RL78/G11

Automatic Brightness Adjustment of LED Ceiling Light

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Introduction

In this application note, a method for automatically adjusting the brightness of an LED ceiling light is explained. In this application system, a phototransistor is used to measure the illuminance, and the timer KB0 of the RL78/G11 is used to control the amount of light from the LED.

Target Device

RL78/G11

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

In this application system, a phototransistor is used to measure the illuminance, and the timer KB0 of the RL78/G11 is used to hold the amount of light from the LED constant.

Figure 1.1 shows the schematic system configuration.

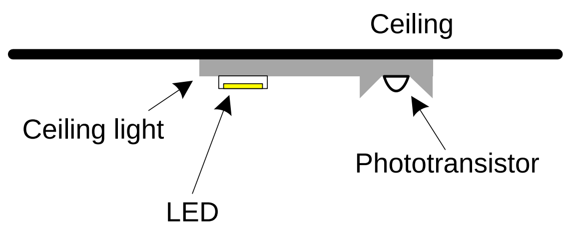

Figure 1.1 Schematic System Configuration

When the ceiling light power is turned on, after initial setting of the RL78/G11, the LED is lit by the PWM output from the 16-bit timer KB0 (hereafter "timer KB0"). A programmable gain amplifier (hereafter "PGA") and an A/D converter are used to measure the current flowing to the LED. At the same time, the brightness is measured within the range detectable by a phototransistor mounted in the LED ceiling light.

In this application system, the brightness is maintained at 300 lx, which is optimal for a conference room. The duty ratio of the PWM output of the timer KB0 is controlled to adjust the current flowing to the LED such that the brightness is 300 lx (feedback control).

In this application system, simple PWM output control is used. In actuality, PI control or the like should be used according to the circuit and the device specifications. For information on PI control, refer to "LED Control Using RL78/I1A (R01AN1087) ".

1.1 Phototransistor

This application system uses a phototransistor. When actually preparing the circuit, the circuit should be designed so that the electrical characteristics of the phototransistor are satisfied.

2. Operation Check Conditions

The sample code contained in this application note has been checked under the conditions listed in the table below.

Figure 2.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/G11(R5F1058A)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 24MHz CPU/peripheral hardware clock: 24MHz / 48MHz
Operating voltage	5.0 V (Operation is possible over a voltage range of 2.7 V to 5.5 V.) LVD operation (V_{LVD}): Reset mode which uses 2.81 V (2.76 V to 2.87 V)
Integrated development environment (CS+)	CS+ V7.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.07.00 from Renesas Electronics Corp.
Integrated development environment (e2 studio)	e2 studio V7.1.0 from Renesas Electronics Corp.
C compiler (e2 studio)	CC-RL V1.07.00 from Renesas Electronics Corp.

3. Related Application Notes

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

RL78/G13 Initialization CC-RL (R01AN2575) Application Note

RL78/G11 LED Control by Using 16-Bit Timer KB0 CC-RL (R01AN4109EJ)

LED Control Using RL78/I1A (R01AN1087EJ)

4. Description of the Hardware

4.1 Hardware Configuration Example

Figure 4.1 shows an example of hardware configuration that is used for this application note.

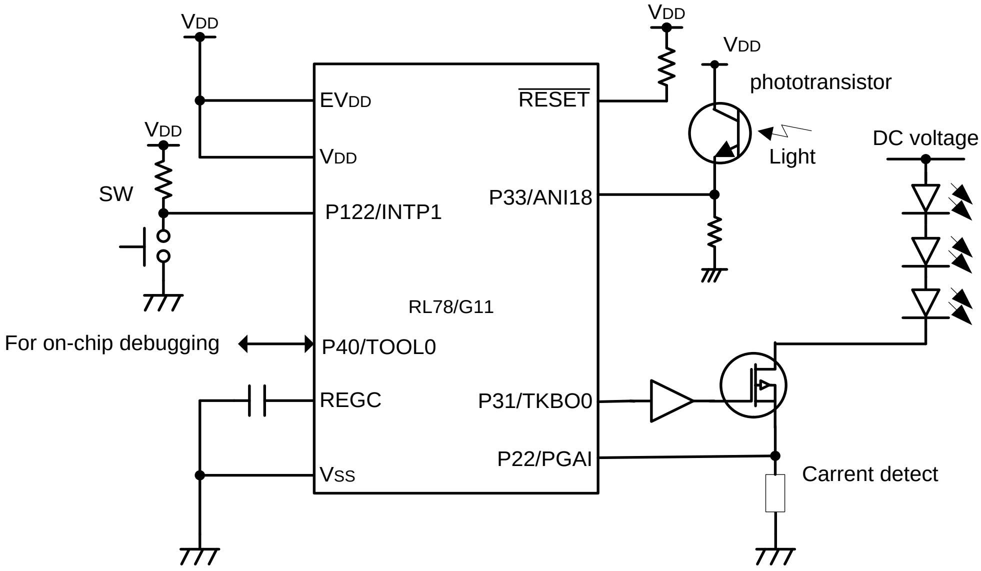

Figure 4.1 Hardware Configuration

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 VDD or VSS via a resistor).
2. Connect any pins whose name begins with EVSS to VSS and any pins whose name begins with EVDD to VDD, respectively.
3. VDD must be held at not lower than the reset release voltage (V_{LVD}) 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
P31/TKBO0	Output	Timer KBO0 output port
P33/ANI18	Input	Phototransistor analog input port
P22/PGAI	Input	Analog input port for LED feedback resistor
P122/INTP1	Input	Switch input port

5. Description of the Software

5.1 Operation Outline

In this application note, when power to the ceiling light is turned on, RL78/G11 initial settings (functions set: timer KB0, A/D converter, D/A converter, PGA, comparator, timer array unit, external interrupt) are executed.

Details of the sample code initial settings are as follows.

1. Timer KB0 initial settings
   - The timer KB0 is set to standalone mode.
   - As the active level of the timer output TKBO0, "high level" is set, and as the default level, "low level" is set.
   - The PWM period is set to 4 μs, and the duty ratio is set to 0%.
   - A TKBO0 forced output stop function 1 is set, and low level fixed output is selected. Comparator 0 is selected as the trigger for the function 1. Type 1 is selected as the operating mode.

2. A/D converter initial settings
   - A/D voltage comparator operation is enabled.
   - Resolution is set to 10 bits.
   - VDD is selected for VREF(+), and VSS is selected for VREF(-).
   - Software trigger mode, one-shot conversion mode, and select mode are set.
   - ANI18 is set as an analog input pin, and the conversion start channel is set to ANI18.
   - Conversion time is set to standard 1 mode and $95/f_{CLK}$ (3.9583 μs).
   - Generation of an interrupt signal (INTAD) upon ADLL $\leq$ ADCR $\leq$ ADUL is selected, with the upper limit set to ADUL = 255 and the lower limit to ADLL = 0.

3. D/A converter initial settings
   - The D/A converter 0 conversion value is set to 163.

   When the LED overcurrent is 400 mA, PGA is set to 8x, and the current detection resistance is 1 □, the reference voltage for overcurrent detection is

   400 mA × 8 × 1 Ω = 3.2 V

   To generate the overcurrent detection reference voltage from the D/A converter analog output,

   analog output voltage VANOi = VDD × (DACSi)/256

   VANOi = 3.2 V, VDD = 5 V, and so DACSi = 163

4. Programmable gain amplifier (PGA) initial settings
   - PGAGND is selected as the PGA GND.
   - The PGA amplification factor is set to 8.

5. Comparator initial settings
   - The comparator speed is set to high-speed mode.
   - Standard mode is selected.
   - The input signal of the + pin of the comparator 0 is set to the output of the programmable gain amplifier.
   - The input signal of the - pin of the comparator 0 is set to the output of channel 0 of the internal D/A converter.
   - Interrupt request by comparator 0 single-edge detection is selected.
   - Interrupt request at the comparator 0 rising edge is selected.
   - A comparator 0 filter is set with sampling at f_{CLK} ($f_{CLK} = f_{IH} = 24$ MHz).
   - Comparator 0 interrupts are enabled, and priority level is set to 3.

6. Timer array unit 0 (TAU0) initial settings
   - Channel 0 is set to the interval timer.
   - The interval time is set to 300 μs.
   - TAU0 channel 0 count end interrupts are enabled, and the priority level is set to 3.

7. 12-bit Interval Timer initial settings
   - The interval time is set to 50 ms.

8. External interrupts initial settings
   - The P122/INTP1 pin is used.
   - The valid edge of the INTP1 pin is set to the falling edge.

After completion of initial settings, the RL78/G11makes a transition to HALT mode.

The RL78/G11 returns from HALT mode with each interrupt factor. Operation at the time of occurrence of different interrupt factors is indicated below.

- TAU0 channel 0 count end interrupt

  The LED current is acquired using the PGA and the A/D converter. The illuminance of the phototransistor is acquired using the A/D converter. The acquired values are then used in simple feedback control. The active level width of the PWM output of the timer KB0 is changed such that the brightness in the environs of the LED lighting fixture is 300 lx.

- INTP1 interrupt

  Switch on/off states are detected. When the switch is detected to be turned off, output from the timer KB0 is stopped. When the switch is detected to be turned on, output from the timer KB0 is started.

When an overcurrent is detected during LED current measurement, the forced output stop function of the timer KB0 is used to stop PWM output. In this application note, the forced output stop function is not canceled.

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 (2.76 V to 2.87 V)
000C2H/010C2H	11110000B	HS mode, f_{IH}: 24MHz, f_{HOCO}: 48MHz
000C3H/010C3H	10000100B	Enables the on-chip debugger.

5.3 List of Constants

Table 5.2 lists the constants that are used in the sample program.

Table 5.2 Constants for the Sample Program

Constant Name	Setting Value	Contents
OFF	0	Flag setting value (OFF)
ON	1	Flag setting value (ON)
TARGET_LUX	0x012C	Lighting target value
TARGET_LED	0x0047	LED current target value

5.4 List of Variables

Table 5.3 lists the global variables that are used in the sample program.

Table 5.3 Global Variables

Type	Variable Name	Contents	Function Used
uint16_t	g_result_buffer	Stores conversion results of A/D converter.	main, r_tau0_channel0_interrupt
uint16_t	g_pwm_duty	Stores duty value of timer KB0.	main, r_tau0_channel0_interrupt
uint8_t	g_switch_flag	Stores switch status.	main, r_tau0_channel0_interrupt
unsigned short int	g_fb_led_value	Stores LED current conversion result.	main, r_tau0_channel0_interrupt
unsigned short int	g_fb_led_value_old	Stores previous LED current conversion result.	main, r_tau0_channel0_interrupt
unsigned short int	g_get_lux	Stores illuminance acquisition result.	main, r_tau0_channel0_interrupt

5.5 List of Functions

Table 5.4 lists the functions.

