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# M16C/26

## Using The M16C/26 Timer in PWM Mode

## 1.0 Abstract

PWM or Pulse Width Modulation is useful in DC motor control, actuator control, synthesized analog output, piezo transducers, etc. PWM produces a signal of (typically) fixed frequency and vary the width of the pulse to control a device or peripheral. The following article describes how to use the M16C/26 timer A in Pulse Width Modulation Mode.

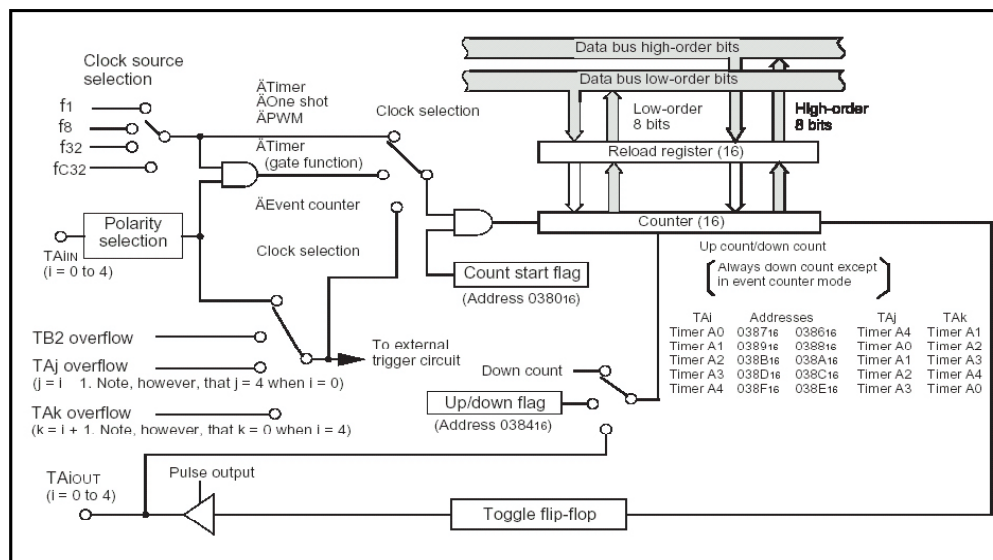
## 2.0 Introduction

The Renesas M30262 is a 16-bit MCU based on the M16C/60 series CPU core. The MCU features include up to 64K bytes of Flash ROM, 2K bytes of RAM, and 4K bytes of Virtual EEPROM. The peripheral set includes 10-bit A/D, UARTS, Timers, DMA, and GPIO. The MCU has eight timers that consists of five Timer A's and three Timer B's. All five timer A's can operate as PWM's.

Timer A has the following additional modes of operation:

- Event Counter Mode
- Timer Mode
- One-Shot Mode

Figure 1 is a block diagram of timer A. The remainder of this document will focus on setting up timer A0 and A1 in PWM Mode.



### Figure 1 Bock Diagram of Timer A

### 3.0 PWM Mode Description

PWM Mode has two “sub” modes: 16-bit and 8-bit. In 16-bit mode, the value of the 16-bit Ai Timer register determines the pulse width and the frequency is fixed to  $f_{X_{in}} / 65535$ . Therefore, the max frequency of the 16-bit PWM (assuming a 20MHz  $f_{X_{in}}$ ) is approx. 305 Hz. In 8-bit mode, the higher order 8-bits are used to determine the pulse width and the lower 8-bit the frequency, where the frequency is  $f_{in} / 255$  or a maximum frequency of approx. 78,431 Hz. Note that the PWM output is free running and interrupts need not be serviced. In addition, the user has the option of triggering the start of the PWM output via the timer's TAI<sub>N</sub> pin.

The pulse width (when the signal is at a high state) of the 16-bit PWM is:

$$\text{Pulse width (high)} = n / f_{in}, \text{ or } \% \text{ duty} = n / 65535 * 100,$$

Where  $n$  is the value loaded into the Ai counter register.

The pulse width (when the signal is at a high state) of the 8-bit PWM is:

$$\text{Pulse width (high)} = n * (m+1) / f_{in}, \text{ or } n / (255 * f_{PWM}), \% \text{ duty} = n / 255 * 100,$$

Where  $n$  is the value loaded into Ai counter register's high order address and  $m$  is loaded into Ai counter register's low order address.

