

RL78/G11

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Dec. 15, 2016

Timer Array Unit Controlling Switched-Mode Power Supply

with Dual Input One-Shot Pulse Output Function CC-RL

Introduction

This application note explains how to use the dual input one-shot pulse output function to control the switched-mode power supply (SMPS or flyback converter).

Target Device

RL78/G11 20-pin (Part name: R5F1056)

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1. Basic Functions

The dual input one-shot pulse output function in the timer array can output a variation of one-shot pulses by changing the pin polarity of the timer output, triggering a valid edge of the timer input pin.

The following is an example of a current-controlled flyback converter using this function.

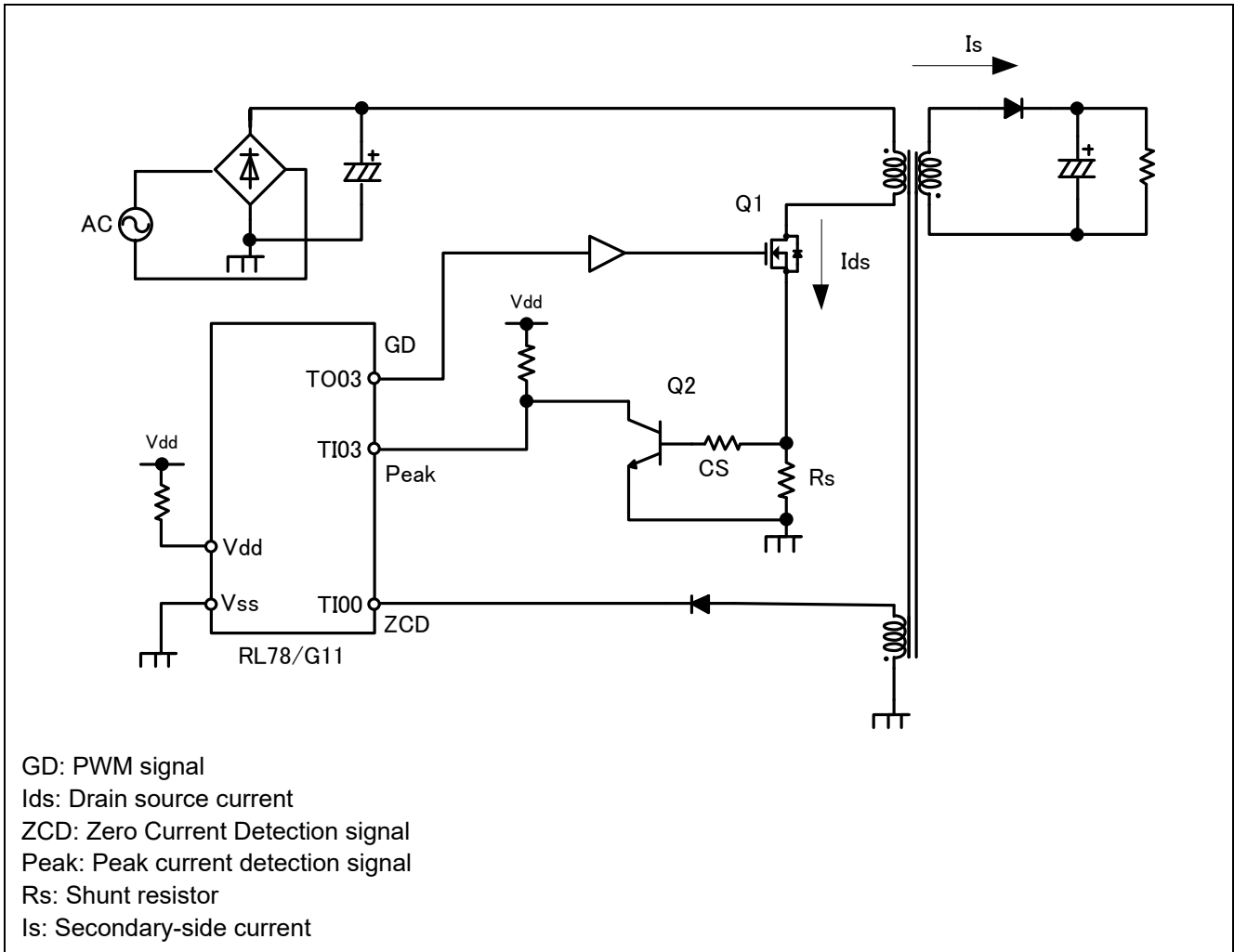


Figure 1-1 Circuit Example

The MCU detects the peak signal of the current (I_{ds}) during the ON state of switching device Q1 when the ZCD (Zero Current Detection) signal indicates the current (I_s) flowing through the transformer coil is zero. Using these two edge signals for the timer module, the MCU then controls the I_{ds} by outputting the one-shot pulse to Q1.

1.1 Peak Current Detection

Transistor Q2 is used to detect the peak current of I_{ds} . Transistor Q2's base and emitter pins are connected to both sides of shunt resistor R_s , which is connected to the Q1 source pin. The Q2 collector pin is connected to timer input pin TI03. As I_{ds} increases, the R_s end-to-end voltage reaches the V_{be} voltage of Q2 ($\approx 0.6V$). This turns Q2 ON and switches the input signal of TI03 to Low. This edge becomes the trigger to switch timer output pin TO03 to Low.

The timing of peak current detection shown in Figures 1-3.

