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M16C/28, 29 Group

Time Measuerment Function of Time S with Gate Function

1. Abstract

This application note describes the time measurement function of Timer S with the gate function.

2. Introduction

This application note is applied to the following microcomputers.

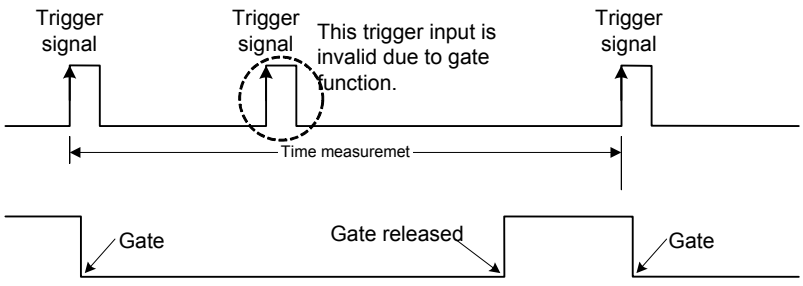
- MCU: M16C/28 Group
  M16C/29 Group

This program can also be used when operating other microcomputers within the M16C family, provided they have the same SFR (Special Function Registers) as the M16C/28, M16C/29 microcomputers. However, some functions may have been modified.
Refer to the Hardware Manual for details. Use functions covered in this Application Note only after careful evaluation.

3. Detailed Description

Timer S has one 16-bit base timer for free-run operation and eight 16-bit registers (channel 0 to 7) for the time measurement function and waveform generation function. Two channels (channel 6 and 7) out of eight have the gate function for the time measurement.
This example shows the time measurement of channel 6. The trigger input is inhibited during the period from receiving the trigger input in the $INPC1_6$ pin until the gate is released. The time between the gate releasing and the next trigger input is measured.

Input pulse waveform



(1) Time Measurement Function Setting
The channel 6 is used. In this example, the rising edge of the time measurement trigger is selected.

(2) Measurement Time Calculation
The time measurement interrupt of the channel 6 is used, and the value of the channel 6 in the time measurement register (G1TM6 register) is read during the interrupt routine.
The measurement time is the difference between the value that is measured last time and that of the channel 6.

(3) Gate Release

The gate is released by writing "1" (gate release) to the GSC bit in the G1TMCR6 register.

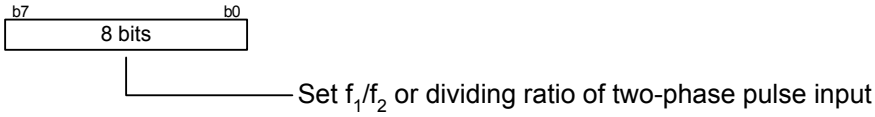
3.1 How to Set Up

This section shows the setting procedure and setting values to execute "3. Detailed Description". Refer to the hardware manuals (M16C/28 Group or M16C/29 Group) for the details of each register.

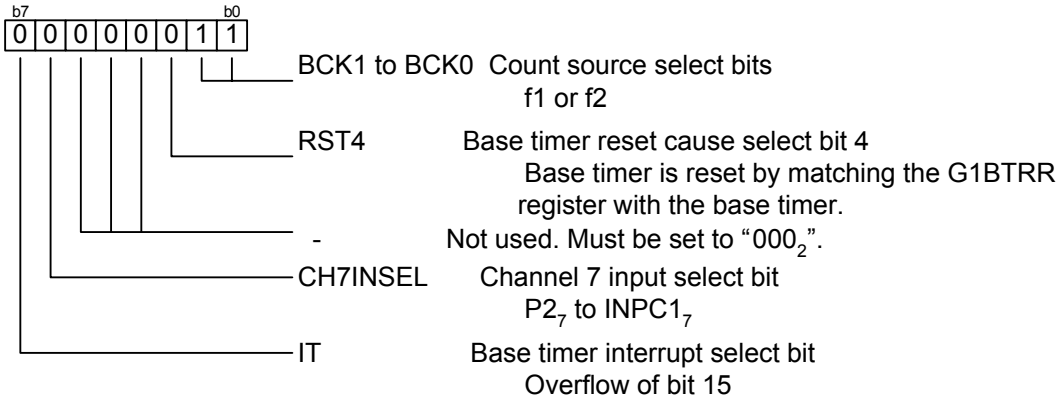
(1) Inhibiting an interrupt

Set I flag = "0". Or set interrupt priority level = "000$_2$" in interrupt control register that accepted interrupt requests issued by the timer S.

