M16C/5LD, M16C/56D, M16C/5L, M16C/56, M16C/5M, M16C/57, and M16C/6C Groups

Time Measurement Function of Timer S with Gate Function

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1. Abstract

This document describes the setting method and an application example for time measurement with the gate function of Timer S in the M16C/5LD, M16C/56D, M16C/5L, M16C/56, M16C/5M, M16C/57, and M16C/6C Groups.

2. Introduction

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

- MCU: M16C/5LD, M16C/56D, M16C/5L, M16C/56, M16C/5M, M16C/57, and M16C/6C Groups

This application note can be used with other M16C Family MCUs which have the same special function registers (SFRs) as the above groups. Check the user's manual for any modifications to functions. Careful evaluation is recommended before using the program described in this application note.

3. Outline

Timer S has an input capture/output compare function (IC/OC). The input capture (IC) is used for time measurement and the output compare (OC) is used for waveform generation. The IC/OC has one 16-bit free-running base timer and eight channels for time measurement and waveform generation.

3.1 Time Measurement Function

Input pulse cycle or pulse width from external devices can be measured using time measurement function.
Table 3.1 lists the Time Measurement Function Settings. The operation using the settings checked with '✓' is explained in this application note.

Table 3.1 Time Measurement Function Settings

Item		Setting
Trigger input polarities	✓	Rising edge of the INPC1_j (j = 0 to 7) pin input
		Falling edge of the INPC1_j pin input
		Both edges of the INPC1_j pin input
Digital filter functions	✓	No digital filter
		fBT1
		f1TIMS or f2TIMS
Prescaler functions	✓	Not used
		Used
Gate functions		Gate function not used
	✓	Gate function used
Gate function release	✓	Gate function release is disabled
		Gate function release is enabled by matching the base timer with the G1POk register (k = 4 when j = 6; k = 5 when j = 7).
Channels		Channel 0
		Channel 1
		Channel 2
		Channel 3
		Channel 4
		Channel 5
	✓	Channel 6
		Channel 7
Interrupts	✓	IC/OC base timer interrupt (interrupt priority level: level 4)
	✓	IC/OC interrupt 0 (interrupt priority level: level 3)
		IC/OC interrupt 1
		IC/OC channel 0 interrupt
		IC/OC channel 1 interrupt
		IC/OC channel 2 interrupt
		IC/OC channel 3 interrupt

3.2 Gate Function

After a time measurement is performed by the first trigger input, subsequent trigger input acceptance is disabled. Trigger input acceptance is enabled again when the following conditions are met:
While the GSC bit in the G1TMCRj register (j = 6 and 7) is set to 1 (gate function release bit) or the GOC bit in the G1TMCRj register is 1 (gate is released by matching with the G1POk register (k = 4 when j = 6; k = 5 when j = 7)), the G1POk register value matches the base timer value.
Figure 3.1 shows the Time Measurement Period with Gate Function.