Table 5.4 Functions

Function Name	Outline
main	Main function
R_MAIN_UserInit	Main user initialization function
R_DAC0_Start	DAC0 operation start
R_PGA_Start	PGA operation start
R_COMP0_Start	Comparator 0 operation start
R_INTC1_Start	Enables INTP1 external interrupt
R_TAU0_Channel0_Start	Timer array unit channel 0 start processing
R_TMR_KB0_Start	16-bit timer KB0 operation start
R_TMR_KB0_Stop	16-bit timer KB0 operation stop
r_tau0_channel0_interrupt	Timer array unit channel 0 interrupt processing
R_ADC_Start	A/D Converter operation start
R_ADC_Get_Result	Get A/D conversion results.
R_ADC_Stop	A/D Converter operation stop
r_intc1_interrupt	Processes INTP1 external interrupt
R_IT_Start	12-bit interval timer operation start
R_IT_Stop	12-bit interval timer operation stop

5.6 Function Specifications

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

[Function Name] main

Synopsis	Main function
Header	r_cg_macrodriver.h, r_cg_cgc.h, r_cg_tau.h, r_cg_it.h, r_cg_tmkb.h, r_cg_adc.h, r_cg_dac.h, r_cg_pga.h, r_cg_comp.h, r_cg_intp.h, r_cg_userdefine.h
Declaration	-
Explanation	After execution of the main user initialization function, enables interrupts, makes a transition to HALT mode, and waits for the occurrence of an interrupt.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_MAIN_UserInit

Synopsis	Main user initialization function
Header	r_cg_macrodriver.h, r_cg_cgc.h, r_cg_tau.h, r_cg_it.h, r_cg_tmkb.h, r_cg_adc.h, r_cg_dac.h, r_cg_pga.h, r_cg_comp.h, r_cg_intp.h, r_cg_userdefine.h
Declaration	static void R_MAIN_UserInit(void);
Explanation	Enables interrupts by the EI instruction.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_DAC0_Start

Synopsis	Starts the D/A converter operation.
Header	r_cg_macrodriver.h, r_cg_dac.h, r_cg_userdefine.h
Declaration	void R_DAC0_Start(void);
Explanation	Starts the D/A converter operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_PGA_Start

Synopsis	Starts the PGA operation.
Header	r_cg_macrodriver.h, r_cg_dac.h, r_cg_userdefine.h
Declaration	void R_PGA_Start(void);
Explanation	Starts the PGA operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_COMP0_Start

Synopsis	Starts the Comparator 0 operation.
Header	r_cg_macrodriver.h, r_cg_comp.h, r_cg_userdefine.h
Declaration	void R_COMP0_Start(void);
Explanation	Starts the Comparator 0 operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_INTC1_Start

Synopsis	Enables INTP1 external interrupt.
Header	r_cg_macrodriver.h, r_cg_intp.h, r_cg_userdefine.h
Declaration	void R_INTC1_Start(void);
Explanation	Enables INTP1 external interrupt.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_TAU0_Channel0_Start

Synopsis	Timer array unit channel 0 starts count operation.
Header	r_cg_macrodriver.h, r_cg_tau.h, r_cg_userdefine.h
Declaration	void R_TAU0_Channel0_Start(void);
Explanation	Timer array unit channel 0 starts count operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_TMR_KB0_Start

Synopsis	Starts the 16-bit timer KB0 operation.
Header	r_cg_macrodriver.h, r_cg_tmkb.h, r_cg_userdefine.h
Declaration	void R_TMR_KB0_Start(void);
Explanation	Starts the 16-bit timer KB0 operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_TMR_KB0_Stop

Synopsis	Stops the 16-bit timer KB0 operation.
Header	r_cg_macrodriver.h, r_cg_tmkb.h, r_cg_userdefine.h
Declaration	void R_TMR_KB0_Stop(void);
Explanation	Stops the 16-bit timer KB0 operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_tau0_channel0_interrupt

Synopsis	Timer array unit channel 0 interrupt processing.
Header	r_cg_macrodriver.h, r_cg_tmkb.h, r_cg_userdefine.h
Declaration	void __near r_tau0_channel0_interrupt(void)
Explanation	Timer array unit channel 0 interrupt processing.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_ADC_Start

Synopsis	Starts A/D conversion processing.
Header	r_cg_macrodriver.h, r_cg_adc.h, r_cg_userdefine.h
Declaration	void R_ADC_Start (void);
Explanation	Starts A/D conversion processing.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_ADC_Get_Result

Synopsis	Get A/D conversion results.
Header	r_cg_macrodriver.h, r_cg_adc.h, r_cg_userdefine.h
Declaration	void R_ADC_Get_Result(void);
Explanation	Get A/D conversion results.
Arguments	uint16_t * const buffer
Return value	None
Remarks	None

[Function Name] R_ADC_Stop

Synopsis	Stops A/D conversion processing.
Header	r_cg_macrodriver.h, r_cg_adc.h, r_cg_userdefine.h
Declaration	void R_ADC_Stop (void);
Explanation	Stops A/D conversion processing.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_intc1_interrupt

Synopsis	Processes INTP1 external interrupt.
Header	r_cg_macrodriver.h, r_cg_intp.h, r_cg_userdefine.h
Declaration	static void __near r_intc1_interrupt(void);
Explanation	Processes INTP1 external interrupt.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_IT_Start

Synopsis	Starts 12-bit interval timer operation.
Header	r_cg_macrodriver.h, r_cg_it.h, r_cg_userdefine.h
Declaration	void R_IT_Start(void);
Explanation	Starts 12-bit interval timer operation.
Arguments	None
Return value	None
Remarks	None

[Function Name] R_IT_Stop

Synopsis	Stops 12-bit interval timer operation.
Header	r_cg_macrodriver.h, r_cg_it.h, r_cg_userdefine.h
Declaration	void R_IT_Stop(void);
Explanation	Stops 12-bit interval timer operation.
Arguments	None
Return value	None
Remarks	None

5.7 Flowcharts

5.7.1 Overall Flow

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

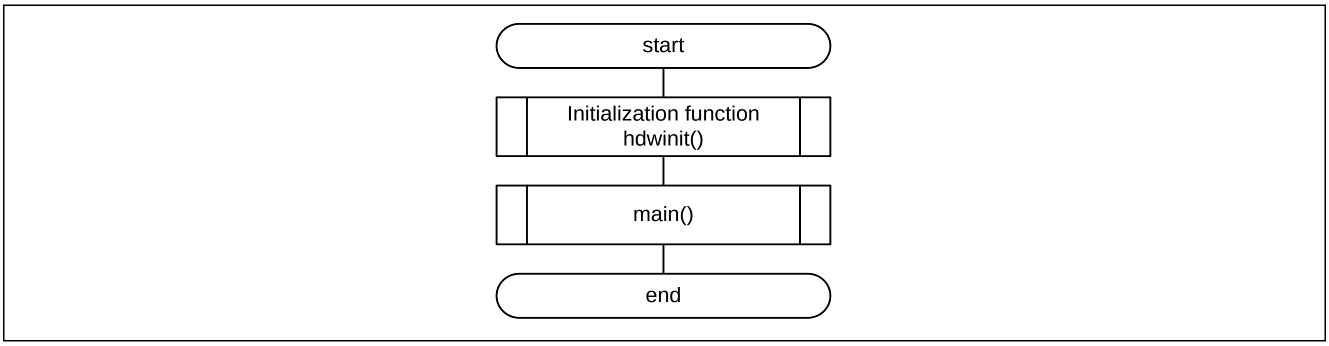

Figure 5.1 Overall Flow

5.7.2 Initialization Function

Figure 5.2 shows the flowchart for the initialization function.

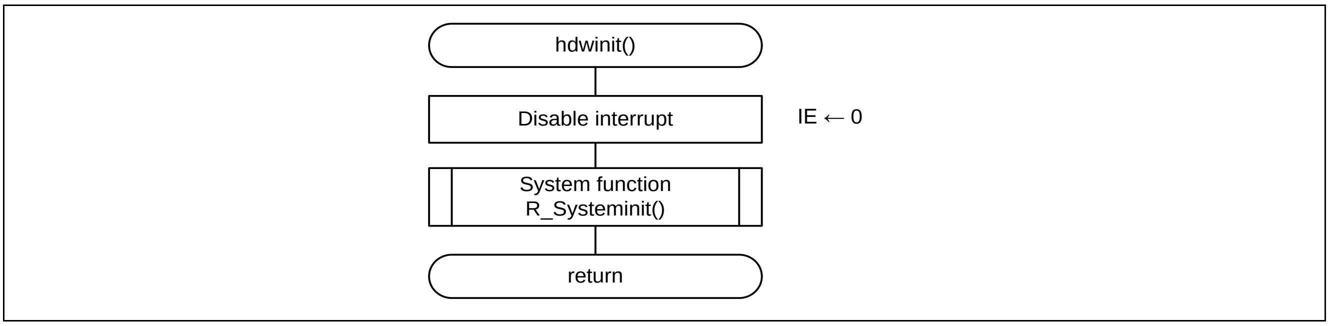

Figure 5.2 Initialization Function

5.7.3 System Function

Figure 5.3 shows the flowchart for the system function.