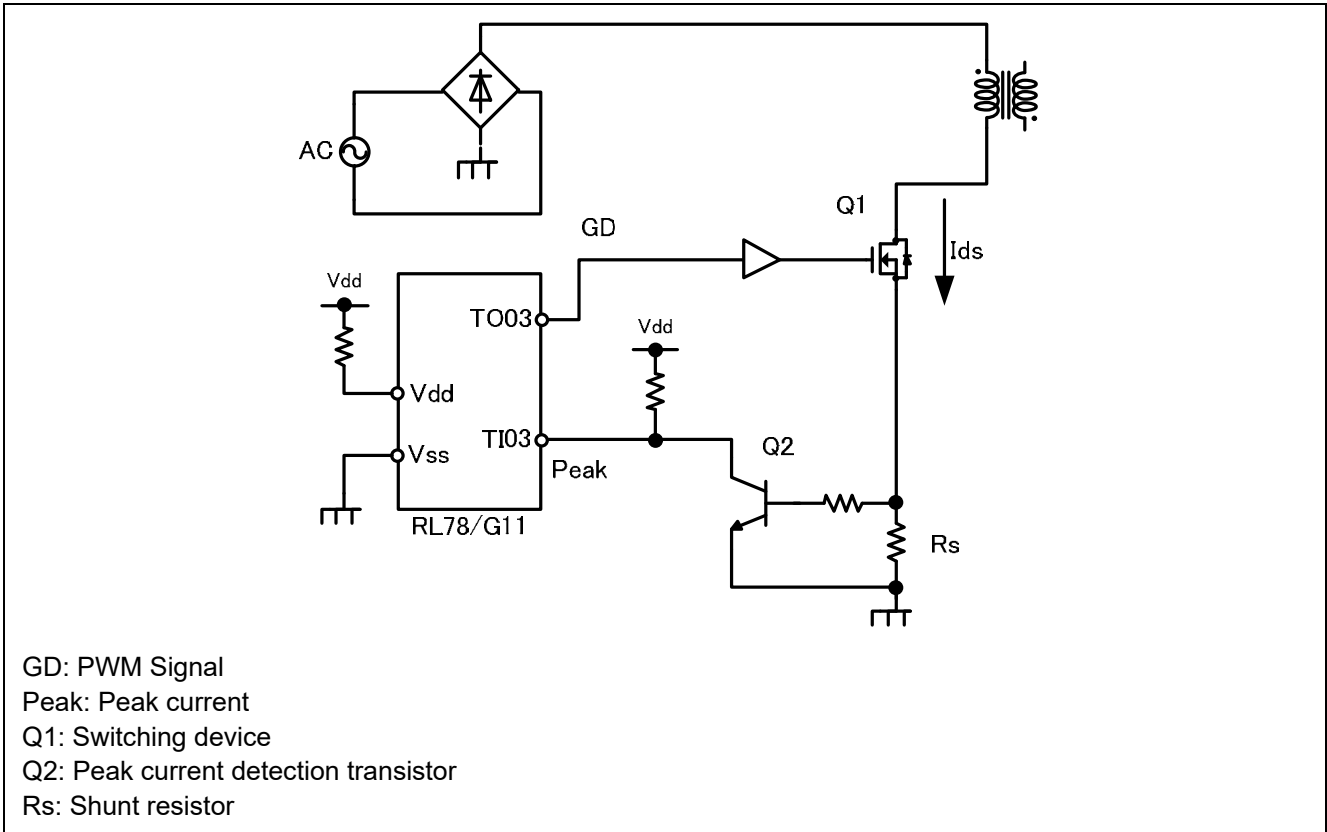


Figure 1-2 Peak Current Output Detection Using External Circuit

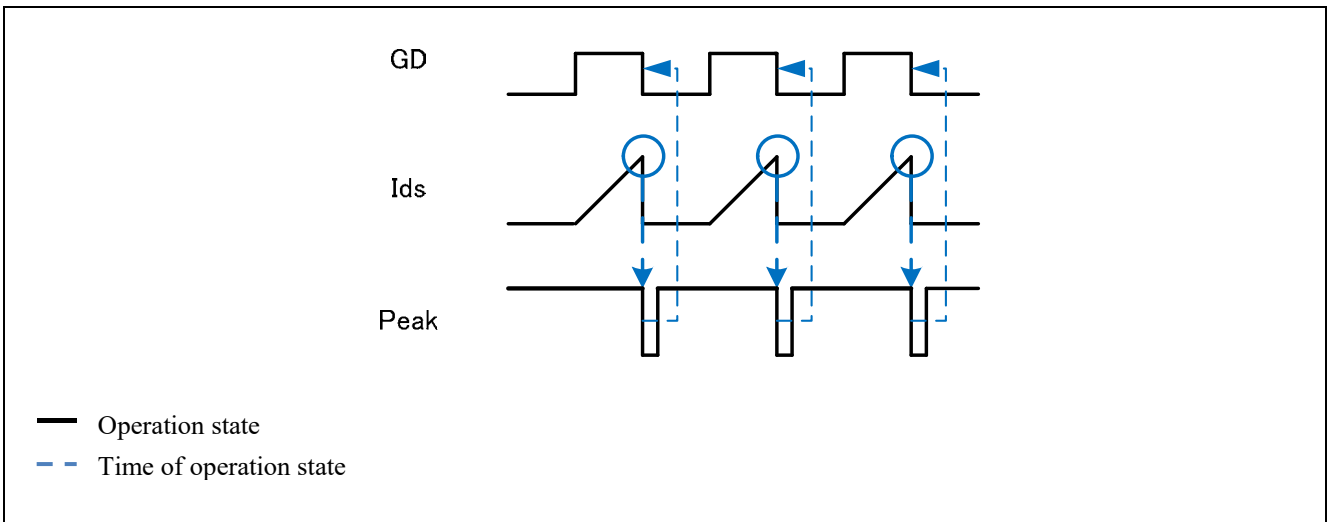


Figure 1-3 Timing Chart (peak current detection)

1.2 ZCD Signal Detection

This application detects the zero timing of secondary-side current I_s using the winding voltage of the transformer, as shown in Figure 1-4. The method used to detect this zero current I_s called Zero Current Detection (ZCD). When Q1 turns OFF, the energy accumulated in the transformer is transferred to the secondary side (winding). Because I_s flows in the same direction as the diode on the secondary side, power is supplied to the output capacitor and the load. When all of the accumulated energy is transferred from the transformer, the ZCD signal goes to Low. This edge is input to timer input pin T10x and the PWM signal switches to High.