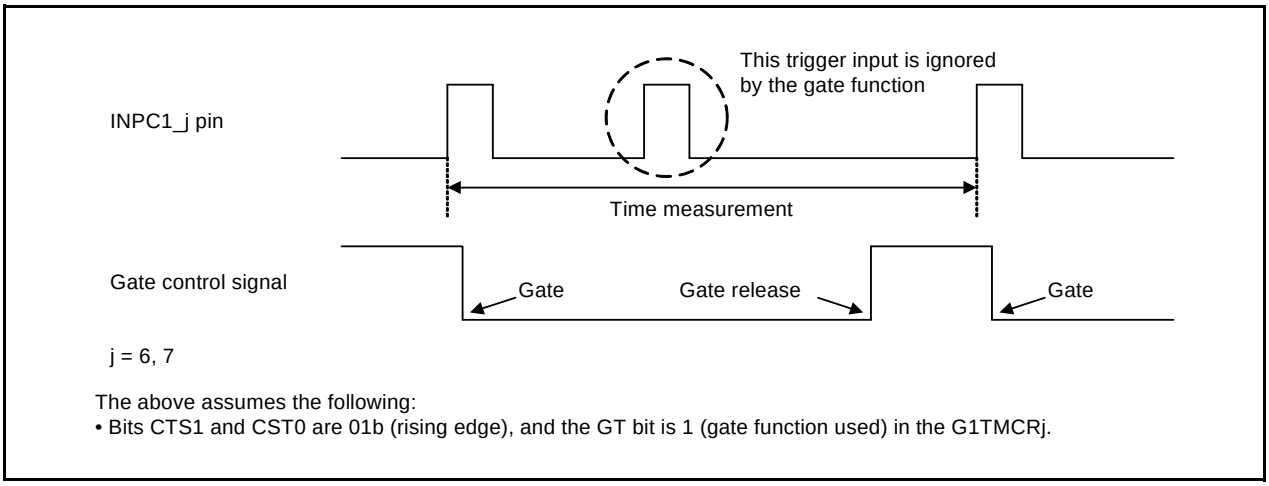


Figure 3.1 Time Measurement Period with Gate Function

4. Peripheral Functions

This chapter provides supplementary information about notes on timer S. Refer to the User's Manual: Hardware for details.

4.1 Notes on Timer S

4.1.1 Interrupt Request When Selecting Time Measurement Function

When the FSCj bit (j = 0 to 7) in the G1FS register is set to 1, and the IFEj bit in the G1FE register is also set to 1, the G1IRj bit in the G1IR register, or the IR bits in registers ICOCiIC (i = 0, 1) or ICOCHjIC (j = 0 to 3) may become 1 (interrupt requested) after a maximum of two fBT1 cycles (1).

When using IC/OC interrupt i or IC/OC channel j interrupt, set bits FSCj and IFEj to 1, then perform the following:

(1) Wait for two or more fBT1 cycles (1).

(2) Set the IR bit in the ICOCiIC register and/or the ICOCHjIC register to 0.

(3) Wait for three or more fBT1 cycles (1) after the time measurement function is selected. Set the G1IR register to 00h (2) after setting the IR bit in the ICOCiIC register to 0.

Notes:

1. When using the digital filter, time required for the function also needs to be considered.
2. Verify the value in the G1IR register is 00h by reading. If the read value is not 00h, repeat writing 00h to the G1IR register.

5. Application Example

5.1 Explanation of the Sample Program

This section describes the method to disable an edge acceptance for approximately 100 μs after a rising edge is accepted with the time measurement function of channel 6.
In the IC/OC interrupt 0 handler, the G1TM6 register value is read, and the time for measurement is calculated by the difference between the previous and current read values. The gate is released by writing 1 to the GSC bit in the G1TMCR6 register (gate release).
In this sample program, a time for a maximum of two cycles of the base timer (i.e., for one overflow) can be measured.

The clock conditions are as follows:

- Main clock: 20 MHz
- Base timer operation clock (fBT1): 10 MHz

Table 5.1 lists the Variables for the Sample Program, and Figure 5.1 shows the Sample Program Operation.

Table 5.1 Variables for the Sample Program

Variable Name	Purpose
old_tr	To store the G1TM6 register value before gate function setting
new_tr	To store the G1TM6 register value after gate function released
measurement	To store the measured value of time measurement
over_run_f (overrun flag)	To confirm whether a base timer overflow occurs or not

(1) After timer S is initialized, the BTS bit in the G1BCR1 register is set to 1 (base timer count starts).

(2) When a rising edge is input to the INPC1_6 pin, the gate function is set automatically, trigger input acceptance is disabled, and IC/OC interrupt 0 occurs.
In the IC/OC interrupt 0 handler, the G1IR6 bit in the G1IR register is cleared and timer A0 one-shot timer starts.
The previous measured value is stored in the variable (old_tr), and the current measured value is stored in the variable (new_tr). Then, the overrun flag is read to confirm whether the base timer overflows while measuring.

