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April 1st, 2010
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M16C/Tiny Series

Operation of Watchdog Timer

1. Abstract

This application note describes how to use watchdog timer of the M16C/Tiny series microcomputers.

2. Introduction

The explanation of this issue is applied to the following condition:

- MCU: M16C/26A Group
  M16C/28 Group
  M16C/29 Group

This program can be operated under the condition of M16C family products with the same SFR (Special Function Register) as 26A, 28, 29 group products. Because some functions may be modified of the M16C family products, see the user's manual. When using the functions shown in this application note, evaluate them carefully for an operation.

3. Specifications

3.1 Operation

(1) Writing to the watchdog timer start register initializes the watchdog timer to “7FFFh” and causes it to start a down count.
(2) With the watchdog timer’s counting in progress, writing to the watchdog timer start register again initializes the watchdog timer to “7FFFh” and causes it to resume counting.
(3) Either executing the WAIT instruction or going to the stopped state causes the watchdog timer to stop counting and to hold the current value of counter. The watchdog timer resumes counting after returning from the execution of the WAIT instruction or from the stopped state.
(4) If the watchdog timer underflows, it is initialized to “7FFFh” and continues counting. Simultaneously, a watchdog timer interrupt occurs.

Notes:

- The watchdog timer and the prescaler both are inactive after reset, so that the watchdog timer is activated to start counting by writing to the WDTS register. Write the WDTS register with shorter cycle than the watchdog timer cycle in order not to generate any watchdog timer interrupt. Set the WDTS register also in the beginning of the watchdog timer interrupt routine.
- If the watchdog timer function select bit in Processor Mode Register 1 (PM1 register) is set to 1 (watchdog timer reset), the pins, CPU, and SFR are initialized when a watchdog timer interrupt occurs, and the program is executed from the address indicated by the reset vector.

Figure 1 shows the operation timing of watchdog.

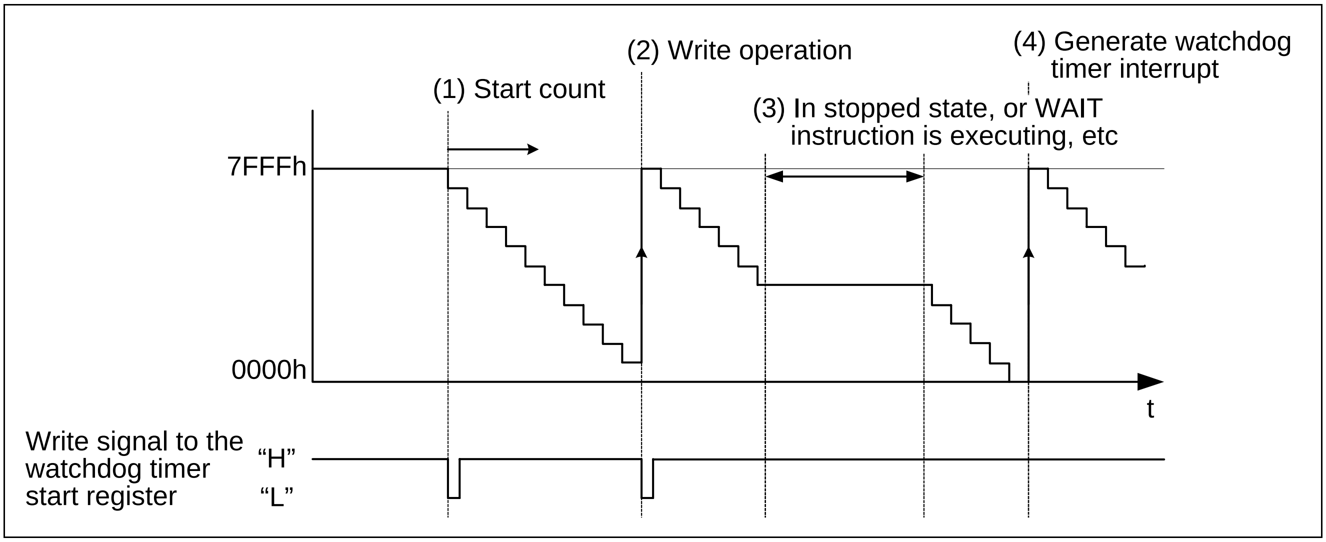
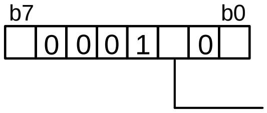

(2) Write operation
(4) Generate watchdog timer interrupt
(1) Start count
(3) In stopped state, or WAIT instruction is executing, etc
7FFFh
0000h
t
Write signal to the watchdog timer start register
“H”
“L”

Figure 1. Operation Timing of Watchdog

3.2 Register setting

The following procedure in this application note is based on M16C/29 group products, other M16C/Tiny series's setup procedure please refer to the hardware user's manual.