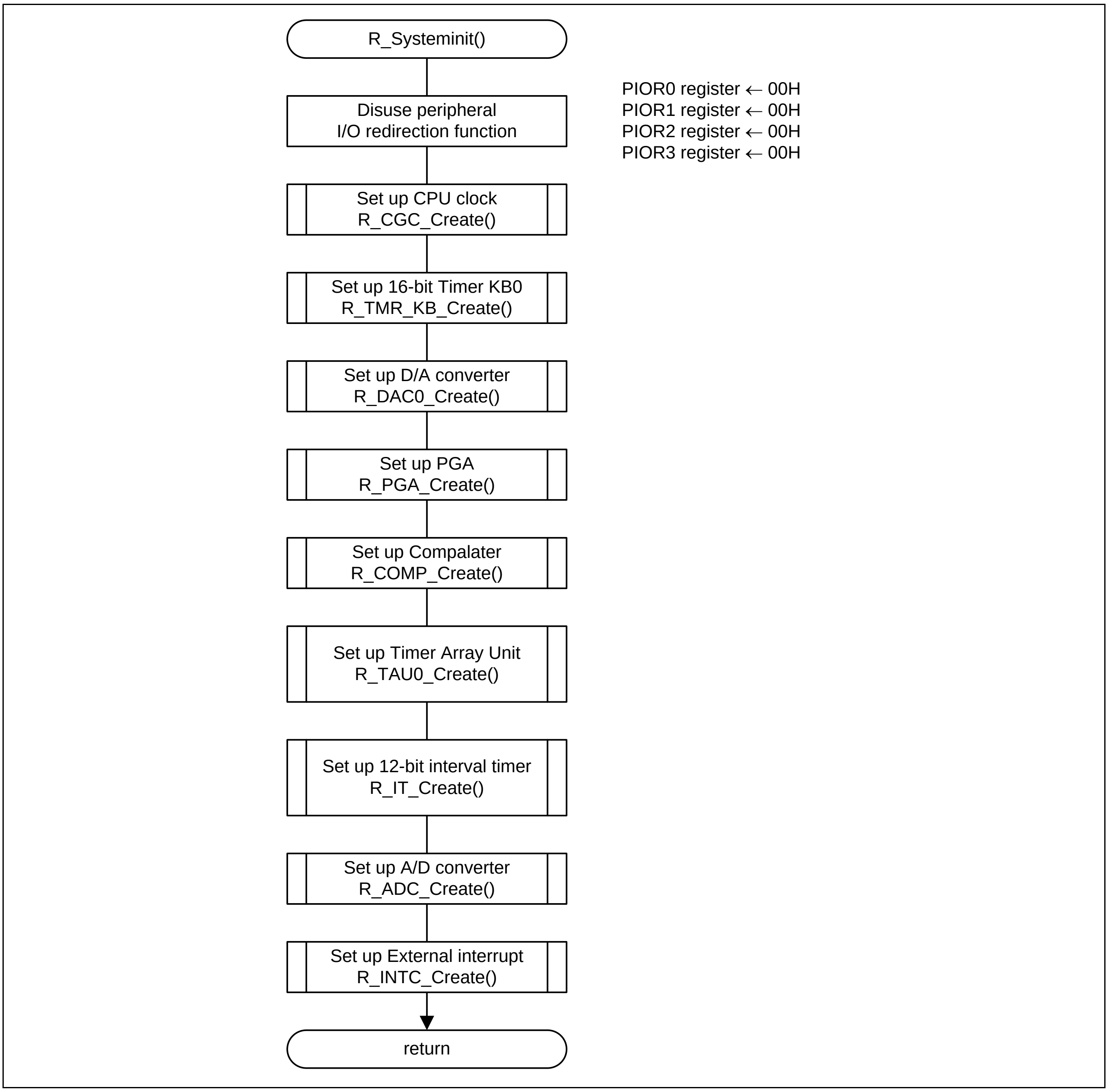

Figure 5.3 System Function

5.7.4 CPU Clock Setup

Figure 5.4 shows the flowchart for setting up the CPU clock.

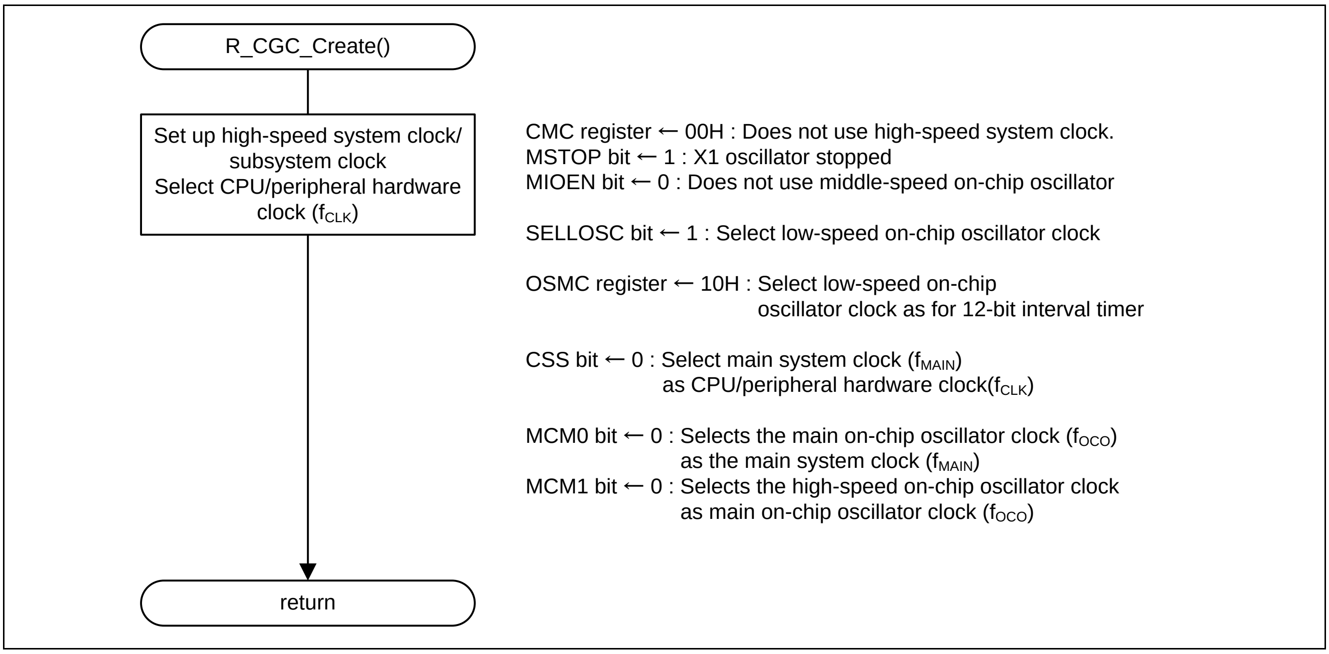

Figure 5.4 CPU Clock Setup

Caution: For details on the procedure for setting up the CPU clock (R_CGC_Create ()), refer to the section entitled "Flowcharts" in RL78/G13 Initialization Application Note (R01AN2575E).

5.7.5 16-bit timer KB0 initial Setting

Figure 5.5 shows the flowchart for the initial setting of the 16-bit timer KB0.

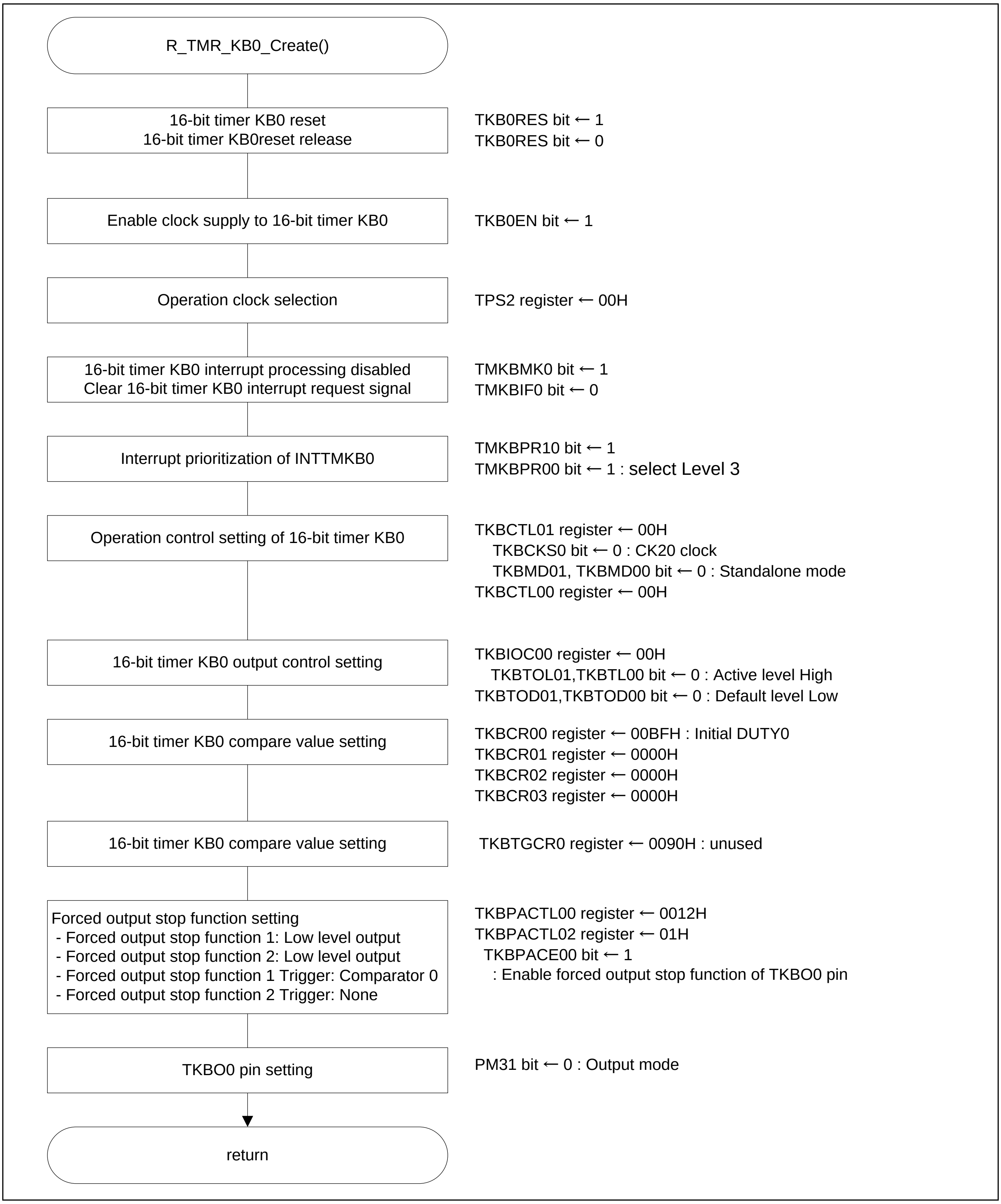

Figure 5.5 16-bit timer KB0 Initial Setting

5.7.6 D/A Converter Initial Setting

Figure 5.6 shows the flowchart for the initial setting of the D/A Converter.

