

RL78/G13

R01AN0457EJ0200

Rev. 2.00

Key Interrupt Function

Dec. 27, 2013

Introduction

This application note explains how to use the key interrupt function.

A 4 x 4 key matrix is scanned to show the numbers of key switches being pressed on a 2-digit 7-segment LED display.

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.

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1. Specifications

This application note shows the use of a key interrupt function for a 4 x 4 key matrix. A key interrupt (INTKR) is used as a trigger for key scan.

When any key is pressed with all scan lines activated to enable all key inputs, an INTKR is generated. After the generation of the INTKR, the number of the pressed key is identified through key scan. A key detection is performed every 30 ms, and if detected key numbers match each other twice, the corresponding key is recognized to be pressed (chattering prevention processing). The number of the recognized key is shown on a 2-digit 7-segment LED display. When multiple keys are pressed simultaneously, “FF” is shown on the 7-segment LED display. When no key is pressed, “00” is shown on the 7-segment LED display.

Table 1.1 lists the peripheral functions to be used and their uses, and figure 1.1 illustrates the key scanning operation.

Table 1.1 Peripheral Functions to be Used and Their Uses

Peripheral Function	Use
KR0 to KR3	Key interrupt detection
P00, P01, P50, and P51	Key scanning output
Timer array unit 0 channel 0	Interval timer for timing of key scanning
P10 to P17	7-segment LED display data output
P30, P31	7-segment LED display data change

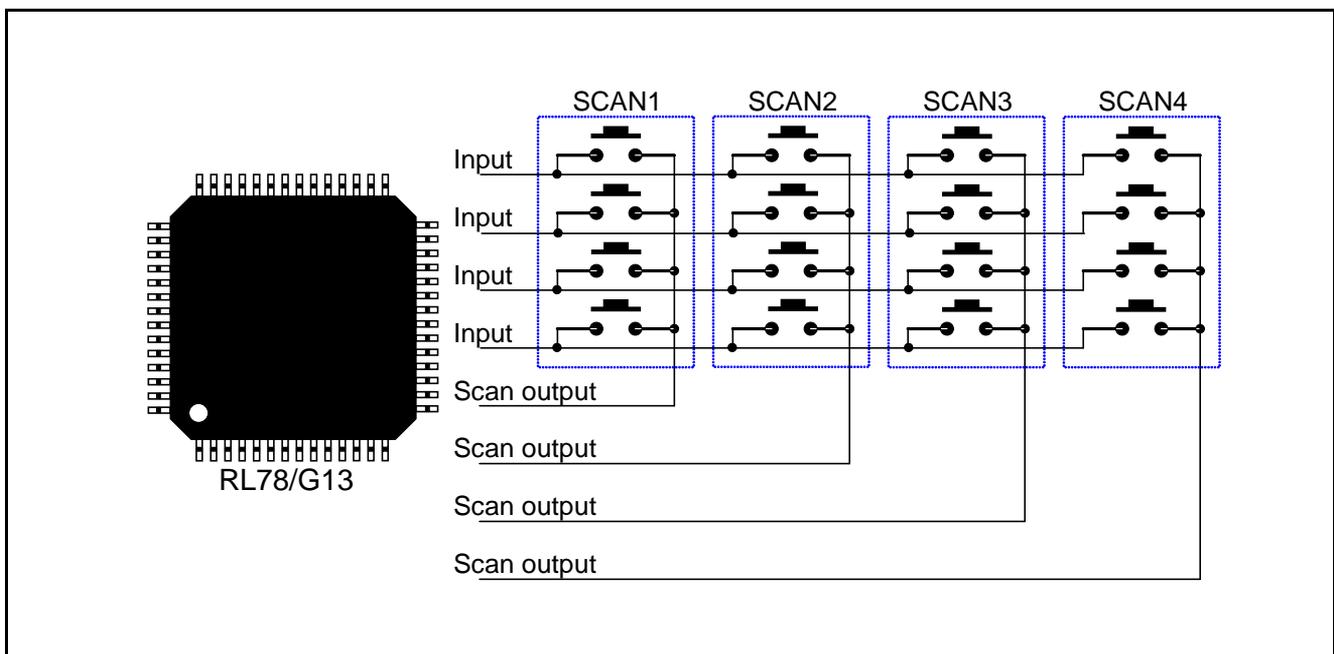


Figure 1.1 Key Scan Operation Summary

Reference: Generally, N-ch open drain output is used for key scan. Here, however, port low-level output is used to make CMOS output simulate N-ch open drain output. Key scanning with N-ch open drain pins does not allow reduction of the intervals between scans. This is because the use of pull-up resistors of several tens of k-ohms causes scan line signals to take several microseconds to several tens of microseconds to rise. Here, port high-level output is used to shorten the time for the signals to rise. This makes the program more complicated, but allows reduction of the scan time.

2. Operation Check Conditions

The sample code contained 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	<ul style="list-style-type: none"> High-speed on-chip oscillator (HOCO) clock: 32 MHz CPU/peripheral hardware clock: 32 MHz
Operating voltage	5.0 V (can run on a voltage range of 2.9 V to 5.5 V.) LVD operation (VLVI): Reset mode 2.81 V (2.76 V to 2.87 V)
Integrated development environment (CubeSuite+)	CubeSuite+ V1.00.01 from Renesas Electronics Corp.
C compiler (CubeSuite+)	CA78K0R V1.20 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2studio V2.0.1.3 from Renesas Electronics Corp.
C compiler (e2studio)	KPIT GNURL78-ELF Toolchain V13.02 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V1.30.2
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V1.30.2

3. Related Application Notes

The application note related to this application note is shown below. Refer to it together with this application note.

- RL78/G13 Initialization (R01AN0451EJ0100) Application Note

4. Description of the Hardware

4.1 Hardware Configuration Example

Figure 4.1 gives an example of hardware configuration used in this application note.

