Abstract

This document describes using timer A to output a PWM waveform that has a variable period and duty ratio.

Products

R32C/116 Group
R32C/117 Group
R32C/118 Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.
Contents

1. Specifications ................................................................. 3
2. Operation Confirmation Conditions .................................. 4
3. Reference Application Notes ........................................... 4
4. Hardware ......................................................................... 4
  4.1 Pin Used .................................................................... 4
5. Software .......................................................................... 5
  5.1 Operation Overview .................................................... 5
  5.2 Constants .................................................................... 7
  5.3 Variable ....................................................................... 7
  5.4 Functions ..................................................................... 7
  5.5 Function Specifications ................................................ 8
  5.6 Flowcharts .................................................................... 9
    5.6.1 Main Processing ..................................................... 9
    5.6.2 Timer A0 Initial Setting ........................................... 9
    5.6.3 Timer A1 Initial Setting ........................................... 10
    5.6.4 Timer A0 Interrupt Handling .................................. 10
6. Sample Code .................................................................... 11
7. Reference Documents ....................................................... 11
1. Specifications

This document describes using timer A0 and timer A1 to output a PWM waveform that has a variable period and duty ratio. Connect timer A0 (in timer mode) to timer A1 (in one-shot timer mode). Alternate outputting PWM waveforms from port P7_2 (TA1OUT); alternate outputting a 1 ms PWM period and 0.5 ms high level width of a PWM pulse with a 0.5 ms PWM period and 0.1 ms high level width of a PWM pulse.

Table 1.1 lists the Peripheral Functions and Their Applications. Figure 1.1 shows the Timer Connection.

Table 1.1 Peripheral Functions and Their Applications

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer A0 in timer mode</td>
<td>Timer A1 trigger signal</td>
</tr>
<tr>
<td>Timer A1 in one-shot timer mode</td>
<td>Use TA1OUT output in PWM output</td>
</tr>
</tbody>
</table>

![Figure 1.1 Timer Connection](image-url)
2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

Table 2.1 Operation Confirmation Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU used</td>
<td>R5F64189DFD (R32C/118 Group)</td>
</tr>
</tbody>
</table>
| Operating frequencies     | Main clock: 16 MHz
                          | PLL clock: 100 MHz
                          | Base clock: 50 MHz
                          | CPU clock: 50 MHz
                          | Peripheral bus clock: 25 MHz
                          | Peripheral function clock source: 25 MHz |
| Operating voltage         | 5 V                                                                      |
| Integrated development    | Renesas Electronics Corporation                                           |
                          | High-performance Embedded Workshop Version 4.08                           |
| C compiler                | Renesas Electronics Corporation                                           |
                          | R32C/100 Series C Compiler V.1.02 Release 01                              |
                          | Compile options                                                          |
                          | -D__STACKSIZE__ =0X300 -D__ISTACKSIZE__ =0X300                             |
                          | -DVECTOR_ADR=0xFFFFFBDC -c -finfo -dir "$(CONFIGDIR)"                      |
                          | (Default setting is used in the integrated development environment.)      |
| Operating mode            | Single-chip mode                                                         |
| Sample code version       | Version 1.00                                                             |
| Renesas Starter kit       | R0K564189S000BE                                                          |

3. Reference Application Notes

Application notes associated with this application note are listed below. Refer to these application notes for additional information.

- R32C/100 Series Timer A Operation in Timer Mode (REJ05B1230-0100)
- R32C/100 Series Timer A Operation in One-shot Timer Mode (REJ05B1200-0100)

4. Hardware

4.1 Pin Used

Table 4.1 lists the Pin Used and Its Function.

Table 4.1 Pin Used and Its Function

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P7_2</td>
<td>Output</td>
<td>TA1OUT output (outputs a PWM waveform)</td>
</tr>
</tbody>
</table>
5. Software

5.1 Operation Overview

(1) Initial setting
Perform initial setting for timer A0 and timer A1. Table 5.1 lists the initial setting values for timer A0 and timer A1.

<table>
<thead>
<tr>
<th>Table 5.1 Initial Setting Values for Timer A0 and Timer A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Start trigger</td>
</tr>
<tr>
<td>Count source</td>
</tr>
<tr>
<td>Port output</td>
</tr>
<tr>
<td>Count value</td>
</tr>
<tr>
<td>Gate function</td>
</tr>
</tbody>
</table>

(2) Timer A0 count starts
When the TA0S or TA1S bit in the TABSR register is set to 1 (start counter), the timer A0 counter starts counting.

(3) Timer A0 underflows
When the timer A0 counter underflows, the value in the reload register is reloaded and the count continues. At this time, the IR bit in the TA0IC register becomes 1 (interrupt requested).

(4) Timer A1 count starts
The timer A0 underflow is the trigger that starts the timer A1 counter. At the same time, the output level of the TA1OUT pin becomes high.

