5.12 Exception Handling of Compare Match Timer 0

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

User's Manual: Hardware

SH7231 Group User's Manual: Hardware (R01UH0073EJ)
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

SuperH C/C++ Compiler Package V.9.04 User's Manual (R20UT0704EJ)
The latest version can be downloaded from the Renesas Electronics website.

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REVISION HISTORY	SH7231 Group Application Note Example of Application for Connecting the Optical Sensor

Rev.	Date	Description	
		Page	Summary
1.00	Jul. 19, 2012	—	First edition issued

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   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.
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3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
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   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.
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   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
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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: +44-1628-585-100, Fax: +44-1628-585-900

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
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