R8C/25 Group

Timer RD in PWM Mode

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1. Abstract

This document describes how to set up and use timer RD in PWM mode in the R8C/25 Group.

2. Introduction

The application example described in this document is applied to the following MCU and parameter(s):

• MCU: R8C/25 Group

This program can be used with other R8C/Tiny Series which have the same special function registers (SFRs) as the R8C/25 Group. Check the manual for any additions and modifications to functions. Careful evaluation is recommended before using this application note.

Note on oscillation stabilization wait time
In chapter 4.2.1 , select the high-speed on-chip oscillator after starting the high-speed on-chip oscillator and waiting until oscillation stabilizes.

3. Applications

3.1 Timer RD

Timer RD has two 16-bit timers (channels 0 and 1). Each channel has four I/O pins.
The operation clock of timer RD is f1 or fOCO40M. Table 3.1 lists the Timer RD Operation Clocks.

Table 3.1 Timer RD Operation Clocks

Conditions	Operation Clock of Timer RD
The count source is f1, f2, f4, f8, f32, or TRDCLK input (bits TCK2 to TCK0 in registers TRDCR0 and TRDCR1 are set to a value from 000b to 101b).	f1
The count source is fOCO40M (bits TCK2 to TCK0 in registers TRDCR0 and TRDCR1 are set to 110b).	fOCO40M

Figure 3.1 shows a Block Diagram of Timer RD. Timer RD has five modes:

- Timer mode
  - Input capture function — Transfer the counter value to a register with an external signal as the trigger
  - Output compare function — Detect register value matches with a counter (Pin output can be changed at detection)

The following four modes use the output compare function:

- PWM mode — Output pulse of any width continuously
- Reset synchronous PWM mode — Output three-phase waveforms (six) without sawtooth wave modulation and dead time
- Complementary PWM mode — Output three-phase waveforms (six) with triangular wave modulation and dead time
- PWM3 mode — Output PWM waveforms (two) with a fixed period

In the input capture function, output compare function, and PWM mode, channels 0 and 1 have the equivalent functions, and functions or modes can be selected individually for each pin. Also, a combination of these functions and modes can be used in one channel.
In reset synchronous PWM mode, complementary PWM mode, and PWM3 mode, a waveform is output with a combination of counters and registers in channels 0 and 1.

Tables 3.2 to 3.10 list the Pin Functions of timer RD.

Table 3.2 Pin Functions TRDIOA0/TRDCLK(P2_0)

Register	TRDOER1	TRDFCR			TRDIORA0		Function
Bit	EA0	PWM3	STCLK	CMD1, CMD0	IOA3	IOA2_IOA0	
Setting value	0	0	0	00b	X	XXXb	PWM3 mode waveform output
	0	1	0	00b	1	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	0	00b	X	1XXb	Timer mode trigger input (input capture function)(1)
		1	1	XXb	X	000b	External clock input (TRDCLK)(1)
	Other than above						I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_0 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function) and external clock input (TRDCLK).

Table 3.3 Pin Functions TRDIOB0(P2_1)

Register	TRDOER1	TRDFCR		TRDPMR	TRDIORA0	Function
Bit	EB0	PWM3	CMD1, CMD0	PWMB0	IOB2_IOB0	
Setting value	0	X	1Xb	X	XXXb	Complementary PWM mode waveform output
	0	X	01b	X	XXXb	Reset synchronous PWM mode waveform output
	0	0	00b	X	XXXb	PWM3 mode waveform output
	0	1	00b	1	XXXb	PWM mode waveform output
	0	1	00b	0	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	0	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above					I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_1 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.4 Pin Functions TRDIOC0(P2_2)

Register	TRDOER1	TRDFCR		TRDPMR	TRDIORC0	Function
Bit	EC0	PWM3	CMD1, CMD0	PWMC0	IOC2_IOC0	
Setting value	0	X	1Xb	X	XXXb	Complementary PWM mode waveform output
	0	X	01b	X	XXXb	Reset synchronous PWM mode waveform output
	0	1	00b	1	XXXb	PWM mode waveform output
	0	1	00b	0	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	0	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above					I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_2 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.5 Pin Functions TRDIOD0(P2_3)

Register	TRDOER1	TRDFCR		TRDPMR	TRDIORC0	Function
Bit	ED0	PWM3	CMD1, CMD0	PWMD0	IOD2_IOD0	
Setting value	0	X	1Xb	X	XXXb	Complementary PWM mode waveform output
	0	X	01b	X	XXXb	Reset synchronous PWM mode waveform output
	0	1	00b	1	XXXb	PWM mode waveform output
	0	1	00b	0	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	0	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above					I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_3 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.6 Pin Functions TRDIOA1(P2_4)

Register	TRDOER1	TRDFCR		TRDIORA1	Function
Bit	EA1	PWM3	CMD1, CMD0	IOA2_IOA0	
Setting value	0	X	1Xb	XXXb	Complementary PWM mode waveform output
	0	X	01b	XXXb	Reset synchronous PWM mode waveform output
	0	1	00b	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above				I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_4 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.7 Pin Functions TRDIOB1(P2_5)

Register	TRDOER1	TRDFCR		TRDPMR	TRDIORA1	Function
Bit	EB1	PWM3	CMD1, CMD0	PWMB1	IOB2_IOB0	
Setting value	0	X	1Xb	X	XXXb	Complementary PWM mode waveform output
	0	X	01b	X	XXXb	Reset synchronous PWM mode waveform output
	0	1	00b	1	XXXb	PWM mode waveform output
	0	1	00b	0	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	0	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above					I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_5 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.8 Pin Functions TRDIOC1(P2_6)

Register	TRDOER1	TRDFCR		TRDPMR	TRDIORC1	Function
Bit	EC1	PWM3	CMD1, CMD0	PWMC1	IOC2_IOC0	
Setting value	0	X	1Xb	X	XXXb	Complementary PWM mode waveform output
	0	X	01b	X	XXXb	Reset synchronous PWM mode waveform output
	0	1	00b	1	XXXb	PWM mode waveform output
	0	1	00b	0	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	0	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above					I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_6 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.9 Pin Functions TRDIOD1(P2_7)

Register	TRDOER1	TRDFCR		TRDPMR	TRDIORC1	Function
Bit	ED1	PWM3	CMD1, CMD0	PWMD1	IOD2_IOD0	
Setting value	0	X	1Xb	X	XXXb	Complementary PWM mode waveform output
	0	X	01b	X	XXXb	Reset synchronous PWM mode waveform output
	0	1	00b	1	XXXb	PWM mode waveform output
	0	1	00b	0	001b, 01Xb	Timer mode waveform output (output compare function)
	X	1	00b	0	1XXb	Timer mode trigger input (input capture function)(1)
	Other than above					I/O port

X: can be 0 or 1, no change in outcome
NOTE:
1. Set the PD2_7 bit in the PD2 register to 0 (input mode) at timer mode trigger input (input capture function).

Table 3.10 Pin Functions $\overline{\text{INT0}}$(P4_5)

Register	TRDOER2	INTEN		PD4	Function
Bit	PTO	INT0PL	INT0EN	PD4_5	
Setting value	1	0	1	0	Pulse output forced cutoff signal input
	Other than above				I/O port or $\overline{\text{INT0}}$ interrupt input

X: can be 0 or 1, no change in outcome

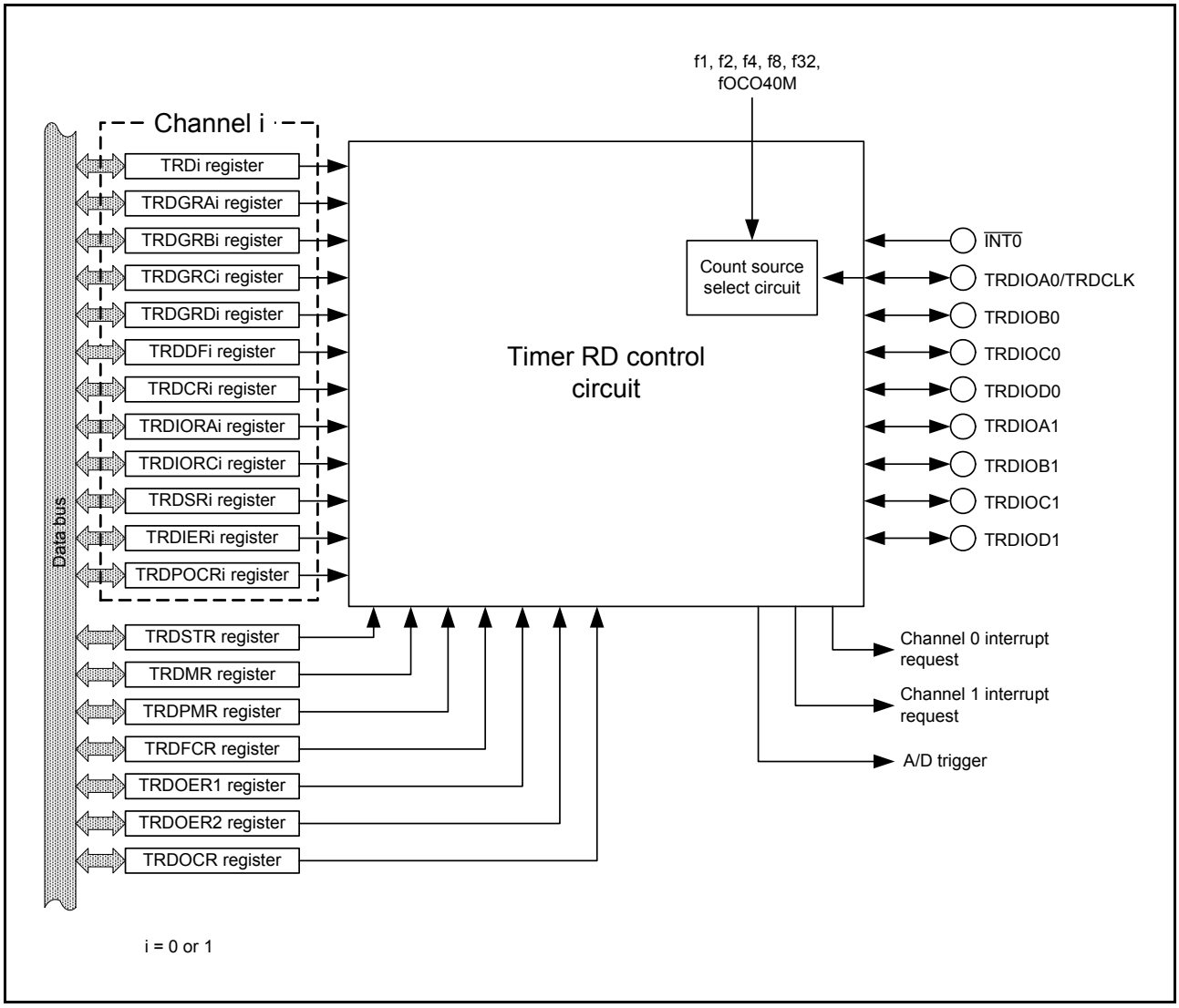


Figure 3.1 Block Diagram of Timer RD

3.2 Count Sources

The count source selection method is the same in all modes. However, in PWM3 mode, the external clock cannot be selected.