The timing of ZCD signal detection as shown in Figures 1-5.

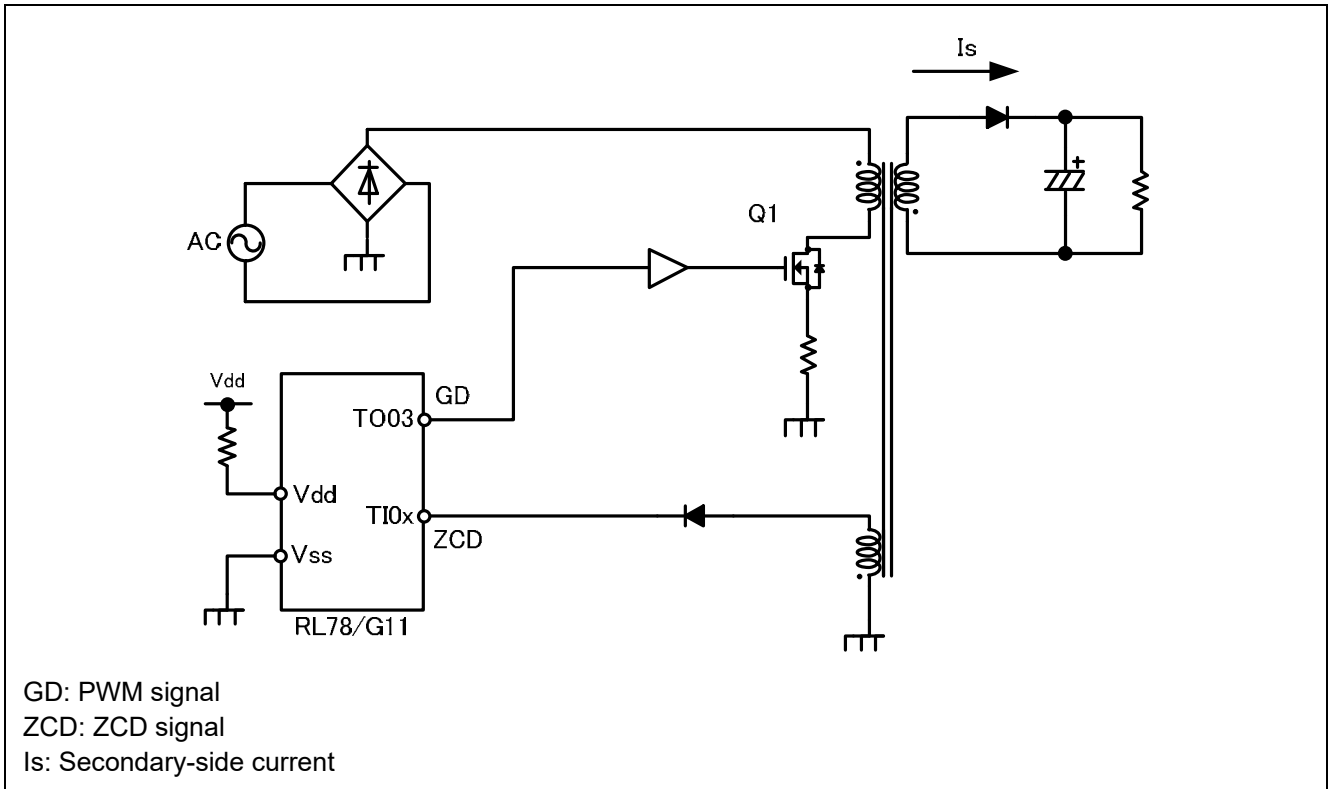


Figure 1-4 ZCD Signal Detection

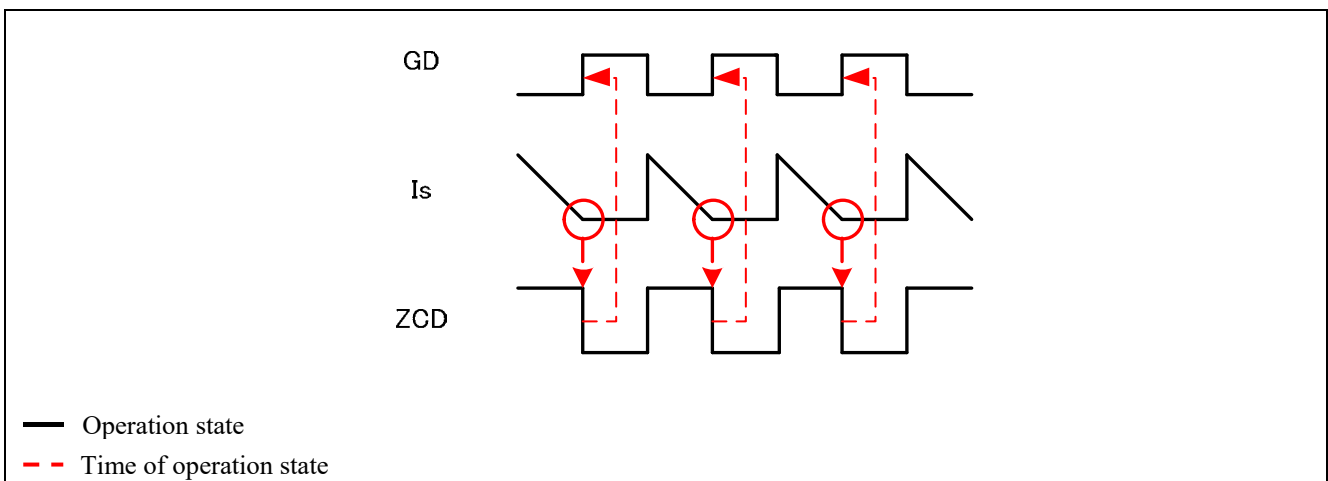


Figure 1-5 Timing Chart (ZCD signal detection)

2. Pin Assignment Example

Table 2-1 shows RL78/G11 pin assignments for the circuit example described above.

