

# How (not) to build a tuner

## PHYS 319 Personal Project

Rio Weil

University of British Columbia

April 13, 2021



# Outline

- 1 Motivation
- 2 High-Level Overview of Functionality
- 3 Brief run-through of components/theory
  - Audio Input and Signal Processing
  - User Controls
  - LCD Display
  - MSP program
- 4 Demo
- 5 Possible Improvements & Outlook

# Motivation

# Motivation

Why I thought it would be a good idea:

# Motivation

Why I thought it would be a good idea:

- I like music and this seems like a nice way to connect that interest with physics.

# Motivation

Why I thought it would be a good idea:

- I like music and this seems like a nice way to connect that interest with physics.
- I don't have a tuner and this seems like a nice way to get around buying one.

# Motivation

Why I thought it would be a good idea:

- I like music and this seems like a nice way to connect that interest with physics.
- I don't have a tuner and this seems like a nice way to get around buying one.
- In theory, I understand everything that needs to be done to make this work.

# Motivation

I like music and this seems like a nice way to connect interest with physics.

I don't have a tuner and this seems like a nice way to get around buying one.

In theory, I understand everything that needs to be done to make this work.

This is going to be fun.



[imgflip.com](https://imgflip.com)

# Demotivation

Why it wasn't a good idea:

# Demotivation

Why it wasn't a good idea:

- I spent more time building a tuner than actually playing music in the last year.

# Demotivation

Why it wasn't a good idea:

- I spent more time building a tuner than actually playing music in the last year.
- 250+ dollar kit worth of parts is outperformed by my brother's 30 dollar device.

# Demotivation

Why it wasn't a good idea:

- I spent more time building a tuner than actually playing music in the last year.
- 250+ dollar kit worth of parts is outperformed by my brother's 30 dollar device.
- Curse of the physicist: Real life often makes everything you thought would be doable harder.

# High-Level Overview of Functionality

The tuner should have...

# High-Level Overview of Functionality

The tuner should have...

- Measure the frequency of the played note and return how off it was

# High-Level Overview of Functionality

The tuner should have...

- Measure the frequency of the played note and return how off it was
- Play the specific frequency for tuning by ear

# High-Level Overview of Functionality

The tuner should have...

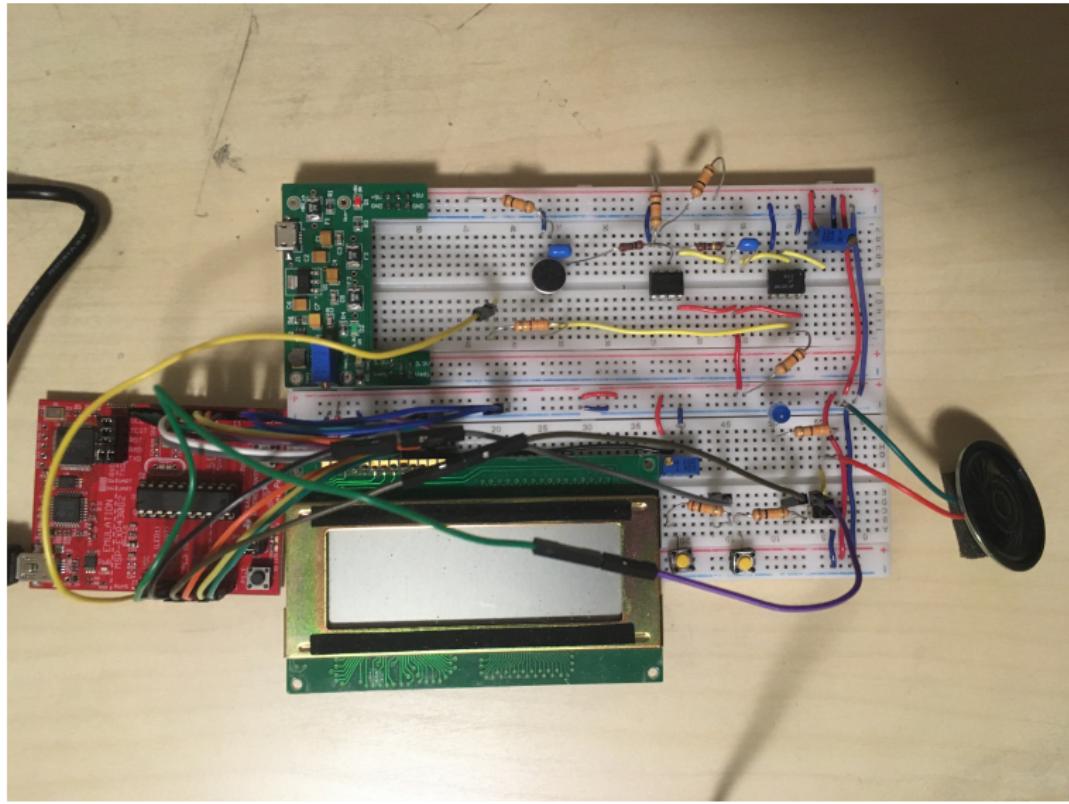
- Measure the frequency of the played note and return how off it was
- Play the specific frequency for tuning by ear
- Metronome for tempo

