Abstract

This document describes how to use the watchdog timer automatic count start in the R32C/100 Series.

Products

- R32C/120 Group
- R32C/121 Group
- R32C/145 Group
- R32C/151 Group
- R32C/152 Group
- R32C/153 Group
- R32C/156 Group
- R32C/157 Group
- R32C/160 Group
- R32C/161 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 Note ............................................................................................ 4  
4. Peripheral Functions ...................................................................................................... 5  
   4.1 Watchdog Timer ....................................................................................................... 5  
   4.2 Setting the Optional Function Select Area .............................................................. 6  
5. Hardware ....................................................................................................................... 6  
   5.1 Pins Used ............................................................................................................... 6  
6. Software ....................................................................................................................... 7  
   6.1 Operation Overview ............................................................................................... 7  
   6.2 Constants .............................................................................................................. 8  
   6.3 Variable .............................................................................................................. 8  
   6.4 Functions ............................................................................................................ 8  
   6.5 Function Specifications ....................................................................................... 9  
   6.6 Flowcharts ........................................................................................................... 10  
      6.6.1 Main Processing ............................................................................................. 10  
      6.6.2 Timer A0 Initial Setting ................................................................................ 11  
      6.6.3 Timer A0 Interrupt Handling ....................................................................... 11  
7. Sample Code .............................................................................................................. 12  
8. Reference Documents ............................................................................................... 12
1. Specifications

This chapter explains how to reset the MCU using the watchdog timer. Table 1.1 lists the Peripheral Functions and Their Applications. Figure 1.1 shows a Usage Example of the Watchdog Timer.

Table 1.1 Peripheral Functions and Their Applications

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watchdog timer</td>
<td>Reset source</td>
</tr>
<tr>
<td>Timer A (timer A0)</td>
<td>Write timing to the WDTS register</td>
</tr>
</tbody>
</table>

Figure 1.1 Usage Example of the Watchdog Timer

This diagram assumes the following:
The PM22 bit in the PM2 register is 0 (peripheral bus clock functions as watchdog timer count source).
The CM06 bit in the CM0 register is 0 (watchdog timer interrupt).
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>R5F64219JFB (R32C/121 Group)</td>
</tr>
<tr>
<td>Operating frequencies</td>
<td>- Main clock: 8 MHz</td>
</tr>
<tr>
<td></td>
<td>- PLL clock: 128 MHz</td>
</tr>
<tr>
<td></td>
<td>- Base clock: 64 MHz</td>
</tr>
<tr>
<td></td>
<td>- CPU clock: 64 MHz</td>
</tr>
<tr>
<td></td>
<td>- Peripheral bus clock: 32 MHz</td>
</tr>
<tr>
<td></td>
<td>- Peripheral function clock source: 32 MHz</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>5 V</td>
</tr>
<tr>
<td>Integrated development environment</td>
<td>Renesas Electronics</td>
</tr>
<tr>
<td></td>
<td>High-performance Embedded Workshop Version 4.07</td>
</tr>
<tr>
<td>C compiler</td>
<td>Renesas Electronics</td>
</tr>
<tr>
<td></td>
<td>R32C/100 Series C Compiler V.1.02 Release 01</td>
</tr>
<tr>
<td></td>
<td>Compile options</td>
</tr>
<tr>
<td></td>
<td>-D__STACKSIZE__=0X300 -D__ISTACKSIZE__=0X300</td>
</tr>
<tr>
<td></td>
<td>-DVECTOR_ADR=0xFFFFFBDC -c -finfo -dir &quot;$(CONFIGDIR)&quot;</td>
</tr>
<tr>
<td></td>
<td>Default setting is used in the integrated development environment.</td>
</tr>
<tr>
<td>Operating mode</td>
<td>Single-chip mode</td>
</tr>
<tr>
<td>Sample code version</td>
<td>Version 1.00</td>
</tr>
</tbody>
</table>

3. Reference Application Note

The application note listed below is associated with this application note. Refer to the following application note for additional information.

• R32C/100 Series Configuring PLL Mode (REJ05B1221-0100)
4. Peripheral Functions

This chapter provides supplementary information on the watchdog timer. Refer to the User’s Manual (hardware) for general information.

4.1 Watchdog Timer

The watchdog timer monitors program executions and detects defective programs. The 15-bit watchdog counter counts downward with the cycle which is the peripheral bus clock frequency or on-chip oscillator clock frequency divided by the prescaler.

The watchdog timer has two prescalers. One is the on-chip oscillator clock divided by 1, 2, 4, or 8; the other is the peripheral bus clock divided by 16 or 128.

Figure 4.1 shows the Watchdog Timer Block Diagram.

The general formula to calculate a watchdog timer period is:

Watchdog timer period = \frac{\text{Prescaler divider factor (16 or 128)} \times 32768}{\text{Peripheral bus clock frequency}}

or

Watchdog timer period = \frac{\text{Prescaler divider factor (1, 2, 4, or 8)} \times 2048}{\text{On-chip oscillator clock frequency}}

Depending on the timing of when a value is written to the WDTS register, a marginal error of one prescaler output cycle (maximum) may occur in the watchdog timer period.

