SH7231 Group

Using Key Scan Controller

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Abstract

This document describes the operation of 4×4-key matrix using the key scan controller on the SH7231.

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

The 16 key matrix switches (SW5 to SW20) are placed in the 4×4-key matrix layout on the board. These switches control the outputs at port G based on the information from the keys that were pressed, and blink the four LEDs at various time intervals.

Each one of four groups with four keys aligned vertically in the key matrix layout corresponds left to right to LEDs: to LED0 with SW5, 9, 13, 17, to LED1 with SW6, 10, 14, 18, to LED2 with SW7, 11, 15, 19, and to LED3 with SW8, 12, 16, 20. The blinking intervals vary from per 100ms, shorter at the top, through per 200ms and per 400ms, to per 800ms, longer on the bottom.

When more than two keys are pressed at one time, the information at horizontally aligned key is reflected to the LEDs, while the information at upper key among vertical alignment has priority.

Table 1.1 lists the peripheral functions and their applications. Figure 1.1 shows the block diagram.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
Key scan controller (KEYC)	Controls 4×4-key matrix input on the board
Pin function controller (PFC)	Sets the functions and input/output for the pins used
Compare match timer (CMT)	100ms timer for port G output (LED blinking) control
Interrupt controller (INTC)	Generates interrupt events at KEYC and CMT0
I/O port	Port D input, Port G output

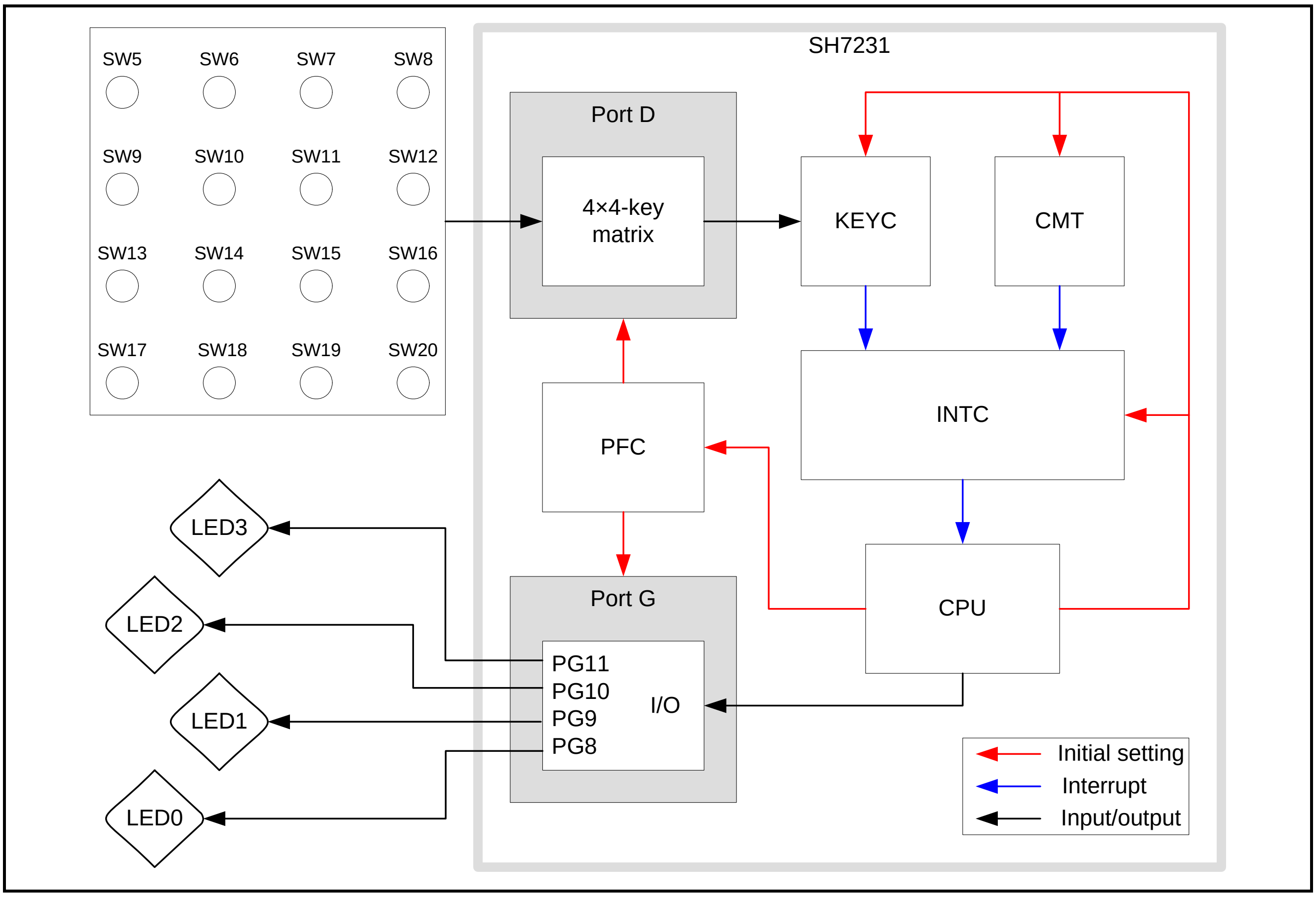

Figure 1.1 Block Diagram

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 C/C++ Compiler Package for SuperH Family 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	None

3. Reference Application Note

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

- SH7231 Group Example of Initialization (R01AN0322EJ)

4. Peripheral Functions

This application note adopts the key scan controller (KEYC), the pin function controller (PFC), the compare match timer (CMT), and the interrupt controller (INTC). Refer to the "SH7231 Group User’s Manual: Hardware" for basic information.

5. Hardware

5.1 Pins Used

Table 5.1 lists the pins used and their functions.