(5) Count value reset
The timer A0 and timer A1 count values are reset by the timer A0 interrupt occurring. Table 5.2 lists the interrupt setting values of timer A0 and timer A1.

<table>
<thead>
<tr>
<th>Table 5.2 Interrupt Setting Values of Timer A0 and Timer A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count value</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Each count value is reloaded when timer A0 underflows and timer A1 underflows, respectively. Thereafter, each time the timer A0 interrupt occurs, the count values in Table 5.1 and Table 5.2 are alternately set to timer A0 and timer A1.

(6) Timer A1 underflows
When the timer A1 counter value becomes 0, the output level of the TA1OUT pin becomes low, the counter reloads the value from the reload register and stops counting.
Figure 5.1 shows the Timing Diagram.

![Timing Diagram](image)

Figure 5.1  Timing Diagram
5.2 Constants
Table 5.3 lists the Constants Used in the Sample Code.

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Setting Value</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM_INTERVAL</td>
<td>12500 - 1</td>
<td>PWM period (timer A0 initial setting value is 0.5 ms)</td>
</tr>
<tr>
<td>PWM_H_PERIOD</td>
<td>2500</td>
<td>High level width of PWM pulse (timer A1 initial setting value is 0.1 ms)</td>
</tr>
<tr>
<td>PWM_INTERVAL_VARIATE</td>
<td>12500</td>
<td>Variate of PWM period (0.5 ms)</td>
</tr>
<tr>
<td>PWM_H_PERIOD_VARIATE</td>
<td>10000</td>
<td>Variate of high level width of PWM pulse (0.4 ms)</td>
</tr>
<tr>
<td>MAX_INT_CNT</td>
<td>2</td>
<td>Maximum value of int_cnt</td>
</tr>
</tbody>
</table>

5.3 Variable
Table 5.4 lists the Global Variable.

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Contents</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>unsigned char</td>
<td>int_cnt</td>
<td>Number of timer A0 interrupt occurrences</td>
<td>_timer_a0</td>
</tr>
</tbody>
</table>

5.4 Functions
Table 5.5 lists the Functions.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>timer_a0_init</td>
<td>Timer A0 initial setting</td>
</tr>
<tr>
<td>timer_a1_init</td>
<td>Timer A1 initial setting</td>
</tr>
<tr>
<td>_timer_a0</td>
<td>Timer A0 interrupt handling</td>
</tr>
</tbody>
</table>
5.5 Function Specifications

The following tables list the sample code function specifications.

<table>
<thead>
<tr>
<th>Function</th>
<th>Outline</th>
<th>Header</th>
<th>Declaration</th>
<th>Description</th>
<th>Argument</th>
<th>Returned value</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>timer_a0_init</td>
<td>Timer A0 initial setting</td>
<td>None</td>
<td>void timer_a0_init(void)</td>
<td>Initial setting to use timer A0 in timer mode. The count value is set to 12500 - 1 (0.5 ms), and the timer A0 interrupt is also set.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>timer_a1_init</td>
<td>Timer A1 initial setting</td>
<td>None</td>
<td>void timer_a1_init(void)</td>
<td>Initial setting to use timer A1 in one-shot timer mode. The timer A0 underflow is set as the trigger to start the count, and the count value is set to 2500 (0.1 ms). The timer A1 interrupt is disabled.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>_timer_a0</td>
<td>Timer A0 interrupt handling</td>
<td>None</td>
<td>void _timer_a0(void)</td>
<td>int_cnt increments and becomes 0 when it matches with MAX_INT_CNT. The count values for timer A0 and timer A1 are reset.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
5.6 Flowcharts

5.6.1 Main Processing

Figure 5.2 shows the Main Processing.

![Flowchart for Main Processing]

- **main**
  - Disable maskable interrupts
  - I flag ← 0
  - Set PLL clock
    - SetPLLClock()
  - Initial setting of timer A0
    - timer_a0_init()
  - Initial setting of timer A1
    - timer_a1_init()
  - Initialize port P7_2
    - P7_2S register ← 01h
    - Bits PSEL2 to PSEL0 = 001b: Timer A1 (TA1OUT) output
    - PD7 register
      - PD7_2 bit ← 1: Output port
  - Enable maskable interrupts
  - I flag ← 1
  - TABSR register ← 03h
    - TA0S bit = 1
    - TA1S bit = 1
  - Start timer A0 and timer A1 counts

Figure 5.2 Main Processing

5.6.2 Timer A0 Initial Setting

Figure 5.3 shows the initial setting for timer A0.

