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Generating PWM with PIC Microcontroller using Hi-Tech C

BY LIGO GEORGE · OCTOBER 23, 2013

PWM (Pulse Width Modulation) is a powerful technique used to generate analog voltage using digital signals. It has a wide variety of applications such as controlling average power delivered to a load, generating analog voltage level, sine wave generation and DC Motor speed control. PWM signals are ON-OFF signals (hence the name Pulse) whose ON duration are changed (hence Width Modulation) according to our requirements. The fraction of time period for which the signal is ON to total time period is termed as Duty Cycle.

CCP Modules are available with a number of PIC Microcontrollers which can be used to generate PWM waves. CCP Stands for Capture/Compare/PWM. For programming this module in Hi-Tech C we should require a good hardware knowledge. Here for demonstration we are using PIC 16F877A.

CCP – Capture/Compare/PWM Modules

PIC 16F877A has two CCP modules named as CCP1 and CCP2. Each CCP Module has a 16 Bit register which can operate as :

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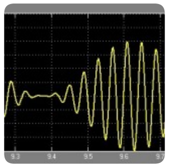
- 16 Bit Capture Register
- 16 Bit Compare Register
- PWM Duty Cycle Register

This article deals only with PWM operation of CCP Modules. It can produce up to 1o-bit resolution PWM output. Since CCP1 and CCP2 output are multiplexed with PORTC (RC2 and RC1), TRIS<2> and TRIS<1> must be cleared to make these pins output. CCP1 and CCP2 modules are similar in operation and **you cannot set different frequencies for them, because both modules uses Timer 2 for their operation**.

Working

The simplified block diagram of CCP module in PWM mode is shown below.



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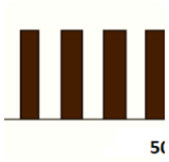

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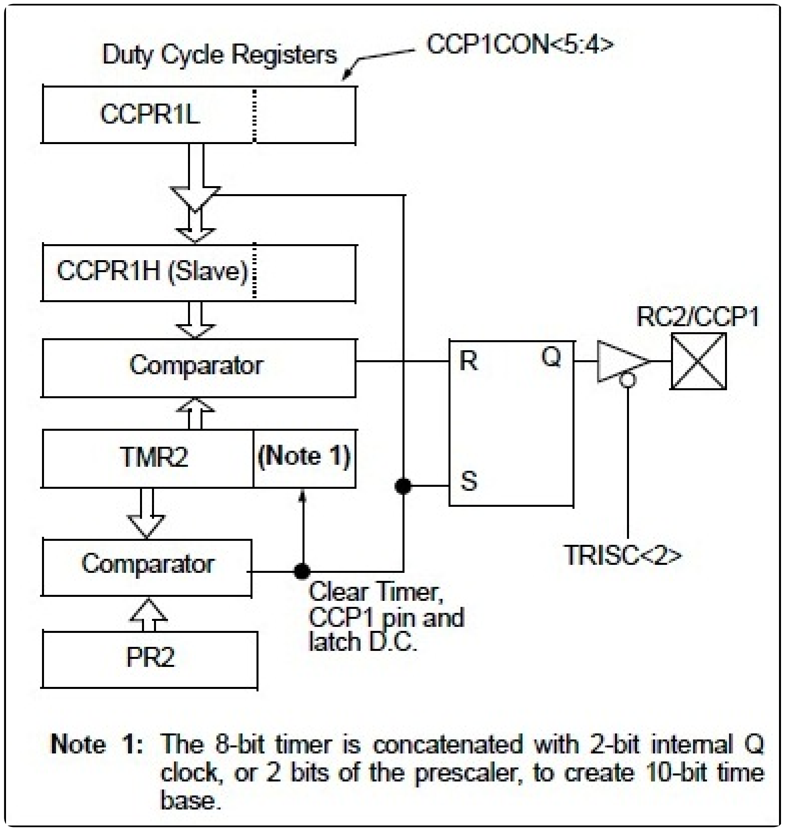

PWM Simplified Block Diagram – PIC 16F877A

CCP modules uses Timer 2 for their operation. Period of the generated PWM waves is determined by the value in the PR2 register. Values of Timer 2 and PR2 are compared every-time using a comparator. When these values become equal, Timer 2 will be reset and output will become HIGH.