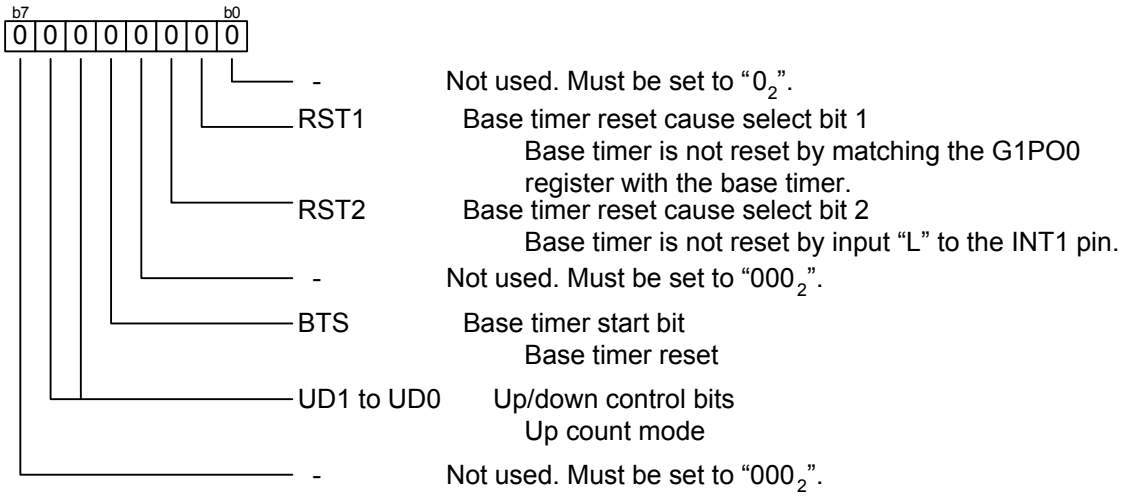
(2) G1DV register



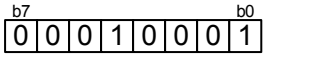
(3) G1BCR0 register



(4) G1BCR1 register



(5) G1TMCR6 register



CTS1 to CTS0 Time measurement trigger select bits
Rising edge

DF1 to DF0 Digital filter function select bits
Digital filter is not used.

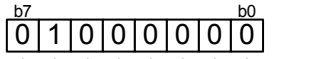
GT Gate function select bit
Gate function is used.

GOC Gate function release select bit
Gate function release mode is not selected.

GSC Gate function release bit
Gate function is released when this bit is set to "1".

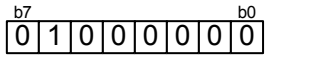
PR Prescaler function select bit
Not used.

(6) G1FS register



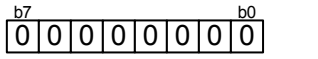
FSC7 to FSC0 Channel 7 to 0 time measurement/waveform generation function select bits
Channel 6 is selected for time measurement function.
(Note) It does not matter either "0" or "1" is set to other channels.

(7) G1FE register



IFE7 to IFE0 Channel 7 to 0 function enabled bits
Set bit of channel 6 to "1"(channel j function enabled).
(Note) Set other channels to "0".

(8) ICOC0IC register (interrupt disable setting /interrupt request bit clear)

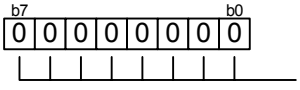


ILVL2 to ILVL0 Interrupt priority level select bits
Set interrupt priority level to "0".

IR Interrupt request bit
Set to "no interrupt request".

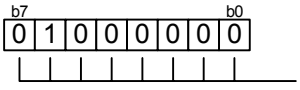
($\overline{b7}$-$\overline{b4}$) Not used. Must be set to "0000$_2$".

