RISC-V

Operation State Switching

Introduction

The application note shows the register setting sequence for the switch of RISC-V operation state, using the Operation State Control. After reset, it operates in the High-speed mode. The flash operation mode is switched one by one by the button pressing (High-speed mode → Middle-speed mode → Low-speed mode → High-speed mode, repetition at the following).

Target Device

RISC-V

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

1.1 Overview of Specifications

Pressing the button generates an IRQ4 interrupt and changes flash operation mode. After cycling through all operation transition states supported by RISC-V, the state immediately after a reset is restored. LED1 and LED2 indicate flash operation modes.

Table 1.1 shows the peripheral function to be used and its use. Figure 1.1 shows the transitions of flash operation modes. Table 1.2 provides details and transitions of operation states.

Table 1.1 Peripheral functions used and their uses

Peripheral Function	Use
External interrupt	Switch input
Port output	Controls the LEDs (LED1, LED2) connected to the P107 and P100 pins.

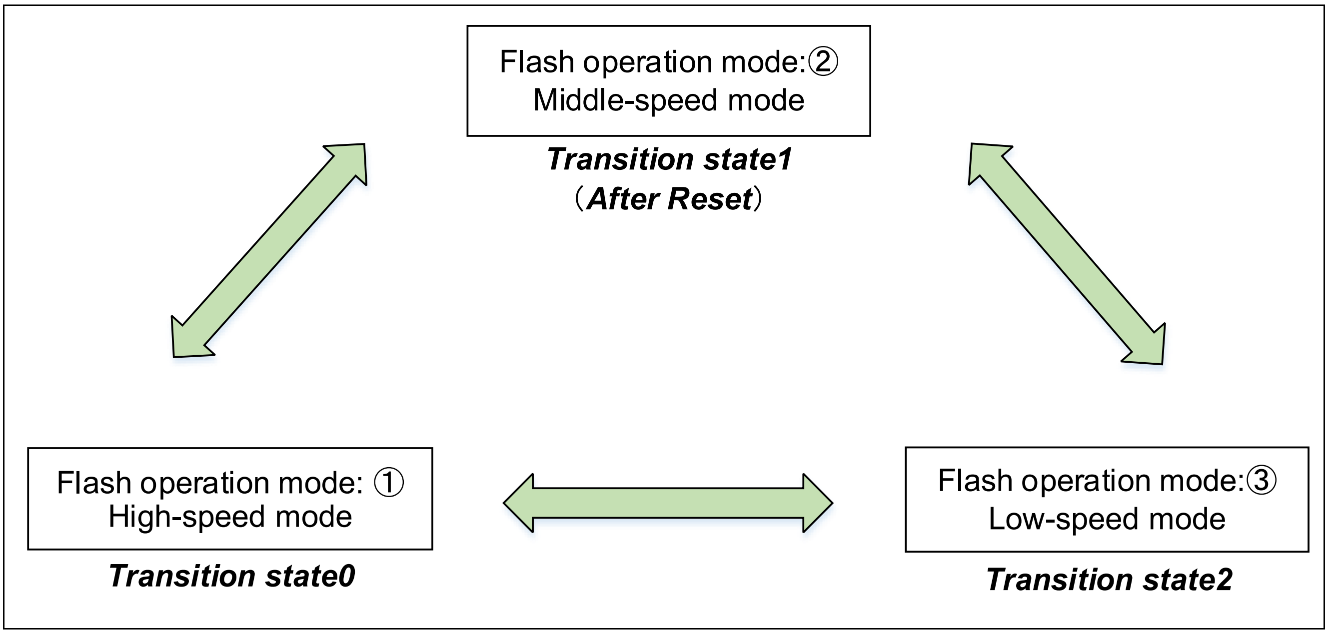

Figure 1.1 Operation state transition sequence order

Table 1.2 Operation state detail and operation state transition

Flash operation mode		LED1	LED2	Operation clock	Range of operation voltage (Electrical characteristics)
①	High-speed mode	Turning on	Turning on	48 MHz	1.8 V to 5.5 V (1 to 48MHz: 1. 8 V to 5.5 V)
②	Middle-speed mode (after reset)	Turning on	Turning off	12 MHz	1.6 V to 5.5 V (1 to 24 MHz: 1.6 V to 5.5 V)
③	Low-speed mode	Turning off	Turning on	1 MHz	1.6 V to 5.5 V (1 MHz: 1.6 V to 5.5 V)

Modes ① to ③ are cycled through when the button is pressed.