Duty cycle is determined by the value in CCPR1L and CCP1CON<5:4>. These registers can be written any time. So to avoid glitches in the PWM output, this duty cycle value is latched to

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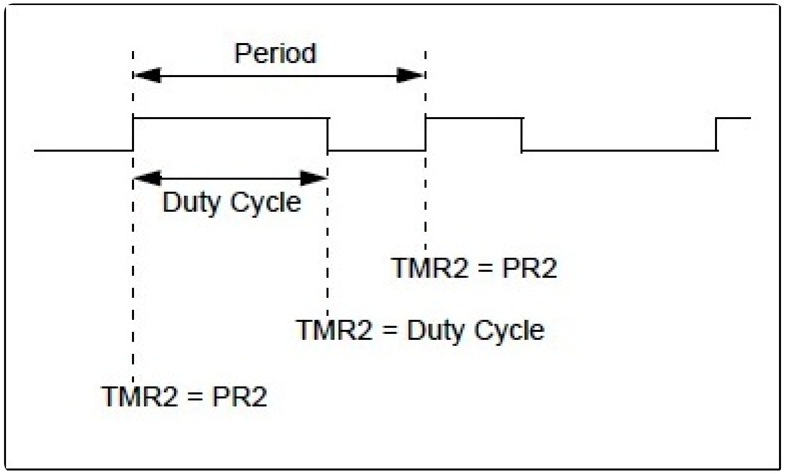
CCPR1H and a 2 bit internal latch when there is a match between Timer 2 and PR2.



PWM Output

Then the value in CCPR1H and 2 bit internal latch is compared with Timer 2. When a match occurs output will become LOW as shown in the above diagram.

Note : The value of Duty Cycle value should not be greater than Time Period (PR2) value, if so the CCP pin will not be cleared.

The PWM resolution can be find using the following equation.

$$\text{Resolution} = \frac{\log\left(\frac{F_{OSC}}{F_{PWM}}\right)}{\log(2)} \text{ bits}$$

The following steps should be taken while configuring the PIC CCP module for PWM operation.

1. Set the PWM Period by writing to the PR2 register and the PWM period can be calculated using the following equation.

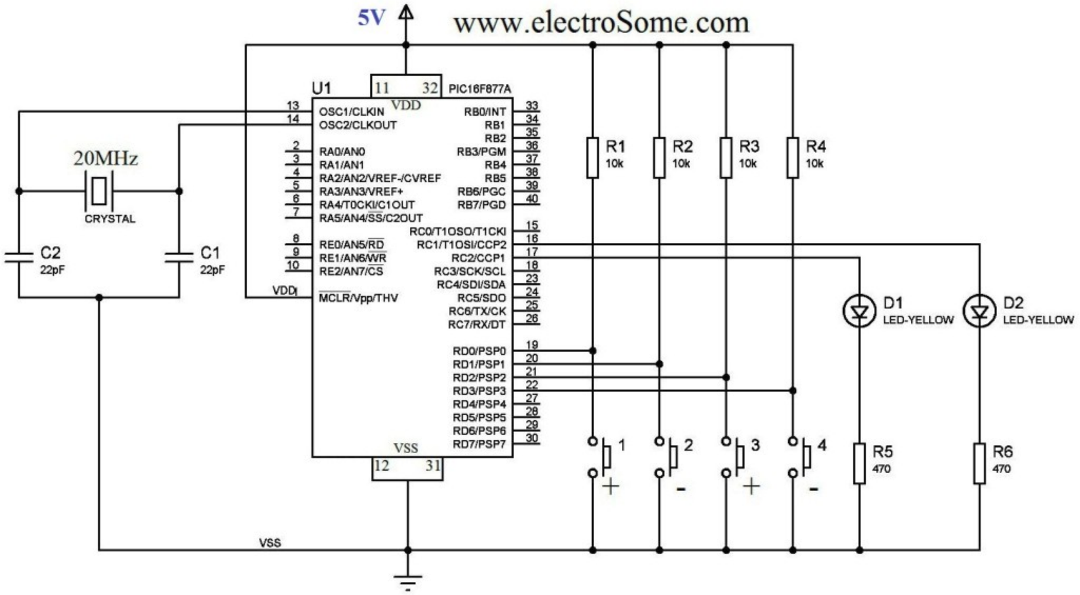
$$\text{PWM Period} = [(\text{PR2}) + 1] \bullet 4 \bullet T_{OSC} \bullet (\text{TMR2 Prescale Value})$$

2. Set the Duty Cycle of the PWM by writing to CCPR1L register and CCP1CON<5:4>. The PWM Duty Cycle can be find using the following equation and it should not exceed the PWM Period.

$$\text{PWM Duty Cycle} = (\text{CCPR1L:CCP1CON}<5:4>) \bullet T_{OSC} \bullet (\text{TMR2 Prescale Value})$$

3. Make CCP pins output by clearing the corresponding TRIS register bits.
4. Set the Timer 2 (TMR2) prescale value and enable the timer by writing to T2CON register.
5. Then configure the CCP module for PWM operation.

