RL78/L13

Timer KB20 Based IH Control (100 V) CC-RL

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Introduction

This application note discusses IH control (100V) using the 16-bit timer KB20 of the RL78/L13.

Target Device

RL78/L13

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

The sample program covered in this application note generates a PWM waveform for IH control (100 V) using the 16-bit timer KB20 and outputs it from the TKBO01-0 pin (100 V).

Table 1.1 lists the peripheral functions to be used and their uses and figure 1.1 illustrates the PWM output function for IH control.

Table 1.1 Peripheral Functions to Be Used and Their Uses

Peripheral Function	Use
16-bit timer KB20 (timer KB20)	PWM output for IH control
External interrupt input INTP3	Restart of PWM output for IH control
External interrupt input INTP0	Forced output shutoff of PWM output for IH control
Timer array unit (TAU)	Generation of main period (10 ms)

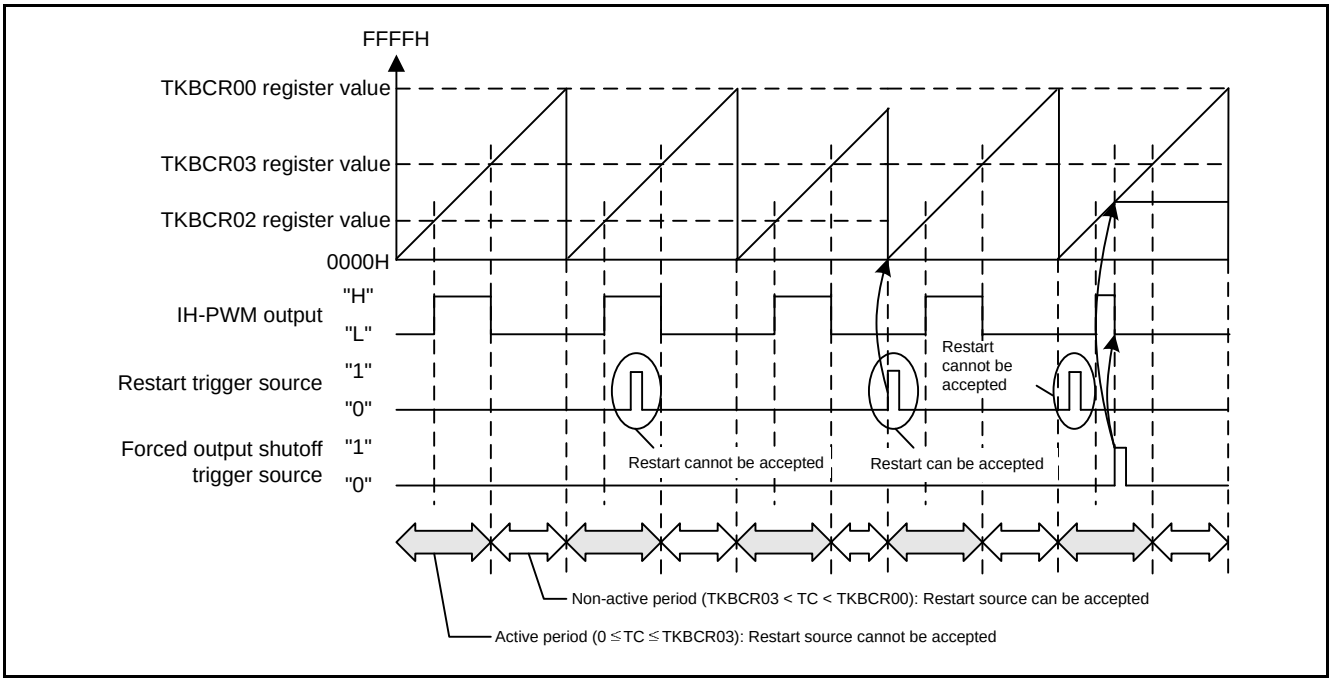


Figure 1.1 PWM Output Function for IH Control

2. Operation Check Conditions

The operation of the sample code covered in this application note has been checked and verified under the conditions summarized below.

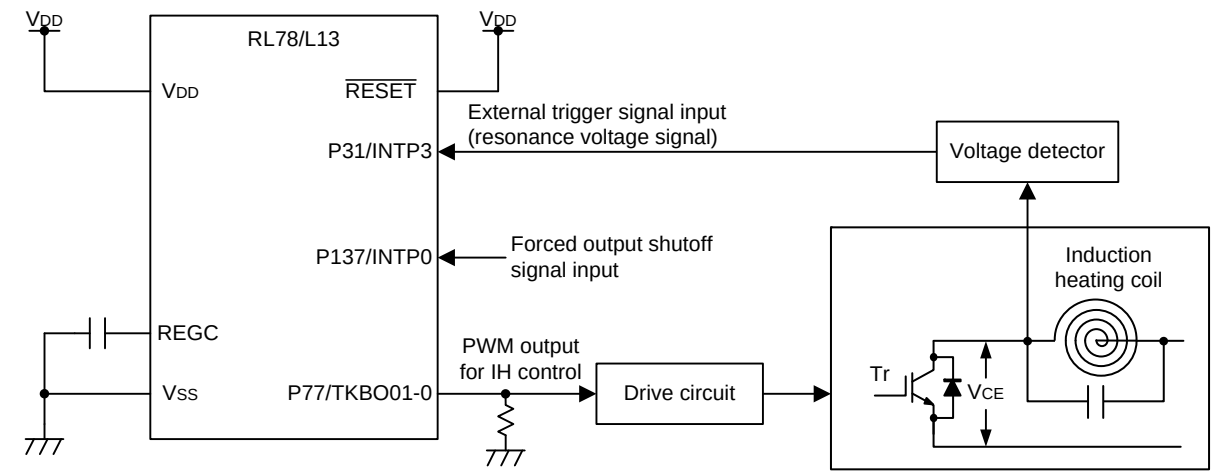
Table 2.1 Operation Check Conditions

Item	Description
Microcomputer used	RL78/L13 (R5F10WMGA)
Operating frequency	• High-speed on-chip oscillator clock (f_{HOCO}): 24 MHz (standard) • CPU/peripheral hardware clock (f_{CLK}): 24 MHz
Operating voltage	5.0 V (can run at 2.9 V to 5.5 V) LVD operation (V_{LVD}): Reset mode (rising edge: 2.81 V, falling edge: 2.75 V)
Integrated development environment(CS+)	CS+ for CC V3.03.00 from Renesas Electronics Corp.
C compiler(CS+)	CC-RL V1.02.00 from Renesas Electronics Corp.
Integrated development environment(e2studio)	e2studio V5.0.0.043 from Renesas Electronics Corp.
C compiler(e2studio)	CC-RL V1.02.00 from Renesas Electronics Corp.
RL78/L13 code library	Code Generator for RL78/L13 V1.03.02.01 from Renesas Electronics Corp.

3. Description of Hardware

3.1 Hardware Configuration Example

Figure 3.1 shows a connection example.



Notes:
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 characteristics conditions are met (connect the input-dedicated ports independently to V_{DD} or V_{SS} via a resistor).
2. Set V_{DD} to a voltage higher than the reset release voltage (V_{LVD}) that is set for the LVD.

Figure 3.1 Connection Example

3.2 List of Pins to be Used

Table 3.1 lists pins to be used and their functions.

Table 3.1 Pins to Be Used and Their Functions

Pin name	I/O	Description
P137/INTP0	Input	Forced output shutoff signal input: Inputs the forced output shutoff signal (falling edge) to stop the PWM output for IH control forcibly.
P31/INTP3	Input	External trigger signal input: Inputs the resonance voltage signal (falling edge) which occurs when the IGBT is subjected to switching. This signal serves as the trigger for regenerating the PWM waveform.
P77/TKBO01-0	Output	PWM output for IH control: Outputs the PWM waveform for IH control.

4. Description of Software

4.1 Operation Outline

1. Generates the PWM waveform for 100V IH control via the timer KB20 and outputs it from the TKBO01-0 pin.
2. With the resonance voltage signal produced by switching of the IGBT as a feedback signal, an external trigger signal is input to the INTP3 pin.
3. An output signal which alternates between the output being stopped and output ON (high output for 10 μs) every second is generated.
4. The output is stopped if the forced output shutoff signal is input while PWM waveform generation is in progress. Once stopped, the output remains in the stopped state for 500 ms
5. The output (output ON) is not resumed if the level on the forced output shutoff signal is low.
   The output (output ON) is resumed if the level on the forced output shutoff signal is high.

Figure 4.1 shows the timing diagram.