1.2 Outline of Operation

Each time a falling edge of the P108 / IRQ4 pin is detected when the switch is pressed, the CPU clock and operating mode are switched.

The following describes the main settings.

(1) Initial settings for input/output ports
P107 and P100 pins: Set as output ports (used for LED ON control)

Table 1.3 Initial Settings for Input/Output Ports (P107 and P100 Pins)

Register/Bit Name	Setting Value	Content
PORT1.PCNTR1 / PDR07 PORT1.PCNTR1 / PDR00	00810081H	P107 and P100 are set to output mode.
PORT1.PCNTR1 / PODR07 PORT1.PCNTR1 / PODR00		Set output data of P107 and P100 to 1

(2) Initial settings for the clock generation circuit.
- Set the frequency of the high-speed on-chip oscillator clock to 48 MHz.
- Select High-speed on-chip oscillator (HOCO) for System clock (ICLK) and Peripheral module clock (PCLKB).

(3) Initial settings for interrupt processing
- Set the effective edge of the IRQ4 pin to falling edge to enable switch input.
- Check the pin voltage level at intervals of approximately 5 ms for determining switch input. When the voltage level is identical twice in a row, switch input is determined to be effective (chattering removed).

Table 1.4 Initial Settings for Input/Output Ports (P108 / IRQ4 Pin)

Register/Bit Name	Setting Value	Content
IRQCR4 / IRQMD[1:0]	00H	Designates the valid edge of IRQ4 as the falling edge.
IRQCR4 / FLTEN		Specify Disable Digital Filter.
IELSR4 / IELS[4:0]	00000016H	Specify ICU event link as IRQ4.
IELSR4 / DTCE		Specify DTC startup permission is disabled.

2. Operation Confirmation Conditions

The operation of the sample code provided with this application note has been tested under the following conditions.

Table 2.1 Operation Confirmation Conditions

Item	Description
MCU used	RISC-V (R9A02G021)
Board used	RISC-V-48p Fast Prototyping Board (RTK9FPG021S000W0BJ)
Operating frequency	High-speed on-chip oscillator clock : 48 MHz, 12 MHz, 1 MHz
Operating voltage	3.3 V (can be operated at 1.6 V to 5.5 V) LVD0 detection voltage: Reset mode At rising edge TYP. 1.95V (1.83 V to 2.07 V) At falling edge TYP. 1.90V (1.78 V to 2.02 V)
Integrated development environment (e^2studio)	e^2studio V2024-01.1 (24.1.1) from Renesas Electronics Corp.
C compiler (e^2studio)	LLVM for RISC-V 17.0.2.202401
Smart configurator (SC)	Smart Configurator for RISC-V V24.1.1.v20240125-1623
Board support package (BSP)	V1.00 from Renesas Electronics Corp.

3. Hardware Descriptions

3.1 Example of Hardware Configuration

Figure 3.1 shows an example of the hardware configuration used in the application note.