Table 5.1 Pins Used and Their Functions

Pin Name	I/O	Function
PD31/P3 to PD28/P0	**Input**	4×4-key matrix input
PD27/$\overline{\text{COM3}}$ to PD24/$\overline{\text{COM0}}$	**Output**	4×4-key matrix output
PG11 to PG8	**Output**	LED3 to LED0 blinking, respectively

6. Software

6.1 Operation Overview

- The functions are initialized after canceling reset, then LED0 to LED3 light up.
- Pressing one of the keys of 4×4-key matrix generates a key scan interrupt, whereat key scan data registers (KSDR_0 to KSDR_3) are read in the key scan exception handling function.
- All the bits in the key scan data registers are set to 1 by default. When a key is pressed, the bit corresponding to the pressed key is cleared to 0 in the key scan register. In the interrupt processing, the data is reversed, which results in setting 1 to the bit that corresponds to the pressed key. The reversed value is stored in the local variable.
- The data read from the register and reversed indicate the keys aligned horizontally (keys in every blue box in Figure 6.1). The data is converted to the vertically aligned data corresponding to the LEDs (keys surrounded by frames in red in Figure 6.1). When there is a bit that is set to 1, the data is assigned to the global variable, *g_key_mem[]*.
- When the value in the key scan register differs from the value scanned previously, a key scan interrupt exception handling occurs. In the sample code, even when the key is given a lift, a key scan interrupt exception handling is executed. When no key is pressed, the data is not updated, therefore the data by the latest key press is retained.
- When a CMI0 interrupt per 100ms occurs by the compare match of CMT_0, the blinking timings for LEDs are determined based on the latest key states (above mentioned global variable), and the port G output is controlled.

Figure 6.1 shows the relationship between key matrix and register, LED and blinking intervals.

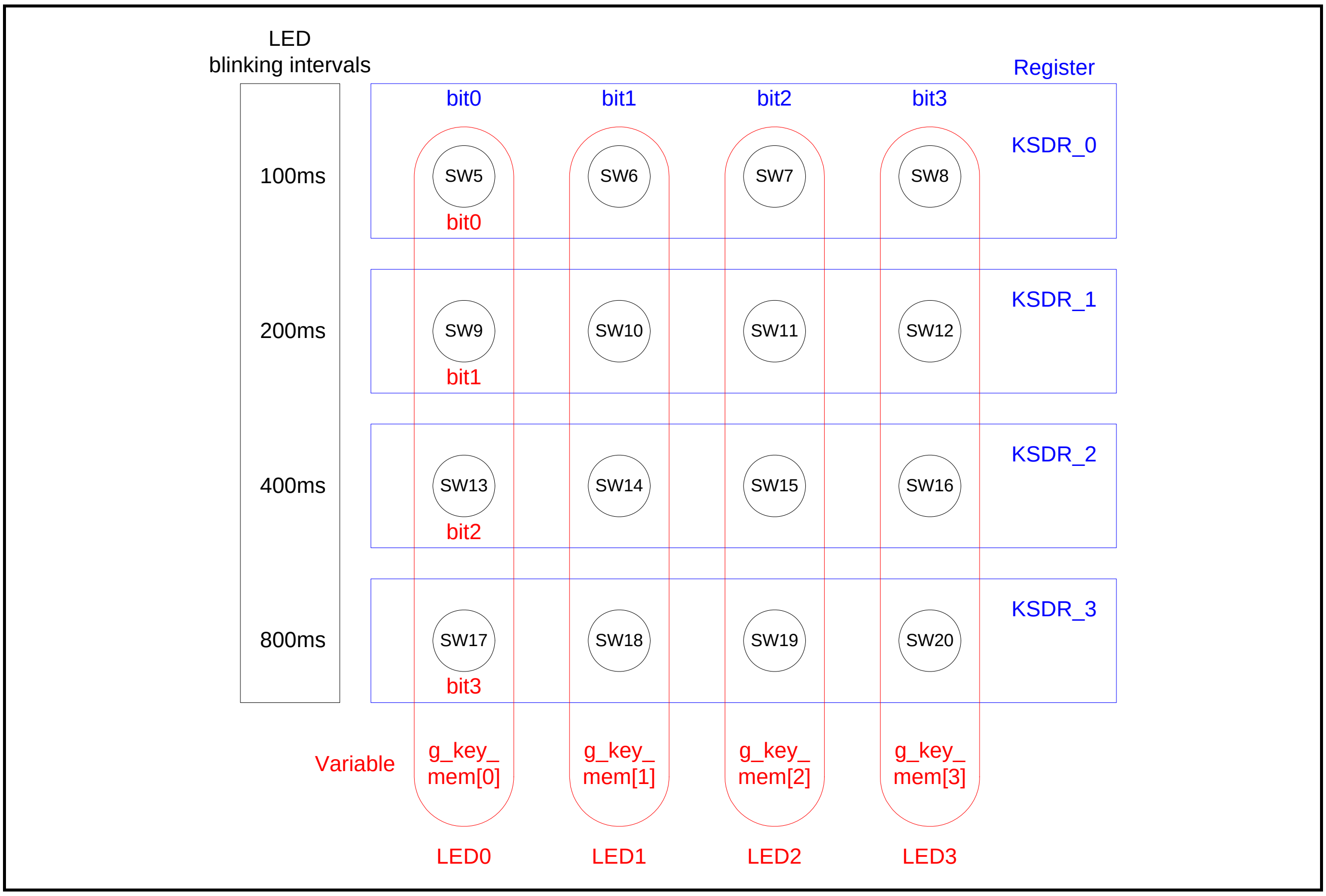

Figure 6.1 Relationship between Key Matrix, Register, LED and Blinking Intervals

6.2 Constants

Table 6.1 lists the constants used in the sample code.

