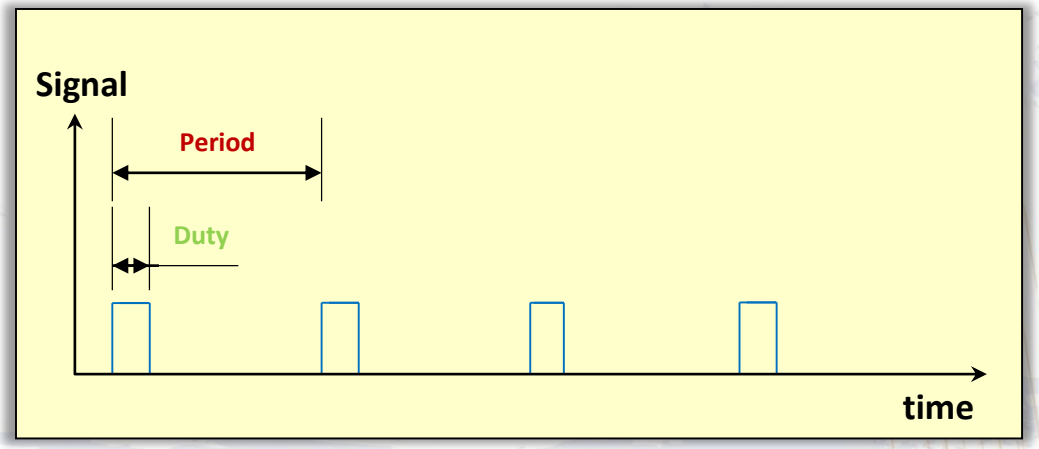
MICROCHIP

Regional Training Centers

Section 11
Output Compare PWM

What's PWM

- The Pulse-width modulation (PWM) Waveform is a modulation technique used to encode a message into a pulsing signal.
- Its main use is to allow the control of the power supplied to electrical devices, ex. motor control, ballast, LED, H-bridge, power converters, and other types of power control applications.
- There have two important terms
  - **Period :**
    The single square wave duration.
  - **Duty :**
    The proportion of active time to the regular interval



PIC24F Output Compare

- **PIC24FJGB provide below modes for Output Compare Module (OCM<2:0):**

Simple Compare Match Mode:

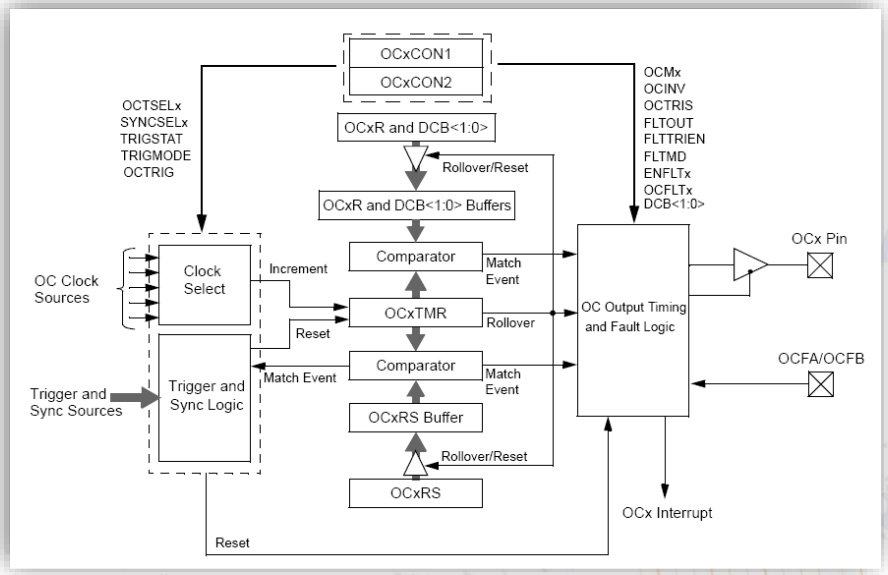
1. Normal Low, High on Match
2. Normal High, Low on Match
3. Toggle on Match

Dual Compare Mode:

1. Single Pulse
2. Continuous pulse

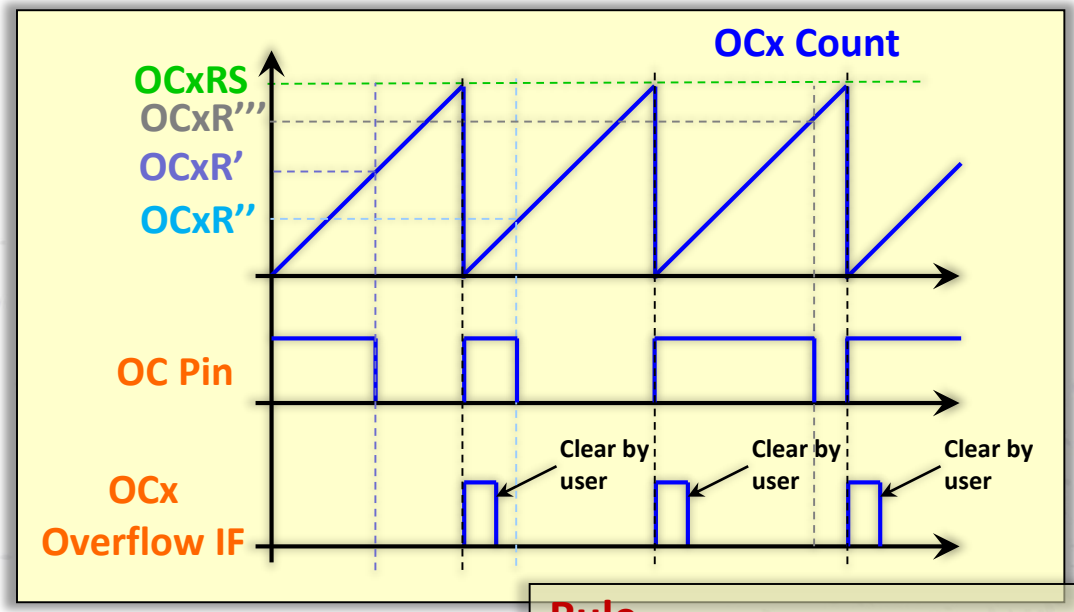
Simple PWM Mode:

