RL78/G10

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Fall Detection Alarm for Walking Stick Using Three-Axis Acceleration Sensor

Introduction

This application note explains a method in which a three-axis acceleration sensor is used to realize a fall detection alarm that causes a buzzer to sound when falling of a walking stick is detected.

Target Device

RL78/G10

When applying the sample program covered in this application note to another microcontroller, modify the program according to the specifications of the microcontroller and conduct an extensive evaluation of the modified program.

Contents

1. Specifications

In this application note, when power is supplied to the fall detection alarm device, an LED flashes for 5 seconds (repeatedly turns on and off every 50 ms), after which the LED is extinguished.

Data from the three-axis acceleration sensor is acquired constantly. When falling is determined based on the data obtained, the LED is caused to flash for 5 seconds (repeatedly turned on and off every 50 ms) as notification of sounding of the buzzer, after which the LED is extinguished. When falling is determined two times in a row, the buzzer is sounded for 20 seconds[Note]. At the same time, the LED is caused to flash for 5 seconds (repeatedly turned on and off every 50 ms) and is then extinguished. Thereafter, the above processing is repeated.

Note: In this application note, a piezoelectric speaker is used as the buzzer. In order to change the audio tone, the input frequency is changed (between 2023 Hz and 2725 Hz) according to the characteristics of the piezoelectric speaker used.

Figure 1.1 shows the system configuration outline.

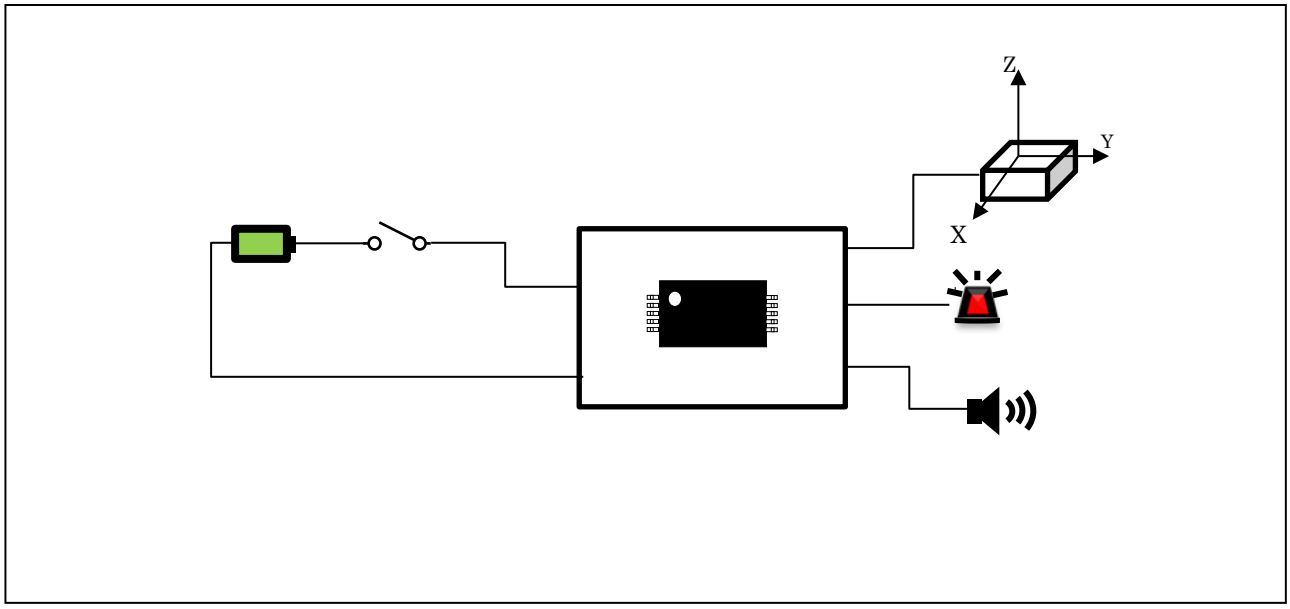


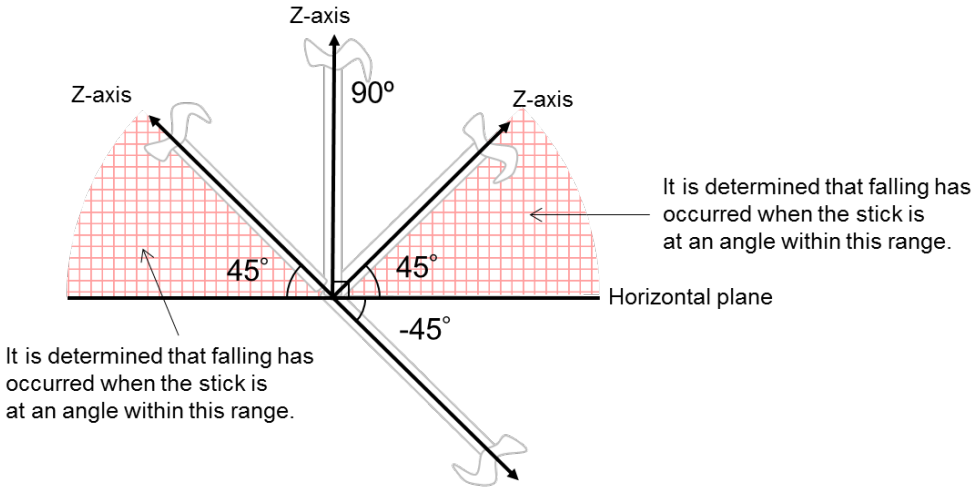
Figure 1.1 the system configuration

1.1 Determination of Falling

In this application note, only the Z-axis data of the three-axis acceleration sensor (analog voltage output) is used to determine falling of the walking stick. The analog voltage output from the three-axis acceleration sensor is acquired as a digital value using an A/D converter. In the case of the three-axis acceleration sensor used in this application note, the relationship between angle made by the Z axis with a horizontal plane and the acquired data is as follows.

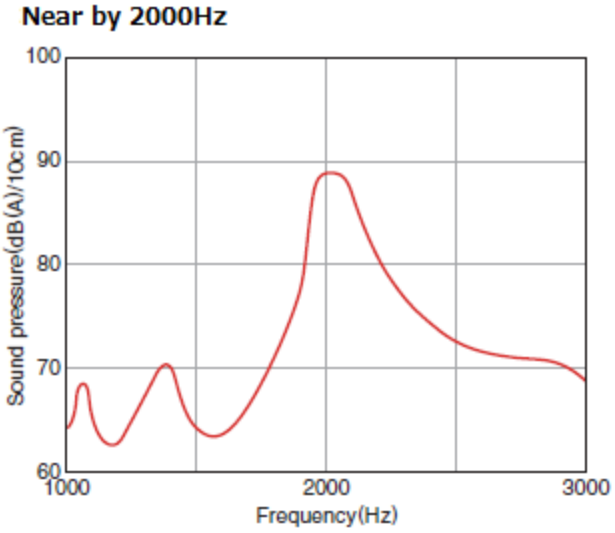
Angle of Z axis with horizontal plane	-90˚ to 0˚	0˚ to 45˚	45˚ to 90˚
Acquired data	310 to 515	516 to 639	640 to 700

In this application note, when an acquired data value is above 515 but less than 640, it is determined that falling has occurred. When acquired data values are 515 or lower or are 640 or higher, it is determined that falling has not occurred.



1.2 Buzzer Specifications

In this application note, a piezoelectric speaker is used as a buzzer. The frequency characteristic of the piezoelectric speaker is shown below. To change the audio tone, the input frequency is changed (between 2023 Hz and 2725 Hz) according to the characteristic of the piezoelectric speaker being used.



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/G10 (R5F10Y17ASP)
Operating frequency	• High-speed on-chip oscillator (HOCO) clock: 5 MHz • CPU/peripheral hardware clock: 5 MHz
Operating voltage	4.5V (can run on a voltage range of 2.0 V to 5.5 V.) SPOR operation: 2.84 V at fall, 2.90 V at rise
Integrated development environment (CS+)	CS+ for CC V6.01.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.06.00 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio V5.4.0.018 from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.06.00 from Renesas Electronics Corp.

3. Related Application Note

The application note that is related to this application note is listed below for reference.

RL78/G10 Initialization (R01AN2668E) Application Note

4. Hardware Descriptions

4.1 Hardware Configuration

Figure 4.1 shows an example of the hardware configuration for the system described in this application note.

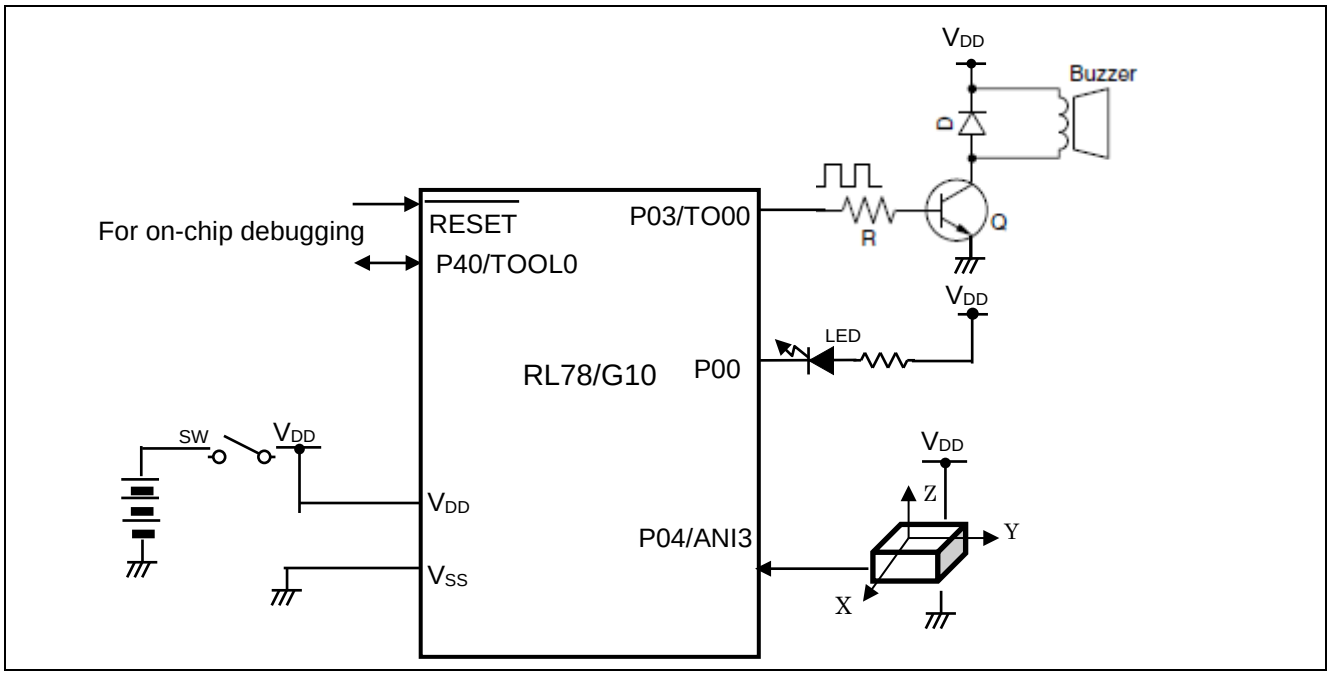


Figure 4.1 the hardware configuration used for this application

Notes: 1. The above figure is a simplified circuit image for showing the outline of the connections. The actual circuit should be designed so that the pins are handled appropriately and that the electrical characteristics are satisfied (input-only ports should be each connected to V_{DD} or V_{SS} via a resistor).

