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R32C/100 Series

Timer A Operation in Pulse-width Modulation Mode (16-bit PWM)

1. Abstract

This mode continuously outputs an arbitrary pulse width. The cycles are fixed. An interrupt request is generated at the falling edge of pulse-width modulation (PWM) output.

PWM high level output width = timer Ai register (i = 0 to 4) × timer count source period
PWM output period = (2^{16} - 1) × timer count source period

f1 = 25 MHz, fC = 32.768 kHz

Count Source	Count Source Period	High Level Width	PWM Period
f1	40 ns	40 ns to approx. 2.62 ms	Approx. 2.62 ms
f8	320 ns	320 ns to approx. 20.97 ms	Approx. 20.97 ms
f2n (n = 15)	1200 ns	1200 ns to approx. 78.6ms	Approx. 78.6 ms
fC32	Approx. 0.977 ms	Approx. 0.977 ms to approx. 63.99 s	64 s

2. Introduction

The application described in this document applies to the following MCU:

- MCU: R32C/118 Group

This program can be used with other R32C/100 Series MCUs which have the same special function registers (SFRs) as the R32C/118 Group. Check the manual for any additions or modifications to functions. Careful evaluation is recommended before using this application note.

3. Application Example

This section describes how to output a 20.97 ms period, 1.00 ms high level width PWM while using count source f8 when the rising edge is input to the TAiIN pin (i = 0 to 4).

3.1 Explanation

(1) While the TAiS bit in the TABSR register is 1 (count started), when the TAiIN pin input signal changes from low to high, the counter decrements the count source. At the same time, output level from the TAiOUT pin becomes high.
(2) Output from the TAiOUT pin changes from high to low when a specified amount of time passes. At the same time, the IR bit in the TAiIC register becomes 1 (interrupt requested).
(3) For every PWM pulse cycle that is output, the value from the reload register is reloaded, and the count continues.
(4) After setting the TAiS bit in the TABSR register to 0 (count stopped), the counter holds the count value and stops. At that time, if output from the TAiOUT pin is high, timer output becomes low, and the IR bit becomes 1 (interrupt requested). When the TAiOUT pin is low, there is no change in output and an interrupt request is not generated.

After setting the timer Ai register to 0000h, the pulse-width modulator does not operate, the TAiOUT pin outputs a low level signal, and a timer Ai interrupt request is not generated.

The diagram below shows operation timing.

This example assumes the TAi register setting value (reload register) is 0005h, and that an external trigger (at the rising edge of the input signal to the TAiIN pin) is selected.

