RX630 Group

R01AN1021EJ0100
Rev.1.00
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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 RX630 Group.

Products

- RX630 Group 177-pin and 176-pin packages with a ROM size between 768 KB and 2 MB
- RX630 Group 145-pin and 144-pin packages with a ROM size between 768 KB and 2 MB
- RX630 Group 100-pin package with a ROM size between 384 KB and 2 MB
- RX630 Group 80-pin package with a ROM size between 384 KB and 512 KB

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

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

Peripheral Function	Application
MTU2a channel 0 (hereinafter referred to as MTU0)	Measure a pulse period

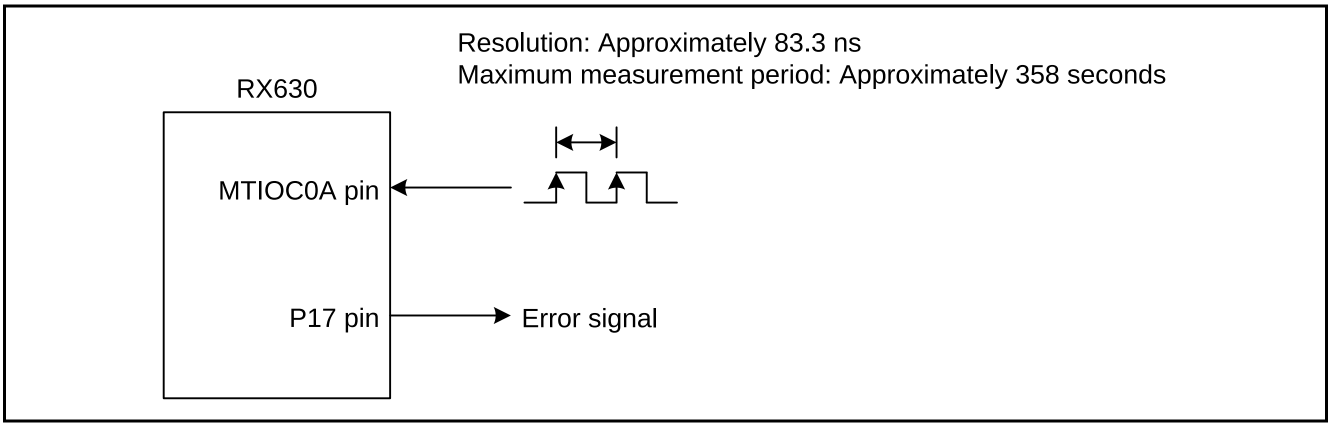


Figure 1.1 Connection Diagram

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

Item	Contents
MCU used	R5F5630EDDFP (RX630 Group)
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 environment	Renesas Electronics Corporation 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 RX630 (product part no.: R0K505630C000BE)

3. Reference Application Note

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

- RX630 Group Initial Setting Rev.1.00 (R01AN1004EJ0100_RX630)

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 100-pin products. When the product with less than 100-pin is used, select appropriate pins for the product used.

Table 4.1 Pins Used and Their Functions

Pin Name	I/O	Function
PB3/MTIOC0A	Input	Input a measurement pulse
P17	Output	Output an error signal

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 ns × (number of overflows × 10000h + 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
  Interrupt source: MTU0.TGRA input capture
- 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.