The pulse width can be changed at any time by writing to the Ai counter register. However, during counting, the write only affects the reload register, and the counter register is updated on the next cycle.

Figure 2 and Figure 3 illustrate the timing for a 16-bit and 8-bit PWM.

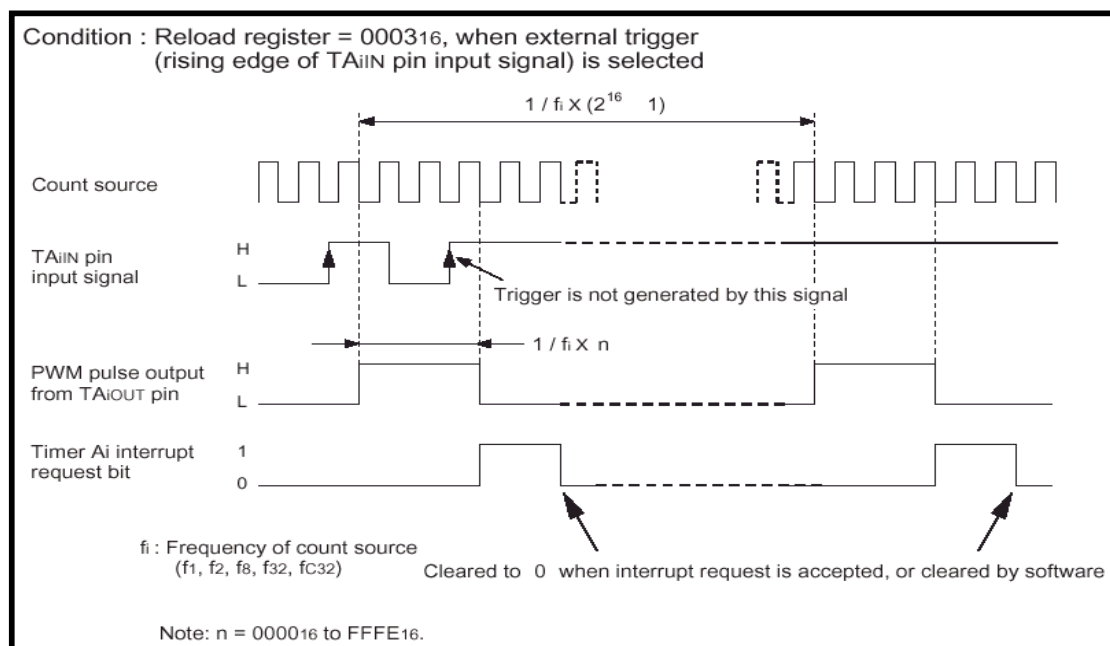


Figure 2 PWM Timing Example (16-bit mode)

