R8C/LA8A Group

Timer RJ in Pulse Width Measurement Mode

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Abstract

This document describes timer RJ in pulse width measurement mode with the R8C/LA8A Group.

Product

R8C/LA8A Group

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

Measure the pulse width of an external signal input from the TRJ0IO pin using timer RJ. In this document, the width between the rising edge and falling edge of a pulse can be measured from a minimum of 50 ns to a maximum of 3.27675 ms. When measuring the width successively, 20 µs or more is necessary between one falling edge and the next falling edge.

Table 1.1 lists the Peripheral Function and Its Application. Figure 1.1 shows an External Signal Measurement.

Table 1.1 Peripheral Function and Its Application

Peripheral Function	Application
Timer RJ	Measure the pulse width of an external signal

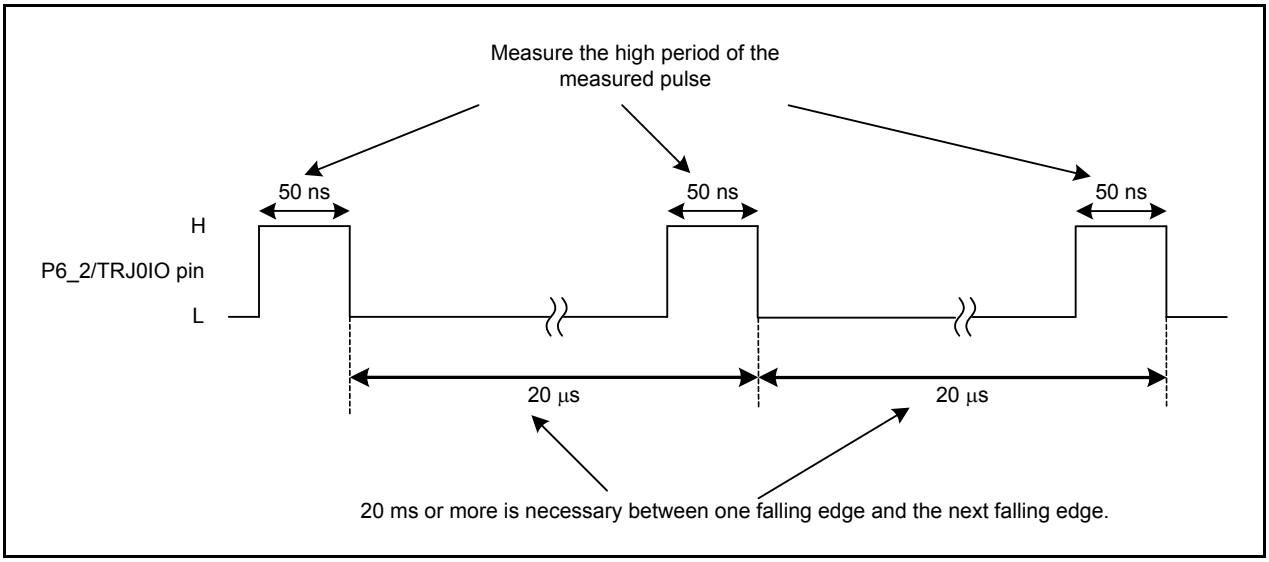


Figure 1.1 External Signal Measurement

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	R8C/LA8A Group
Operating frequencies	• XIN clock: 20 MHz • System clock: 20 MHz • CPU clock: 20 MHz
Operating voltage	5.0 V (2.7 to 5.5 V)
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.07
C compiler	Renesas Electronics Corporation M16C Series, R8C Family C Compiler V.5.45 Release 01
	Compile options -D__UART0__ -c -finfo -dir "$(CONFIGDIR)" -R8C (Default setting is used in the integrated development environment.)

3. Hardware

3.1 Pin Used

Table 3.1 lists the Pin Used and Its Function.

Table 3.1 Pin Used and Its Function

Pin Name	I/O	Function
P6_2/TRJ0IO	Input	Timer RJ0 I/O

4. Software

4.1 Operation Overview

Measure high width of the external signal input from the TRJ0IO pin using timer RJ0. When the rising edge input to the TRJ0IO pin is detected, measurement starts. When the falling edge input is detected or timer RJ0 underflows, a timer RJ0 interrupt is generated. The timer RJ0 underflow counter used for calculating a measured value is incremented in interrupt handling which is triggered by timer RJ0 underflow. Obtain the TRJ0 register value and set 1 to the falling edge detection flag in interrupt handling which is triggered by detecting the falling edge input. After interrupt handling triggered by detecting the falling edge input is completed, calculate the measured value.