# High-Level Overview of Functionality

The tuner should have...

- Measure the frequency of the played note and return how off it was
- Play the specific frequency for tuning by ear
- Metronome for tempo
- Display & Interface on device itself

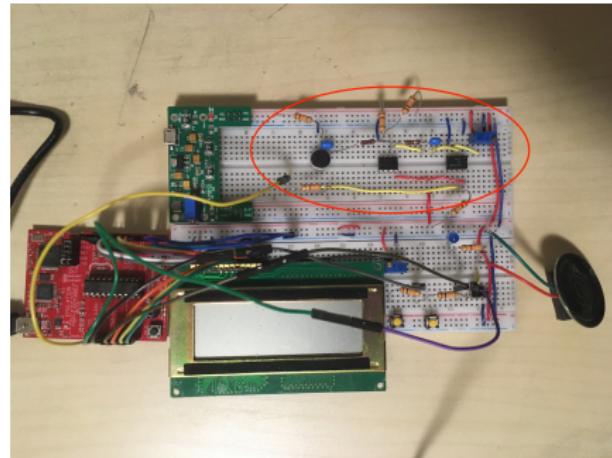
# A complicated mess



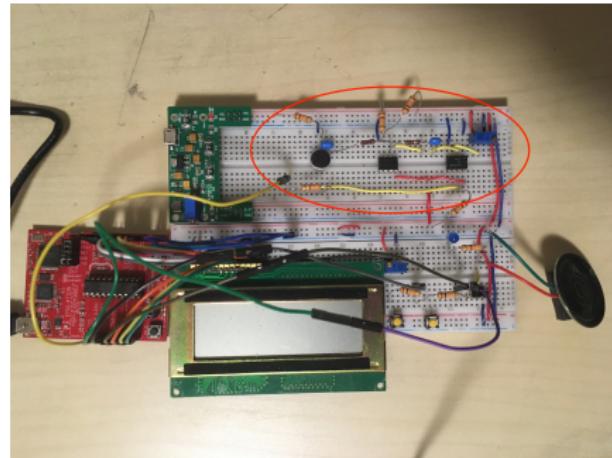
# A complicated mess

```
150  
157     char* int_to_note_string(int note) {  
158         switch(note) {  
159             case 16:  
160                 return "C2";  
161  
162             case 17:  
163                 return "C#2";  
164  
165             case 18:  
166                 return "D2";  
167  
168             case 19:  
169                 return "D#2";  
170  
171             case 20:  
172                 return "E2";  
173  
174             case 21:  
175                 return "F2";  
176  
177             case 22:  
178                 return "F#2";  
179  
180             case 23:  
181                 return "G2";  
182  
183             case 24:  
184                 return "G#2";  
185  
186             case 25:  
187                 return "A2";
```