Table 2-1 Pin Assignment Example

Pin	Port	A/D D/A	PGA Comparator	SIF	Timer	External	Other	Function
1	P01	ANI16		SO10/TxD1		INTP5		
2	P00	ANI17	(VCOUT1)	SI10/RxD1/ SDA10/(SDAA1)	TI03		PCLBUZ1	Peak current detection
3	P40		VCOUT0/ VCOUT1	SCK10/SCL10/ (SCLA1)	TO03	INTFO	TOOL0/ (PCLBUZ0)	
4	P125					INTP9	RESET	Reset
5	P137			SSI00	(TI03)	INTP0		
6	P122			(SI10/RxD1)	(TI02)	INTP1	X2/ EXCLK	
7	P121				(TI01)	INTP2	X1	
8							REGC	
9							V _{SS}	GND
10							V _{DD}	5V
11	P54			SO00/TxD0	(TI03)/ (TO03)	KR4	TOOLTXD	
12	P55		(VCOUT0)	SI00/RxD0/ SDA00/SDAA1	TI02/ TO02	KR3/ INTP11	TOOLRXD	
13	P56	ANI22		SCK00/SCL00 SCLA1/SO11	(TO03)	KR2/ INTP10/ INTFO		PWM Signal
14	P30	ANI21		SCK11/SCL11/ (TXD0)/SDDA0	TI00/ TO01/ TKBO1	KR1/ INTP3	PCLBUZ0	ZCD signal detection
15	P31	ANI20		(RXD0)/SI11/ SDA11/SCLA0	TI01/ TO00/ TKBO0	KR0/ INTP4		
16	P33	ANI18	IVCMP1			(INTP11)		
17	P23	ANI3/ ANO1	PGAGND					
18	P22	ANI2	PGAI/VCMP0					
19	P21	ANI1/ AVREFM	IVREF0					
20	P20	ANI0/ AVREFP	IVREF1	(SO10/TXD1)				

3. Operation Check Conditions

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

Table 3.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/G11 (R5F1056)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 24MHz CPU/peripheral hardware clock: 24MHz
Operating voltage	5.0 V (can run on a voltage range of 2.9 V to 5.5 V.) LVD detection voltage : Rising edge voltage: 2.75V : Falling edge voltage: 2.81V
Integrated development environment (CS+)	CS+ for CC V4.01.00 from Renesas Electronics Corp.
Assembler (CS+)	CC-RL V1.03.00 from Renesas Electronics Corp.
Integrated development environment (e ² studio)	e ² studio V5.2.0.020 from Renesas Electronics Corp.
Assembler (e ² studio)	CC-RL V1.03.00 from Renesas Electronics Corp.

4. Peripheral Function Settings

The following tables describe the peripheral function settings for RL78/G11

Table 4-1 Peripheral Function Settings

Function	Ch	Setting
TAU	Ch0,3	For switching Operating mode: dual input one-shot pulse output TI00: peak current detection TI03: ZCD signal detection TO03: PWM signal output
12-bit interval timer	-	For main interval count (200us interval)

Table 4-2 Option Byte Setting

Address	Setting Value	Description
000C0H	1110 1110B	Watchdog timer not used
000C1H	0111 1111B	LVD detection voltage: Falling edge: VDD < 2.75V Rising edge: VDD >= 2.81V
000C2H	1110 0000B	High-speed on-chip oscillator (24MHz)
000C3H	1000 0101B	Enables on-chip debug operation

5. Flowcharts

5.1 Main and Peripheral Function Initialization

The following flowchart is an example of main processing and peripheral function initialization.

