RL78/G23

Timer Array Unit (Interval timer)

Introduction

This application note describes the interval timer function of the timer array unit (TAU). This unit inverts the LED indication each time a timer interrupt occurs. Also, it changes the timer interrupt cycle time based on the number of times the switch is pressed.

Target Device

RL78/G23

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

This application note describes an example setting for using timer interrupts (INTTM00) from the interval timer and interrupts (INTP0) generated on pin input edge detection.

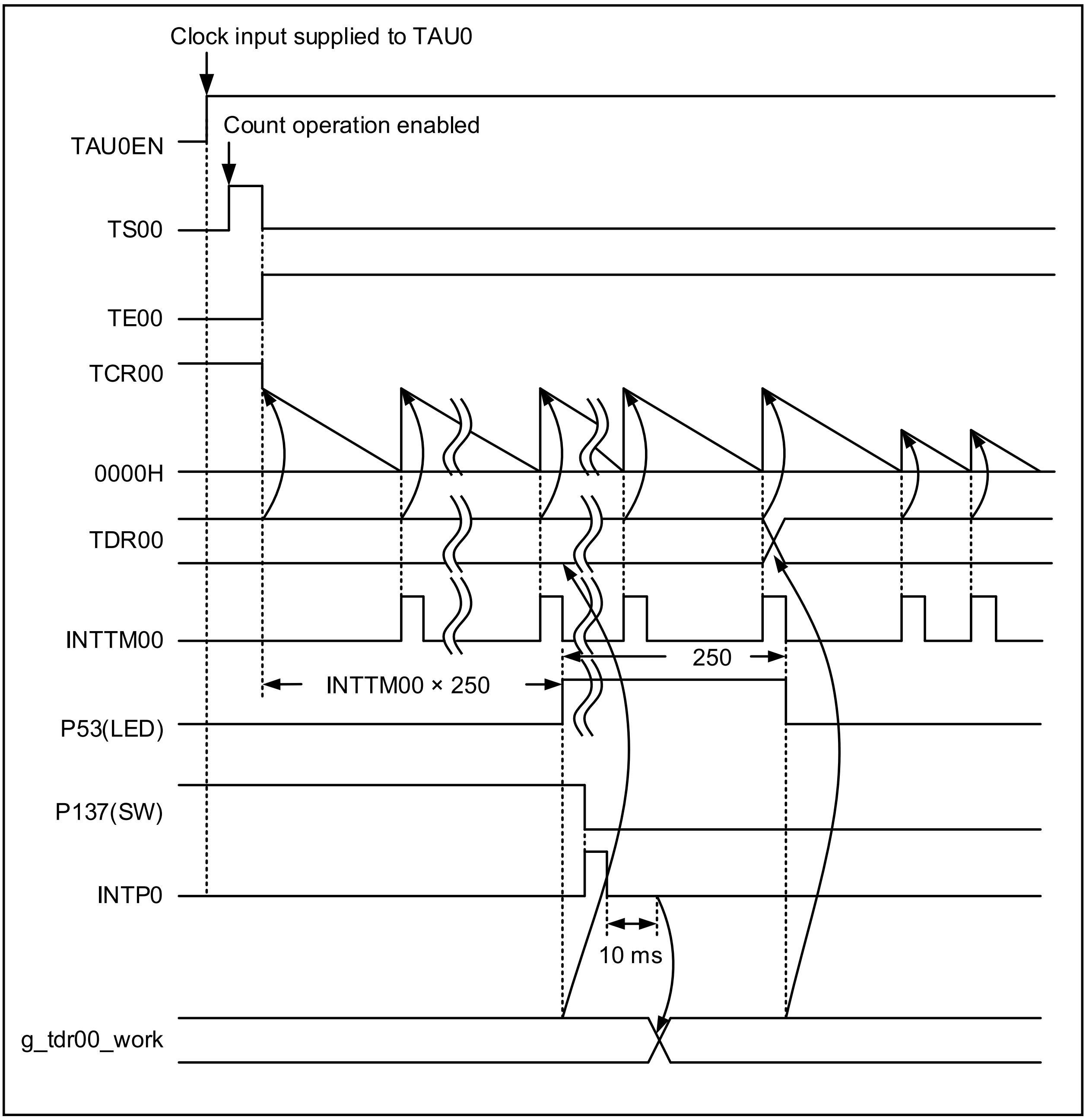
The TAU inverts the LED indication each time a timer interrupt (INTTM00) occurs. Also, this unit changes the timer interrupt (INTTM00) cycle time based on the number of times the switch (SW) is pressed.