Table 3.11 Count Source Selection

Count Source	Selection
f1, f2, f4, f8, f32	The count source is selected by bits TCK2 to TCK0 in the TRDCRi register.
fOCO40M(1)	The FRA00 bit in the FRA0 register is set to 1 (high-speed on-chip oscillator frequency). Bits TCK2 to TCK0 in the TRDCRi register are set to 110b (fOCO40M).
External signal input to TRDCLK pin	The STCLK bit in the TRDFCR register is set to 1 (external clock input enabled). Bits TCK2 to TCK0 in the TRDCRi register are set to 101b (count source: external clock). The valid edge is selected by bits CKEG1 to CKEG0 in the TRDCRi register. The PD2_0 bit in the PD2 register is set to 0 (input mode).

i = 0 or 1

NOTE:

1. The count source fOCO40M can be used with VCC = 3.0 to 5.5 V.

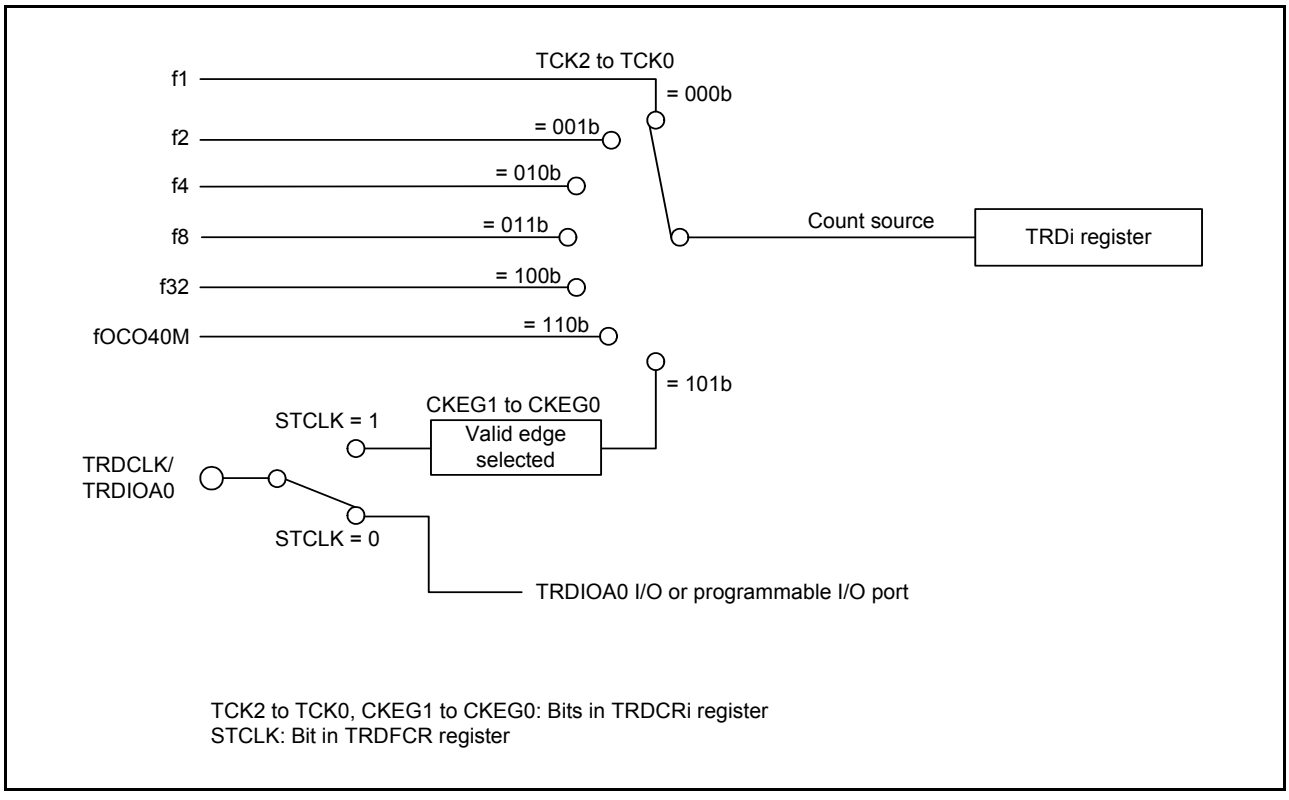


Figure 3.2 Block Diagram of Count Source

Set the pulse width of the external clock which inputs to the TRDCLK pin to 3 cycles or above of the operation clock of timer RD (refer to **Table 3.1 Timer RD Operation Clocks**).

When selecting fOCO40M for the count source, set the FRA00 bit in the FRA0 register to 1 (high-speed on-chip oscillator on) before setting bits TCK2 to TCK0 in the TRDCRi register (i = 0 or 1) to 110b (fOCO40M).

3.3 Buffer Operation

The TRDGRCi (i = 0 or 1) register can be used as the buffer register of the TRDGRAi register, and the TRDGRDi register can be used as the buffer register of the TRDGRBi register by means of bits BFCi and BFDi in the TRDMR register.

- TRDGRAi buffer register: TRDGRCi register
- TRDGRBi buffer register: TRDGRDi register

Buffer operation depends on the mode. Table 3.12 lists the Buffer Operation in Each Mode.

Table 3.12 Buffer Operation in Each Mode

Function and Mode	Transfer Timing	Transfer Register
Input capture function	Input capture signal input	Transfer content in TRDGRAi (TRDGRBi) register to buffer register
Output compare function PWM mode	Compare match with TRDi register and TRDGRAi (TRDGRBi) register	Transfer content in buffer register to TRDGRAi (TRDGRBi) register
Reset synchronous PWM mode	Compare match withTRD0 register and TRDGRA0 register	Transfer content in buffer register to TRDGRAi (TRDGRBi) register
Complementary PWM mode	• Compare match with TRD0 register and TRDGRA0 register • TRD1 register underflow	Transfer content in buffer register to registers TRDGRB0, TRDGRA1, and TRDGRB1
PWM3 mode	Compare match with TRD0 register and TRDGRA0 register	Transfer content in buffer register to registers TRDGRA0, TRDGRB0, TRDGRA1, and TRDGRB1

i = 0 or 1

When using the TRDGRCi or TRDGRDi register as a buffer register for the output compare function, PWM mode, reset synchronous PWM mode, complementary PWM mode, and PWM3 mode, bits IMFC and IMFD in the TRDSRi register are set to 1 by a compare match with the TRDi register.

3.4 Synchronous Operation

The TRD1 register is synchronized with the TRD0 register.

- Synchronous preset

  When the SYNC bit in the TRDMR register is set to 1 (synchronous operation), the data is written to both the TRD0 and TRD1 registers after writing to the TRDi register.

- Synchronous clear

  When the SYNC bit in the TRDMR register is set to 1 and bits CCLR2 to CCLR0 in the TRDCRi register are set to 011b (synchronous clear), the TRD0 register is set to 0000h at the same time the TRD1 register is set to 0000h.

  Also, when the SYNC bit in the TRDMR register is set to 1 and bits CCLR2 to CCLR0 in the TRDCRi register are set to 011b (synchronous clear), the TRD1 register is set to 0000h at the same time the TRD0 register is set to 0000h.

3.5 Pulse Output Forced Cutoff

In the output compare function, PWM mode, reset synchronous PWM mode, complementary PWM mode, and PWM3 mode, the TRDIOji (i = 0 or 1, j = either A, B, C, or D) output pin can be forcibly set to a programmable I/O port by the $\overline{\text{INT0}}$ pin input, and pulse output can be cut off.
The pins used for output in these functions or modes can function as the output pin of timer RD when the applicable bit in the TRDOER1 register is set to 0 (enable timer RD output). When the PTO bit in the TRDOER2 register is set to 1 ($\overline{\text{INT0}}$ of pulse output forced cutoff signal input enabled), all bits in the TRDOER1 register are set to 1 (disable timer RD output, the TRDIOji output pin is used as the programmable I/O port) after "L" is applied to the $\overline{\text{INT0}}$ pin. The TRDIOji output pin is set to the programmable I/O port after "L" is applied to the $\overline{\text{INT0}}$ pin and waiting for one to two cycles of the timer RD operation clock (refer to **Table 3.1 Timer RD Operation Clocks**).

Set as below when using this function:

- Set the pin status (high impedance, "L" or "H" output) to pulse output forced cutoff by registers P2 and PD2.
- Set the INT0EN bit in the INTEN register to 1 (enable $\overline{\text{INT0}}$ input) and the INT0PL bit to 0 (one edge).
- Set the PD4_5 bit in the PD4 register to 0 (input mode).
- Set the $\overline{\text{INT0}}$ digital filter by bits INT0F1 to INT0F0 in the INTF register.
- Set the PTO bit in the TRDOER2 register to 1 (enable pulse output forced cutoff signal input $\overline{\text{INT0}}$).

According to the selection of the POL bit in the INT0IC register and change of the $\overline{\text{INT0}}$ pin input, the IR bit in the INT0IC register is set to 1 (interrupt request). Refer to the **R8C/25 Group Hardware Manual** for details of interrupts.