Table 6.1 Constants Used in the Sample Code

Constant	Setting Value	Contents
COUNT_MAX	16	Maximum count value for port G control (LED blinking)
KEY_REG_NUM	4	Number of 4×4-key scan data register
KEY_BIT_NUM	4	Bit counts used in the 4×4-key scan data register
LED_ON	0	For LED lights on
LED_OFF	1	For LED lights off

6.3 Variables

Table 6.2 lists the global variables.

Table 6.2 Global Variables

Form	Variable Name	Contents	Function Used
uint8_t	g_blink_counter	LED blinking cycle counter	cal_led_blink INT_CMT_CMI0
uint8_t	g_key_mem[KEY_BIT_MEM]	Storage for the key aligned vertically and corresponding to the LED blinking cycle	INT_CMT_CMI0 INT_KEYC_KSI

6.4 Functions

Table 6.3 lists the functions.

Table 6.3 Functions

Function Name	Outline
main	Main processing
io_init_pfc	Initializing pin function controller
io_init_intc	Initializing interrupt controller
io_init_cmt	Initializing compare match timer
io_init_keyc	Initializing key scan controller
cal_led_blink	Determining LED blinking states
INT_CMT_CMI0	Exception handling for compare match interrupt
INT_KEYC_KSI	Exception handling for key scan interrupt

6.5 Function Specifications

The following tables list the sample code function specifications.

main	
Outline	Main processing
Header	
Declaration	void main(void)
Description	Initializes the functions.
Arguments	None
Return Value	None

io_init_pfc	
Outline	Initializing pin function controller
Header	
Declaration	void io_init_pfc(void)
Description	• Sets the pin functions 11 to 8 at port G to port output. • Sets the pin functions 31 to 28 at port D to P3 to P0 input (KEYC). • Sets the pin functions 27 to 24 at port D to $\overline{\text{COM3}}$ to $\overline{\text{COM0}}$ output (KEYC).
Arguments	None
Return Value	None

io_init_intc	
Outline	Initializing interrupt controller
Header	
Declaration	void io_init_intc(void)
Description	• Sets the interrupt priority level at KEY to 15. • Sets the interrupt priority level at CMT0 to 12.
Arguments	None
Return Value	None

io_init_cmt	
Outline	Initializing compare match timer
Header	
Declaration	void io_init_cmt(void)
Description	Enables CMT0 compare match interrupt (CMI0) and sets the compare match cycle to 100ms, then starts CMT0 timer count operation.
Arguments	None
Return Value	None

io_init_keyc	
Outline	Initializing key scan controller
Header	
Declaration	void io_init_keyc(void)
Description	Enables 4×4-key matrix input/output and key scan interrupt, then starts key scan operation.
Arguments	None
Return Value	None

cal_led_blink	
Outline	Determining LED blinking state
Header	
Declaration	uint8_t cal_led_blink(uint8_t key_data)
Description	Determines the LED ON/OFF state from the currently pressed key and the value of g_blink_counter.
Arguments	unit8_t key_data : The states of four vertically aligned keys corresponding to LED blinking cycles (H'00 to H'0F)
Return Value	None

INT_CMT_CMI0	
Outline	Exception handling for compare match interrupt
Header	
Declaration	void INT_CMT_CMI0(void)
Description	• Determines the LEDs' ON/OFF states by cal_led_blink function, and sets the result to port G. • Updates g_blink_counter.
Arguments	None
Return Value	None

INT_KEYC_KSI	
Outline	Exception handling for key scan interrupt
Header	
Declaration	void INT_KEYC_KSI(void)
Description	• Reverses four values in the key scan data registers (KSDR_0 to KSDR_3), and converts the reversed data to vertically aligned four data that correspond to the LED blinking cycles. • When the converted data is other than 0, assigns the data to the array variable, g_key_mem.
Arguments	None
Return Value	None

6.6 Flowcharts

6.6.1 Main Processing

Figure 6.2 shows the procedure of main processing.