Table 1-1 lists the peripheral functions to be used and their uses. Figure 1-1 shows the timer and its interrupt operation.

Table 1-1 Peripheral Functions and Uses

Peripheral Function	Use
Timer array unit 0 (TAU0) channel 0	The 16-bits interval timer interrupt (INTTM00) Controls the time interval for inversion of LED indication
P53	The output port for the LED indications
External interrupt	The pin input edge detection (INTP0) by switch input Controls the interval between each generation of the timer interrupt (INTTM00)

Figure 1-1 Overview of Timer Operation and Interrupts



1.2 Outline of Operation

This application note describes how to set up the interval timer function of TAU0.

This setup is followed by operation for counting the number of timer interrupts (INTTM00) generated by the interval timer. Each time the count reaches 250, the LED indication is inverted. The timer interrupt (INTTM00) cycle time is changed by changing the value of timer data register 00 (TDR00) according to the number of times the switch is pressed. The LED on/off cycle time is changed as follows.

500 ms -> 250 ms -> 125 ms -> 62.5 ms -> 500 ms

(1) Initialize the TAU.
- Use the interval timer mode as the timer operation mode.
- Initialize timer data register 00 (TDR00) to F9FFH (2 ms).
- Set the timer output enable register to disable operation.
- Use timer interrupts (INTTM00) from timer channel 0.

(2) Initialize the I/O port.
- P53 pin: Set as an output port.

(3) Initialize the external interrupt.
- Select a falling edge as the valid edge for INTP0.
- Use INTP0 interrupts.

(4) Execute a HALT instruction and wait for a timer interrupt (INTTM00).

(5) After the HALT mode is cancelled by a timer interrupt (INTTM00), the number of INTTM00 interrupts generated is counted.

(6) When the timer interrupt count reaches 250, the LED indication is inverted. The value (g_tdr00_work) in RAM for the timer data register is set in the timer data register (TDR00).

(7) INTP0 interrupt processing changes the switch input count (INTP0 interrupt count) and g_tdr00_work value.

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

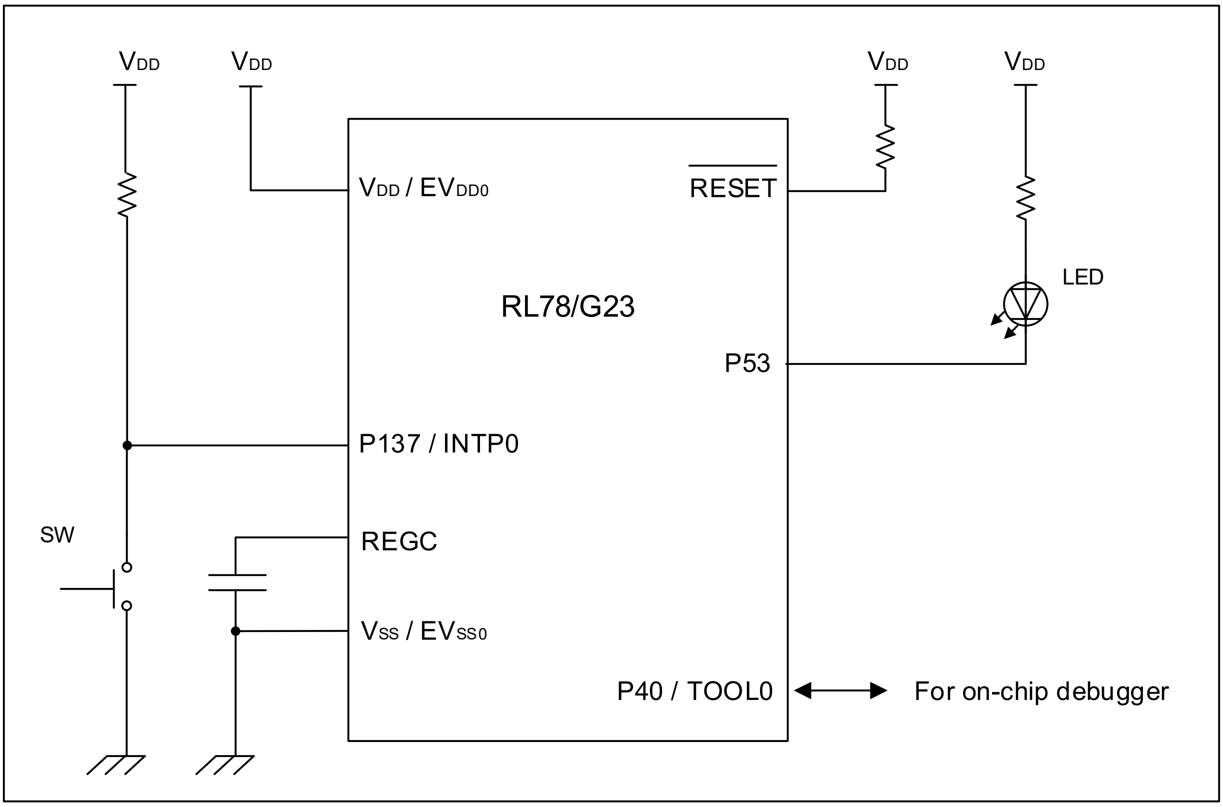
Item	Description
MCU used	RL78/G23 (R7F100GLG)
Board used	RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)
Operating frequency	High-speed on-chip oscillator clock: 32 MHz CPU/peripheral hardware clock: 32 MHz
Operating voltage	3.3 V (can be operated at 1.8 V to 5.5 V) LVD0 detection voltage: Reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
Integrated development environment (CS+)	CS+ V8.05.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.10.00 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2 studio V2021-04 (21.4.0) from Renesas Electronics Corp.
C compiler (e2studio)	CC-RL V1.10.00 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V4.21.1 from IAR Systems Corp.
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V4.21.1 from IAR Systems Corp.
Smart configurator (SC)	V1.0.1 from Renesas Electronics Corp.
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 V_{DD} or V_{SS} through a resistor).