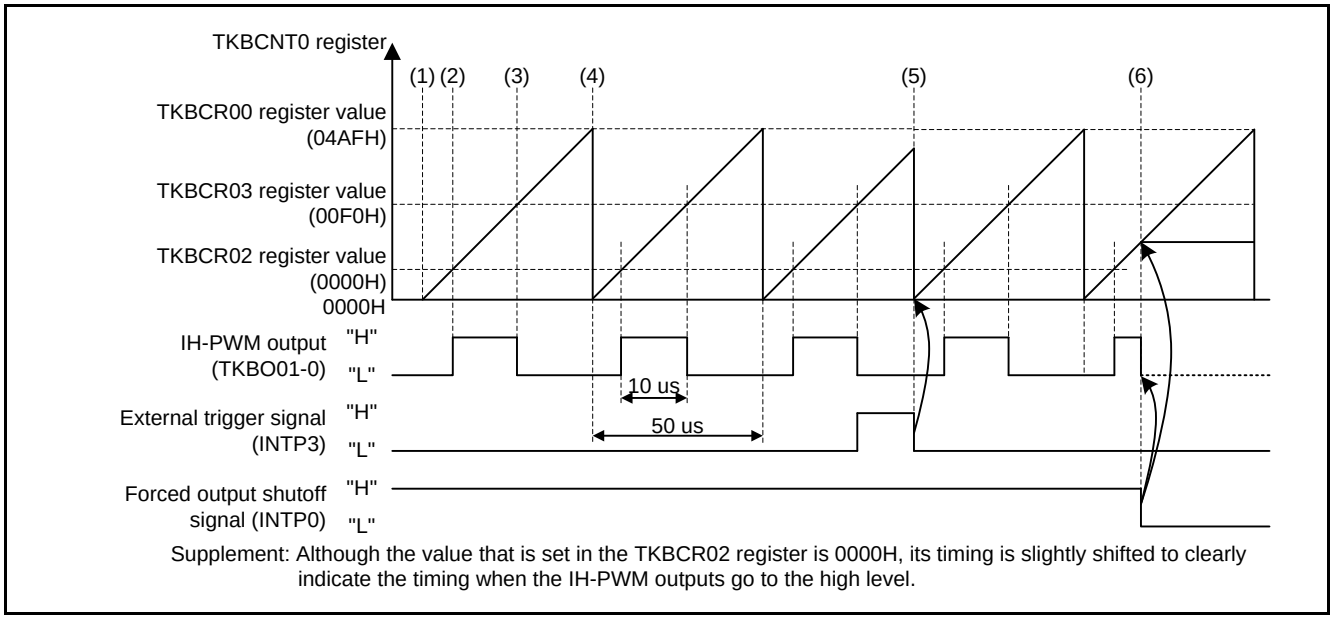


Figure 4.1 Timing Diagram

(1) Counter start (S/W: software)
Setting the TKBCE0 bit to 1 starts counting by TKBCNT0.

(2) High level output (H/W: hardware)
When the value of TKBCNT0 matches the value (0000H) of TKBCR02, the level on the TKBO01-0 pin goes high.

(3) Low level output (H/W)
When the value of TKBCNT0 matches the value (00F0H) of TKBCR03, the level on the TKBO01-0 pin goes low.

(4) PWM period (H/W)
When the value of TKBCNT0 matches the value (04AFH) of TKBCR00, TKBCNT0 is cleared to 0.

(5) Restart of PWM output (H/W)
When a falling edge is input to INTP3, TKBCNT0 is cleared to 0.

(6) Stop of PWM output by forced output shutoff (H/W)
When a falling edge is input to INTP0, the TKBO01-0 pin is placed in the high impedance state.

4.2 List of Option Byte Settings

Table 4.1 summarizes the settings of the option bytes.

Table 4.1 Option Byte Settings

Address	Setting	Description
000C0H/010C0H	11101111B	Disables the watchdog timer. (Stops counting after the release of the reset state.)
000C1H/010C1H	01111111B	LVD reset mode Detection voltage: 2.81 V (rising edge), 2.75 V (falling edge)
000C2H/010C2H	11100000B	High-speed on-chip oscillator HS mode, 24 MHz
000C3H/010C3H	10000100B	Enables the on-chip debugger.

4.3 List of Variables

Table 4.2 lists the static variables and Table 4.3 lists const variables.

Table 4.2 Static Variables

Type	Variable Name	Contents	Function Used
uint8_t	pwm_select	Selects high width	main
uint16_t	Period	IH output period	main
uint16_t	Ton_width	High width of IH output	main
uint8_t	delay_time	Delay time of IH output	main
uint8_t	pwm_change_period	PWM period control of IH output	main
uint8_t	release_time	Release time of IH output	main

Table 4.3 const Variables

Type	Variable Name	Contents	Function Used
uint16_t	_H_Width_TBL	High width table	main

4.4 List of Functions

Table 4.4 gives the functions that are used.

Table 4.4 List of Functions

Function Name	Outline
hdwinit	Initialization
R_Systeminit	Peripheral function initialization
R_CGC_Create	CPU initialization
R_TAU0_Create	TAU0 initialization
R_TAU0_Channel0_Start	Enable TAU00 operation
R_KB20_Create	Timer KB20 initialization
R_KB20_Start	Enable timer KB20 operation
R_KB20_Stop	Stop timer KB20 operation
Igbt_Outdrv	IGBT output driver setup
igbt_width_set	IGBT output setup
main	Main processing
R_MAIN_UserInit	Main initialization

4.5 Function Specifications

This section describes the function specifications for the sample code.

hdwinit

Synopsis	Initialization
Header	None
Declaration	void hdwinit(void)
Explanation	Initializes the peripheral functions.
Arguments	None
Return value	None

R_Systeminit

Synopsis	Peripheral function initialization
Header	None
Declaration	void R_Systeminit(void)
Explanation	Initializes the peripheral functions that are used by the sample code covered in this application note.
Arguments	None
Return value	None

R_CGC_Create

Synopsis	CPU initialization
Header	r_cg_cgc.h
Declaration	void R_CGC_Create(void)
Explanation	Initializes the CPU.
Arguments	None
Return value	None

R_TAU0_Create

Synopsis	TAU0 initialization
Header	r_cg_timer.h
Declaration	void R_TAU0_Create(void)
Explanation	Initializes the TAU00 for use as an interval timer.
Arguments	None
Return value	None

R_TAU0_Channel0_Start

Synopsis	Enable TAU00 operation
Header	r_cg_timer.h
Declaration	void R_TAU0_Channel0_Start(void)
Explanation	Starts the TAU00 for counting.
Arguments	None
Return value	None

R_KB20_Create

Synopsis	Timer KB20 initialization
Header	r_cg_timer.h
Declaration	void R_KB20_Create(void)
Explanation	Initializes timer KB20 for use as the PWM output function for IH control
Arguments	None
Return value	None

R_KB20_Start

Synopsis	Enable timer KB20 operation
Header	r_cg_timer.h
Declaration	void R_KB20_Start(void)
Explanation	Starts counting and output by the timer KB20.
Arguments	None
Return value	None

R_KB20_Stop

Synopsis	Stop timer KB20 operation
Header	r_cg_timer.h
Declaration	void R_KB20_Stop(void)
Explanation	Stops counting and output by the timer KB20.
Arguments	None
Return value	None

Igbt_Outdrv

Synopsis	IGBT output driver setup	
Header	r_cg_userdefine.h	
Declaration	void Igbt_Outdrv(uint16_t period, uint16_t Ton_width, uint8_t delay_time)	
Explanation	Calculates the values to be set in the general registers.	
Arguments	uint16_t period	Period
	uint16_t Ton_width	Ton width
	uint8_t delay_time	Delay time
Return value	None	

igbt_width_set

Synopsis	IGBT output setup	
Header	None	
Declaration	static void igbt_width_set(uint8_t out_mode, uint16_t tkbcr00_calc, uint16_t tkbcr02_calc, uint16_t tkbcr03_calc)	
Explanation	Makes settings for IGBT output start, change, and stop processing.	
Arguments	uint8_t out_mode	Output mode 0: Output stopped 1: Output started/changed
	uint16_t tkbcr00_calc	TKBCR00 value
	uint16_t tkbcr02_calc,	TKBCR02 value
	uint16_t tkbcr03_calc	TKBCR03 value
Return value	None	

main

Synopsis	Main processing
Header	None
Declaration	void main(void)
Explanation	Performs the main processing.
Arguments	None
Return value	None

R_MAIN_UserInit

Synopsis	Main initialization
Header	None
Declaration	void R_MAIN_UserInit(void)
Explanation	Performs processing necessary for initializing the main processing.
Arguments	None
Return value	None

4.6 Flowcharts

4.6.1 Overall Flowchart

Figure 4.2 shows the overall flowchart.

