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April 1st, 2010
Renesas Electronics Corporation

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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

\[ f_1 = 25 \text{ MHz}, \quad f_C = 32.768 \text{ kHz} \]

<table>
<thead>
<tr>
<th>Count Source</th>
<th>Count Source Period</th>
<th>High Level Width</th>
<th>PWM Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f_1 )</td>
<td>40 ns</td>
<td>40 ns to approx. 2.62 ms</td>
<td>Approx. 2.62 ms</td>
</tr>
<tr>
<td>( f_8 )</td>
<td>320 ns</td>
<td>320 ns to approx. 20.97 ms</td>
<td>Approx. 20.97 ms</td>
</tr>
<tr>
<td>( f_{2n} ) (n = 15)</td>
<td>1200 ns</td>
<td>1200 ns to approx. 78.6 ms</td>
<td>Approx. 78.6 ms</td>
</tr>
<tr>
<td>( f_C32 )</td>
<td>Approx. 0.977 ms</td>
<td>Approx. 0.977 ms to approx. 63.99 s</td>
<td>64 s</td>
</tr>
</tbody>
</table>

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.

![Operation in Pulse-width Modulation Mode (16-bit PWM)](image)

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).

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).

Continued on next page
Continued from previous page

(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.

**Port P3 Direction Register (PD3)**

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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

**Port P7 Direction Register (PD7)**

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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

When Using P7 and P8 with the TAiIN Pin

**Port P7 Direction Register (PD7)**

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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

**Port P8 Direction Register (PD8)**

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

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

(3) Set the timer Ai mode register.

**Timer Ai Mode Register (TAiMR)**

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- TMOD1 to TMOD0 Operating Mode Select Bit
  - 11b: Pulse-width modulation mode
  - 00b: Timer operation

- MR1 External Trigger Select Bit
  - 0: Input port
  - 1: Trigger select

- MR2 Trigger Select Bit
  - 0: Input port
  - 1: Trigger select

- MR3 16-/8-Bit PWM Mode Select Bit
  - 11b: 8-bit PWM mode
  - 01b: 16-bit PWM mode
  - 00b: Timer operation

- TCK1 to TCK0 Count Source Select Bit
  - 00b: f1
  - 01b: f8
  - 10b: f2n
  - 11b: fc32

Continued on next page
(4) Set the timer Ai register (i = 0 to 4).

Timer Ai Register (TAi)

<table>
<thead>
<tr>
<th>bit15</th>
<th>bit7</th>
<th>bit0</th>
</tr>
</thead>
</table>

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)

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
</table>

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

Trigger Select Register (TRGSR)

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
</table>

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

Timer A1 Event/Trigger Select Bit
00b: Select the input to the TA1IN pin

Timer A2 Event/Trigger Select Bit
00b: Select the input to the TA2IN pin

Timer A3 Event/Trigger Select Bit
00b: Select the input to the TA3IN pin

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)

<table>
<thead>
<tr>
<th>b7</th>
<th>b0</th>
</tr>
</thead>
</table>

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.
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).
(8) Set the count start register.

Count Start Register (TABSR)

b7 b6 b5 b4 b3 b2 b1 b0

- 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
   The latest version can be downloaded from the Renesas Technology website.
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http://www.renesas.com/

Inquiries
http://www.renesas.com/inquiry
csc@renesas.com

<table>
<thead>
<tr>
<th>REVISION HISTORY</th>
<th>Timer A Operation in Pulse-width Modulation Mode (16-bit PWM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rev. 1.00</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>Mar. 5, 2010</td>
</tr>
</tbody>
</table>

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