1. Edge-Aligned PWM Mode
2. Center-Aligned PWM Mode



Edge-Aligned PWM Mode

- For Edge-Aligned PWM Mode, the period time (T) is controlled by the OCxRS register. OCx pin change stats on each OCx counter = OCxRS and OCxR condition.



Rule

1.OCx Counter = OCxR -> Output Set to low

2.OCx Counter = OCxRS -> Output Set to high

Lab14 Edge-Aligned PWM

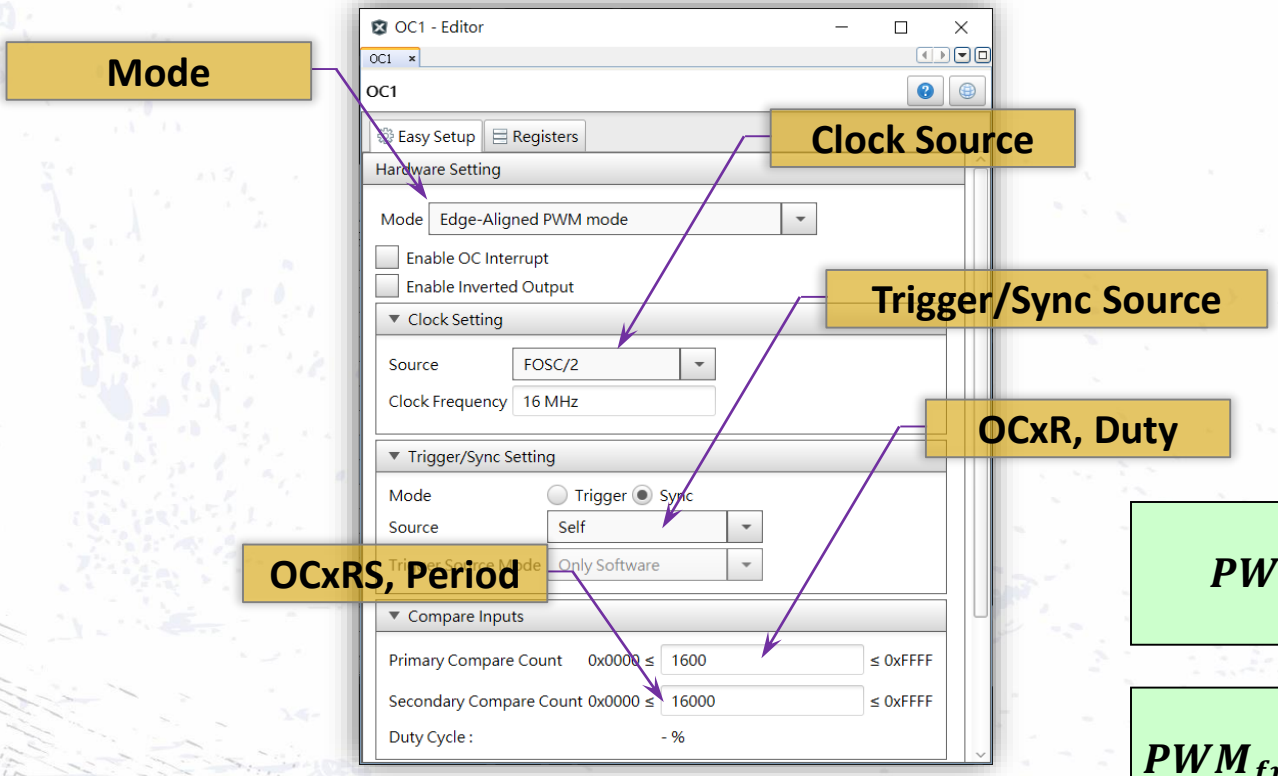
Lab14 Edge-Aligned PWM

- Try to initial OC1 module to Edge-Aligned PWM Mode, than use PWM to control LED brightness.
- OC1 module clock source set to F_{CY} (F_{osc} /2), Sync Self, Frequency is 1KHz, Duty cycle 10%.
- Please connect RG6(OC1) to LED(D6) to observe LED brightness.