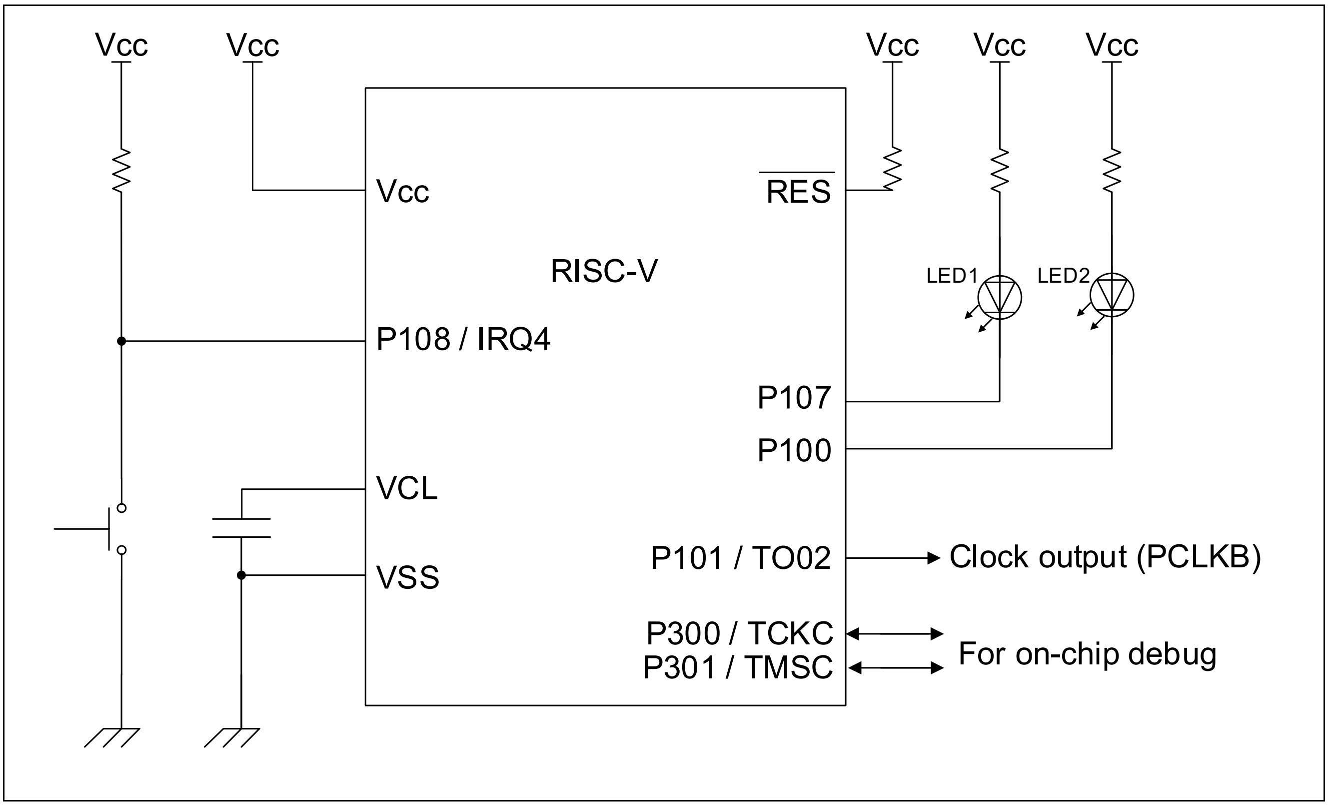

Figure 3.1 Hardware Configuration

Note 1 This simplified circuit diagram was created to show an overview of connections only. When actually designing your circuit, make sure the design includes appropriate pin handling and meets electrical characteristic requirements (connect each input-only port to Vcc or Vss through a resistor).

Note 2 Vcc must not be lower than the reset release voltage (VLVD0) that is specified for the LVD0.

3.2 List of Pins Used

Table 3.1 shows the pins used and their functions.

Table 3.1 Pins used and their functions

Pin name	I/O	Function
P107	Output	LED1 turning on control
P100	Output	LED2 turning on control
P108 / IRQ4	Input	Operation state switching
P101 / TO02	Output	Clock output

Caution In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

4. Software Explanation

4.1 Setting of Option byte

Table 4.1 shows the option byte settings. Please set the appropriate value to fit the different system.

Table 4.1 Option Byte Settings

Address	Setting Value	Contents
0000_0400H	FFFF_FFFFH	Disables the watchdog timer. (Counting stopped after reset)
0000_0404H	FFFF_CFDBH	LVD0 detection voltage: reset mode At rising edge TYP. 1.95 V (1.83 V to 2.07 V) At falling edge TYP. 1.90 V (1.78 V to 2.02 V)
		High-speed on-chip oscillator clock : 48 MHz
0101_0008H	FFFF_FFFFH	Enables on-chip debugging

4.2 List of Constants

Table 4.2 lists the constants that are used in the sample code.