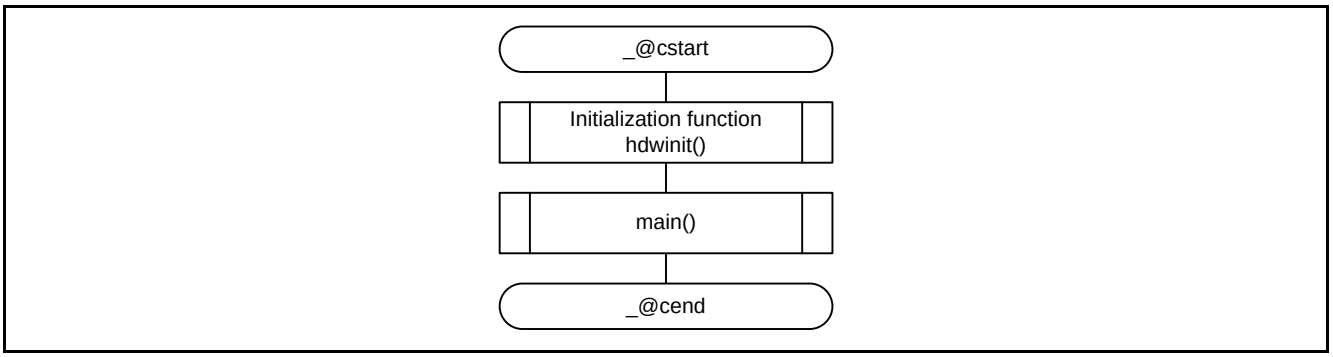


Figure 4.2 Overall Flowchart

4.6.2 Initialization

Figure 4.3 shows the flowchart for initialization.

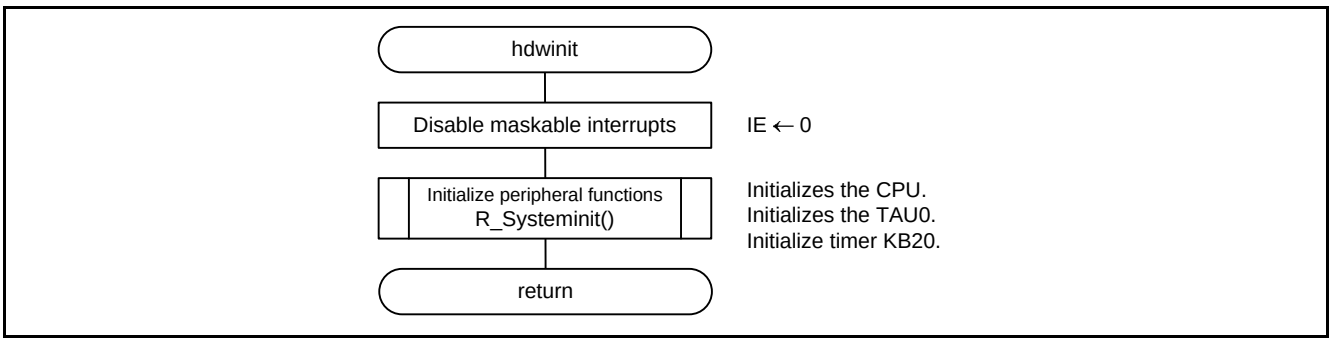


Figure 4.3 Initialization

4.6.3 Peripheral Function Initialization

Figure 4.4 shows the flowchart for peripheral function initialization.

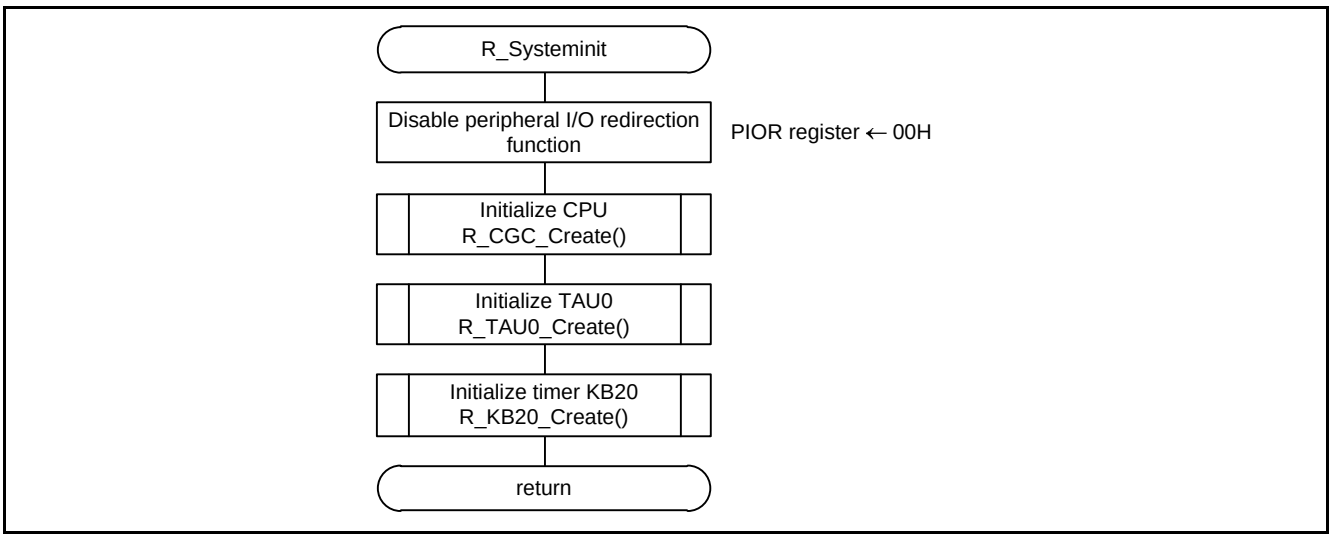


Figure 4.4 Peripheral Function Initialization

4.6.4 CPU Initialization

Figure 4.5 shows the flowchart for CPU initialization.

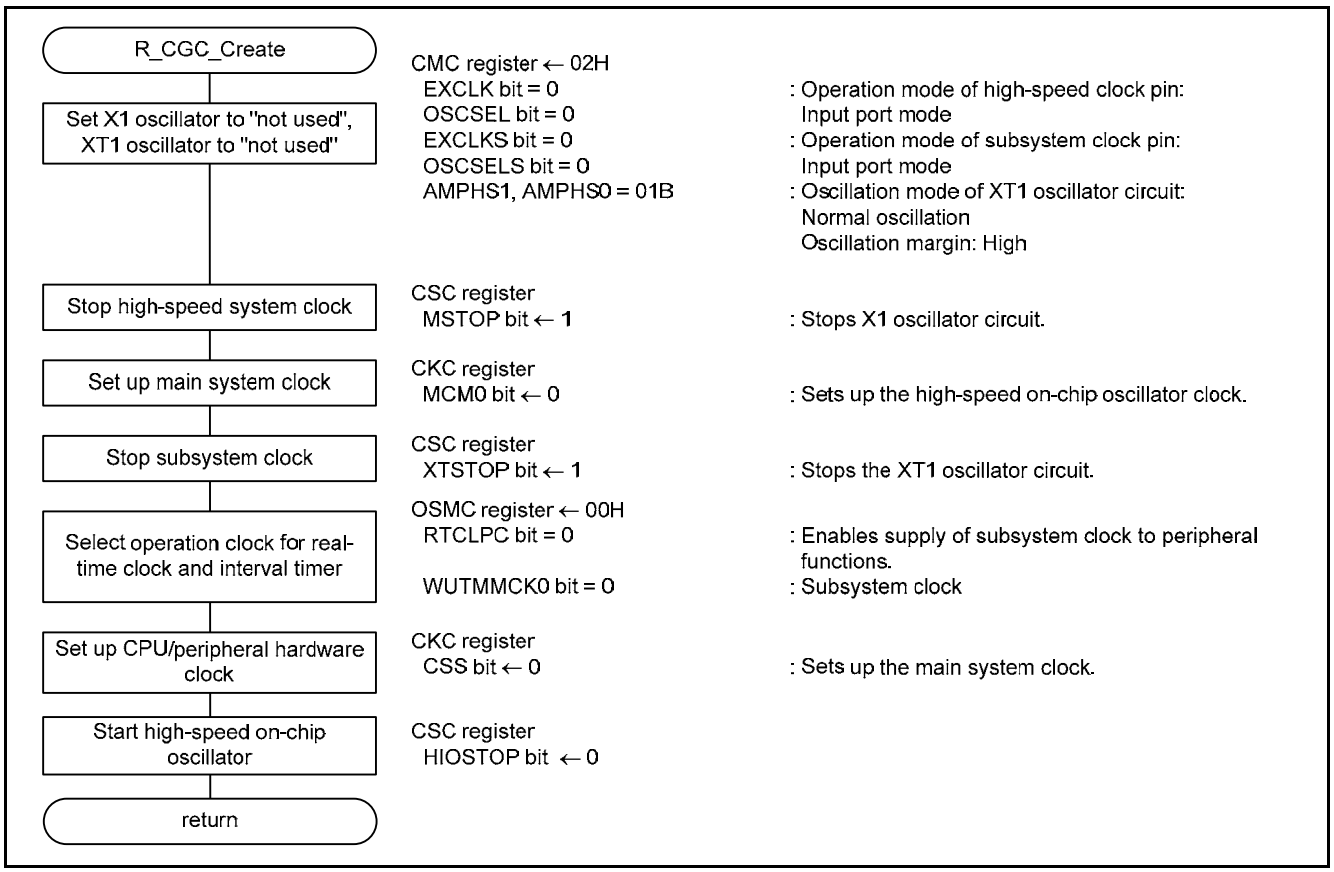


Figure 4.5 CPU Initialization

4.6.5 TAU0 Initialization

Figure 4.6 shows the flowchart for TAU0 initialization.