# Audio Input and Signal processing



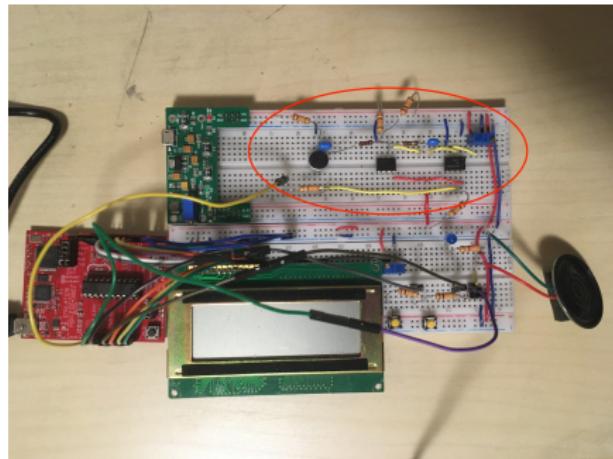
# Audio Input and Signal processing



- Electret mic. picks up the signal

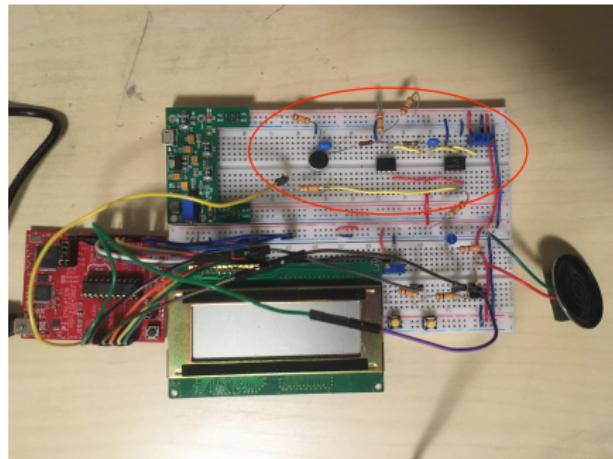


# Audio Input and Signal processing



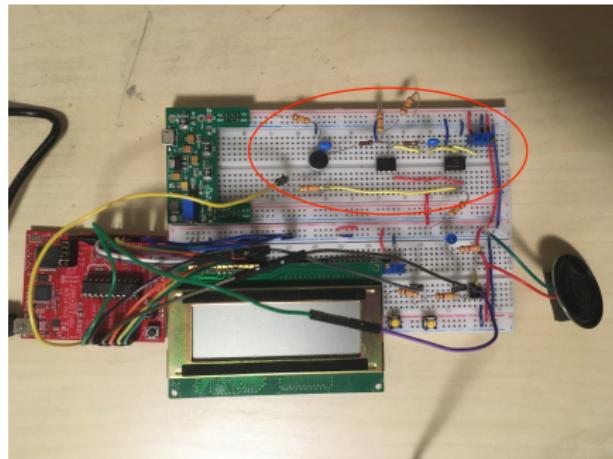
- Electret mic. picks up the signal 
- Op-Amp amplifies signal 