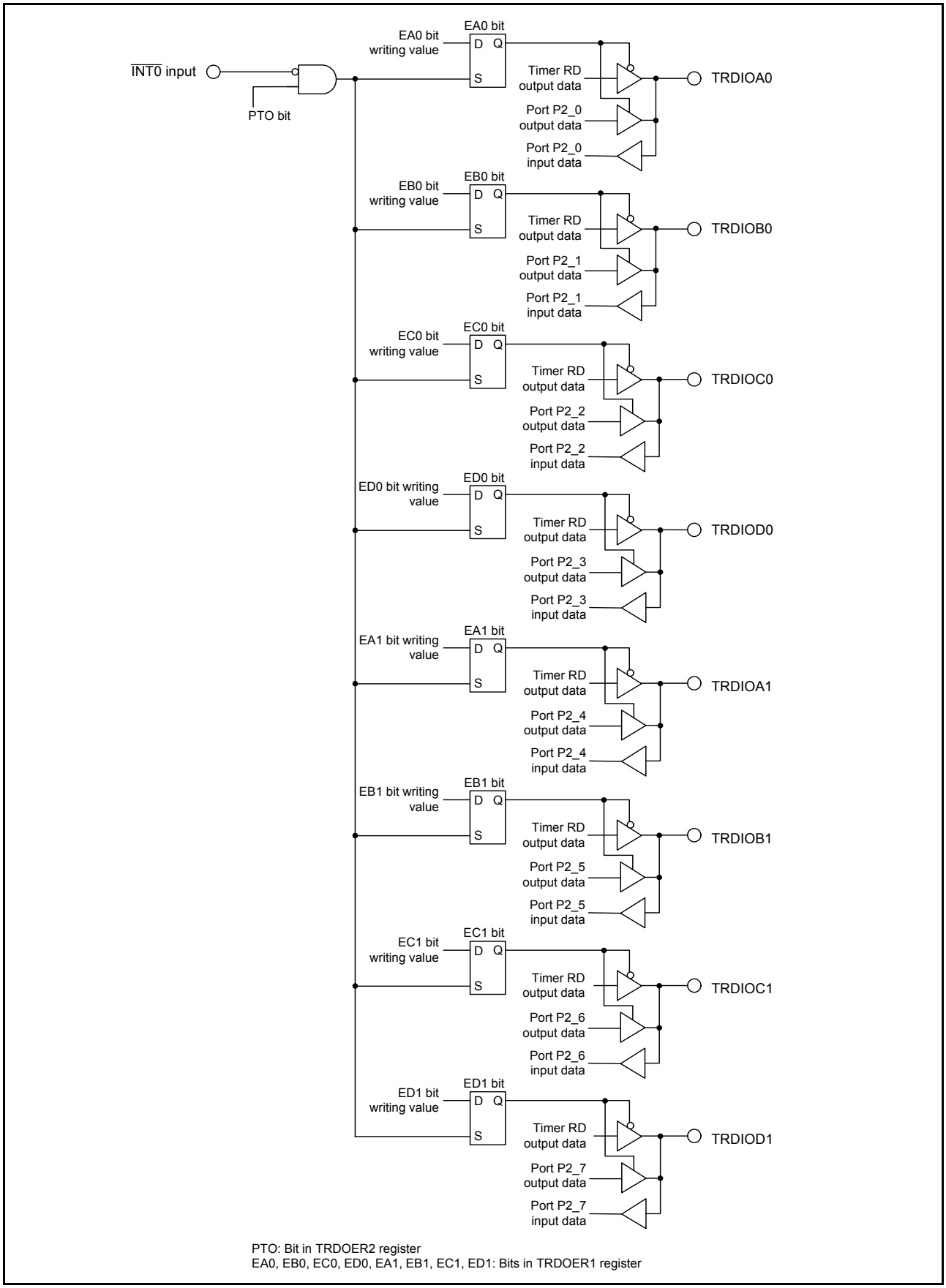


Figure 3.3 Pulse Output Forced Cutoff

3.6 PWM Mode

In PWM mode, a PWM waveform is output. Up to three PWM waveforms with the same period can be output by 1 channel. Also, up to six PWM waveforms with the same period can be output by synchronizing channels 0 and 1. Since this mode functions by a combination of the TRDIOji (i = 0 or 1, j = B, C, or D) pin and TRDGRji register, the PWM mode, or any other mode or function, can be selected for each individual pin. (However, since the TRDGRAi register is used when using any pin for PWM mode, the TRDGRAi register cannot be used for other modes.)

Figure 3.4 shows a Block Diagram of PWM Mode, and Table 3.13 lists the PWM Mode Specifications. Figures 3.5 to 3.13 show the Registers Associated with PWM Mode, and Figures 3.14 and 3.15 show the Operations of PWM Mode.

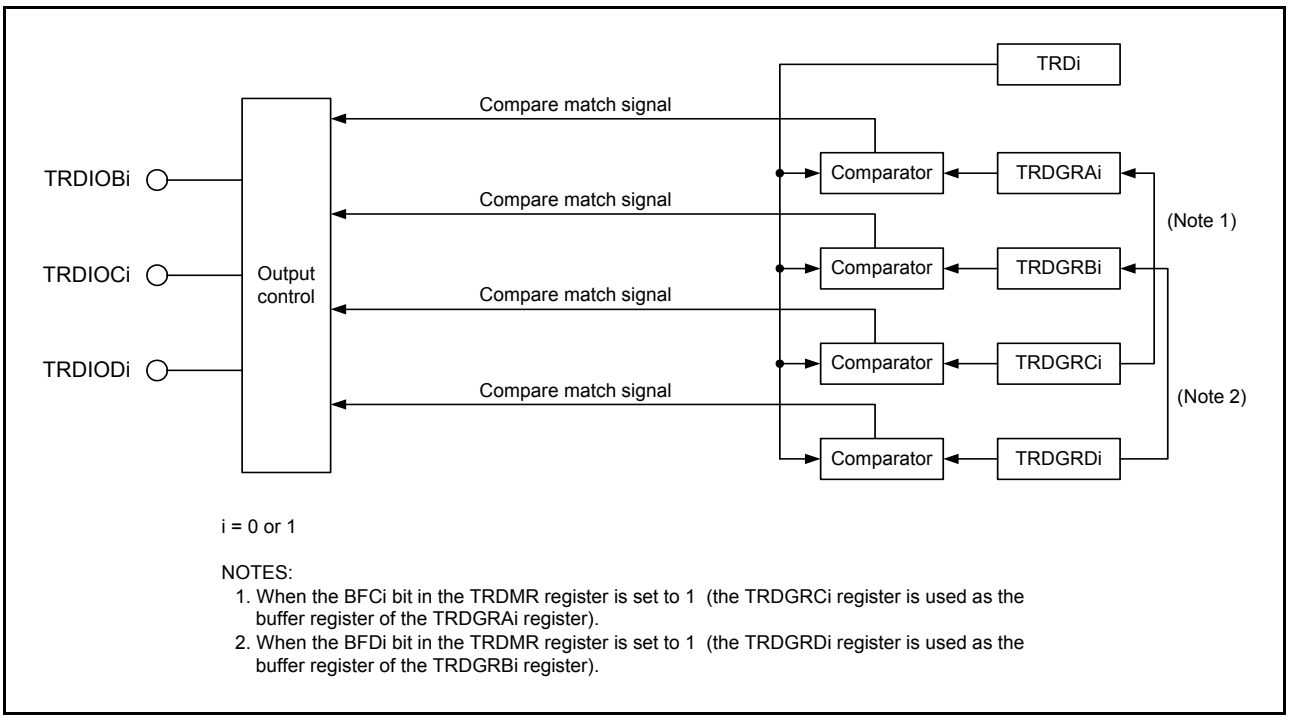
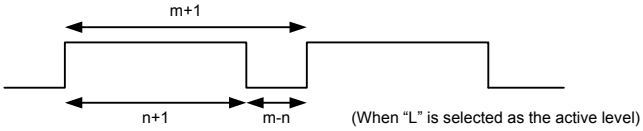


Figure 3.4 Block Diagram of PWM Mode

Table 3.13 PWM Mode Specifications

Item	Specification
Count sources	f1, f2, f4, f8, f32, fOCO40M External signal input to the TRDCLK pin (valid edge selected by a program)
Count operations	Increment
PWM waveform	PWM period: 1/fk x (m+1) Active level width: 1/fk x (m-n) Inactive level width: 1/fk x (n+1) fk: Frequency of count source m: Value set in the TRDGRAi (i = 0 or 1) register n: Value set in the TRDGRji (j = B, C, or D) register 
Count start condition	1 (count starts) is written to the TSTARTi bit in the TRDSTR register.
Count stop conditions	• 0 (count stops) is written to the TSTARTi bit in the TRDSTR register when the CSELi bit in the TRDSTR register is set to 1. • The PWM output pin holds output level before the count stops. • When the CSELi bit in the TRDSTR register is set to 0, the count stops at the same time as the TRDi register is set to 0000h at the compare match in the TRDGRAi register. • The PWM output pin holds level after output change by compare match.
Interrupt request generation timing	• Compare match (the content of the TRDi register matches the content of the TRDGRji register.) • TRDi register overflows
TRDIOA0 pin function	Programmable I/O port or TRDCLK (external clock) input
TRDIOA1 pin function	Programmable I/O port
TRDIOB0, TRDIOC0, TRDIOD0, TRDIOB1, TRDIOC1, TRDIOD1 pin functions	Programmable I/O port or pulse output (selectable by pin)
$\overline{\text{INT0}}$ pin function	Programmable I/O port, pulse output forced cutoff signal input, or $\overline{\text{INT0}}$ interrupt input
Read from timer	The count value can be read by reading the TRDi register.
Write to timer	The value can be written to the TRDi register.
Select functions	• One to three PWM output pins selected per channel • Either one pin or multiple pins of the TRDIOBi, TRDIOCi or TRDIODi pin. • The active level selected by pin. • Initial output level selected by pin. • Synchronous operation (refer to **3.4 Synchronous Operation**) • Buffer operation (refer to **3.3 Buffer Operation**) • Pulse output forced cutoff signal input (refer to **3.5 Pulse Output Forced Cutoff**)

i = 0 or 1

Timer RD Start Register(1)

b7 b6 b5 b4 b3 b2 b1 b0

Symbol	Address	After Reset
TRDSTR	0137h	11111100b

Bit Symbol	Bit Name	Function	RW
TSTART0	TRD0 count start flag(4)	0: Count stops(2) 1: Count starts	RW
TSTART1	TRD1 count start flag(5)	0: Count stops(3) 1: Count starts	RW
CSEL0	TRD0 count operation select bit	0: Count stops at compare match with the TRDGRA0 register after the count is cleared 1: Count continues at compare match with the TRDGRA0 register after the count is cleared	RW
CSEL1	TRD1 count operation select bit	0: Count stops at compare match with the TRDGRA1 register after the count is cleared 1: Count continues at compare match with the TRDGRA1 register after the count is cleared	RW
— (b7 - b4)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—

NOTES:
1. Set the TRDSTR register using the MOV instruction (do not use the bit handling instruction). Refer to **3.8.1 TRDSTR Register** of **Notes on Timer RD**.
2. When the CSEL0 bit is set to 1, write 0 to the TSTART0 bit.
3. When the CSEL1 bit is set to 1, write 0 to the TSTART1 bit.
4. When the CSEL0 bit is set to 0 and the compare match signal (TRDIOA0) is generated, this bit is set to 0 (count stops).
5. When the CSEL1 bit is set to 0 and the compare match signal (TRDIOA1) is generated, this bit is set to 0 (count stops).