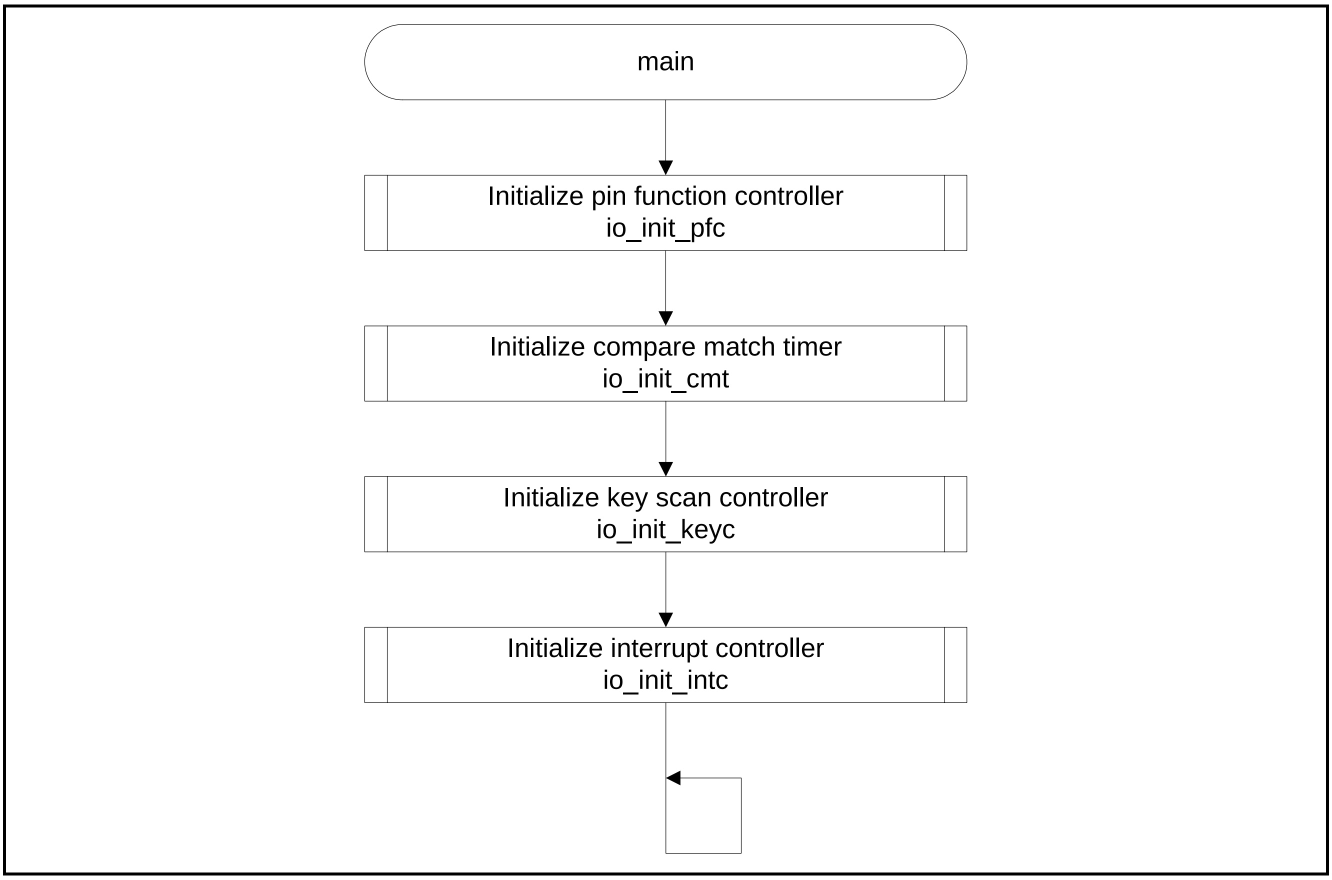

Figure 6.2 Main Processing

6.6.2 Initializing Pin Function Controller

Figure 6.3 shows the procedure of initialization for the pin function controller.

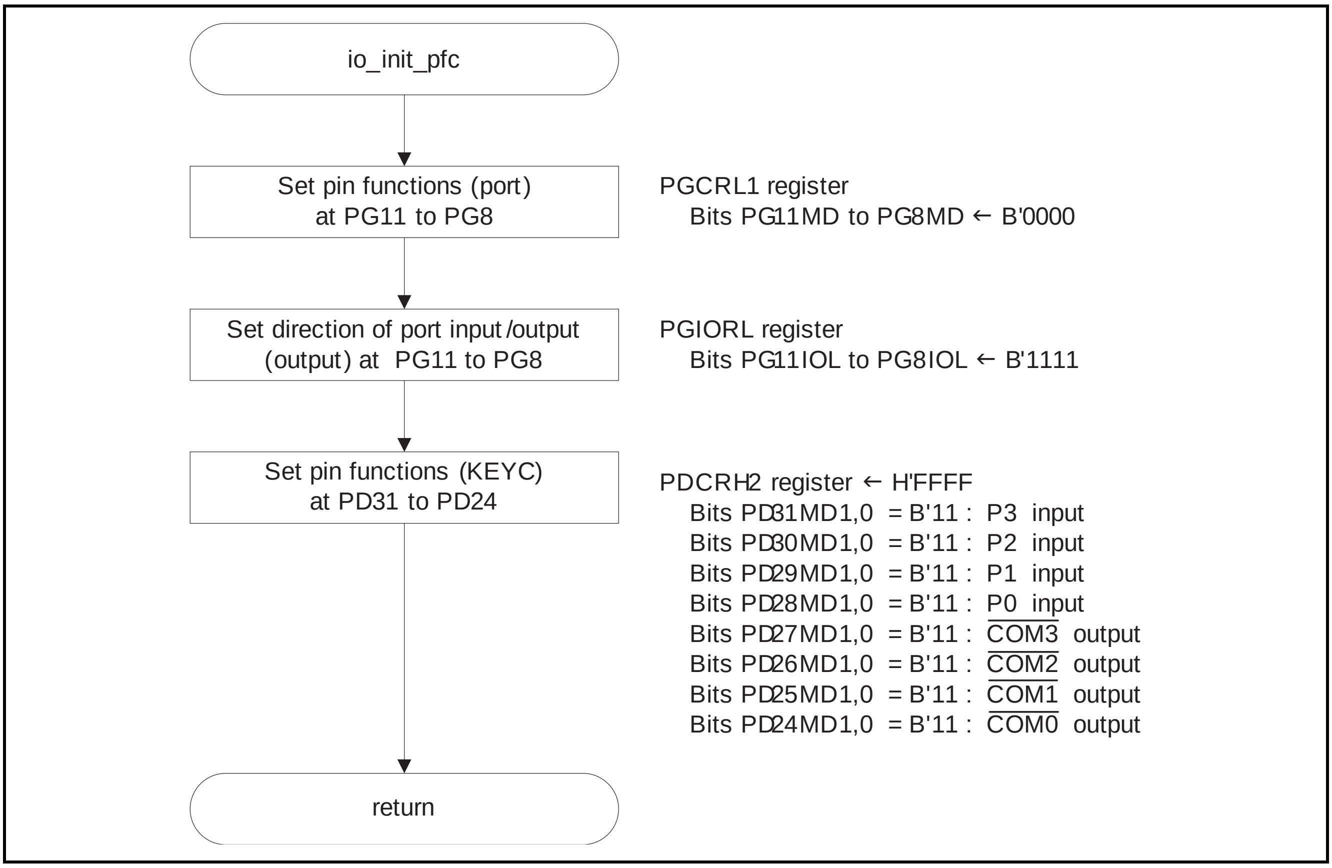

Figure 6.3 Initializing Pin Function Controller

6.6.3 Initializing Interrupt Controller

Figure 6.4 shows the procedure of initialization for the interrupt controller.

