RX63N Group, RX631 Group

Pulse Period Measurement Using MTU2a

Abstract

This document describes a method to measure a pulse period input to the input capture input pin (MTIOC0A) using multi-function timer pulse unit 2 (hereinafter referred to as MTU) in the RX63N Group and RX631 Group.

Products

- RX63N Group 177-pin and 176-pin packages with a ROM size between 768 KB and 2 MB
- RX63N Group 145-pin and 144-pin packages with a ROM size between 768 KB and 2 MB
- RX63N Group 100-pin package with a ROM size between 768 KB and 2 MB
- RX631 Group 177-pin and 176-pin packages with a ROM size between 256 KB and 2 MB
- RX631 Group 145-pin and 144-pin packages with a ROM size between 256 KB and 2 MB
- RX631 Group 100-pin package with a ROM size between 256 KB and 2 MB

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

Using the input capture function of the MTU, measure the period of two consecutive rising edges of the pulse input to the MTIOC0A pin. Measurement starts from the first rising edge of the input pulse and a period is calculated from the second rising edge.

- Details
  
  Resolution: Approximately 83.3 ns
  
  Maximum measurable period: Approximately 358 seconds

Table 1.1 lists the Peripheral Function and Its Application and Figure 1.1 shows a Connection Diagram.

### Table 1.1 Peripheral Function and Its Application

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU2a channel 0 (hereinafter referred to as MTU0)</td>
<td>Measure a pulse period</td>
</tr>
</tbody>
</table>

**Figure 1.1 Connection Diagram**
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>R5F563NBDDFC (RX63N Group)</td>
</tr>
</tbody>
</table>
| Operating frequencies     | • Main clock: 12 MHz  
                            |   • PLL: 192 MHz (main clock divided by 1 and multiplied by 16)   
                            |   • System clock (ICLK): 96 MHz (PLL divided by 2)   
                            |   • Peripheral module clock B (PCLKB): 48 MHz (PLL divided by 4) |
| Operating voltage         | 3.3 V                                                                    |
| Integrated development   | Renesas Electronics Corporation                                         |
| environment              | High-performance Embedded Workshop Version 4.09.01                      |
| C compiler               | Renesas Electronics Corporation                                          |
|                          | C/C++ Compiler Package for RX Family V.1.02 Release 01                  |
|                          | Compile options                                                         |
|                          | -cpu=rx600 -output=obj="$(CONFIGDIR)\$(FILELEAF).obj" -debug -nologo   |
|                          | (The default setting is used in the integrated development environment.) |
| iodefine.h version        | Version 1.50                                                             |
| Endian                    | Little endian                                                            |
| Operating mode           | Single-chip mode                                                         |
| Processor mode           | Supervisor mode                                                          |
| Sample code version       | Version 1.00                                                             |
| Board used               | Renesas Starter Kit+ for RX63N (product part no.: R0K50563NS000BE)      |

3. Reference Application Note

For additional information associated with this document, refer to the following application note.

- RX63N Group, RX631 Group Initial Setting Rev. 1.00 (R01AN1245EJ0100_RX63N)

The initial setting functions in the reference application note are used in the sample code in this application note. The revision number of the reference application note is the one when this application note was made. However the latest version is always recommended. Visit the Renesas Electronics Corporation website to check and download the latest version.
4. Hardware

4.1 Pins Used

Table 4.1 lists the Pins Used and Their Functions.

The pins described here are for 176-pin products. When the product with less than 176-pin is used, select appropriate pins for the product used.

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P34/MTIOC0A</td>
<td>Input</td>
<td>Input a measurement pulse</td>
</tr>
<tr>
<td>P11</td>
<td>Output</td>
<td>Output an error signal</td>
</tr>
</tbody>
</table>

5. Software

This software calculates the period between two consecutive rising edges of a pulse input to the MTIOC0A pin. The number of overflows is counted in the overflow interrupt handler of the MTU0.TCNT register. When the number of overflows exceeds 65,535, an error signal is output and measurement stops. The pulse period is calculated in the MTU0 input capture A interrupt handler based on the number of overflows and the MTU0.TGRA register value.

Formula for calculating a pulse period: \(83.3 \text{ ns} \times (\text{number of overflows} \times 10000h + \text{MTU0.TGRA})\)

Below are the settings for the peripheral functions used in the software.

MTU0
- Count clock: Rising edge of PCLKB/4 (PCLKB = 48 MHz)
- Operating mode: Normal mode
- Synchronous operation: Not used
- Counter clear: Input capture of TGRA
- Timer general register (TGRA): Use as the input capture register
  Input capture at a rising edge of the MTIOC0A pin

Interrupts
- Input capture A interrupt (TGIA0)
  Interrupt priority level: 3
- Overflow interrupt (TCIV0) \(^{(1)}\)
  Interrupt priority level: 4
  Interrupt source: MTU0.TCNT overflow

Note:
1. The overflow interrupt of MTU0 (TCIV0) is assigned to the group 1 interrupt.
5.1 Operation Overview

5.1.1 Measuring a Pulse Period

(1) When the TSTR.CST0 bit is set to 1, MTU0 counter starts counting.