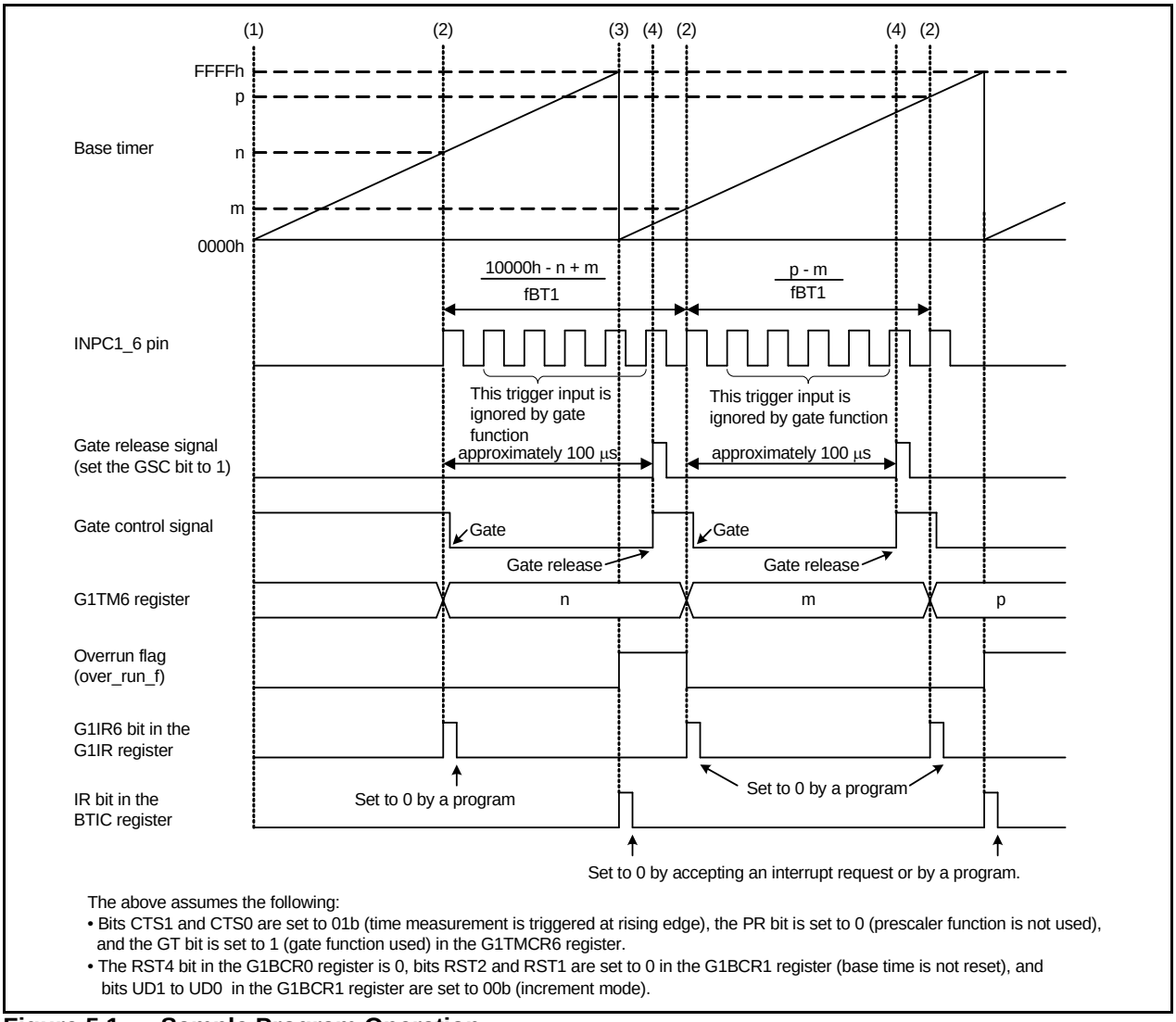
When an overflow occurs:
The time for measurement is calculated by the calculation method with overflow (10000h - old_tr + new_tr), and the result is stored in the variable (measurement).

When an overflow does not occur:
The time for measurement is calculated by the calculation method without overflow (new_tr - old_tr), and the result is stored in the variable (measurement).

(In this sample program, the first calculated result of time measurement is undefined.)
The overrun flag is cleared at the end.

(3) When a base timer overflows, the IC/OC base timer interrupt occurs. The overrun flag is set in the base timer interrupt handler.

(4) When timer A0 underflows, the timer A0 interrupt occurs.
The GSC bit in the G1TMR6 register is set to 1 (gate release) to enable trigger input acceptance in the timer A0 interrupt handler.