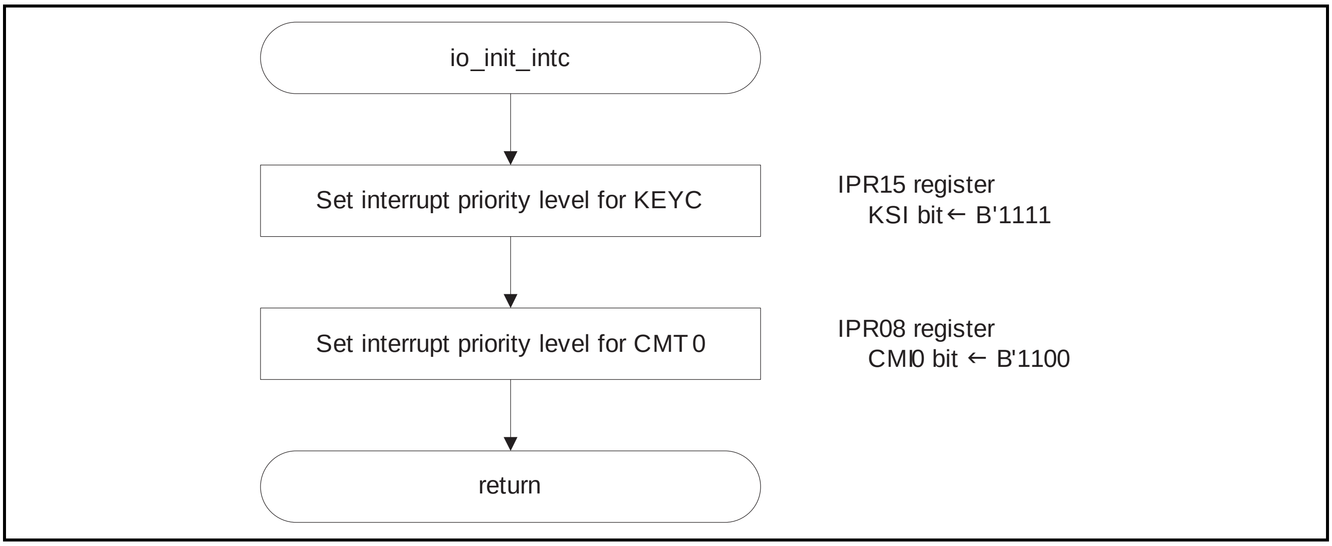

Figure 6.4 Initializing Interrupt Controller

6.6.4 Initializing Compare Match Timer

Figure 6.5 shows the procedure of initialization for the compare match timer.