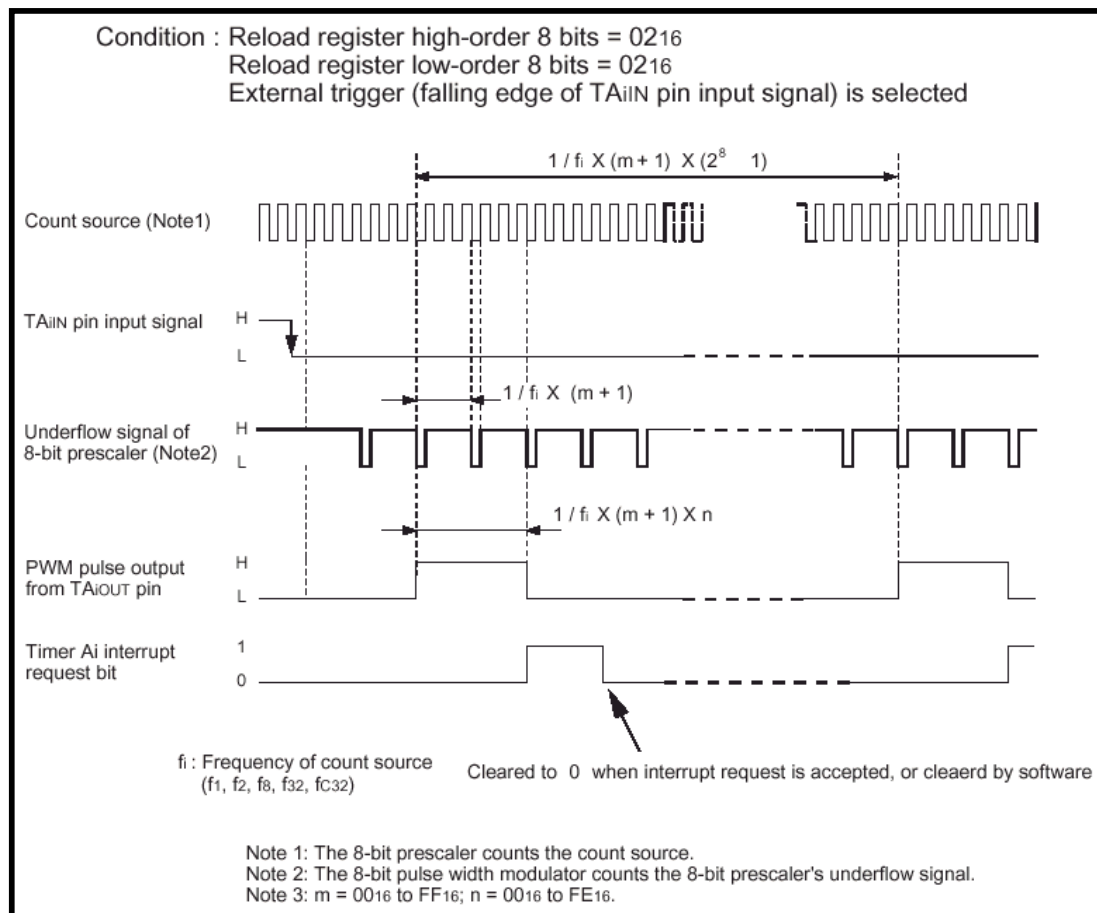


Figure 3 PWM Timing Example (8-bit mode)

## 4.0 Configuring PWM Mode

The steps to configure timer A for PWM mode are shown below.

1. Load Timer Ai register with pulse width value (16-bit) or frequency and pulse width value (8-bit).

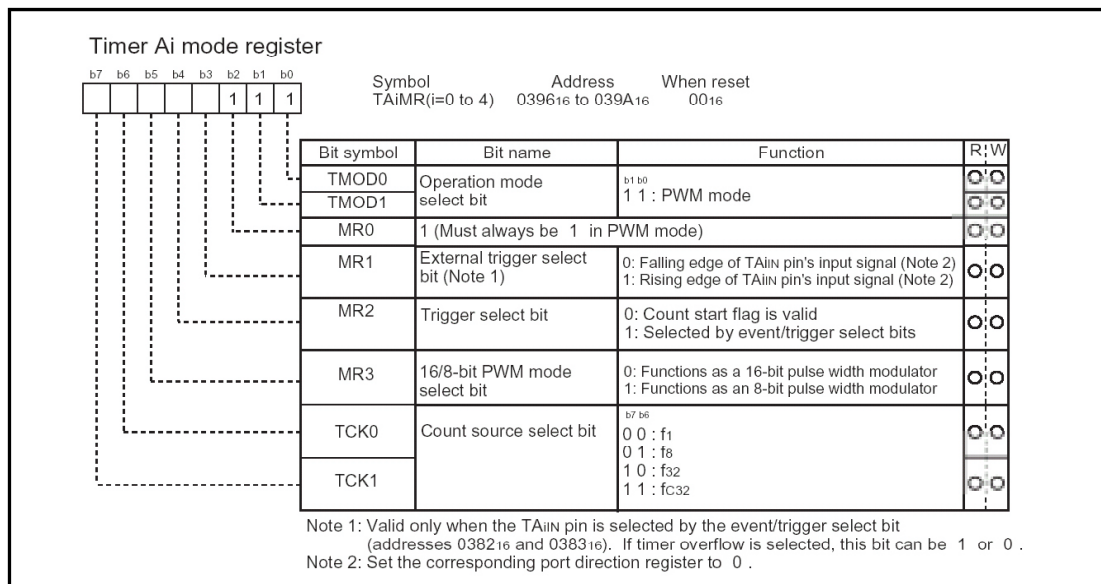
**Note:** Note: For 16-bit 65535 is not valid for the pulse width value. For 8-bit 255 is not valid for the frequency and pulse width value.

2. Load the timer mode register, TAIMR
  - Select PWM mode: bits TMOD0 and TMOD1 = 1.
  - Set the MR0 bit = 1 for PWM Mode.
  - Clear the MR1 bit for a falling edge external trigger, or set it for rising edge.
  - Clear the MR2 bit to use the 'count start flag' as a trigger, or set it for external trigger.
  - Clear the MR3 bit for 16-bit PWM, set it for 8-bit PWM.
  - Select the clock source ( $f_1, f_8, f_{32}$ , or  $f_{c32}$ ): bits TCK0, TCK1 register.