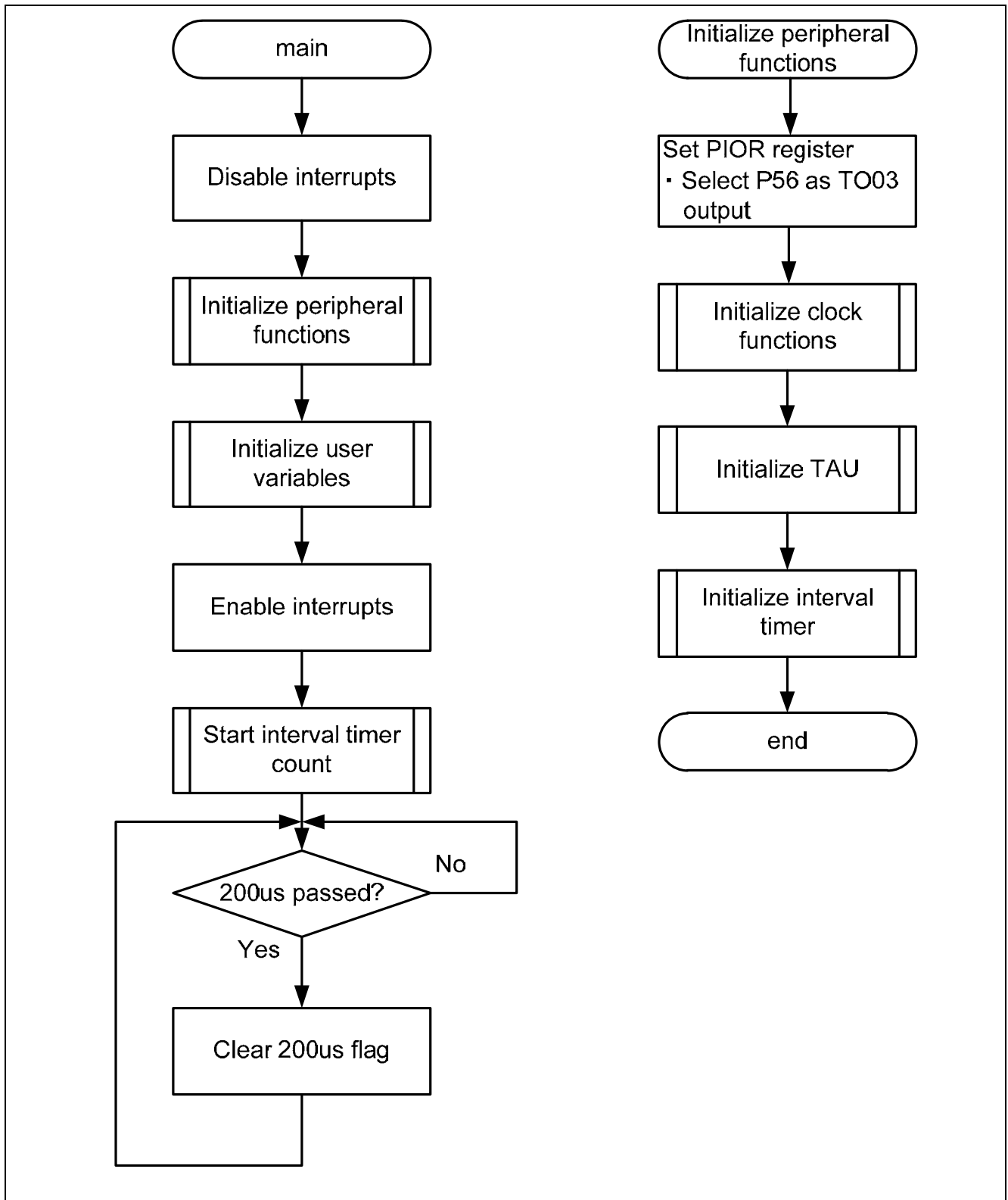


Figure 5-1 Main Processing Flow

5.2 Clock Generation Circuit Initialization

The following flowchart is an example of the clock generation circuit initialization.