Table 4.2 Constants used in sample code

Constant Name	Setting Value	Description
_00_TRANSITION_STATUS_0	00H	Transition status 0
_01_TRANSITION_STATUS_1	01H	Transition status 1
_02_TRANSITION_STATUS_2	02H	Transition status 2
LED_ON	00H	LED control: ON
LED_OFF	01H	LED control: OFF
WAITCOUNT_48M	7400	5 ms count value during High-speed mode 48 MHz operation
WAITCOUNT_12M	1850	5 ms count value during Middle-speed mode 12 MHz operation
WAITCOUNT_1M	160	5 ms count value during Low-speed mode 1 MHz operation

4.3 List of Variables

Table 4.3 lists global variables.

Table 4.3 Global variables

Type	Variable identifier	Content	Use function
uint16_t	g_transition_status	Transition state variable	main (), r_Config_ICU_IRQ4_interrupt ()

4.4 List of Functions

Table 4.4 shows a list of functions.

Table 4.4 Functions

Function name	Outline
r_switch_flashmode_to_HS()	The flash operation state is switched to the High-speed mode.
r_switch_flashmode_to_MS()	The flash operation state is switched to the Middle-speed mode.
r_switch_flashmode_to_LS()	The flash operation state is switched to the Low-speed mode.
r_Config_ICU_IRQ4_interrupt()	External interrupt processing.

4.5 Specification of Functions

The function specifications of the sample code are shown below.

r_switch_flashmode_to_HS

Overview	The flash operation state is switched to the High-speed mode.
Header	r_cg_userdefine.h
Declaration	void r_switch_flashmode_to_HS (void)
Description	The flash operation state is switched to the High-speed mode.
Argument	None
Return value	None

r_switch_flashmode_to_MS

Overview	The flash operation state is switched to the Middle-speed mode.
Header	r_cg_userdefine.h
Declaration	void r_switch_flashmode_to_MS (void)
Description	The flash operation state is switched to the Middle-speed mode.
Argument	None
Return value	None

r_switch_flashmode_to_LS

Overview	The flash operation state is switched to the Low-speed mode.
Header	r_cg_userdefine.h
Declaration	void r_switch_flashmode_to_LS (void)
Description	The flash operation state is switched to the Low-speed mode.
Argument	None
Return value	None

r_Config_ICU_IRQ4_interrupt

Overview	External interrupt processing
Header	r_cg_interrupt_handlers.h
Declaration	void r_Config_ ICU_IRQ4_interrupt (void)
Description	Pushing button calls this function where operation state switching is executed.
Argument	None
Return value	None

4.6 Flowcharts

4.6.1 Main Processing

Figure 4.1 shows the flowchart of the main processing.

