1. Abstract

This document describes the setting procedure and operation example for multi-channel PWM output using DMA transfer.

2. Introduction

The application example described in this document applies to the following microcomputers (MCUs):

MCUs: R32C/116 Group, R32C/117 Group, and R32C/118 Group

This application note can be used with other R32C/100 Series MCUs which have the same special function registers (SFRs) as the above groups. Check the manuals for any modifications to functions. Careful evaluation is recommended before using the program described in this application note.
## 3. Application Example

This application example describes how to output 16 PWM pulses from ports P0 to P2 using timer B0 and two channels of DMAC. Change the PWM output every time timer B0 underflows.

Table 3.1 and Table 3.2 list the Clock Frequency Settings and DMAC Channel Settings, respectively.

**Note:**
1. Timer B0 setting: Timer mode, count source = f1 (25 MHz), cycle (change between 100 $\mu$s and 900 $\mu$s)

### Table 3.1 Clock Frequency Settings

<table>
<thead>
<tr>
<th>Clock</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main clock</td>
<td>16 MHz</td>
</tr>
<tr>
<td>PLL clock</td>
<td>100 MHz</td>
</tr>
<tr>
<td>Base clock</td>
<td>50 MHz</td>
</tr>
<tr>
<td>CPU clock</td>
<td>50 MHz</td>
</tr>
<tr>
<td>Peripheral bus clock</td>
<td>25 MHz</td>
</tr>
<tr>
<td>Peripheral function clock source</td>
<td>25 MHz</td>
</tr>
</tbody>
</table>

### Table 3.2 DMAC Channel Settings

<table>
<thead>
<tr>
<th>Item</th>
<th>DMA0</th>
<th>DMA1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer mode</td>
<td>Repeat transfer</td>
<td></td>
</tr>
<tr>
<td>Transfer size</td>
<td>8 bits</td>
<td></td>
</tr>
<tr>
<td>DMA request sources</td>
<td>Timer B0</td>
<td></td>
</tr>
<tr>
<td>Update source address</td>
<td>Incrementing addressing</td>
<td></td>
</tr>
<tr>
<td>Destination address</td>
<td>P0</td>
<td>P2</td>
</tr>
<tr>
<td>Update destination address</td>
<td>Non-incrementing addressing</td>
<td></td>
</tr>
<tr>
<td>Number of transfers</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Transfer complete interrupt</td>
<td>Not used</td>
<td></td>
</tr>
</tbody>
</table>
3.1 Operation

After setting ports P0 and P2 as output, timer B0 starts counting. Every time timer B0 underflows, a DMA transfer is generated, and a PWM pulse is output from ports P0 and P2.

Rewrite the TB0 register in the TB0 interrupt handler to change the PWM pulse output width.

Figure 3.1 shows the PWM Output Timing.

![PWM Output Timing Diagram](image)

Note:
1. The changed timer value in the timer B0 interrupt handler is reloaded to the counter at the next reload timing.

Figure 3.1 PWM Output Timing
3.2 Notes

• DMA Transfer Priority
  When multiple DMA transfer requests are generated simultaneously, channel priority is as follows:
  DMA0 > DMA1 > DMA2 > DMA3

• Delay Time When Timer B0 Starts
  In the initial pulse output, the difference from when the ports are set and timer B0 starts is the delay time.

• Delay Time of Pulse Output
  The actual pulse output is delayed by the delay time of the number of DMA transfer cycles + DMA transfer
  delay cycles after a timer B0 interrupt request is generated.
3.3 Flowcharts

Figure 3.2 to Figure 3.5 show the Main Function, the DMAi Setting (i = 0, 1), the Timer B0 Setting Function, and the Timer B0 Interrupt Function, respectively.

![Flowchart of Main Function]

Note:
1. Refer to the hardware user's manual for initializing the clock.

Figure 3.2 Main Function
Multi-channel PWM Output Using DMA Transfer

Figure 3.3 DMAi Setting (i = 0, 1)

(a) Set the DMDi register to DMA transfer disabled (1)

(b) DMiSL ← 08h
    DMiSL2 ← 00h

(c) DCTi ← 00000004h
    DCRi ← 00000004h

(d) Set the destination port register in the DDAi register.