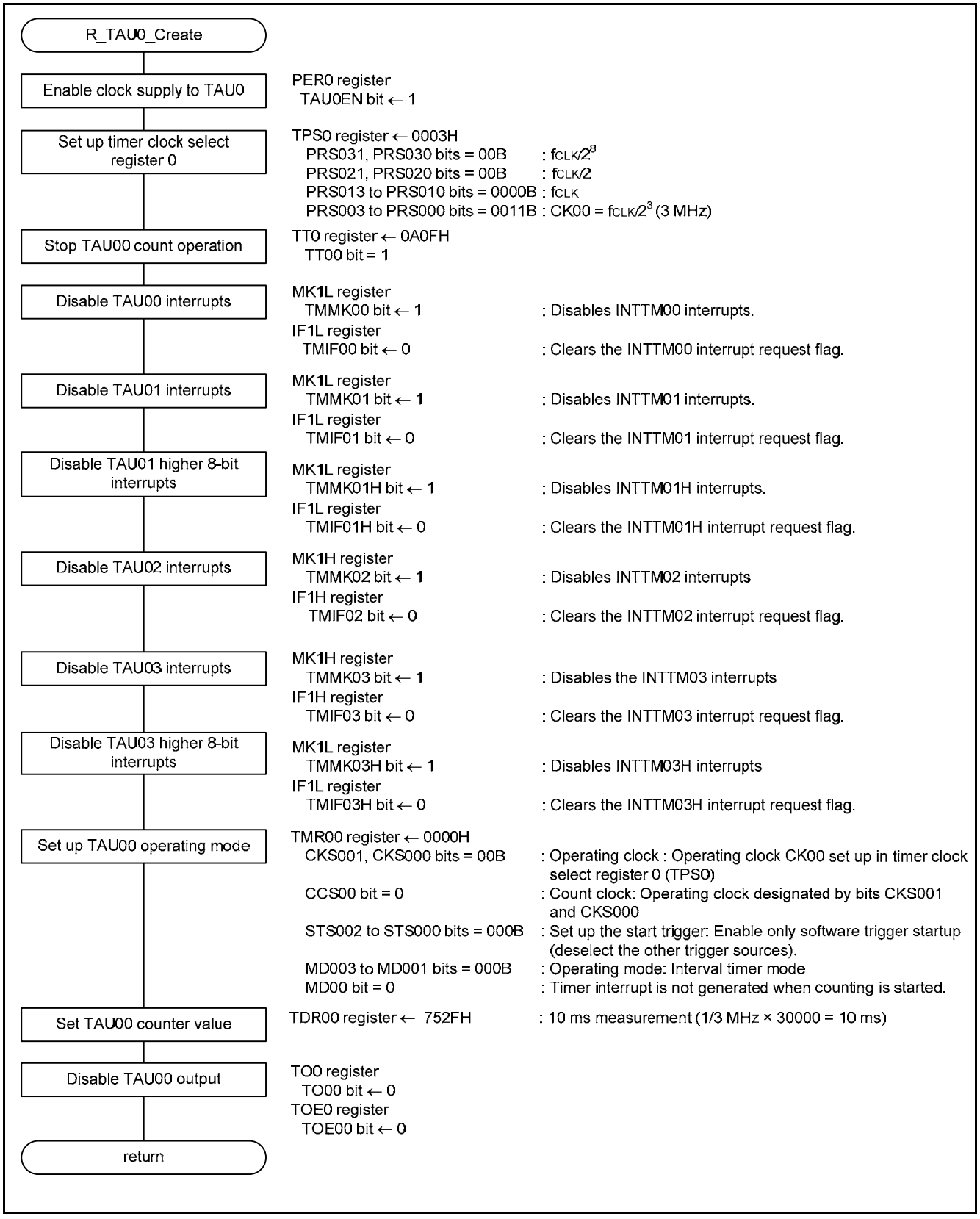


Figure 4.6 TAU0 Initialization

4.6.6 Enable TAU00 Operation

Figure 4.7 shows the flowchart for enabling TAU00 operation.

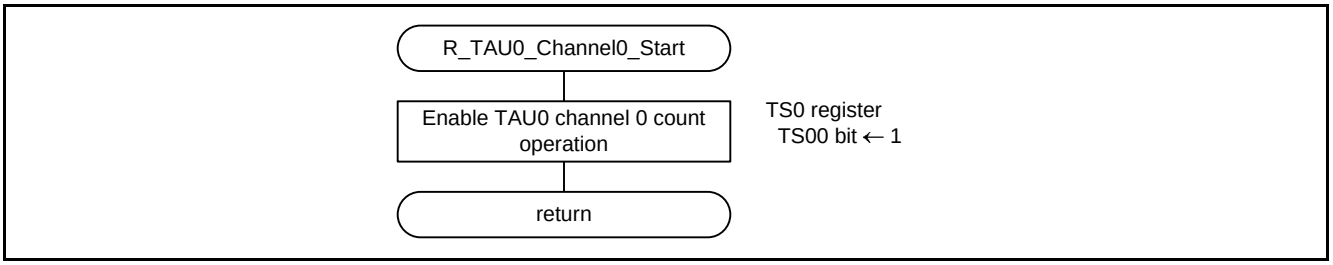


Figure 4.7 Enable TAU00 Operation

4.6.7 Timer KB20 Initialization

Figure 4.8, figure 4.9, figure 4.10, and figure 4.11 show the flowcharts for timer KB20 initialization.

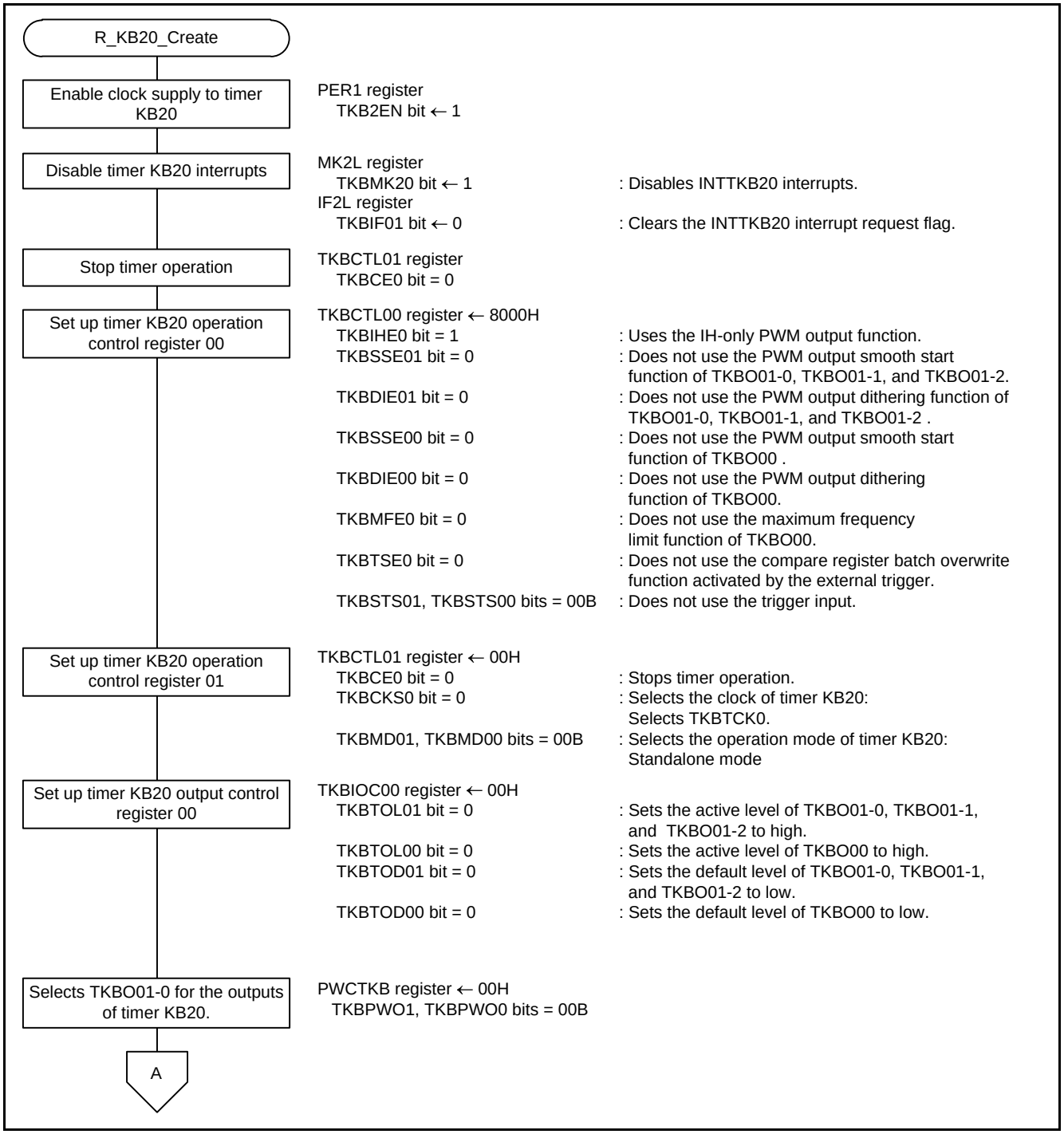


Figure 4.8 Timer KB20 Initialization (1/4)