Timer RD Mode Register

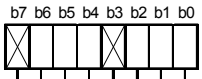
b7 b6 b5 b4 b3 b2 b1 b0

Symbol	Address	After Reset
TRDMR	0138h	00001110b

Bit Symbol	Bit Name	Function	RW
SYNC	Timer RD synchronous bit	0: Registers TRD0 and TRD1 operate independently 1: Registers TRD0 and TRD1 operate synchronously	RW
— (b3 - b1)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—
BFC0	TRDGRC0 register function select bit	0: General register 1: Buffer register of TRDGRA0 register	RW
BFD0	TRDGRD0 register function select bit	0: General register 1: Buffer register of TRDGRB0 register	RW
BFC1	TRDGRC1 register function select bit	0: General register 1: Buffer register of TRDGRA1 register	RW
BFD1	TRDGRD1 register function select bit	0: General register 1: Buffer register of TRDGRB1 register	RW

Figure 3.5 Registers TRDSTR and TRDMR in PWM Mode

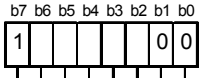
Timer RD PWM Mode Register



Symbol	Address	After Reset
TRDPMR	0139h	10001000b

Bit Symbol	Bit Name	Function	RW
PWMB0	PWM mode of TRDIOB0 select bit	0: Timer mode 1: PWM mode	RW
PWMC0	PWM mode of TRDIOC0 select bit	0: Timer mode 1: PWM mode	RW
PWMD0	PWM mode of TRDIOD0 select bit	0: Timer mode 1: PWM mode	RW
— (b3)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—
PWMB1	PWM mode of TRDIOB1 select bit	0: Timer mode 1: PWM mode	RW
PWMC1	PWM mode of TRDIOC1 select bit	0: Timer mode 1: PWM mode	RW
PWMD1	PWM mode of TRDIOD1 select bit	0: Timer mode 1: PWM mode	RW
— (b7)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—

Timer RD Function Control Register



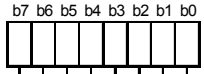
Symbol	Address	After Reset
TRDFCR	013Ah	10000000b

Bit Symbol	Bit Name	Function	RW
CMD0	Combination mode select bits(1)	Set to 00b (timer mode, PWM mode, or PWM3 mode) in PWM mode.	RW
CMD1			RW
OLS0	Normal-phase output level select bit (in reset synchronous PWM mode or complementary PWM mode)	This bit is disabled in PWM mode.	RW
OLS1	Counter-phase output level select bit (in reset synchronous PWM mode or complementary PWM mode)	This bit is disabled in PWM mode.	RW
ADTRG	A/D trigger enable bit (in complementary PWM mode)	This bit is disabled in PWM mode.	RW
ADEG	A/D trigger edge select bit (in complementary PWM mode)	This bit is disabled in PWM mode.	RW
STCLK	External clock input select bit	0: External clock input disabled 1: External clock input enabled	RW
PWM3	PWM3 mode select bit(2)	Set this bit to 1 (other than PWM3 mode) in PWM mode.	RW

NOTES:
1. Set bits CMD1 to CMD0 w hen both the TSTART0 and TSTART1 bits are set to 0 (count stops).
2. When bits CMD1 to CMD0 are set to 00b (timer mode, PWM mode, or PWM3 mode), the setting of the PWM3 bit is enabled.

Figure 3.6 Registers TRDPMR and TRDFCR in PWM Mode

Timer RD Output Master Enable Register 1



Symbol	Address	After Reset
TRDOER1	013Bh	FFh

Bit Symbol	Bit Name	Function	RW
EA0	TRDIOA0 output disable bit	Set this bit to 1 (the TRDIOA0 pin is used as a programmable I/O mode) in PWM mode.	RW
EB0	TRDIOB0 output disable bit	0: Enable output 1: Disable output (The TRDIOB0 pin is used as a programmable I/O mode.)	RW
EC0	TRDIOC0 output disable bit	0: Enable output 1: Disable output (The TRDIOC0 pin is used as a programmable I/O mode.)	RW
ED0	TRDIOD0 output disable bit	0: Enable output 1: Disable output (The TRDIOD0 pin is used as a programmable I/O mode.)	RW
EA1	TRDIOA1 output disable bit	Set this bit to 1 (the TRDIOA0 pin is used as a programmable I/O mode) in PWM mode.	RW
EB1	TRDIOB1 output disable bit	0: Enable output 1: Disable output (The TRDIOB1 pin is used as a programmable I/O mode.)	RW
EC1	TRDIOC1 output disable bit	0: Enable output 1: Disable output (The TRDIOC1 pin is used as a programmable I/O mode.)	RW
ED1	TRDIOD1 output disable bit	0: Enable output 1: Disable output (The TRDIOD1 pin is used as a programmable I/O mode.)	RW

Timer RD Output Master Enable Register 2

Symbol	Address	After Reset
TRDOER2	013Ch	01111111b

Bit Symbol	Bit Name	Function	RW
— (b6 - b0)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—
PTO	$\overline{INT0}$ of pulse output forced cutoff signal input enabled bit(1)	0: Pulse output forced cutoff input disabled 1: Pulse output forced cutoff input enabled (All bits in the TRDOER1 register are set to 1 (disable output) when "L" is applied to the $\overline{INT0}$ pin.)	RW

NOTE:
1. Refer to **3.5 Pulse Output Forced Cutoff.**

Figure 3.7 Registers TRDOER1 to TRDOER2 in PWM Mode

Timer RD Output Control Register(1)

b7	b6	b5	b4	b3	b2	b1	b0
			0				0

Symbol	Address	After Reset
TRDOCR	013Dh	00h

Bit Symbol	Bit Name	Function	RW
TOA0	TRDIOA0 output level select bit	Set this bit to 0 (enable output) in PWM mode.	RW
TOB0	TRDIOB0 output level select bit	0: Initial output is inactive level 1: Initial output is active level	RW
TOC0	TRDIOC0 initial output level select bit		RW
TOD0	TRDIOD0 initial output level select bit		RW
TOA1	TRDIOA1 initial output level select bit	Set this bit to 0 (enable output) in PWM mode.	RW
TOB1	TRDIOB1 initial output level select bit	0: Inactive level 1: Active level	RW
TOC1	TRDIOC1 initial output level select bit		RW
TOD1	TRDIOD1 initial output level select bit		RW

NOTE:
1. Write to the TRDOCR register when both the TSTART0 and TSTART1 bits in the TRDSTR register are set to 0 (count stops).

Timer RD Control Register i (i = 0 or 1)

b7	b6	b5	b4	b3	b2	b1	b0
0	0	1					

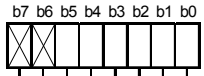
Symbol	Address	After Reset
TRDCR0	0140h	00h
TRDCR1	0150h	00h

Bit Symbol	Bit Name	Function	RW
TCK0	Count source select bits	b2 b1 b0 0 0 0: f1 0 0 1: f2 0 1 0: f4 0 1 1: f8 1 0 0: f32 1 0 1: TRDCLK input(1) 1 1 0: fOCO40M 1 1 1: Do not set.	RW
TCK1			RW
TCK2			RW
CKEG0	External clock edge select bits(2)	b4 b3 0 0: Count at the rising edge 0 1: Count at the falling edge 1 0: Count at both edges 1 1: Do not set.	RW
CKEG1			RW
CCLR0	TRDi counter clear select bits	Set to 001b (the TRDi register cleared at compare match with TRDGRAi register) in PWM mode.	RW
CCLR1			RW
CCLR2			RW

NOTES:
1. This setting is enabled when the STCLK bit in the TRDFCR register is set to 1 (external clock input enabled).
2. Bits CKEG1 to CKEG0 are enabled when bits TCK2 to TCK0 are set to 101b (TRDCLK input) and the STCLK bit in the TRDFCR register is set to 1 (external clock input enabled).

Figure 3.8 Registers TRDOCR, and TRDCR0 to TRDCR1 in PWM Mode

Timer RD Status Register i (i=0 or 1)[3]



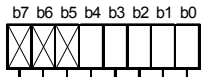
Symbol	Address	After Reset
TRDSR0	0143h	11100000b
TRDSR1	0153h	11000000b

Bit Symbol	Bit Name	Function	RW
IMFA	Input capture/compare match flag A	[Source for setting this bit to 0] Write 0 after read[2]. [Source for setting this bit to 1] When the value in the TRDi register matches with the value in the TRDGRAi register.	RW
IMFB	Input capture/compare match flag B	[Source for setting this bit to 0] Write 0 after read[2]. [Source for setting this bit to 1] When the value in the TRDi register matches with the value in the TRDGRBi register.	RW
IMFC	Input capture/compare match flag C	[Source for setting this bit to 0] Write 0 after read[2]. [Source for setting this bit to 1] When the value in the TRDi register matches with the value in the TRDGRCi register[3].	RW
IMFD	Input capture/compare match flag D	[Source for setting this bit to 0] Write 0 after read[2]. [Source for setting this bit to 1] When the value in the TRDi register matches with the value in the TRDGRDi register[3].	RW
OVF	Overflow flag	[Source for setting this bit to 0] Write 0 after read[2]. [Source for setting this bit to 1] When the TRDi register overflows.	RW
UDF	Underflow flag[1]	This bit is disabled in PWM mode.	RW
— (b7 - b6)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—

NOTES:
1. Nothing is assigned to b5 in the TRDSR0 register. When writing to b5, write 0. When reading, the content is 1.
2. The writing results are as follows:
   - This bit is set to 0 when the read result is 1 and 0 is written to the same bit.
   - This bit remains unchanged even if the read result is 0 and 0 is written to the same bit. (This bit remains 1 even if it is set to 1 from 0 after reading, and writing 0.)
   - This bit remains unchanged if 1 is written.
3. Including when the BFji bit in the TRDMR register is set to 1 (TRDGRji is used as the buffer register).