2. VDD must be equal to or greater than the reset release voltage (V_{SPOR}) specified with SPOR.

4.2 List of Pins Used

Table 4.1 lists the pins used and their functions.

Table 4.1 Pins Used and Their Functions

Pin Name	I/O	Description
P00	**Output**	LED lighting control port
P04/ANI3	**Input**	z-axis analog input port of three-axis acceleration sensor
P03/TO00	**Output**	Buzzer drive port
P40/TOOL0	**I/O**	For on-chip debugging
P125/RESET	**Input**	Reset

5. Software Descriptions

5.1 Operation Summary

In this application note, the timer array unit channel 0 is used to output a square wave with a duty ratio of 50% to the buzzer. The lower 8 bits of the timer array unit channel 1 are used to control the LED blinking. The A/D converter is used to acquire the analog output from the three-axis acceleration sensor as a digital value.

5.2 List of Option Byte Settings

Table 5.1shows the option byte settings.

Table 5.1Option Byte Settings

Address	Setting	Description
000C0H	11101111B	Disables the watchdog timer. (Stops counting after the release from the reset state.)
000C1H	11110111B	SPOR detection voltage: 2.90 V at fall; 2.84 V at rise
000C2H	11111011B	HOCO: 5 MHz
000C3H	10000101B	Enables the on-chip debugger.

5.3 List of Variables

Table 5.2lists the global variables.

Table 5.2 Global Variables

Type	Variable Name	Contents	Function Used
unsigned short	g_1ms_Blink	counter for LED reversal	main()
unsigned short	count_blink	counter for LED blinking	main()
unsigned short	count_blink5	counter for LED blinking(5.)	main()
unsigned short	count_buzzer	counter for buzzer alarm	main()

5.4 List of Functions (Subroutines)

Table 5.3 lists the functions (subroutines).

Table 5.3 List of Functions (Subroutines)

Function (Subroutine) Name	Outline
R_TAU0_Channel0_Start	Starts count operation of the timer array unit channel 0.
R_TAU0_Channel0_Stop	Stops count operation of the timer array unit channel 0.
R_TAU0_Channel1_Lower8bits_Start	Starts count operation of the lower 8-bit timer of the timer array unit channel 1.
R_TAU0_Channel1_Lower8bits_Stop	Stops count operation of the lower 8-bit timer of the timer array unit channel 1.
R_TAU0_Buzzer	Outputs the frequency for buzzer alarm (2.6 kHz to 3.9 kHz).
Zaxis_adc_result	Data obtained from the z-axis of the three-axis acceleration sensor

5.5 Function Specifications

This section gives the specifications of the functions used in the sample program.

[Function Name] R_TAU0_Channel0_Start		
Synopsis	Start operation of the timer array unit channel0.	
Header	r_cg_tau.h	
Declaration	void R_TAU0_Channel0_Start (void)	
Explanation	-	
Arguments	None	
Return value	None	
Remarks	None	

[Function Name] R_TAU0_Channel0_Stop		
Synopsis	Stop operation of the timer array unit channel0.	
Header	r_cg_tau.h	
Declaration	void R_TAU0_Channel0_Start (void)	
Explanation	-	
Arguments	None	
Return value	None	
Remarks	None	

[Function Name] R_TAU0_Channel1_Lower8bits_Start		
Synopsis	Start operation of the timer array unit channel1.	
Header	r_cg_tau.h	
Declaration	void R_TAU0_Channel1_Lower8bits_Stop (void)	
Explanation	-	
Arguments	None	
Return value	None	
Remarks	None	

[Function Name] R_TAU0_Channel1_Lower8bits_Stop		
Synopsis	Stop operation of the timer array unit channel1.	
Header	r_cg_tau.h	
Declaration	void R_TAU0_Channel1_Lower8bits_Stop (void)	
Explanation	-	
Arguments	None	
Return value	None	
Remarks	None	

[Function Name] R_TAU0_Buzzer		
Synopsis	Outputs the frequency for buzzer alarm (2.6 kHz to 3.9 kHz).	
Header	r_cg_tau.h	
Declaration	void R_TAU0_Buzzer(void)	
Explanation	-	
Arguments	None	
Return value	None	
Remarks	None	

[Function Name] Zaxis_adc_result		
Synopsis	Data obtained from the z-axis of the three-axis acceleration sensor	
Declaration	void Zaxis_adc_result (void)	
Explanation	-	
Arguments	None	
Return value	None	
Remarks	None	

5.6 Flowcharts

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

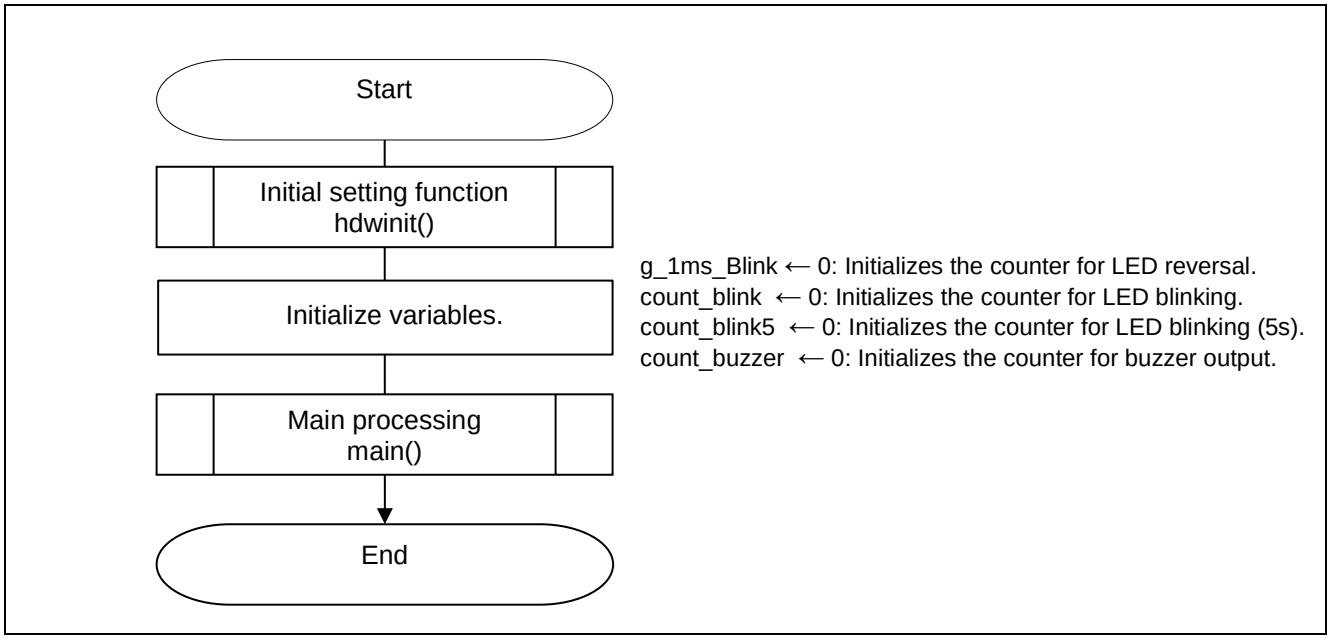


Figure 5.1 the hardware configuration used for this application

5.6.1 Initial Setting Function

Figure 5.2 shows the flowchart of the initial setting function.

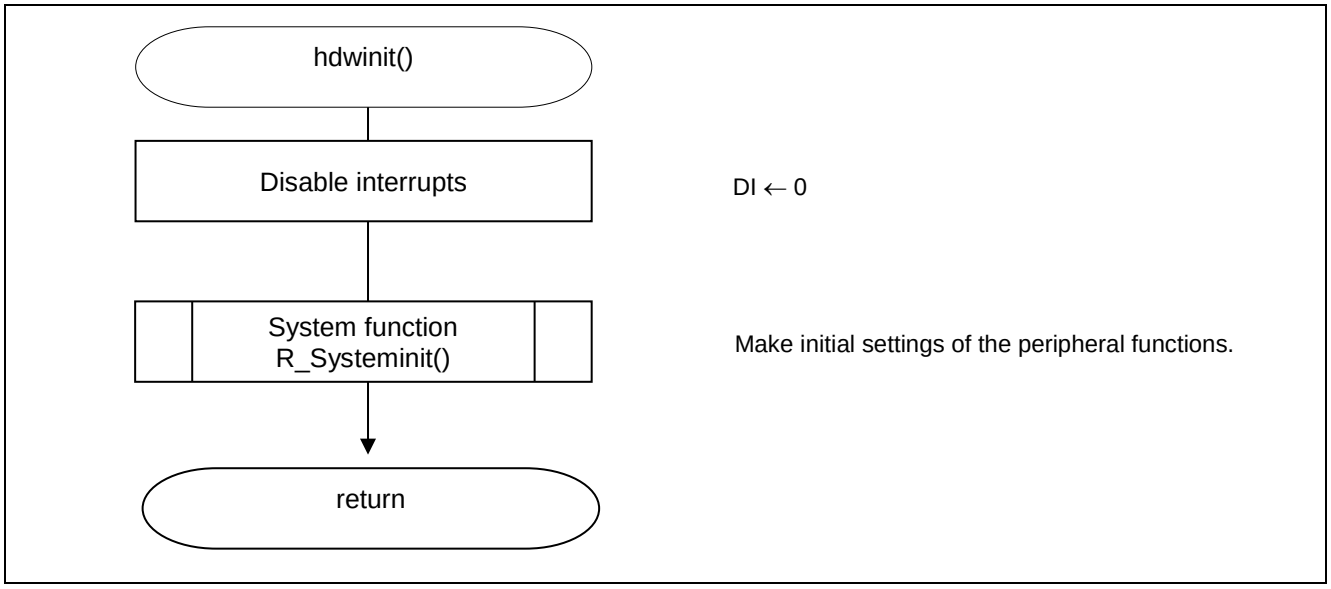


Figure 5.2 Initial Setting Function

5.6.2 System Function

Figure 5.3 shows the flowchart of the system function.