# Audio Input and Signal processing



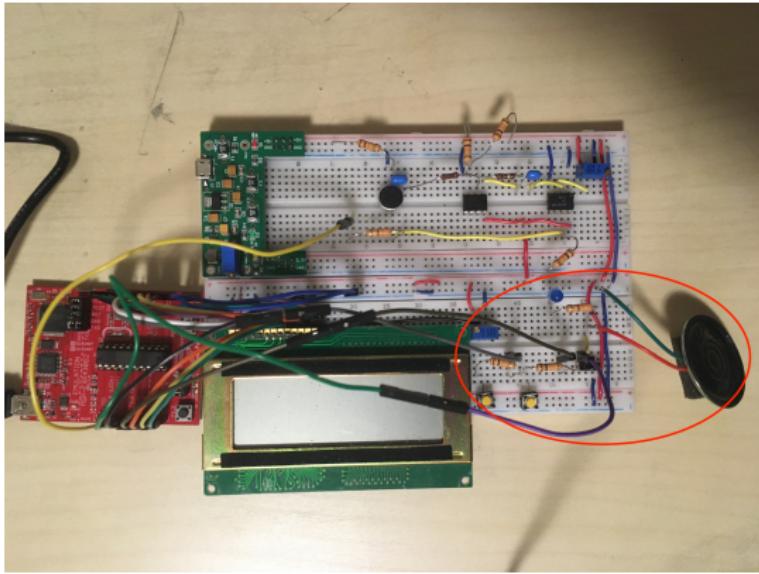
- Electret mic. picks up the signal 
- Op-Amp amplifies signal 
- Comparator converts to square wave

# Audio Input and Signal processing

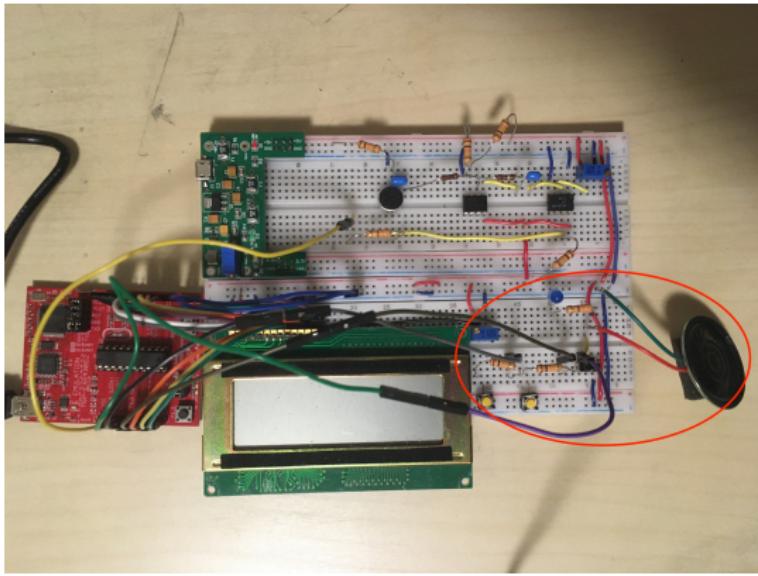


- Electret mic. picks up the signal 
- Op-Amp amplifies signal 
- Comparator converts to square wave
- Processed Signal gets sent to MSP