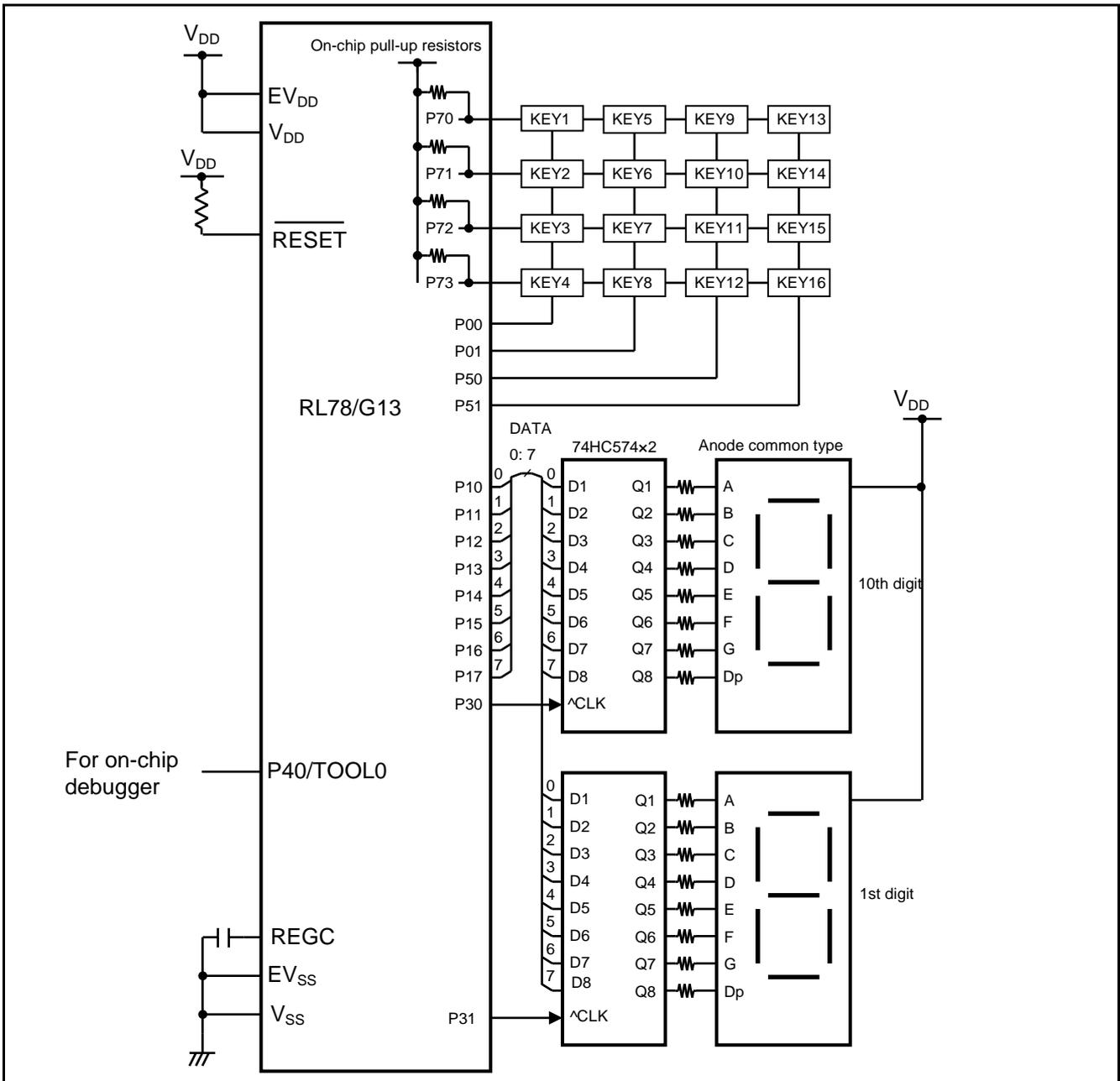


Figure 4.1 Hardware Configuration

- 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_{LVI}) 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
P70 to P73	Input	Key interrupt detection
P00 and P01, P50 and P51	Output	Key scan output
P10 to P17	Output	7-segment LED display data output
P30 and P31	Output	7-segment LED display data change

5. Description of the Software

5.1 Operation Overview

This application note shows the use of key interrupt (INTKR) and timer interrupt (INTTM00).

When any key is pressed with all scan lines activated to enable all key inputs, an INTKR is generated. After the generation of the INTKR, the number of the pressed key is identified through key scan. A key detection is performed every 30 ms, and if detected key numbers match each other twice, the corresponding key is recognized to be pressed (chattering prevention processing). The number of the recognized key is shown on a 2-digit 7-segment LED display. When multiple keys are pressed simultaneously, FF is shown on the 7-segment LED display. When no key is pressed, 00 is shown on the 7-segment LED display. This processing continues until all keys are released.

(1) Make initial setting.

<Setting Conditions>

- Set channel 0 of TAU0 to a 30-ms-period interval timer.
- Set the key interrupt detection pins to an interrupt enable state.
- Set all the key scan output pins to an output state.

(2) Wait until a key is pressed.

(3) Perform key scan after an INTKR is generated.

(4) Perform key scan every 30 ms and perform chattering prevention processing.

(5) When a key number is recognized, the LED display indicates that the corresponding key is pressed.

(6) When all the keys are released, all the scan lines are activated to return the system to a key input wait state in (2).

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 +/- 0.07 V
000C2H/010C2H	11101000B	HS mode HOCO: 32 MHz
000C3H/010C3H	10000100B	Enables the on-chip debugger.

5.3 List of Functions

Table 5.2 gives a list of functions that are used by this sample program.

Table 5.2 Functions

Function Name	Outline
R_PORT_ScanData_Low	Key scan low-level output setting
R_PORT_ScanData_High	Key scan high-level output setting
R_PORT_ScanLine_Input	Key scan input setting
R_PORT_ScanLine_Output	Key scan output setting
R_PORT_ScanLine_SetScan	Key scan output
R_Wait	30 ms wait
R_Getkey	Key scan processing
R_Ledout	LED display control

5.4 Function Specifications

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

[Function Name] R_PORT_ScanData_Low

Synopsis	Key scan low-level output setting
Header	r_cg_port.h
Declaration	void R_PORT_ScanData_Low(void)
Explanation	Sets all key scan outputs to low-level.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_PORT_ScanData_High

Synopsis	Key scan high-level output setting
Header	r_cg_port.h
Declaration	void R_PORT_ScanData_High(void)
Explanation	Sets all key scan output to high-level.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_PORT_ScanLine_Input

Synopsis	Key scan input setting
Header	r_cg_port.h
Declaration	void R_PORT_ScanLine_Input(void)
Explanation	Sets all key interrupt detection pins to input mode/on-chip pull-up use.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_PORT_ScanLine_Output

Synopsis	Key scan output setting
Header	r_cg_port.h
Declaration	void R_PORT_ScanLine_Output(void)
Explanation	Sets all key scan output pins to output mode.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_PORT_ScanLine_SetScan

Synopsis	Key scan output
Header	r_cg_port.h
Declaration	void R_PORT_ScanLine_SetScan(uint8_t scanline)
Explanation	Performs output control of key scan to be output next, according to the arguments.
Arguments	Currently output key scan signal
Return value	None
Remarks	None

[Function Name] R_Wait

Synopsis	30 ms wait
Header	—
Declaration	static void R_Wait(void)
Explanation	Waits for 30 ms using timer interrupt.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_Getkey

Synopsis	Key scan processing
Header	—
Declaration	void R_Getkey(void)
Explanation	Checks the key press status of the key matrix.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_Ledout

Synopsis	LED display control
Header	—
Declaration	static void R_Ledout(uint16_t onkey)
Explanation	Shows the key press status on the 7-segment LED display.
Arguments	Key data
Return value	None
Remarks	None