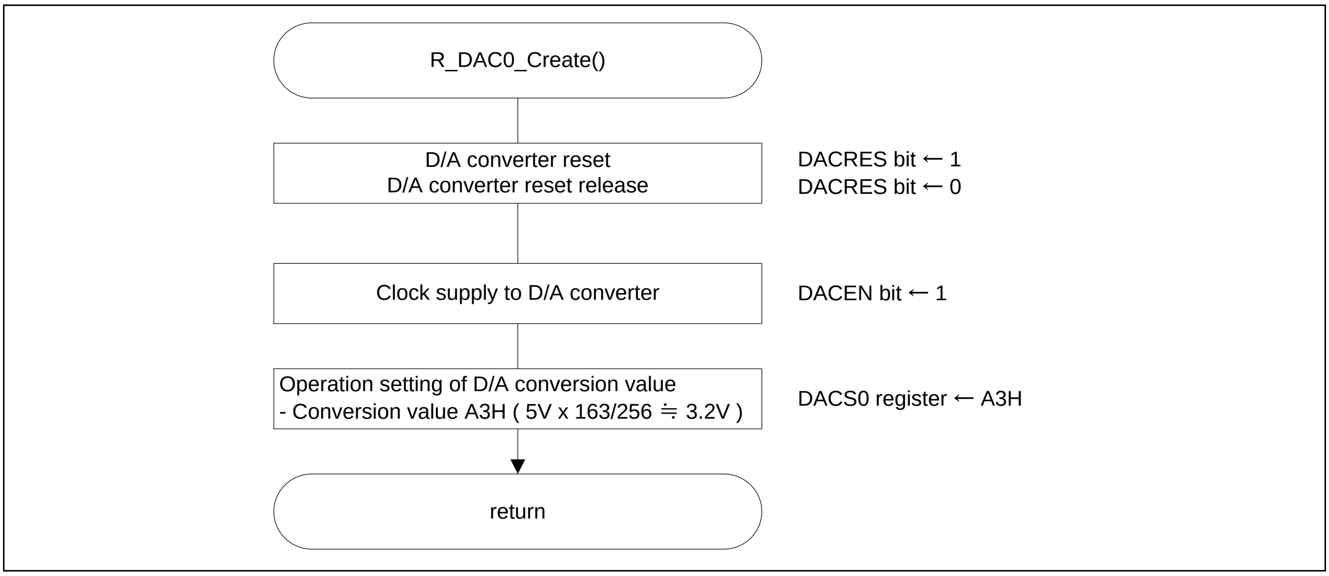

Figure 5.6 D/A Converter Initial Setting

5.7.7 Programmable gain amplifier (PGA) Initial Setting

Figure 5.7 shows the flowchart for the initial setting of the Programmable gain amplifier (PGA).

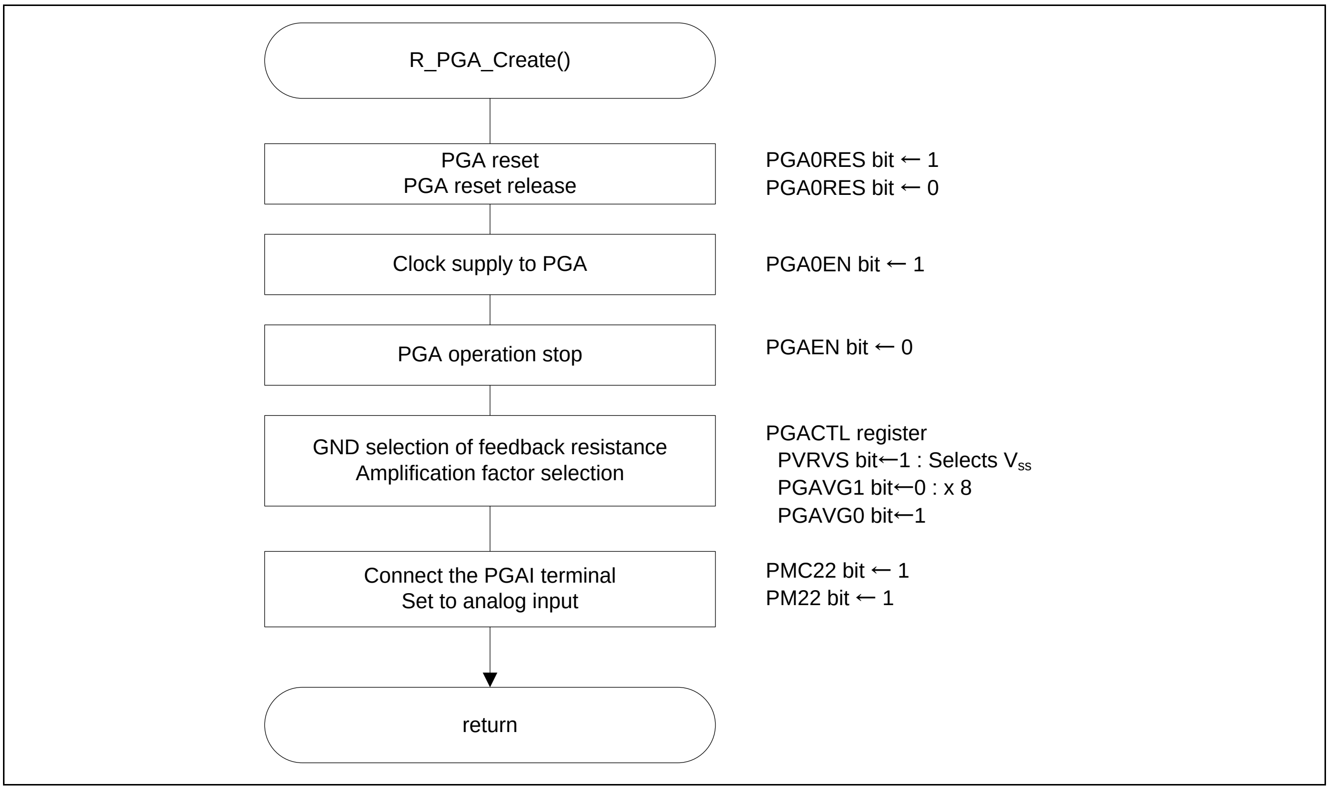

Figure 5.7 Programmable gain amplifier (PGA) Initial Setting

5.7.8 Comparator 0 Initial Setting

Figure 5.8 shows the flowchart for the initial setting of the comparator 0.

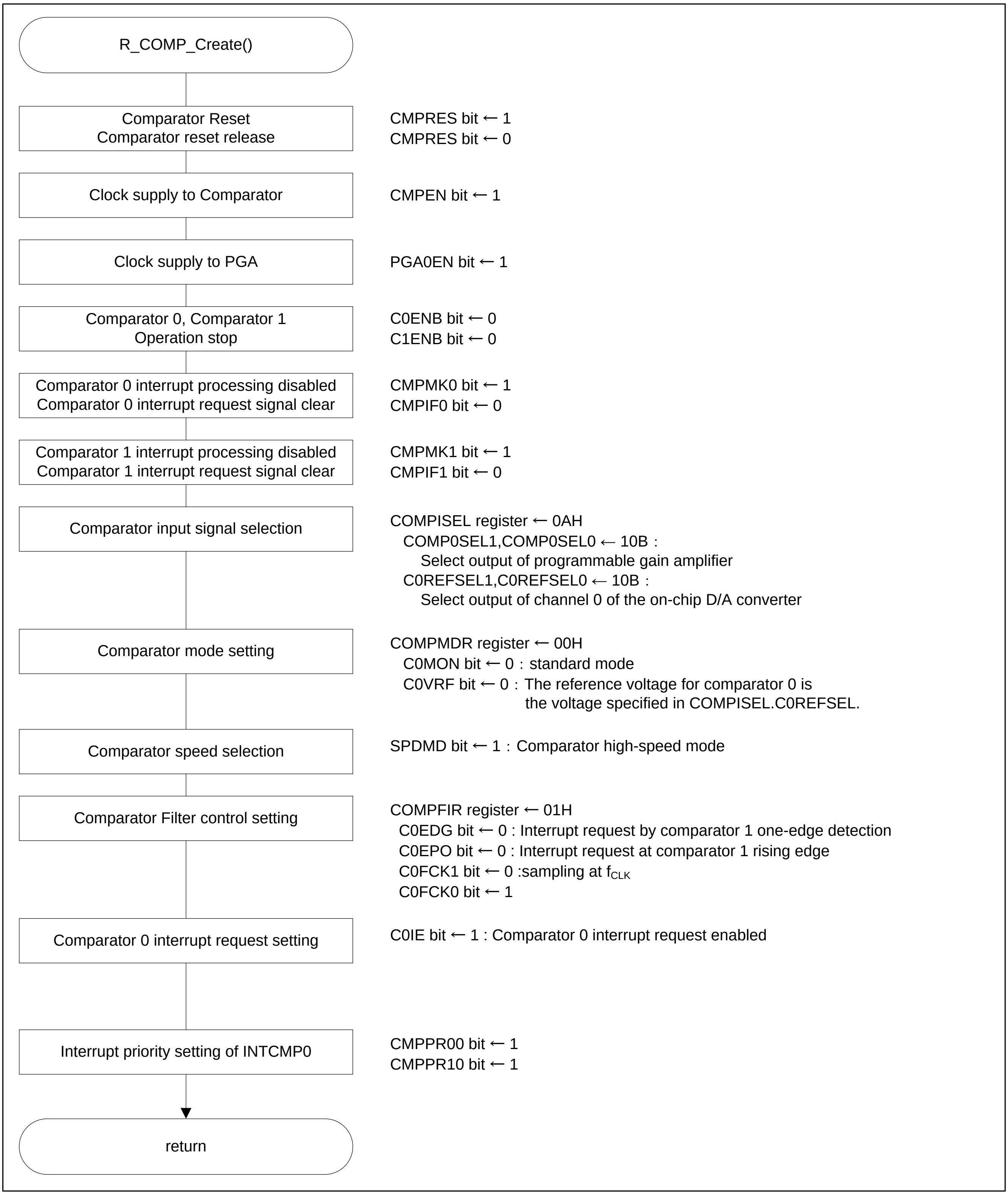

Figure 5.8 Comparator 0 Initial Setting

5.7.9 Timer Array Unit Initial Setting

Figure 5.9 shows the flowchart for the initial setting of the timer Array Unit.