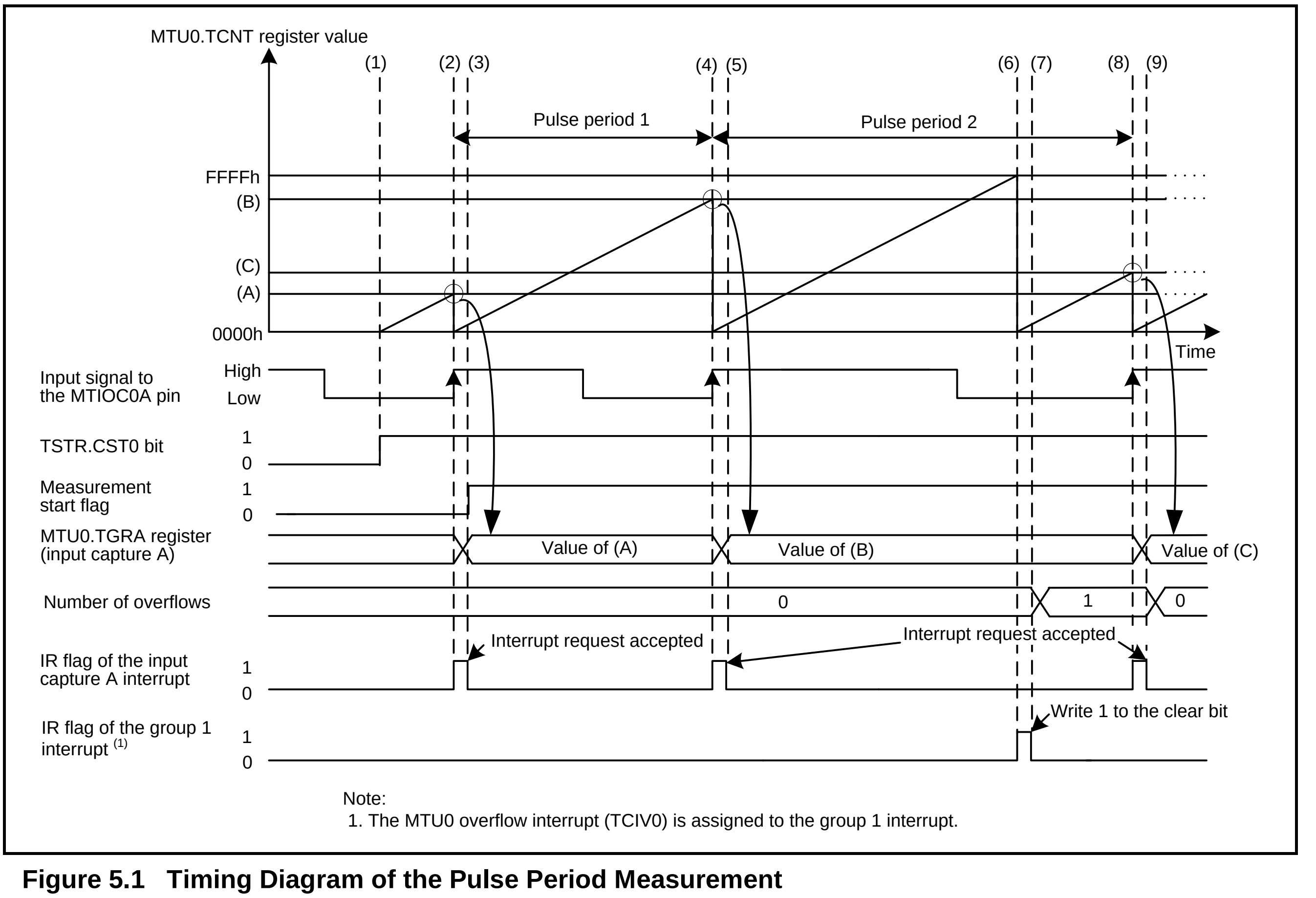


Figure 5.1 Timing Diagram of the Pulse Period Measurement

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.