- **Let's go!**

Lab14 Edge-Aligned PWM Hits

- *Primary Compare (OCxR, Duty)
  *Secondary Compare (OCxRS, Period)

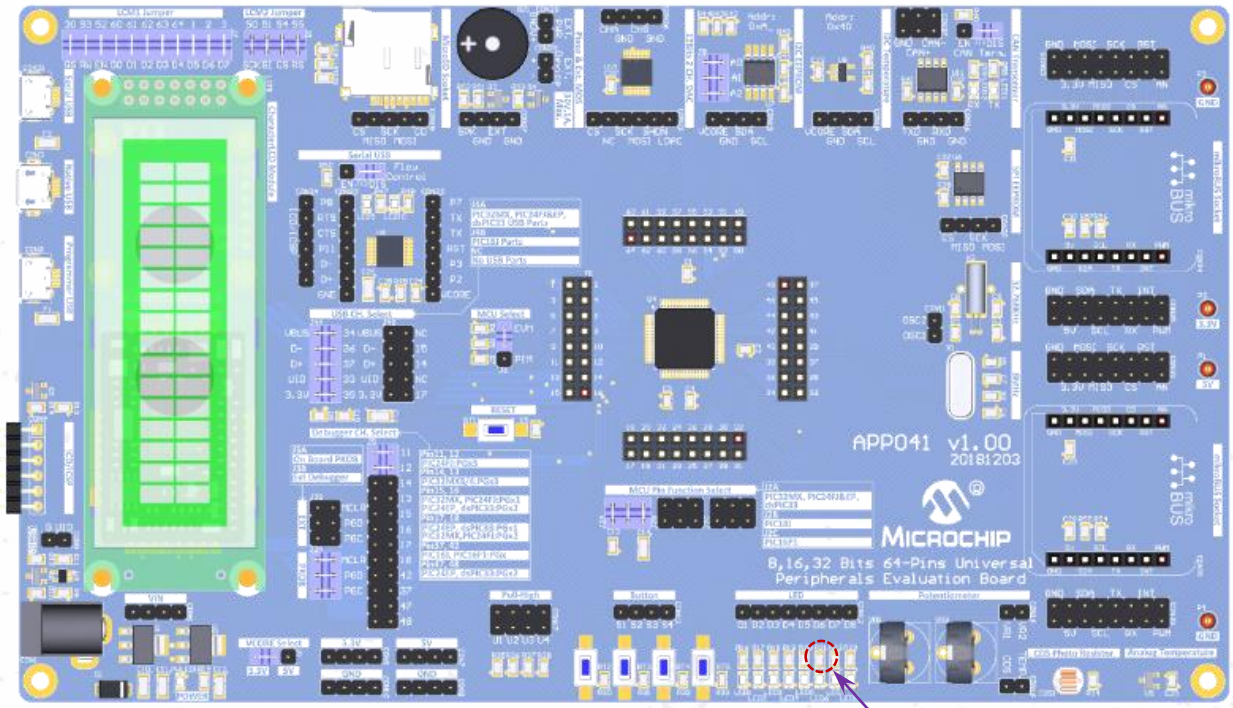


$$PWM_{Duty} = \left(\frac{OCxR}{OCxRS}\right)$$

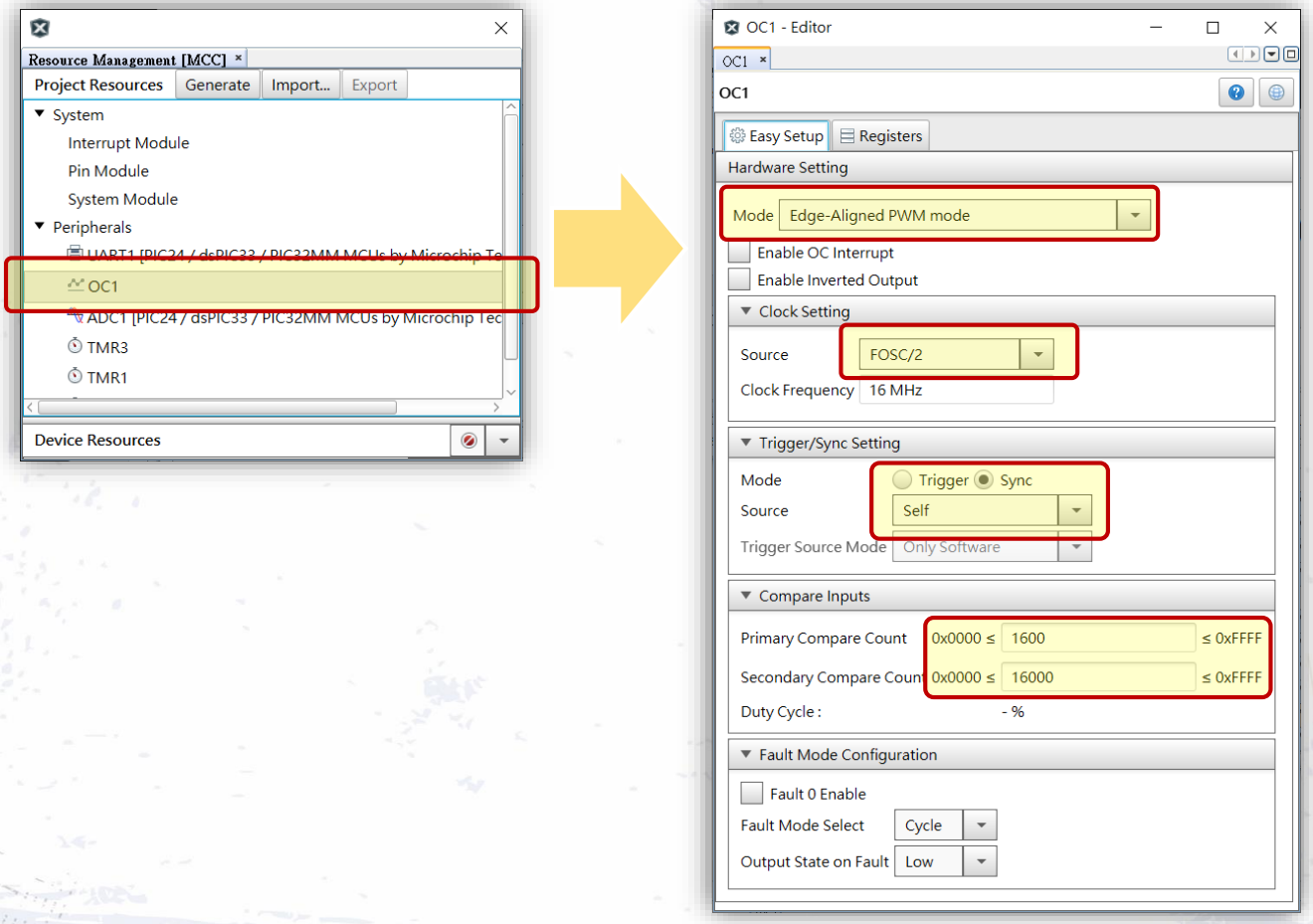
$$PWM_{freq.} = \left(\frac{Clock\ Source}{OCxRS + 1}\right)$$