(9) G1IE0 register (interrupt enabled register reset)



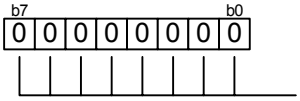
G1IE07 to G1IE00 Initialize channels to be unused for interrupt to “0”

(10) G1IE1 register



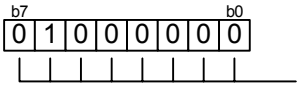
G1IE17 to G1IE10 Initialize channels to be unused for interrupt to “0”

(11) G1IR register



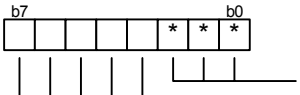
G1IR7 to G1IR0 Initialize interrupt request register

(12) G1IE1 register



G1IE17 to G1IE10 Set channel to be used for interrupt to “1”

(13) ICOC1IC register (interrupt priority level setting)(*)



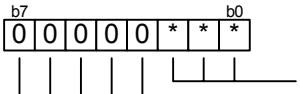
ILVL2 to ILVL0 Interrupt priority level select bit
Set interrupt priority level.

IR Interrupt request bit

($\overline{b7\text{-}b4}$) Not used. Must be set to “0000$_2$”.

(*) Use “OR” instruction so that the interrupt request bit is not changed when setting the interrupt priority level.

(14) BTIC register



ILVL2 to ILVL0 Interrupt priority level select bits
Set interrupt priority level.

IR Interrupt request bit
Set to “no interrupt request”.

($\overline{b7\text{-}b4}$) Not used. Must be set to “0000$_2$”.

3.2 Precaution on Interrupt

In the process of Timer S interrupt, the description varies depending on the interrupt routine by the base timer or by each channel.

In the case of the base timer interrupt, interrupt request bit is “0” when the request is accepted. (It is not necessary to set to “0” by the program.)

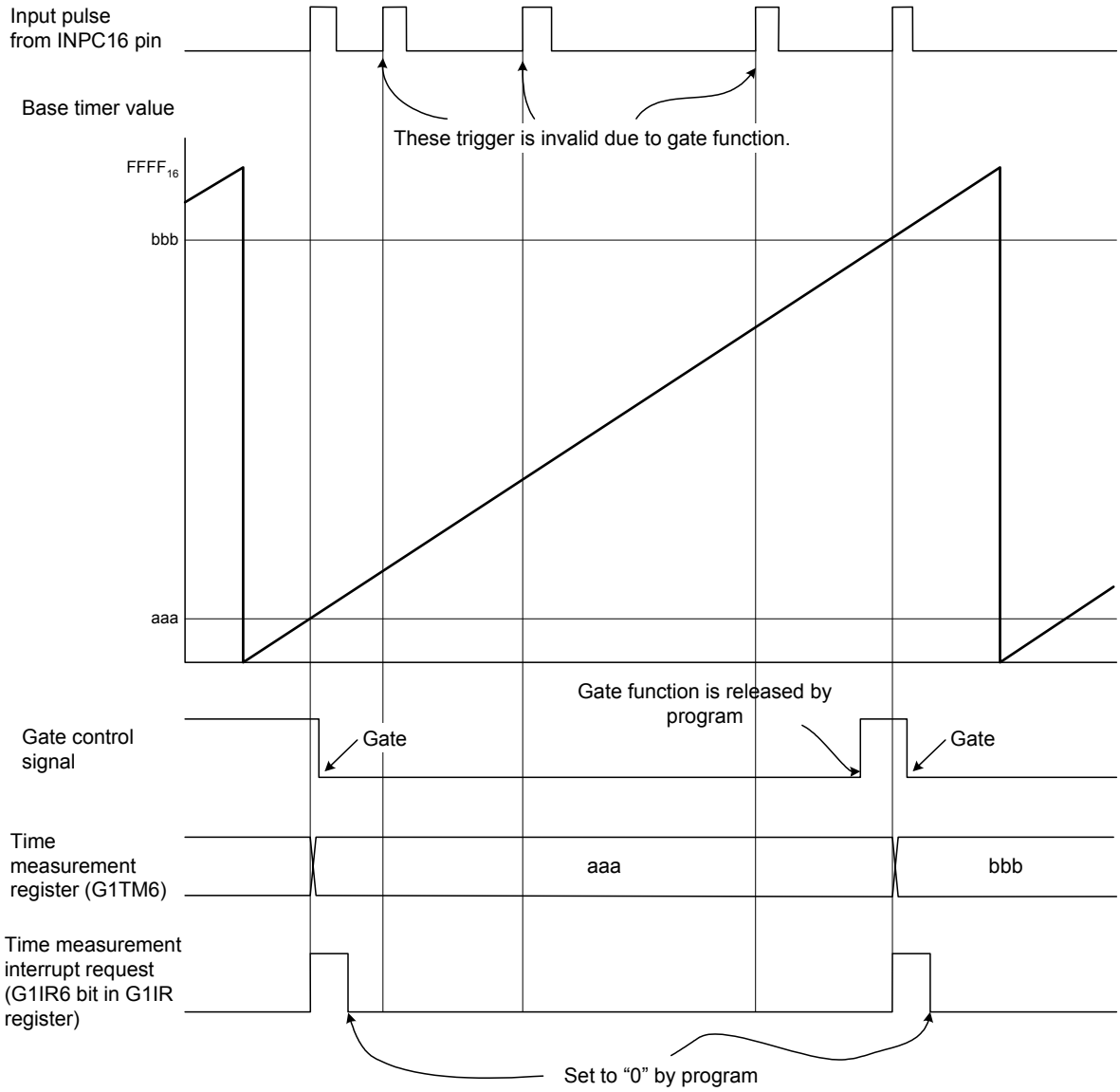
In the case of interrupt by each channel, interrupt requests for each channel are set in the interrupt request register (G1IR Register). When an interrupt request in the channel i occurs, the bit i in the G1IR Register is set to “1”.
If the bit i in the interrupt enable register 0 (G1IE0 Register) is “1”, the interrupt request bit in the IC/OC0 interrupt control register (ICOC0IC Register) is set to “1”.
If the bit i in the G1IE1 register is “1”, the interrupt request bit in the IC/OC1 interrupt control register (ICOC1IC Register) is set to “1”.