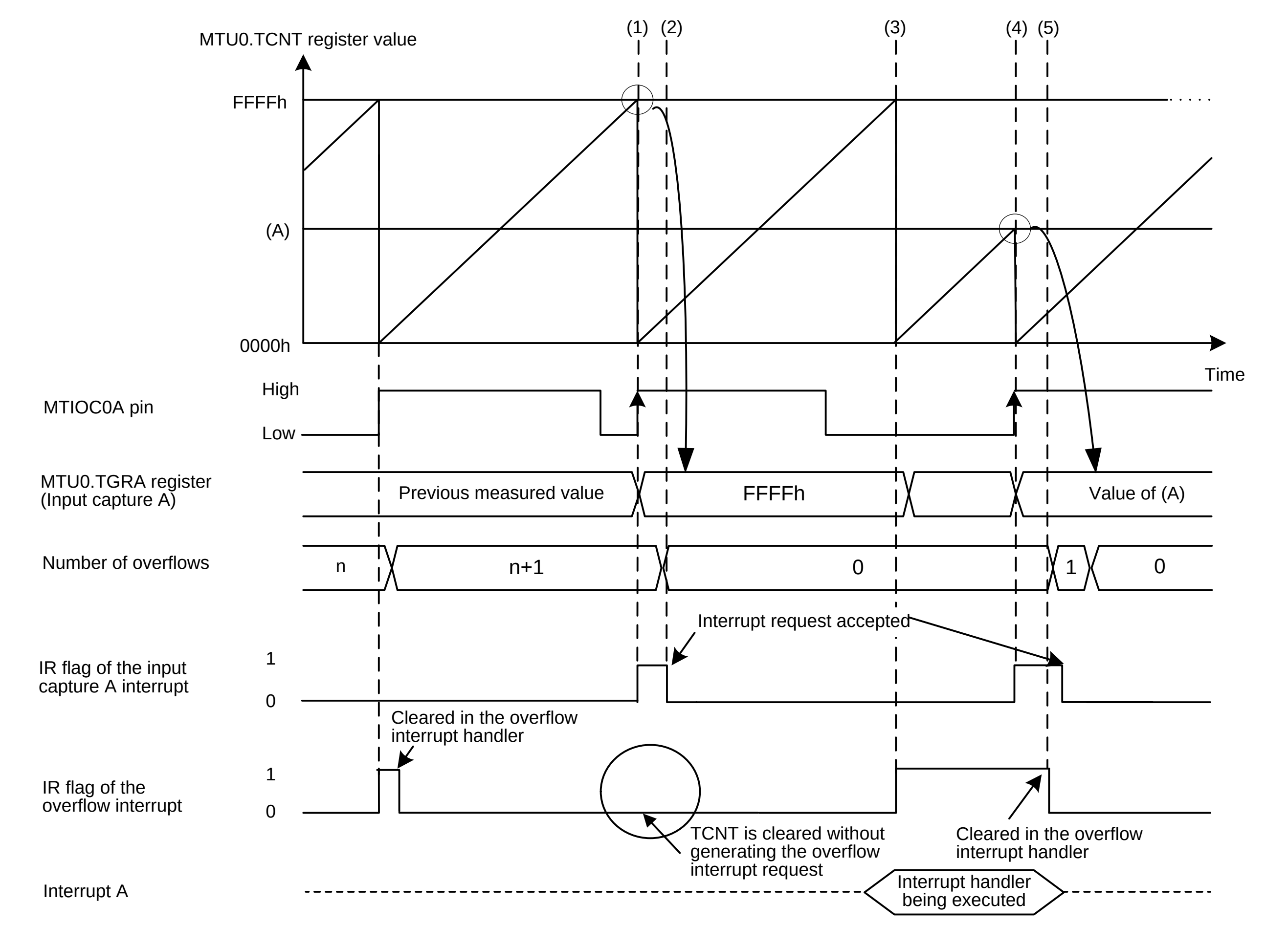


Figure 5.2 Timing Diagram When an Input Capture and Overflow Occur Simultaneously

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 5.1 Files Used in the Sample Code

File Name	Outline	Remarks
main.c	Main processing	
r_init_stop_module.c	Stop processing for active peripheral functions after a reset	
r_init_stop_module.h	Header file for r_init_stop_module.c	
r_init_non_existent_port.c	Nonexistent port initialization	
r_init_non_existent_port.h	Header file for r_init_non_existent_port.c	
r_init_clock.c	Clock initialization	
r_init_clock.h	Header file for r_init_clock.c	

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 5.2 Option-Setting Memory Configured in the Sample Code

Symbol	Address	Setting Value	Contents
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	The IWDT is stopped after a reset. The WDT is stopped after a reset.
OFS1	FFFF FF8Bh to FFFF FF88h	FFFF FFFFh	The voltage monitor 0 reset is disabled after a reset. HOCO oscillation is disabled after a reset.
MDES	FFFF FF83h to FFFF FF80h	FFFF FFFFh	Little endian

5.4 Constants

Table 5.3 lists the Constants Used in the Sample Code.

Table 5.3 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
P_OVF_ERR	PORT1.PODR.BIT.B7	Port output data register for error signal output
PD_OVF_ERR	PORT1.PDR.BIT.B7	Port direction register for error signal output

5.5 Variables

Table 5.4 lists the Global Variables.

Table 5.4 Global Variables

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

5.6 Functions

Table 5.5 lists the Functions.

Table 5.5 Functions

Function Name	Outline
main	Main processing
port_init	Port initialization
R_INIT_StopModule	Stop processing for active peripheral functions after a reset
R_INIT_NonExistentPort	Nonexistent port initialization
R_INIT_Clock	Clock initialization
peripheral_init	Peripheral function initialization
error_proc	Error processing
Excep_MTU0_TGIA0	MTU0 input capture A interrupt handler
Excep_ICU_GROUP1	MTU0 overflow interrupt handler

5.7 Function Specifications

The following tables list the sample code function specifications.

main	
Outline	Main processing
Header	None
Declaration	void main(void)
Description	Start the count operation for MTU0 after initialization.
Arguments	None
Return Value	None

port_init	
Outline	Port initialization
Header	None
Declaration	void port_init(void)
Description	Initialize ports.
Arguments	None
Return Value	None

R_INIT_StopModule	
Outline	Stop processing for active peripheral functions after a reset
Header	r_init_stop_module.h
Declaration	void R_INIT_StopModule(void)
Description	Configure the setting to enter the module-stop state.
Arguments	None
Return Value	None
Remarks	Transition to the module-stop state is not performed in the sample code. Refer to the RX630 Group Initial Setting Rev. 1.00 application note for details on this function.