# User Controls

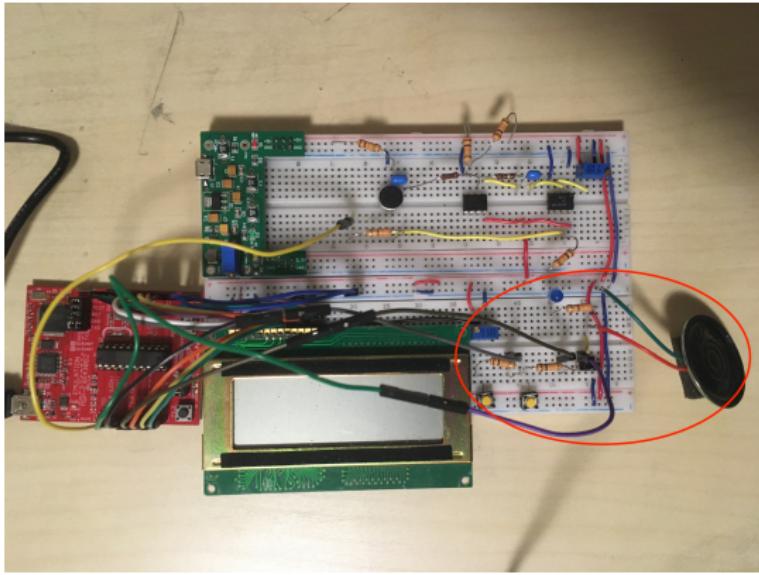


# User Controls



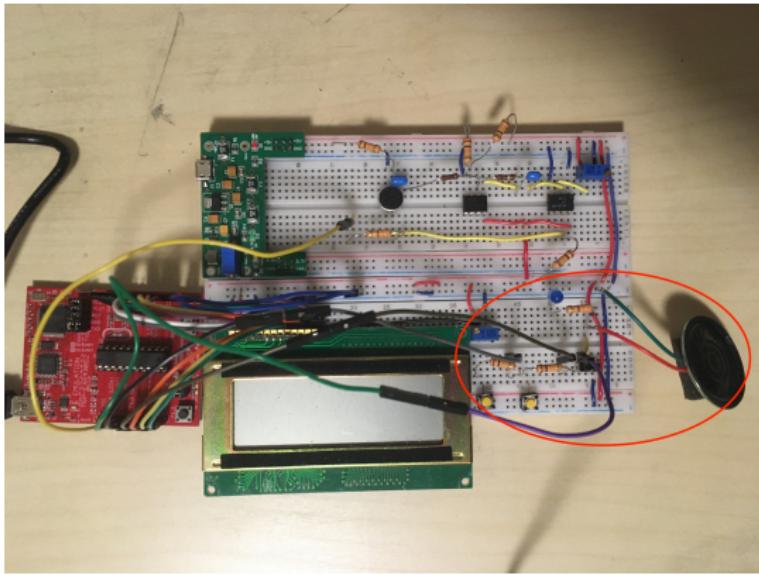
- Buttons to change notes

# User Controls



- Buttons to change notes
- Switch to turn speaker on/off

# User Controls



- Buttons to change notes
- Switch to turn speaker on/off
- Interrupt buttons on MSP to switch tuning/metronome modes

# LCD Display



# LCD Display



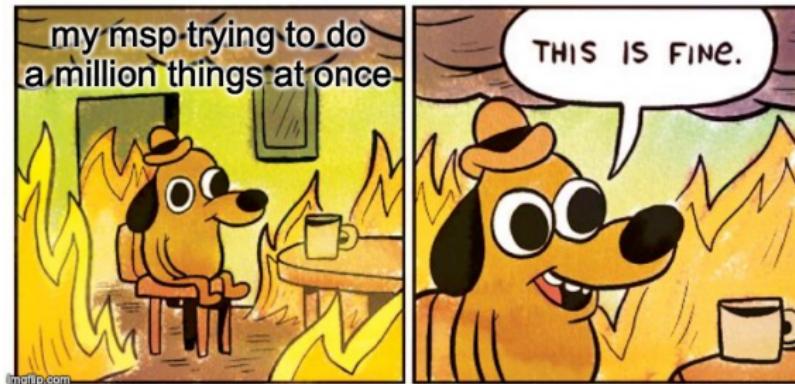
- Potentiometer for screen contrast

# LCD Display

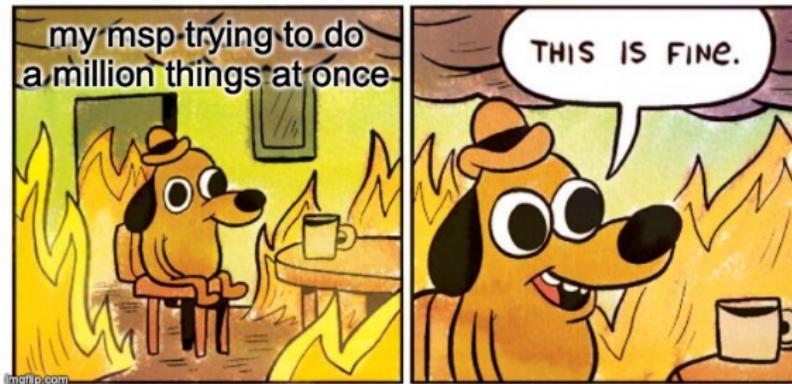


- Potentiometer for screen contrast
- R/S pin, E pin, and 8 data pin inputs from MSP