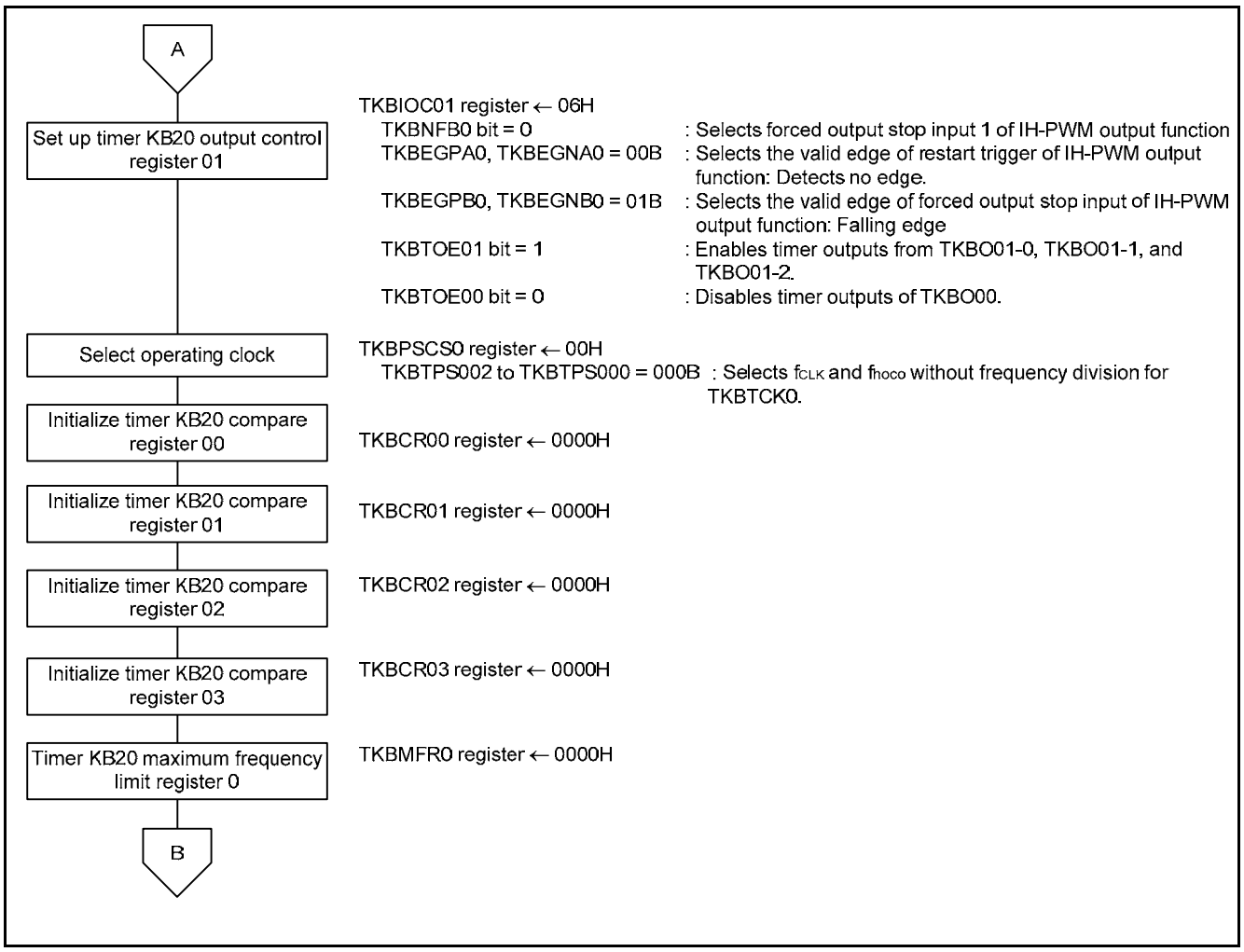


Figure 4.9 Timer KB20 Initialization (2/4)

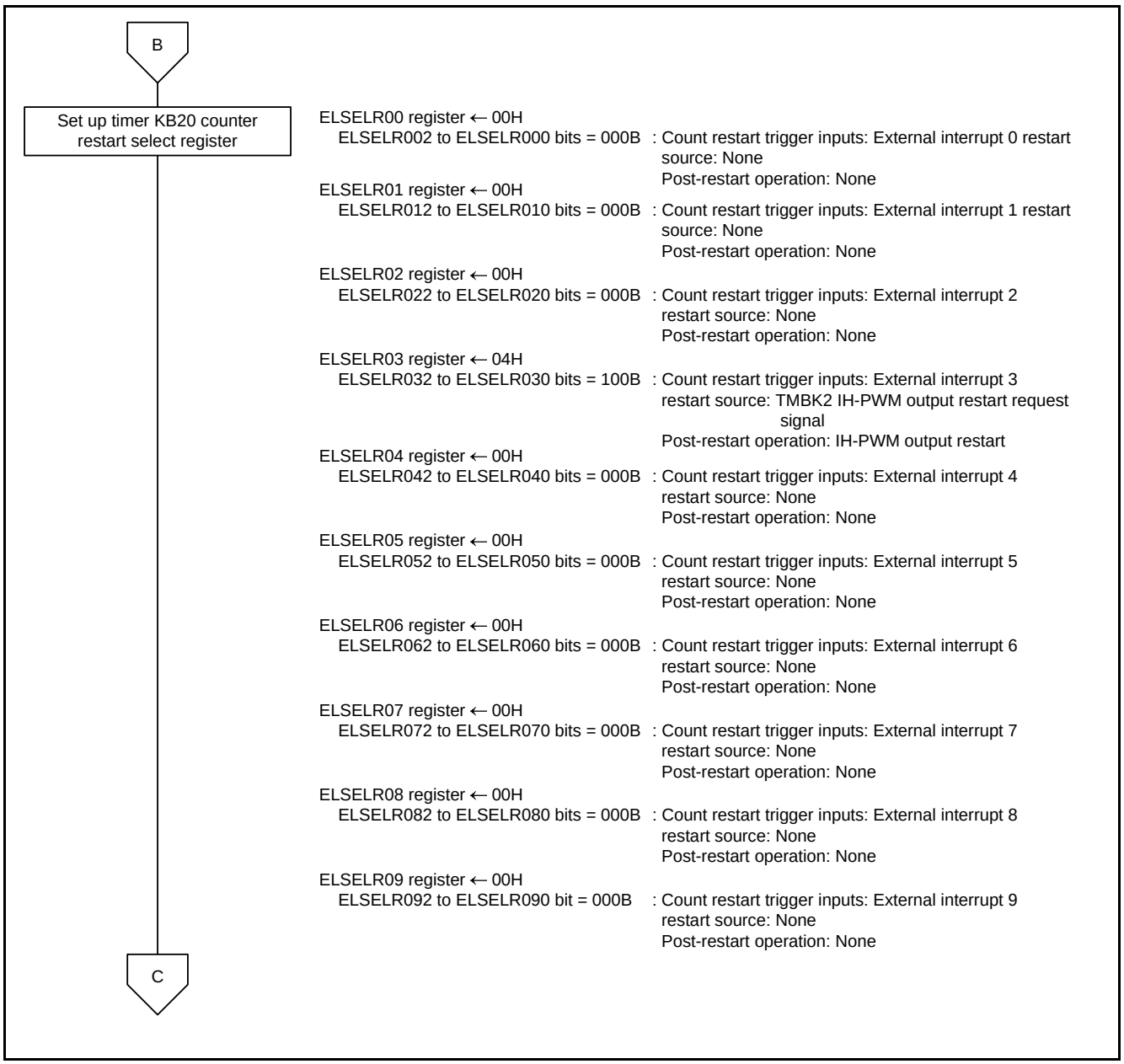
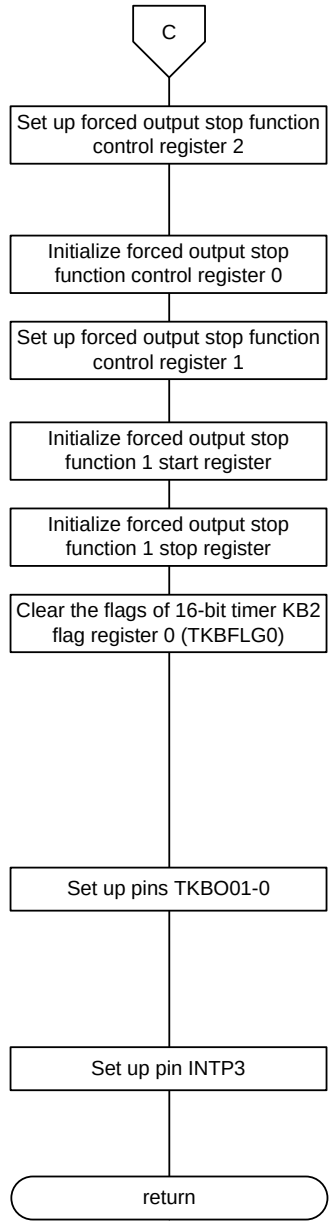