Figure 3.9 Registers TRDSR0 to TRDSR1 in PWM Mode

Timer RD Interrupt Enable Register i (i = 0 or 1)

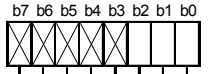


Symbol	Address	After Reset
TRDIER0	0144h	11100000b
TRDIER1	0154h	11100000b

Bit Symbol	Bit Name	Function	RW
IMIEA	Input capture/compare match interrupt enable bit A	0: Disable interrupt (IMIA) by the IMFA bit 1: Enable interrupt (IMIA) by the IMFA bit	RW
IMIEB	Input capture/compare match interrupt enable bit B	0: Disable interrupt (IMIB) by the IMFB bit 1: Enable interrupt (IMIB) by the IMFB bit	RW
IMIEC	Input capture/compare match interrupt enable bit C	0: Disable interrupt (IMIC) by the IMFC bit 1: Enable interrupt (IMIC) by the IMFC bit	RW
IMIED	Input capture/compare match interrupt enable bit D	0: Disable interrupt (IMID) by the IMFD bit 1: Enable interrupt (IMID) by the IMFD bit	RW
OVIE	Overflow /underflow interrupt enable bit	0: Disable interrupt (OVI) by the OVF bit 1: Enable interrupt (OVI) by the OVF bit	RW
— (b7 - b5)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—

Figure 3.10 Registers TRDIER0 to TRDIER1 in PWM Mode

Timer RD PWM Mode Output Level Control Register i (i = 0 or 1)

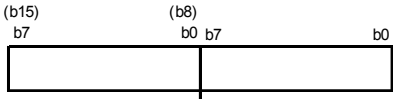


Symbol	Address	After Reset
TRDPOCR0	0145h	11111000b
TRDPOCR1	0155h	11111000b

Bit Symbol	Bit Name	Function	RW
POLB	PWM mode output level control bit B	0: “L” active TRDIOBi output level is selected 1: “H” active TRDIOBi output level is selected	RW
POLC	PWM mode output level control bit C	0: “L” active TRDIOCi output level is selected 1: “H” active TRDIOCi output level is selected	RW
POLD	PWM mode output level control bit D	0: “L” active TRDIODi output level is selected 1: “H” active TRDIODi output level is selected	RW
— (b7 - b3)	Nothing is assigned. If necessary, set to 0. When read, the content is 1.		—

Figure 3.11 Registers TRDPOCR0 to TRDPOCR1 in PWM Mode

Timer RD Counter i (i = 0 or 1)(1)



Symbol	Address	After Reset
TRD0	0147h-0146h	0000h
TRD1	0157h-0156h	0000h

Function	Setting Range	RW
Count a count source. Count operation is incremented. When an overflow occurs, the OVF bit in the TRDSRi register is set to 1.	0000h to FFFFh	RW

NOTE:
1. Access the TRDi register in 16-bit units. Do not access it in 8-bit units.

Figure 3.12 Registers TRD0 to TRD1 in PWM Mode

Timer RD General Registers Ai, Bi, Ci, and Di (i = 0 or 1)(1)

(b15) (b8)
b7 b0 b7 b0

Symbol	Address	After Reset
TRDGRA0	0149h-0148h	FFFFh
TRDGRB0	014Bh-014Ah	FFFFh
TRDGRC0	014Dh-014Ch	FFFFh
TRDGRD0	014Fh-014Eh	FFFFh
TRDGRA1	0159h-0158h	FFFFh
TRDGRB1	015Bh-015Ah	FFFFh
TRDGRC1	015Dh-015Ch	FFFFh
TRDGRD1	015Fh-015Eh	FFFFh

Function	RW
Refer to **Table 3.14 TRDGRji Register Functions in PWM Mode.**	RW

NOTE:
1. Access registers TRDGRAi to TRDGRDi in 16-bit units. Do not access them in 8-bit units.

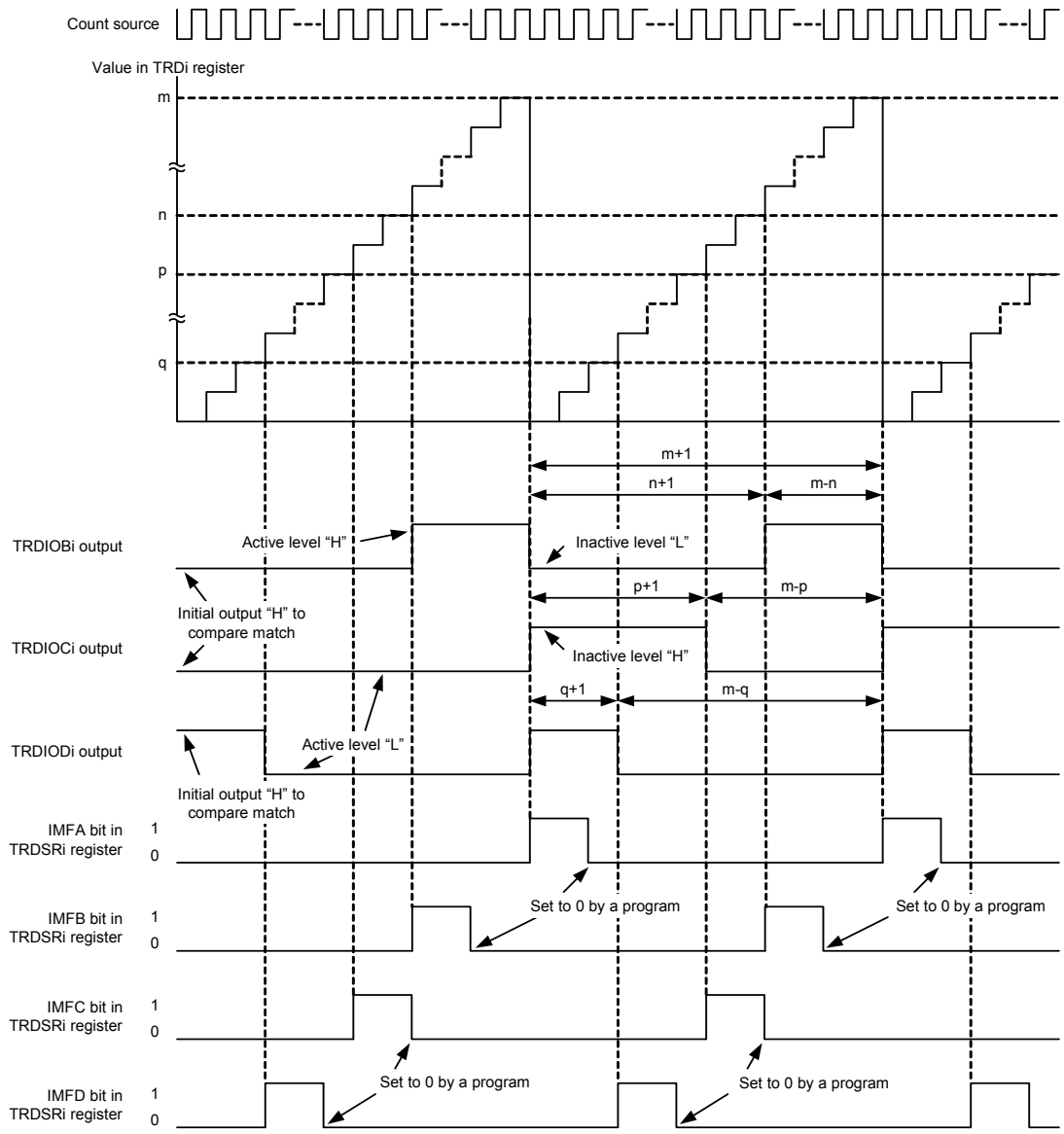
Figure 3.13 Registers TRDGRAi, TRDGRBi, TRDGRCi, and TRDGRDi in PWM Mode

The following registers are disabled in PWM mode: TRDDF0, TRDDF1, TRDIORA0, TRDIORC0, TRDIORA1, and TRDIORC1.

Table 3.14 TRDGRji Register Functions in PWM Mode

Register	Setting	Register Function	PWM Output Pin
TRDGRAi	–	General register. Set the PWM period	–
TRDGRBi	–	General register. Set the changing point of PWM output	TRDIOBi
TRDGRCi	BFCi = 0	General register. Set the changing point of PWM output	TRDIOCi
TRDGRDi	BFDi = 0		TRDIODi
TRDGRCi	BFCi = 1	Buffer register. Set the next PWM period (refer to **3.3 Buffer Operation**).	–
TRDGRDi	BFDi = 1	Buffer register. Set the changing point of the next PWM output (refer to **3.3 Buffer Operation**).	TRDIOBi

i = 0 or 1
BFCi, BFDi: Bits in TRDMR register



i = 0 or 1

m: Value set in TRDGRAi register
n: Value set in TRDGRBi register
p: Value set in TRDGRCi register
q: Value set in TRDGRDi register

The above applies under the following conditions:
Bits BFCi and BFDi in the TRDMR register are set to 0 (registers TRDGRCi and TRDGRDi are not used as buffer registers).
Bits EBi, ECi and EDi in the TRDOER1 register are set to 0 (enable TRDIOBi, TRDIOCi and TRDIODi pin outputs).
Bits TOBi and TOCi in the TRDOCR register are set to 0 (initial output “L” to compare match), the TODi bit is set to 1 (initial output “H” to compare match).
The POLB bit in the TRDPOCRi register is set to 1 (active level “H”), bits POLC and POLD are set to 0 (active level “L”).