5.5 Flowcharts

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

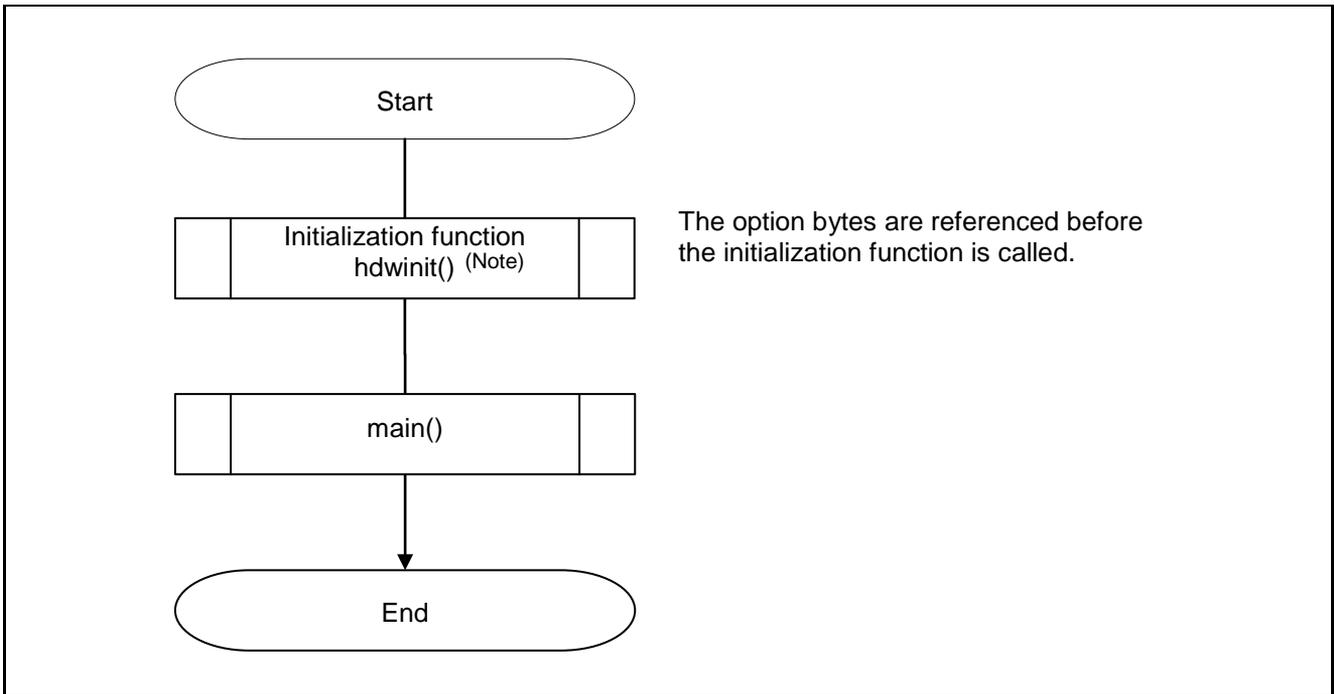


Figure 5.1 Overall Flow

5.5.1 Initialization Function

Figure 5.2 shows the flowchart for the initialization function.

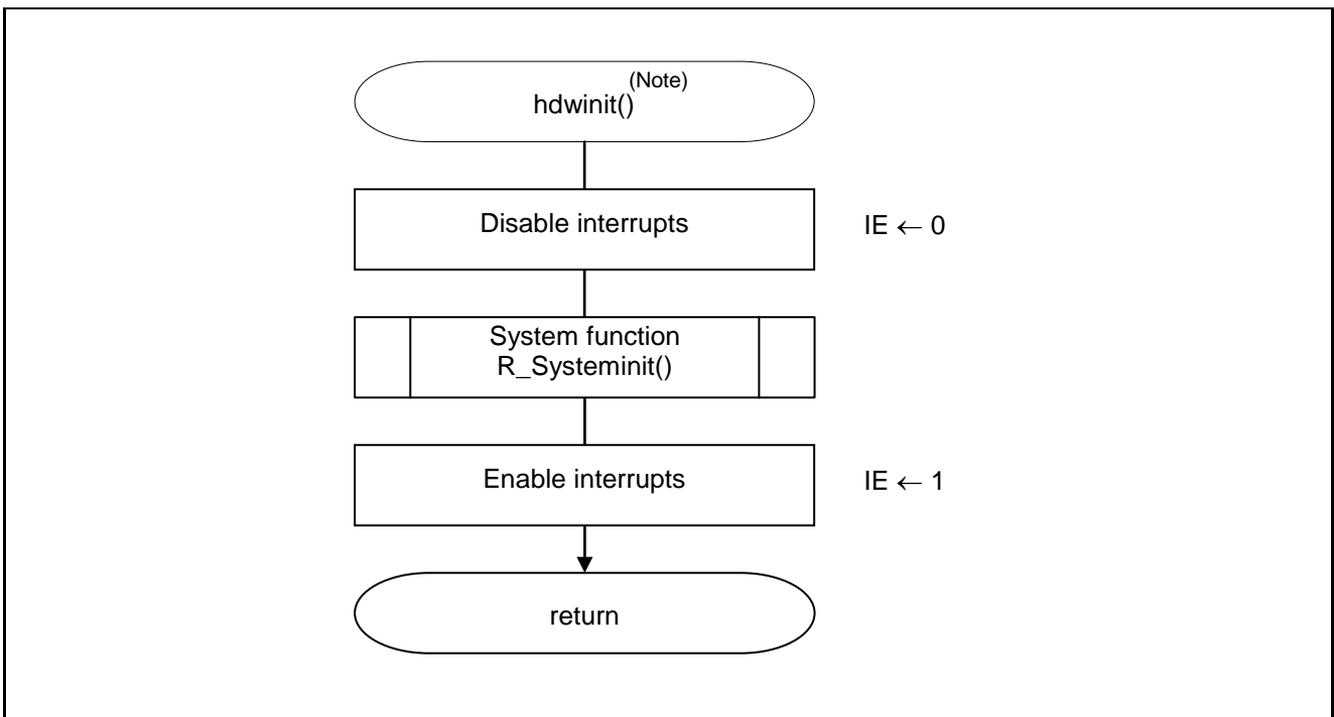


Figure 5.2 Initialization Function

Note: The `__low_level_init` function initializes the system in the IAR Workbench IDE-Oriented sample code.

5.5.2 System Function

Figure 5.3 shows the flowchart for the system function.