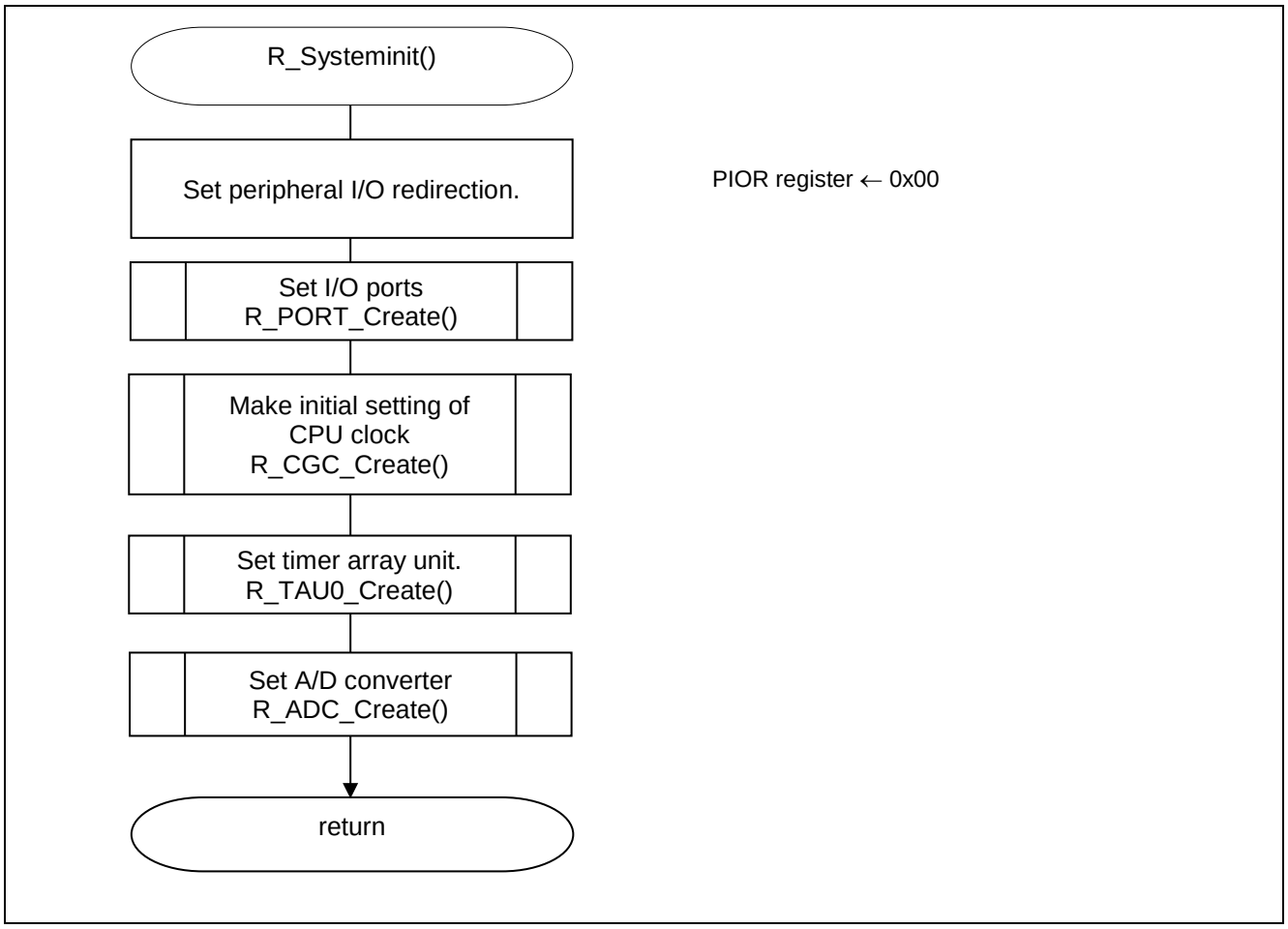


Figure 5.3 System Function

5.6.3 I/O Port Setup

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

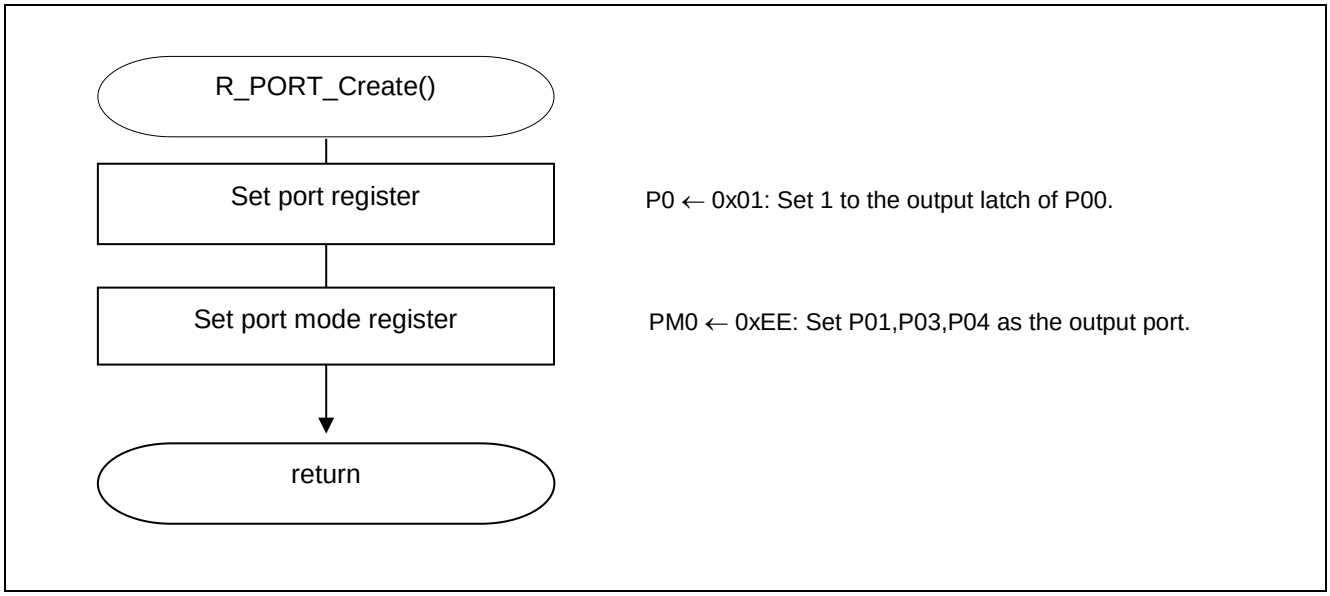


Figure 5.4 I/O Port Setup

Notes: 1. For details on register setting when using the ports as the alternate functions of the peripheral functions, refer to the RL78/G10 User's Manual: Hardware.

2. Provide proper treatment for unused pins so that their electrical specifications are observed. Connect each of unused input-only ports to V_{DD} or V_{SS} via a separate resistor.

