CMPE 322: Micro-controllers and Interfacing

Lab #5
Due 11/27/2023

Fall 2023

Deliverables

- Code (C or assembly)
- Answer the questions and show your work (take pictures for the report)
- Demo to the instructor

Introduction

Pulse width modulation (PWM) method is used in many applications such as servo motor control, communications, power delivery and voltage regulation. PWM signal is a rectangular signal used to control analog devices with a digital output where the modulating signal from the microcontroller is used to drive an analog device. It's one of the primary means by which a microcontroller drives analog devices like servo motors, dimmable lights, and speakers. PWM is not a true analog output, but it gives the impression of an analog signal based on the amount of time the signal is on and off. The duty cycle is the most important characteristic of a PWM signal. The duty signal can be defined as the percentage corresponding to HIGH in a given period. Examples are shown below.

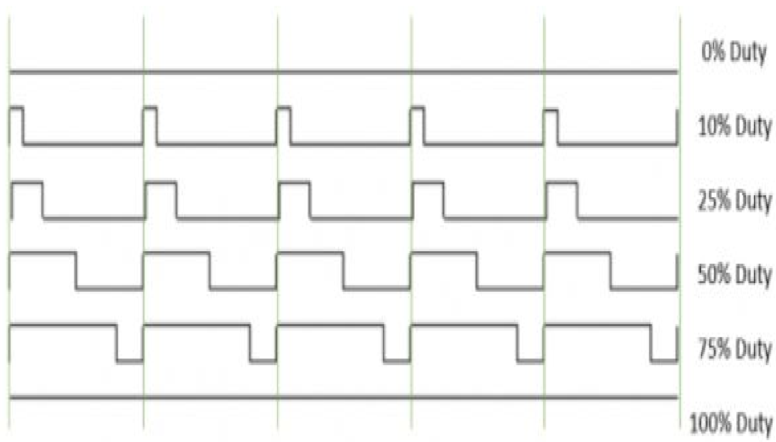

Figure 2: Examples of PWM signals

Part 1: Creating PWM signals

One possibility to create PWM signals is by using the Output Compare (OC) peripheral modules along with a timer. One timer (Timer y) is assigned to the OC module. Setting the PRy register of the timer will set the PWM period. Setting the OCxRS register of the OC module will set the actual duty cycle. The figure below from PIC32 data sheet explains how one period of the PWM is generated using OC.

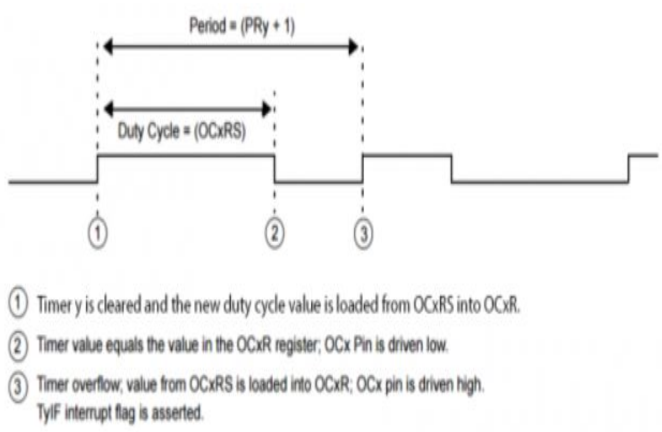

Figure 2: Generating PWM signal using Output Compare

Note that you don't have to use the OC module for this lab. You have the flexibility to use timers or other means to create the delays.

1. Write code to generate PWM signals with the following duty cycles
   (a) 10%
   (b) 25%
   (c) 50%
   (d) 75%
2. Use of the LEDs as an output to show the PWM signal for each of the cases above
3. Use the logic analyzer from MPLAB to show the PWM signals for each of the cases above.
4. Explain how you designed the PWM signal.

Part 2: RGB LED

An RGB LED consists of three internal LEDs (Red, Green, and Blue) that can be combined to produce almost any color output. The common anode and common cathode configurations are shown below.

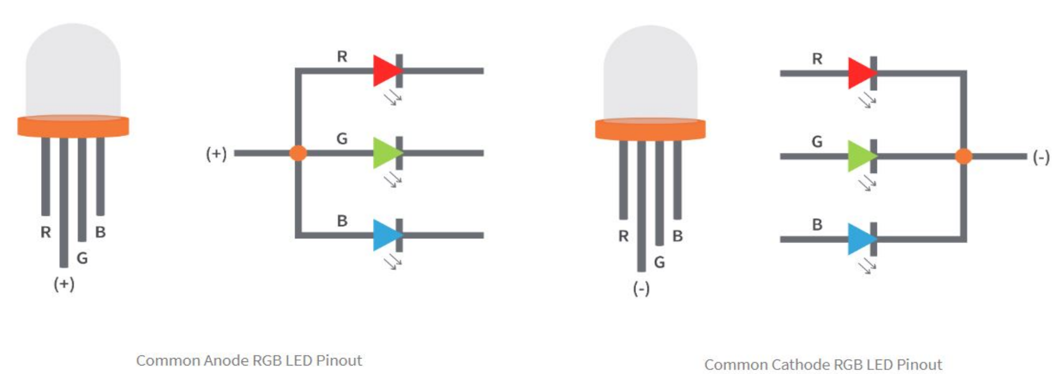

Figure 3: Common anode and common cathode RGB LED

The RGB LED can be used to produce any color. In order to produce a specific color, we need to set the intensity of each internal LED and combine the three-color outputs. We use PWM to adjust the intensity of the red, green, and blue LEDs individually. Our eyes will see the combination of the colors instead of the individual colors. Color generation from RGB is illustreated below.