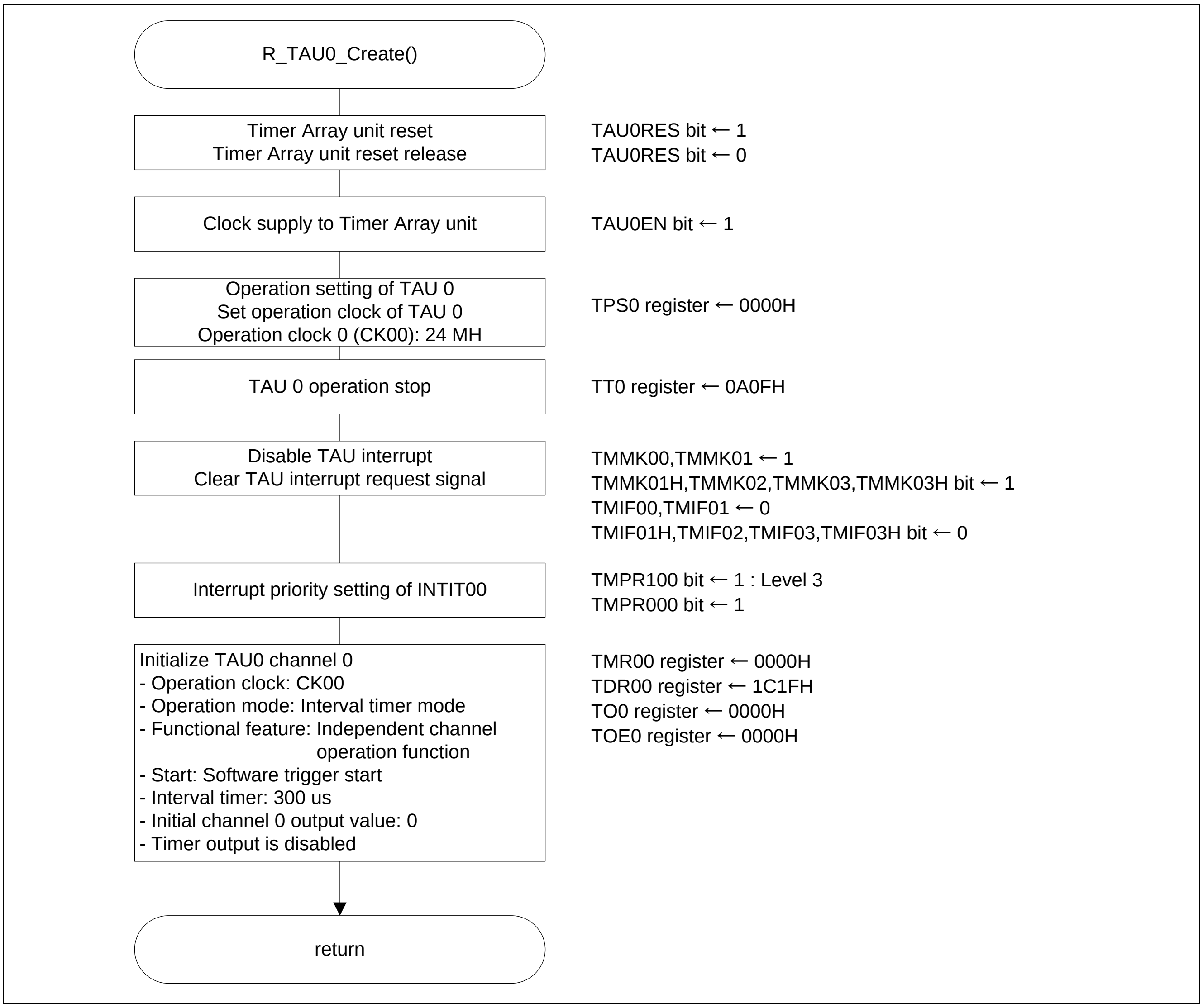

Figure 5.9 Timer Array Unit Initial Setting

5.7.10 12-bit Interval Timer Initial Setting

Figure 5.10 shows the flowchart for the initial setting of the 12-bit Interval Timer.

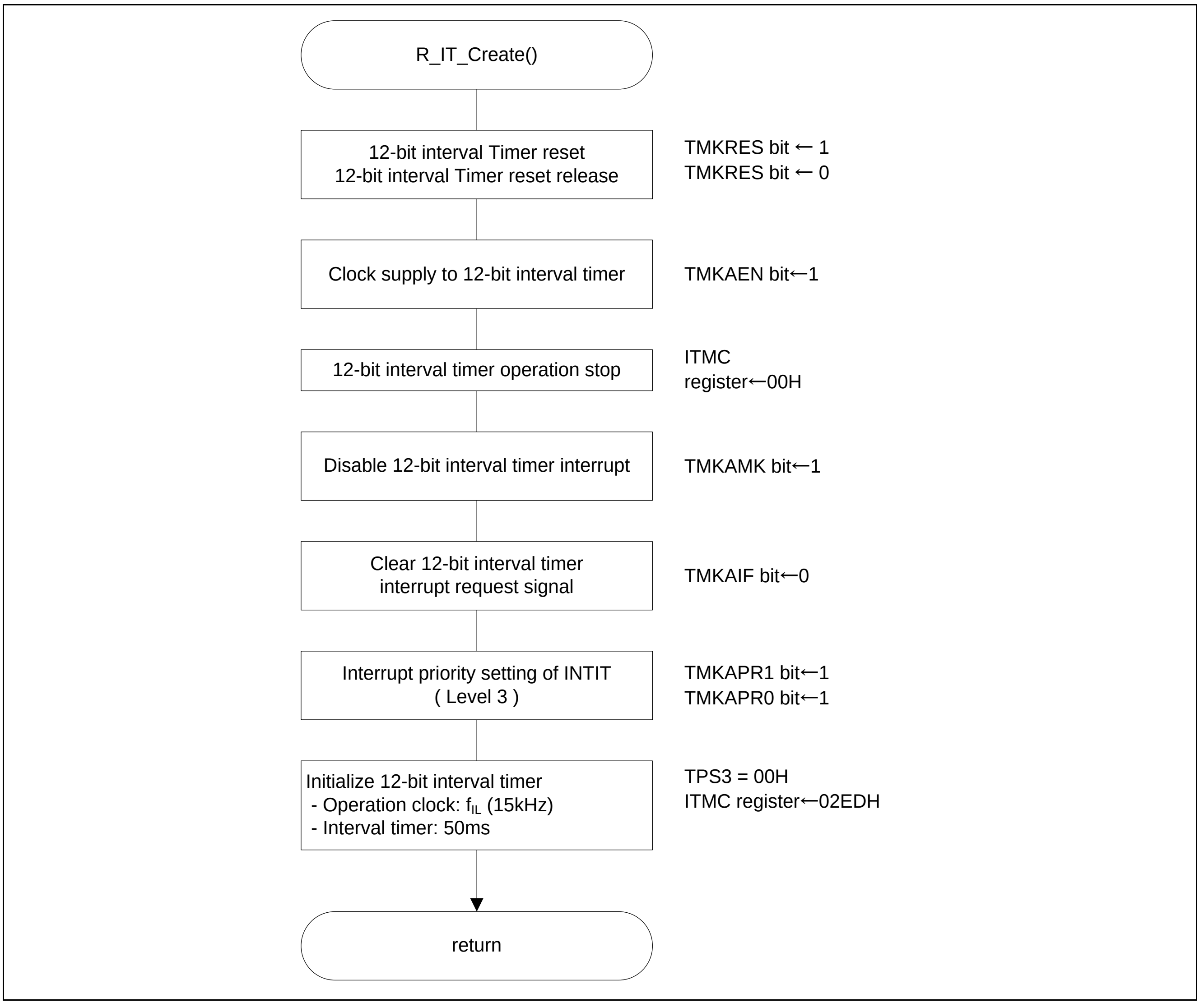

Figure 5.10 12-bit Interval Timer Initial Setting

5.7.11 A/D Converter Initial Setting

Figure 5.11 shows the flowchart for the initial setting of the A/D Converter.

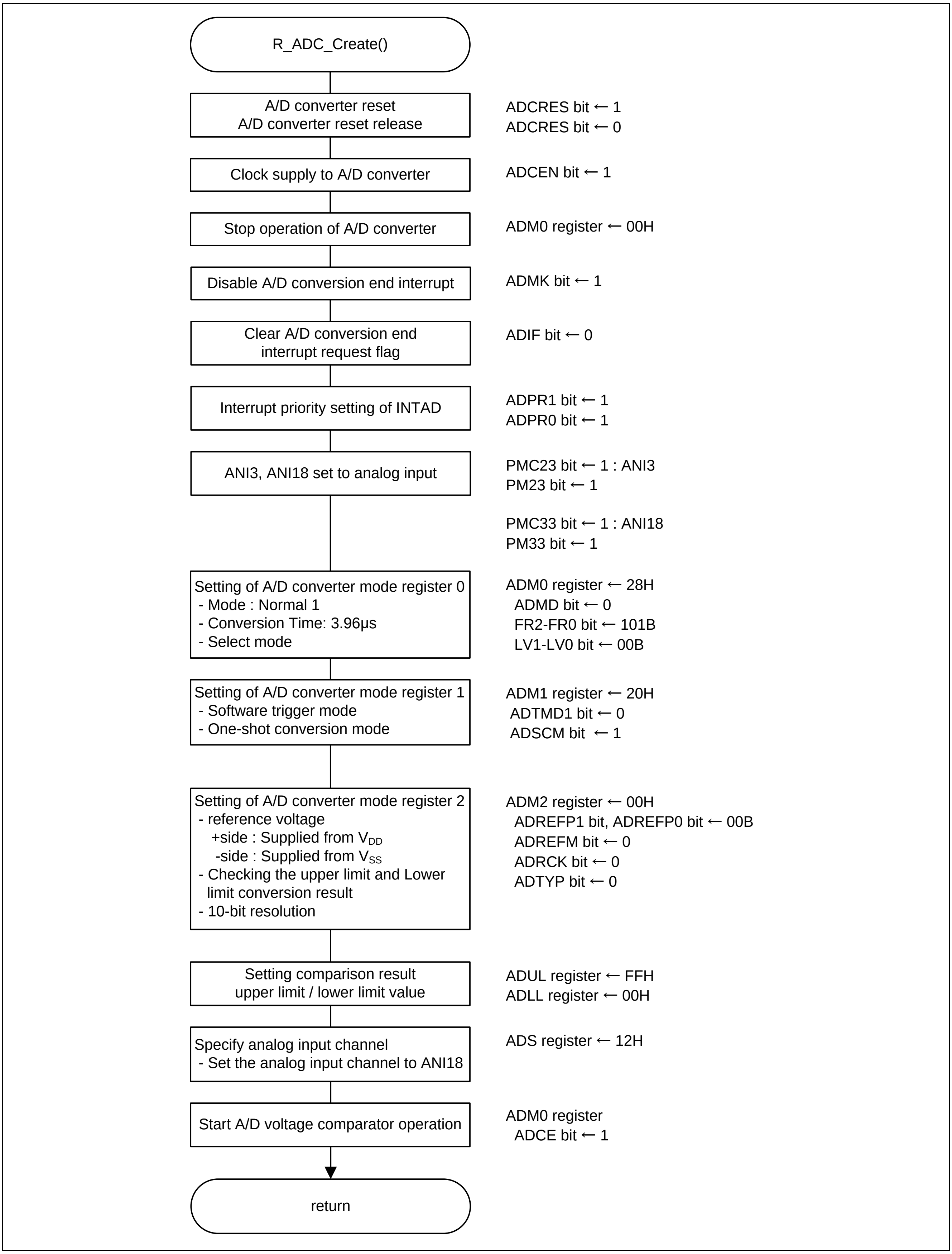

Figure 5.11 A/D Converter Initial Setting

5.7.12 Initial Setting of External Interrupt

Figure 5.12 shows the flowchart for the initial setting of the external interrupt.