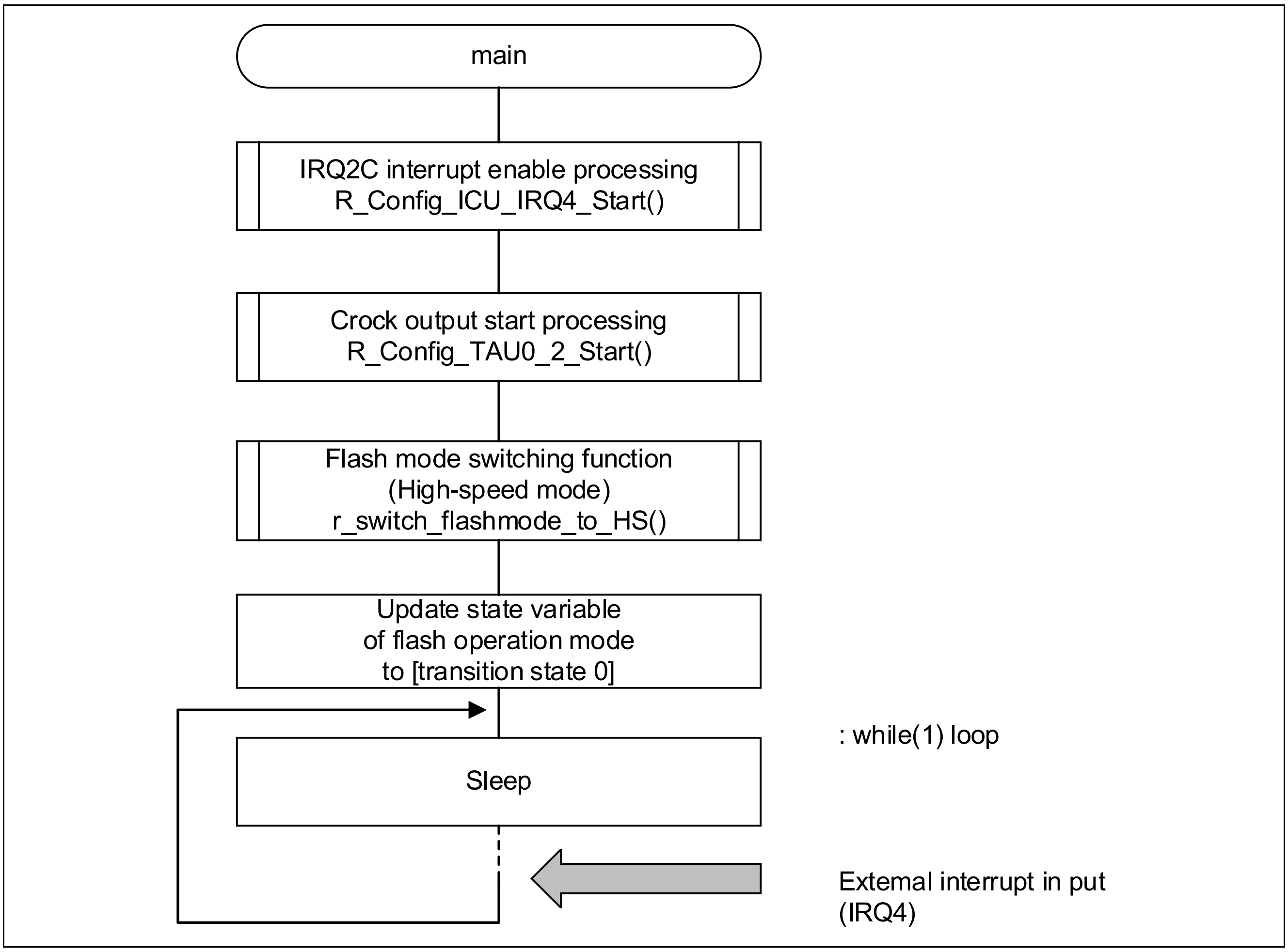

Figure 4.1 Main Processing

4.6.2 Flash Operation Mode Switching High-speed Processing

Figure 4.2 shows the flowchart of the flash operation mode switching High-speed mode processing.