R_INIT_NonExistentPort	
Outline	Nonexistent port initialization
Header	r_init_non_existent_port.h
Declaration	void R_INIT_NonExistentPort(void)
Description	Initialize port direction registers for ports that do not exist in products with less than 176 pins.
Arguments	None
Return Value	None
Remarks	The number of pins in the sample code is set for the 100-pin package (PIN_SIZE=100). 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 RX630 Group Initial Setting Rev. 1.00 application note for details on this function.

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 RX630 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.

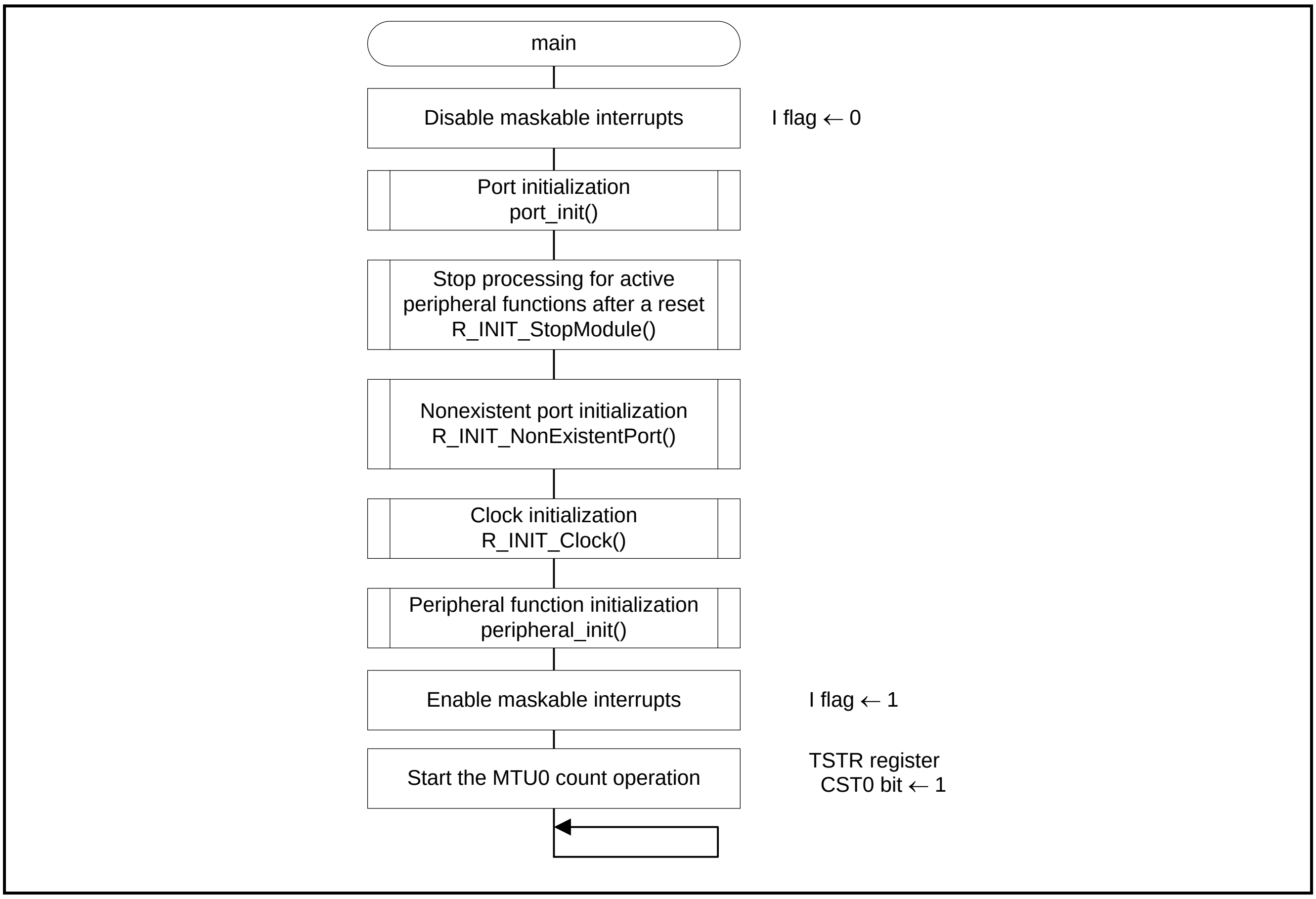


Figure 5.3 Main Processing

5.8.2 Port Initialization

Figure 5.4 shows the Port Initialization.