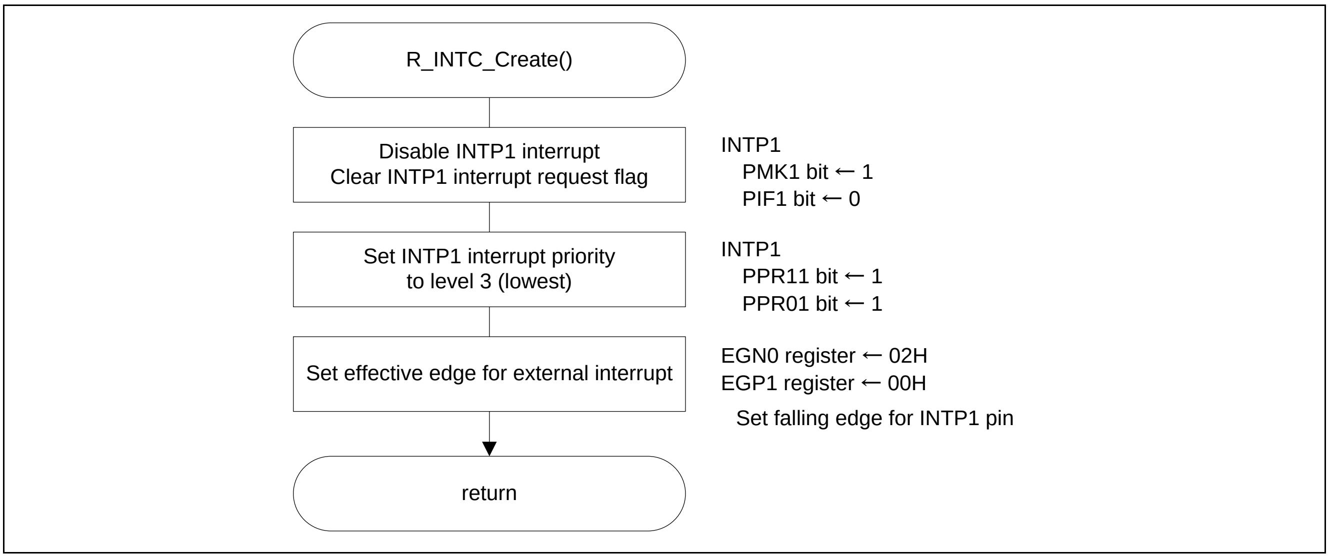

Figure 5.12 Initial Setting of External Interrupt

5.7.13 Main Processing

Figure 5.13 shows the flowchart for main processing.

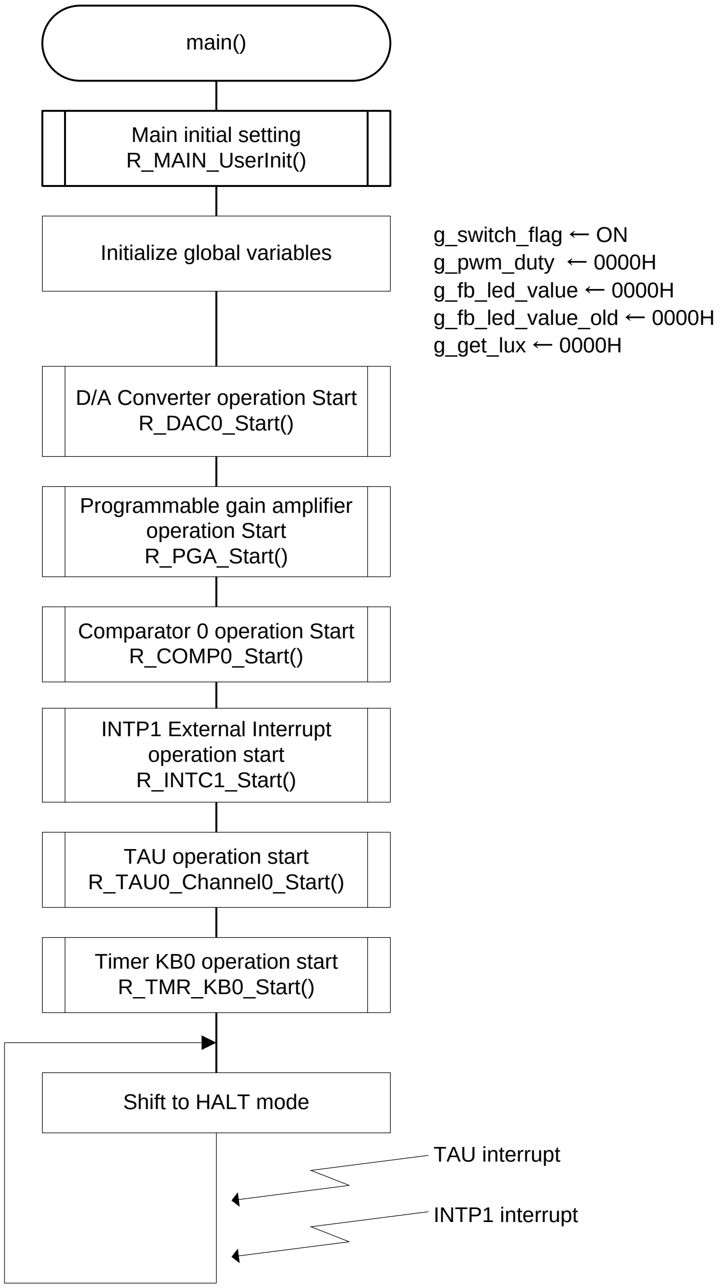

Figure 5.13 Main Processing

5.7.14 Main Initialization Setting

Figure 5.14 shows the flowchart for the main initialization settings.

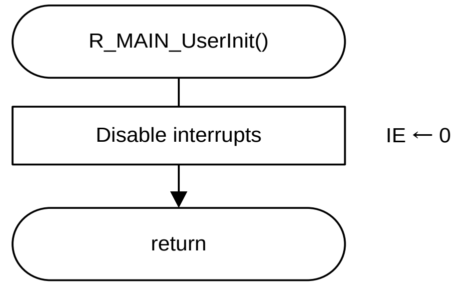

Figure 5.14 Main Initialization Setting

5.7.15 D/A converter Operation Startup

Figure 5.15 shows the flowchart for starting the D/A converter operation.

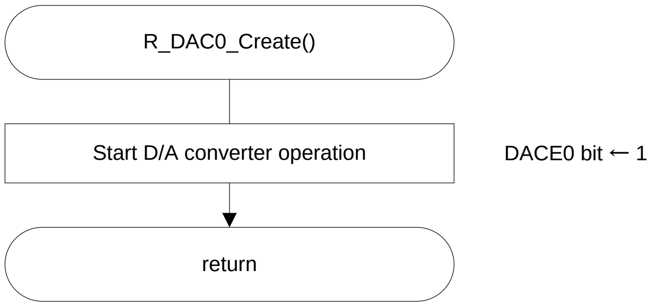

Figure 5.15 D/A converter Operation Startup

5.7.16 Programmable gain amplifier Operation Startup

Figure 5.16 shows the flowchart for starting the Programmable gain amplifier Operation.

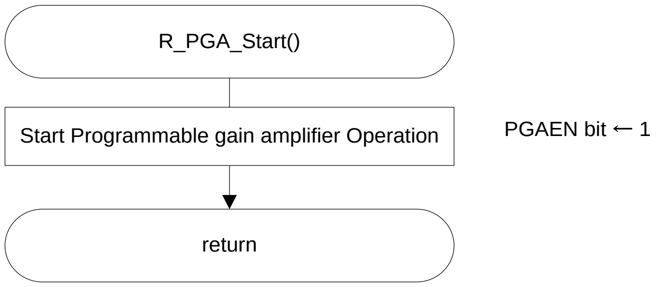

Figure 5.16 Programmable gain amplifier Operation Startup

5.7.17 Comparator 0 Operation Startup

Figure 5.17 shows the flowchart for starting the Comparator 0 Operation.

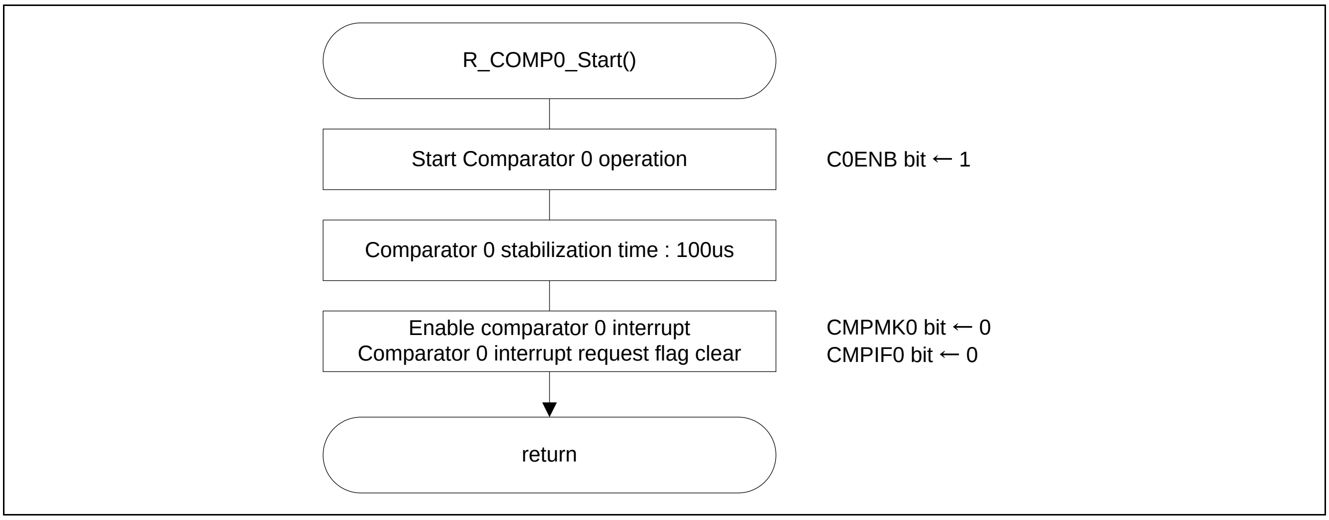

Figure 5.17 Comparator 0 Operation Startup

5.7.18 INTP1 External Interrupt Enabling Function

Figure 5.18 shows the flowchart for the INTP1 external interrupt enabling function.

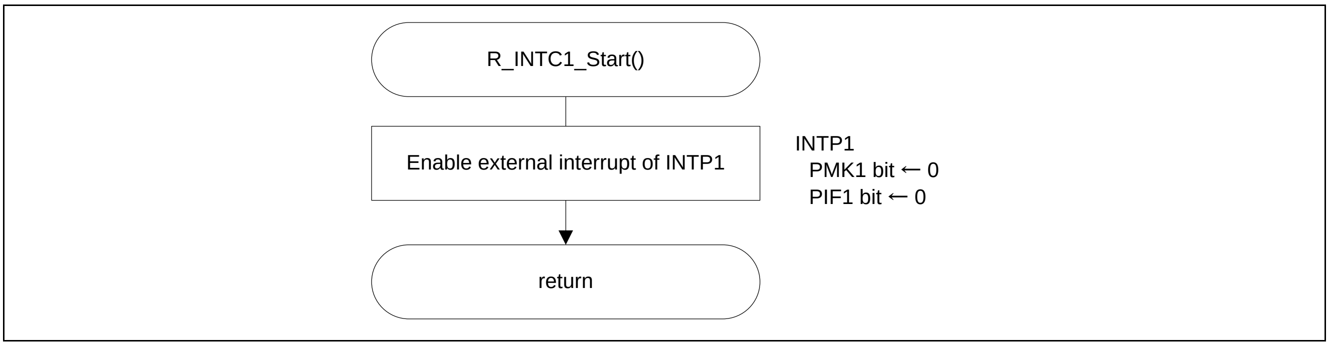

Figure 5.18 INTP1 External Interrupt Enabling Function

5.7.19 Timer Array Unit Operation Startup

Figure 5.19 shows the flowchart for starting the Timer Array Unit Operation.