# MSP program

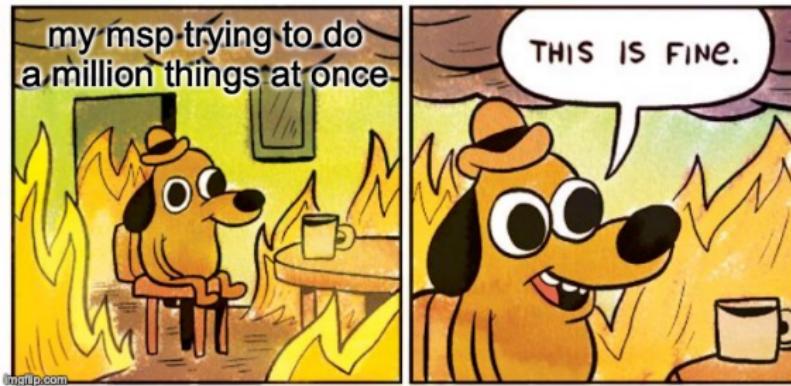


# MSP program



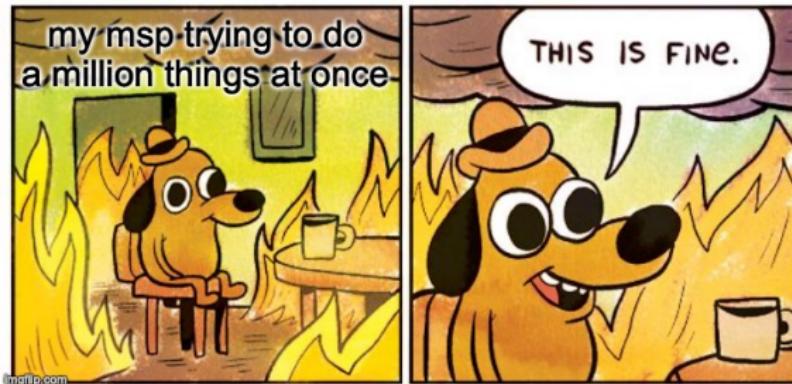
- Measuring input signal width

# MSP program



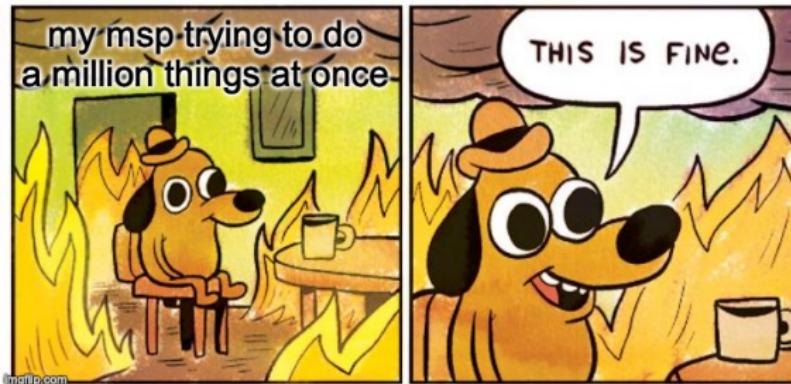
- Measuring input signal width
- Outputs to LCD display