Interrupt request bits in the IC/OC0 and IC/OC1 interrupt control register are set to “0” automatically when they receive the interrupt request. However the interrupt request bits of each channel in the G1IR register are not set to “0” automatically, so set to “0” (no interrupt request) by the program.

Use the following instructions when writing “0” to each bit in the G1IR register.
AND, BCLR

3.3 Timing Diagram

The following shows a timing diagram according to the section “3.1” and “3.2”.



4. Sample Program

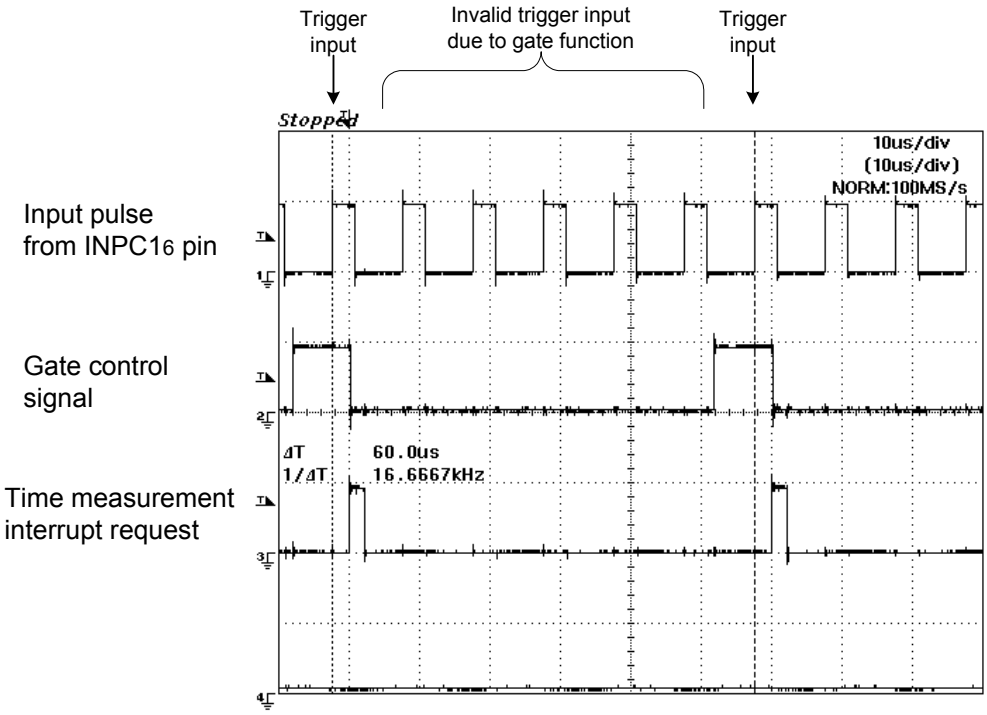
```
/************************************************************ *
 *                                                           *
 *   FILE NAME :                                             *
 *   Version   : 1.10                                         *
 *   Function  : 16-bit Time measurement mode with gate function  *
 *                                                           *
 *   Copyright (C)2004, Renesas Technology Corp.              *
 *   Copyright (C)2004, Renesas Solutions Corp.               *
 *                                                           *
 ************************************************************/
/***************************
 *   include file          *
 ***************************/
#include "sfr28.h"

/***************************
 *   Function Definition   *
 ***************************/
void      bt_int(void);
#pragma INTERRUPT bt_int

void      icoc1_int(void);
#pragma INTERRUPT icoc1_int

void      port_init(void);
void      icoc_init(void);
/***************************
 *   Global variable       *
 ***************************/

static unsigned short pluse;
static unsigned short new_tr;
static unsigned short old_tr;
static unsigned short gate_n;

/***************************
 *   main                  *
 ***************************/
void main(void) {

   port_init();
   icoc_init();

   pluse = 0;
   new_tr = 0;
   old_tr = 0;
   gate_n = 0x40;

   bts_g1bcr1 = 1;         /* Base Timer Start */
   asm (" fset I");
   while (1) {
           if ( p10_5 == 0) {
                   gate_n--;
                   if ( gate_n == 0 ) {
                           gsc_g1tmcr6 = 1;
                           p10_5 = 1;