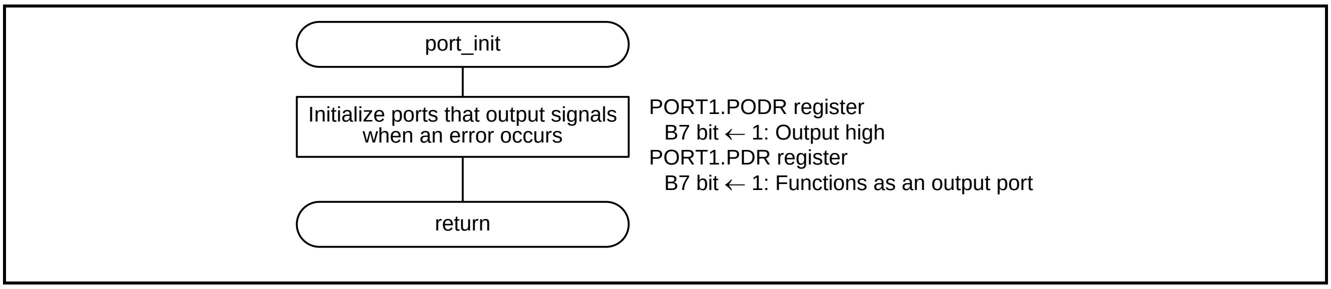
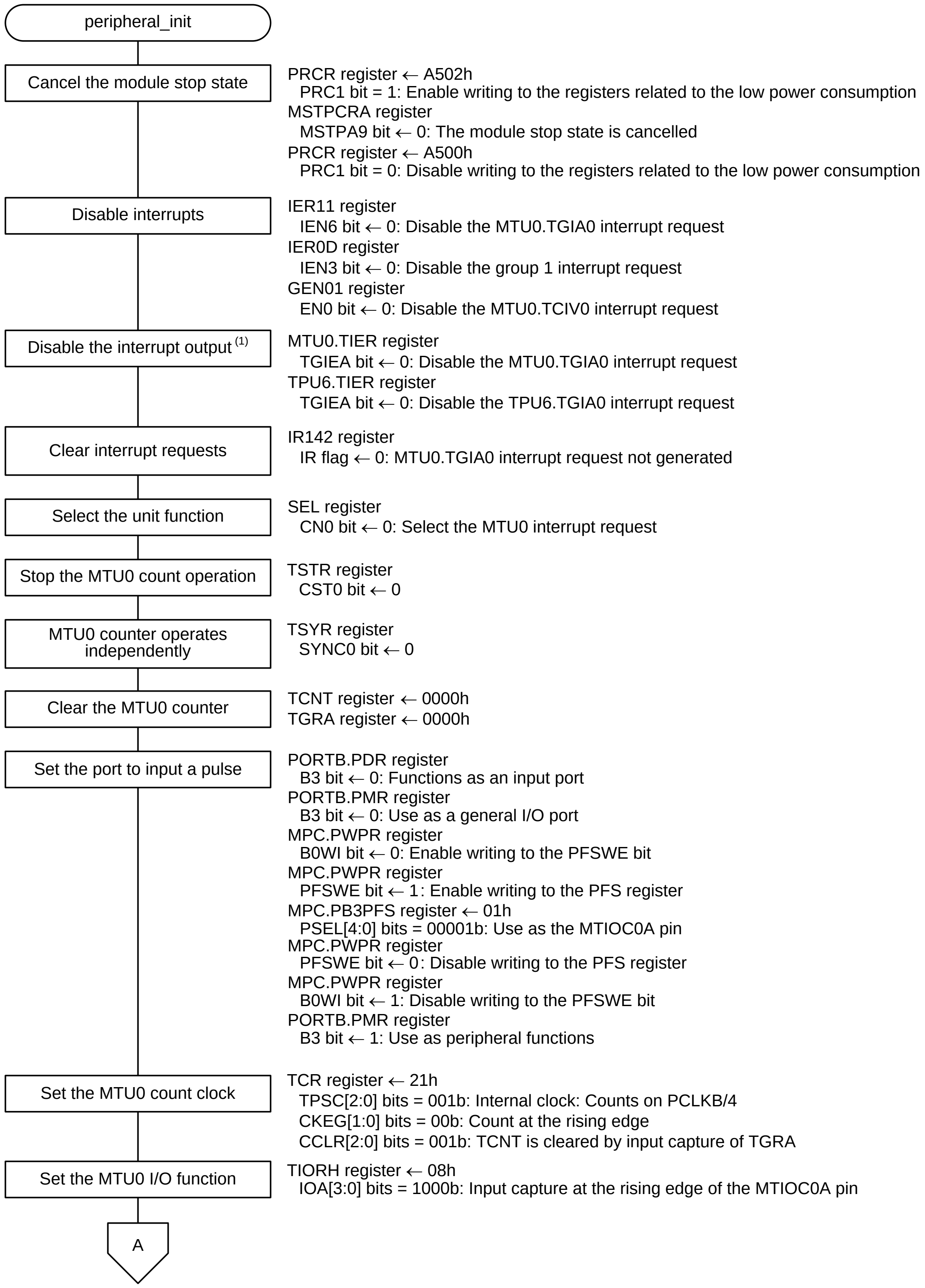