Settings

- Use timer RJ0.
- Use pulse width measurement mode.
- Measure the width between the rising edge and falling edge of the measured pulse.
- Use the active edge judgment flag of timer RJ0.
- Use the underflow flag of timer RJ0.
- Use f1 as the timer RJ0 count source.
- Use the timer RJ0 interrupt.
- Use the P6_2/TRJ0IO pin as the input pin.
- Do not use the TRJ0IO input filter.

Maximum measured pulse width:

(1/20 MHz × f1) × (Timer RJ0 underflow count value × number of times timer RJ0 underflows) - current measured value + previous measured value)
= 50 ns × ((100h × FFh) - 00h + FFh) = 3.27675 ms

Minimum measured pulse width:

(1/20 MHz × f1) × (previous measured value - current measured value)
= 50 ns × 01h = 50 ns

Interval between one falling edge and the next falling edge of a pulse:

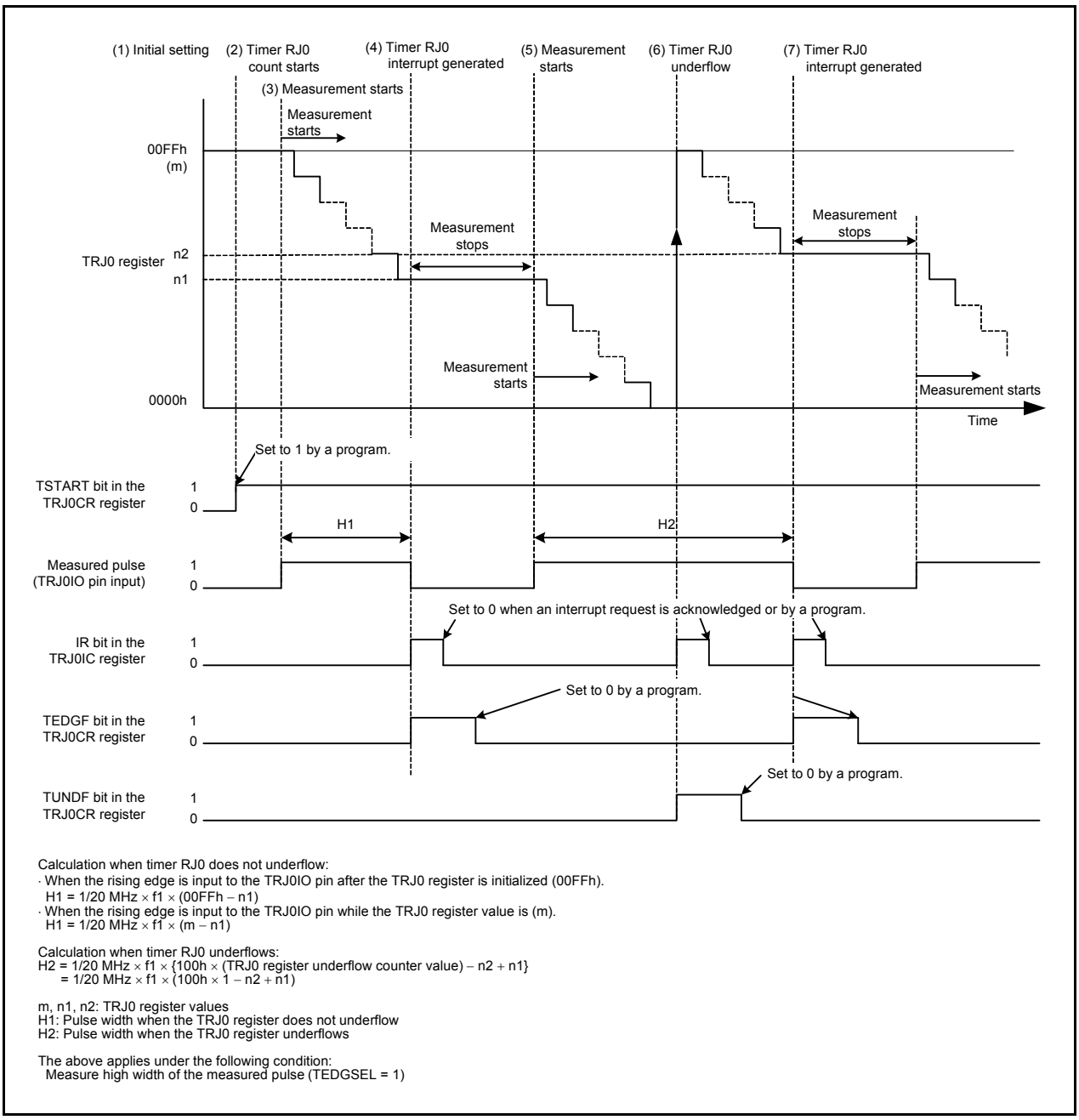
Set 20 µs or more between one falling edge and the next falling edge of a pulse based on the time between the falling edge detection and calculation completion of the pulse width. When the interval is shorter than 20 µs, an accurate pulse width cannot be measured.