5.6.4 CPU Clock Setup

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

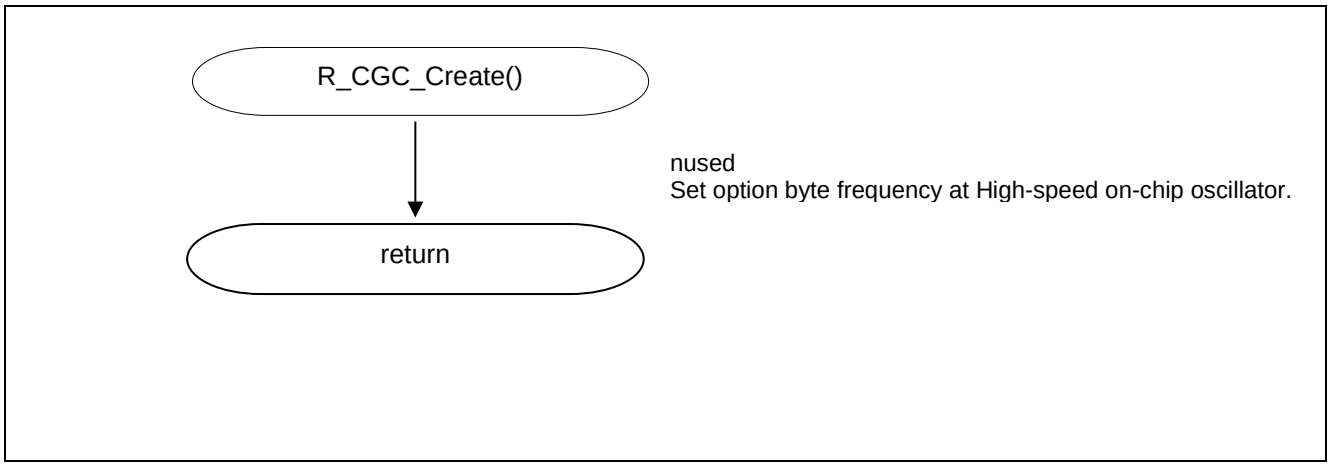


Figure 5.5 CPU Clock Setup

5.6.5 Timer array unit Setup

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

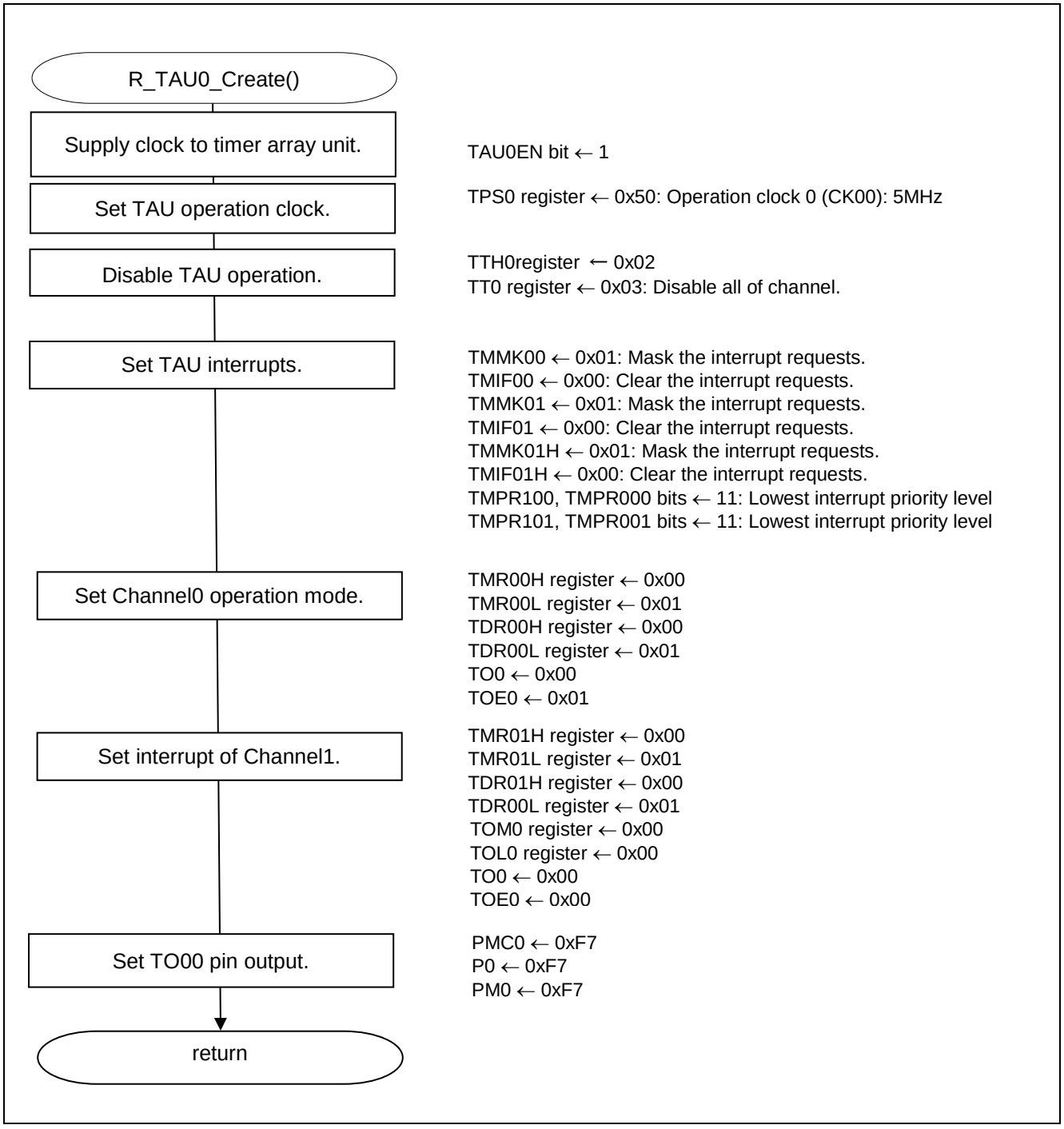


Figure 5.6 Timer Array Unit Channel0 Setup

5.6.6 Timer array unit Start

Figure 5.7 shows the flowchart for starting the timer array unit.

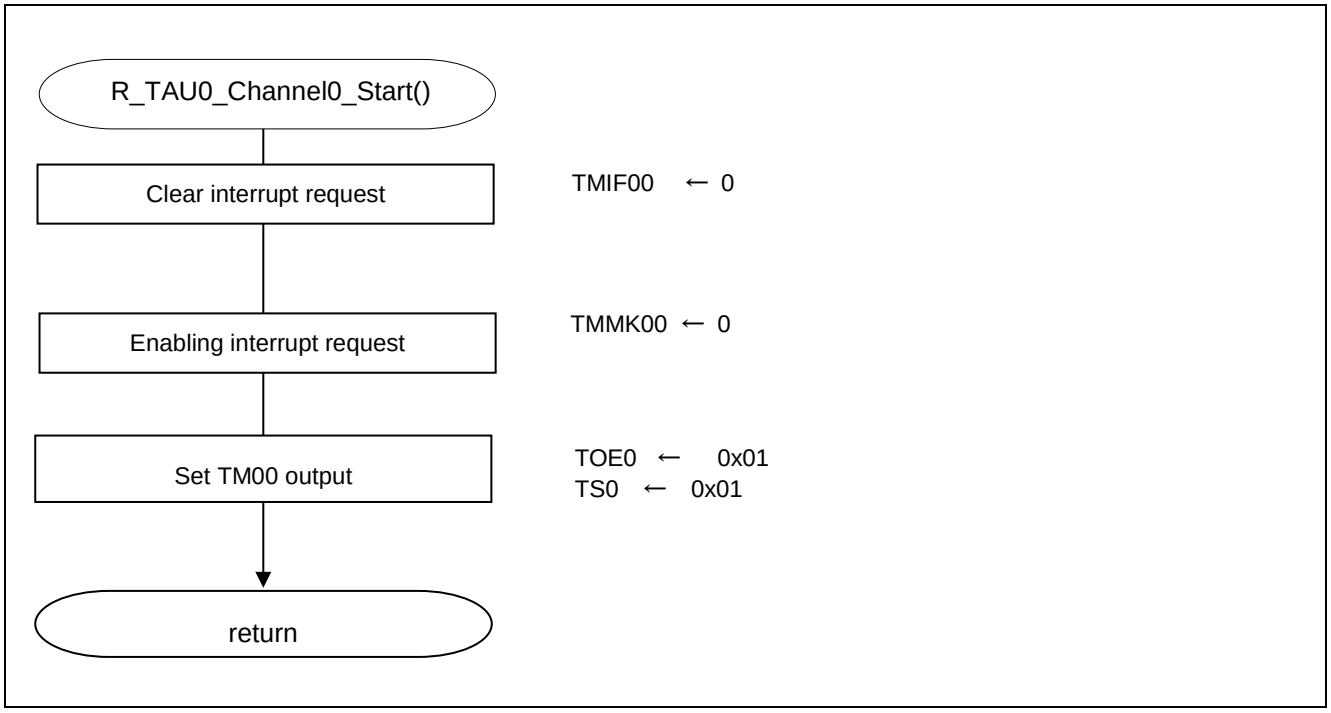


Figure 5.7 Timer Array Unit Channel0 Start

5.6.7 Timer array unit Stop

Figure 5.8 shows the flowchart for stopping the timer array unit.

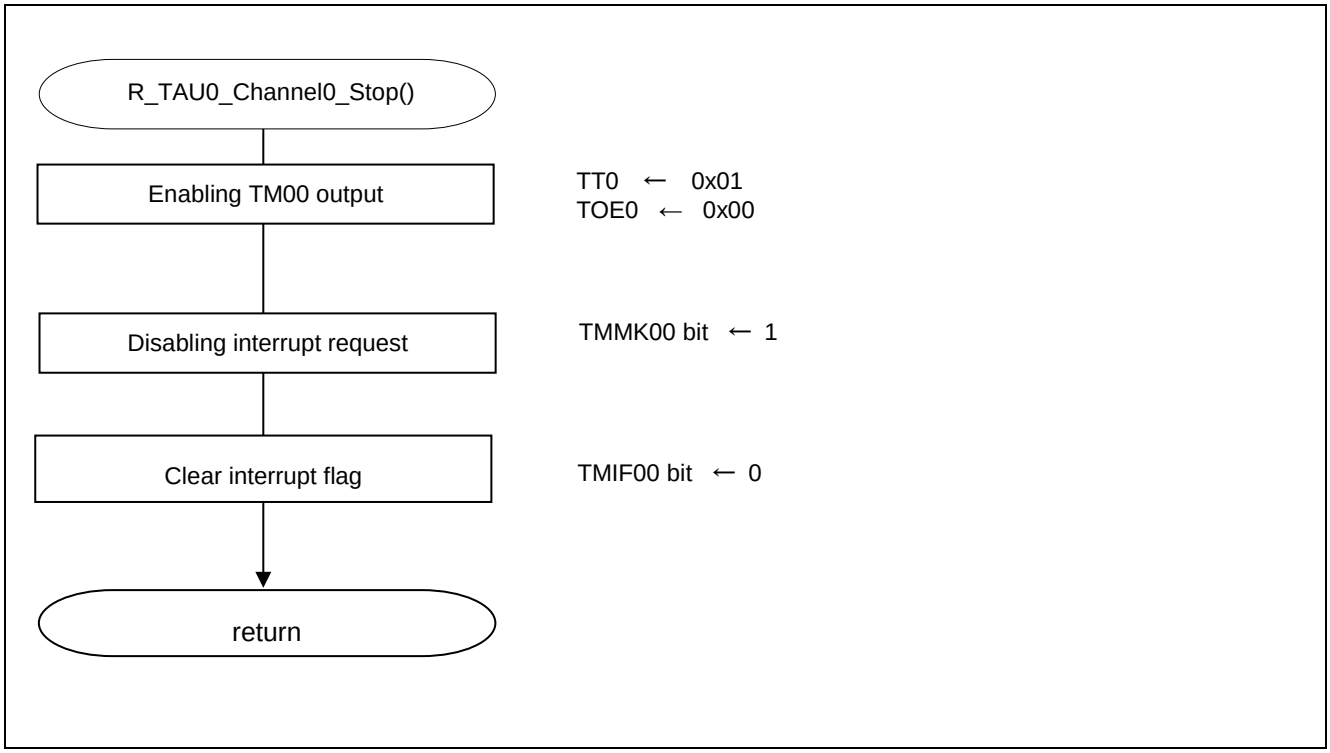


Figure 5.8 Timer Array Unit Stop

5.6.8 Timer array unit Channel1 Low8bit Start

Figure 5.9 shows the flowchart for starting the timer array unit.