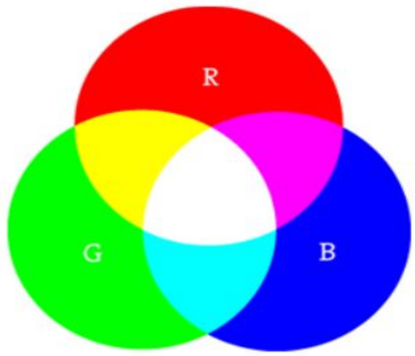

Figure 4: Creating colors from RGB.

The Basys MX3 has one RGB LED. This allows the user to obtain any color by configuring the R, G and B components. PWM is one way to do this configuration. Using this method, the intensity of each component of the RGB LED is determined by the duty cycle being applied to it. The RGB LED connections are shown the table below.

Label	Schematic Name	PIC32 Pin	Description
R	LED8_R	AN25/RPD2/RD2	Signal corresponding to the R component of the RGB
G	LED8_G	RPD12/PMD12/RD12	Signal corresponding to the G component of the RGB
B	LED8_B	AN26/RPD3/RD3	Signal corresponding to the R component of the RGB

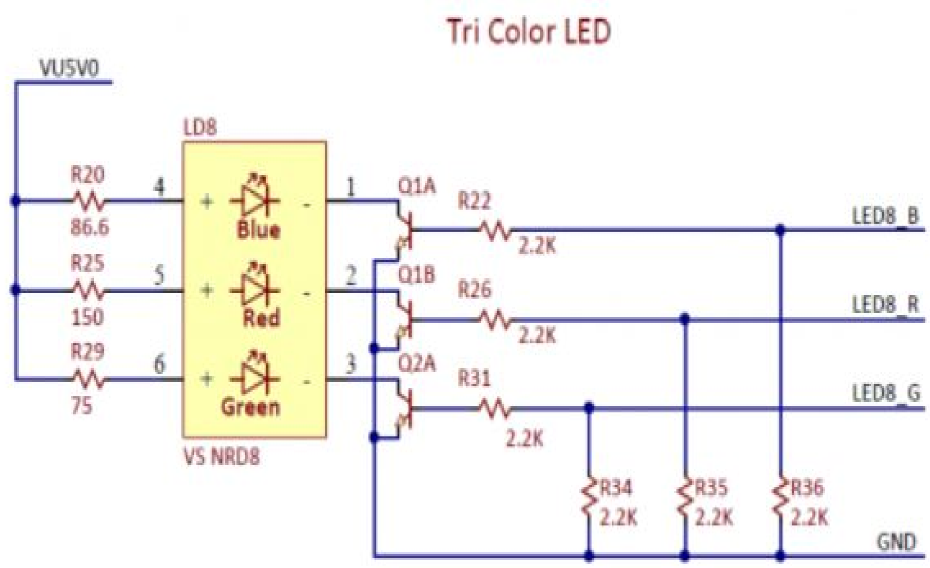

Figure 5: Basys 3 RGB connections

1. Write code to show the primary colors.
2. Write code to show three other colors of your choice (separately). Explain the mix and how is it related to the PWM signal.

3. Write code to display different colors (for example the seven colors shown in figure 4 or the colors shown in figure 6) gradually in a cycle.

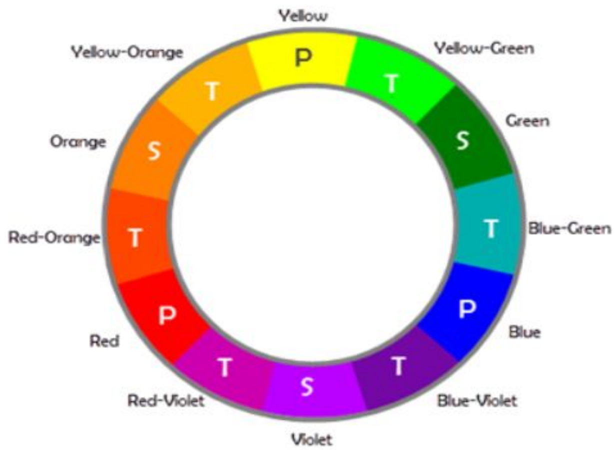

Figure 6: Primary, secondary and tertiary Colors