(1) Initial setting
Perform an initial setting of timer RJ0.
(2) Timer RJ0 count start
Set the TSTART bit in the TRJ0CR register to 1. After setting 1 to the TSTART bit, the timer RJ0 count starts in 0 to 1 cycles of the count source.

When timer RJ0 does not underflow:
(3) Measurement starts
When the rising edge input to the TRJ0IO pin is detected, measurement starts.
(4) Measurement stops
When the falling edge input to the TRJ0IO pin is detected, a timer RJ0 interrupt is generated. Set the TRJ0 register value to the current measured result in timer RJ0 interrupt handling. Clear the active edge judgment flag to set the TEDGF bit in the TRJ0CR register to 0. After the MCU exits timer RJ0 interrupt handling to the main processing, calculate the high width using the method when the TRJ0 register does not underflow.

When timer RJ0 underflows:
(5) Measurement starts
When the rising edge input to the TRJ0IO pin is detected, measurement starts.
(6) Timer RJ0 underflow
When the timer RJ0 register underflows, a timer RJ0 interrupt is generated. The timer RJ0 underflow counter value is incremented in timer RJ0 interrupt handling. Clear the timer RJ0 underflow flag to set the TUNDF bit in the TRJ0CR register to 0.
(7) Measurement stops
When the falling edge input to the TRJ0IO pin is detected, a timer RJ0 interrupt is generated. Set the TRJ0 register value to the current measured result in timer RJ0 interrupt handling. Clear the active edge judgment flag to set the TEDGF bit in the TRJ0CR register to 0. After the MCU exits timer RJ0 interrupt handling to the main processing, calculate the high width using the method when the TRJ0 register underflows.

Figure 4.1 shows the Timing Diagram.



Calculation when timer RJ0 does not underflow:
· When the rising edge is input to the TRJ0IO pin after the TRJ0 register is initialized (00FFh).
H1 = 1/20 MHz × f1 × (00FFh − n1)
· When the rising edge is input to the TRJ0IO pin while the TRJ0 register value is (m).
H1 = 1/20 MHz × f1 × (m − n1)

Calculation when timer RJ0 underflows:
H2 = 1/20 MHz × f1 × {100h × (TRJ0 register underflow counter value) − n2 + n1}
= 1/20 MHz × f1 × (100h × 1 − n2 + n1)

m, n1, n2: TRJ0 register values
H1: Pulse width when the TRJ0 register does not underflow
H2: Pulse width when the TRJ0 register underflows

The above applies under the following condition:
Measure high width of the measured pulse (TEDGSEL = 1)

Figure 4.1 Timing Diagram

4.2 Required Memory Size

Table 4.1 lists the Required Memory Size.

Table 4.1 Required Memory Size

Memory Used	Size	Remarks
ROM	308 bytes	In the r01an0379_src.c module
RAM	8 bytes	In the r01an0379_src.c module
Maximum user stack usage	11 bytes	
Maximum interrupt stack usage	18 bytes	

The required memory size varies depending on the C compiler version and compile options.

4.3 Variables

Table 4.2 lists the Global Variables.