Table 4.1 lists examples of watchdog timer periods.

Table 4.1 Examples of Watchdog Timer Periods When the Peripheral Bus Clock is 32 MHz and the On-Chip Oscillator is Approximately 125 kHz

<table>
<thead>
<tr>
<th>Count Source</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral bus clock divided by 16</td>
<td>Approximately 16.4 ms</td>
</tr>
<tr>
<td>Peripheral bus clock divided by 128</td>
<td>Approximately 131.1 ms</td>
</tr>
<tr>
<td>On-chip oscillator clock with no division</td>
<td>Approximately 16.4 ms</td>
</tr>
<tr>
<td>On-chip oscillator clock divided by 2</td>
<td>Approximately 32.8 ms</td>
</tr>
<tr>
<td>On-chip oscillator clock divided by 4</td>
<td>Approximately 65.5 ms</td>
</tr>
<tr>
<td>On-chip oscillator clock divided by 8</td>
<td>Approximately 131.1 ms</td>
</tr>
</tbody>
</table>
4.2 Setting the Optional Function Select Area

This section describes an example of creating a new project work space after selecting C source startup Application in the High-performance Embedded Workshop. The fixed vector table is defined in fvector.c. Figure 4.2 shows the Initial Settings of the Fixed Vector Table.

```
#pragma interrupt/v _dummy_int //udi
#pragma interrupt/v _dummy_int //over_flow
#pragma interrupt/v _dummy_int //brki
#pragma interrupt/v 0xffffffff
#pragma interrupt/v 0xffffffff
#pragma interrupt/v _dummy_int //wdt (1)
#pragma interrupt/v _dummy_int
#pragma interrupt/v _dummy_int //nmi
#pragma interrupt/v start

#pragma interrupt _dummy_int()
void _dummy_int(void);
void _dummy_int(void());

// Set ID Code Protection
//_asm(" .id ""#FFFFFFFFFFFFFFF;"");

// Set Optional Function Select Area
//_asm(" .ofsa 0FFH"); (2)

Notes:
1. Set this vector when using the watchdog timer interrupt.
2. Set this OFS area as shown in Figure 4.3 when using the watchdog timer automatic count start.
```

Figure 4.2 Initial Settings of the Fixed Vector Table

This area cannot be set by a program. Use a flash programmer when rewriting. Figure 4.3 shows an example of Setting the Optional Function Select Area.

```
_asm(" .ofsa 072H"); /* WDTON = 0 : Starts counting automatically */
/* WPSC1 and WPSC0 = 00b : Divide-by-8 (WDK3 and WDK2 = 00b) */
/* CSPM = 0 : Enabled (PM22 = 1) */
```

Figure 4.3 Setting the Optional Function Select Area

5. Hardware

5.1 Pins Used

Table 5.1 lists the Pins Used and Their Functions.

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P10_0 to P10_6</td>
<td>Output</td>
<td>Output level changes every 100 ms</td>
</tr>
</tbody>
</table>
6. Software

Write a value to the WDTS every 1 ms period and increment the output value of port P10 every 100 ms period. When the output value reaches 40h, incrementing stops and values are not written to the WDTS register. When the watchdog timer underflows, the MCU initializes the CPU, SFRs, and pins. Then the program is executed from the address listed in the reset vector. The settings are shown below.

Settings
- Set the watchdog timer to automatic count start.
- Set the watchdog timer on-chip oscillator prescaler to divided by 8.
- After a reset, set to count source protect mode (the on-chip oscillator clock is the watchdog timer count source).
- Do not use the watchdog timer interrupt.

6.1 Operation Overview

The sample program performs the following operations:

(1) Program write
   When writing a program to an on-chip flash area, set the OFS area to 72h.

(2) MCU reset
   As the WDTON bit in the OFS area is set to 0 (start counting automatically), after the MCU is reset, the watchdog timer automatically starts.

(3) Initial setting
   Initial settings are made for the watchdog timer, port P10, and timer A0.

(4) Timer A0 interrupt
   (4)-1 When the timer A0 interrupt occurs, a value is written to the WDTS register and the watchdog timer is initialized in the timer A0 interrupt processing. The port P10 output value increments every 100 ms.
   (4)-2 When the port P10 value is 40h, the WDTS is not written to, and the watchdog timer is not initialized.

(5) Watchdog timer reset
   When the watchdog timer underflows, the MCU initializes the CPU, SFRs, and pins. Then the program is executed from the address listed in the reset vector.

Figure 6.1 shows an Operation Example of the Sample Code.