Lab14 Edge-Aligned PWM

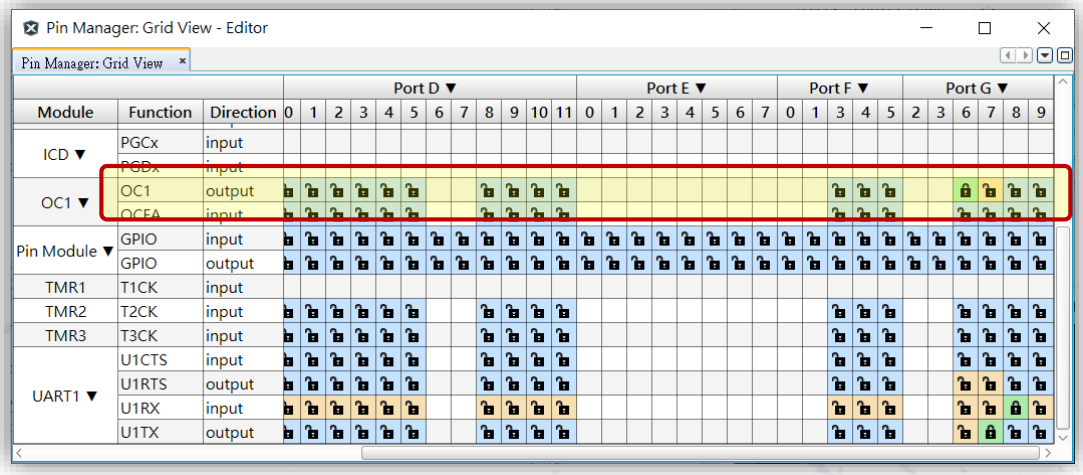
Result



Lab14 Edge-Aligned PWM
MCC's Setting & Code Example



Lab14 Edge-Aligned PWM MCC's Setting & Code Example



MCC's O.C.PWM Function

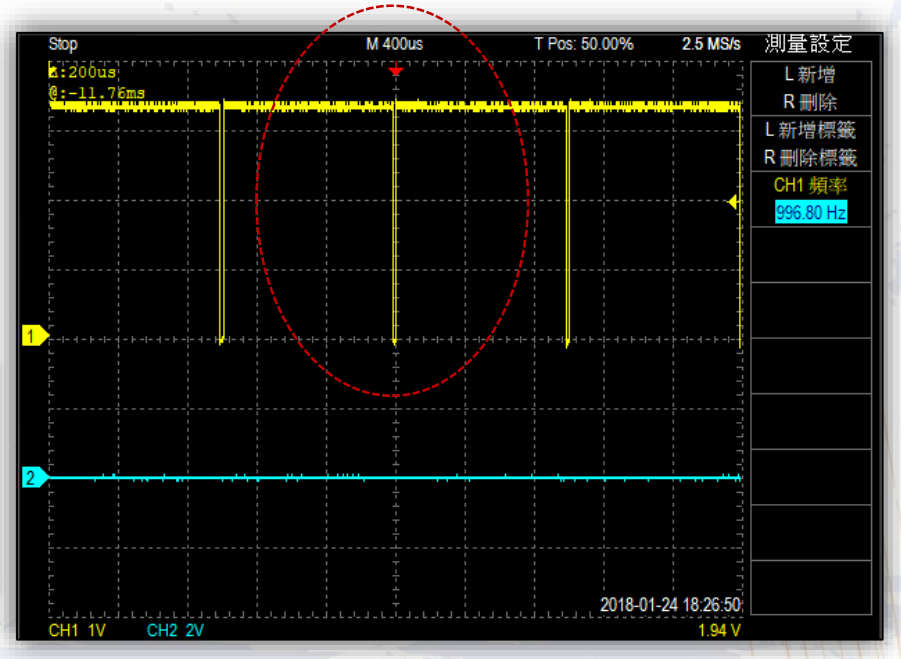
- MCC Provide below common functions:

```
void OC1_Initialize(void)
        // Initial OC.
void OC1_Start(void); void OC1_Stop(void);
        // OC Enable & Disable.
void OC1_SingleCompareValueSet(value)
        // Single Compare Mode Setting ( OC1R <- value)
void OC1_DualCompareValueSet(priVal, secVal)
        // Dual Compare Mode Setting ( OC1R <- priVal, OC1RS <- secVal)
 void OC1_CentreAlignedPWMConfig(priVal, secVal)
        // Centre Aligned Mode Setting ( OC1R <- priVal, OC1RS <- secVal)
void OC1_EdgeAlignedPWMConfig(priVal, secVal)
void OC1_PrimaryValueSet( uint16_t priVal)
void OC1_SecondaryValueSet( uint16_t secVal )
        // Edge Aligned PWM Mode Setting ( OC1R <- priVal, OC1RS <- secVal)
```