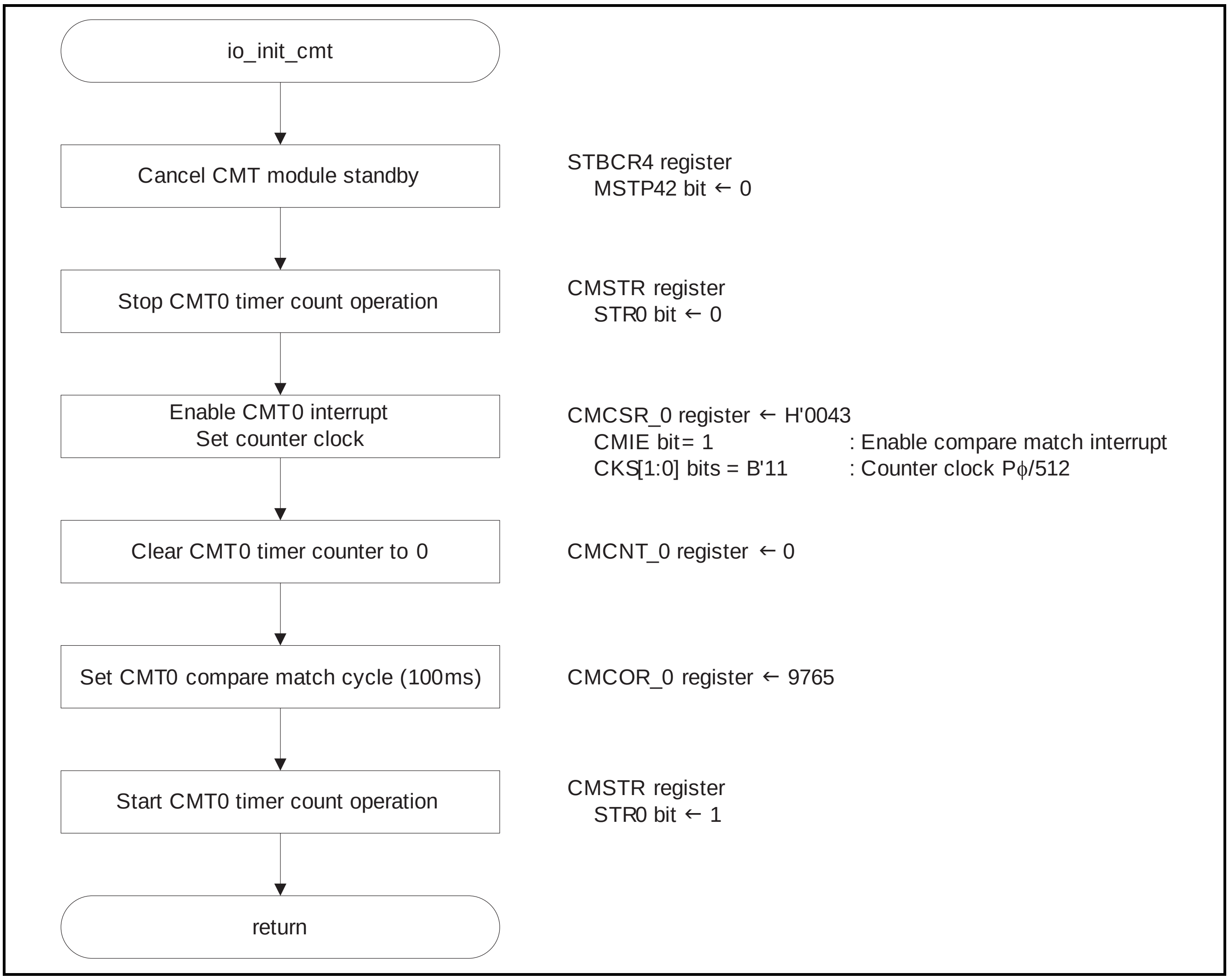

Figure 6.5 Initializing Compare Match Timer

6.6.5 Initializing Key Scan Controller

Figure 6.6 shows the procedure of initialization for the key scan controller.

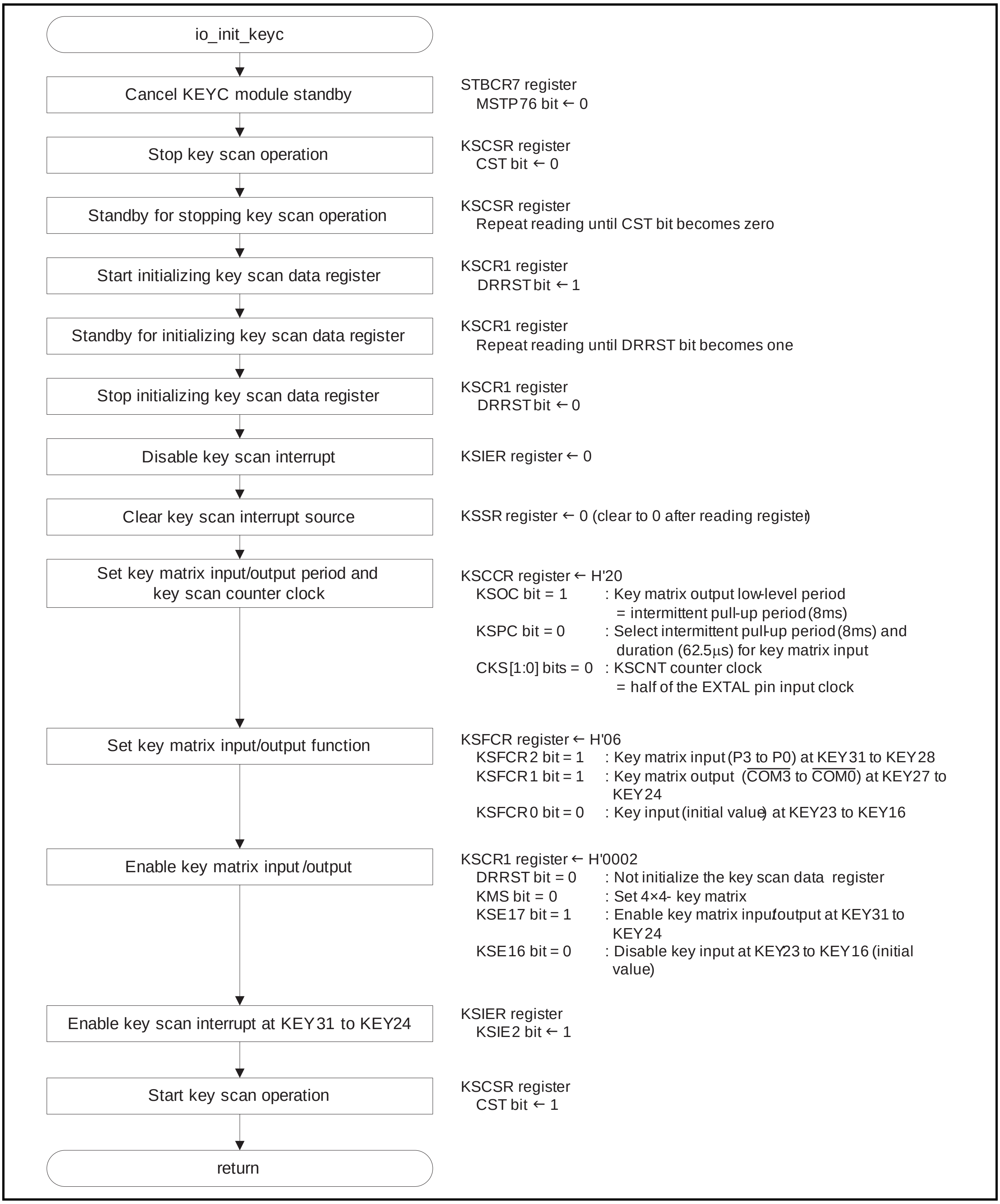

Figure 6.6 Initializing Key Scan Controller

6.6.6 Determining LED Blinking State

Figure 6.7 shows the procedure for determining the LED blinking state.