Table 4.2 Global Variables

Type	Variable Name	Contents	Function Used
unsigned char	flg_edge	Falling edge detection flag	pulse_width_calculation, _timer_rj_ch0
unsigned char	cnt_undf	Timer RJ0 underflow counter	pulse_width_calculation, _timer_rj_ch0
unsigned short	present_contents	The current measured result is retained.	pulse_width_calculation, _timer_rj_ch0
unsigned short	last_contents	The previous measured result is retained.	pulse_width_calculation
unsigned short	measurement_value	The calculated result of the high width is retained based on the measured result.	pulse_width_calculation

4.4 Functions

Table 4.3 lists the Functions.

Table 4.3 Functions

Function Name	Outline
mcu_init	System clock setting
timer_rj_init	Initial setting of timer RJ0
pulse_width_calculation	Pulse width calculation
_timer_rj_ch0	Timer RJ0 interrupt handling

4.5 Function Specifications

The following tables list the sample code function specifications.

mcu_init	
Outline	System clock setting
Header	None
Declaration	void mcu_init(void)
Description	Set the system clock.
Argument	None
Returned value	None
Remark	—

timer_rj_init	
Outline	Initial setting of timer RJ0
Header	None
Declaration	void timer_rj_init(void)
Description	Perform the initial setting to use timer RJ0 in pulse width measurement mode.
Argument	None
Returned value	None
Remark	—

pulse_width_calculation	
Outline	Pulse width calculation
Header	None
Declaration	void pulse_width_calculation(void)
Description	Calculate the high width based on the measured result.
Argument	None
Returned value	None
Remark	—

_timer_rj_ch0	
Outline	Timer RJ0 interrupt handling
Header	None
Declaration	void _timer_rj_ch0(void)
Description	• When the falling edge is detected, the measured result is stored to the variable. • When timer RJ0 underflows, the underflow counter value is incremented. • When an active edge is received and an underflow occurs, set 00FFh to the current measured result regardless of the TRJ0 register value.
Argument	None
Returned value	None
Remark	—

4.6 Flowcharts

4.6.1 Main Processing

Figure 4.2 shows the Main Processing.

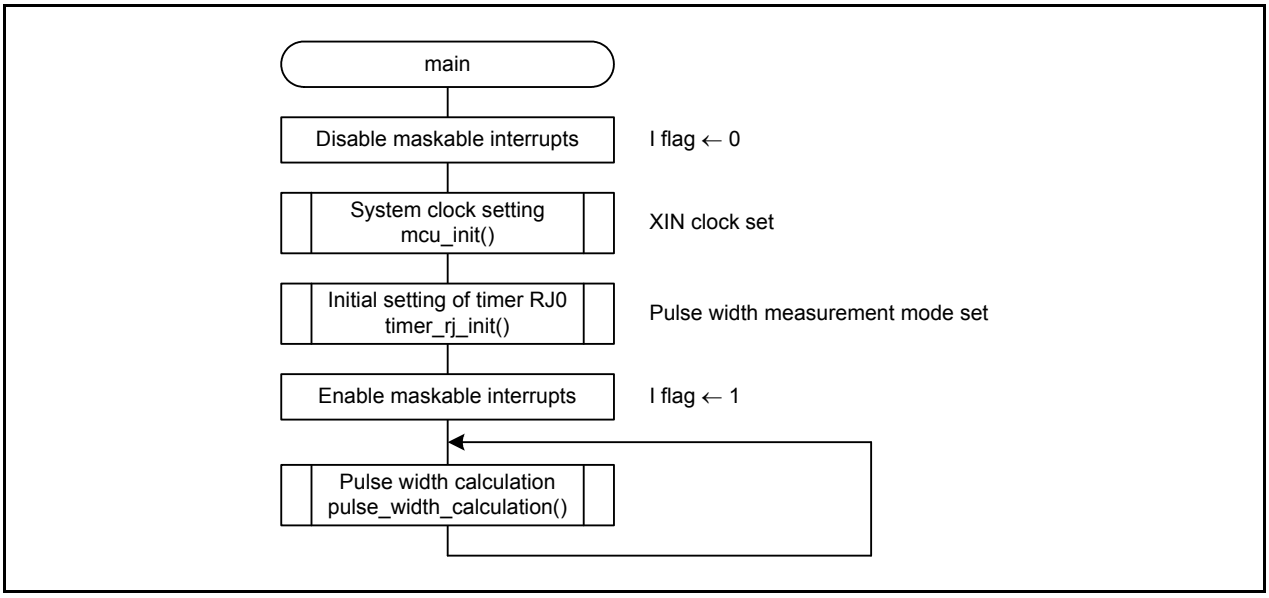


Figure 4.2 Main Processing

4.6.2 System Clock Setting

Figure 4.3 shows the System Clock Setting.