Figure 3.14 Operating Example of PWM Mode

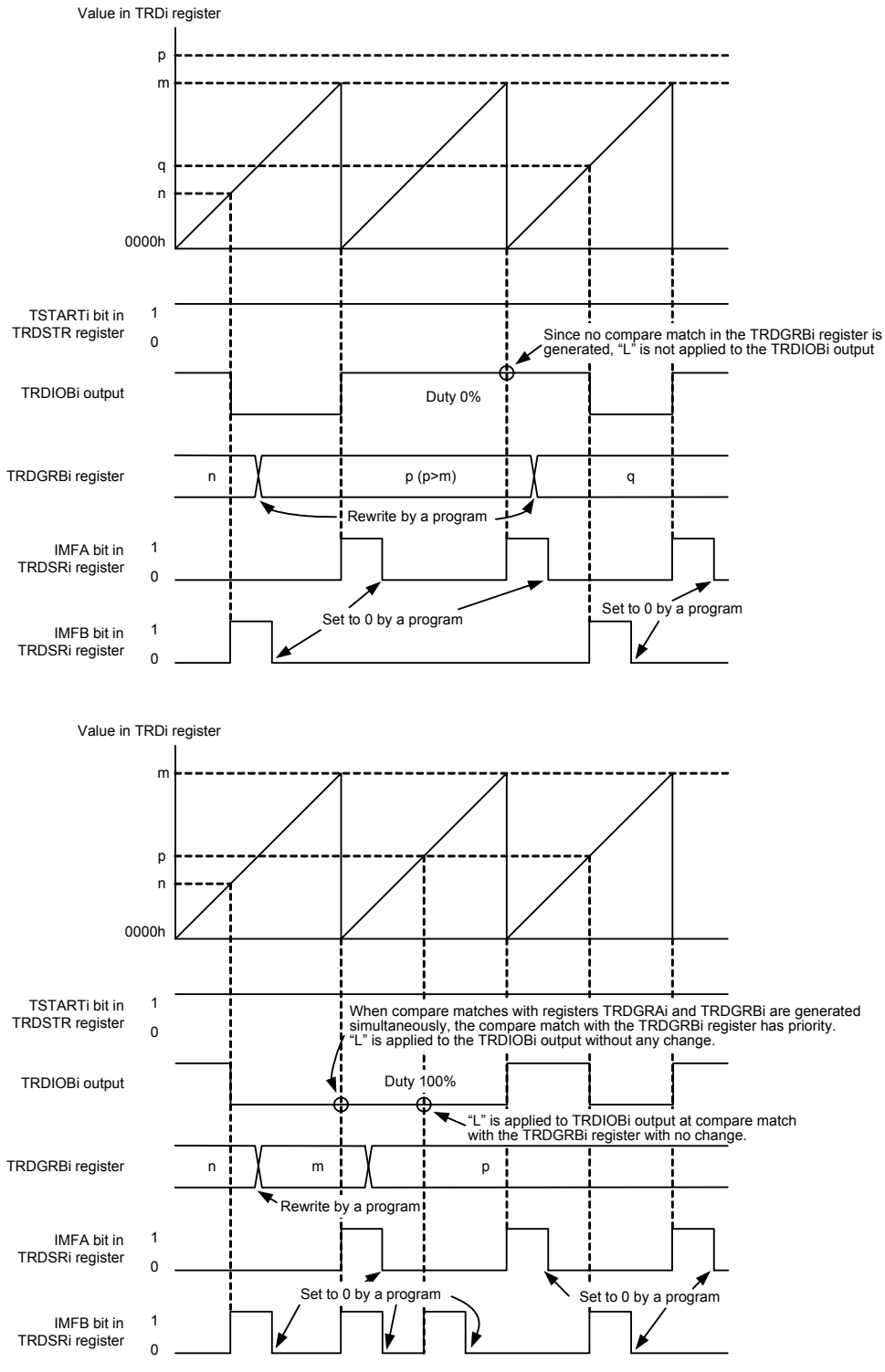


Figure 3.15 Operating Example of PWM Mode (Duty 0%, Duty 100%)

3.7 Timer RD Interrupt

Timer RD generates the timer RD interrupt request based on six sources for each channel. The timer RD interrupt has one TRDiIC register (bits IR, and ILVL0 to ILVL2), and one vector for each channel.
Table 3.15 lists the Registers Associated with Timer RD Interrupt, and Figure 3.16 shows a Block Diagram of Timer RD Interrupt.

Table 3.15 Registers Associated with Timer RD Interrupt

	Timer RD Status Register	Timer RD Interrupt Enable Register	Timer RD Interrupt Control Register
Channel 0	TRDSR0	TRDIER0	TRD0IC
Channel 1	TRDSR1	TRDIER1	TRD1IC

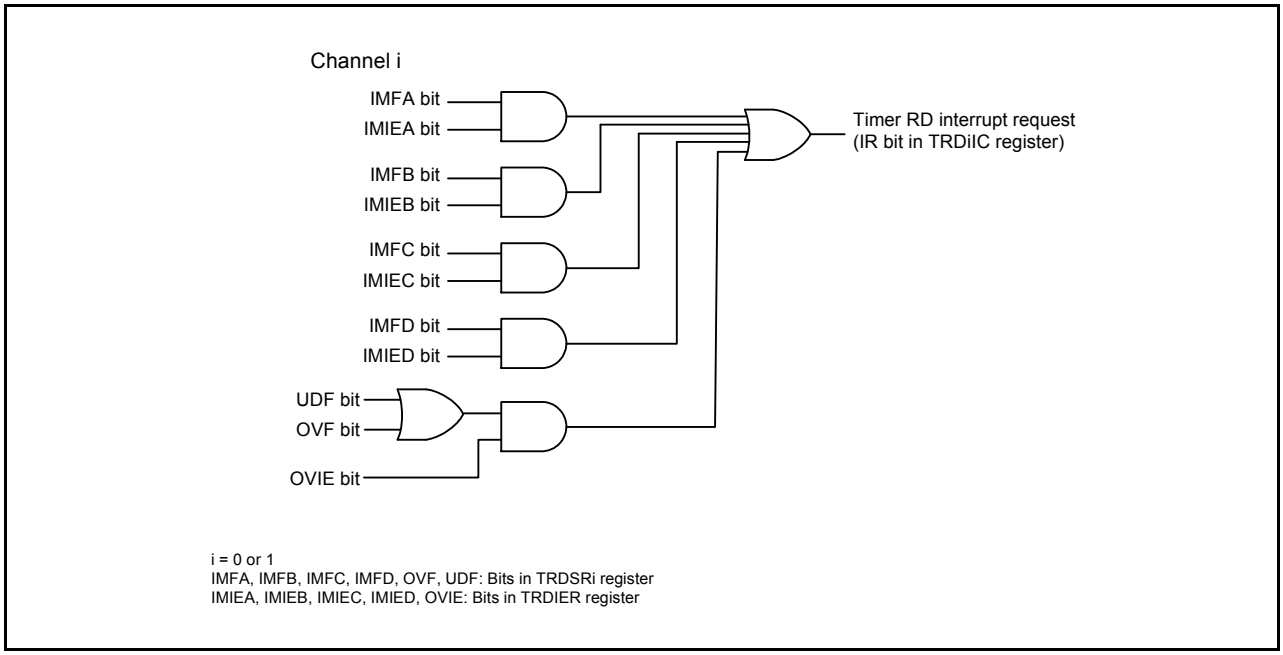


Figure 3.16 Block Diagram of Timer RD Interrupt

As with other maskable interrupts, the timer RD interrupt is controlled by the combination of the I flag, IR bit, bits ILVL0 to ILVL2, and IPL. However, since the interrupt source (timer RD interrupt) is generated by a combination of multiple interrupt request sources, the following differences from other maskable interrupts apply:

- When bits in the TRDSRi register corresponding to bits set to 1 in the TRDIERi register are set to 1 (enable interrupt), the IR bit in the TRDiIC register is set to 1 (interrupt requested).
- When either bits in the TRDSRi register or bits in the TRDIERi register corresponding to bits in the TRDSRi register, or both, are set to 0, the IR bit is set to 0 (interrupt not requested). Therefore, even though the interrupt is not acknowledged after the IR bit is set to 1, the interrupt request will not be maintained.
- When the conditions of other request sources are met, the IR bit remains 1.
- When multiple bits in the TRDIERi register are set to 1, which request source causes an interrupt is determined by the TRDSRi register.
- Since each bit in the TRDSRi register is not automatically set to 0 even if the interrupt is acknowledged, set each bit to 0 in the interrupt routine.

For information on how to set these bits to 0, refer to **Registers TRDSR0 to TRDSR1 in PWM Mode (Figure 3.9)**.

Refer to **Registers TRDSR0 to TRDSR1 in PWM Mode (Figure 3.9)** for the TRDSRi register. Refer to **Registers TRDIER0 to TRDIER1 in PWM Mode (Figure 3.10)** for the TRDIERi register.
Refer to the **R8C/25 Group Hardware Manual** for information on the TRDiIC register and the interrupt vectors.

3.8 Notes on Timer RD

3.8.1 TRDSTR Register

- Set the TRDSTR register using the MOV instruction.

- When the CSELi (i = 0 or 1) is set to 0 (the count stops after the count is cleared at compare match of registers TRDi and TRDGRAi), the count does not stop and the TSTARTi bit remains unchanged even if 0 (count stops) is written to the TSTARTi bit.
- Therefore, set the TSTARTi bit to 0 to change other bits without changing the TSTARTi bit when the CSELi bit is set to 0.
- To stop counting by a program, set the TSTARTi bit after setting the CSELi bit to 1. Although the CSELi bit is set to 1 and the TSTARTi bit is set to 0 at the same time (with one instruction), the count cannot be stopped.

- Table 3.16 lists the Timer RD Operation Clocks to use the TRDIOji (j = A, B, C, or D) pin with the timer RD output.

Table 3.16 TRDIOji (j = A, B, C, or D) Pin Output Level when Count Stops

Count Stop	TRDIOji Pin Output when Count Stops
When the CSELi bit is set to 1, set the TSTARTi bit to 0 and the count stops.	Hold the output level immediately before the count stops.
When the CSELi bit is set to 0, the count stops after the count is cleared at compare match of registers TRDi and TRDGRAi.	Hold the output level after output changes by compare match.