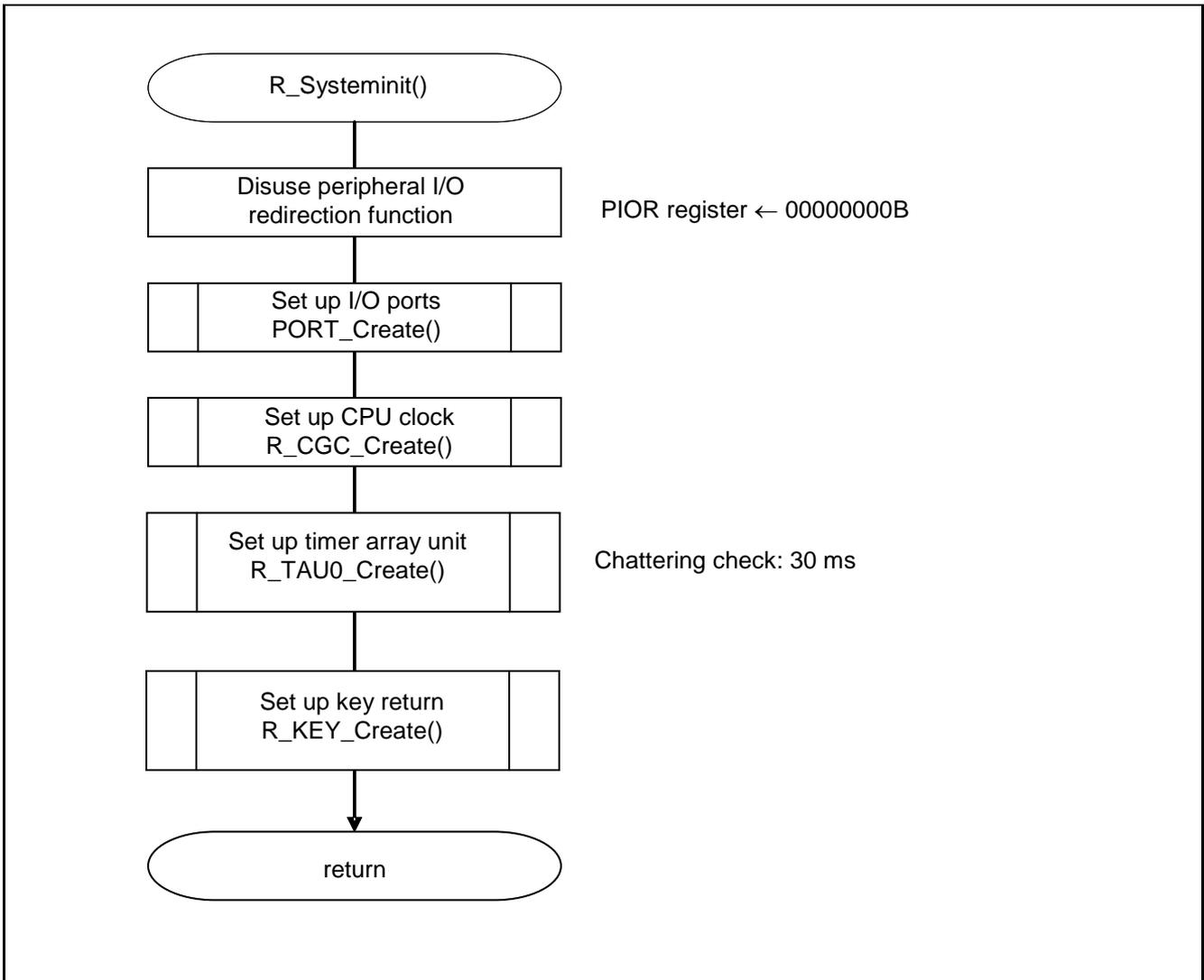


Figure 5.3 System Function

5.5.3 Setting up the I/O Ports

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

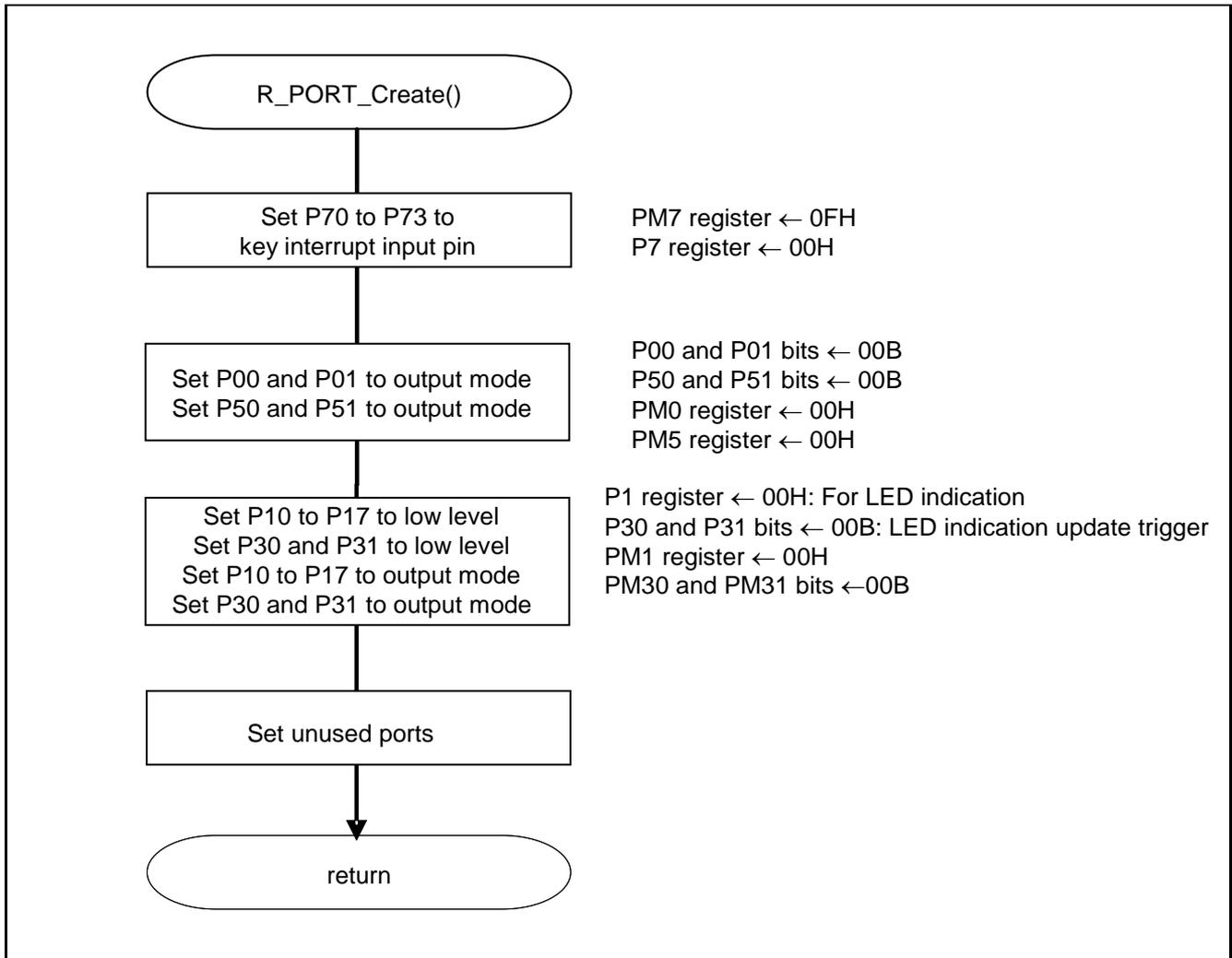


Figure 5.4 I/O Port Setup

Note: For the setting of the unused ports, refer to RL78/G13 Initialization (R01AN0451EJ0100) Application Note “Flowcharts”.

Caution: For the unused ports, pin processing should be performed appropriately, and they should be designed according to the electrical specifications. Also, the unused ports dedicated to input should be connected to V_{DD} or V_{SS} via separate resistors.

Key Interrupt Input Pin Setting

- Port mode register (PM7)
Set to input mode the pins with which key interrupt is to be used.

Symbol: PM7

7	6	5	4	3	2	1	0
PM77	PM76	PM75	PM74	PM73	PM72	PM71	PM70
0	0	0	0	1	1	1	1

Bits 7 to 0

PM7	Select I/O mode of P7n pin (n = 0 to 7)
0	Output mode (output buffer on)
1	Input mode (output buffer off)

Caution: For details on the procedure for setting up the registers, refer to RL78/G13 User's Manual: Hardware.

When setting the desired bits of the KRM0 to KRM7 bits to 1, bits 0 to 3 (PU70 to PU73) of the corresponding pull-up resistor option register 7 (PU7) need to be set to 1. This is performed during I/O port setting.

On-chip Pull-up Control

- Pull-up Resistor Option Register (PU7)
The pins with which key interrupt is to be used are set to use on-chip pull-up resistors.

Symbol: PU7

7	6	5	4	3	2	1	0
PU77	PU76	PU75	PU74	PU73	PU72	PU71	PU70
x	x	x	x	1	1	1	1

Bits 0 to 3

PU7n	P7n pin on-chip pull-up resistor setting (n = 0 to 7)
0	On-chip pull-up resistor is not connected
1	On-chip pull-up resistor is connected

Caution: For details on the procedure for setting up the registers, refer to RL78/G13 User's Manual: Hardware.