Note 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.

Note 3. VDD must not be lower than the reset release voltage (VLVD0) that is specified for the LVD0.

3.2 List of Pins to be Used

Table 3-1 lists the pins to be used and their functions.

Table 3-1 Pins to be Used and Their Functions

Pin name	I/O	Function
P53	Output	Output port for LED indications
P137 / INTP0	Input	Input pin for the switch (SW) (external interrupt request input pin)

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. Set the values that are most suited to your system as necessary.

Table 4-1 Option Byte Settings

Address	Setting Value	Contents
000C0H / 040C0H	11101111B	Disables the watchdog timer. (Counting stopped after reset)
000C1H / 040C1H	11111110B	LVD0 detection voltage: reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
000C2H / 040C2H	11101000B	HS mode, High-speed on-chip oscillator clock (f_{IH}): 32 MHz
000C3H / 040C3H	10000101B	Enables on-chip debugging

4.2 List of Constants

Table 4-2 shows the constants that are used in this sample program.

Table 4-2 Constants for the Sample Program

Constant	Setting	Description
g_tdr00_data[]	(64000-1) (32000-1) (16000-1) (8000-1)}	TDR00 settings by number of times the switch is pressed
g_10ms_count[]	(5+1) (10+1) (20+1) (40+1)	10 ms timer count values by number of times the switch is pressed

4.3 List of Variables

Table 4-3 lists global variables.

Table 4-3 Global Variables

Type	Variable Name	Description	Function Used
__saddr uint8_t	g_sw_counter	Switch press count	main r_Config_INTC_intp0_interrupt
__saddr uint16_t	g_tdr00_work	Value which is set in TDR00 each time the timer interrupt count reaches 250.	main r_invert_led r_Config_INTC_intp0_interrupt
__saddr uint8_t	g_inttm00_counter	The number of timer interrupt generation	main r_invert_led

4.4 List of Functions

Table 4-4 shows a list of functions.

Table 4-4 Functions

Function name	Outline
r_Config_TAU0_0_interrupt()	TAU0 channel 0 timer interrupt processing
r_Config_INTC_intp0_interrupt()	External interrupt processing.
r_invert_led()	Counts the number of INTTM00 interrupts generated. Inverts the LED indication each time the interrupt count reaches 250.