3.8.2 TRDi Register (i = 0 or 1)

- When writing the value to the TRDi register by a program while the TSTARTi bit in the TRDSTR register is set to 1 (count starts), avoid overlapping with the timing for setting the TRDi register to 0000h, and then write. If the timing for setting the TRDi register to 0000h overlaps with the timing for writing the value to the TRDi register, the value is not written and the TRDi register is set to 0000h.
  These precautions are applicable when selecting the following by bits CCLR2 to CCLR0 in the TRDCRi register.
  - 001b (Clear by the TRDi register at compare match with the TRDGRAi register.)
  - 010b (Clear by the TRDi register at compare match with the TRDGRBi register.)
  - 011b (Synchronous clear)
  - 101b (Clear by the TRDi register at compare match with the TRDGRCi register.)
  - 110b (Clear by the TRDi register at compare match with the TRDGRDi register.)

- When writing the value to the TRDi register and continuously reading the same register, the value before writing may be read. In this case, execute the JMP.B instruction between writing and reading.

```
Program example     MOV.W   #XXXXh, TRD0      ;Writing
                    JMP.B   L1                ;JMP.B
                L1: MOV.W   TRD0,DATA         ;Reading
```

3.8.3 TRDSRi Register (i = 0 or 1)

When writing the value to the TRDSRi register and continuously reading the same register, the value before writing may be read. In this case, execute the JMP.B instruction between writing and reading.

```
Program example     MOV.B   #XXh, TRDSR0      ;Writing
                    JMP.B   L1                ;JMP.B
                L1: MOV.B   TRDSR0,DATA       ;Reading
```

3.8.4 Count Source Switch

- Switch the count source after the count stops.

Change procedure

(1) Set the TSTARTi (i = 0 or 1) bit in the TRDSTR register to 0 (count stops).
(2) Change bits TCK2 to TCK0 in the TRDCRi register.

- When changing the count source from fOCO40M to another source and stopping fOCO40M, wait two or more cycles of f1 after setting the clock switch, and then stop fOCO40M.

Change procedure

(1) Set the TSTARTi (i = 0 or 1) bit in the TRDSTR register to 0 (count stops).
(2) Change bits TCK2 to TCK0 in the TRDCRi register.
(3) Wait two or more cycles of f1.
(4) Set the FRA00 bit in the FRA0 register to 0 (high-speed on-chip oscillator stops).

3.8.5 Count Source fOCO40M

- The count source fOCO40M can be used with supply voltage VCC = 3.0 to 5.5 V. For supply voltage other than that, do no set bits TCK2 to TCK0 in registers TRDCR0 and TRDCR to 110b (select fOCO40M as the count source).

4. Program Overview

This program can be used on timer RD to output a compare match signal between timer RD counter and general registers (TRDIOB0, TRDIOC0, and TRDIOD0) at the PWM period (100 µs).
The output signals are as follows:

TRDIOB0 pin: inactive level ("L") 25 µs = 40 MHz × (TRDGRB0 + 1) = 25 ns × 1000
active level ("H") 75 µs = 40 MHz × ((TRDGRA0 + 1) – (TRDGRB0 + 1))
= 25 ns × (4000 – 1000) = 25 ns × 3000

TRDIOC0 pin: inactive level ("L") 50 µs = 40 MHz × (TRDGRC0 + 1) = 25 ns × 2000
active level ("H") 50 µs = 40 MHz × ((TRDGRA0 + 1) – (TRDGRC0 + 1))
= 25 ns × (4000 – 2000) = 25 ns × 2000

TRDIOD0 pin: inactive level ("L") 75 µs = 40 MHz × (TRDGRD0 + 1) = 25 ns × 3000
active level ("H") 25 µs = 40 MHz × ((TRDGRA0 + 1) – (TRDGRD0 + 1))
= 25 ns × (4000 – 3000) = 25 ns × 1000

Set TRDGRA0 to the PWM period (100 µs).
100 µs = 40 MHz (TRDGRA0 + 1)
= 25 ns × 4000

The setting conditions of this program are as follows:
- Select the high-speed on-chip oscillator (fOCOM40M) as count source.
- Clear timer RD counter0 (TRD0) at compare match with TRDGRA0.
- For the TRDGRB0 pin, set the output level to active ("H") and the initial output level to inactive ("L")
- For the TRDGRC0 pin, set the output level to active ("H") and the initial output level to inactive ("L")
- For the TRDGRD0 pin, set the output level to active ("H") and the initial output level to inactive ("L")
- Output an active level signal ("H") from the TRDIOB0 output pin at compare match between TRD0 and TRDGRB0.
- Output an active level signal ("H") from the TRDIOC0 output pin at compare match between TRD0 and TRDGRC0.
- Output an active level signal ("H") from the TRDIOD0 output pin at compare match between TRD0 and TRDGRD0.
- Output an inactive level signal ("L") from the TRDIOB0, TRDIOC0, and TRDIOD0 output pins at compare match between TRD0 and TRDGRA0.
- Do not use the pulse output forced cutoff input function.

Figure 4.1 shows the Pin Used.