3. Set the timer 'interrupt priority level', TAIIC (to zero if interrupts are not required)
4. Enable interrupts if required (CPU I flag set).
5. Set the 'start count' flag bit, TAI<sub>S</sub> in the 'count start flag' register, TABSR

For the most part, the order shown above is not important, but the count register should be loaded before the 'start count' flag is set. In addition, the priority level should not be modified when there is a chance of an interrupt occurring.

Figure 4 to Figure 7 show the registers for configuring Timer A for PWM.



**Figure 4 Timer Ai mode register in Pulse Width Modulation Mode**

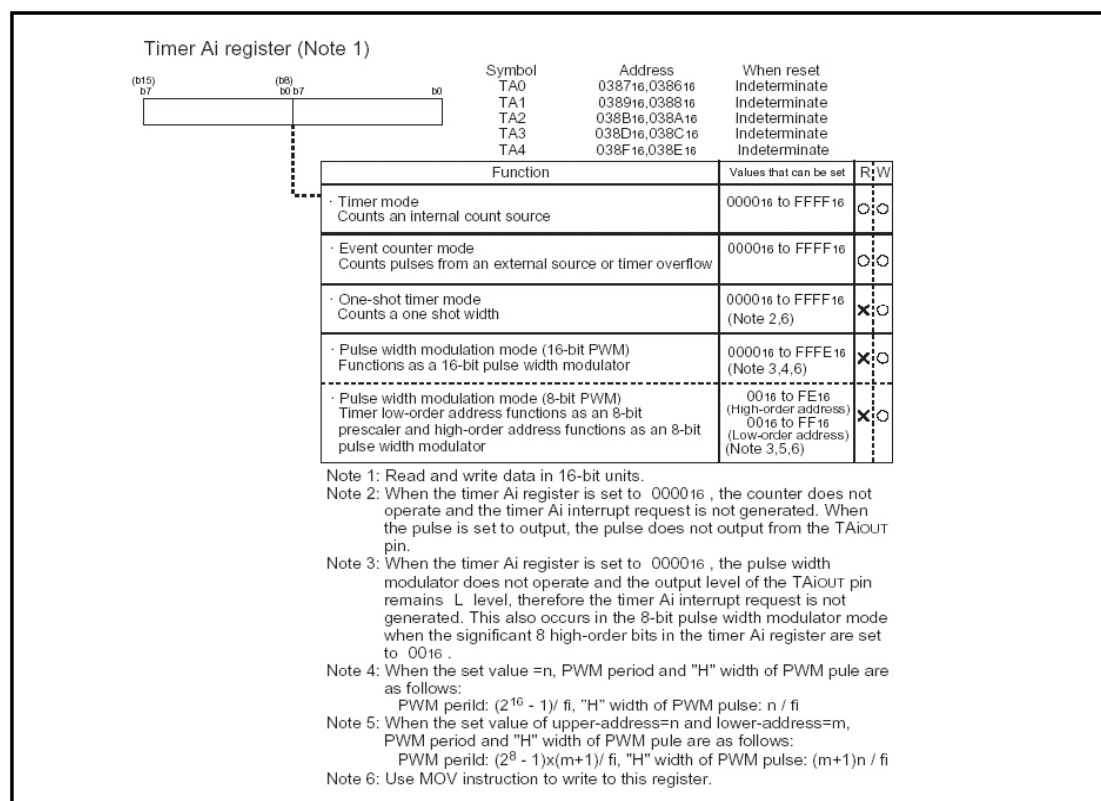


Figure 5 Timer Ai register

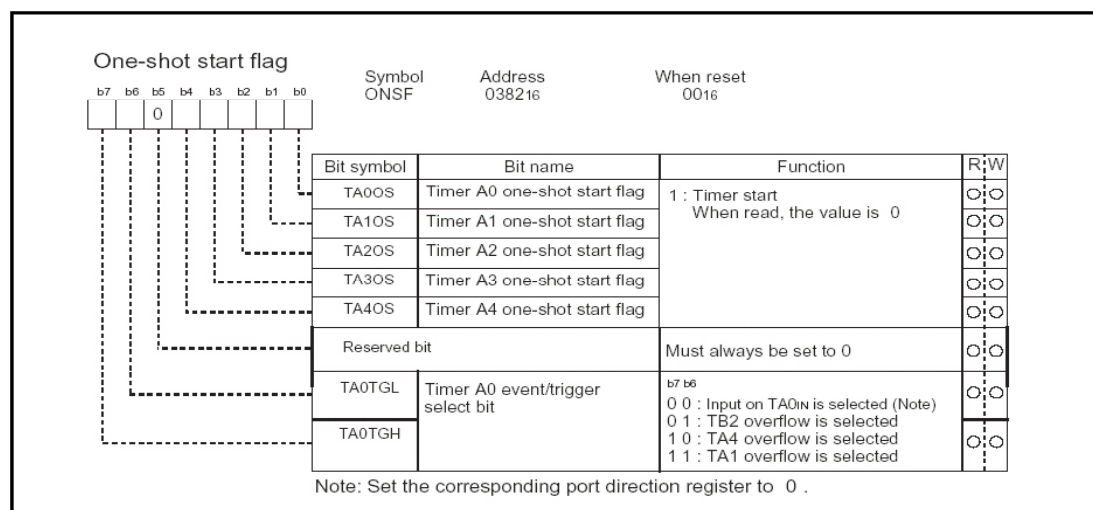
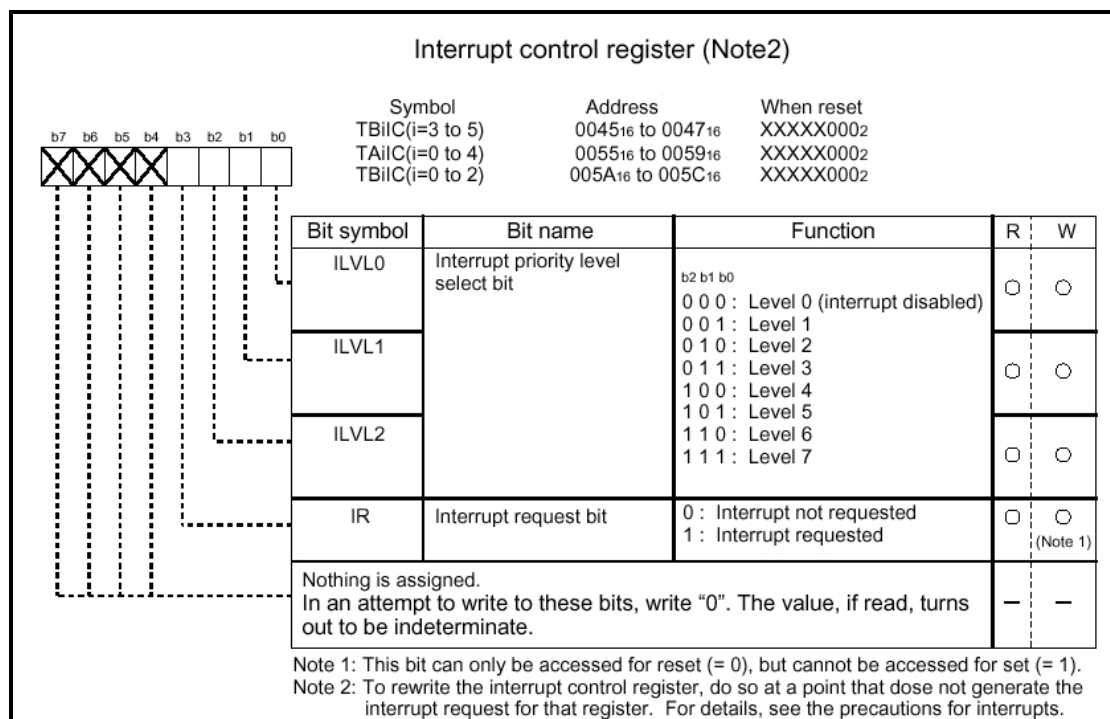


Figure 6 Count start flag register



**Figure 7 Interrupt control register**

## 5.0 Reference

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### E-mail Support

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### Data Sheets

- M16C/26 datasheet, M30262eds.pdf

### User's Manual

- KNC30 Users Manual, KNC30UE.PDF
- M16C/60 and M16C/20 C Language Programming Manual, 6020EC.PDF
- Application Note: Writing interrupt handlers in C for the M16C
- MSV30262-SKP or MSV-Mini26-SKP Quick start guide
- MSV30262-SKP or MSV-Mini26-SKP Users Manual
- MDECE30262 or MSV-Mini26-SKP Schematic

### 6.0 Software Code

A sample program written in C and compiled using the KNC30 compiler to illustrate how to set up a 16-bit PWM Mode on timer A0, and an 8-bit PWM on timer A1 is shown below. This program runs on the MSV30262 Starter Kit Board.