![Flowchart for Timer A0 Initial Setting]

- **timer_a0_init**
  - Disable timer A0 interrupt
  - TA0IC register ← 00h
    - Bits ILVL2 to ILVL0 = 000b: Level 0 (interrupt disabled)
    - IR bit = 0: No interrupt requested
  - Stop timer A0 count
  - Set timer A0 mode register
    - TA0MR register ← 00h
      - Bits TMOD1 and TMOD0 = 00b: Timer mode
      - Bits MR2 and MR1 = 00b: No gate function
      - Bits TCK1 and TCK0 = 00b: f1
  - Set the timer A0 register
    - TA0 register ← 12500 - 1: 0.5 ms
  - Enable timer A0 interrupt
    - TA0IC register ← 03h
      - Bits ILVL2 to ILVL0 = 011b: Level 3
      - IR bit = 0: No interrupt requested

Figure 5.3 Timer A0 Initial Setting
5.6.3 Timer A1 Initial Setting

Figure 5.4 shows the initial setting of timer A1.

![Diagram of Timer A1 Initial Setting]

- **timer_a1_init**
  - Disable timer A1 interrupt
  - TA1IC register ← 00h
    - Bits ILVL2 to ILVL0 = 000b: Level 0 (interrupt disabled)
    - IR bit = 0: No interrupt requested
  - Stop timer A1 count
  - TA1MR register
    - TA1S bit ← 0
  - Set timer A1 mode register
    - TA1MR register ← 12h
      - Bits TMOD1 and TMOD0 = 10b: One-shot timer mode
      - MR2 bit = 1: Trigger select bit. Selected by bits TA1TGH
        and TA1TGL in the TRGSR register.
      - Bits TCK1 and TCK0 = 00b: f1
  - Set timer A1 register
    - TA1 register ← 2500: 0.1 ms
  - Set the trigger select register
    - TRGSR register ← 02h
      - Bits TA1TGH and TA1TGL = 10b: Timer A1 event/trigger select bit
        Select the underflow of TA0
  - Disable timer A1 interrupt (1)
    - TA1IC register ← 00h
      - Bits ILVL2 to ILVL0 = 000b: Level 0 (interrupt disabled)
      - IR bit = 0: No interrupt requested

Note:
1. When rewriting bits TMOD1 and TMOD0 in the TA1MR register to 10b (one-shot timer mode),
the IR bit may become 1 (interrupt requested), so it must be cleared.

Figure 5.4 Timer A1 Initial Setting

5.6.4 Timer A0 Interrupt Handling

Figure 5.5 shows the interrupt handling for timer A0.

![Diagram of Timer A0 Interrupt Handling]

- **_timer_a0**
  - Increment number of interrupts and then reset
    - int_cnt ← (int_cnt + 1) % 2: 0 or 1
  - Set timer A0 register
    - TA0 register ← 12500 - 1 + 12500 * int_cnt: 0.5 ms or 1 ms
  - Set timer A1 register
    - TA1 register ← 2500 + 10000 * int_cnt: 0.1 ms or 0.5 ms
  - Return

Figure 5.5 Timer A0 Interrupt Handling
6. **Sample Code**

   Sample code can be downloaded from the Renesas Electronics website.

7. **Reference Documents**

   R32C/118 Group User's Manual: Hardware Rev.1.10

   The latest versions can be downloaded from the Renesas Electronics website.

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

   C Compiler Manual
   R32C/100 Series C Compiler Package V.1.02
   C Compiler User’s Manual Rev.2.00

   The latest version can be downloaded from the Renesas Electronics website.

**Website and Support**

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

   Inquiries
   http://www.renesas.com/contact/
## R32C/100 Series
### Using Timer A to Output a Variable Period and Duty Ratio PWM Waveform

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Aug. 24, 2012</td>
<td>First edition issued</td>
</tr>
</tbody>
</table>

All trademarks and registered trademarks are the property of their respective owners.
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.

<table>
<thead>
<tr>
<th>1. Handling of Unused Pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Processing at Power-on</th>
</tr>
</thead>
<tbody>
<tr>
<td>The state of the product is undefined at the moment when power is supplied.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Prohibition of Access to Reserved Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to reserved addresses is prohibited.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Clock Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Differences between Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>
Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.

3. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics product.

5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

- "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots etc.
- "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; and safety equipment etc.

Renesas Electronics products are neither intended nor authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems, surgical implants etc.), or may cause serious property damage (nuclear reactor control systems, military equipment etc.). You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application for which it is not intended. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.

6. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard against the possibility of physical injury, injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technology may not be used for or incorporated into any products or systems where manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You should use Renesas Electronics products or technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. When exporting the Renesas Electronics products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations.

10. If the distributor or Renesas Electronics products, who distributes, disposes of, or otherwise places the product with a third party, to notify such third party in advance of the contents and conditions set forth in this document. Renesas Electronics assumes no liability if any Renesas Electronics product is used for any purpose other than as intended by Renesas Electronics.

11. The document may not be reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Notice 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Notice 2) "Renesas Electronics products" means any product developed or manufactured by or for Renesas Electronics.