(1) Setting watchdog timer function select bit (Note 1)

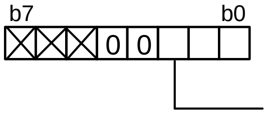


Processor mode register 1 [Address 0005h] PM1

Watchdog timer function select bit
0 : Watchdog timer interrupt
1 : Watchdog timer reset (Note 2)

Note 1: Write to this register after setting the PRC1 bit in the PRCR register to "1" (write enable).
Note 2: PM12 bit is set to "1" by writing "1" in a program. (Writing "0" has no effect.)

(2) Setting WDT count source protective bit

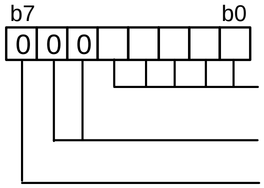


Processor mode register 2 [Address 001Eh] PM2

WDT count source protective bit (Note 1, 2)
0 : Select CPU clock
1 : Select On-chip oscillator clock

Note 1: Once this bit is set to "1", it cannot be cleared to "0" in a program.
Note 2: Setting PM22 bit to "1" results in the following condition:
- The on-chip oscillator clock becomes the WDT count source.
- The CM10 bit of CM1 register is disabled against write. (writing "1" has no effect, nor is stop mode entered.)
- The WDT does not stop when in wait mode.

(3) Setting watchdog timer control register



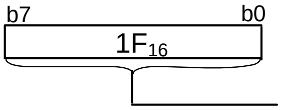
Watchdog timer control register [Address 000Fh] WDC

High-order bit of watchdog timer

Must set to "0"

Prescaler select bit
0 : Divided by 16
1 : Divided by 128

(4) Setting watchdog timer start register



Watchdog timer start register [Address 000Eh] WDTS

The watchdog timer is initialized and starts counting after a write instruction to this register. The watchdog timer value is always initialized to "7FFFh" regardless of whatever value is written.

4. The example of reference program

Figure 2 shows the sample circuit of reference program.

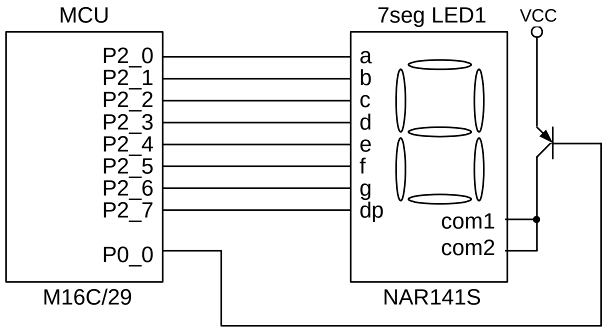


Figure 2. Sample Circuit of Reference Program

4.1 Using the watchdog timer interrupt program

While this program writes to the watchdog timer start register, it increases the indication of port P2. When the output of port P2 reaches “9”, the program stops writing to the watchdog timer start register to stop updating the indication of port P2.