100% Duty Issue

- How to generate 100% duty PWM ?
  - Rule Review
    1.OCx Counter = OCxR -> Output Set to low
    2.OCx Counter = OCxRS -> Output Set to high
- 100% is means OCxR = OCxRS must be set for 100% duty output. Which rule be executed ?
  - Result :
    Glitch !
- To prevent this issue
  - set OCxR > OCxRS for 100% duty.

```
if( DutyVlaue >= OCxRS ) /* 100% duty */
   OC1_PrimaryValueSet(OCxRS+ 1);
else
   OC1_PrimaryValueSet(DutyVlaue);
```



Lab15 PWM ADC Duty Adj

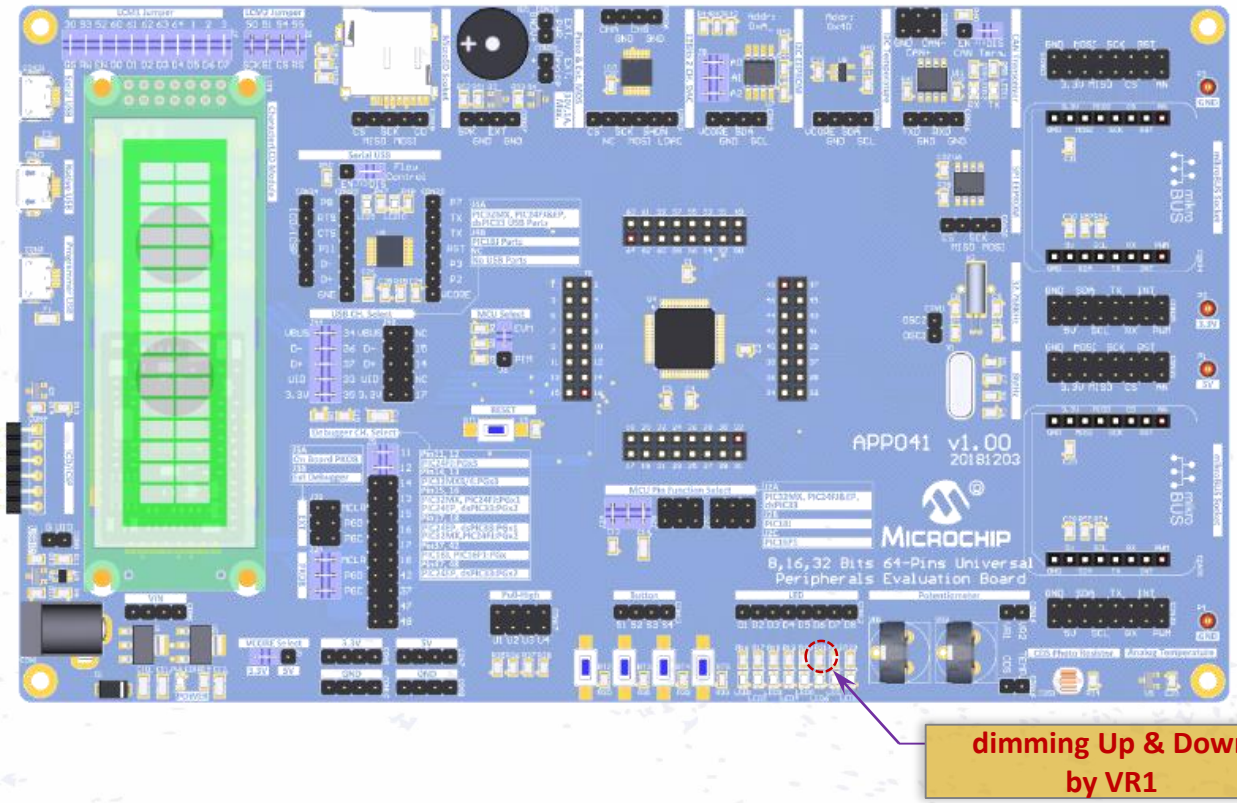
Lab15 PWM ADC Duty Adj

- Try to use Potentiometer(VR1) to control LED(D6) brightness.
- VR Value(0 ~1023) <-> PWM Duty (0% ~ 100%)
- OC1 Setting same as lab14.

- **Let's go!**

Lab15 PWM ADC Duty Adj

Result



Lab15 PWM ADC Duty Adj
MCC's Setting & Code Example

```
int main(void)
{
   ...
   while (1)
   {
      if (AD1Flag)
      {
         AD1Flag = 0;
         ...

         if (ADCResult[0] >= 1023)
            OC1_PrimaryValueSet(OC1RS + 1);
         else
            OC1_PrimaryValueSet(((long) ADCResult[0] * OC1RS) / 1023);
      }
   }
}
```

```
if( DutyVlaue >= OCxRS ) /* 100% duty */
   OC1_PrimaryValueSet(OCxRS+ 1);
else
   OC1_PrimaryValueSet(DutyVlaue);
```

OC's Duty & Period update

- OC's duty (OCxR) can update at any time, hardware will auto reload the new value at new PWM cycle moment.
- OC's period (OCxRS) only allow update at new PWM cycle moment.
- Enable OC interrupt more easy to update PWM period.
- For example:

```
void OC2_CallBack(void)
{
   OC2_SecondaryValueSet(NewPeriodValue);
   OC2_PrimaryValueSet(OC2RS >> 1); /* 50% Duty */
   …;
}
```