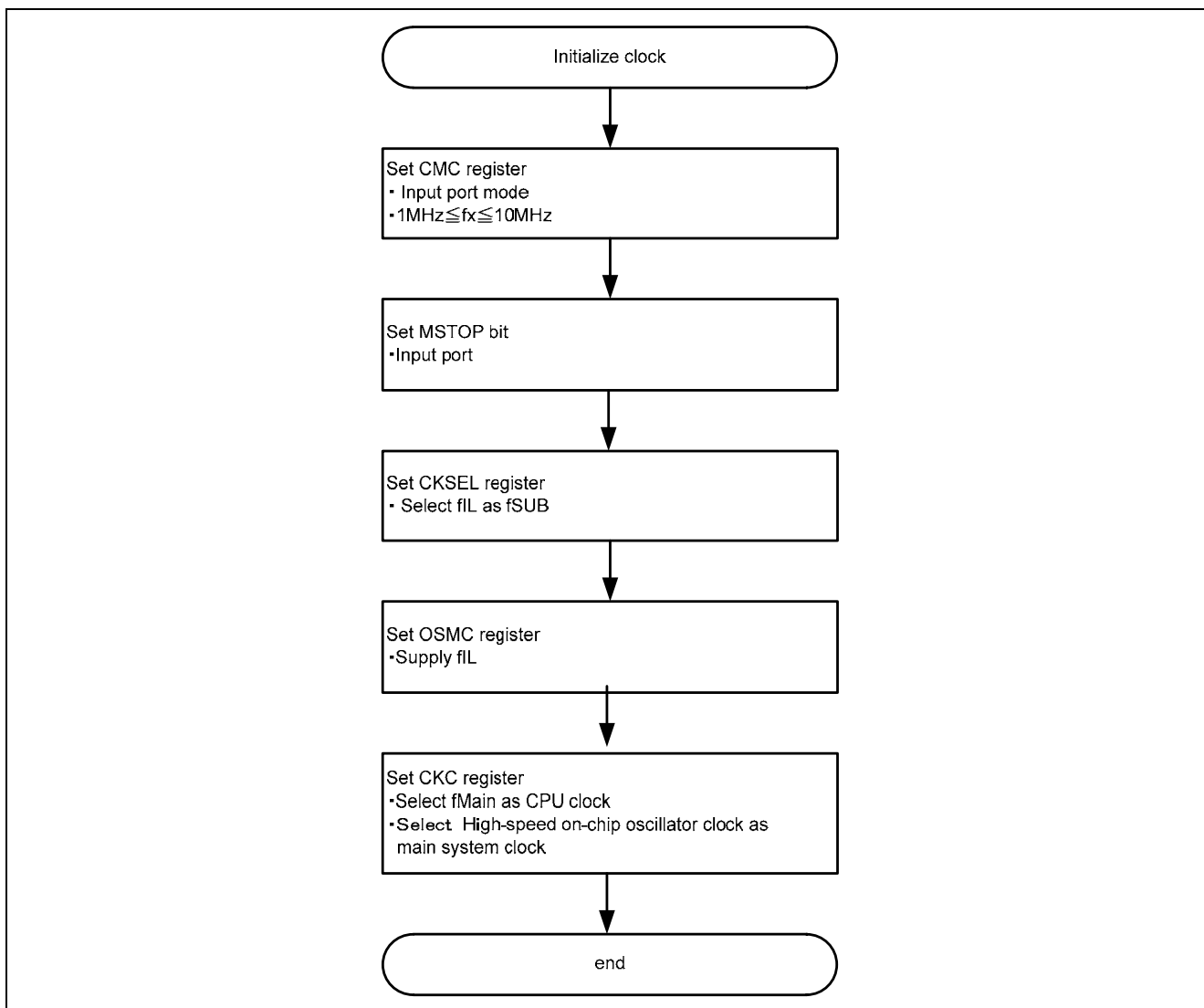


Figure 5-2 Clock Generation Circuit Initialization Flowchart

5.3 TAU Initialization

The following flowchart shows the initialization of the timer array unit (TAU).

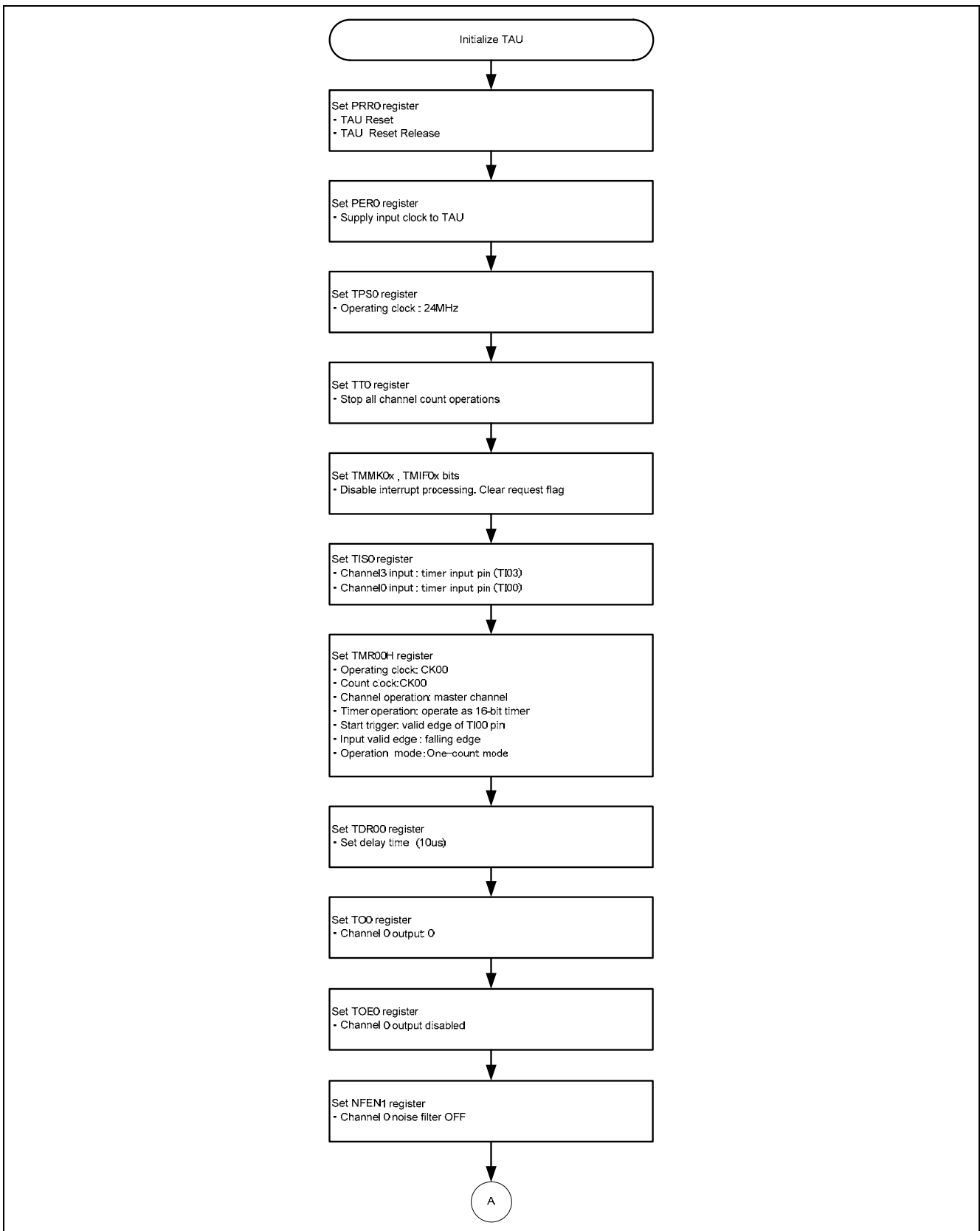


Figure 5-3 TAU Initialization Flowchart (1)