When a watchdog timer interrupt occurs, the program writes to the watchdog timer start register while it decreases the indication of port P2 in a watchdog timer interrupt service routine. When the output of port P2 reaches “0”, the program stops updating the indication of port P2.

```
/********************************************************/
/*                                                      */
/* M16C/Tiny Series Program Collection                  */
/*                                                      */
/* FILE NAME    : rec05b0006-0102_int.c                 */
/* CPU          : M16C/29 Group                         */
/* FUNCTION     : Operation of Watchdog Timer           */
/* HISTORY      : 2006.04.13 Ver 1.02                   */
/*                                                      */
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/* All right reserved.                                  */
/********************************************************/

/********************************************************/
/*    Include File                                      */
/********************************************************/
#include "sfr29.h"       // Special function register header file

/********************************************************/
/*    Function Definition                               */
/********************************************************/
void init_mcu(void);     // SFR initialize
void wait_10ms(void);    // Main clock oscillation stable wait routine
#pragma INTERRUPT wdt_int
```

```
/*******************************************************/
/*    Define Label                                     */
/*******************************************************/
#define PRODUCT_TYPE 0   // 28,29 group: 0   26A group: 1
#define PIN_TYPE 0       // 80 pin: 0        64 pin: 1 (28,29 group)
                         // 48 pin: 0        42 pin: 1 (26A group)

/*******************************************************/
/*    Define Const                                     */
/*******************************************************/
/* port2_0 - port2_7 data : 0  1  2  3  4  5  6  7  8  9 */
unsigned char count_data[10] =
{0xC0,0xF9,0xA4,0xB0,0x99,0x92,0x82,0xD8,0x80,0x90};

unsigned int i,j;

/*******************************************************/
/*    Main Program                                     */
/*******************************************************/
void main(void)
{
   init_mcu();               // SFR initialize

   j = 0;
   i = 0;

   wdc = 0;                  // Setting watchdog timer control register
                             // Prescaler select bit is set to 0 (0: divided by 16)

   wdts = 1;                 // Setting watchdog timer start register

   while (1)
   {
      while (ir_ta0ic == 0); // 1ms?

      ta0ic = 0x00;          // Timer A0 interrupt level: 0
      i++;

      if ( i == 500 )
      {
         i = 0;
         if ( j <= 9 )
         {
            p2 = count_data[j];
         }
         j++;
      }
      if ( j <= 9 )
      {
         wdts = 1;           // Setting watchdog timer start register
      }
   }
}
```

```
/*******************************************************/
/*    Watchdog Timer Interrupt Routine                 */
/*******************************************************/
void wdt_int()
{
   wdts = 1;                    // Set the WDTS register in the beginning of the
                                // watchdog timer interrupt routine.

   while (1)
   {
      wdts = 1;                 // For long-time loop, set WDTS register again to
                                // avoid the underflow of watchdog timer.

      while (ir_ta0ic == 0);    // 1ms?

      ta0ic = 0x00;             // Timer A0 interrupt level: 0
      i++;

      if ( i == 500 )
      {
         i = 0;
         if ( j != 0 )
         {
            j--;
            if ( j <= 9 )
            {
               p2 = count_data[j];
            }
         }
      }
   }
}

/*******************************************************/
/*    MCU Initialize                                   */
/*******************************************************/
void init_mcu(void)
{
   prcr = 0x03;      // Protect register off

                     // Set processor mode registers
   pm0 = 0x00;       // Single-chip mode
   pm1 = 0x08;       // No expansion, No wait

   wait_10ms();      // Waiting for main clock oscillation stable

                     // Set system clock control registers
   cm2 = 0x00;       // System clock select Main clock or PLL clock
   cm1 = 0x20;       // Xin-Xout High, Main clock is no division
   cm0 = 0x08;       // Xcin-Xcout drive capacity select bit (1: high)

   pclkr = 0x03;     // TimerA, B clock select bit (1: f1)
```

```
                     // WDT clock setting
   pm22 = 0;         // Set WDT count source protective bit
                     // <PM22>  : select CPU clock
                     // 0: select CPU clock

                     // Set WDT function select bit
   pm12 = 0;         // <PM12>  :0: WDT interrupt;  1: WDT reset
                     // (writing a 1 by program, writing a 0 has no effect)

   prcr = 0x00;      // Protect register on

   #if PRODUCT_TYPE      // Product selection: 26A group
      ifsr2a = 1;        // Interrupt request cause select register2 IFSR2A
                         // <IFSR20>   : Reserved bit (Must be set to "1")
      prcr = 0x04;       // Protect register off
      #if PIN_TYPE       // Port setting
         pacr = 0x01;    // 42pin type
      #else
         pacr = 0x04;    // 48pin type
      #endif
      prcr = 0x00;       // Protect register on
   #else                 // Product selection: 28,29 group
      ifsr2a = 0;        // Interrupt request cause select register2 IFSR2A
                         // <IFSR20>   : Reserved bit (Must be set to "0")
      prcr = 0x04;       // Protect register off
      #if PIN_TYPE       // Port setting
         pacr = 0x02;    // 64pin type
      #else
         pacr = 0x03;    // 80pin type
      #endif
      prcr = 0x00;       // Protect register on
   #endif

   p0 = 0x02;        // Select LED1
   p2 = 0;           // Port2 output
   pd0 = 0xff;       // Port direction0: output mode
   pd2 = 0xff;       // Port direction2: output mode

                     // Timer A0 setup
   ta0mr = 0x40;     // Selection of timer mode
                     // Pulse output function select bit (0: pulse is not output)
                     // Gate function select bit (00: gate function not available)
                     // Count source (01: f8)
   ta0 = 2500-1;     // Setting counter value (1msec @20MHz, f8)
   ta0ic = 0x00;     // Setting interrupt priority levels in timer A0
   ta0s = 1;         // Timer A0 count start
}

/*******************************************************/
/*    Main Clock Oscillation Stable Wait 10ms Routine  */
/*******************************************************/
void wait_10ms(void)
```

```
{
   ta0mr = 0x00;     // Set Timer A0 mode register (Timer mode, count source: f1)

   ta0 = 20000-1;    // Setting counter value (10msec @4MHz/2, f1)

   ta0ic = 0x00;     // Clear interrupt request bit

   tabsr = 0x01;     // Timer A0 start counting

   while (ir_ta0ic == 0){    }

   ir_ta0ic = 0;     // Clear interrupt request bit

   tabsr = 0x00;     // Timer A0 stops counting
}
```