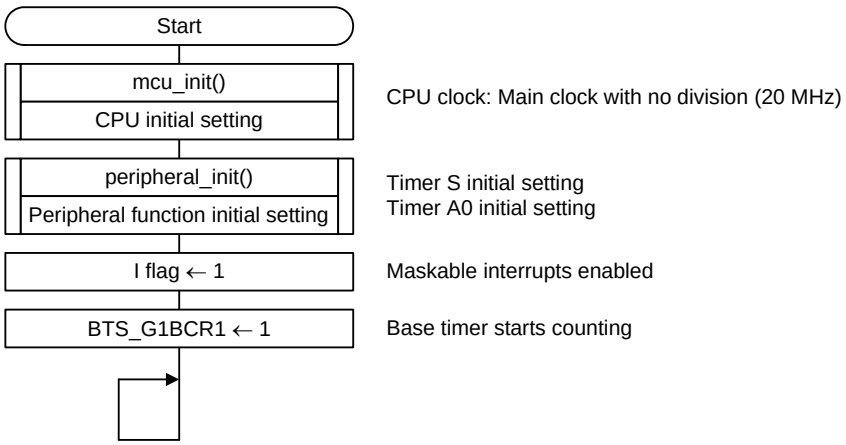


The above assumes the following:
- Bits CTS1 and CTS0 are set to 01b (time measurement is triggered at rising edge), the PR bit is set to 0 (prescaler function is not used), and the GT bit is set to 1 (gate function used) in the G1TMCR6 register.
- The RST4 bit in the G1BCR0 register is 0, bits RST2 and RST1 are set to 0 in the G1BCR1 register (base time is not reset), and bits UD1 to UD0 in the G1BCR1 register are set to 00b (increment mode).