Lab16 PWM Buzzer Tone

Lab16 PWM Buzzer Tone

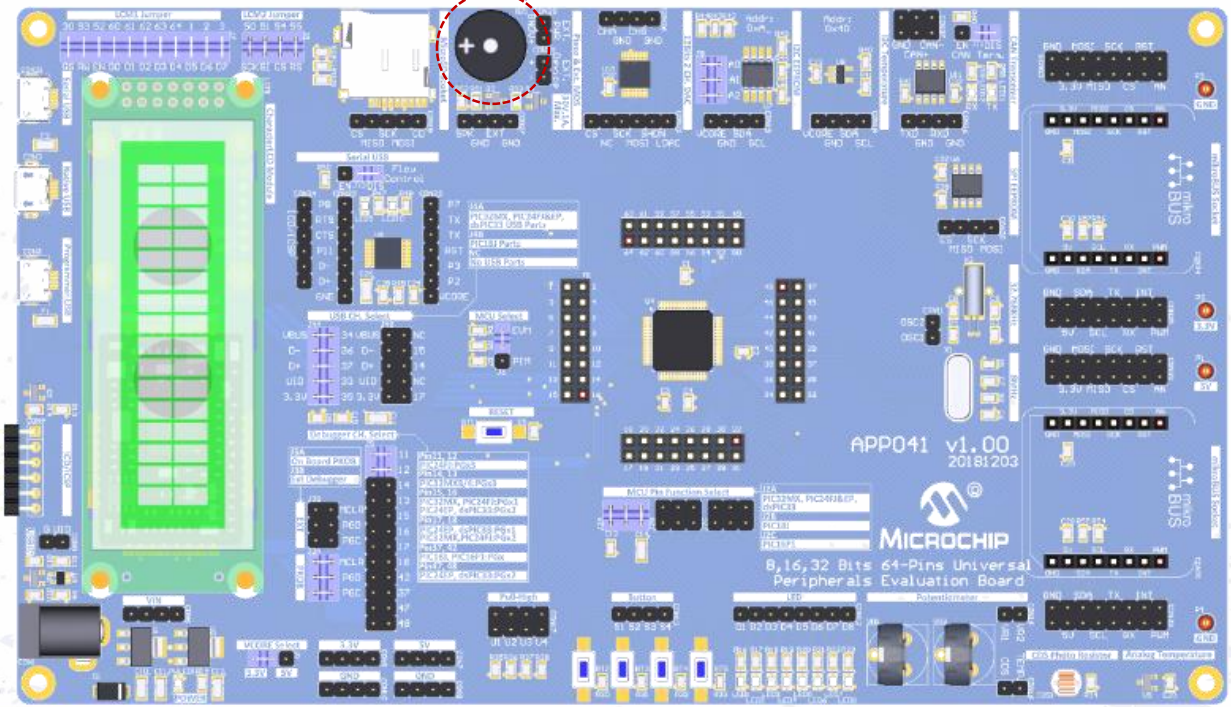
- Try to initial OC2 to export special frequency (Tone) to Buzzer, change the tone every second.
  - Tone[] = {262,294, 330, 349, 392, 440, 494}; /*Do, Re, Mi, etc.. */
- Enable OC2 interrupt, priority set to 7 (highest).
  Tyr to change OC2 frequency at OC2 callback function.
- Please connect RG9(OC2) to Buzzer(SPK).