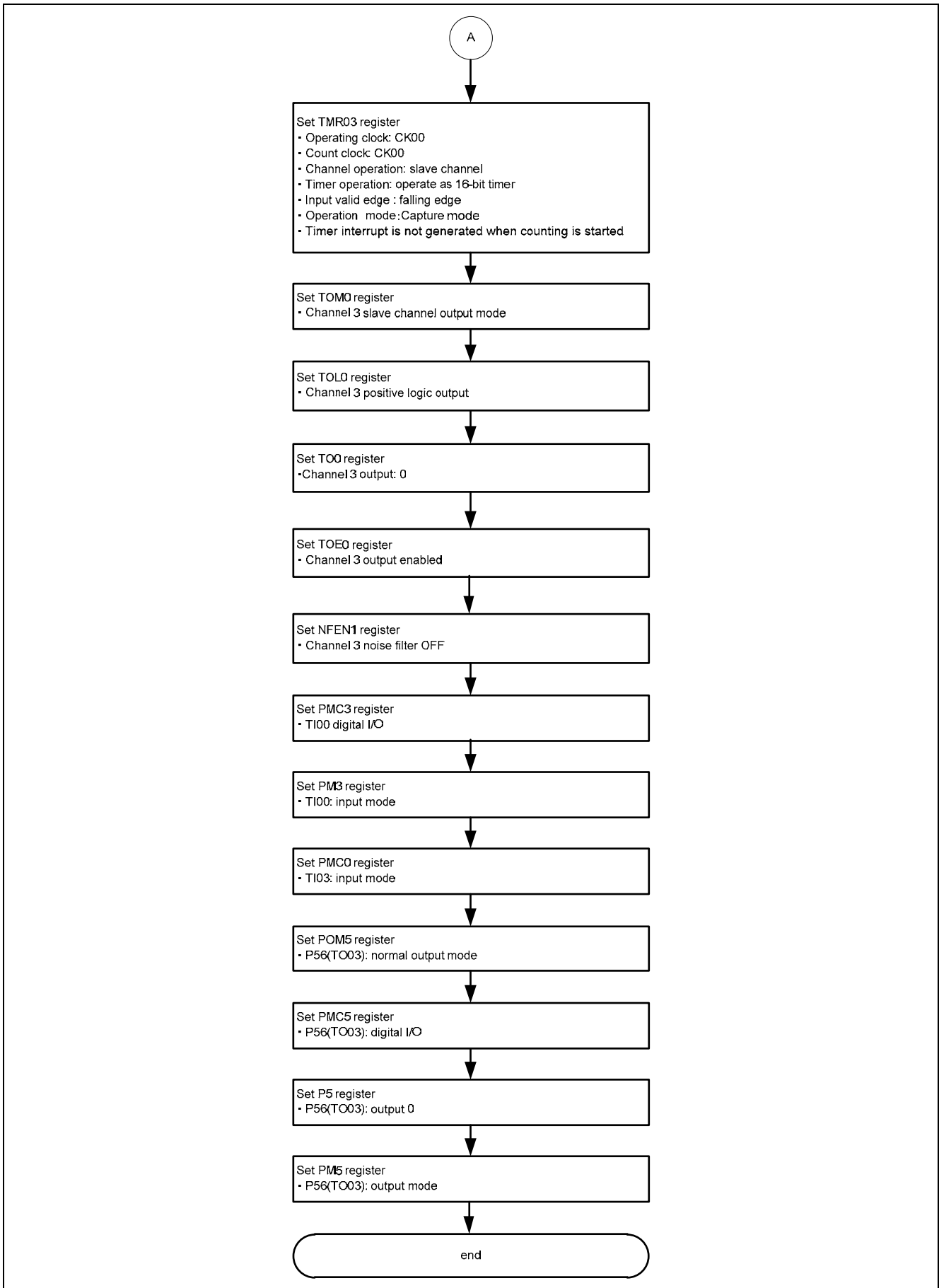


Figure 5-4 TAU Initialization Flowchart (2)

5.4 12-bit Interval Timer Initialization

The following flowchart shows the initialization of the 12-bit interval timer.