Figure 5.4 Port Initialization

5.8.3 Peripheral Function Initialization

Figure 5.5 and Figure 5.6 show the Peripheral Function Initialization.



Note:
1. Read the last register written to and confirm that the value written can be read.

Figure 5.5 Peripheral Function Initialization (1/2)

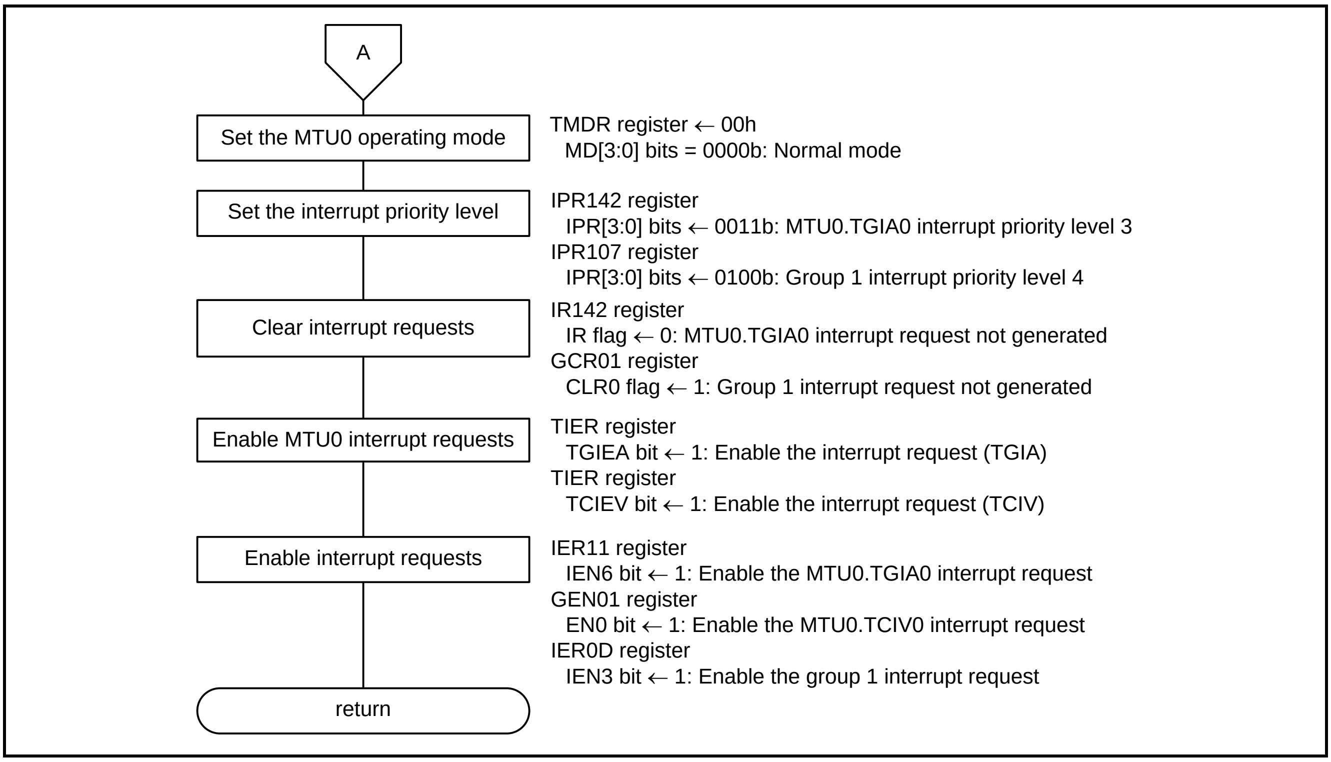


Figure 5.6 Peripheral Function Initialization (2/2)

5.8.4 Error Processing

Figure 5.7 shows the Error Processing.