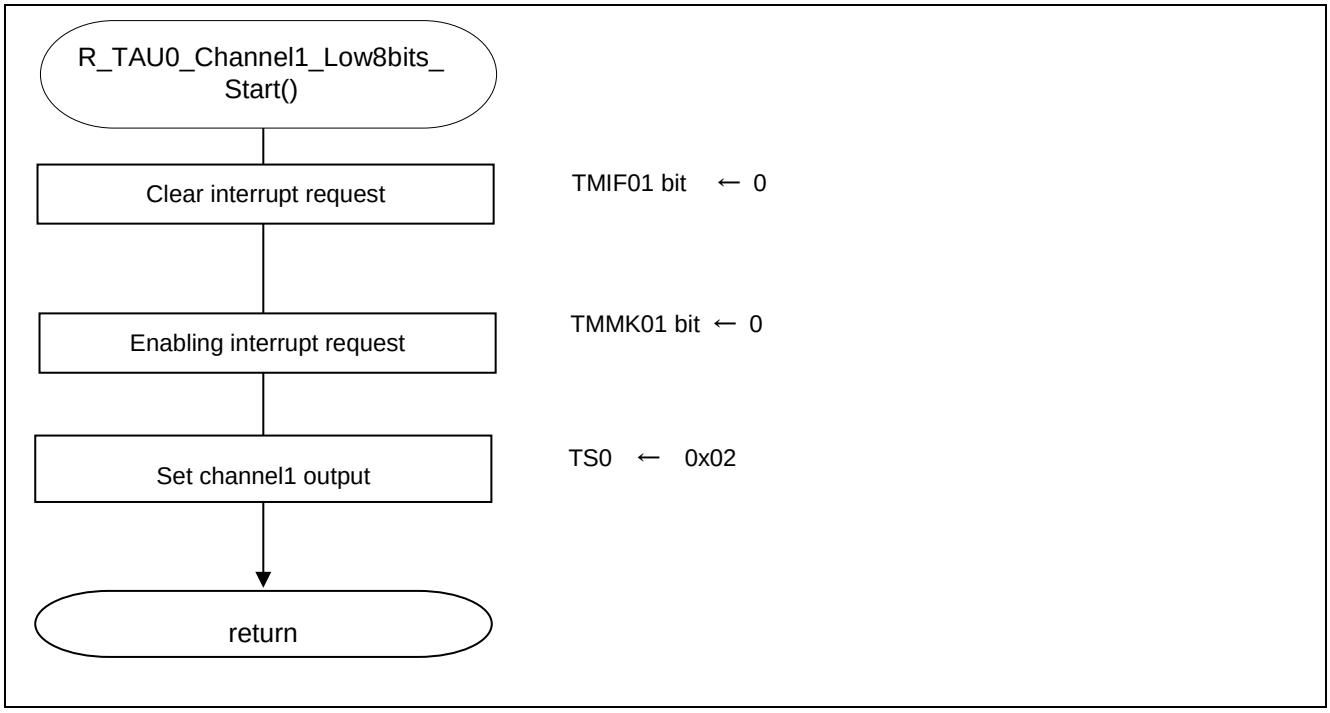


Figure 5.9 Timer Array Unit Channel1 Start

5.6.9 Timer array unit Channel1 Low8bit Stop

Figure 5.10 shows the flowchart for stopping the timer array unit.

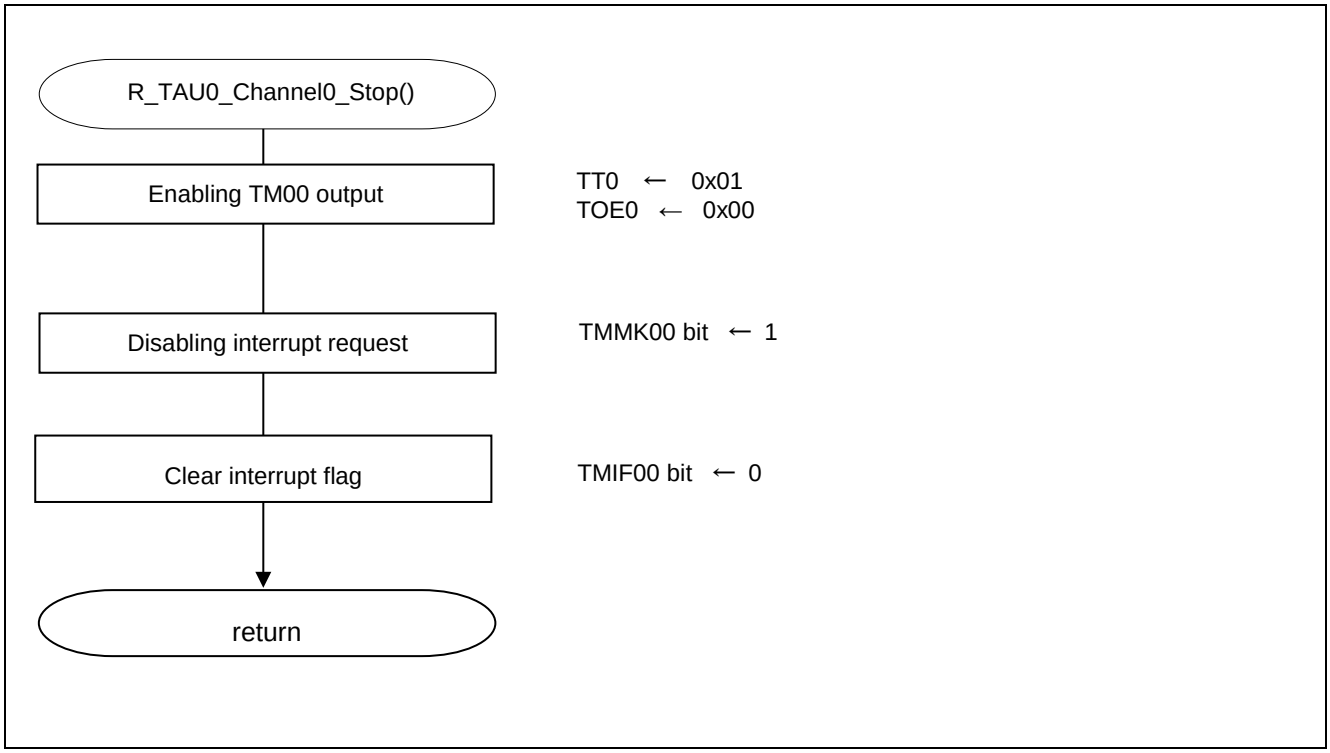


Figure 5.10 Timer Array Unit Stop

Note: For details on timer array unit register setting, refer to the chapter on the timer array unit in RL78/G10 User's Manual: Hardware.

5.6.10 A/D converter Setup

Figure 5.11 shows the flowchart for setting up the A/D converter.

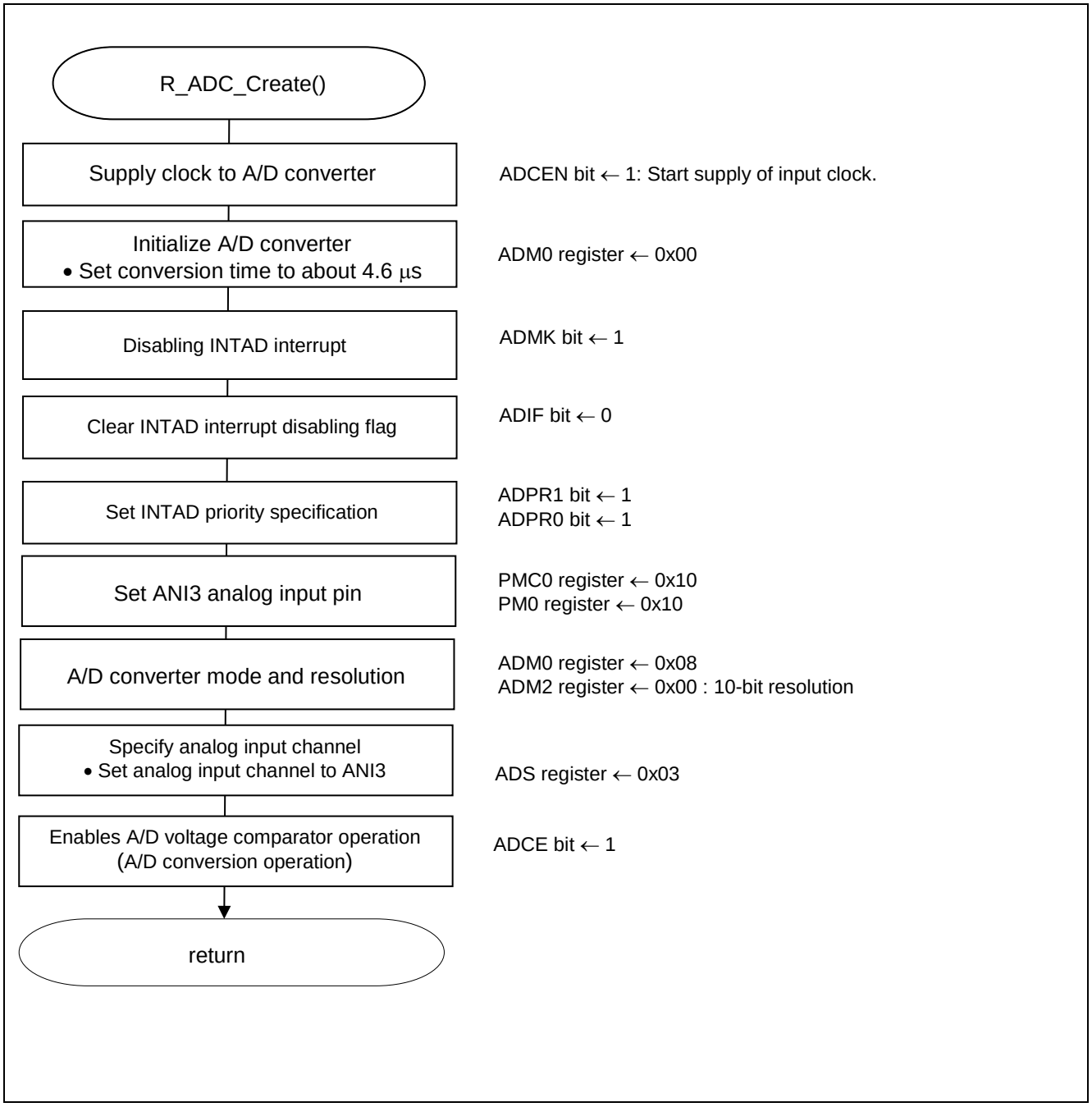


Figure 5.11 A/D Converter Setup

5.6.11 External Interrupt Setup

Figure 5.12 shows the flowchart for setting up the external interrupts.