                           gate_n = 0x40;
                   }
           } else {
                   gate_n = 0x40;
           }
   }
}

void port_init() {
   p0 = 0;
   p1 = 0;
   p2 = 0;
   p3 = 0;

   p7 = 0;
   p8 = 0;
   p9 = 0;
```

```
    p10 = 0x20;

    pd0 = 0xff;
    pd1 = 0xff;
    pd2 = 0x00;
    pd3 = 0xff;

    pd7 = 0xff;
    pd8 = 0xff;
    prcr = 4;
    pd9 = 0xff;
    pd10 = 0xff;
}

void icoc_init() {

    g1dv = 2-1;             /* fBT is 10MHz */
    g1bcr0 = 0x03;
    g1bcr1 = 0x00;          /* The base timer is reset by matching the G1PO0 regiser */

    g1tmcr6 = 0x11;         /* ch-6 Time Measurement set */

    g1fs = 0x40;            /* ch-0 to ch-5,ch-7 Waveform generation function select */
                            /* ch-6     Time Measurement function select    */

    g1fe = 0x40;            /* ch-6     function enable */

    ifsr2a = 0;

    icoc1ic = 0;            /* IC/OC 1 Interrupt control register set to 0 */

    g1ie0 = 0;              /* Interrupt enable register 0 set to 0 */
    g1ie1 = 0;              /* Interrupt enable register 1 set to 0 */

    g1ir = 0;                       /* Interrupt request register initialize */

    g1ie1 = 0x40;           /* Interrupt enable register 1 set */

    icoc1ic |= 0x04;                /* IC/OC 1 Interrupt control register set */

    btic = 0x04;            /* Base timer Interrupt control register set */
}

void      bt_int() {

    p10_7 = 1;              /* for Base timer over flow detection */
}

void      icoc1_int() {

    p10_4 = 1;
    p10_5 = 0;
    g1ir6 = 0;
    old_tr = new_tr;
    new_tr =(unsigned short)g1tm6;
    if ( p10_7 == 1) {
            pluse = 0xFFFF -old_tr;
            pluse = pluse + new_tr;
            p10_7 = 0;
    } else {
            pluse = new_tr - old_tr;
    }
    p10_4 = 0;
}
```

5. Example

Conditions: Supply voltage = 5V
Main clock (X_{IN}) = 20MHz
Base timer operation clock (f_{BT1}) = 10MHz

Trigger period = 100kHz



6. Reference

Hardware Manual

M16C/28 Group Hardware Manual

M16C/29 Group Hardware Manual

(The latest version is available on the website: http://www.renesas.com)

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