- **Let's go!**

Lab16 PWM Buzzer Tone

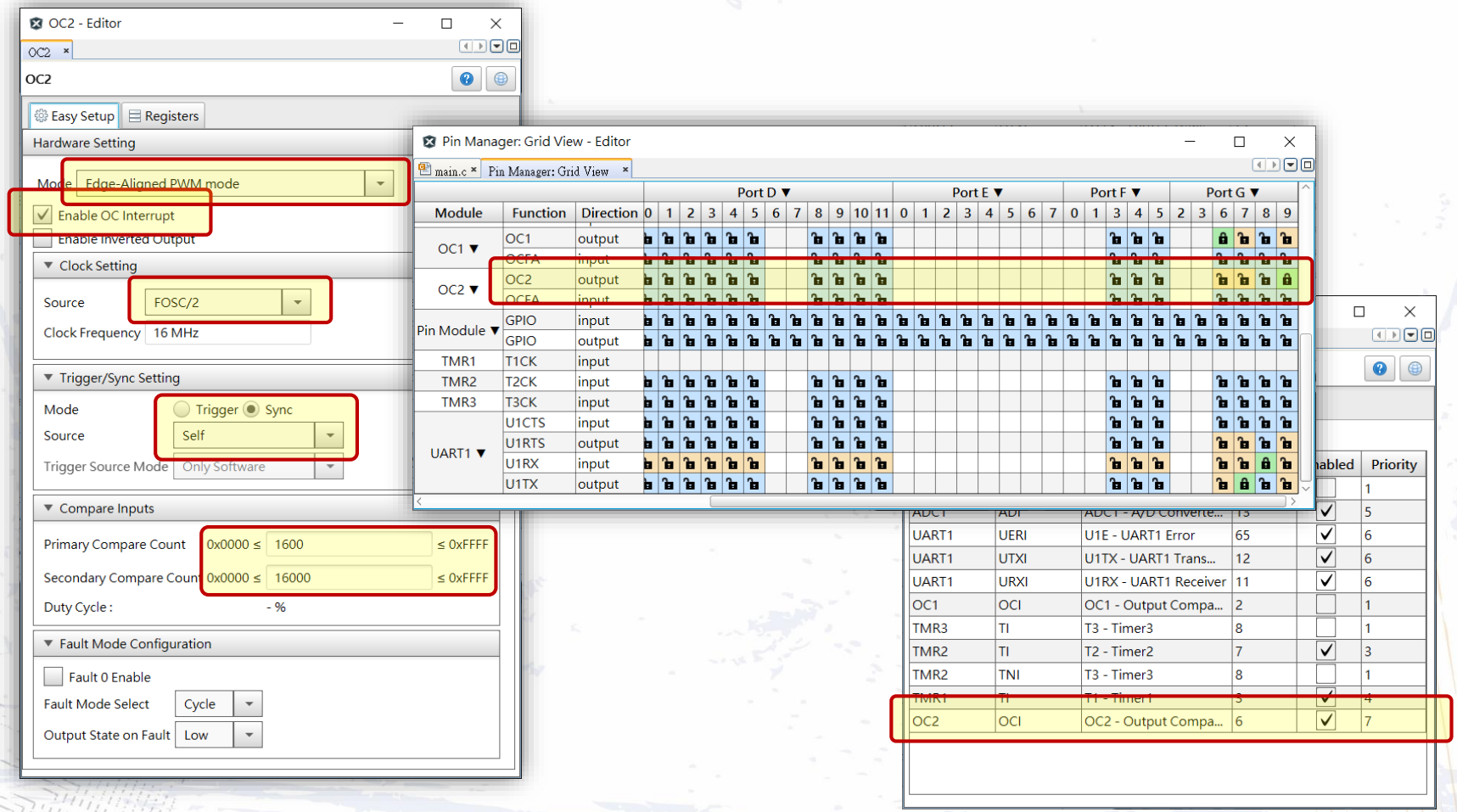
Result

Tone by your code



Lab16 PWM Buzzer Tone

MCC's Setting & Code Example



Lab16 PWM Buzzer Tone
MCC's Setting & Code Example

```
const unsigned int Tone[] = {262, 294, 330, 349, 392, 440, 494};
volatile unsigned char T2Flag = 0;
int main(void)
{
   ...
   while (1)
   {
      ...
   }
}
void TMR2_CallBack(void)
{
   ...
   T2Flag = 1;
}
void OC2_CallBack(void)
{
   static unsigned char i = 0;
   if (T2Flag)
   {
      T2Flag = 0;

      OC2_SecondaryValueSet(16000000 / Tone[i]);
      OC2_PrimaryValueSet(OC2RS >> 1);
      if (++i > 6)
         i = 0;
   }
}
```