Circuit Diagram



Generating PWM with PIC Microcontroller – Circuit Diagram

The above circuit diagram can be used for demonstrate the working of CCP modules in PWM mode. A 20MHz crystal is used for providing the necessary clock for the operation of the microcontroller and 22pF capacitors are used to stabilize the operation of crystal. Outputs of CCP1 and CCP2 modules are connected to LEDs using a series resistor to limit current. Four Switches are used to vary the duty cycle of the PWM waves. 10Ω resistors are used to Pull Up the inputs pins of microcontroller used for reading switches, when the switch is not ON.

Hi-Tech C Code

```
#include<htc.h>

#define _XTAL_FREQ 20000000
#define TMR2PRESCALE 4
long freq;

int PWM_Max_Duty()
{
  return(_XTAL_FREQ/(freq*TMR2PRESCALE);
}

PWM1_Init(long fre)
{
  PR2 = (_XTAL_FREQ/(freq*4*TMR2PRESCALE)) - 1;
  freq = fre;
}

PWM2_Init(long fre)
{
  PR2 = (_XTAL_FREQ/(freq*4*TMR2PRESCALE)) - 1;
  freq = fre;
}

PWM1_Duty(unsigned int duty)
{
  if(duty<1024)
  {
    duty = ((float)duty/1023)*PWM_Max_Duty();
    CCP1X = duty & 2;
    CCP1Y = duty & 1;
    CCPR1L = duty>>2;
  }
}

PWM2_Duty(unsigned int duty)
{
  if(duty<1024)
  {
    duty = ((float)duty/1023)*PWM_Max_Duty();
    CCP2X = duty & 2;
    CCP2Y = duty & 1;
    CCPR2L = duty>>2;
  }
}

PWM1_Start()
{
  CCP1M3 = 1;
  CCP1M2 = 1;
  #if TMR2PRESCALAR == 1
    T2CKPS0 = 0;
    T2CKPS1 = 0;
  #elif TMR2PRESCALAR == 4
    T2CKPS0 = 1;
    T2CKPS1 = 0;
  #elif TMR2PRESCALAR == 16
    T2CKPS0 = 1;
    T2CKPS1 = 1;
  #endif
  TMR2ON = 1;
  TRISC2 = 0;
}

PWM1_Stop()
{
  CCP1M3 = 0;
  CCP1M2 = 0;
}

PWM2_Start()
{
  CCP2M3 = 1;
  CCP2M2 = 1;
  #if TMR2PRESCALE == 1
    T2CKPS0 = 0;
    T2CKPS1 = 0;
  #elif TMR2PRESCALE == 4
    T2CKPS0 = 1;
    T2CKPS1 = 0;
  #elif TMR2PRESCALE == 16
    T2CKPS0 = 1;
    T2CKPS1 = 1;
  #endif
    TMR2ON = 1;
    TRISC1 = 0;
}

PWM2_Stop()
{
  CCP2M3 = 0;
  CCP2M2 = 0;
}

void main()
{
  unsigned int i=0,j=0;
  PWM1_Init(5000);
  PWM2_Init(5000);
  TRISD = 0xFF;
  TRISB = 0;
  PWM1_Duty(0);
  PWM2_Duty(0);
  PWM1_Start();
  PWM2_Start();
  do
  {
    if(RD0 == 0 && i<1000)
      i=i+10;
    if(RD1 == 0 && i>0)
      i=i-10;
    if(RD2 == 0 && j<1000)
      j=j+10;
    if(RD3 == 0 && j>0)
```

```
      j=j-10;
    PWM1_Duty(i);
    PWM2_Duty(j);

    __delay_ms(50);
  }while(1);
}
```

I thinks the code is self explanatory. *PWM1_Init(frequency)* and *PWM2_Init(frequency)* are used to initialize the CCP1 and CCP2 module in PWM mode with a particular frequency. You cannot have different frequencies for the two PWM modules. *PWM1_Duty(duty)* and *PWM2_Duty(duty)* are used to set the duty cycle of the PWM waves. The parameter *duty* can be any value ranging from *0 to 1024*. *Calling PWM1_Start()* and *PWM2_Start()* will start generating PWM waves and calling *PWM1_Stop()* and *PWM2_Stop()* will stop the PWM waves.