In order for this program to run properly, the watchdog timer interrupt vector needs to point to the service routines for the interrupt. The interrupt vector table information is included in the startup file "sect30.inc". Insert the function label " _wdt_int " into the interrupt vector table locations as shown below.

```
;/******************************************************************
; C Compiler for R8C/Tiny, M16C/60, 30, 20, 10
; Copyright(C) 1999(2000-2004). Renesas Technology Corp.
; and Renesas Solutions Corp., All rights reserved.
;
; Written by T.Aoyama
;
; sect30.inc      : section definition
; This program is applicable when using the basic I/O library
;
; $Id: sect30.inc,v 1.23.4.6 2004/10/29 14:06:39 simomura Exp $
;
;*******************************************************************/

;===================================================================
; fixed vector section
;-------------------------------------------------------------------
   .section fvector,ROMDATA
   .org  0fffdcH
   .glb _wdt_int
;UDI:
;  .lword   dummy_int
;OVER_FLOW:
;  .lword   dummy_int
;BRKI:
;  .lword   dummy_int
;ADDRESS_MATCH:
;  .lword   dummy_int
;SINGLE_STEP:
;  .lword   dummy_int
   .org  0ffff0H
WDT:
   .lword   _wdt_int
;DBC:
;  .lword   dummy_int
;NMI:
;  .lword   dummy_int
   .org  0ffffcH
RESET:
   .lword   start
;*******************************************************************
```