5.5.4 CPU Clock Setup

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

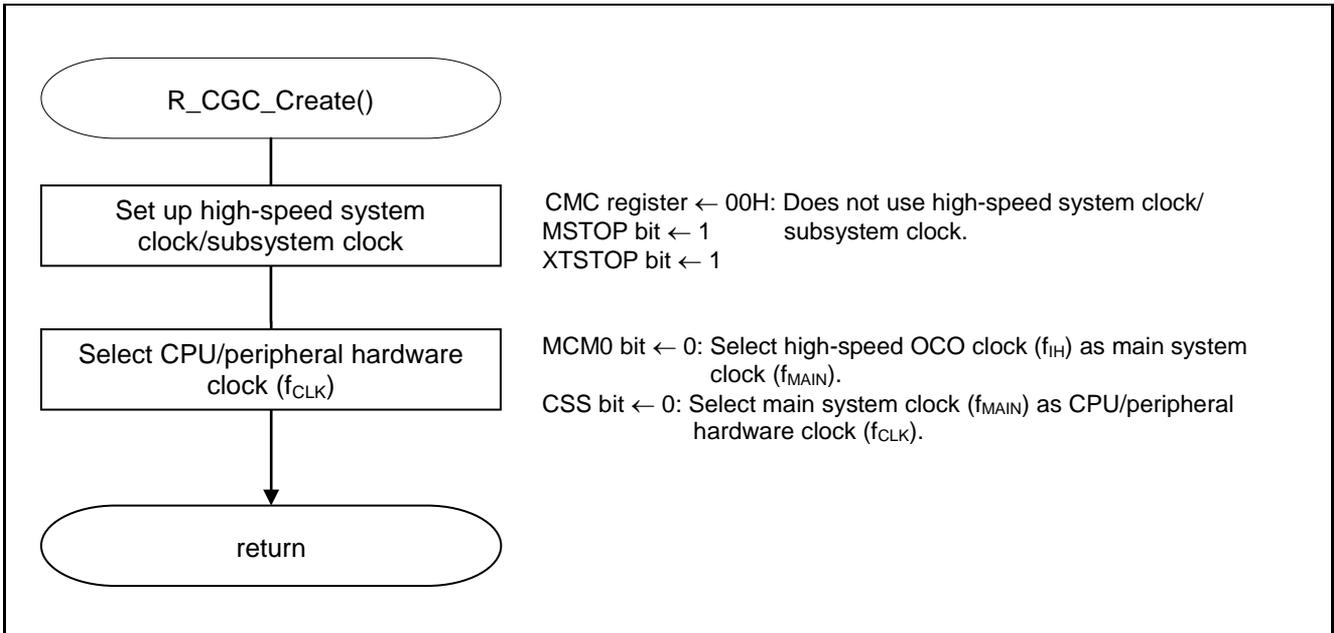


Figure 5.5 CPU Clock Setup

Caution: For the setting of the CPU clock (R_CGC_Create()), refer to RL78/G13 Initialization (R01AN0451EJ0100 Application Note “Flowcharts”).

5.5.5 Timer Array Unit Setup

Figure 5.6 shows the flowchart for setting up the timer array unit.

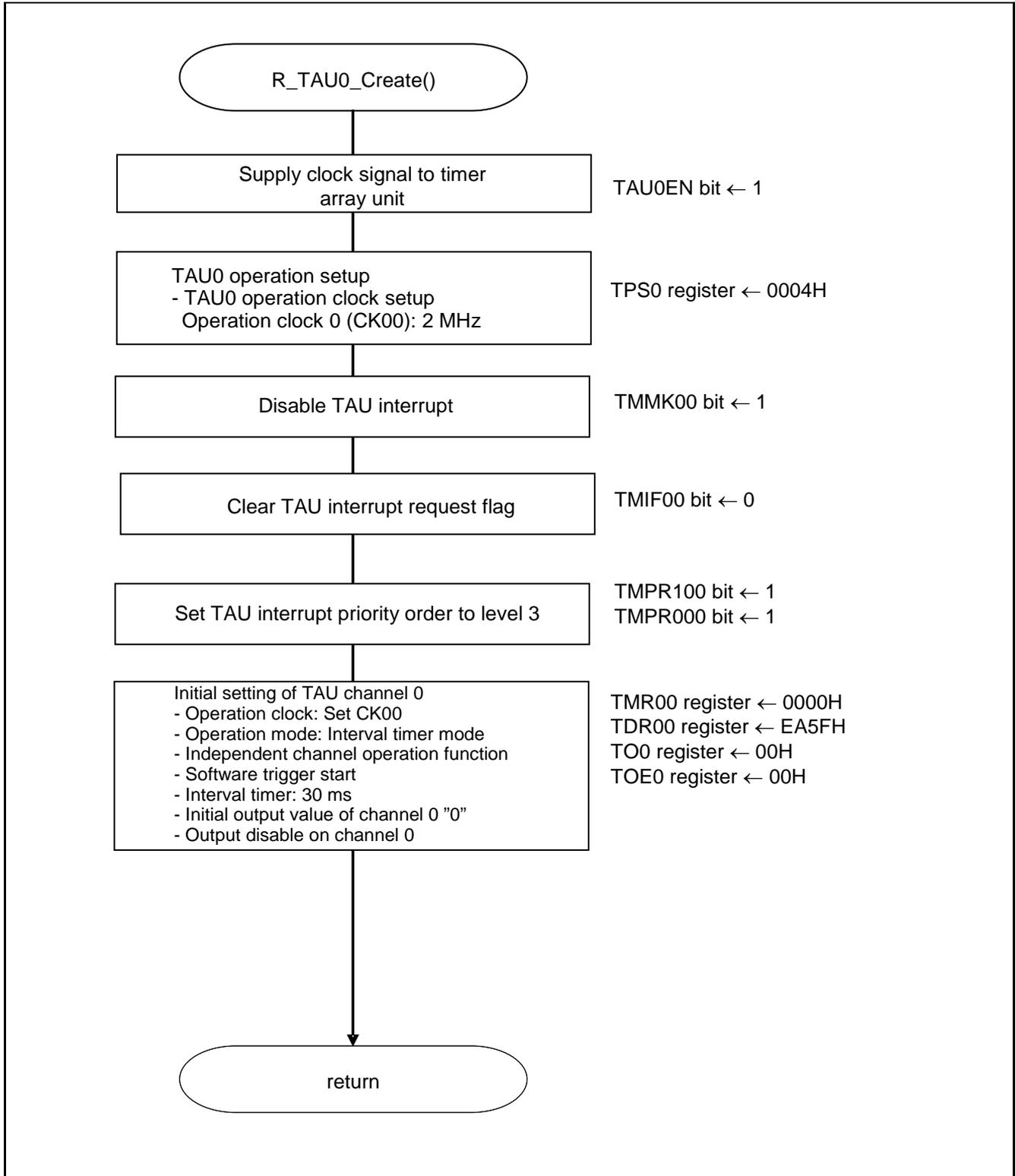


Figure 5.6 Timer Array Unit Setup

5.5.6 Key Interrupt Setup

Figure 5.7 shows the flowchart for setting up key interrupt.