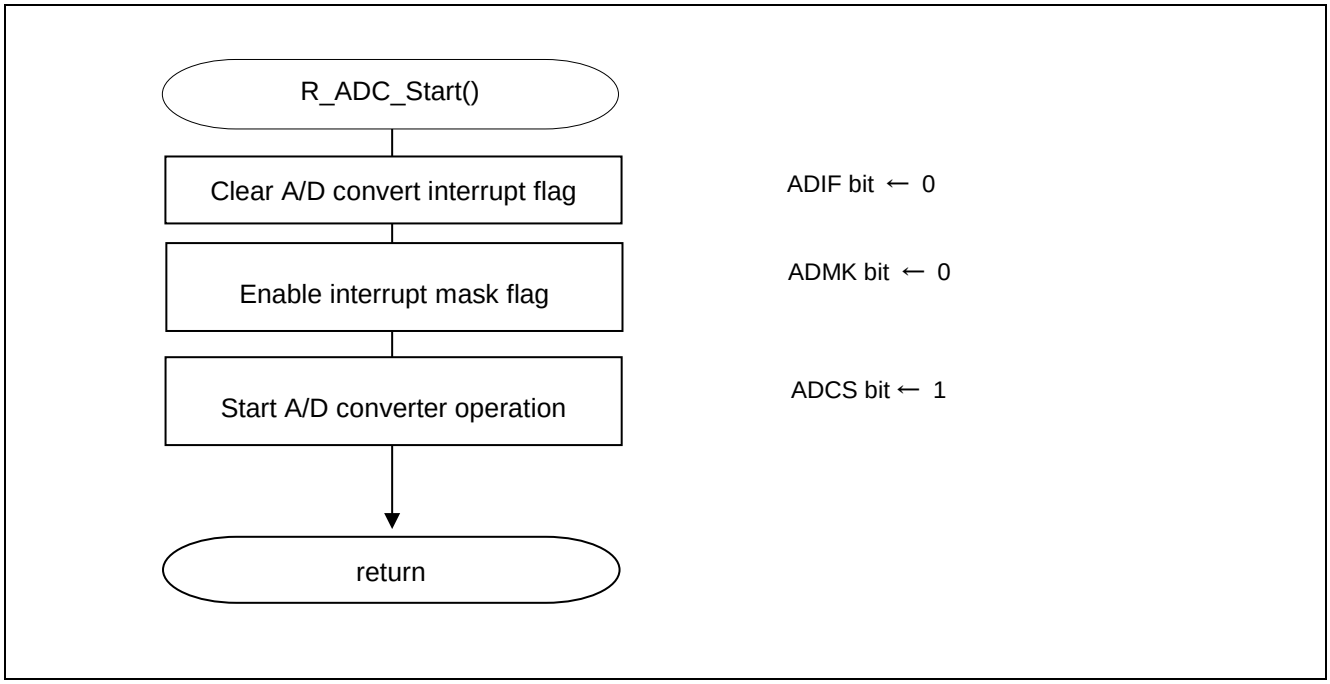


Figure 5.12 External Interrupt Setup

5.6.12 Storing A/D Conversion Results

Figure 5.13 shows the flowchart for storing A/D converter conversion results.

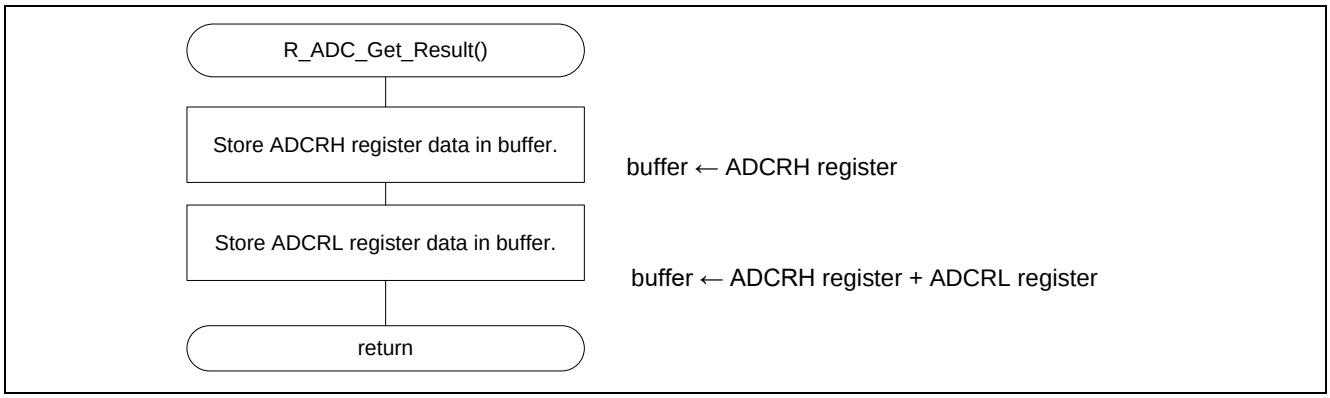


Figure 5.13 Flowchart for Storing A/D Converter Conversion Results

Note: For details on A/D converter register setting, refer to the chapter on the A/D converter in RL78/G10 User's Manual: Hardware.

5.6.13 Main Processing

Figure 5.14, Figure 5.15 shows the flowchart of the main processing.

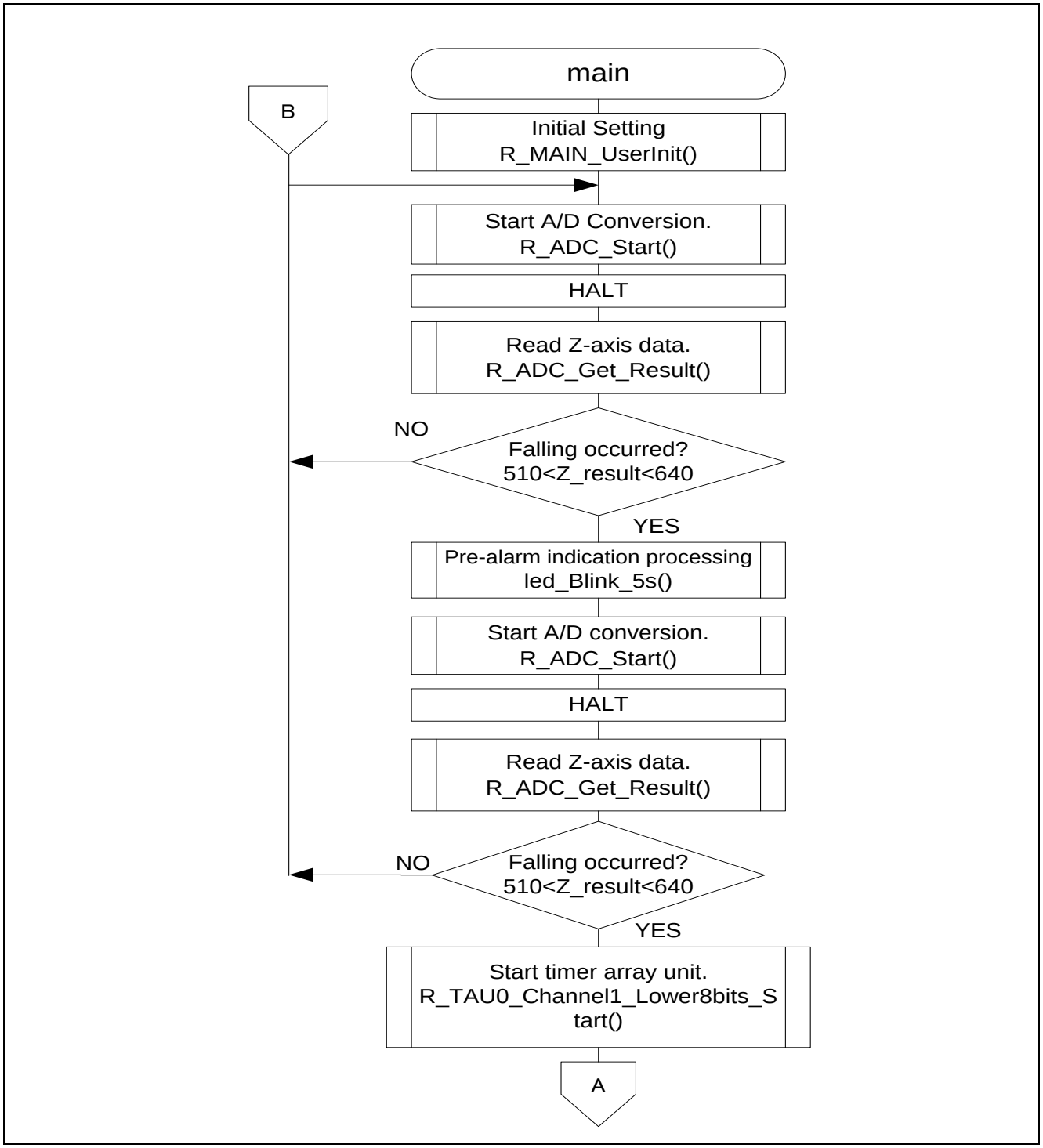


Figure 5.14 Flowchart of Main Processing (1/2)