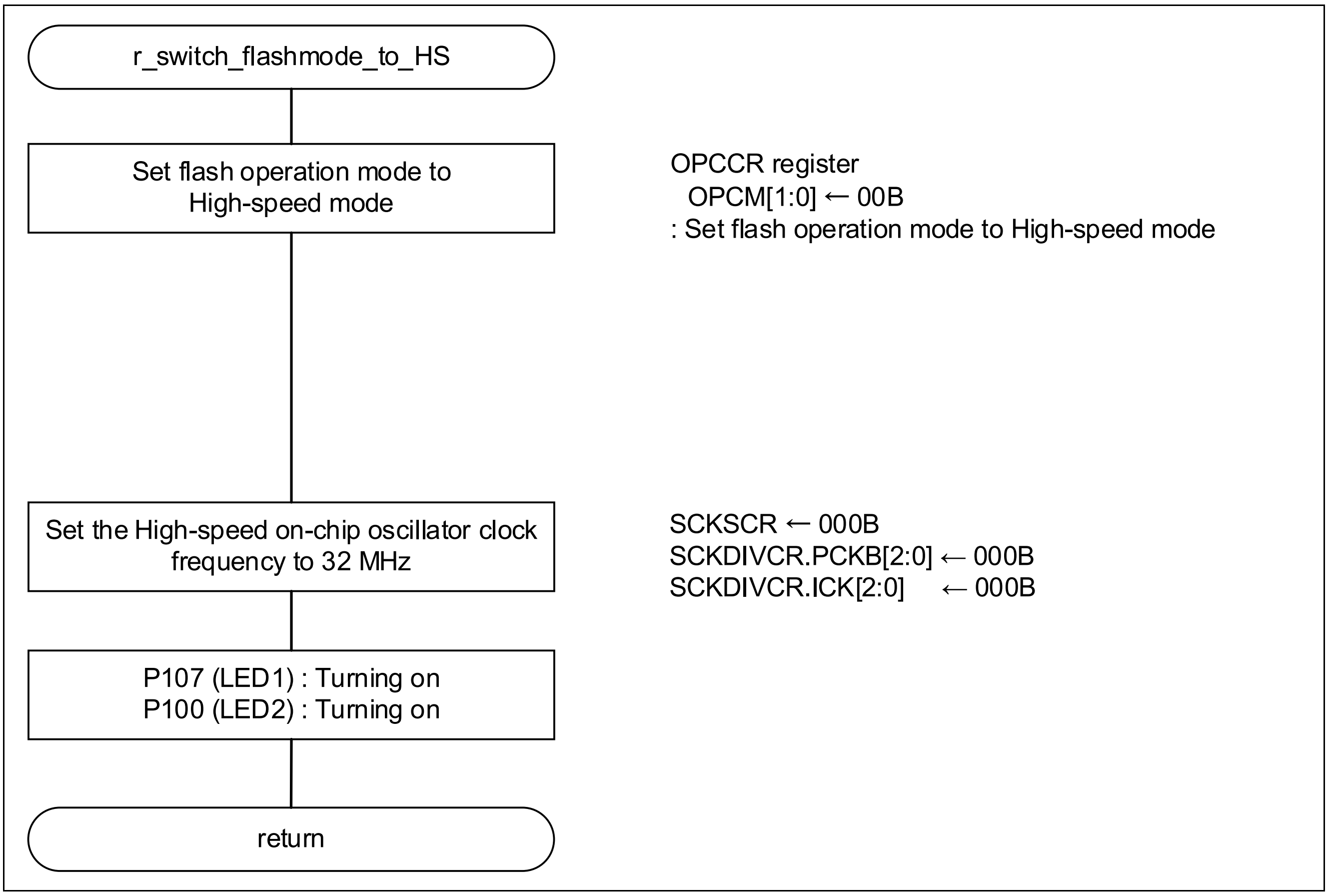

Figure 4.2 Flash Operation Mode Switching High-speed Processing

4.6.3 Flash Operation Mode Switching Middle-speed Processing

Figure 4.3 shows the flowchart of the flash operation mode switching Middle-speed mode processing.