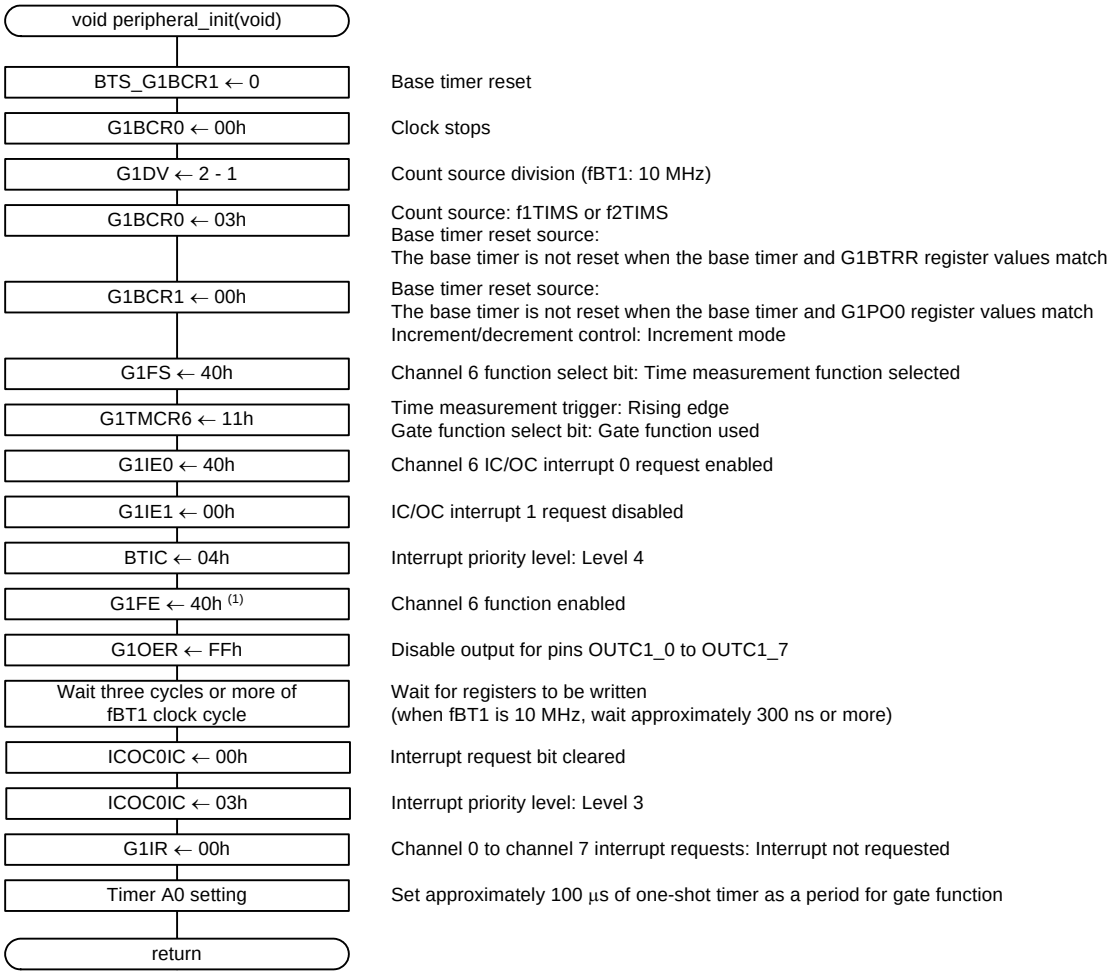
Figure 5.1 Sample Program Operation

5.2 Settings

5.2.1 Main Function

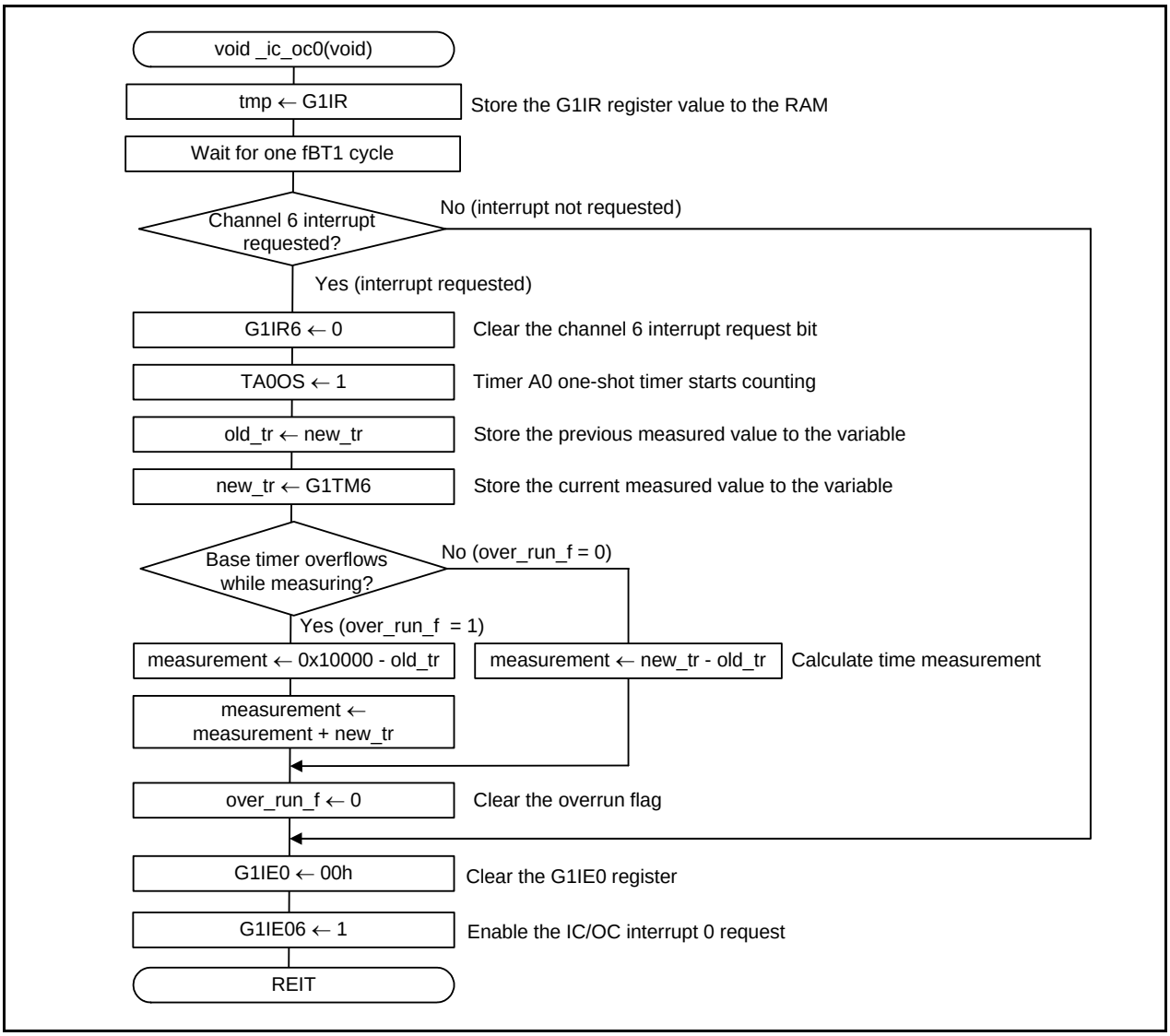


5.2.2 Peripheral Function Initial Setting

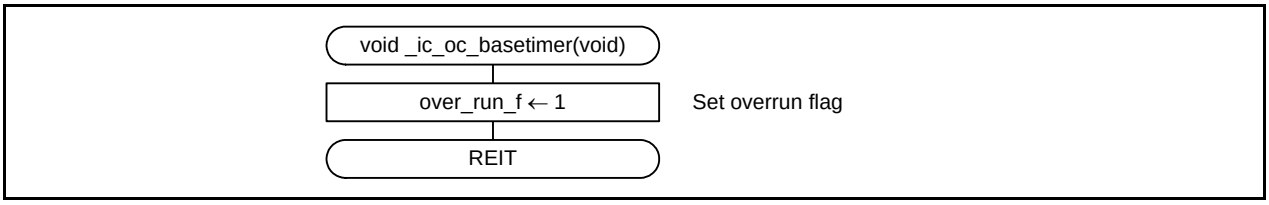


Note:
1. The value written to the register is reflected to the internal circuit when the clock is synchronized with the base timer count source (fBT1).

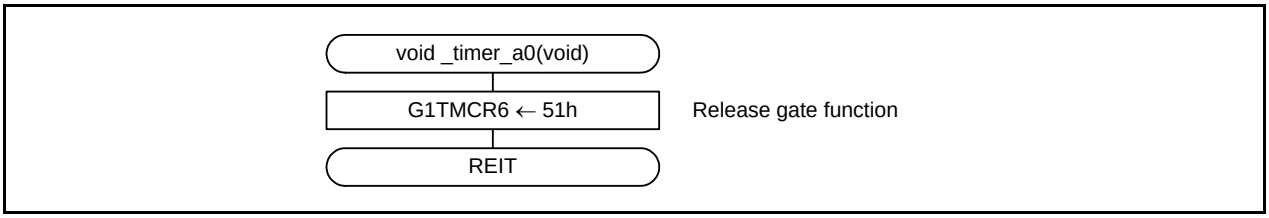
5.2.3 IC/OC Interrupt 0 Function



5.2.4 Base Timer Interrupt Function



5.2.5 Timer A0 Interrupt Function



6. Sample Program

A sample program can be downloaded from the Renesas Electronics website.

7. Reference Documents

M16C/5LD Group, M16C/56D Group User's Manual: Hardware Rev.1.20
M16C/5L Group, M16C/56 Group User's Manual: Hardware Rev.1.10
M16C/5M Group, M16C/57 Group User's Manual: Hardware Rev.1.10
M16C/6C Group User's Manual: Hardware Rev.2.00
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 User's Manual
M16C 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	M16C/5LD, M16C/56D, M16C/5L, M16C/56, M16C/5M, M16C/57, and M16C/6C Groups Time Measurement Function of Timer S with Gate Function

Rev.	Date	Description	
		Page	Summary
1.00	Jul 30, 2010	—	First edition issued.
1.01	Feb 29, 2012	—	Added M16C/57 Group.
		4	4. Peripheral Functions: Added.
		5	5.1 Explanation of the Sample Program: Written.
		6	Figure 5.1 Sample Program Operation: Modified the unit of period for the gate release signal.
		7	5.2.2 Peripheral Function Initial Setting: Changed.
		8	5.2.3 IC/OC Interrupt 0 Function: Changed.
		9	7. Reference Documents: Updated.
		9	Website and Support: Updated the URL of the Inquiries.

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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