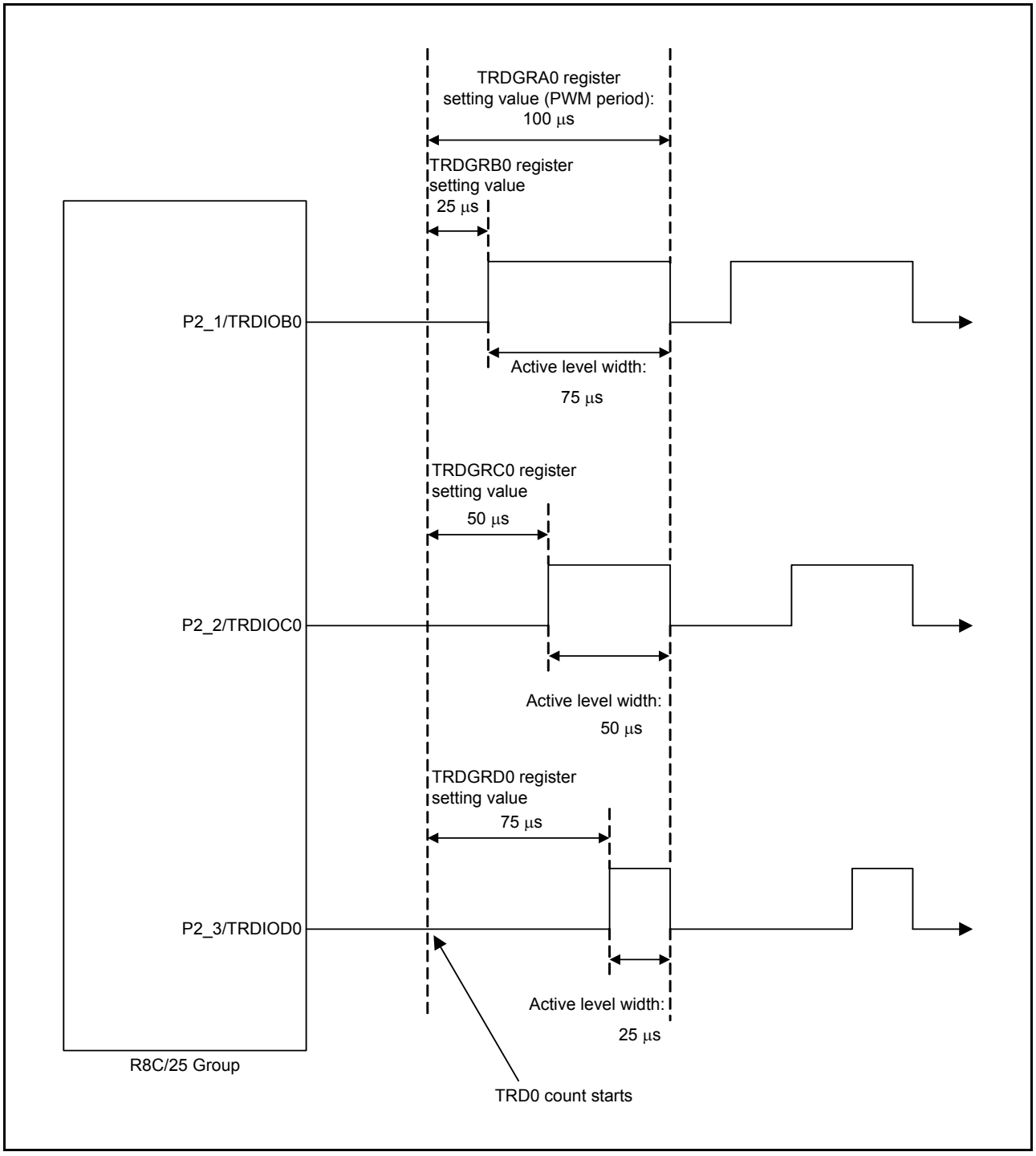


Figure 4.1 Pin Used

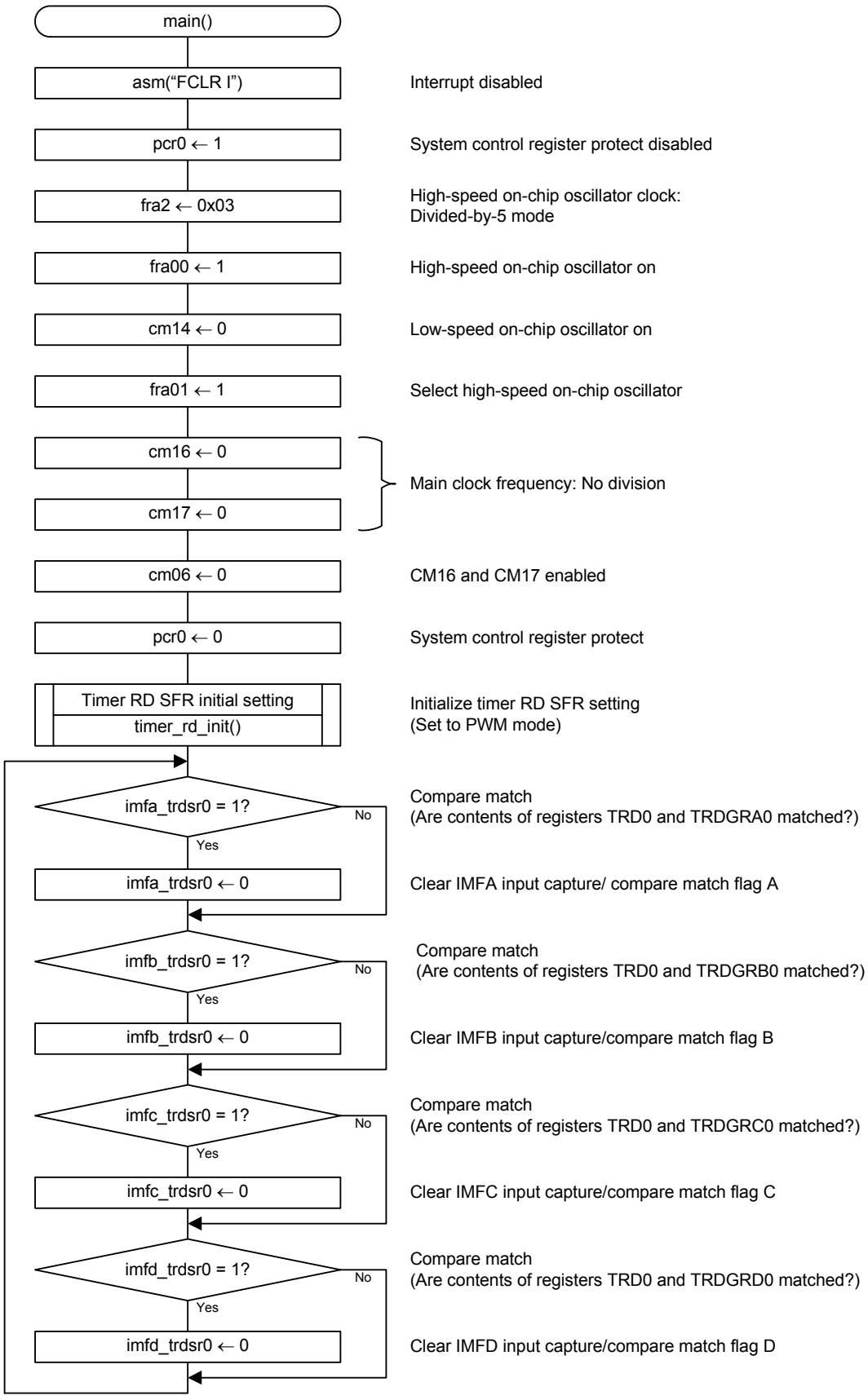
4.1 Function Table

Table 4.1

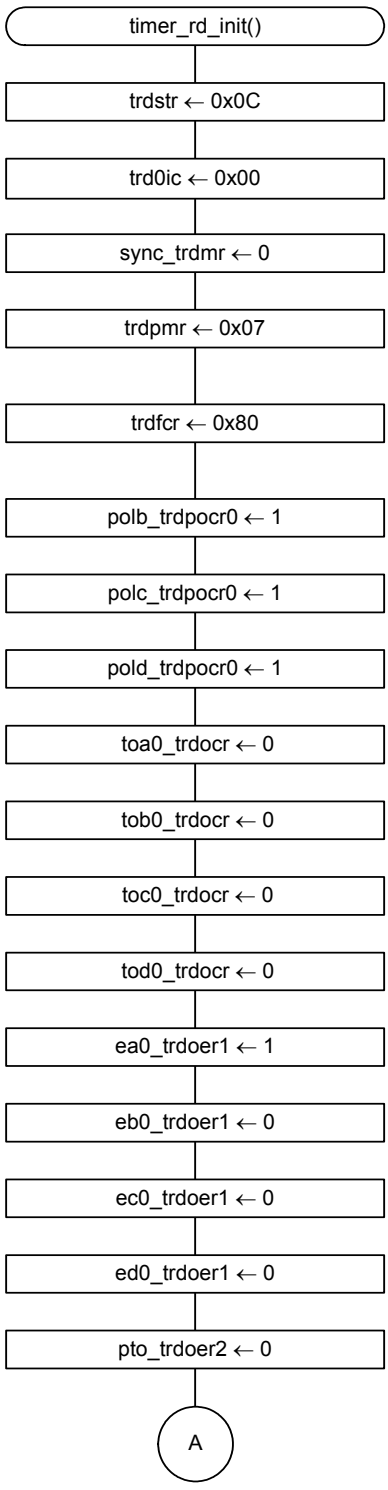
Declaration	void timer_rd_init(void)		
Overview	SFR initial setting associated with timer RD		
Argument	Argument name		Meaning
	None		
Variable used (global)	Variable name		Usage
	None		
Return value	Type	Value	Meaning
	None		
Function	Initialize the SFR registers associated with timer RD		

4.2 Flow chart

4.2.1 Main Function



4.2.2 Timer RD SER Initial Setting



TRD0 count stops

TRD0 interrupt disabled

Operate TRD0 and TRD1 individually

Set TRDIOB0, TRDIC0, and TRDID0 pins to PWM mode

CMD1 to CMD0: Set 00b in PWM mode
STCLK: External clock input disabled (0)
PWM3: Set to 1 in PWM mode

TRDIOB0 pin: Active “H”

TRDIOC0 pin: Active “H”

TRDIOD0 pin: Active “H”

Set to 0 in PWM mode

TRDIOB0 pin: Set initial output level to inactive “L”

TRDIOC0 pin: Set initial output level to inactive “L”

TRDIOD0 pin: Set initial output level to inactive “L”

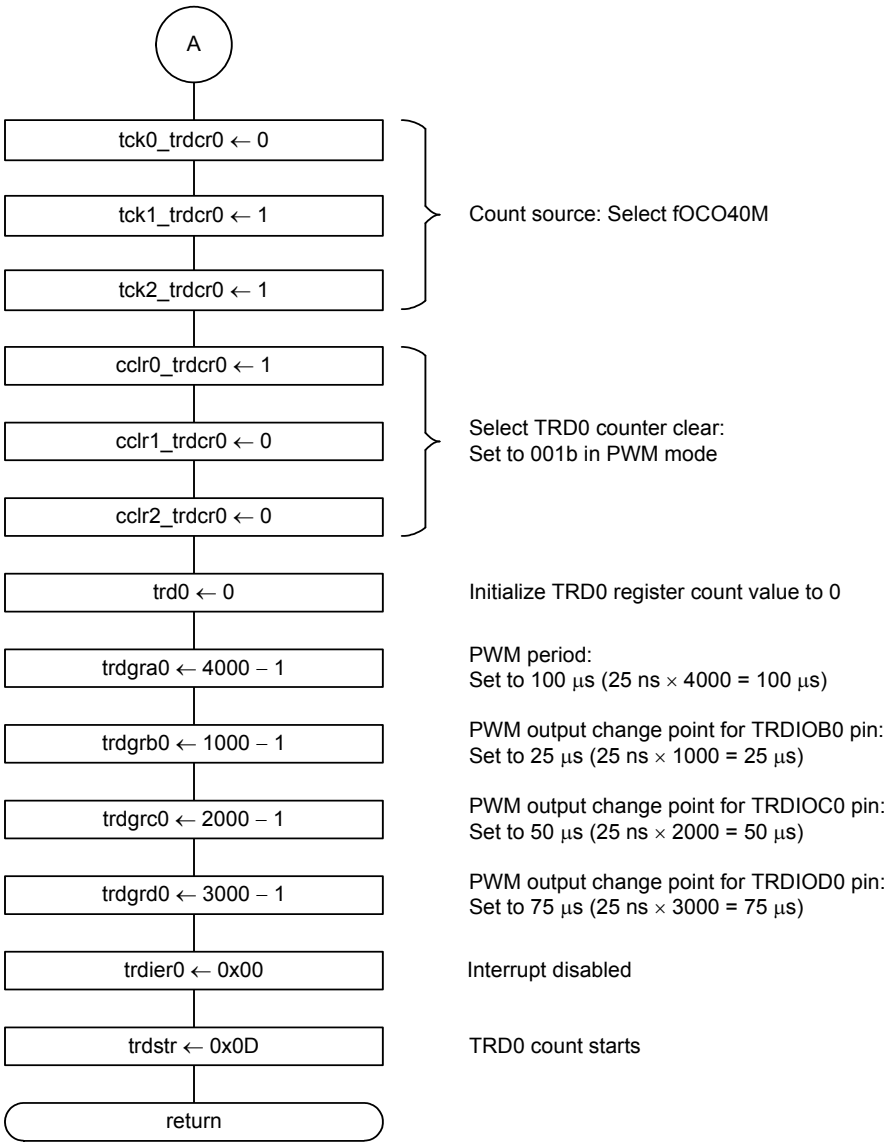
TRDIOA0 pin: Set to 1 in PWM mode

TRDIOB0 pin: Output disabled

TRDIOC0 pin: Output disabled

TRDIOD0 pin: Output disabled

Pulse output forced cutoff input disabled


A
tck0_trdcr0 ← 0
tck1_trdcr0 ← 1
tck2_trdcr0 ← 1
Count source: Select fOCO40M
cclr0_trdcr0 ← 1
cclr1_trdcr0 ← 0
cclr2_trdcr0 ← 0
Select TRD0 counter clear:
Set to 001b in PWM mode
trd0 ← 0
Initialize TRD0 register count value to 0
trdgra0 ← 4000 – 1
PWM period:
Set to 100 μs (25 ns × 4000 = 100 μs)
trdgrb0 ← 1000 – 1
PWM output change point for TRDIOB0 pin:
Set to 25 μs (25 ns × 1000 = 25 μs)
trdgrc0 ← 2000 – 1
PWM output change point for TRDIOC0 pin:
Set to 50 μs (25 ns × 2000 = 50 μs)
trdgrd0 ← 3000 – 1
PWM output change point for TRDIOD0 pin:
Set to 75 μs (25 ns × 3000 = 75 μs)
trdier0 ← 0x00
Interrupt disabled
trdstr ← 0x0D
TRD0 count starts
return

5. Sample Programming Code

A sample program can be downloaded from the Renesas Electronics website.

6. Reference Documents

User's Manual: Hardware
R8C/25 Group Hardware Manual
The latest version can be downloaded from the Renesas Electronics website.

Technical Update/Technical News
The latest information can be downloaded from the Renesas Electronics website.

Website and Support

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

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

REVISION HISTORY	R8C/25 Group Timer RD in PWM Mode

Rev.	Date	Description	
		Page	Summary
1.00	Dec 01, 2006	–	First Edition issued
1.10	June 1, 2012	1	Note on oscillation stabilization wait time added
		–	Previous document number: REJ05B0843

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins

   Handle unused pins in accord 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 one with a different part number, confirm that the change will not lead to problems.

   — The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.

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