Figure 4.10 Timer KB20 Initialization (3/4)



TKBPACTL02 register ← 00H
- TKBPACE01 bit = 0: Disables the forced output stop function for TKBO01-0, TKBO01-1, and TKBO01-2 pins.
- TKBPACE00 bit = 0: Disables the forced output stop function for TKBO00 pin (note 1).

TKBPACTL00 register ← 0000H (note 2)

TKBPACTL01 register ← 0010H
- TKBPAHZS010 bit = 1: Select the forced output stop function 1 trigger input: Uses INTP0 which does not pass through the noise filter as the trigger (note 3).

TKBPAHFS0 register ← 00H (note 4)

TKBPAHFT0 register ← 00H (note 5)

TKBCLR0 register ← 3EH
- TKBCLSE01 bit = 1 : Clears the error flag for the PWM output smooth start function of TKBO01-0, TKBO01-1, and TKBO01-1 pins.
- TKBCLSE00 bit = 1 : Clears the error flag for the PWM output smooth start function of the TKBO pin.
- TKBCLIR0 bit = 1 : Clears the undetected restart trigger source 1 trigger error flag for interleave PFC mode.
- TKBCLIE0 bit = 1 : Clears restart trigger source 1 trigger multiple detection error flag for interleave PFC mode.
- TKBCLMF0 bit = 1 : Clears the status flag for the maximum frequency limit function.

PFSEG2 register
- PFSEG19 bit ← 0 : Uses as a port (except for segment output).

P7 register
- P77 bit ← 0 : Outputs "0".

PM7 register
- PM77 bit ← 0 : Output mode

PFSEG2 register
- PFSEG21 bit ← 0 : Uses as a port (except for segment output).

PM3 register
- PM31 bit ← 1 : Input mode

Note 1. Bit 0 (TKBPACE00) of the TKBPACTL02 register cannot be used when the IH-PWM output function is to be used. Be sure to set this bit to 0.
Note 2. The TKBPACTL00 register cannot be used when the IH-PWM output function is to be used. Be sure to set the register to its initial value (0000H).
Note 3. Only bit 4 (TKBPAHZS010) of the TKBPACTL01 register can be used when the IH-PWM output function is to be used. Be sure to set the other bits to 0.
Note 4. The TKBPAHFS0 register cannot be used when the IH-PWM output function is to be used. Be sure to set the register to its initial value (00H). Be sure to set the other bits to 0.
Note 5. Bit 0 (TKBPAHTT00) of the TKBPAHFT0 register cannot be used when the IH-PWM output function is to be used. Be sure to set this bit to 0.

Figure 4.11 Timer KB20 Initialization (4/4)

4.6.8 Enable Timer KB20 Operation

Figure 4.12 shows the flowchart for enabling timer KB20 operation.

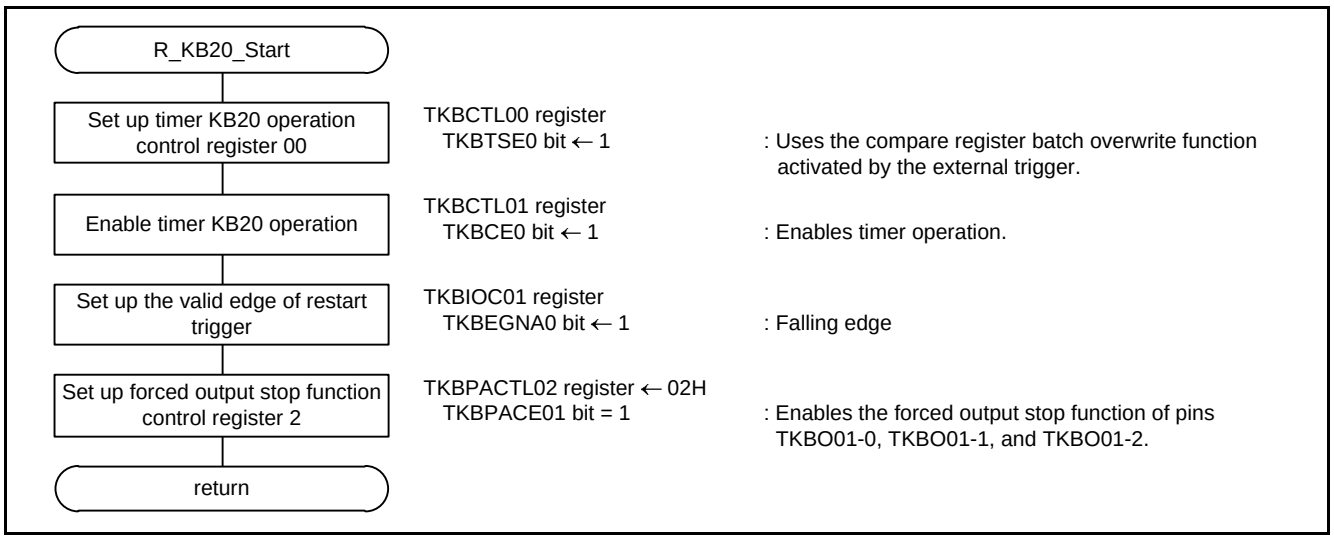


Figure 4.12 Enable Timer KB20 Operation

4.6.9 Stop Timer KB20 Operation

Figure 4.13 shows the flowchart for stopping timer KB20 operation.

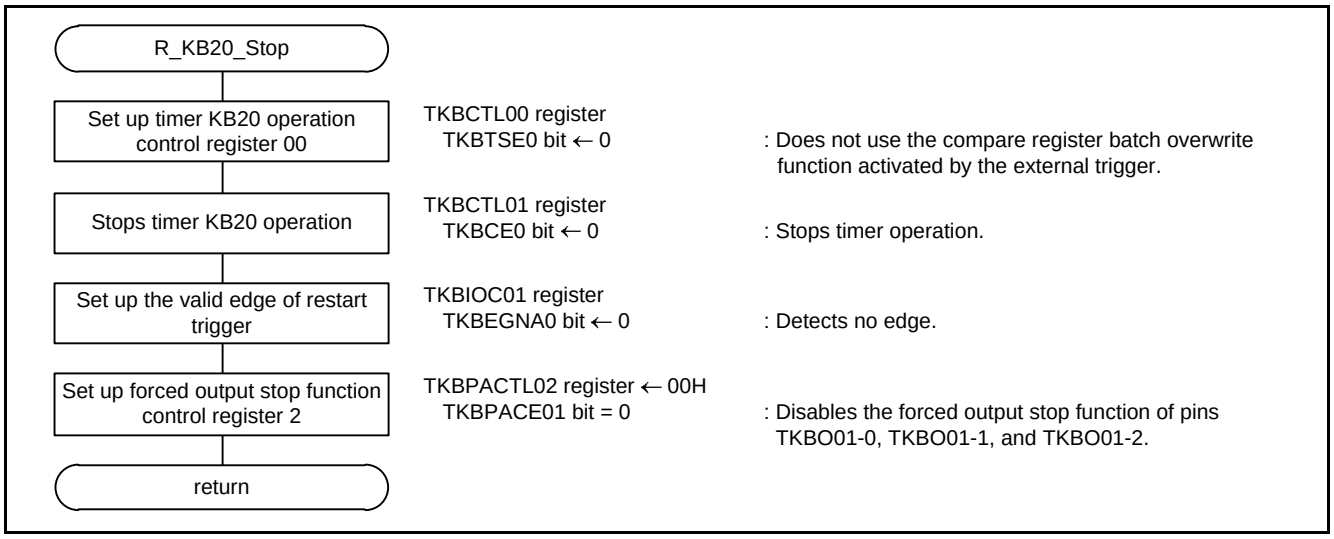


Figure 4.13 Stop Timer KB20 Operation

4.6.10 IGBT Output Driver Setup

Figure 4.14 shows the flowchart for IGBT output driver setup.