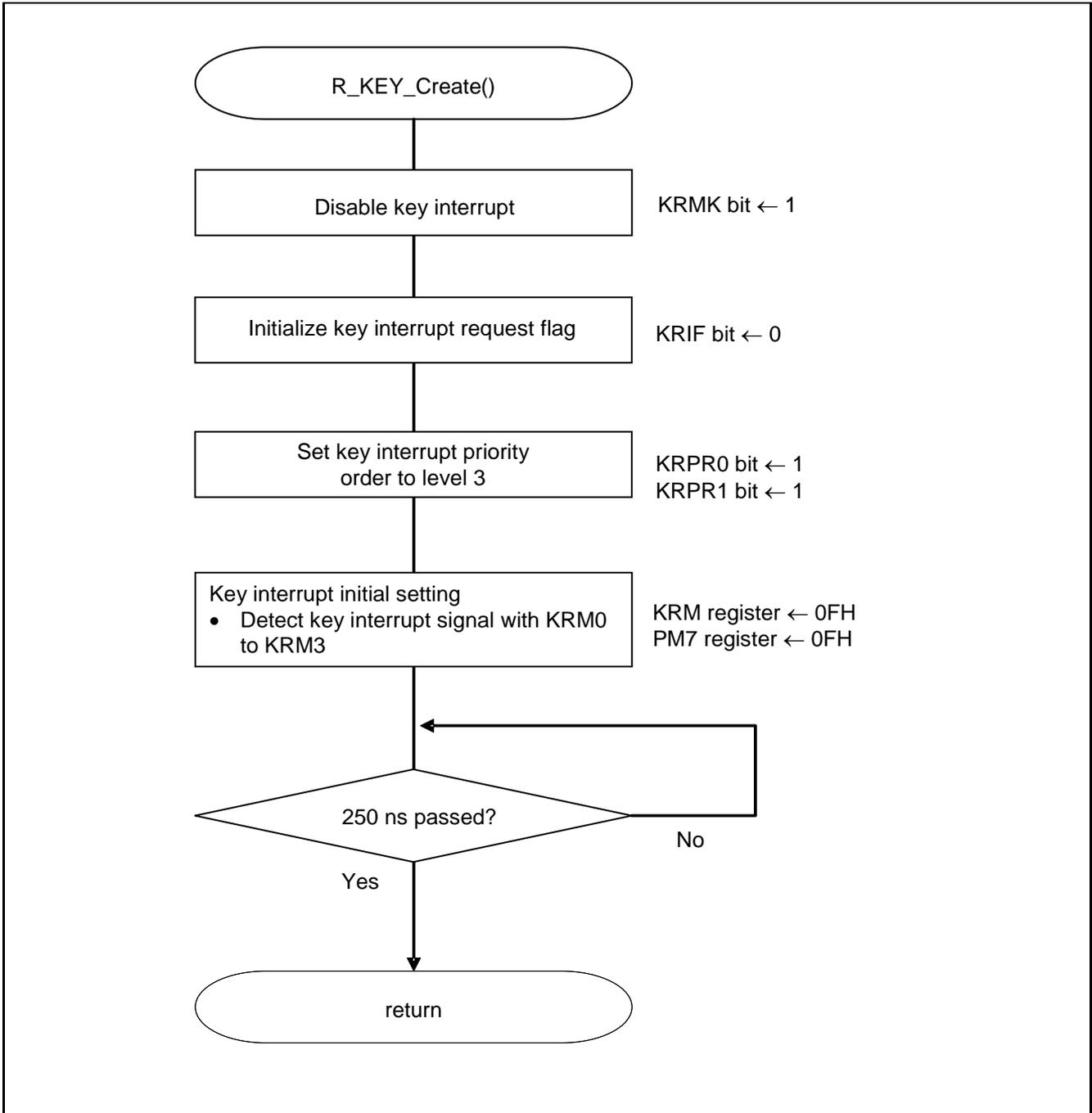


Figure 5.7 Key Interrupt Setup

Key Interrupt Setup

- Interrupt request flag register (IF1H)
Clear interrupt request flag.
- Interrupt mask flag register (MK1H)
Clear interrupt mask
- Priority specification flag register
Select level 3 (low priority)
- Key return mode register (KRM)
Detect key interrupt signal of the pins to be used.
- Port mode register 7 (PM7)
Set to input mode the pins with which key interrupt signal is to be used.

Symbol: IF1H

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

Bit 3

KRIF	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	ITIMK	RTCMK	ADMK
x	x	x	x	1	x	x	x

Bit 3

KRMK	Interrupt handling control
0	Interrupt handling is enabled
1	Interrupt handling is disabled

Caution: For details on how to set registers, refer to RL78/G13 User's Manual: Hardware.

Symbol: PR01H

7	6	5	4	3	2	1	0
TMPR00 4	TMPR01 3	SRPR03 CSIPR031 IICPR031	STPR03 CSIPR030 IICPR030	KRPR0	ITPR0	RTCPR0	RTCPR0 ADPR1
x	x	x	x	1	x	x	x

Symbol: PR11H

7	6	5	4	3	2	1	0
TMPR10 4	TMPR11 3	SRPR13 CSIPR131 IICPR131	STPR13 CSIPR130 IICPR130	KRPR1	ITPR1	RTCPR1	RTCPR1 ADPR1
x	x	x	x	1	x	x	x

Bit 3

KRPR1	KRPR0	Priority level selection
0	0	Selects level 0 (highest priority)
0	1	Selects level 1
1	0	Selects level 2
1	1	Selects level 3 (lowest priority)

Symbol: KRM

7	6	5	4	3	2	1	0
KRM7	KRM6	KRM5	KRM4	KRM3	KRM2	KRM1	KRM0
0	0	0	0	1	1	1	1

Bits 7 to 0

KRMn (n = 0 to 7)	Key interrupt mode control
0	Key interrupt signal is not detected
1	Key interrupt signal is detected

Caution: For details on the setting of registers, refer to RL78/G13 User's Manual: Hardware.

When setting the desired bits of the KRM0 to KRM7 bits to 1, bits 0 to 3 (PU70 to PU73) of the corresponding pull-up resistor option register 7 (PU7) need to be set to 1. This setting is made during the I/O port setting described in 5.5.3.

5.5.7 Main Processing

Figures 5.8 and Figure 5.9 show the flowchart for the main processing.

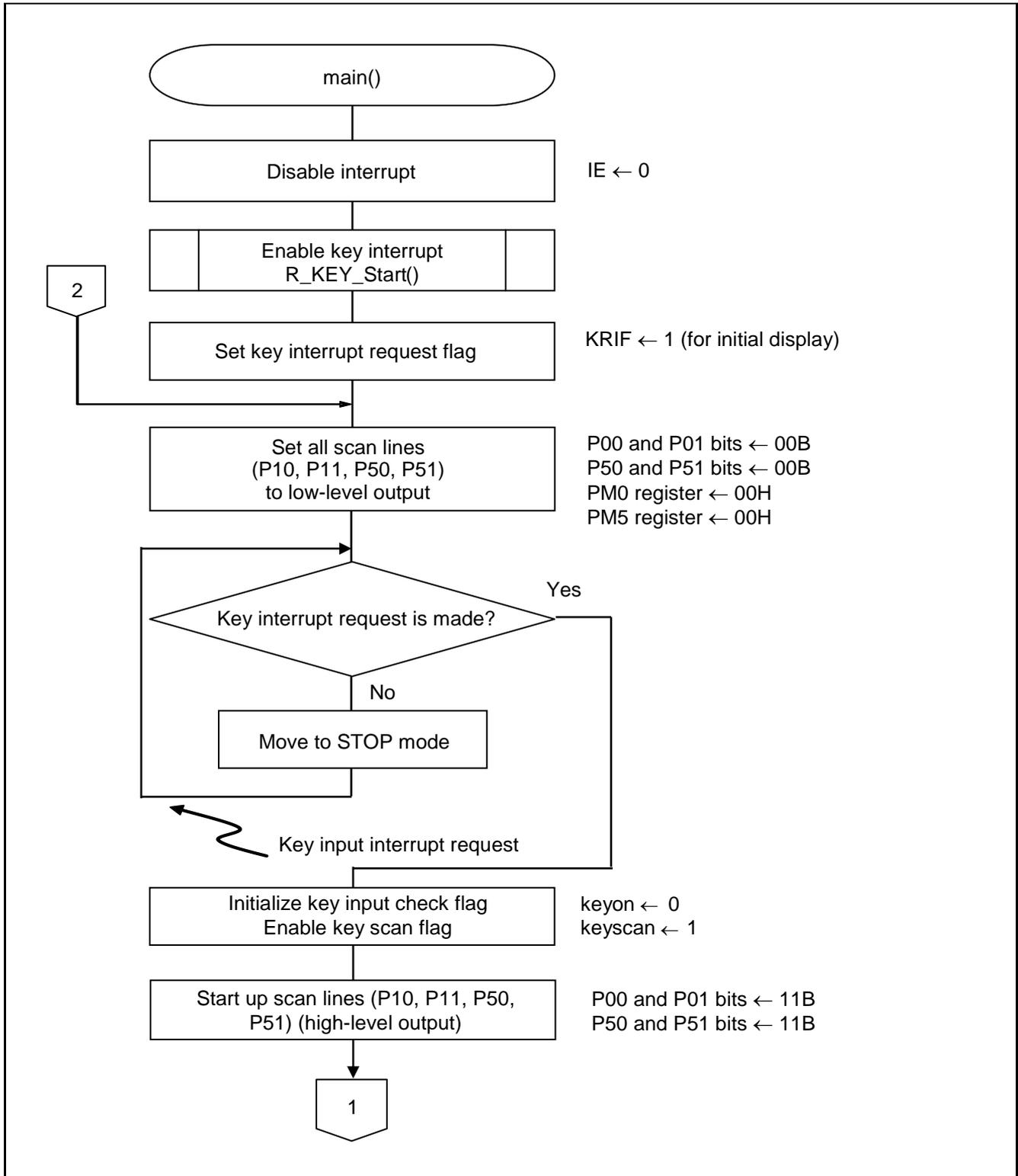


Figure 5.8 Main Processing (1/2)