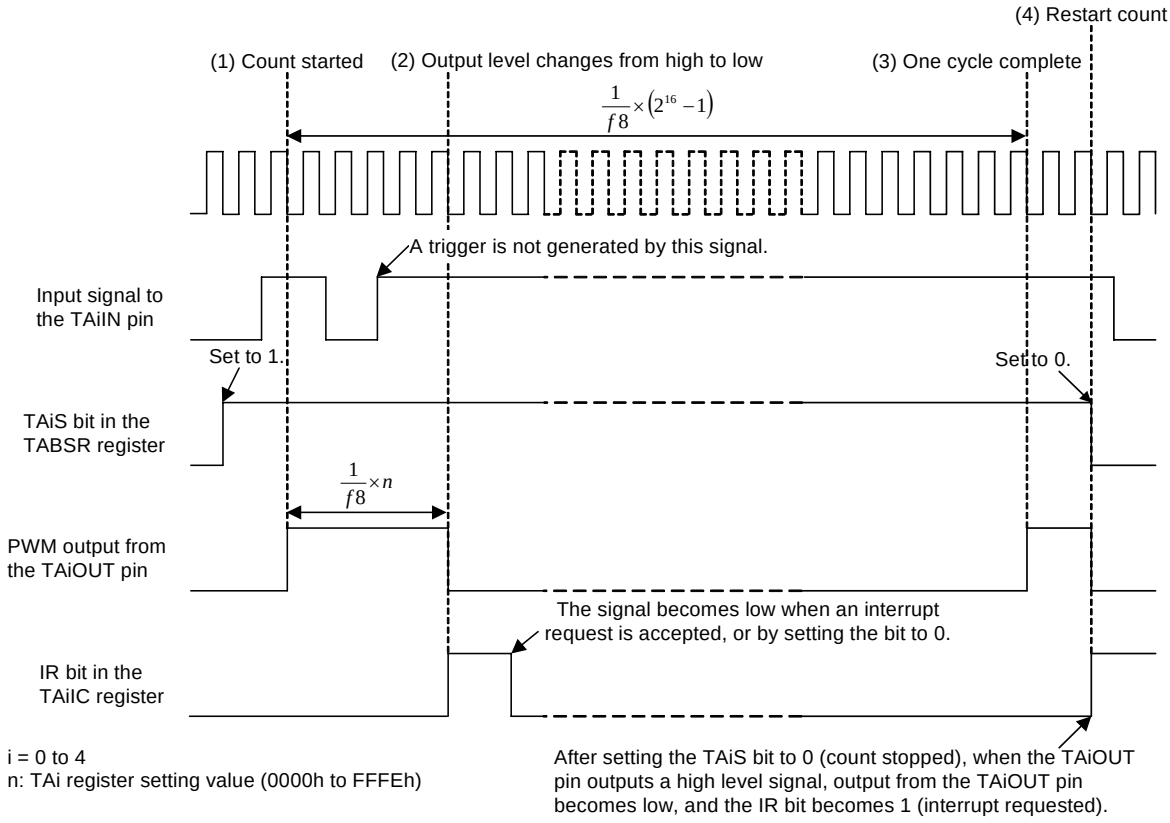


Figure 3.1 Operation in Pulse-width Modulation Mode (16-bit PWM)

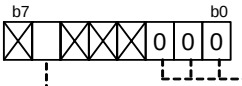
3.2 Setting

This section shows the procedures and values to set the example in section **3.1 "Explanation"**. Refer to individual MCU hardware manuals for details on individual registers.

(1) Set the function select registers. The TAiIN pin (i = 0 to 4) is assigned to P7_1 (TA0IN), P3_3 (TA1IN), P3_5 (TA2IN), P7_7 (TA3IN), and P3_7 (TA4IN). Set the output function select bit in the function select register to 000b (I/O port).

Port P3_j Function Select Register (P3_jS) (j = 3, 5, 7)

PSEL2 to PSEL0 — Port P3_j Output Function Select Bit
000b: I/O port P3_j



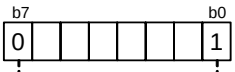
Port P7_k Function Select Register (P7_kS) (k = 1, 7)

PSEL2 to PSEL0 — Port P7_k Output Function Select Bit
000b: I/O port P7_k

NOD — N-channel Open-drain Output Select Bit
0: Push-pull output
1: N-channel open-drain output

When Using P7 and P8 with the TAiIN Pin

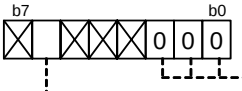
When setting the IFS00 bit in the IFS0 register (input function select register 0) to 1, the TAiIN pin is assigned to P7_1 (TA0IN), P7_3 (TA1IN), P7_5 (TA2IN), P7_7 (TA3IN), and P8_1 (TA4IN). Set the output function select bit in the function select register to 000b (I/O port).



Input Function Select Register 0 (IFS0)

IFS00 — Timer A Input Pin Switch Bit
1: Assign timer A input to port P7/port p8

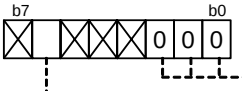
Set to 0.