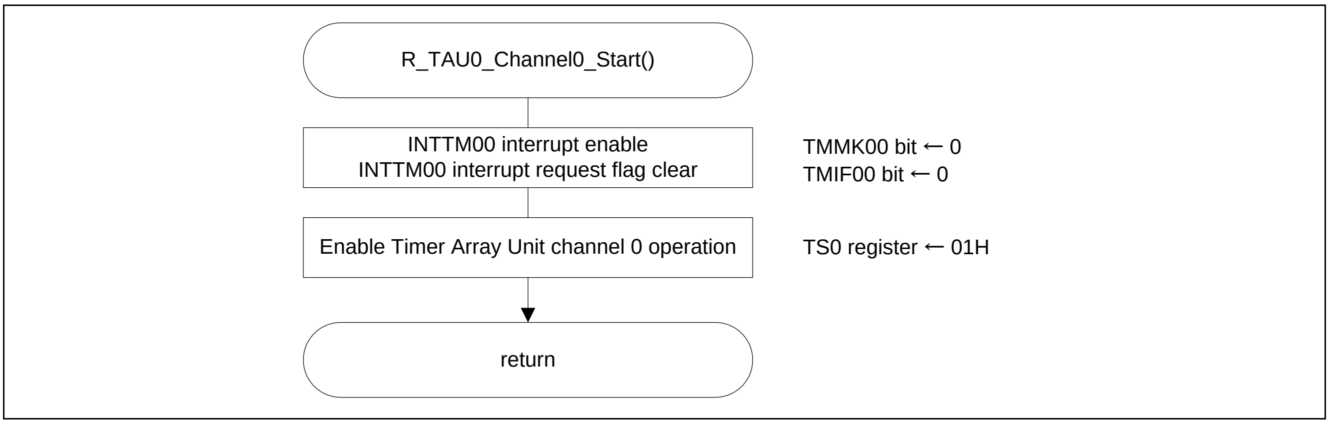

Figure 5.19 Timer Array Unit Operation Startup

5.7.20 16-bit timer KB0 Operation Startup

Figure 5.20 shows the flowchart for starting the 16-bit timer KB0 Operation.

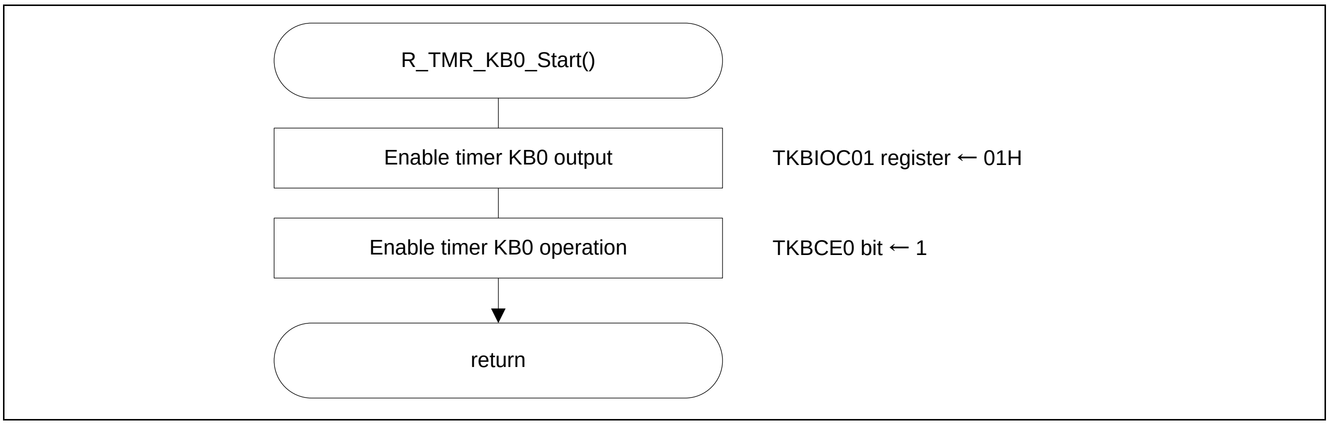

Figure 5.20 16-bit timer KB0 Operation Startup

5.7.21 INTP1 External Interrupt Function

Figure 5.21 shows the flowchart for INTP1 external interrupt function.

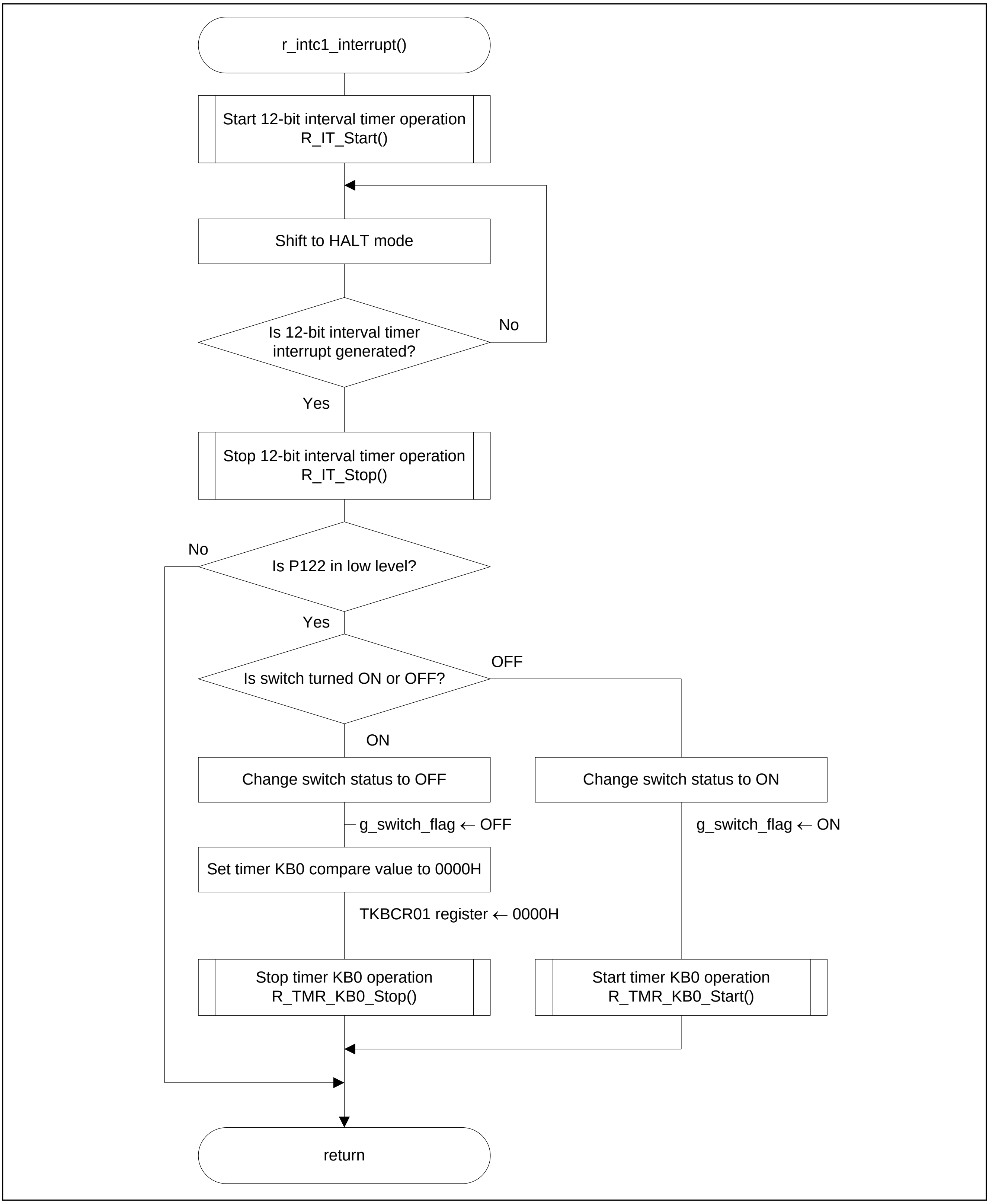

Figure 5.21 INTP1 External Interrupt Function

5.7.22 16-bit timer KB0 Operation Stop

Figure 5.22 shows the flowchart for stopping the 16-bit timer KB0 Operation.

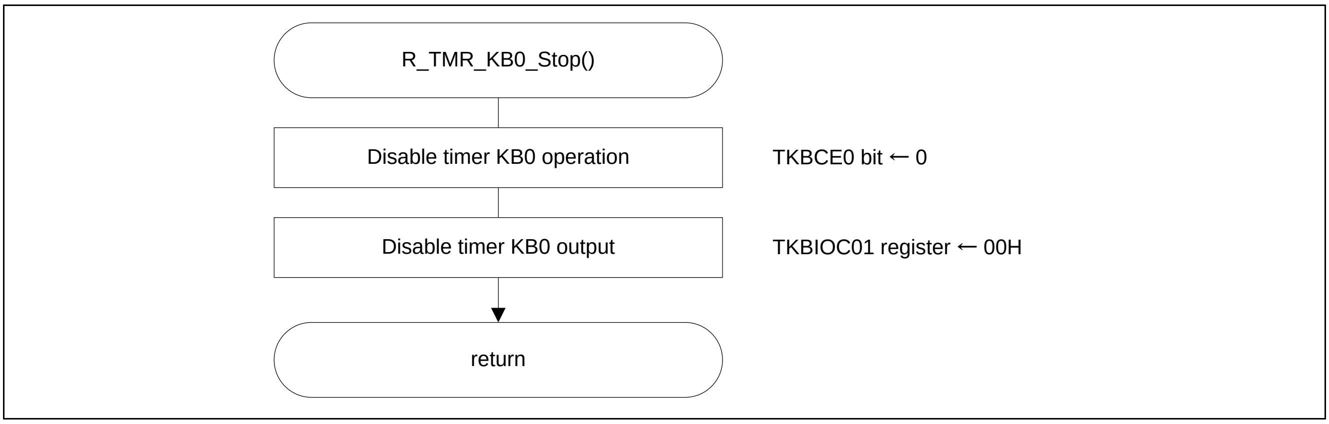

Figure 5.22 16-bit timer KB0 Operation Stop

5.7.23 Timer Array Unit Interrupt Processing

Figure 5.23 shows the flowchart for alarm Timer Array Unit interrupt processing.