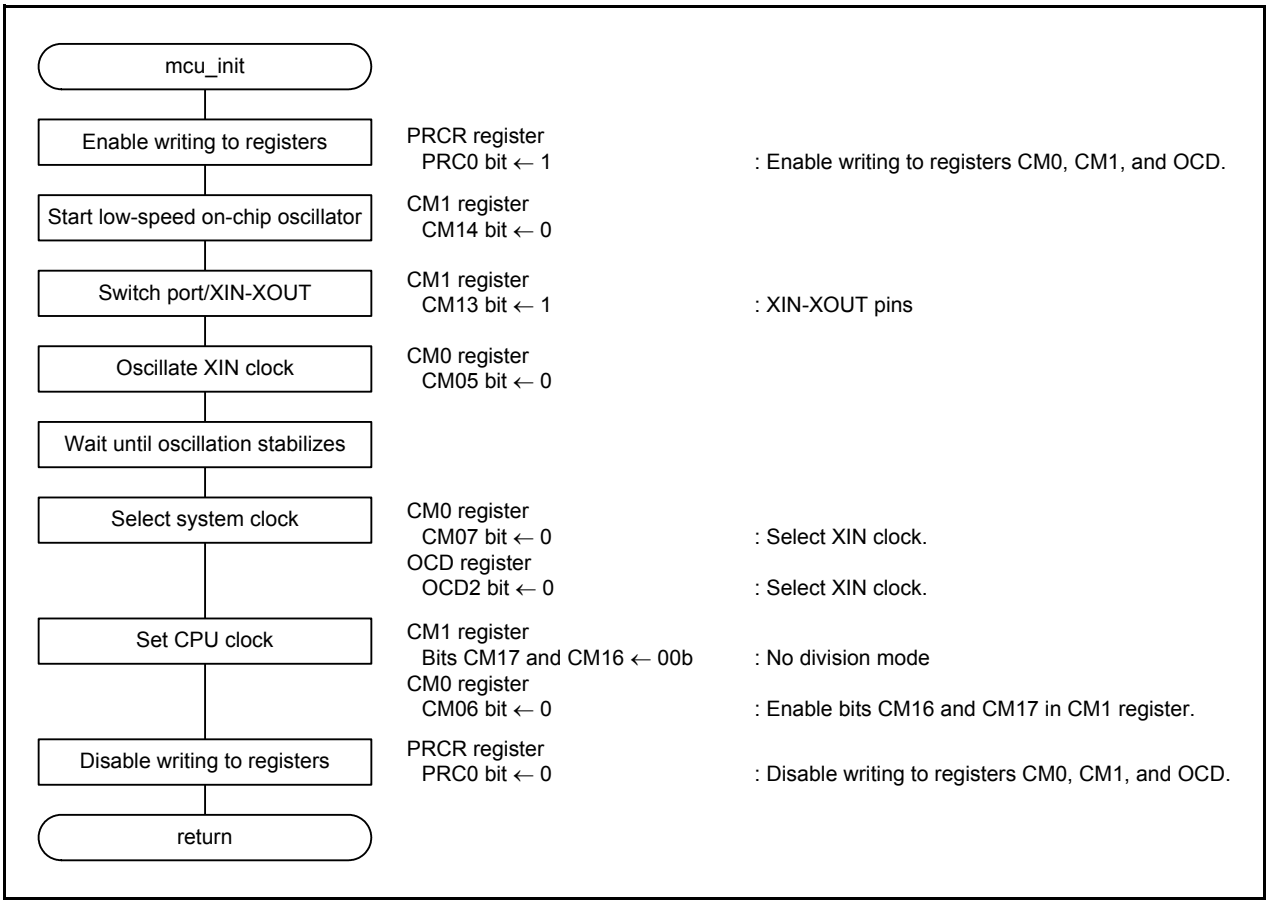