$$PWM_{freq.} = \left(\frac{Clock\ Source}{OCxRS + 1}\right)$$

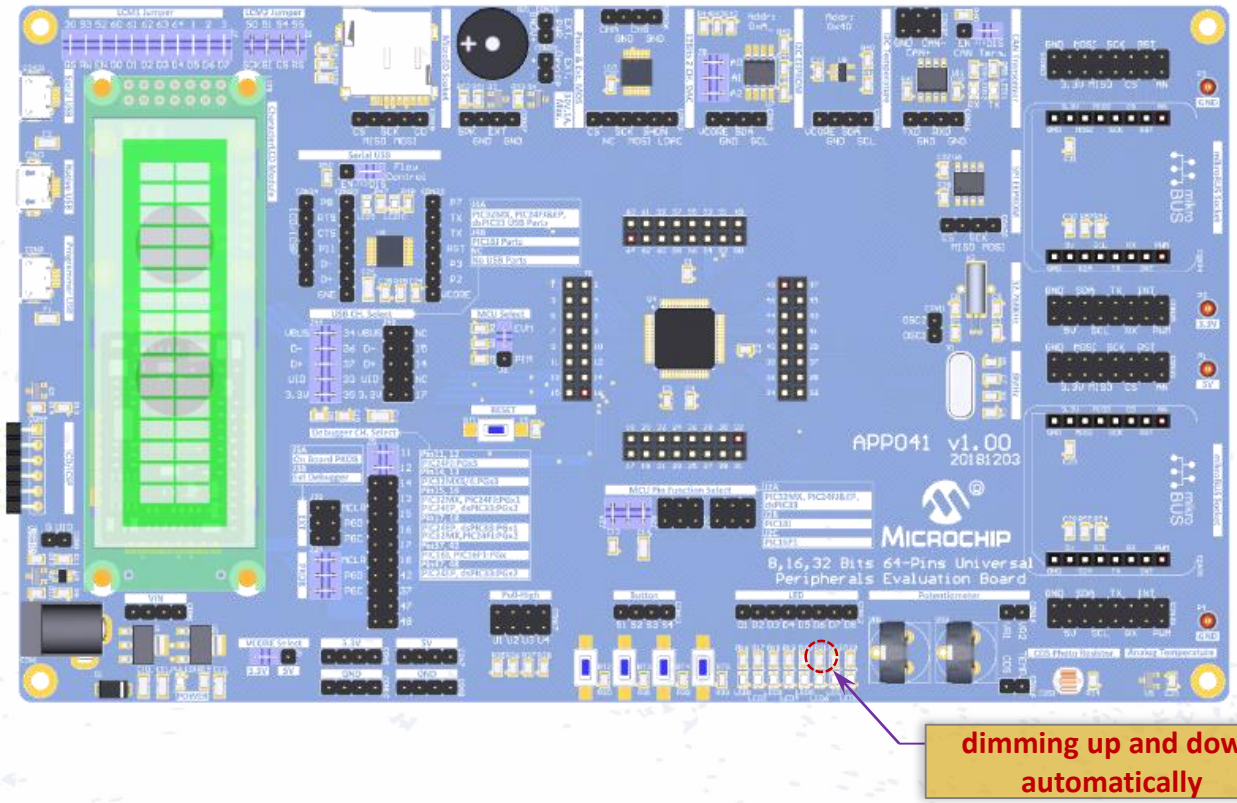
Lab17 PWM Auto Duty Adj

Lab17 PWM Auto Duty Adj

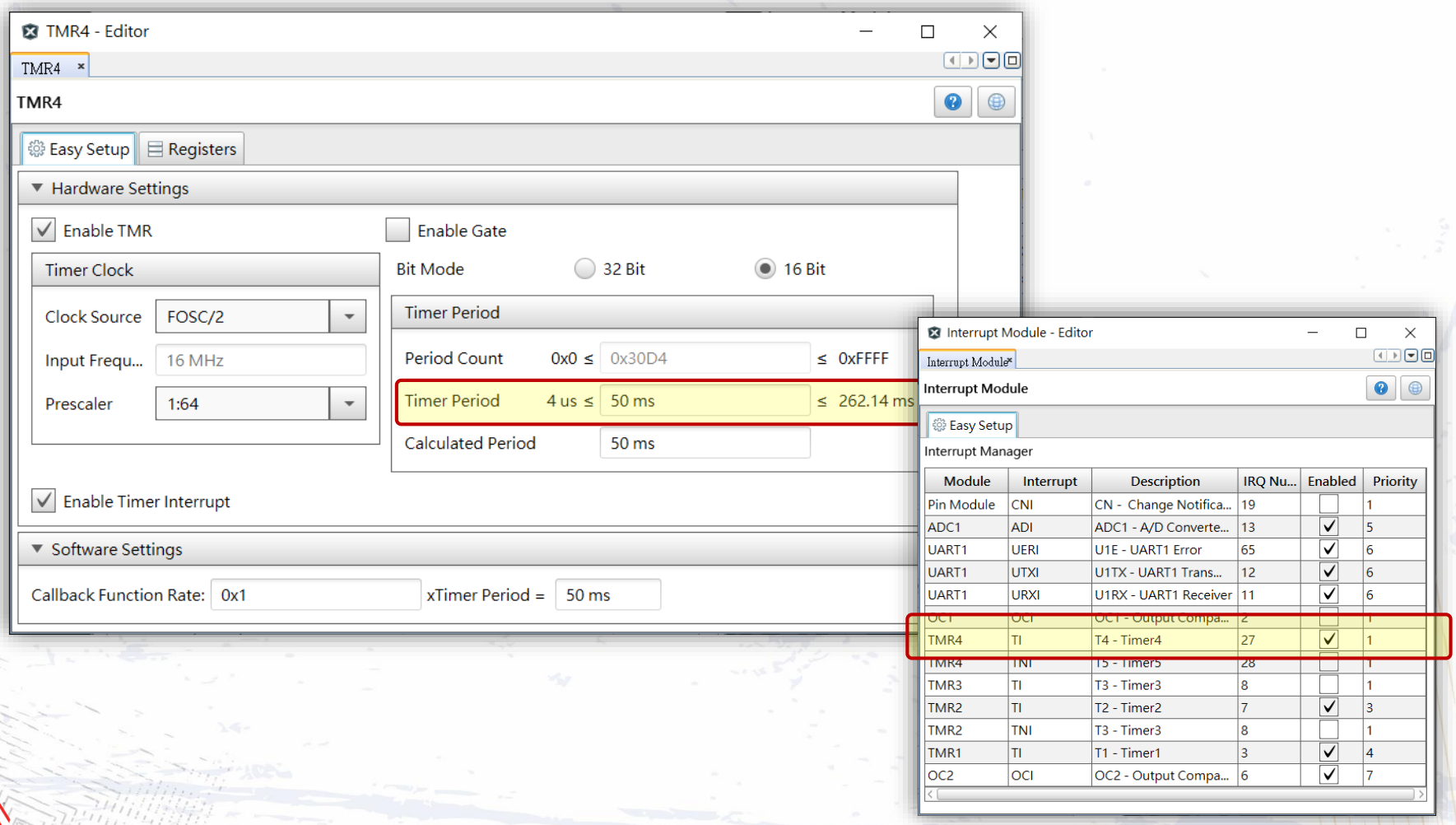
- **Try to use timer to control OC1's PWM duty, automatically.**
- **Duty 0% -> Duty 100% -> Duty 0% -> …**
- **Change duty one time per 50ms.**
  (2% - 5% duty change every time suggest)

Lab17 PWM Auto Duty Adj

Result



Lab17 PWM Auto Duty Adj
MCC's Setting & Code Example



Lab17 PWM Auto Duty Adj
MCC's Setting & Code Example

```
volatile unsigned char T4Flag = 0;
unsigned int Duty = 50;
char DutyDistance = 2;
int main(void)
{
   ...
   while (1)
   {
      if (T4Flag)
      {
         T4Flag = 0;

         Duty += DutyDistance;

         if (Duty >= 100 || Duty <= 0)
            DutyDistance = -DutyDistance;

         if (Duty >= 100)
            OC1_PrimaryValueSet(OC1RS + 1);
         else
            OC1_PrimaryValueSet(((long) Duty * OC1RS) / 100);
      }
   ...
   }
}

void TMR4_CallBack(void)
{
   T4Flag = 1;
}
```