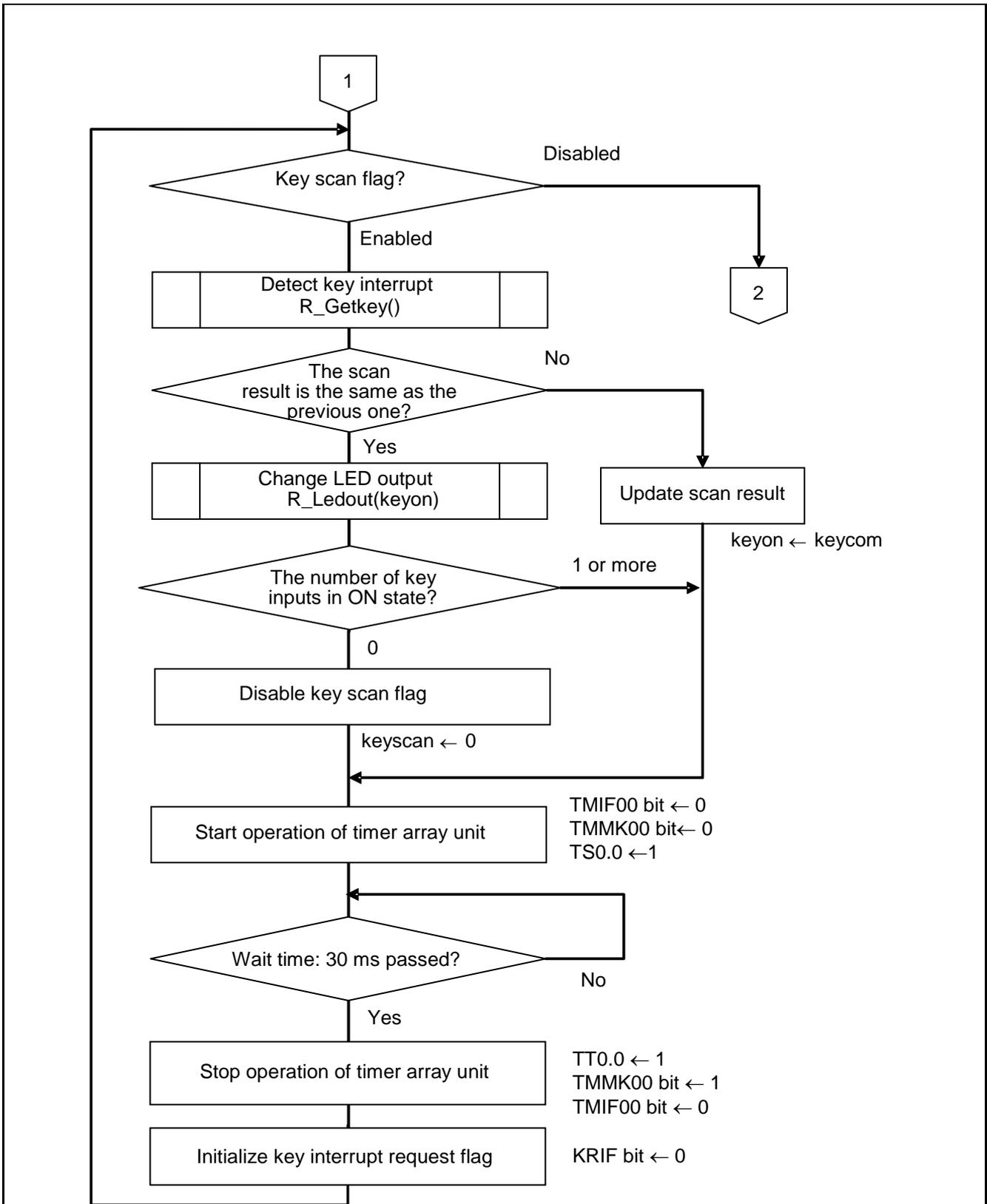


Figure 5.9 Main Processing (2/2)

5.5.8 Enabling Key Interrupt

Figure 5.10 shows the flowchart for enabling key interrupt.

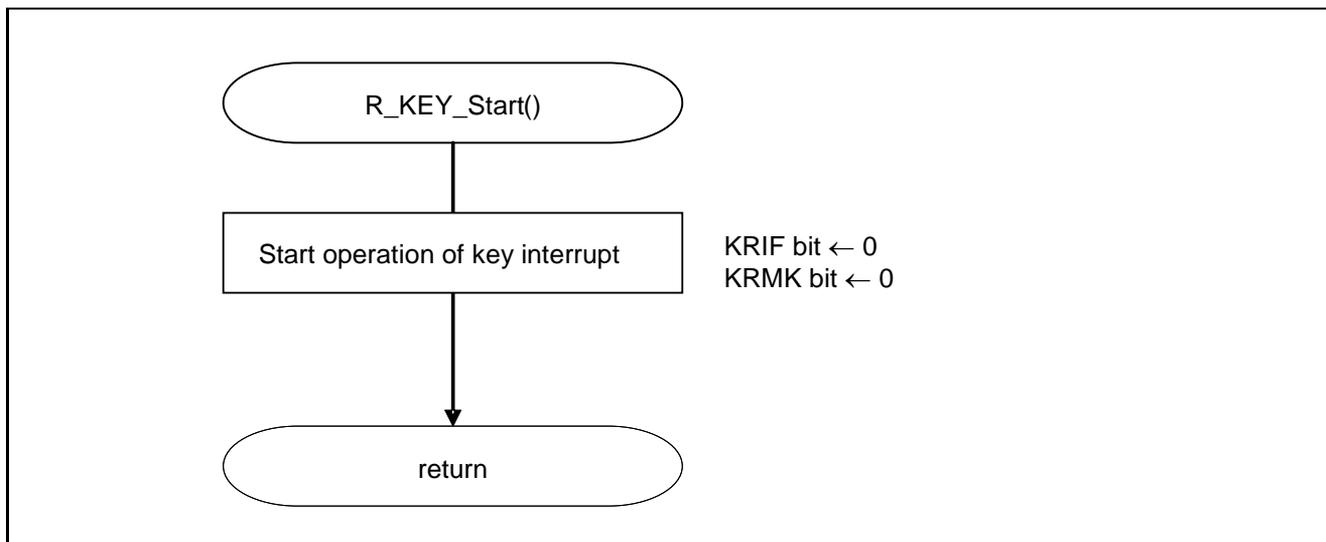


Figure 5.10 Enabling Key Interrupt

5.5.9 Detecting Key Interrupt

Figure 5.11 shows the flowchart for detecting key interrupt.