(2) When the MTIOC0A pin level changes from low to high, the MTU0.TCNT register value is transferred to the MTU0.TGRA register and the counter is cleared. At the same time, an MTU0 input capture A interrupt request is generated.

(3) In the input capture A interrupt handler, the measurement start flag is set to 1 (measurement starts) and the number of overflows is cleared.

(4) When the MTIOC0A pin level changes from low to high, the same operation as (2) is performed.

(5) A pulse period is calculated (pulse period 1 in Figure 5.1) based on the number of overflows of the MTU0.TCNT register (0 in (5) of Figure 5.1) and the MTU0.TGRA register value ((B) in Figure 5.1) in the input capture A interrupt handler. Then the number of overflows is cleared.

(6) When the MTU0.TCNT register overflows, an overflow interrupt request is generated.

(7) The number of overflows is counted in the overflow interrupt handler.

(8) When the MTIOC0A pin level changes from low to high, the same operation as (2) is performed.

(9) A pulse period is calculated (pulse period 2 in Figure 5.1) based on the number of overflows of the MTU0.TCNT register (1 in (9) of Figure 5.1) and the MTU0.TGRA register value ((C) in Figure 5.1) in the input capture A interrupt handler. Then the number of overflows is cleared.

Figure 5.1 shows the Timing Diagram of the Pulse Period Measurement. (1) to (9) in the figure correspond to (1) to (9) in the description above.

![Figure 5.1 Timing Diagram of the Pulse Period Measurement](image-url)
5.1.2 Operation When Input Capture and Overflow Occur Simultaneously

(1) When a rising edge occurs on the signal input to the MTIOC0A pin while the MTU0.TCNT register value is FFFFh, the MTU0.TCNT register is cleared and the input capture A interrupt request is generated after FFFFh in the MTU0.TCNT register is transferred to the MTU0.TGRA register.

(2) In the input capture A interrupt handler, the number of overflows is cleared.

(3) When the MTU0.TCNT register value overflows while an interrupt handler (hereinafter referred to as interrupt handler A) other than an overflow interrupt handler and input capture A interrupt handler is being executed, the overflow interrupt handler is delayed.

(4) When a rising edge occurs on the signal input to the MTIOC0A pin while interrupt handler A is being executed, the MTU0.TCNT register value is transferred to the MTU0.TGRA register and the input capture A interrupt request is generated (input capture A interrupt handler is delayed.)

(5) When interrupt handler A is completed, the overflow interrupt which has the higher interrupt priority level is executed first. In the overflow interrupt handler, the number of overflows increments by 1. In the input capture A interrupt handler which is subsequently accepted, the pulse period is calculated. Then the number of overflows is cleared.

Figure 5.2 shows the Timing Diagram When an Input Capture and Overflow Occur Simultaneously. (1) to (5) in the figure correspond to (1) to (5) in the description above.
Notes when embedding the sample codes

When embedding the sample code of this application note in the user system, note the following:

- When an interrupt used in this application note is delayed for a prolonged time due to other interrupt handlers, the sample code may not be executed properly.
- When the measured pulse period is short, the software cannot perform the processes in time and the pulse period cannot be measured properly.

5.2 File Composition

Table 5.1 lists the Files Used in the Sample Code. Files generated by the integrated development environment are not included in this table.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Outline</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>main.c</td>
<td>Main processing</td>
<td></td>
</tr>
<tr>
<td>r_init_stop_module.c</td>
<td>Stop processing for active peripheral functions</td>
<td></td>
</tr>
<tr>
<td>r_init_stop_module.h</td>
<td>Header file for r_init_stop_module.c</td>
<td></td>
</tr>
<tr>
<td>r_init_non_existent_port.c</td>
<td>Nonexistent port initialization</td>
<td></td>
</tr>
<tr>
<td>r_init_non_existent_port.h</td>
<td>Header file for r_init_non_existent_port.c</td>
<td></td>
</tr>
<tr>
<td>r_init_clock.c</td>
<td>Clock initialization</td>
<td></td>
</tr>
<tr>
<td>r_init_clock.h</td>
<td>Header file for r_init_clock.c</td>
<td></td>
</tr>
</tbody>
</table>