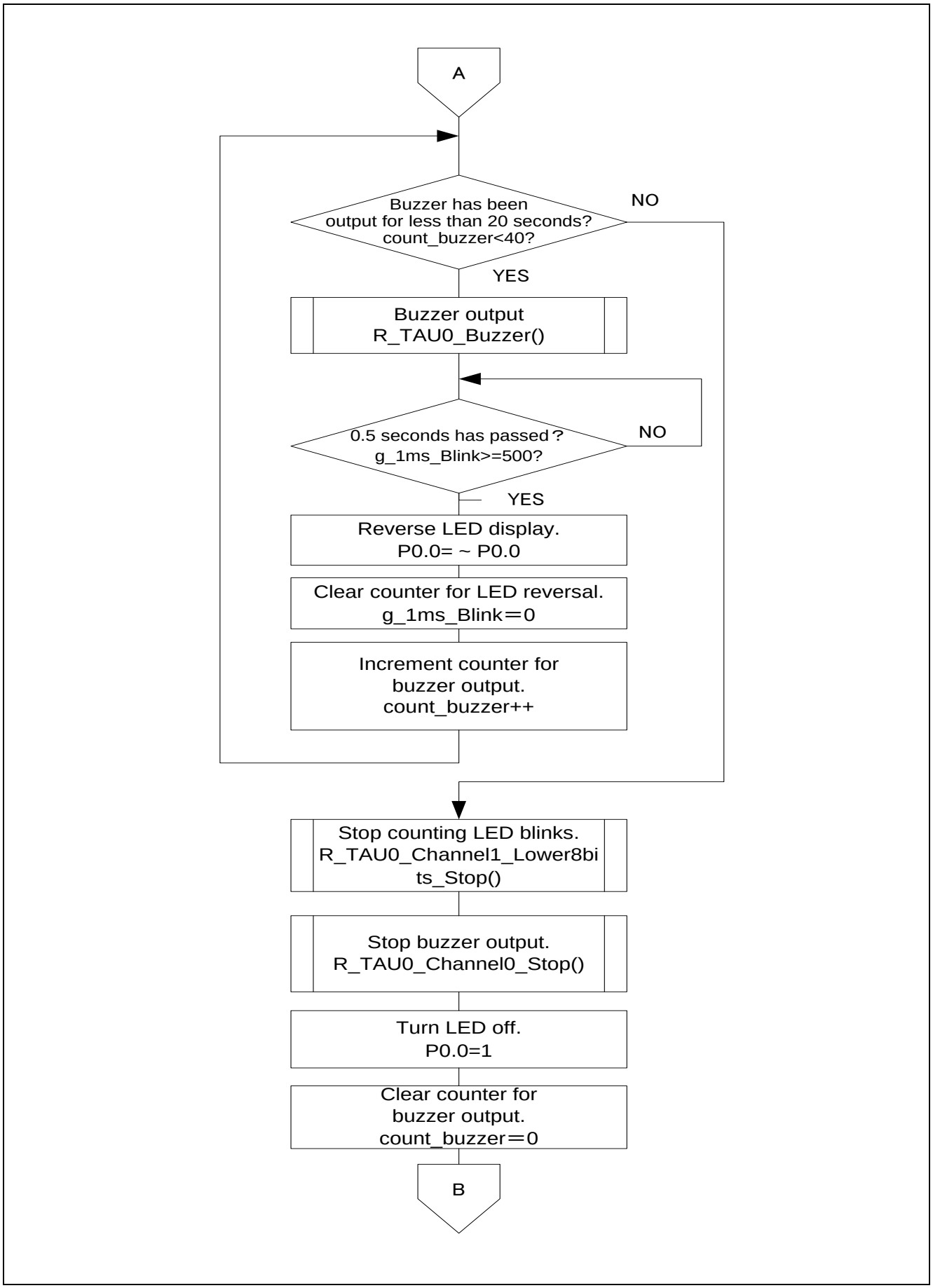


Figure 5.15 Flowchart of Main Processing (2/2)

5.6.14 Flowchart of Initial Setting

Figure 5.16 shows the flowchart of the initial setting in the main processing.

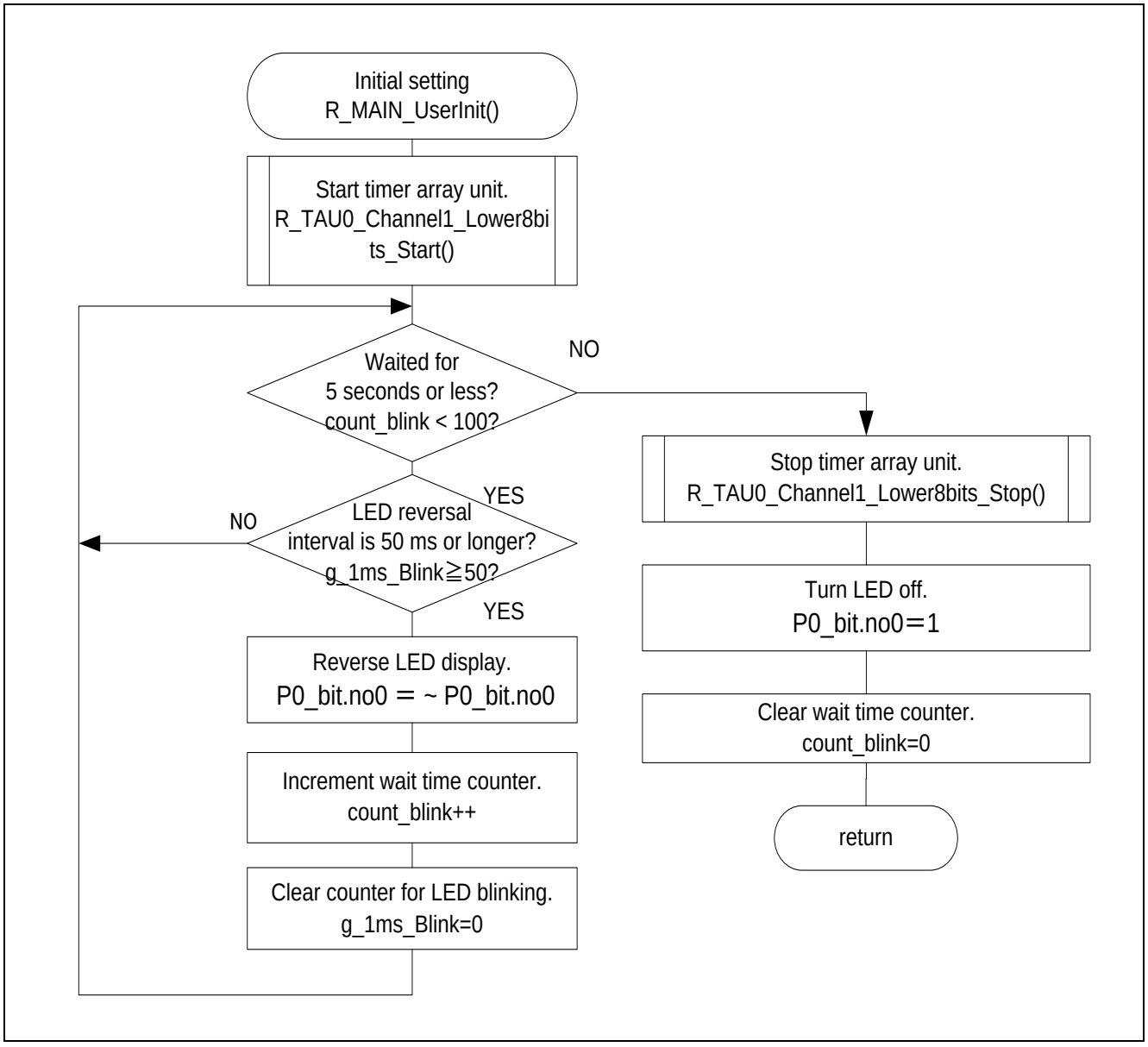


Figure 5.16 Flowchart of Initial Setting in Main Processing

5.6.15 Flowchart of Pre-Alarm Indication Processing

Figure 5.17 shows the flowchart of pre-alarm indication processing.

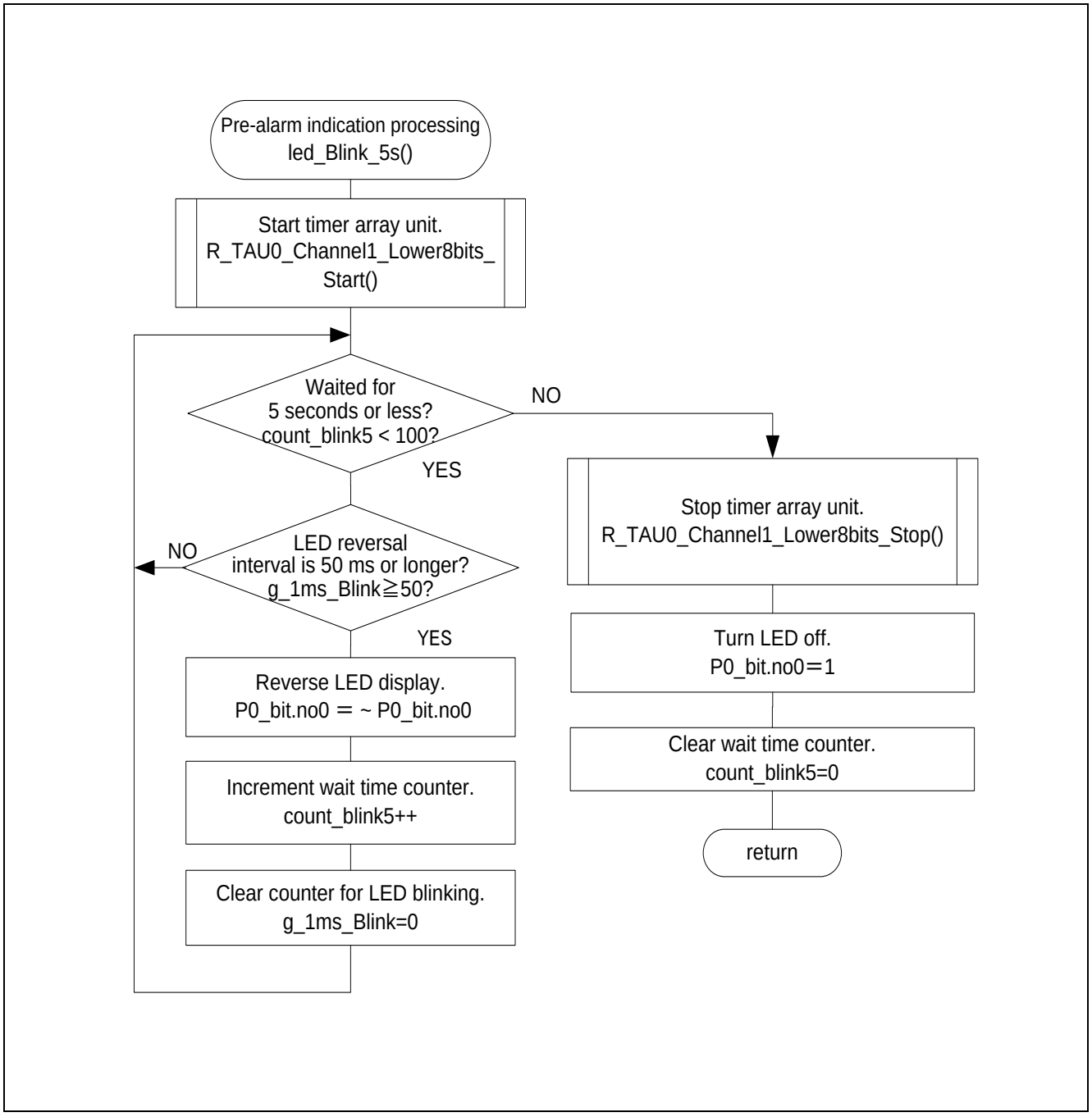


Figure 5.17 Flowchart of Pre-Alarm Indication Processing

5.6.16 Temperature Data Transmission Function

Figure 5.18,Figure 5.19 show the flowcharts of the processing to synthesize an alarm sound with a frequency between 2023 Hz and 2725 Hz in the main processing.