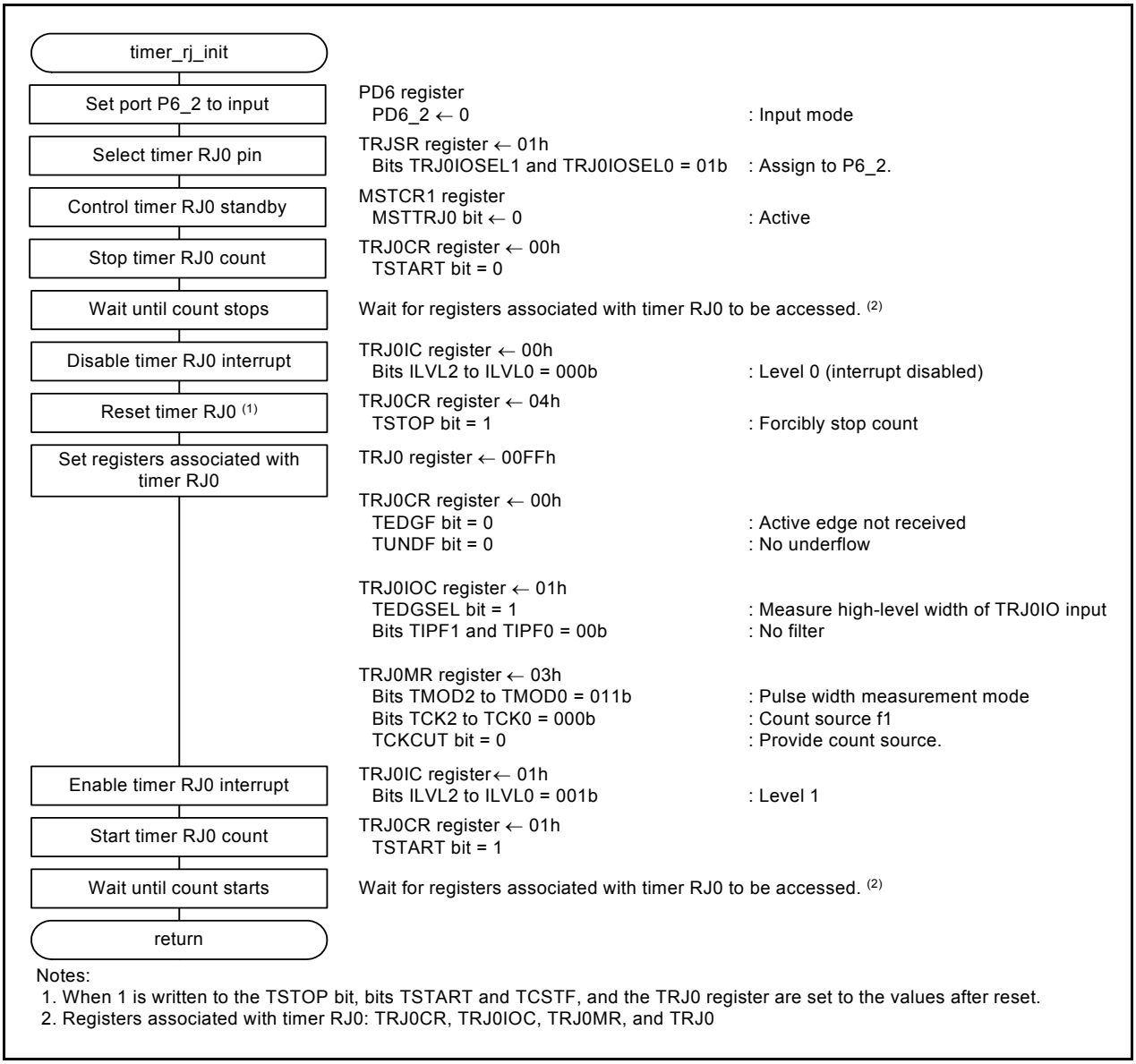