Port P7_k Function Select Register (P7_kS) (k = 3, 5)

PSEL2 to PSEL0 — Port P7_k Output Function Select Bit
000b: I/O port P7_k

NOD — N-channel Open-drain Output Select Bit
0: Push-pull output
1: N-channel open-drain output



Port P8_1 Function Select Register (P8_1S)

PSEL2 to PSEL0 — Port P8_1 Output Function Select Bit
000b: I/O port P8_1

NOD — N-channel Open-drain Output Select Bit
0: Push-pull output
1: N-channel open-drain output

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(2) Set the port P3 and port P7 direction registers. Set the pins to be used at TAiIN pins (i = 0 to 4) as input ports.

b7 b0

Port P3 Direction Register (PD3)

PD3_3	Port P3_3 Direction Bit 0: Input port
PD3_5	Port P3_5 Direction Bit 0: Input port
PD3_7	Port P3_7 Direction Bit 0: Input port

b7 b0

Port P7 Direction Register (PD7)

PD7_1	Port P7_1 Direction Bit 0: Input port
PD7_7	Port P7_7 Direction Bit 0: Input port

When Using P7 and P8 with the TAiIN Pin

b7 b0

Port P7 Direction Register (PD7)

PD7_1	Port P7_1 Direction Bit 0: Input port
PD7_3	Port P7_3 Direction Bit 0: Input port
PD7_5	Port P7_5 Direction Bit 0: Input port
PD7_7	Port P7_7 Direction Bit 0: Input port

b7 b0

0

Port P8 Direction Register (PD8)

PD8_1	Port P8_1 Direction Bit 0: Input port
Set to 0.	

(3) Set the timer Ai mode register.

b7 b0

0 1 0 1 1 0 1 1

Timer Ai Mode Register (TAiMR)

TMOD1 to TMOD0	Operating Mode Select Bit 11b: Pulse-width modulation mode
Set to 0.	
MR1	External Trigger Select Bit 0: Falling edge of input signal to the TAiIN pin 1: Rising edge of input signal to the TAiIN pin
MR2	Trigger Select Bit 0: TAiS bit in the ONSF register 1: Selected using bits TAiTGH and TAiTGL in registers ONSF and TRGSR
MR3	16-/8-Bit PWM Mode Select Bit 0: 16-bit pulse-width modulator 1: 8-bit pulse-width modulator
TCK1 to TCK0	Count Source Select Bit 00b: f1 **01b: f8** 10b: f2n 11b: fC32

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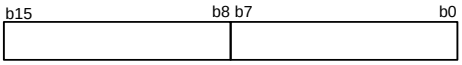
(4) Set the timer Ai register (i = 0 to 4).

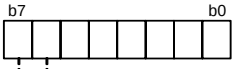


Timer Ai Register (TAi)

Setting range: 0000h to FFFEh

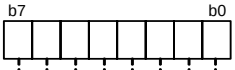
After setting the TAi register to 0000h, the pulse-width modulator does not operate, the TAiOUT pin is held low, and a TAi interrupt request is not generated.

(5) Set the one-shot start register and trigger select register.



One-Shot Start Register (ONSF)

TA0TGH to TA0TGL — Timer A0 Event/Trigger Select Bit
00b: Select the input to the TA0IN pin



Trigger Select Register (TRGSR)

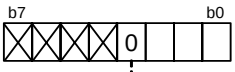
TA1TGH and TA1TGL — Timer A1 Event/Trigger Select Bit
00b: Select the input to the TA1IN pin

TA2TGH and TA2TGL — Timer A2 Event/Trigger Select Bit
00b: Select the input to the TA2IN pin

TA3TGH and TA3TGL — Timer A3 Event/Trigger Select Bit
00b: Select the input to the TA3IN pin

TA4TGH and TA4TGL — Timer A4 Event/Trigger Select Bit
00b: Select the input to the TA4IN pin

(6) Clear the interrupt request flag.