4.5 Specification of Functions

The function specifications of the sample code are shown below.

r_Config_TAU0_0_interrupt()

Outline	TAU0 channel 0 timer interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_TAU0_0.h
Declaration	static void __near r_Config_TAU0_0_interrupt(void)
Description	This function calls the function which will invert the LED indication.
Argument	None
Return Value	None

r_Config_INTC_intp0_interrupt()

Outline	External interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_INTC.h
Declaration	static void __near r_Config_INTC_intp0_interrupt(void)
Description	External interrupt (INTP0) processing by SW input. It waits 10 ms or longer and then scans P13.7 (SW input pin). When the switch is pressed, this function changes the g_tdr00_work value.
Argument	None
Return Value	None

r_invert_led()

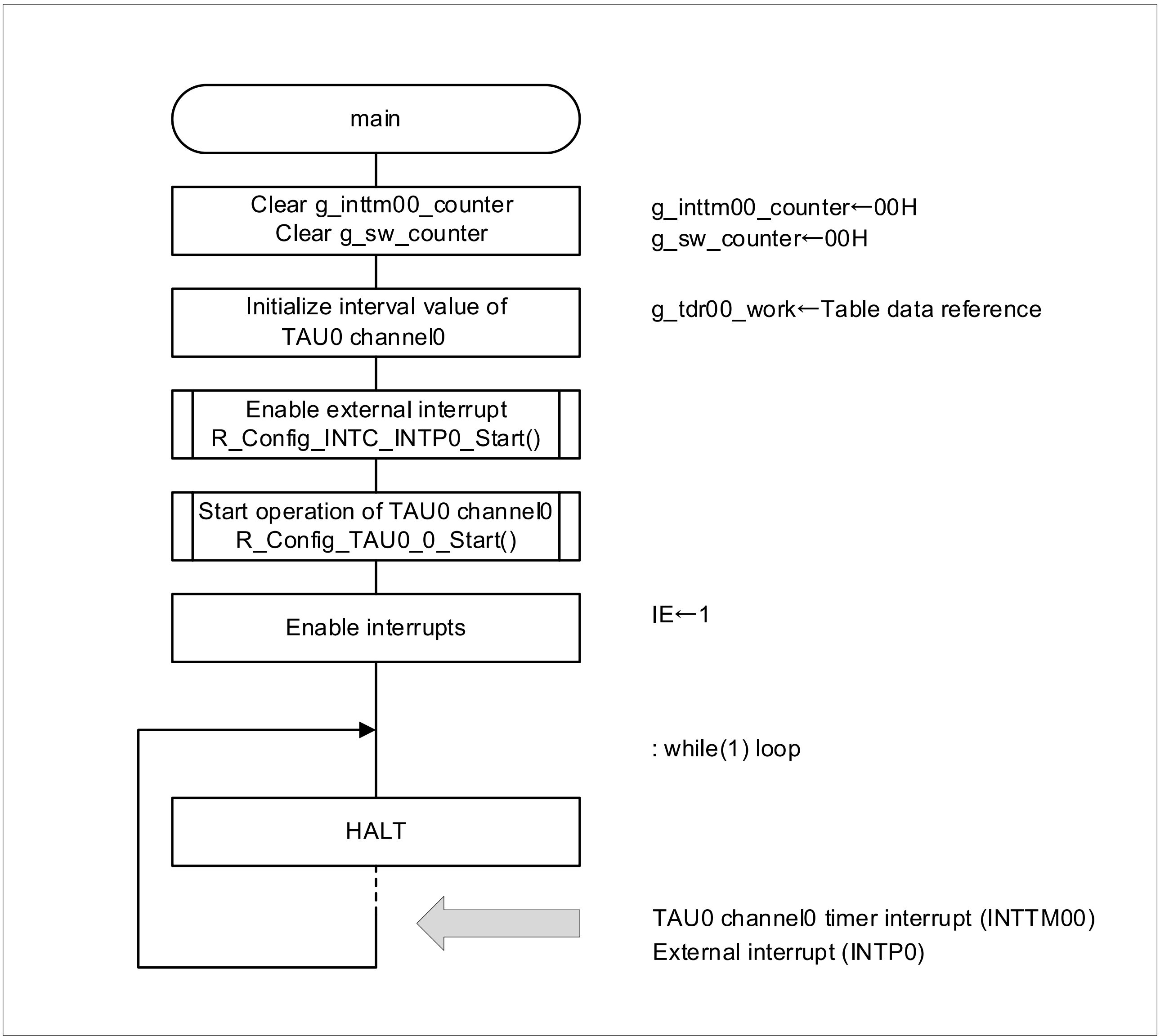
Outline	External interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h
Declaration	void r_invert_led(void)
Description	This function counts 250 timer interrupts (INTTM00) and then inverts the LED indication (for port latch inversion). It also changes the TDR00 setting to the value specified with g_tdr00_work.
Argument	None
Return Value	None