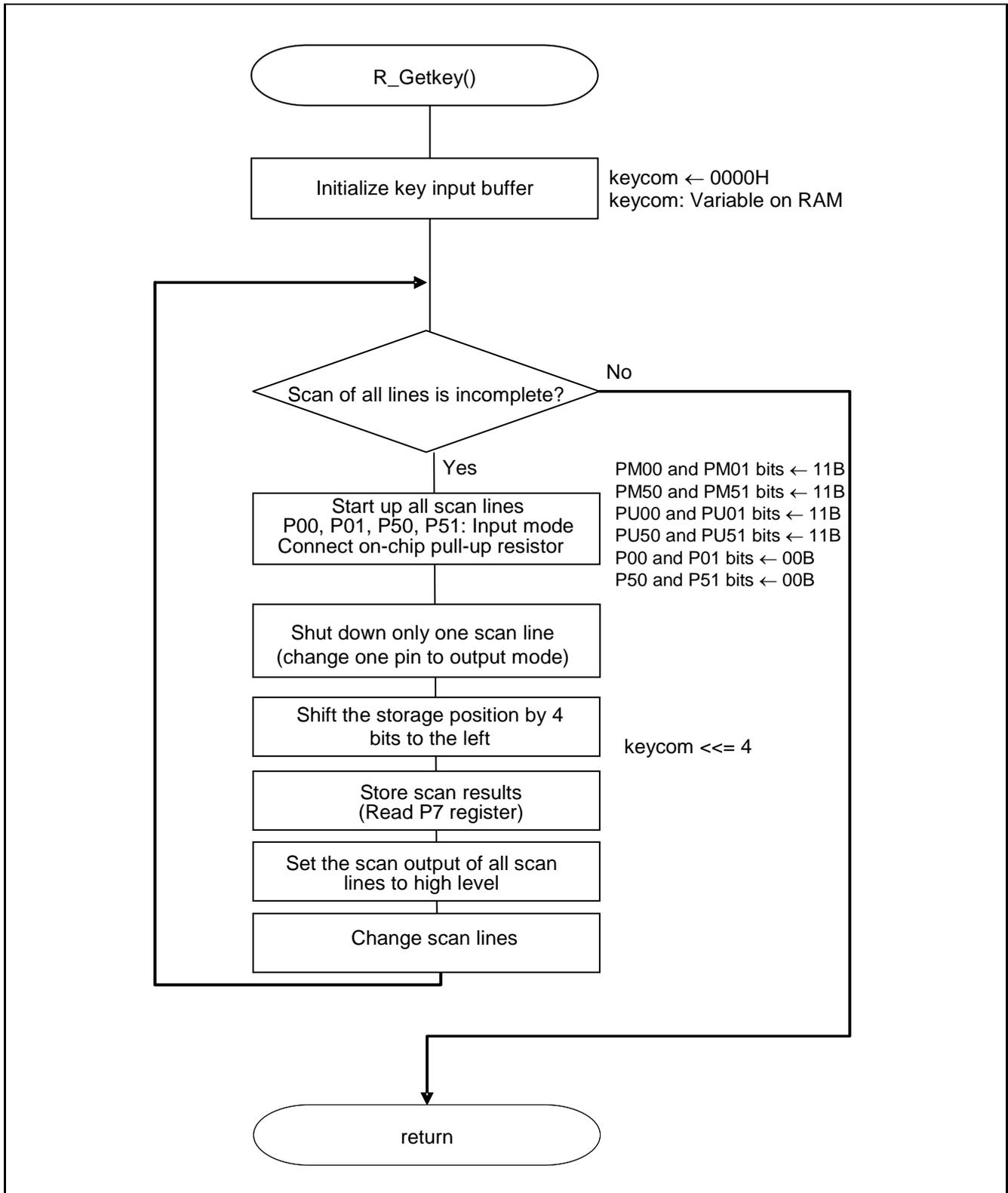


Figure 5.11 Detecting Key Interrupt

5.5.10 Changing LED Output

Figure 5.12 shows the flowchart for changing LED output.

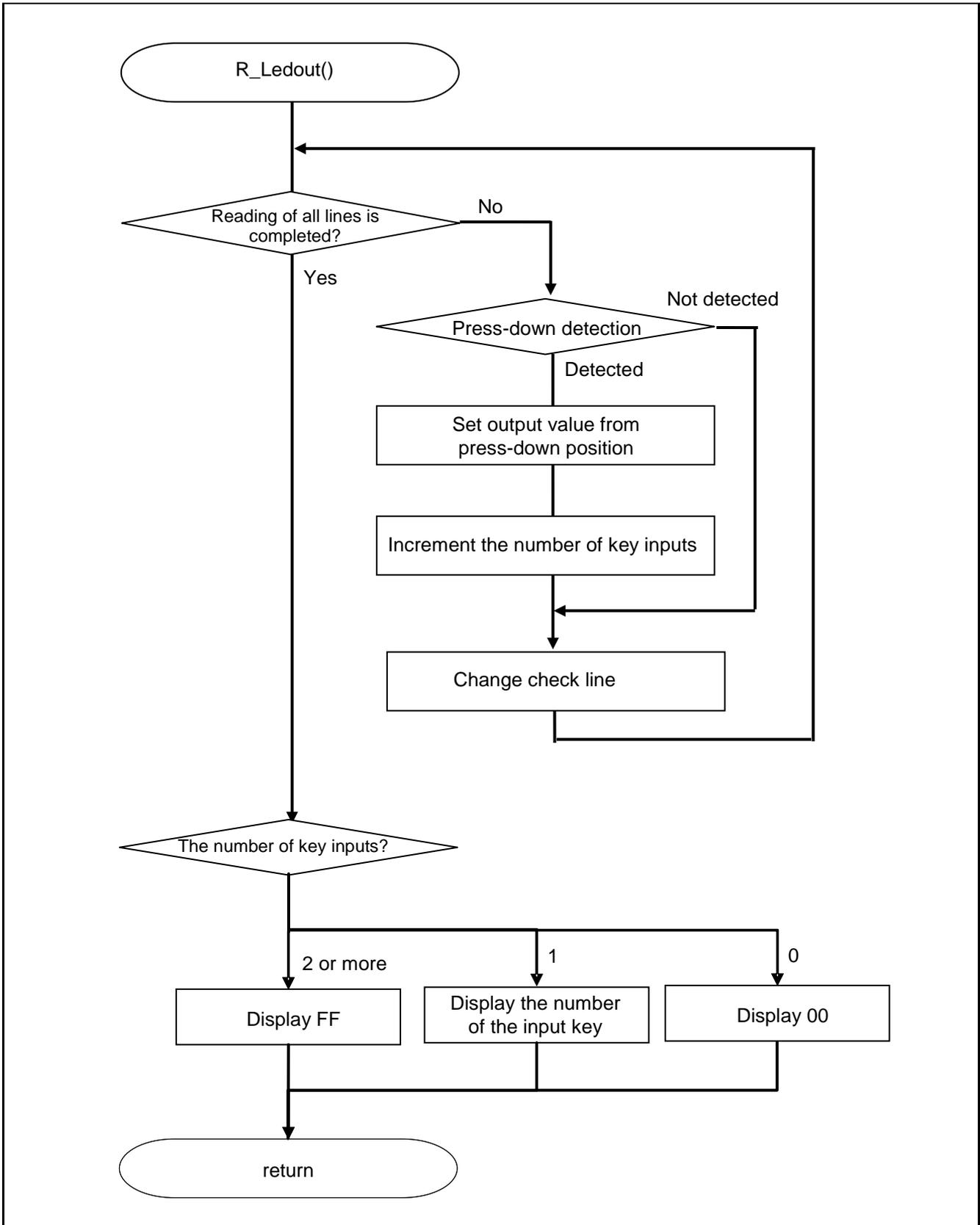


Figure 5.12 Changing LED Output

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 (R01UH0146EJ)

RL78 Family User's Manual: Software (R01US0015EJ)

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

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REVISION HISTORY	RL78/G13 Key Interrupt Function
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Rev.	Date	Description	
		Page	Summary
1.00	Sep. 30, 2011	—	First edition issued
2.00	Dec. 27, 2013	4	Table 2.1: Added e2studio and IAR information
		11	Added note Figure 5.2: Fixed typo in function name
		12	Figure 5.3: Fixed typo in function name

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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 document as well as any technical updates that have been issued for the products.

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 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 a different part number may differ in terms of the internal memory capacity and 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 products with a different part number, implement a system-evaluation test for the given product.

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