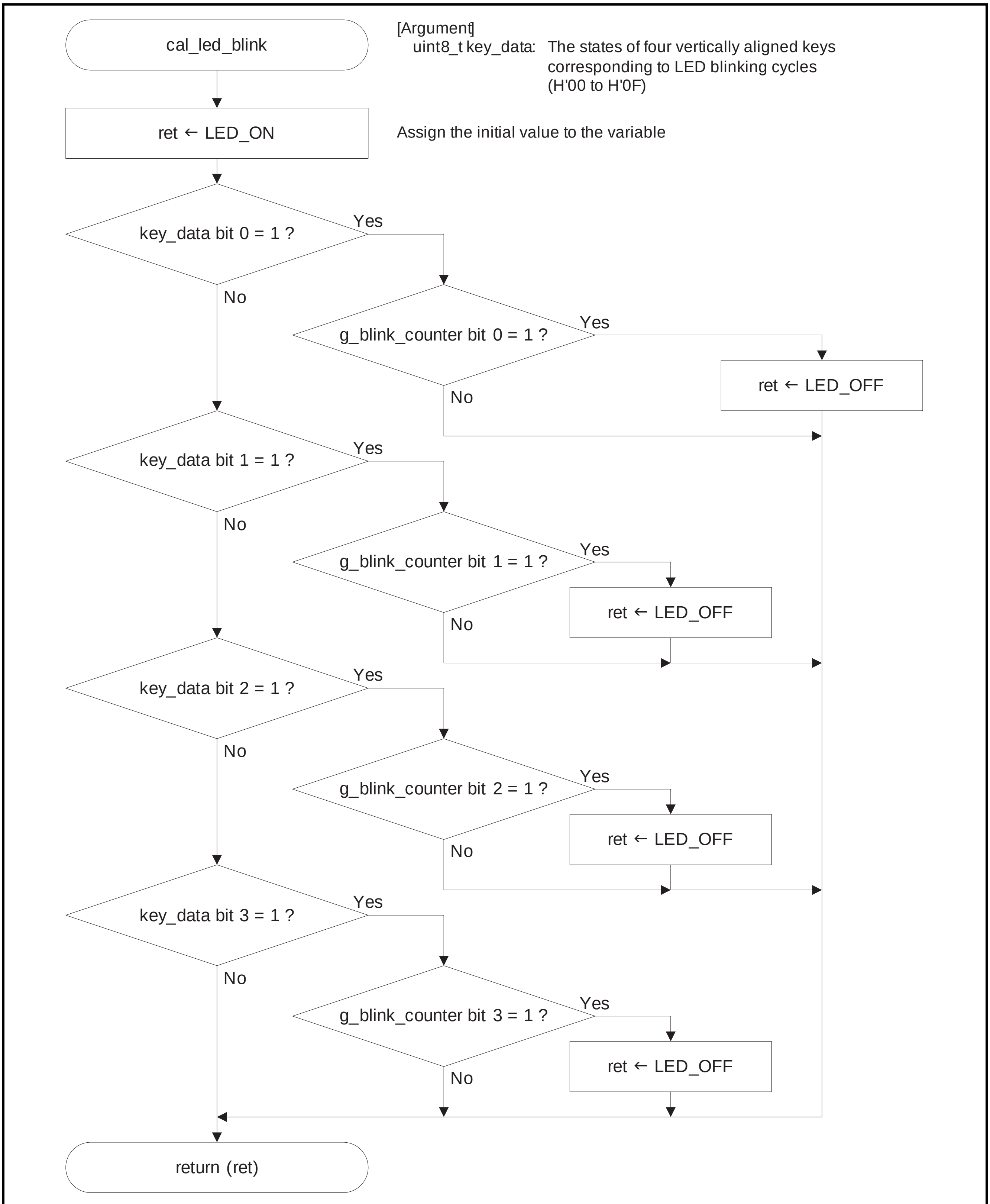

Figure 6.7 Determining LED Blinking State

6.6.7 Exception Handling for Compare Match Interrupt

Figure 6.8 shows the procedure of exception handling for compare match interrupt.