4.6 Flowcharts

4.6.1 Main Processing

Figure 4-1 shows the flowchart of the main processing.

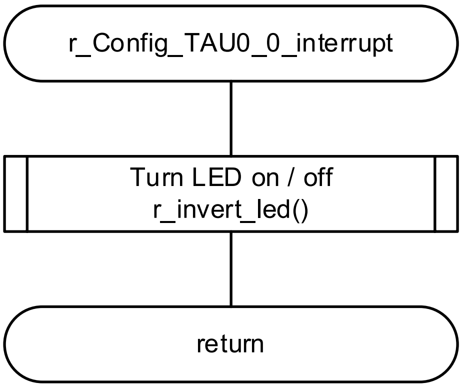
Figure 4-1 Main Processing



4.6.2 TAU0 Channel 0 Timer Interrupt Processing

Figure 4-2 shows the flowchart of TAU0 channel 0 timer interrupt processing.

Figure 4-2 TAU0 Channel 0 Timer Interrupt Processing



4.6.3 External Interrupt Processing

Figure 4-3 and Figure 4-4 show the flowchart of external interrupt processing.

Figure 4-3 External Interrupt Processing (1/2)

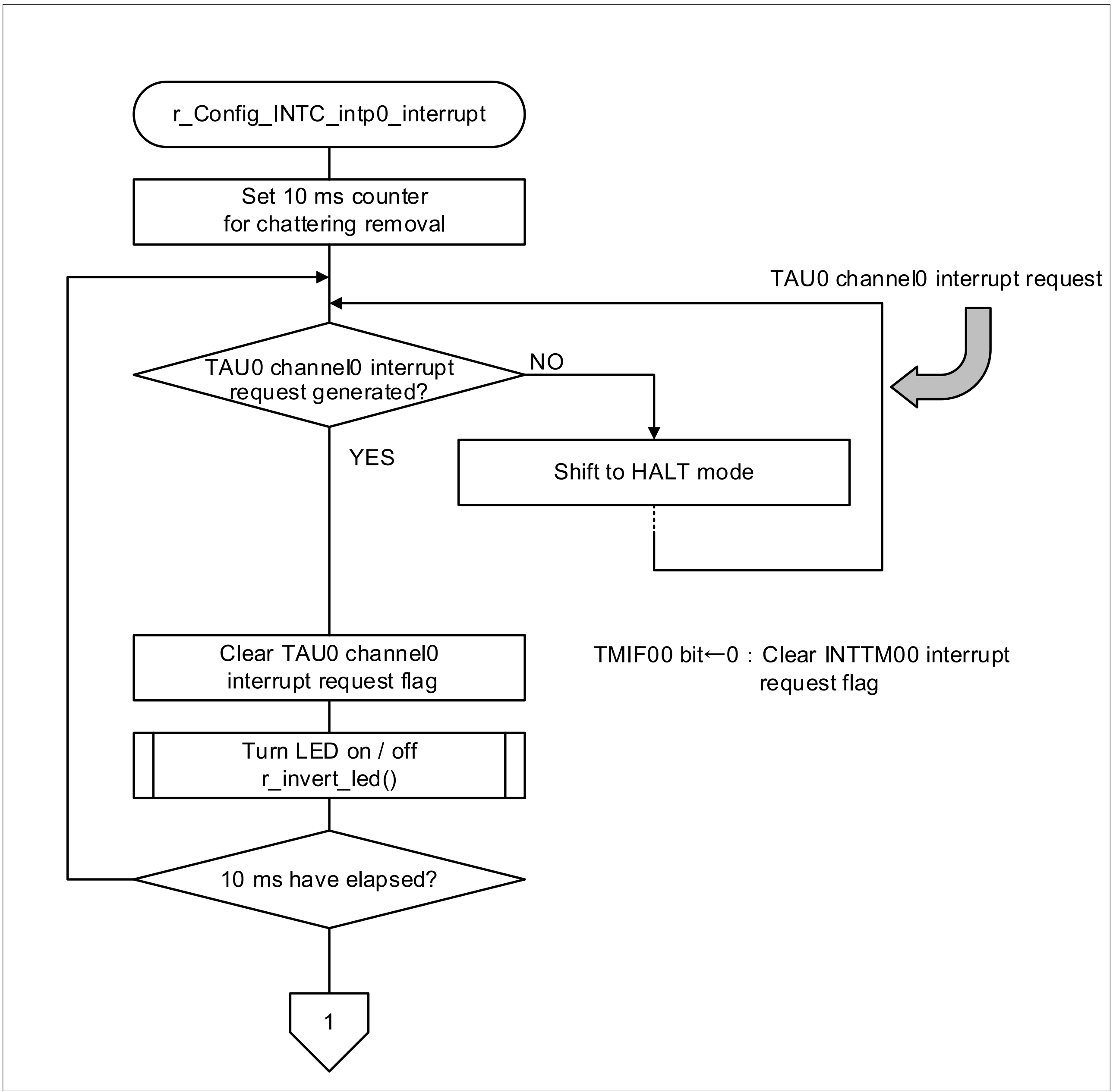
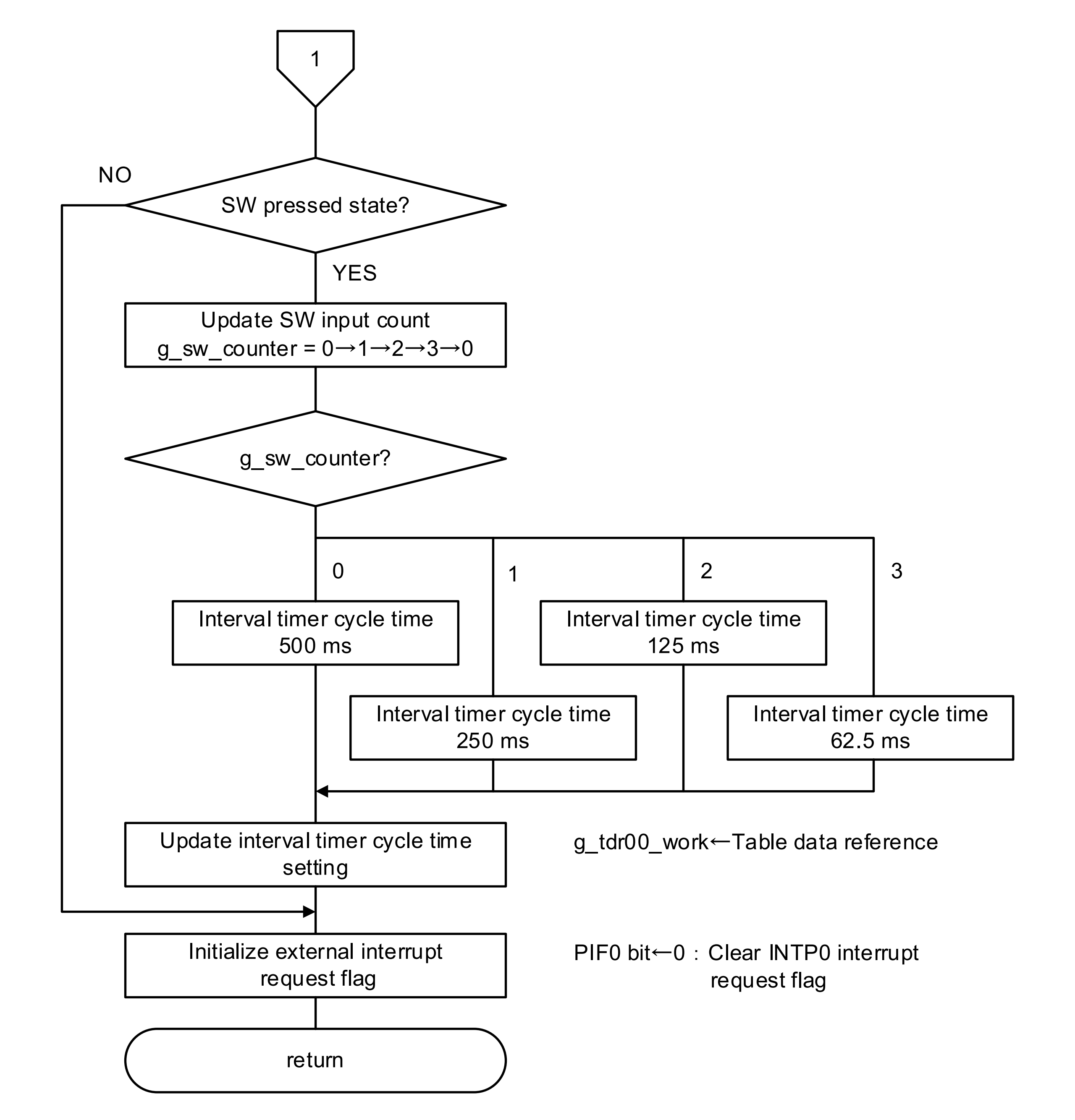