You can download Hi-Tech C and Proteus files here…

Generating PWM with PIC Microcontroller – Hi Tech C

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Atoki • 3 months ago

Hi Ligo George,
please how can i program pic16f88 to be able to measure voltage current sampling ? I need it to track mppt of a 12V solar panel. I have written one program in hitech c, but not measuring anything.
Cheers.

1 △ | ▽ • Reply • Share ›

marlon • a month ago

Hi, Mr. Ligo George. I would like to know if can you help me design this same type of Light dimmer but need to add a MOC and Triac to dim and manage 110vac light bulb. Also on the second output use this as a 3 stage level Fan dim (LOW-MEDIUM-High) . I need help! I am willing to pay for your services. (I am a college student).

△ | ▽ • Reply • Share ›

Ligo George Mod > marlon • 15 days ago

Hello,
These comments section are for asking doubts about the above article..
If you need further assistance.. you can contact me through the Contact Us page .

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fsmoke • 2 months ago

```
long freq;
......
......
PWM1_Init(long fre)
{
PR2 = (_XTAL_FREQ/(freq*4*TMR2PRESCALE)) - 1;
freq = fre;
}

void main()
{
unsigned int i=0,j=0;
PWM1_Init(5000);
.......
.......
```

Where the initialization of "freq" ??? It seem you are using uninitialized variable, so PR2 initialized by undefined value.

I think must be PR2 = (_XTAL_FREQ/(fre*4*TMR2PRESCALE)) - 1;

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sudha • 5 months ago

How to display the voltage stored in the battery on the LCD screen, already i have used portB to get analog input from the sensor...........how to code for this???

△ | ▽ • Reply • Share ›

miss pooja • 7 months ago

Hiii,
Me generate the PWM using PIC16F1933 micro controller using MPLAB IDE with Hi-Tech compiler......
please send some code for this project.

△ | ▽ • Reply • Share ›

Ligo George Mod > miss pooja • 7 months ago

Sorry I haven't the code for 16F1933... above codes are verified only with 16F877A.... try the above code.... if it is not working read the datasheet carefully and make required changes in the above program..

△ | ▽ • Reply • Share ›

miss pooja > Ligo George • 7 months ago

Hello.....

how to generate PWM at battery voltage 12v.

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Ligo George Mod > miss pooja • 7 months ago

Use a transistor (eg: 2N2222).. connect the base of transistor to pic pwm output with a series resistor...connect the load in series with collector and 12V..

1 △ | ▽ • Reply • Share ›

miss pooja > Ligo George • 7 months ago

How to show the battery charging status on the LCD screen.

Remember me used MPLAB IDE with Hi-Tech compiler and PIC 16F1933.

Please send me some code.

Me used 12V battery and battery status showing on LCD same as mobile Phone battery status.

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Ligo George Mod > miss pooja • 7 months ago

Step down the battery voltage to 0-5V range... using resistor voltage divider... and give it to ADC input of pic microcontroller..

△ | ▽ • Reply • Share ›

miss pooja > Ligo George • 7 months ago

ya me step down the voltage of 12v battery to 0-5V and me also write the code of custom character for showing the battery level on the LCD screen. tell me how to show according to charging of battery. for eg. if battery voltage is 0% then show the 1st custom character and when battery voltage is 25% then show 2nd custom character and when battery voltage is 50% then show 3rd custom character, when battery voltage 75% then show 4th custom character and when battery voltage 100% then show the 5th custom character on the LCD screen.

how to write the code for this project???
send me some code for this project...

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Ligo George Mod > miss pooja • 7 months ago

try like this:

```
a = ADC_Read(0) // 0 is the ADC Channel
if(a>1000)
battery 100%
else if(a>768)
battery 75%
else if(a>512)
battery 50%
else if (a>256)
battery 25%
```

1 △ | ▽ • Reply • Share ›

miss pooja > Ligo George • 7 months ago

Me used above code but how to display on LCD??

how to interface that code with LCD ????

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Ligo George Mod > miss pooja • 7 months ago

Read our LCD tutorial and its comments..

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anonymous > Ligo George • 2 months ago

Hi I have as a final project "automatic street lights" I have used

pic16f877a but still don't know how to connect pwm to a relay such that it switches ON and OFF, could you help please ?

△ | ▽ • Reply • Share ›

ibrahim > anonymous • 2 months ago

are you sure you have to use pwm? you should design it directly.

△ | ▽ • Reply • Share ›

electroSome