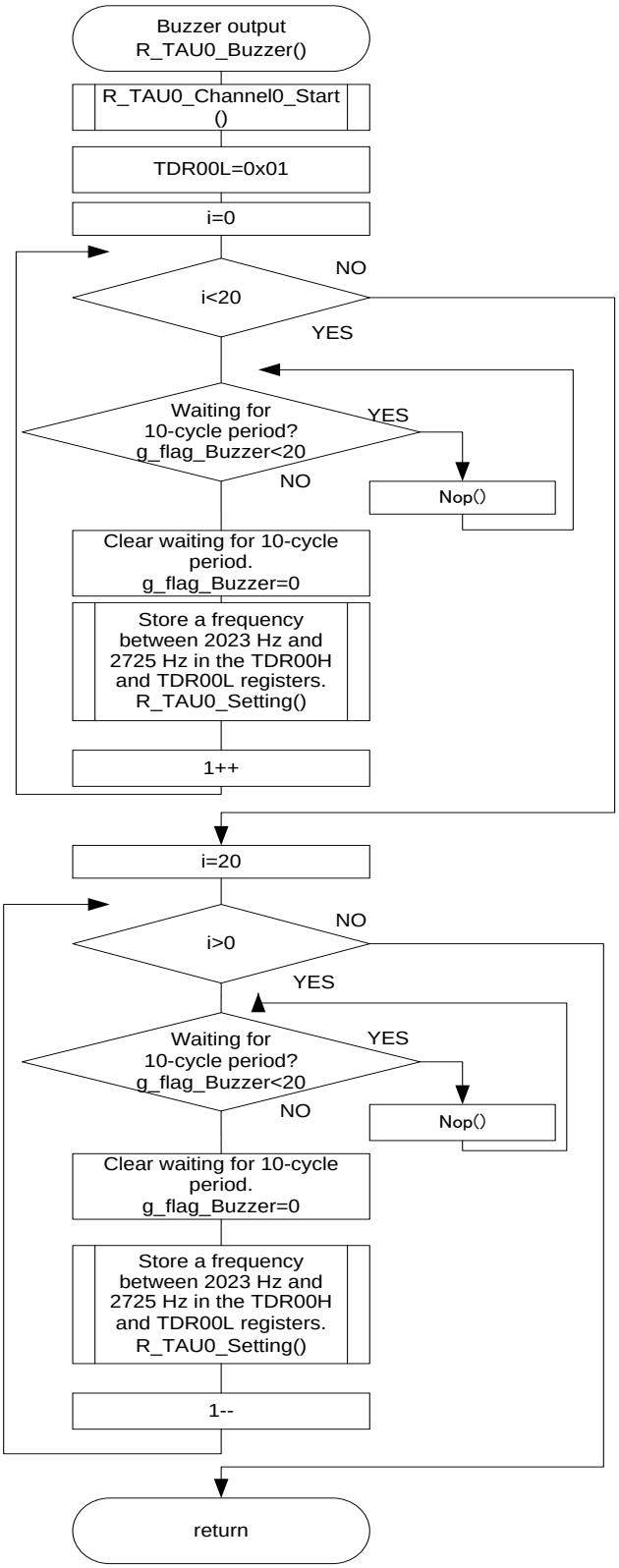


Figure 5.18 Flowchart for Synthesizing Buzzer Sound with a Frequency between 2023 Hz to 2725 Hz

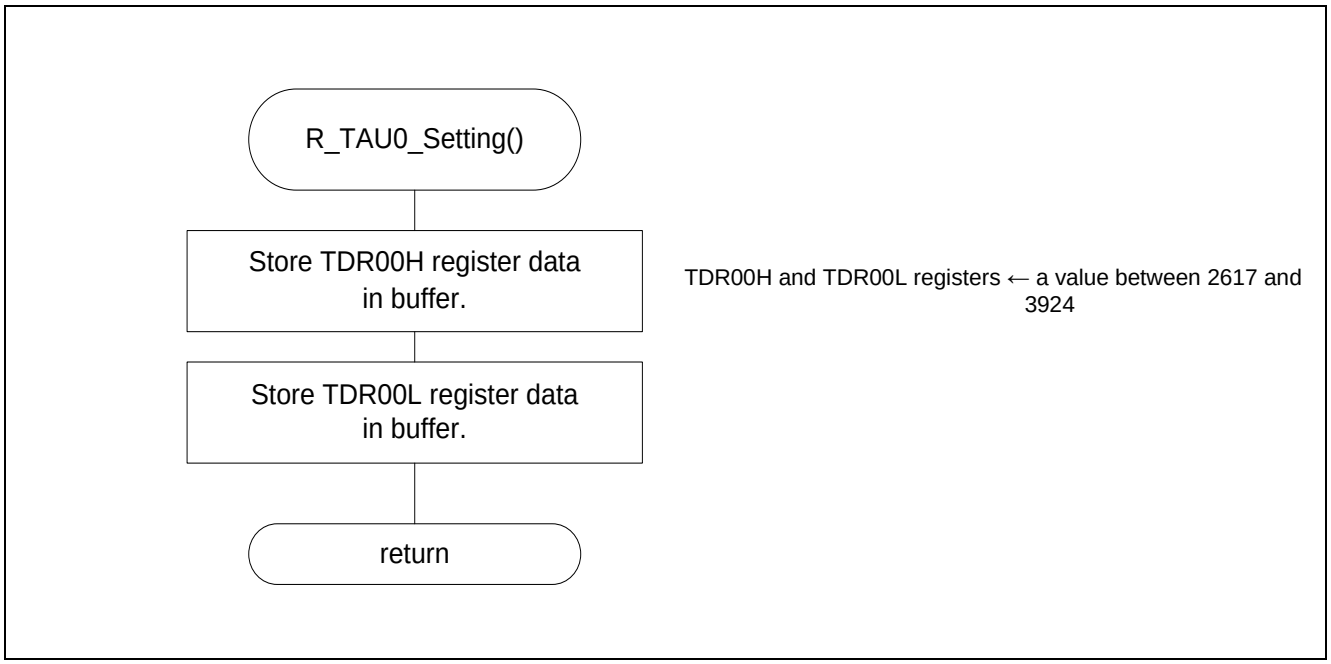


Figure 5.19 Flowchart for Storing Buzzer Frequency

5.6.17 Interrupt Processing

Figure 5.20 shows the flowchart of interrupt processing.

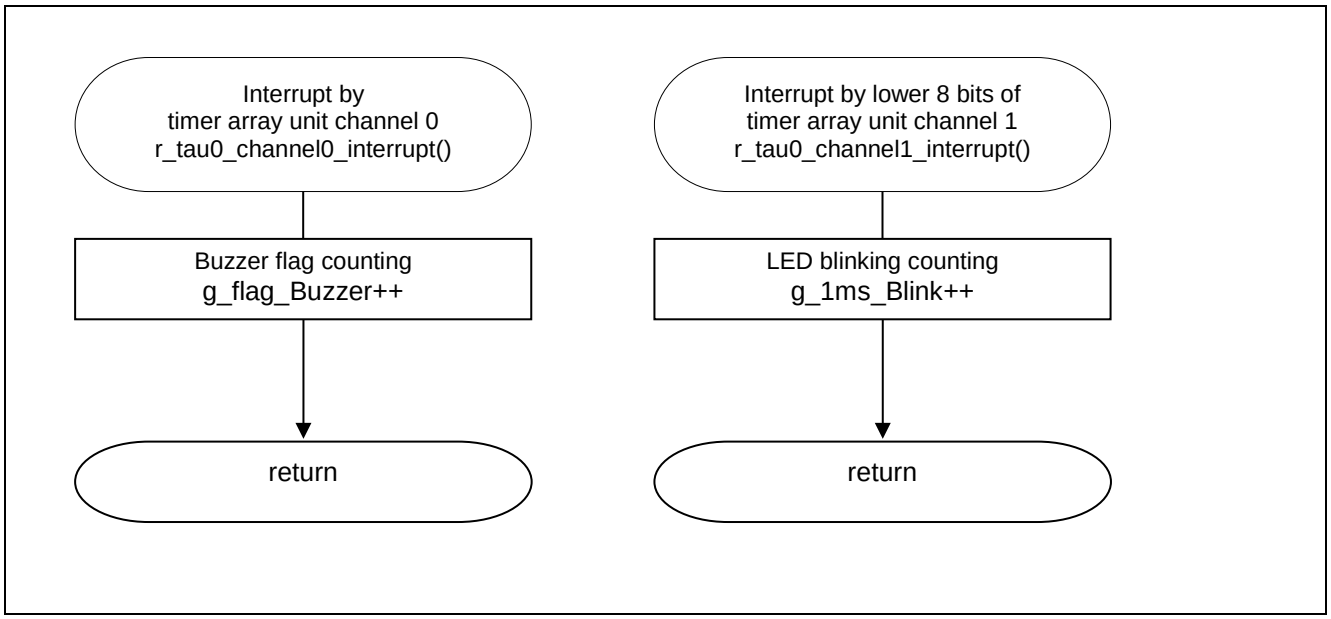


Figure 5.20 Flowchart of Interrupt Processing

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Revision History <revision history,rh>

Rev.	Date	Description	
		Page	Summary
1.00	2018.11.30	-	

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. 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 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 a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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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