5.3 Option-Setting Memory

Table 5.2 lists the Option-Setting Memory Configured in the Sample Code. When necessary, set a value suited to the user system.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Address</th>
<th>Setting Value</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFS0</td>
<td>FFFF FF8Fh to FFFF FF8Ch</td>
<td>FFFF FFFFh</td>
<td>The IWDT is stopped after a reset. The WDT is stopped after a reset.</td>
</tr>
<tr>
<td>OFS1</td>
<td>FFFF FF8Bh to FFFF FF88h</td>
<td>FFFF FFFFh</td>
<td>The voltage monitor 0 reset is disabled after a reset. HOCO oscillation is disabled after a reset.</td>
</tr>
<tr>
<td>MDES</td>
<td>FFFF FF83h to FFFF FF80h</td>
<td>FFFF FFFFh</td>
<td>Little endian</td>
</tr>
</tbody>
</table>

5.4 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>P_OVF_ERR</td>
<td>PORT1.PODR.BIT.B1</td>
<td>Port output data register for error signal output</td>
</tr>
<tr>
<td>PD_OVF_ERR</td>
<td>PORT1.PDR.BIT.B1</td>
<td>Port direction register for error signal output</td>
</tr>
</tbody>
</table>
5.5 Variables

Table 5.4 lists the Global Variables.

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Contents</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>unsigned short</td>
<td>mtu0_ovf_cnt</td>
<td>Overflow counter of the MTU0.TCNT register</td>
<td>Excep_ICU_GROUP1, Excep_MTU0_TGIA0</td>
</tr>
<tr>
<td>unsigned long</td>
<td>pulse_cnt</td>
<td>Pulse period measurement counter</td>
<td>Excep_MTU0_TGIA0</td>
</tr>
<tr>
<td>unsigned char</td>
<td>start_flag</td>
<td>Measurement start flag 0: Measurement stopped</td>
<td>Excep_ICU_GROUP1, Excep_MTU0_TGIA0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Measurement starts</td>
<td></td>
</tr>
<tr>
<td>unsigned char</td>
<td>error_flag</td>
<td>Measurement error flag 0: Normal</td>
<td>Excep_ICU_GROUP1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Error</td>
<td></td>
</tr>
</tbody>
</table>

5.6 Functions

Table 5.5 lists the Functions Used in the Sample Code.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>main</td>
<td>Main processing</td>
</tr>
<tr>
<td>port_init</td>
<td>Port initialization</td>
</tr>
<tr>
<td>R_INIT_StopModule</td>
<td>Stop processing for active peripheral functions</td>
</tr>
<tr>
<td></td>
<td>after a reset</td>
</tr>
<tr>
<td>R_INIT_NonExistentPort</td>
<td>Nonexistent port initialization</td>
</tr>
<tr>
<td>R_INIT_Clock</td>
<td>Clock initialization</td>
</tr>
<tr>
<td>peripheral_init</td>
<td>Peripheral function initialization</td>
</tr>
<tr>
<td>error_proc</td>
<td>Error processing</td>
</tr>
<tr>
<td>Excep_MTU0_TGIA0</td>
<td>MTU0 input capture A interrupt handler</td>
</tr>
<tr>
<td>Excep_ICU_GROUP1</td>
<td>MTU0 overflow interrupt handler</td>
</tr>
</tbody>
</table>
## 5.7 Function Specifications

The following tables list the sample code function specifications.

### main

<table>
<thead>
<tr>
<th>Outline</th>
<th>Main processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>None</td>
</tr>
<tr>
<td>Declaration</td>
<td>void main(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Start the count operation for MTU0 after initialization.</td>
</tr>
<tr>
<td>Arguments</td>
<td>None</td>
</tr>
<tr>
<td>Return Value</td>
<td>None</td>
</tr>
</tbody>
</table>

### port_init

<table>
<thead>
<tr>
<th>Outline</th>
<th>Port initialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>None</td>
</tr>
<tr>
<td>Declaration</td>
<td>void port_init(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Initialize ports.</td>
</tr>
<tr>
<td>Arguments</td>
<td>None</td>
</tr>
<tr>
<td>Return Value</td>
<td>None</td>
</tr>
</tbody>
</table>

### R_INIT_StopModule

<table>
<thead>
<tr>
<th>Outline</th>
<th>Stop processing for active peripheral functions after a reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>r_init_stop_module.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>void R_INIT_StopModule(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Configure the setting to enter the module-stop state.</td>
</tr>
<tr>
<td>Arguments</td>
<td>None</td>
</tr>
<tr>
<td>Return Value</td>
<td>None</td>
</tr>
<tr>
<td>Remarks</td>
<td>Transition to the module-stop state is not performed in the sample code. Refer to the RX63N Group, RX631 Group Initial Setting Rev. 1.00 application note for details on this function.</td>
</tr>
</tbody>
</table>