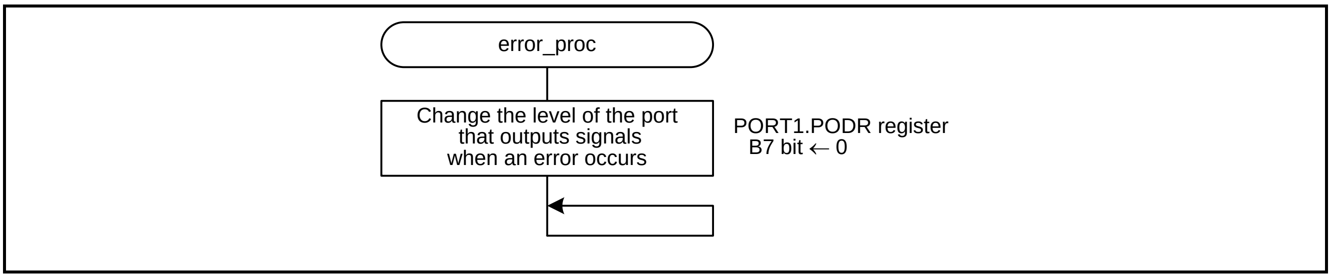


Figure 5.7 Error Processing

5.8.5 MTU0 Input Capture A Interrupt Handler

Figure 5.8 shows the MTU0 Input Capture A Interrupt Handler.

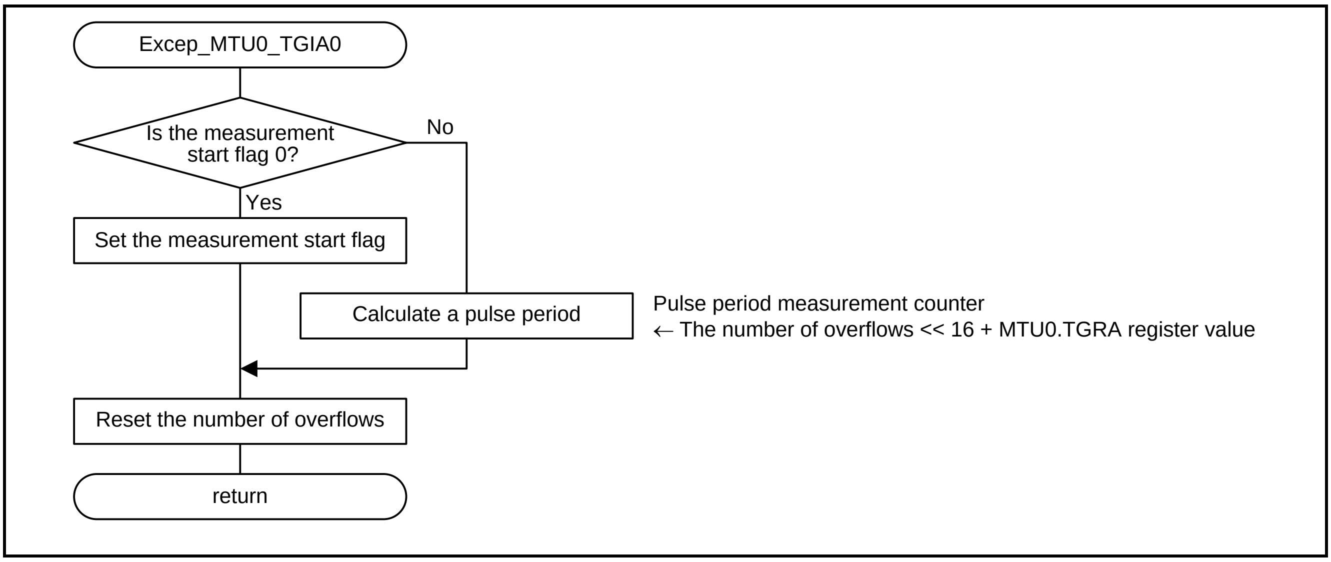


Figure 5.8 MTU0 Input Capture A Interrupt Handler

5.8.6 MTU0 Overflow Interrupt Handler

Figure 5.9 shows the MTU0 Overflow Interrupt Handler.