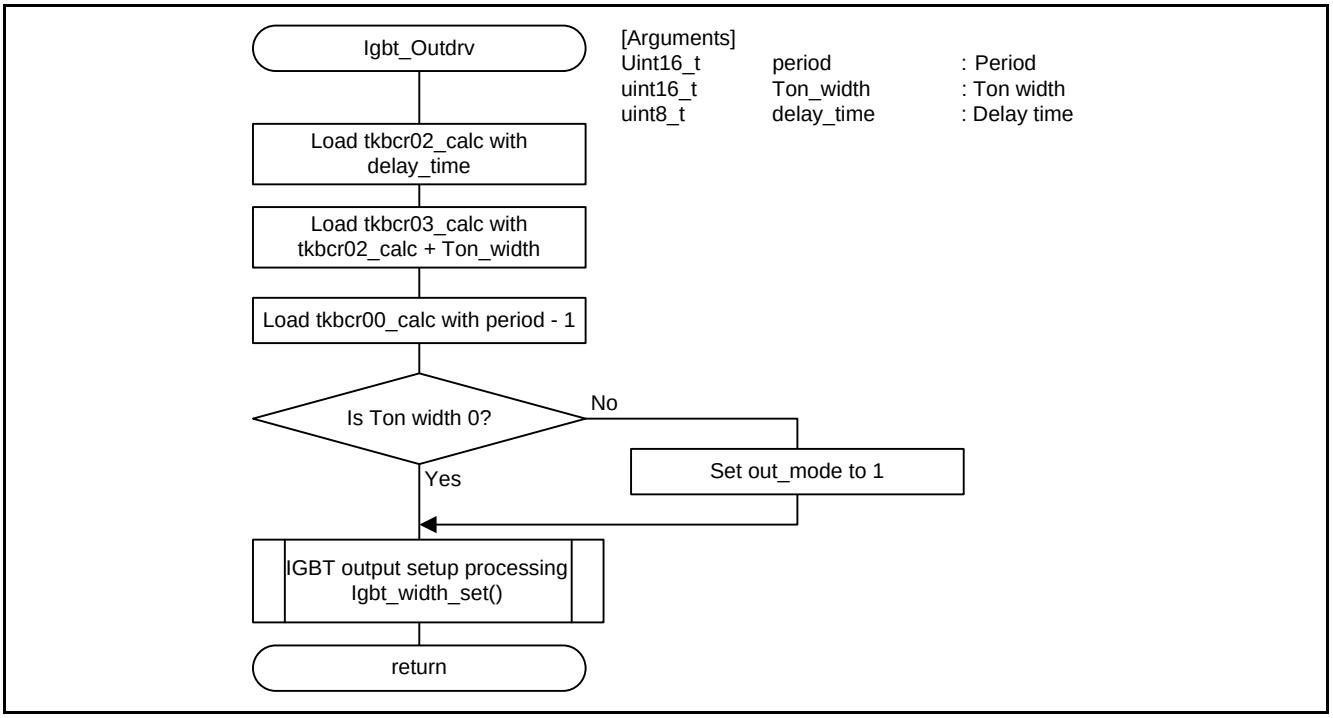


Figure 4.14 IGBT Output Driver Setup

4.6.11 IGBT Output Setup

Figure 4.15 shows the flowchart for IGBT output setup.

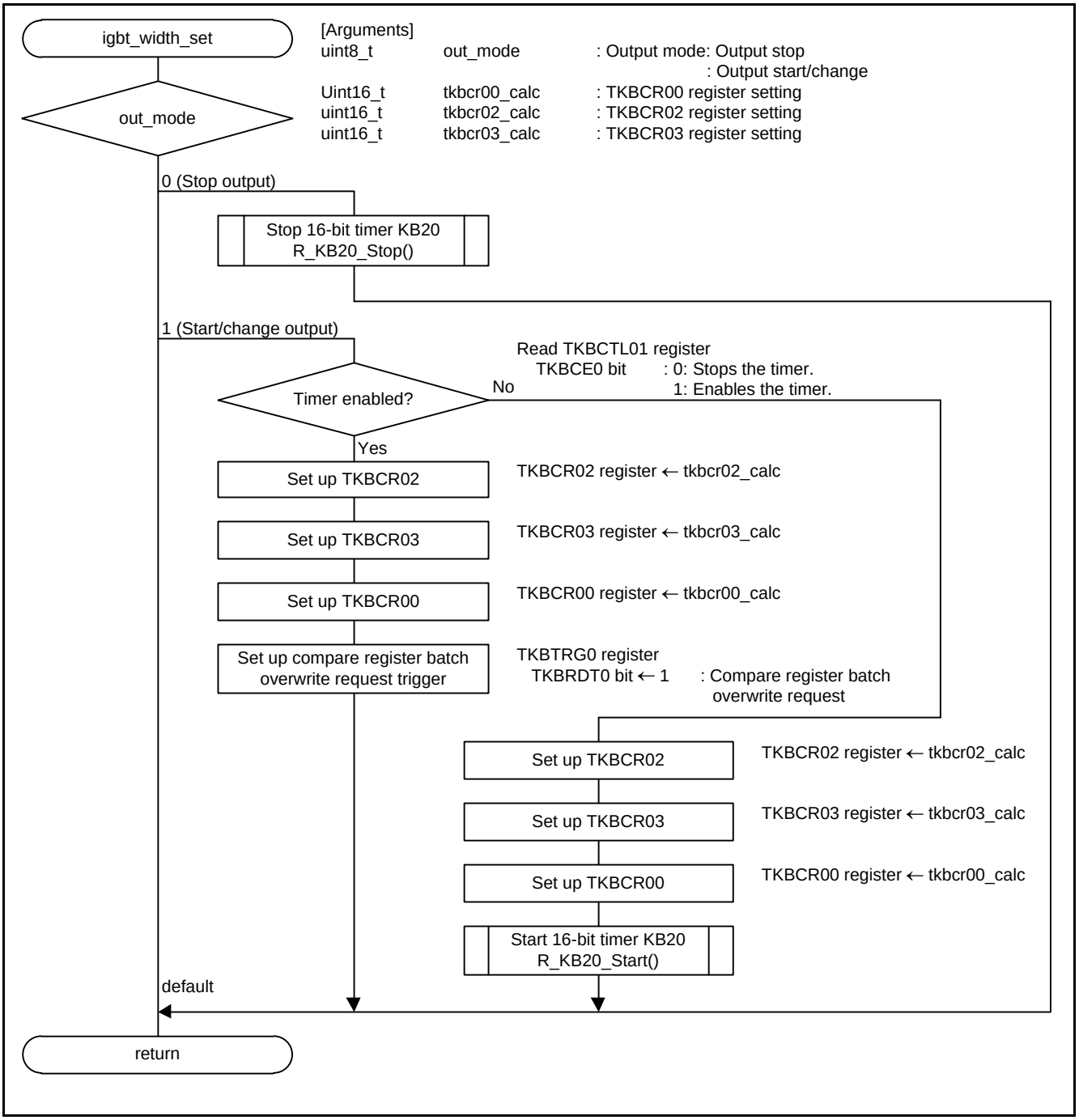


Figure 4.15 IGBT Output Setup

4.6.12 Main Processing

Figure 4.16 and figure 4.17 show the flowchart for main processing.