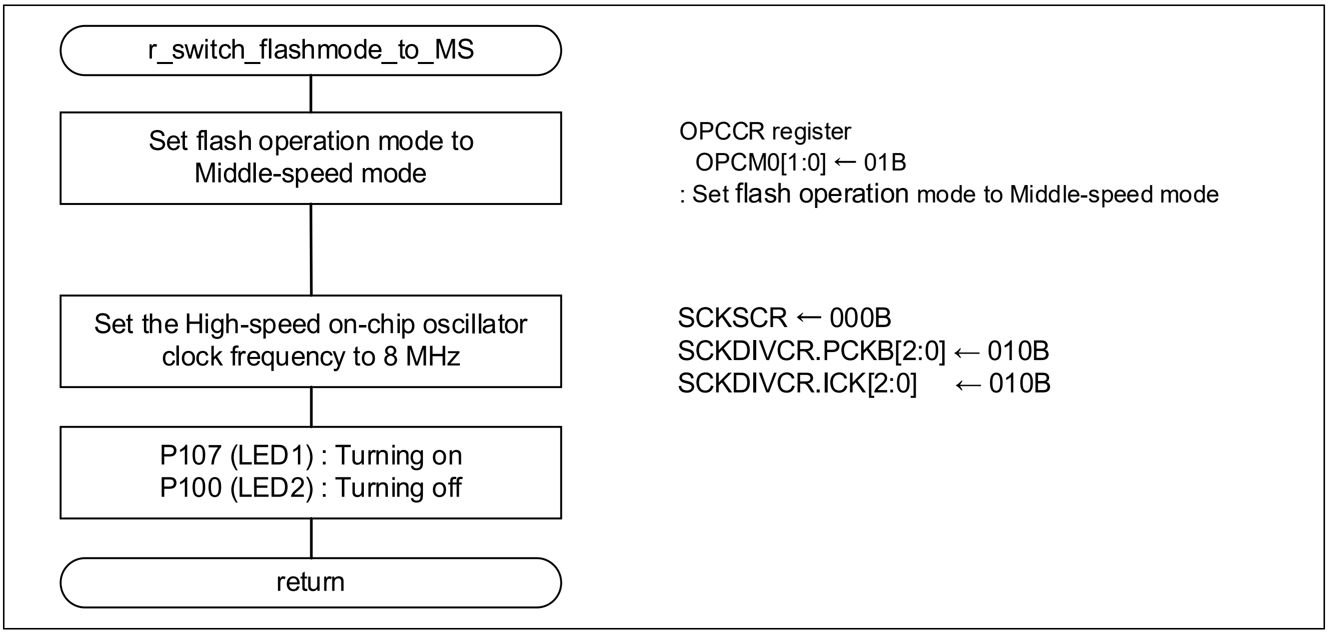

Figure 4.3 Flash Operation Mode Switching Middle-speed Processing

4.6.4 Flash Operation Mode Switching Low-speed Processing

Figure 4.4 shows the flowchart of the flash operation mode switching Low-speed mode processing.

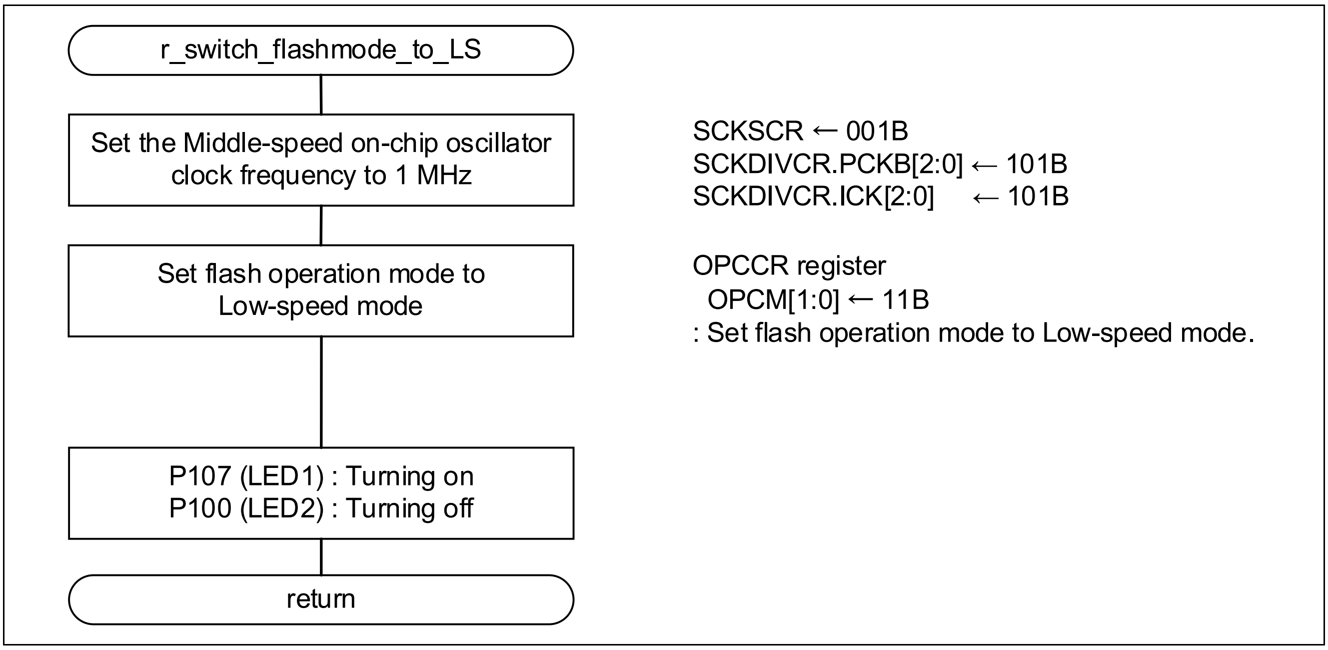

Figure 4.4 Flash Operation Mode Switching Low-speed Processing

4.6.5 External Interrupt (IRQ4) Processing

Figure 4.5 shows the flowchart of the external interruption (IRQ4) processing.