(e) Set data table start address in the DSAi register.

(f) DMiIC ← 00h

(g) Insert dummy cycle

(h) DMDi ← 00000010h

(i) DMDi ← 00000013h

Start of DMAi setting

End of DMAi setting

Select DMA request sources.
DMAI request source select register
  DMA request source: Timer B0 interrupt request
  DMAi request source select register 2
  DMA request source: Software trigger
  Software DMA transfer request: DMA transfer request is not generated

Set the number of DMA transfers.
DMAI terminal count register
  Number of transfers: 4 times
  DMAi terminal count reload register
  Number of transfers: 4 times

Set the destination port register in the DDRi register.

Set data table start address in the DSRi register.

Set DMA transfer transfer complete interrupt request level.
Interrupt control register
  Interrupt request level: Level 0 (interrupt disabled)
  Interrupt request flag: No interrupt requested

(Note 2)

Set DMA transfer mode.
DMAI mode register
  Transfer mode: DMA transfer disabled
  Transfer size: 8 bits
  Source addressing mode: Incrementing addressing
  Destination addressing mode: Non-incrementing addressing

Enable DMA transfer.
DMAI mode register
  Transfer mode: repeat transfer

Notes:
1. Set DMAC-associated registers while bits MDi1 and MDi0 are 00b (DMA transfer disabled) (i = 0 to 3).
   Then, set bits MDi1 and MDi0 to 01b (single transfer) or 11b (repeat transfer) at the end of the setup procedure.
2. After setting registers DMiSL and DMiSL2, wait six or more peripheral clocks before enabling the DMA transfer (i = 0, 1).
Multi-channel PWM Output Using DMA Transfer

Figure 3.4 Timer B0 Setting Function

- **init_timerb0**
  - **(1)** $\text{TB0MR} \leftarrow 00\text{h}$
    - Set timer B0 mode register.
    - Operating mode: Timer mode
    - Count source: f1
  - **(2)** $\text{TB0} \leftarrow 2500 - 1$
    - Set 100 $\mu$s as time until interrupt request is generated.
  - **(3)** $\text{TB0IC} \leftarrow 06\text{h}$
    - Set the interrupt control register.
    - Interrupt priority level: Level 6
    - Interrupt request flag: No interrupt requested
  - **return**

Note:
1. The changed timer value in the timer B0 interrupt handler is reloaded to the counter at the next reload timing.

Figure 3.5 Timer B0 Interrupt Function

- **_timer_b0**
  - **(1)** 900 $\mu$s was set?
    - No
    - Yes
  - **(2)** Change setting time to 100 $\mu$s
  - **(3)** Change setting time (add 100 $\mu$s)
  - **(4)** Write a value to timer B0 to change the period until the interrupt $^{(1)}$
    - REIT

Note:
1. The changed timer value in the timer B0 interrupt handler is reloaded to the counter at the next reload timing.
4. Sample Program
A sample program can be downloaded from the Renesas Electronics website.

5. Reference Documents
User’s Manuals
- R32C/116 Group User’s Manual: Hardware Rev.1.00
- R32C/117 Group User’s Manual: Hardware Rev.1.00
- R32C/118 Group User’s Manual: Hardware Rev.1.00
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/inquiry
<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Nov. 26, 2010</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.

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.
Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.

2. 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.

3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.

4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application example. 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 losses incurred by you or third parties arising from the use of these circuits, software, or information.

5. When exporting the 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. You should not use Renesas Electronics products or the 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. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.

6. 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 or omissions from the information included herein.

7. Renesas Electronics products are classified according to the following three quality grades: “Standard”, “High Quality”, and “Specific”. The recommended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below. 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 categorized as “Specific” without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. 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 an application categorized as “Specific” or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics.

8. The quality grade of each Renesas Electronics product is “Standard” unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   9. “Standard” – Computer: office equipment; communication equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal equipment; industrial robots.

   10. “High Quality” – Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   11. “Specific” – Aircraft; aerospace equipment; submarine repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems); surgical implants; or healthcare intervention (e.g. aeration, etc.). and any other applications or purposes that pose a direct threat to human life.

9. 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.

10. 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 malfunction 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, and 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 a microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.

11. 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.

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

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

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.