**Overview**

For my microcontroller project I chose to make a metronome.

The LCD screen displays the beats per minute of the current tempo, the volume level, the tempo name, and the time signature. The rotary encoder is used for modifying the tempo, volume level, and time signature. The tempo in incremented by 5 BPM each time, and the range is from 40-170s BPM. Updating the tempo will also update the tempo name associated to it. The user button is used to control the LEDs of the bar graph and the bicolor LED (whether they are on or off). For every beat, the loudspeaker plays a short beep, and the bicolor LED blinks (red for low beats, green for high beats). The device runs on batteries, but can also be plugged in to a separate power source via micro USB. When plugged in, the LCD backlight turns on.

**Hardware**

The board implements the following components:

Newhaven NHD-C0216CiZ-FSW-FBW-3V3 LCD screen,

* The LCD screen uses an I2C interface to communicate with the CPU. It has two rows with 16 characters each per row.

Kingbright DC20/20YWA 20-LED bar graph display,

* The bar graph consisted of 20 yellow LEDs aligned next to each other that were used to emulate the swinging of a pendulum.

CUI CVS-1508 loudspeaker,

* The loudspeaker was used to make an audible beep in-time with the given tempo.

Bourns PEC11R-4215K-S0024 rotary encoder,

* Rotary encoder is used to control the tempo speed, volume level, and time signature. Features a switch that is used to cycle between the three settings.

User button

* A simple button used to control whether the bar graph and bicolor LED are on or off.

Bicolor LED

* An LED that can switch between red and green (or both at once) based on which signals are active.

Programming connector

* Used to program the device.

Amplifier

* Used to provide enough voltage to the loudspeaker.

DC/DC boost converter

* Boots voltage up to 3.3v.

Battery switch

* Disconnects the battery when the device is plugged in to an external power source.

Step-down linear regulator

* Decreases the voltage from 5v to 3v (for USB).

**Software**

Software for the metronome was developed using PSoC Creator 4.0 in C. The software contains a list of clock period values for each corresponding BPM that is used to trigger an event (such as a beep from the loudspeaker). The device listens for an interrupt either from the timer component or one of the two buttons. If the interrupt is from the timer, the bar graph updates and the device checks to see if it should change the beep frequency, play a beep, or blink the bicolor LED according to if it is a “low” accent or “high” accent. If the interrupt if from a button, the device checks to see which button has been pressed (either the user button or the rotary encoder button), then sets a flag accordingly. Pressing the user button will result in activating/deactivating the bar graph and bicolor LED (both on -> bar graph only -> bicolor LED only -> both off). Pressing the rotary encoder button will cycle between selecting different settings that the user is allowed to update (BPM -> volume level -> time signature). Turning the rotary encoder will change the state of either the BPM, volume level, or time signature according to whichever setting is selected.

**Final Thoughts**

I was really satisfied by the way the project turned out. This was my first attempt at a project where I had to make choices about which hardware to use and then program it, and though I wasn’t so confident with my abilities at first, I felt learned a lot and made a lot of progress during the course of the semester. Overall, it was a very fun and very rewarding experience.

**Turning on/off:**

To turn the metronome on, press and hold the user button for approximately 1 second. The device will immediately begin.

To turn off, press and hold the user button for 2 seconds.

**Standard (volume) mode cycling:**

Each time the user button is pressed, the metronome will enter a new “mode.” Mode descriptions are listed below.

Mode 0 – Standard mode:

* Both the bar graph and Bicolor LED are on.

Mode 1 – Only bar graph

* The bar graph LED is on. The Bicolor LED is off.

Mode 2- Only Bicolor LED

* The Bicolor LED is on. The bar graph is off.

Mode 3—No LEDs

* Both the bar graph and the Bicolor LED is off

**Beat mode (Mode 4):**

To access beat mode, press the rotary encoder button. To return to the last visited standard mode, press the encoder button again.

**Volume changing:**

While inside one of the standard modes (modes 0-3), use the rotary encoder to change the volume level. Every time the rotary encoder is moved clockwise, the volume is incremented by 1 and the display is updated to show the new volume level. The same occurs when the rotary encoder is rotated counter-clockwise except that the volume is decremented by 1 instead.

**Beat changing:**

While inside beat mode (mode 4), turn the rotary encoder clockwise to increment the bpm by 5, or counter-clockwise to decrement the bpm by 5. The beat cannot be less than 40 or less than 170. The display will update to show the new bpm.

**LCD display**

Where What How

Top left: BPM Rotary encoder

Top right: Mode name User button

Bottom left: Tempo name --

Bottom right: Volume Rotary button / Rotary encoder

**Button Functionality**

Standard Modes:

Mode 0: Standard mode Press user button

Mode 1: Bar graph LEDs only Press user button

Mode 2: BICOLOR LED only Press user button

Mode 3: No LEDs Press user button

Special Modes:

Mode 4: Beat mode Press rotary encoder

Further functionality:

Turn On: Hold user button 1 second when off

Turn Off: Hold user button 2 seconds when on