![Figure 6.1 Operation Example of the Sample Code](image-url)
6.2 Constants

Table 6.1 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>D_MAX_P10_CNT</td>
<td>40h</td>
<td>When port P10 becomes 40h, the WDTS register becomes write disabled.</td>
</tr>
<tr>
<td>D_MAX_TA0_WAIT</td>
<td>100</td>
<td>This is used for changing the output level of port P10 in 100 ms intervals.</td>
</tr>
</tbody>
</table>

6.3 Variable

Table 6.2 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>uint16_t</td>
<td>cnt_ta0</td>
<td>This counter is used for changing the output level of port P10 in 100 ms intervals.</td>
<td>main, _timer_A0</td>
</tr>
</tbody>
</table>

6.4 Functions

Table 6.3 lists the Functions.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>timerA0_init</td>
<td>Timer A0 initial setting</td>
</tr>
<tr>
<td>_timer_a0</td>
<td>Timer A0 interrupt handling</td>
</tr>
</tbody>
</table>
## 6.5 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>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>timerA_init</td>
<td>Timer A0 initial setting</td>
<td>None</td>
<td>void timerA0_init</td>
<td>Set a 1 ms period timer.</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</td>
<td>Write a value to the WDTS every 1 ms period. Increment the output value of</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(void)</td>
<td>port P10 every 100 ms period. When the output value becomes 40h, stop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>incrementing and do not write values to the WDTS register.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


6.6 Flowcharts

6.6.1 Main Processing

Figure 6.2 shows the Main Processing.

```
main()
PLL clock setting
SetPLLClock()
Enable write protection
Watchdog timer function select
Disable write protection
Initialize port P10
Initial setting of timer A0
timerA0_init()
Enable maskable interrupts
Start the timer A0 count
```

- Set the OFS area value in advance. OFS area ← 72h
- WDTON bit = 0: Starts counting automatically
- Bits WPSC1 and WPSC0 = 00b: Divide-by-8
- CSPM bit = 0: Enabled (PM22 = 1)

- I flag ← 0
- Set each clock frequency in PLL mode.
- PRCR register ← 01h
  - PRC0 bit = 1: CM0 register is write enabled
- CM0 register
  - CM06 bit ← 1: Reset
- PRCR register ← 00h
  - PRC0 bit = 0: CM0 register is write disabled
- P10 register ← 00h
- PD10 register ← 7Fh

- I flag ← 1
- Enable maskable interrupts
- Start the timer A0 count
- TABSR register
  - TA0S bit ← 1

Figure 6.2 Main Processing
6.6.2 Timer A0 Initial Setting

Figure 6.3 shows the Timer A0 Initial Setting.

```
6.6.2 Timer A0 Initial Setting

Figure 6.3 Timer A0 Initial Setting

timerA0_init()

Set timer A0

TA0MR register ← 40h
  Bits TMOD1 and TMOD0 = 00b: Timer mode
  Bits MR2 and MR1 = 00b: No gate function
  Bits TCK1 and TCK0 = 01b: Count source is f8

TA0 register ← 4000 - 1: 1 ms timer setting (f8 = 4 MHz)

TA0IC register ← 01h
  Bits ILVL2 to ILVL0 = 001b: Level 1
  IR bit = 0: No interrupt requested

return
```

Figure 6.3 Timer A0 Initial Setting

6.6.3 Timer A0 Interrupt Handling

Figure 6.4 shows the Timer A0 Interrupt Handling.

```
6.6.3 Timer A0 Interrupt Handling

Figure 6.4 Timer A0 Interrupt Handling

_timer_a0

Is the port P10 output value less than 40h?

No

Yes

Disable write protection

Initialize watchdog timer count

Enable write protection

Has 100 ms elapsed?

No

Yes

PRCR4 register ← 01h
  PRC40 bit = 1: WDTS register is write enabled

WDTS register ← FFh

PRCR4 register ← 00h
  PRC40 bit = 0: WDTS register is write disabled

Is the port P10 output value less than 40h?

No

Yes

Increment the port P10 output value

return
```

Figure 6.4 Timer A0 Interrupt Handling
7. **Sample Code**
   Sample code can be downloaded from the Renesas Electronics website.

8. **Reference Documents**
   - R32C/120 Group User's Manual: Hardware Rev.1.10
   - R32C/121 Group User's Manual: Hardware Rev.1.10
   - R32C/152 Group User's Manual: Hardware Rev.1.10
   - R32C/156 Group User's Manual: Hardware Rev.1.10
   - R32C/160 Group User's Manual: Hardware Rev.1.02
   - R32C/161 Group User’s Manual: Hardware Rev.1.02
   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
   - 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/
# Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Feb. 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.

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 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 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 any 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 manufacturer, 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 in 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 depend 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.

- "Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal computer equipment, and industrial robots.
- "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 the support.
- "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 implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.

8. 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.

9. 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 them 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 safety design, such as safety circuits, 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 recombination software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.

10. 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.

11. This 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 2) "Renesas Electronics products/" means any product developed or manufactured by or for Renesas Electronics.