Timer Ai Interrupt Control Register (TAiIC)

IR — Interrupt Request Flag
0: No interrupt requested

The IR bit sometimes becomes 1 (interrupt requested) when rewriting the TMOD1 to TMOD0 bits in the TAiMR register to 11b (pulse width modulation mode). Set the TMOD1 to TMOD0 bits before clearing the IR bit.

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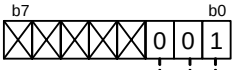
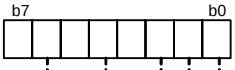
(7) Set TAiOUT (i = 0 to 4) output. The timer A output pin is assigned to P3_0 (TA0OUT), P3_2 (TA1OUT), P3_4 (TA2OUT), P3_1 (TA3OUT), and P3_6 (TA4OUT). When outputting a timer, set the output function select bit in the function select register to 001b (timer output), and the direction bit in the direction register to 1 (output).



Port P3_j Function Select Register (P3_jS) (j = 0, 1, 2, 4, 6)

PSEL2 to PSEL0	Port P3_j Output Function Select Bit 001b: Timer output

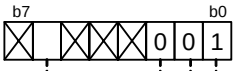


Port P3 Direction Register (PD3)

PD3_0	Port P3_0 Direction Bit 1: Output port
PD3_1	Port P3_1 Direction Bit 1: Output port
PD3_2	Port P3_2 Direction Bit 1: Output port
PD3_4	Port P3_4 Direction Bit 1: Output port
PD3_6	Port P3_6 Direction Bit 1: Output port

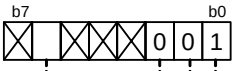
Using P7 and P8 with TAiOUT Output

The timer A output pin is also assigned to P7_0 (TA0OUT), P7_2 (TA1OUT), P7_4 (TA2OUT), P7_6 (TA3OUT), and P8_0 (TA4OUT). When outputting a timer, set the output function select bit in the function select register to 001b (timer output), and the direction bit in the direction register to 1 (output).



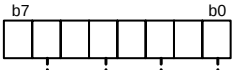
Port P7_k Function Select Register (P7_kS) (k = 0, 2, 4, 6)

PSEL2 to PSEL0	Port P7_k Output Function Select Bit 001b: Timer output
NOD	N-channel Open-drain Output Select Bit 0: Push-pull output 1: N-channel open-drain output



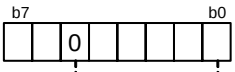
Port P8_0 Function Select Register (P8_0S)

PSEL2 to PSEL0	Port P8_0 Output Function Select Bit 001b: Timer output
NOD	N-channel Open-drain Output Select Bit 0: Push-pull output 1: N-channel open-drain output



Port P7 Direction Register (PD7)

PD7_0	Port P7_0 Direction Bit 1: Output port
PD7_2	Port P7_2 Direction Bit 1: Output port
PD7_4	Port P7_4 Direction Bit 1: Output port
PD7_6	Port P7_6 Direction Bit 1: Output port



Port P8 Direction Register (PD8)

PD8_0	Port P8_0 Direction Bit 1: Output port
Set to 0.	

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(8) Set the count start register.

Count Start Register (TABSR)

TA0S	Timer A0 Count Start Bit 1: Count started
TA1S	Timer A1 Count Start Bit 1: Count started
TA2S	Timer A2 Count Start Bit 1: Count started
TA3S	Timer A3 Count Start Bit 1: Count started
TA4S	Timer A4 Count Start Bit 1: Count started

4. Sample Program

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

5. Reference Documents

Hardware Manual
R32C/118 Group Hardware Manual Rev.1.00
The latest version can be downloaded from the Renesas Technology website.

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

C Compiler Manual
R32C/100 Series C Compiler Package Ver. 1.02 Compiler User's Manual Rev. 1.00
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REVISION HISTORY	Timer A Operation in Pulse-width Modulation Mode (16-bit PWM)

Rev.	Date		Description
		Page	Summary
1.00	Mar. 5, 2010	—	Initial release

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