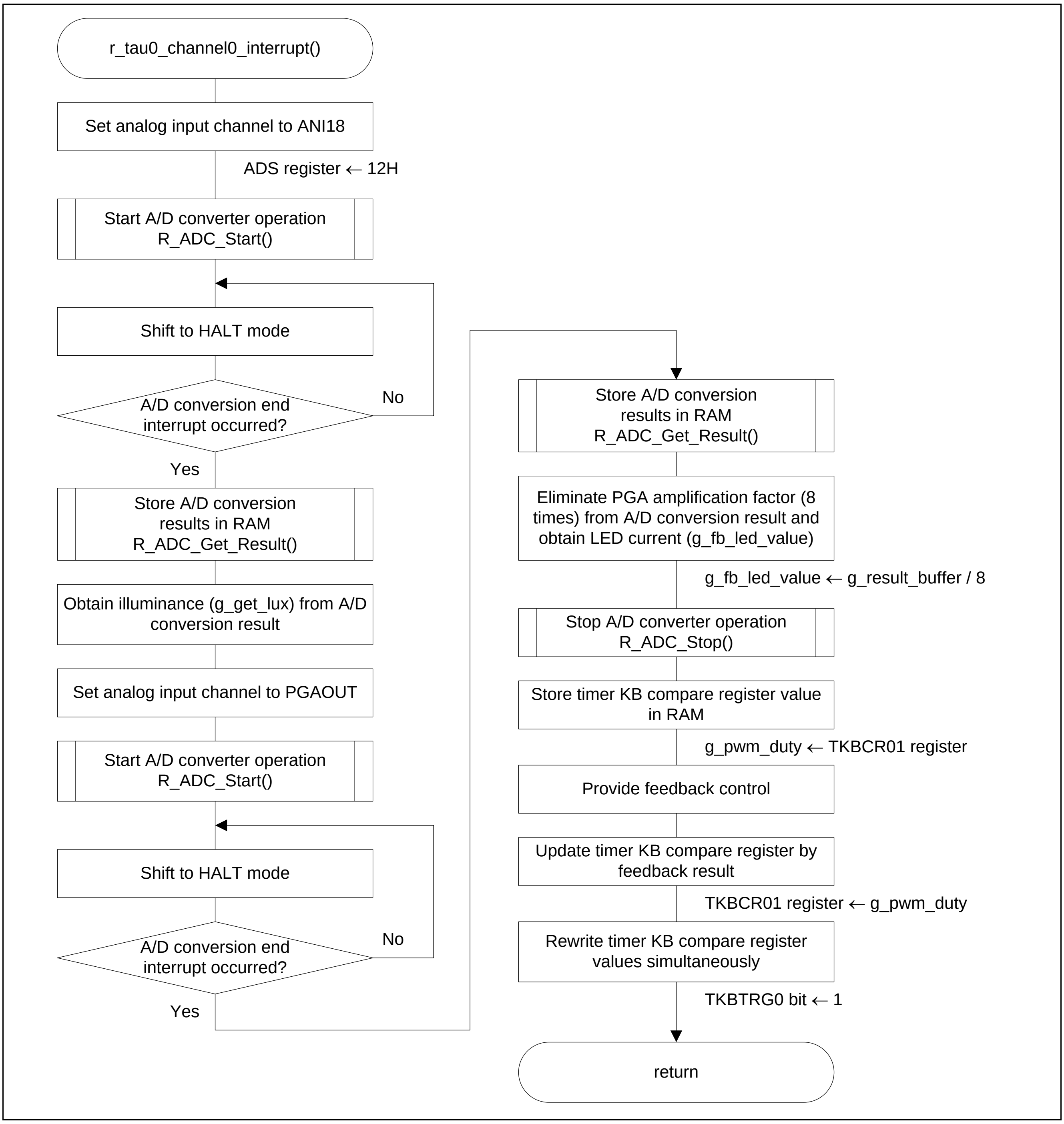

Figure 5.23 Timer Array Unit Interrupt Processing

5.7.24 A/D Converter Operation Startup

Figure 5.24 shows the flowchart for starting the A/D converter operation.

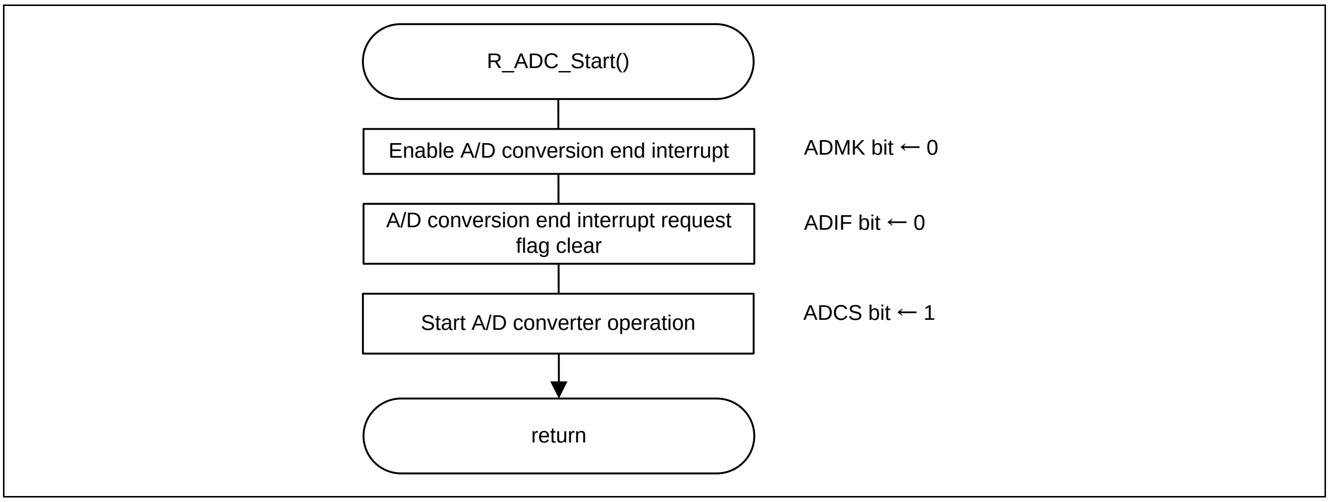

Figure 5.24 A/D Converter Operation Startup

5.7.25 A/D Conversion Result Acquisition

Figure 5.25 shows the flowchart for acquiring conversion results of the A/D conversion.

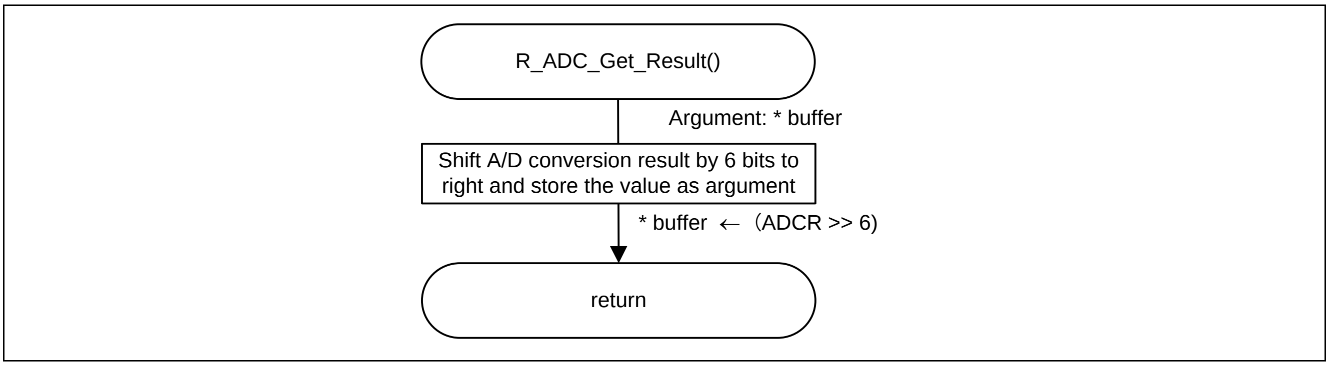

Figure 5.25 A/D Conversion Result Acquisition

5.7.26 A/D Converter Operation Stop

Figure 5.26 shows the flowchart for stopping the A/D Converter Operation.

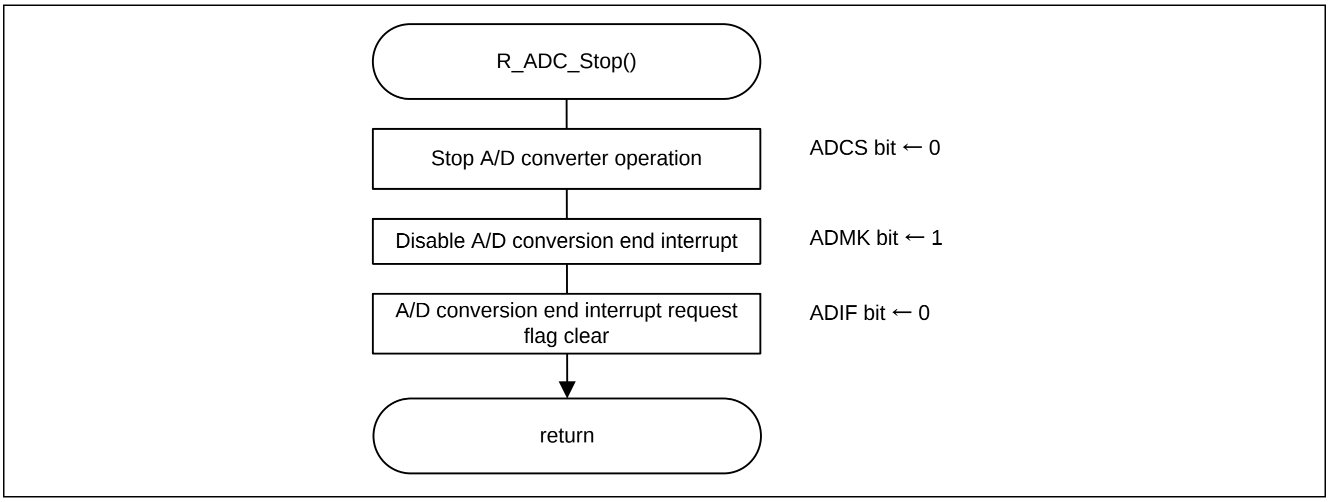

Figure 5.26 A/D Converter Operation Stop

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Documents for Reference

RL78/G11 User's Manual: Hardware (R01UH0637E)

RL78 Family User's Manual: Software (R01US0015E)

(The latest versions of the documents are available on the Renesas Electronics Website.)

Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/contact/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jan. 28, 2019	-	First edition issued

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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