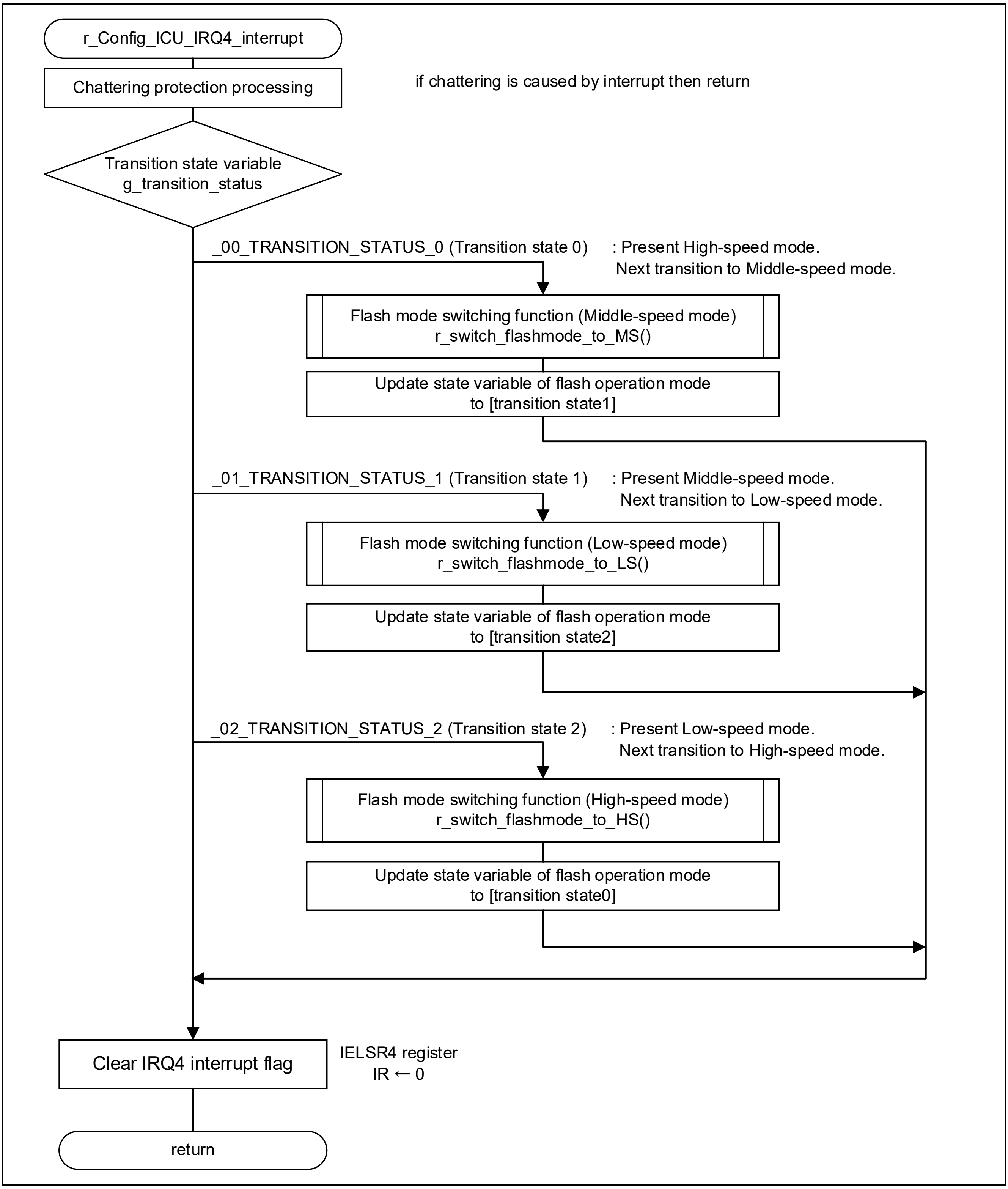

Figure 4.5 External Interrupt (IRQ4) Processing

5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RISC-V User's Manual: Hardware (R01UH1036EJ)

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

Technical update

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

7. Website and Support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar.18.24	—	Initial release

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit 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. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. 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 the 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.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of 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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