### R_INIT_NonExistentPort

<table>
<thead>
<tr>
<th>Outline</th>
<th>Nonexistent port initialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>r_init_non_existent_port.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>void R_INIT_NonExistentPort(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Initialize port direction registers for ports that do not exist in products with less than 176 pins.</td>
</tr>
<tr>
<td>Arguments</td>
<td>None</td>
</tr>
<tr>
<td>Return Value</td>
<td>None</td>
</tr>
<tr>
<td>Remarks</td>
<td>The number of pins in the sample code is set for the 176-pin package (PIN_SIZE=176). After this function is called, when writing in byte units to PDR registers or PODR registers which have nonexistent ports, set the corresponding bits for nonexistent ports as follows: set the I/O select bits in the PDR registers to 1 and set the output data store bits in the PODR registers to 0. Refer to the RX63N Group, RX631 Group Initial Setting Rev. 1.00 application note for details on this function.</td>
</tr>
</tbody>
</table>
### R_INIT_Clock

**Outline**
Clock initialization

**Header**
r_init_clock.h

**Declaration**
void R_INIT_Clock(void)

**Description**
Initialize the clock.

**Arguments**
None

**Return Value**
None

**Remarks**
The sample code selects processing which uses PLL as the system clock without using the sub-clock.
Refer to the RX63N Group, RX631 Group Initial Setting Rev. 1.00 application note for details on this function.

### peripheral_init

**Outline**
Peripheral function initialization

**Header**
None

**Declaration**
void peripheral_init(void)

**Description**
Initialize peripheral functions to be used.

**Arguments**
None

**Return Value**
None

### error_proc

**Outline**
Error processing

**Header**
None

**Declaration**
void error_proc(void)

**Description**
Output an error signal and enter an infinite loop.

**Arguments**
None

**Return Value**
None

### Excep_MTU0_TGIA0

**Outline**
MTU0 input capture A interrupt handler

**Header**
None

**Declaration**
void Excep_MTU0_TGIA0(void)

**Description**
When the measurement start flag is 1 (measurement starts), calculate a pulse period and clear the overflow counter.

**Arguments**
None

**Return Value**
None

### Excep_ICU_GROUP1

**Outline**
MTU0 Overflow interrupt handler

**Header**
None

**Declaration**
void Excep_ICU_GROUP1(void)

**Description**
When the measurement start flag is 1 (measurement starts), the number of overflows is counted. When the number of overflows exceeds 65535 and a request other than the MTU0 overflow interrupt request in the group 1 interrupt is generated, the MCU enters error processing.

**Arguments**
None

**Return Value**
None
5.8 Flowcharts

5.8.1 Main Processing

Figure 5.3 shows the Main Processing.

![Figure 5.3 Main Processing](image)

5.8.2 Port Initialization

Figure 5.4 shows the Port Initialization.

![Figure 5.4 Port Initialization](image)
5.8.3 Peripheral Function Initialization

Figure 5.5 and Figure 5.6 show the Peripheral Function Initialization.

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**Figure 5.5 Peripheral Function Initialization (1/2)**

1. Read the last register written to and confirm that the value written can be read.
5.8.4 Error Processing

Figure 5.7 shows the Error Processing.

Figure 5.6 Peripheral Function Initialization (2/2)
5.8.5 MTU0 Input Capture A Interrupt Handler

Figure 5.8 shows the MTU0 Input Capture A Interrupt Handler.

Excep_MTU0_TGIA0

Is the measurement start flag 0?

Yes

Set the measurement start flag

No

Calculate a pulse period

Pulse period measurement counter ← (Number of overflows << 16) + MTU0.TGRA register value

Reset the number of overflows

return

Figure 5.8 MTU0 Input Capture A Interrupt Handler
5.8.6 MTU0 Overflow Interrupt Handler

Figure 5.9 shows the MTU0 Overflow Interrupt Handler.

Figure 5.9 MTU0 Overflow Interrupt Handler
6. **Sample Code**

Sample code can be downloaded from the Renesas Electronics website.

7. **Reference Documents**

User’s Manual: Hardware
RX63N Group, RX631 Group User’s Manual: Hardware Rev.1.50 (R01UH0041EJ)
The latest version can be downloaded from the Renesas Electronics website.

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

User’s Manual: Development Tools
RX Family C/C++ Compiler Package V.1.01 User’s Manual Rev.1.00 (R20UT0570EJ)
The latest version can be downloaded from the Renesas Electronics website.

**Website and Support**

Renesas Electronics website
[http://www.renesas.com](http://www.renesas.com)

Inquiries
[http://www.renesas.com/contact/](http://www.renesas.com/contact/)
<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>June 3, 2013</td>
<td>First edition issued</td>
</tr>
</tbody>
</table>

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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 type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.
Note

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 losses incurred by you or third parties arising from the use of these circuits, software, or information.

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