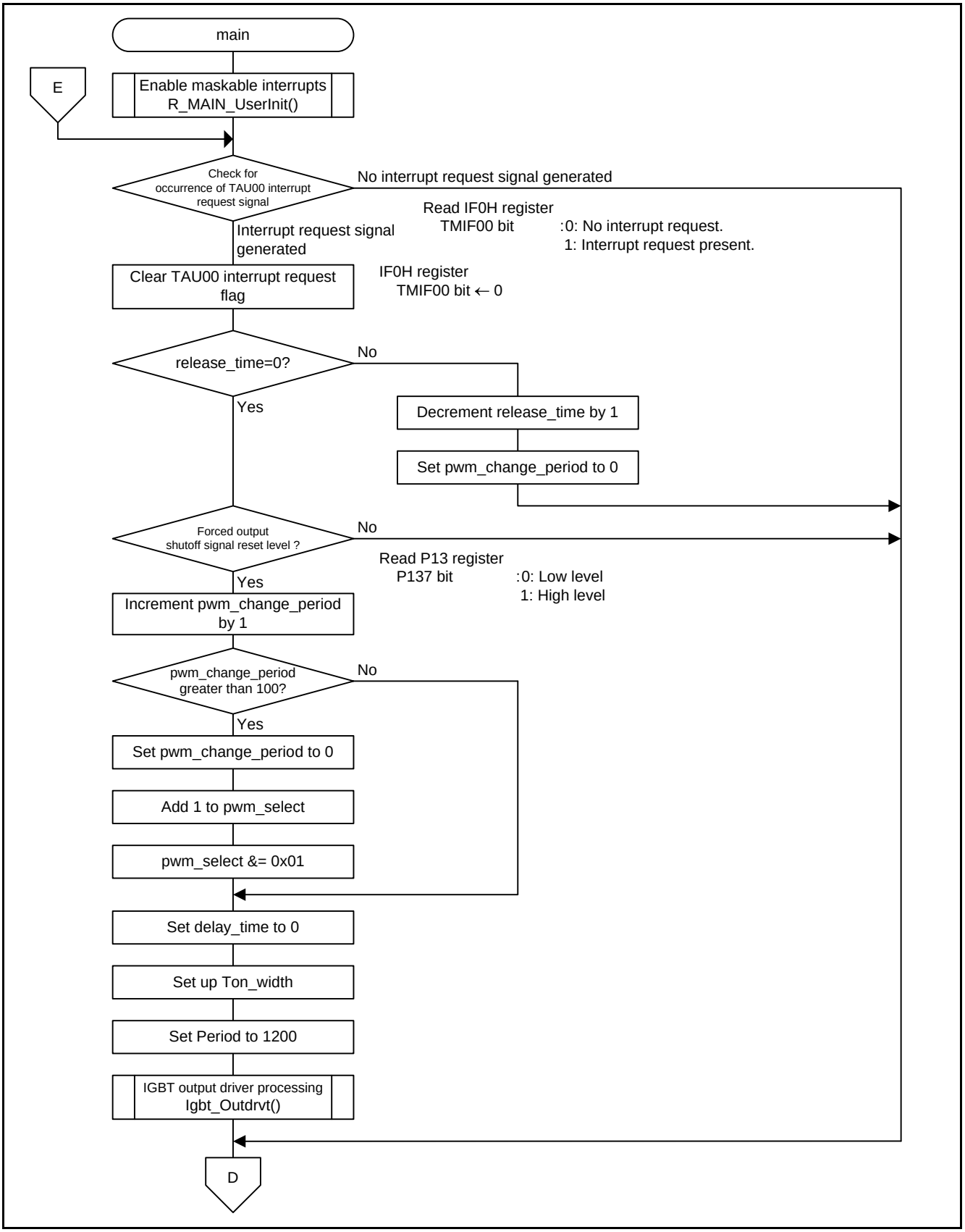


Figure 4.16 Main Processing (1/2)

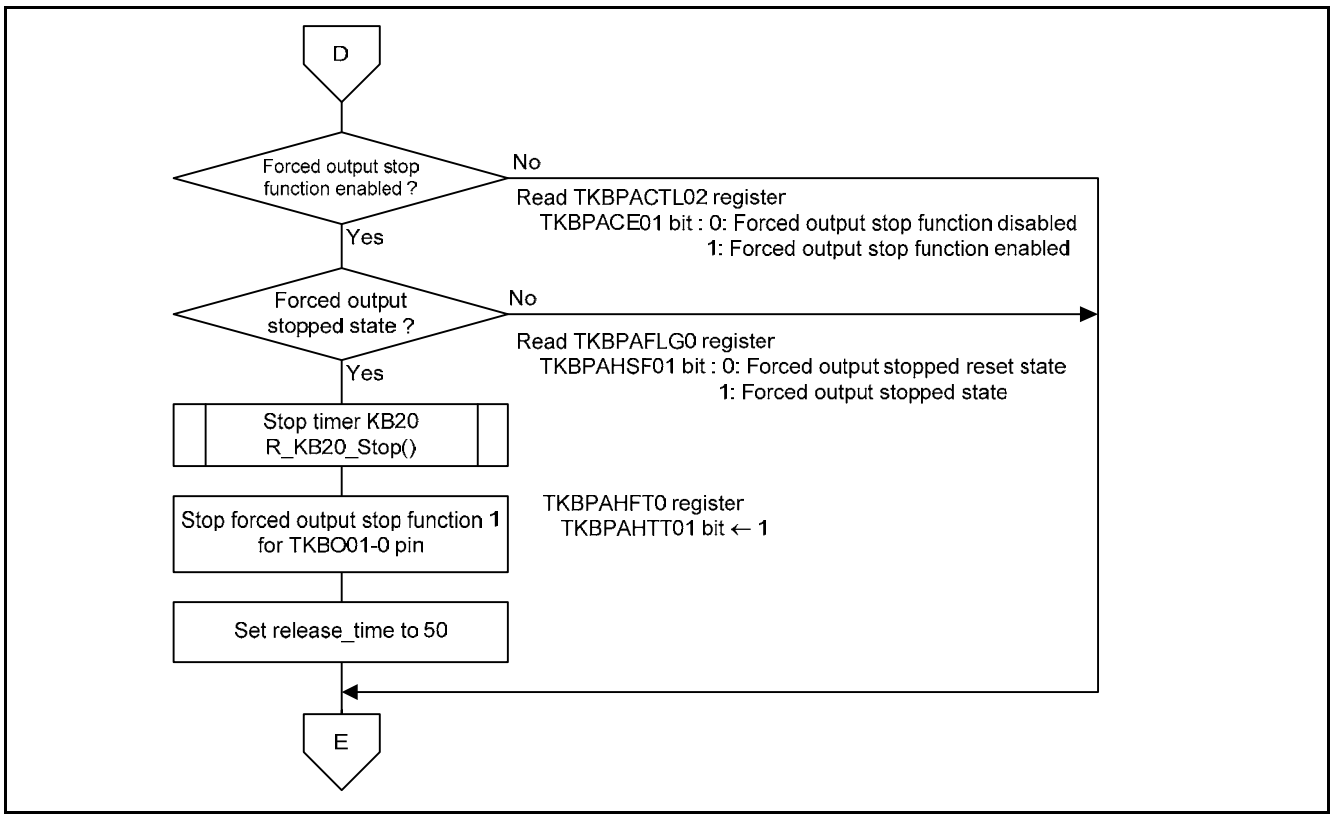


Figure 4.17 Main Processing (2/2)

4.6.13 Main Initialization

Figure 4.18 shows the flowchart for main initialization.

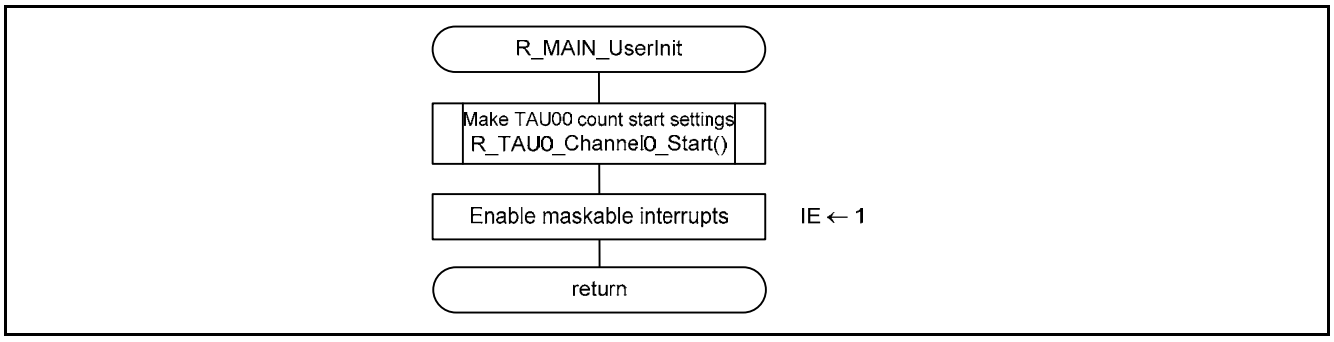


Figure 4.18 Main Initialization

5. Sample Code

The sample code is available on the Renesas Electronics Website.

6. Documents for Reference

RL78/L13 User's Manual: Hardware
RL78 Family User's Manual: Software
(The latest versions of the documents are available on the Renesas Electronics Website.)

Technical updating/Technical news
(The latest information is available on the Renesas Electronics Website.)

Website and Support

Renesas Electronics Website

http://www.renesas.com/

Inquiries

https://www.renesas.com/en-us/support/contact.html

Revision Record	RL78/L13 Timer KB20 Based IH Control (100 V) CC-RL

Rev.	Date	Description	
		Page	Summary
1.00	Mar 31, 2016	—	First edition issued
2.00	June 10, 2016	4	Added e2studio

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.

The following usage notes are applicable to all MPU/MCU 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.

Notice

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SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

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Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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