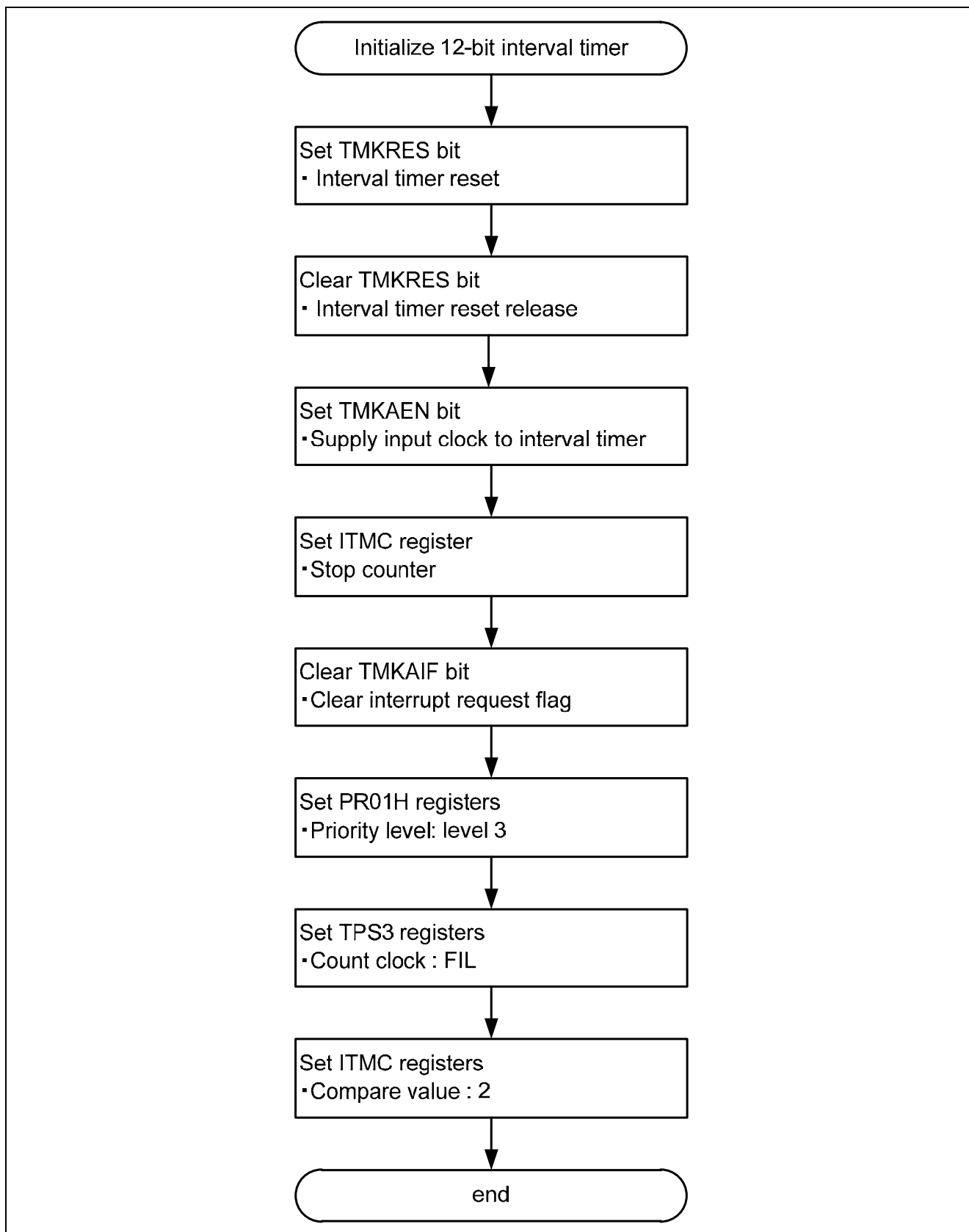


Figure 5-5 12-bit Interval Timer Initialization Flowchart

6. Switching Waveform

The following shows the switching waveform for this example.

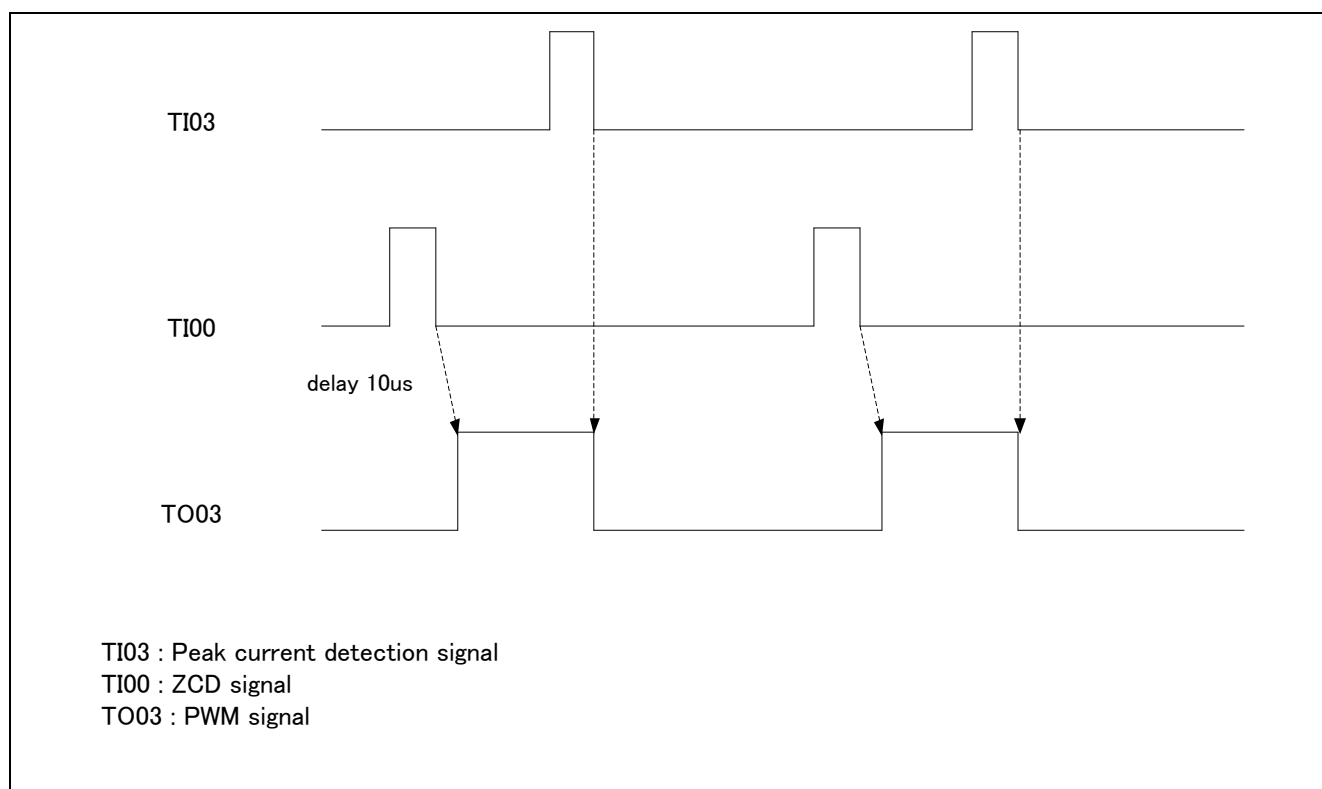


Figure 6-1 Switching Waveform

7. Sample Code

The sample code is available on the Renesas Electronics Website.

8. 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.)

Technical Updates/Technical Brochures

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

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Revision Record	RL78/G11 Timer Array Unit Controlling Switched-Mode Power Supply with Dual Input One-Shot Pulse Output Function CC-RL
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Rev.	Date	Description	
		Page	Summary
1.00	Dec. 15, 2016	—	First edition issued

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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

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Renesas Electronics India Pvt. Ltd.

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

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