Figure 4.3 System Clock Setting

4.6.3 Initial Setting of Timer RJ0

Figure 4.4 shows the Initial Setting of Timer RJ0.



Notes:
1. When 1 is written to the TSTOP bit, bits TSTART and TCSTF, and the TRJ0 register are set to the values after reset.
2. Registers associated with timer RJ0: TRJ0CR, TRJ0IOC, TRJ0MR, and TRJ0

Figure 4.4 Initial Setting of Timer RJ0

4.6.4 Pulse Width Calculation

Figure 4.5 shows the Pulse Width Calculation.

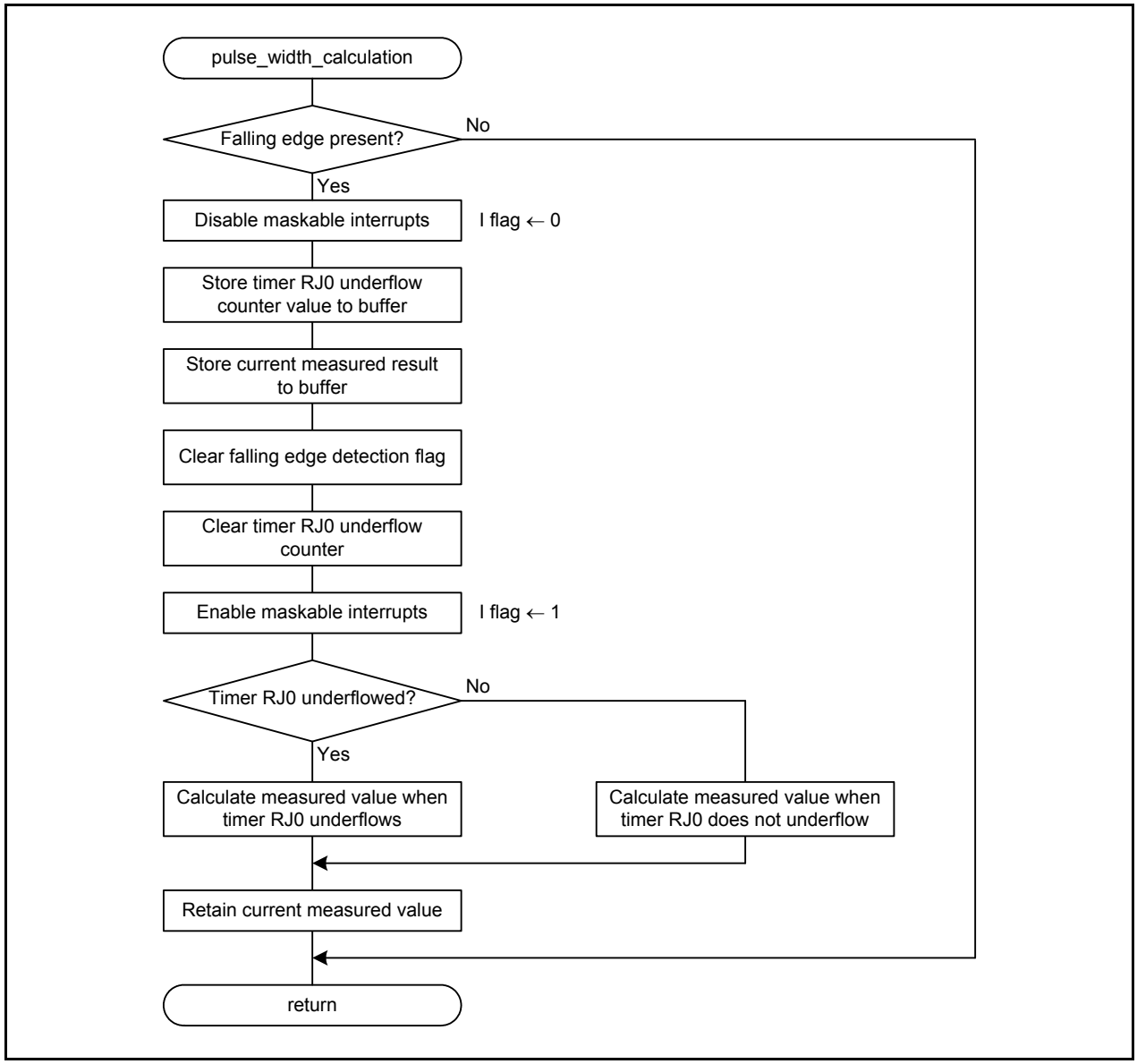
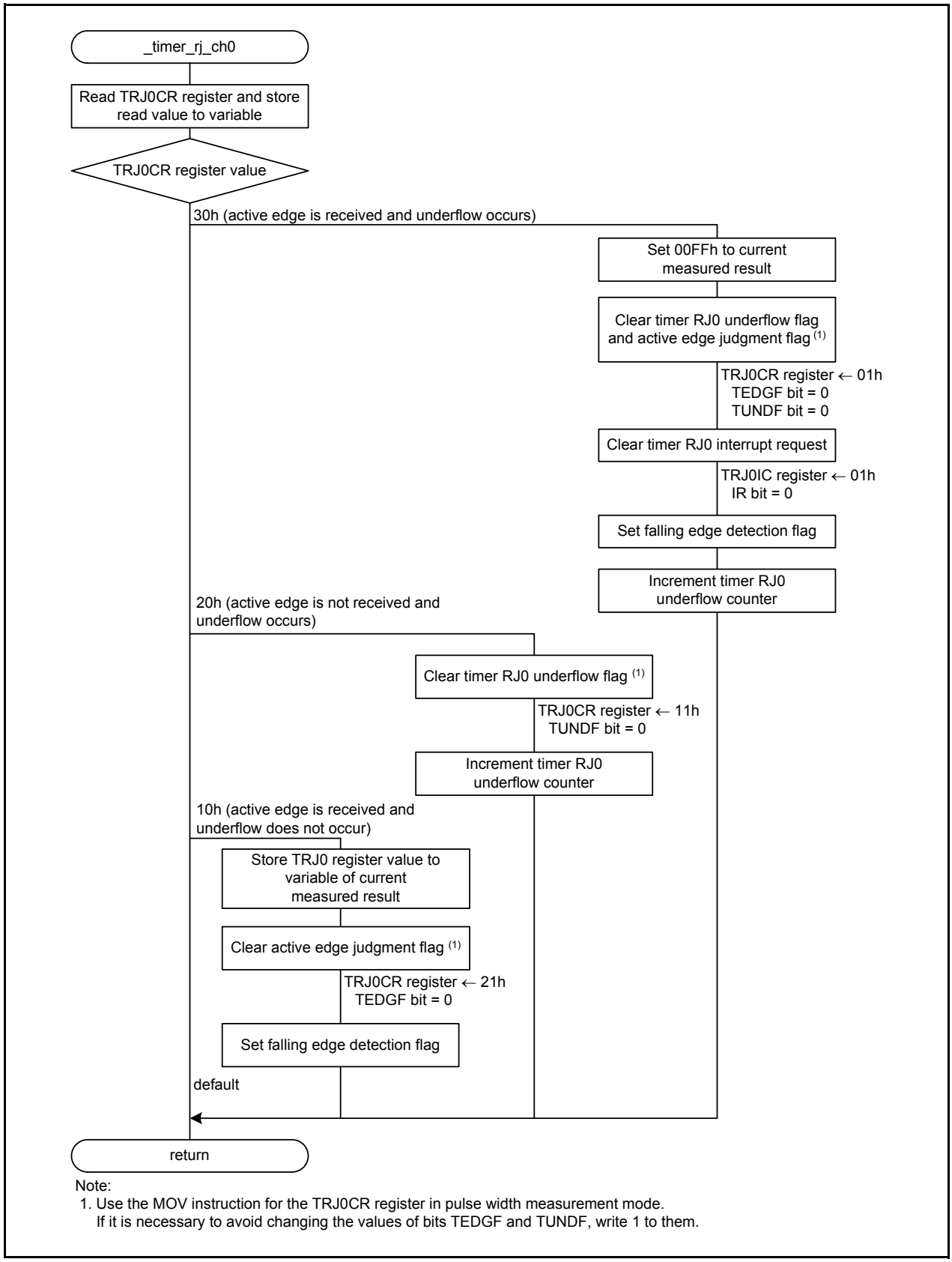


Figure 4.5 Pulse Width Calculation

4.6.5 Timer RJ0 Interrupt Handling

Figure 4.6 shows Timer RJ0 Interrupt Handling.



Note:
1. Use the MOV instruction for the TRJ0CR register in pulse width measurement mode. If it is necessary to avoid changing the values of bits TEDGF and TUNDF, write 1 to them.

Figure 4.6 Timer RJ0 Interrupt Handling

5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

R8C/LA8A Group User's Manual: Hardware Rev.1.02
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.

C Compiler Manual
M16 Series, R8C Family C Compiler Package V.5.45
C Compiler User's Manual Rev.2.00
The latest version can be downloaded from the Renesas Electronics website.

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Revision History	R8C/LA8A Group Timer RJ in Pulse Width Measurement Mode

Rev.	Date	Description	
		Page	Summary
1.00	Jan. 6, 2012	—	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 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.

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