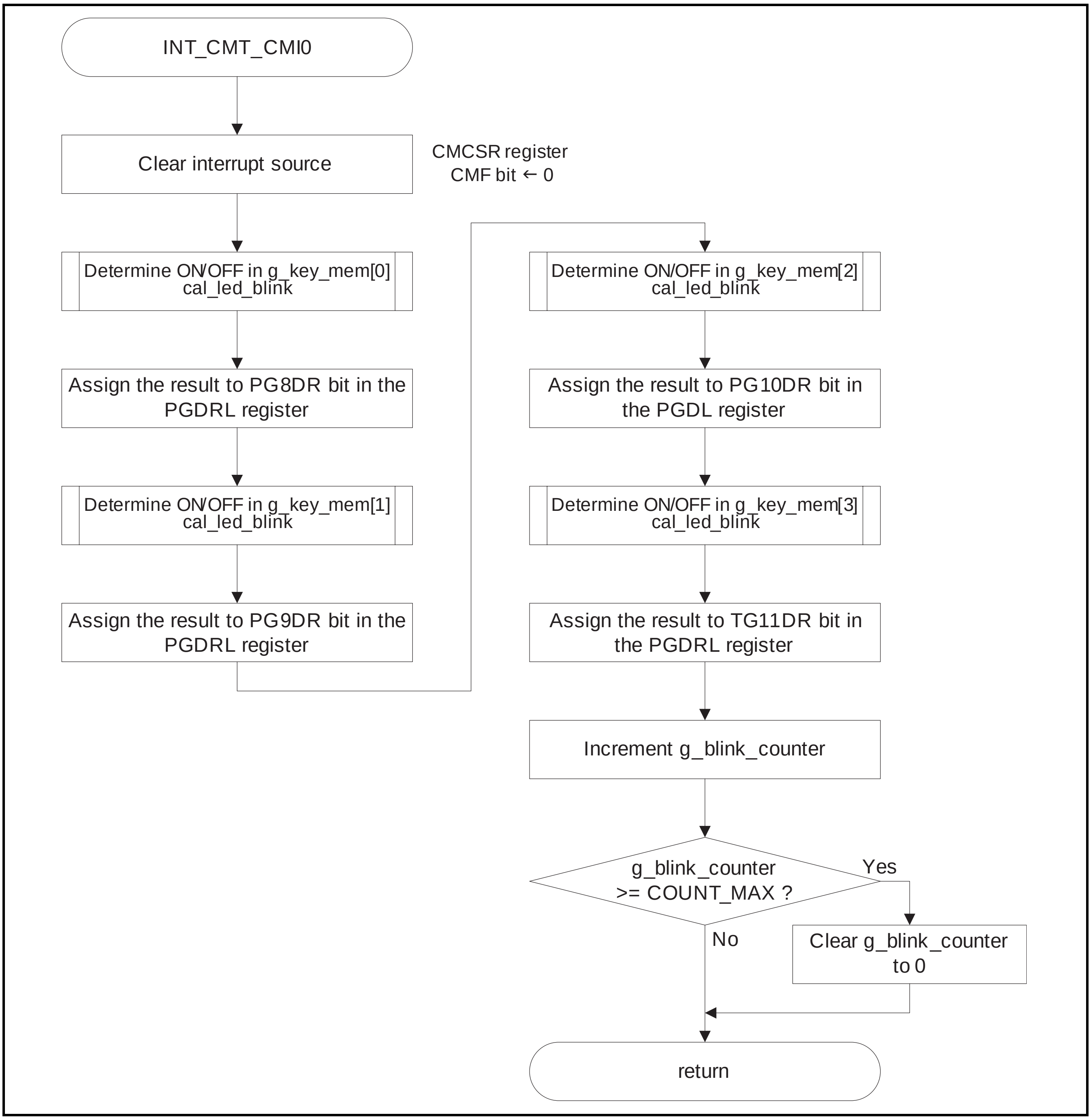

Figure 6.8 Exception Handling for Compare Match Interrupt

6.6.8 Exception Handling for Key Scan Interrupt

Figure 6.9 shows the procedure of exception handling for key scan interrupt.

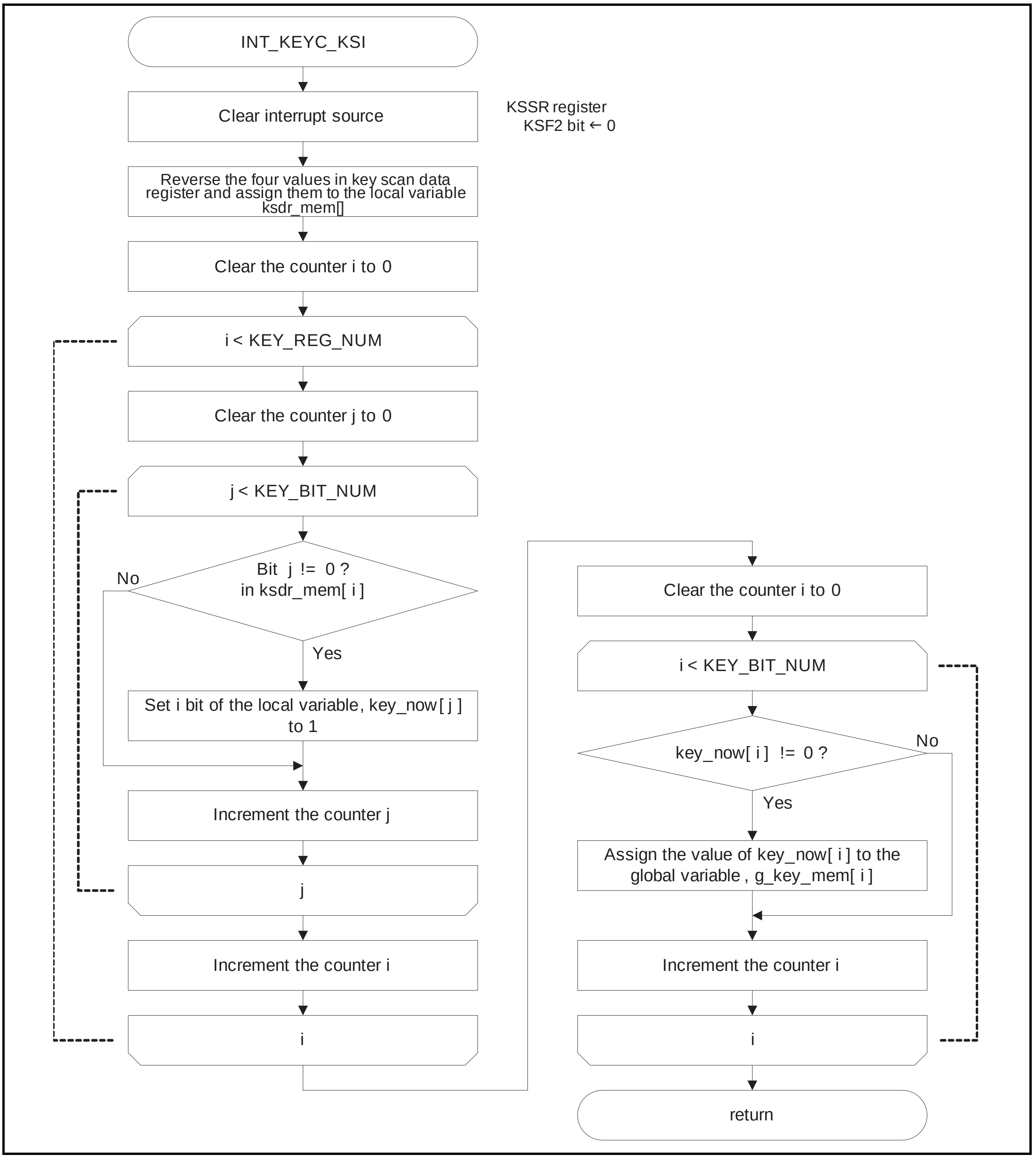

Figure 6.9 Exception Handling for Key Scan Interrupt

7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

8. Reference Documents

User's Manual: Hardware

SH7231 Group User's Manual: Hardware Rev.1.00 (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.

Website and Support

Renesas Electronics website

http://www.renesas.com

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REVISION HISTORY	SH7231 Group Application Note Using Key Scan Controller

Rev.	Date	Description	
		Page	Summary
1.00	Mar. 2, 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 type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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