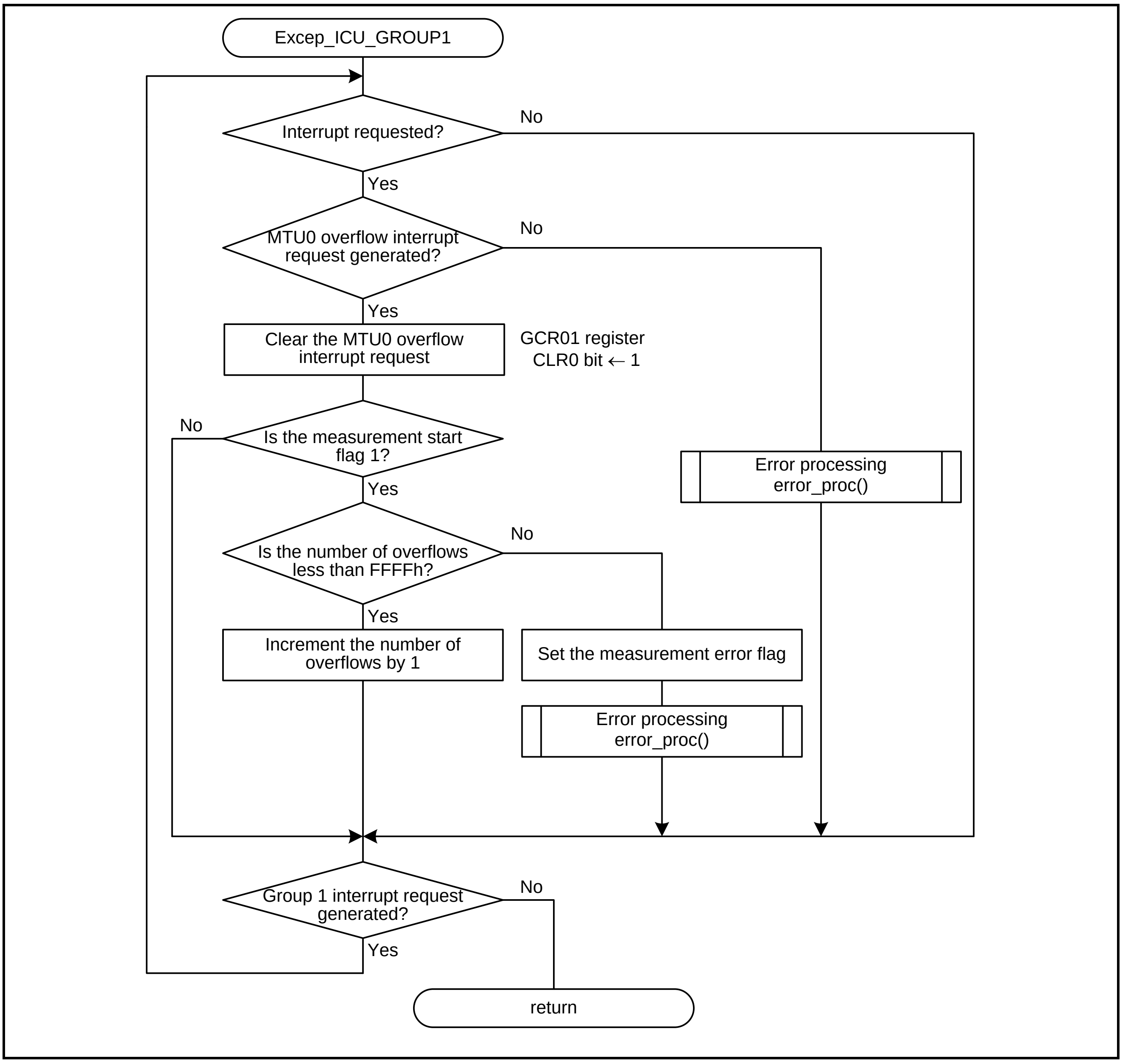


Figure 5.9 MTU0 Overflow Interrupt Handler

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

User's Manual: Hardware
RX630 Group User's Manual: Hardware Rev.1.50 (R01UH0040EJ)
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
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REVISION HISTORY	RX630 Group Pulse Period Measurement Using MTU2a

Rev.	Date	Description	
		Page	Summary
1.00	Apr. 05, 2013	—	First edition issued

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 document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

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 a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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Refer to "http://www.renesas.com/" for the latest and detailed information.

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