4.2 Using the watchdog timer interrupt to reset program

When the watchdog timer underflows after reaching terminal count, the program is reset and writes to the watchdog timer start register while it increases the indication of port P2. When the output of port P2 reaches “9”, the program stops updating the indication of port P2. Because the program stops writing to the watchdog timer start register, the program will be reset soon.

```
/*******************************************************/
/*                                                     */
/* M16C/Tiny Series Program Collection                 */
/*                                                     */
/* FILE NAME   : rec05b0006-0102_rst.c                 */
/* CPU         : M16C/29 Group                         */
/* FUNCTION    : Operation of Watchdog Timer           */
/* HISTORY     : 2006.04.13 Ver 1.02                   */
/*                                                     */
/* Copyright (C) 2006. Renesas Technology Corp.        */
/* All right reserved.                                 */
/*                                                     */
/*******************************************************/

/*******************************************************/
/*    Include File                                     */
/*******************************************************/
#include "sfr29.h"       // Special function register header file

/*******************************************************/
/*    Function Definition                              */
/*******************************************************/
void init_mcu(void);     // SFR initialize
void wait_10ms(void);    // Main clock oscillation stable wait routine

/*******************************************************/
/*    Define Label                                     */
/*******************************************************/
#define PRODUCT_TYPE 0   // 28,29 group: 0   26A group: 1
#define PIN_TYPE 0       // 80 pin: 0        64 pin: 1 (28,29 group)
                         // 48 pin: 0        42 pin: 1 (26A group)

/*******************************************************/
/*    Define Const                                     */
/*******************************************************/
/* port2_0 - port2_7 data : 0  1  2  3  4  5  6  7  8  9 */
unsigned char count_data[10] =
{0xC0,0xF9,0xA4,0xB0,0x99,0x92,0x82,0xD8,0x80,0x90};

unsigned int i,j;

/*******************************************************/
/*    Main Program                                     */
/*******************************************************/
void main(void)
{
   init_mcu();                // SFR initialize

   j = 0;
   i = 0;

   wdc = 0;                   // Setting watchdog timer control register
                              // Prescaler select bit is set to 0 (0: divided by 16)

/* wdt reset   */
   wdts = 1;                  // Setting watchdog timer start register

   while (1)
   {
      while (ir_ta0ic == 0); // 1ms?

      ta0ic = 0x00;           // Timer A0 interrupt level: 0
      i++;

      if ( i == 500 )
      {
         i = 0;
         if ( j <= 9 )
         {
            p2 = count_data[j];
         }
         j++;
      }
      if ( j <= 9 )
      {
         wdts = 1;            // Setting watchdog timer start register
      }
   }
}

/*******************************************************/
/*    MCU Initialize                                   */
/*******************************************************/
void init_mcu(void)
{
   prcr = 0x03;      // Protect register off

                     // Set processor mode registers
   pm0 = 0x00;       // Single-chip mode
   pm1 = 0x08;       // No expansion, No wait

   wait_10ms();      // Waiting for main clock oscillation stable

                     // Set system clock control registers
   cm2 = 0x00;       // System clock select Main clock or PLL clock
   cm1 = 0x20;       // Xin-Xout High, Main clock is no division
   cm0 = 0x08;       // Xcin-Xcout drive capacity select bit (1: high)

   pclkr = 0x03;     // TimerA, B clock select bit (1: f1)
```

```
                     // WDT clock setting
   pm22 = 0;         // Set WDT count source protective bit
                     // <PM22>  : select CPU clock
                     // 0: select CPU clock

                     // Set WDT function select bit
   pm12 = 1;         // <PM12>  :0: WDT interrupt;  1: WDT reset
                     // (writing a 1 by program, writing a 0 has no effect)

   prcr = 0x00;      // Protect register on

   #if PRODUCT_TYPE      // Product selection: 26A group
      ifsr2a = 1;        // Interrupt request cause select register2 IFSR2A
                         // <IFSR20>   : Reserved bit (Must be set to "1")
      prcr = 0x04;       // Protect register off
      #if PIN_TYPE       // Port setting
         pacr = 0x01;    // 42pin type
      #else
         pacr = 0x04;    // 48pin type
      #endif
      prcr = 0x00;       // Protect register on
   #else                 // Product selection: 28,29 group
      ifsr2a = 0;        // Interrupt request cause select register2 IFSR2A
                         // <IFSR20>   : Reserved bit (Must be set to "0")
      prcr = 0x04;       // Protect register off
      #if PIN_TYPE       // Port setting
         pacr = 0x02;    // 64pin type
      #else
         pacr = 0x03;    // 80pin type
      #endif
      prcr = 0x00;       // Protect register on
   #endif

   p0 = 0x02;        // Select LED1
   p2 = 0;           // Port2 output
   pd0 = 0xff;       // Port direction0: output mode
   pd2 = 0xff;       // Port direction2: output mode

                     // Timer A0 setup
   ta0mr = 0x40;     // Selection of timer mode
                     // Pulse output function select bit (0: pulse is not output)
                     // Gate function select bit (00: gate function not available)
                     // Count source (01: f8)
   ta0 = 2500-1;     // Setting counter value (1msec @20MHz, f8)
   ta0ic = 0x00;     // Setting interrupt priority levels in timer A0
   ta0s = 1;         // Timer A0 count start
}

/*******************************************************/
/*    Main Clock Oscillation Stable Wait 10ms Routine   */
/*******************************************************/
void wait_10ms(void)
```

```
{
   ta0mr = 0x00;     // Set Timer A0 mode register (Timer mode, count source: f1)

   ta0 = 20000-1;    // Setting counter value (10msec @4MHz/2, f1)

   ta0ic = 0x00;     // Clear interrupt request bit

   tabsr = 0x01;     // Timer A0 start counting

   while (ir_ta0ic == 0){    }

   ir_ta0ic = 0;     // Clear interrupt request bit

   tabsr = 0x00;     // Timer A0 stops counting
}
```

5. Reference

Renesas web-site
http://www.renesas.com/

Inquiry
http://www.renesas.com/inquiry
csc@renesas.com

Hardware manual
M16C/26A Group (M16C/26A, M16C/26T) Hardware Manual Rev.1.00
M16C/28 Group Hardware Manual Rev.1.01
M16C/28 Group (T-ver./V-ver.) Hardware Manual Rev.1.00
M16C/29 Group Hardware Manual Rev.1.00
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Revision

Rev.	Issue data	Description	
		Page	Summary
1.00	Dec.23.05	-	First edition issued
1.01	Jan.25.06	-	Sample program modified: define PRODUCT_TYPE
1.02	Apr.14.06	-	Modified function “wait_10ms” in sample program

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