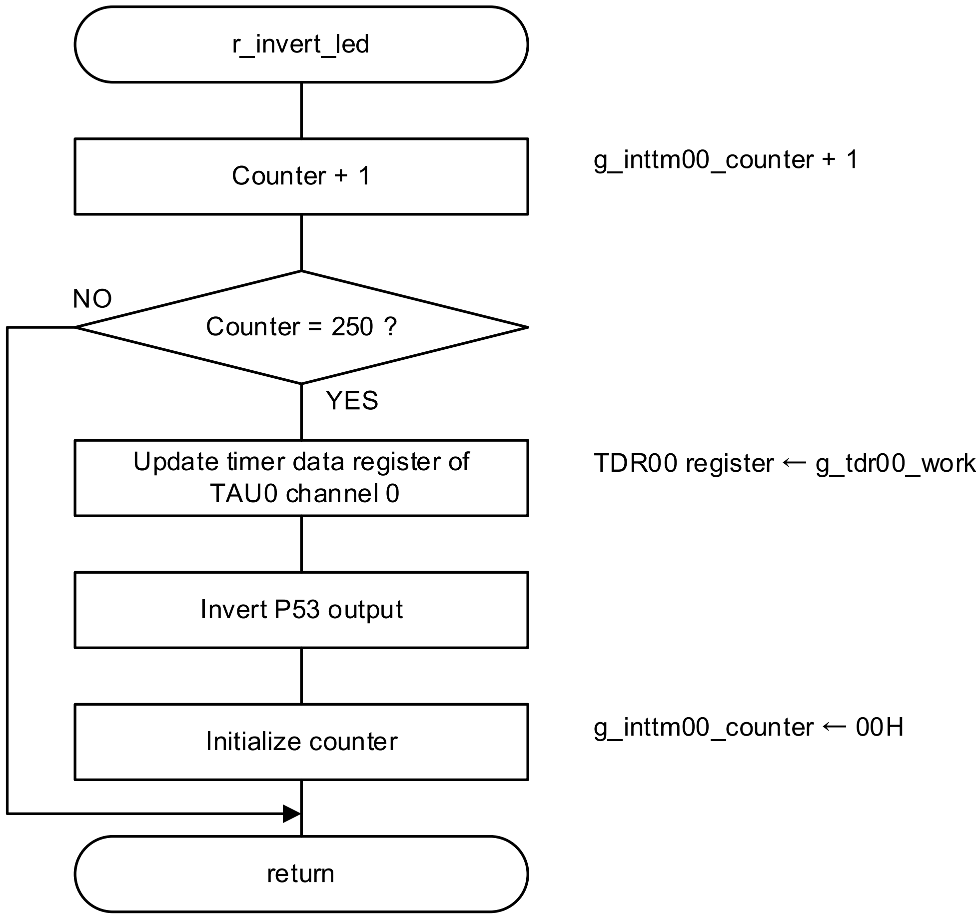
Figure 4-4 External Interrupt Processing (2/2)



4.6.4 LED Turn-On/Off Processing

Figure 4-5 shows the flowchart of LED turn-on/off processing.

Figure 4-5 LED Turn-On/Off Processing



5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896J)
RL78 family user's manual software (R01US0015J)
The latest versions can be downloaded from the Renesas Electronics website.

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun. 09, 2021	-	First Edition

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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