To get familiar with the PWM, try changing the clock source or switch to a different timer (i.e. TA2, TA3, etc).

```

/*****
*
*      File Name: pwm.c
*
*      Content: Example program using Timer A in "PWM mode" .This program
*               is written for the 'Timer A PWM Mode' application note. Timer
*               A0 is set up as an 8-bit PWM (output on TA0out or P7_0),
*               timer A1 set up as a 16-bit PWM (output on TA1out or P7_2), and
*               the output varied. The frequency of the 16-bit PWM is set to 305Hz,
*               and the 8-bit PWM is set to 9765Hz. The outputs can be viewed
*               on a scope. This program works with the MSV30262 starter kit board.
*               Note: Port P7_0 is an open drain output and may require a pull-up
*               resistor on target hardware.
*
*      Compiled with KNC30.
*
*      All timing based on 20 MHz Xtal
*
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*=====
*      $Log:$
*=====*/
#include "sfr62.h"

#define PWM8_CONFIG 0x67 /* 01100111 value to load into timer A0 mode register
    |||||_ TMOD0, TMOD1: PWM MODE SELECTED
    ||||_ MR0:      = 1 FOR PWM MODE
    ||||_ MR1, MR2:  EXTERNAL TRIGGER NOT SELECTED
    ||_ MR3:        SET TO 1 FOR 8-BIT PWM
    ||_ TCK0, TCK1:  F8 SELECTED */

#define PWM16_CONFIG 0x07 /* 00000111 value to load into timer A1 mode register
    |||||_ TMOD0, TMOD1: PWM MODE SELECTED
    ||||_ MR0:      = 1 FOR PWM MODE
    ||||_ MR1, MR2:  EXTERNAL TRIGGER NOT SELECTED
    ||_ MR3:        SET TO 0 FOR 16BIT PWM
    ||_ TCK0, TCK1:  F1 SELECTED */

#define CNTR_IPL 0x00 // TA0 AND TA1 interrupt priority level
int time_cnt; // loop counter

//prototypes
void init(void);

/*****

```

```

Name:    main()
Parameters: none
Returns: nothing
Description: initializes variables, then goes into an infinite loop. A
             simple delay loop is used to "slowly" increase the pulse widths
             ***** */
void main (void)
{
    int pwm16;
    char pwm8;

    pwm16 = 100; //16bit PWM changes slowly so give it a reasonable width to start
    pwm8 = 0;
    time_cnt = 0;
    init();
    while (1)
    {
        while(time_cnt <10000)
            time_cnt++; // delay loop

        time_cnt = 0;
        pwm8++;          // cannot read-modify-write on timer counter
        pwm16+=10;        // registers: while counting, value is indeterminate.
        if (pwm8 > 0xfe)   // the 8bit PWM value cannot exceed 0xFE
            pwm8 = 0;
        if (pwm16 > 0xfffe) // the 16bit PWM value cannot exceed 0xFFFFE
            pwm16 = 100;
        ta0h = pwm8;
        ta1 =pwm16;
    }
}
/*****
Name:    initial()
Parameters: none
Returns: nothing
Description: Timer TA0 and TA1 setup for PWM mode.
             ***** */
void init()
{
    ta0l = 0x00;    // PWM TA0 frequency set to 7,843 Hz

    /* the following procedure for writing an Interrupt Priority Level follows that as described
    in the M16C datasheets under 'Interrupts' */

    // initialize TA0
    _asm ("    fclr i" ) ;    // turn off interrupts before modifying IPL
    ta0ic |= CNTR_IPL;        // use read-modify-write instruction to write IPL
    ta0mr = PWM8_CONFIG;
    _asm ("    fset i");

```

```
    ta0s = 1; //start PWM

// initialize TA1
_asm ("    fclr i") ;// turn off interrupts before modifying IPL
talic |= CNTR_IPL;      // use read-modify-write instruction to write IPL
talmr = PWM16_CONFIG;
_asm ("    fset i");

tals = 1; //start PWM
}
```

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