# MSP program



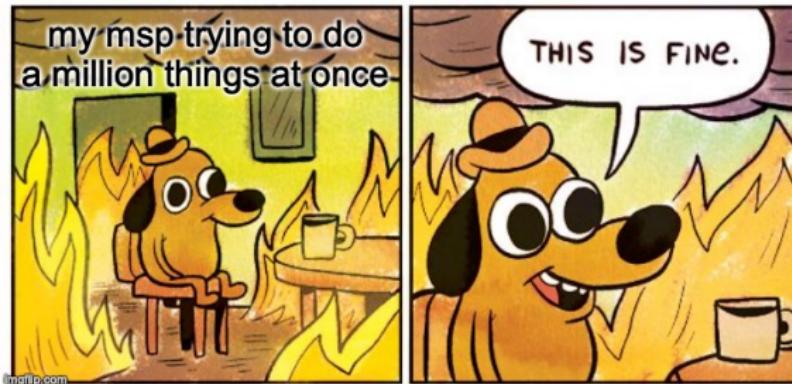
- Measuring input signal width
- Outputs to LCD display
- PWM output

# MSP program



- Measuring input signal width
- Outputs to LCD display
- PWM output
- Interrupt Handling

# MSP program

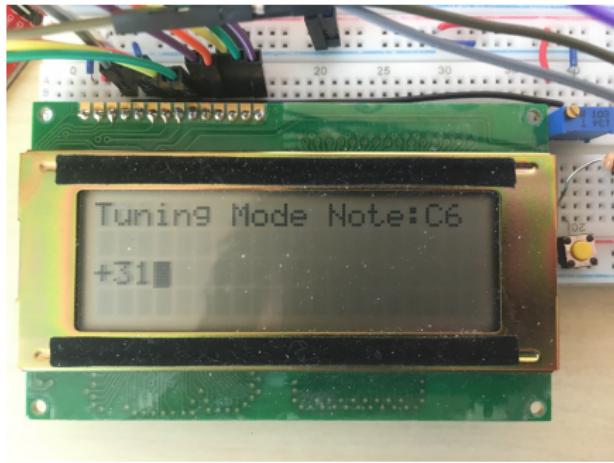


- Measuring input signal width
- Outputs to LCD display
- PWM output
- Interrupt Handling
- Internal counter and input handling for bpm/notes

# Demo



# LCD photos as I anticipate it will be impossible to see on camera



# Issues/Improvements

## Issues/Improvements

- ① Some inaccuracies in metronome rate as well as played frequencies

# Issues/Improvements

- ① Some inaccuracies in metronome rate as well as played frequencies
  - ▶ Potential errors in system clock, or rounding errors in calculating rate/frequencies to investigate

# Issues/Improvements

- ① Some inaccuracies in metronome rate as well as played frequencies
  - ▶ Potential errors in system clock, or rounding errors in calculating rate/frequencies to investigate
- ② Inconsistencies in measured frequency, difficulty in reading inputs with multiple harmonics

# Issues/Improvements

- ① Some inaccuracies in metronome rate as well as played frequencies
  - ▶ Potential errors in system clock, or rounding errors in calculating rate/frequencies to investigate
- ② Inconsistencies in measured frequency, difficulty in reading inputs with multiple harmonics
  - ▶ Adjustments in comparator calibration, how the MSP counts the pulse width, implementation of averaging.

# Issues/Improvements

- ① Some inaccuracies in metronome rate as well as played frequencies
  - ▶ Potential errors in system clock, or rounding errors in calculating rate/frequencies to investigate
- ② Inconsistencies in measured frequency, difficulty in reading inputs with multiple harmonics
  - ▶ Adjustments in comparator calibration, how the MSP counts the pulse width, implementation of averaging.
- ③ Difficulty in handling tones that are not consistently loud.

# Issues/Improvements

- ① Some inaccuracies in metronome rate as well as played frequencies
  - ▶ Potential errors in system clock, or rounding errors in calculating rate/frequencies to investigate
- ② Inconsistencies in measured frequency, difficulty in reading inputs with multiple harmonics
  - ▶ Adjustments in comparator calibration, how the MSP counts the pulse width, implementation of averaging.
- ③ Difficulty in handling tones that are not consistently loud.
  - ▶ Potential stronger amplification, but could be a hardware limitation due to low SNR for quiet signal.

# Outlook

