Using Refracting Radio Waves to Characterize Inversions

Shannon Mellin

Advisor Peter Conwell PhD (KG7VKJ)

Hypothesis

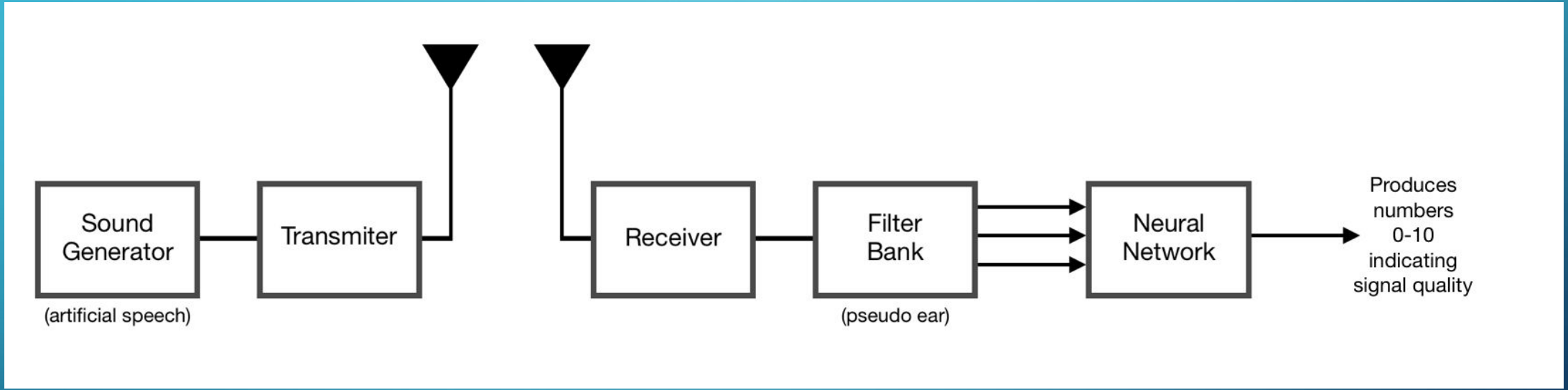
- The angle at which a signal refracts (bends) as it passes through the inversion layer, can determine the bulk properties that make up the pollution
- The degree of bending is related to the *index of refraction* of the medium

Image credit: New York Times “Nature Lovers' Paradise”

Introduction

- 1940s radio operators noted very enhanced range of high frequency radio signals when transmitting through an atmospheric inversion
- It was suspected that the inversion layer had a significantly different index of refraction than the clear layer above
  - This caused the signal to continually bounce from the earth to the top of the inversion layer
- No quantitative research has been done on this

Big Picture


Sound Generator
(artificial speech)
Transmiter
Receiver
Filter Bank
(pseudo ear)
Neural Network
Produces numbers 0-10 indicating signal quality

Antenna Orientation and Signal Quality

- Highly directional antennas
- The amount the beam bends relates to the index of refraction
- Determining that bending angle requires knowing the angle of the antennas
- The signal quality will be greatest when the beam and the antenna are aligned
- I worked on a method to help determine the signal quality

My Part

- Build a crude artificial ear to couple with a neural network that will determine the quality/strength of the received signal

Artificial Ear

- I made a filter bank consisting of three filters
- They listen for three different frequencies (pitches) within the range of human hearing
  - 50Hz
  - 500Hz
  - 5,000Hz

Process

1. Design
2. Simulation
    - bug fixes
3. Bread Board
    - simulation vs reality
4. Circuit Boards

Design Parameters

- Designed three bandpass filters (a bandpass filter allows signals of specific frequencies to pass, and discriminates against signals at other frequencies)
- Powered with a single 0 to 12 volt supply

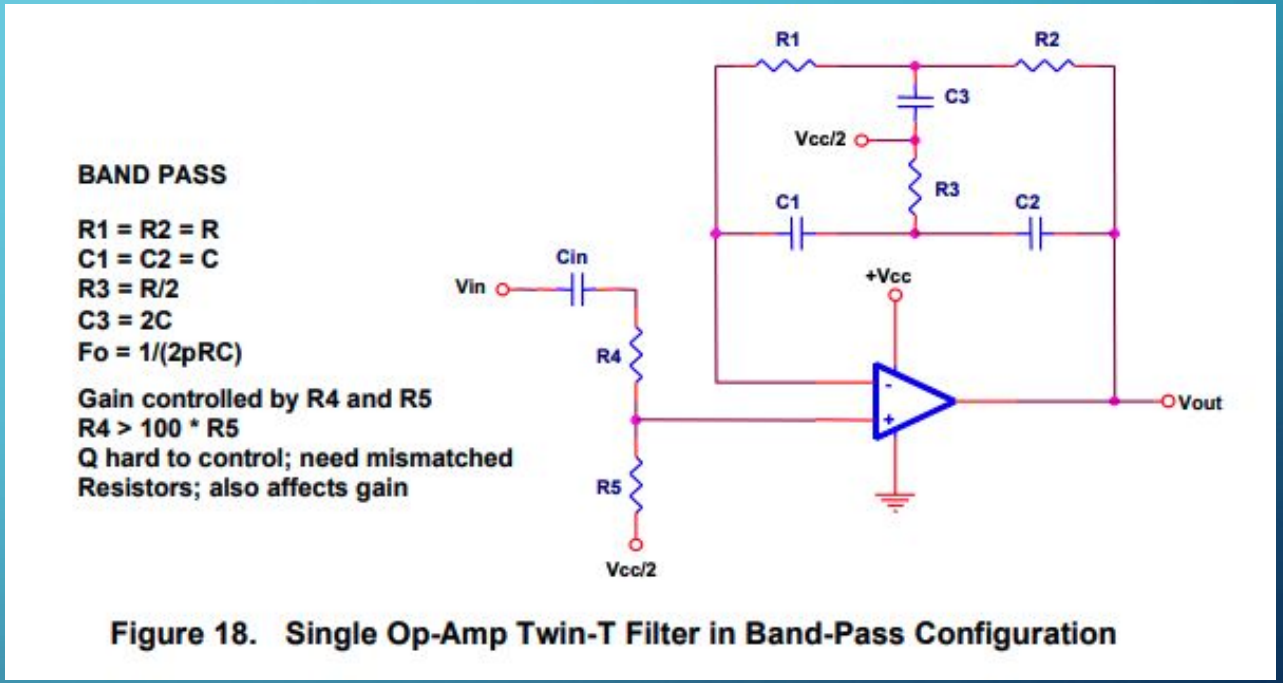
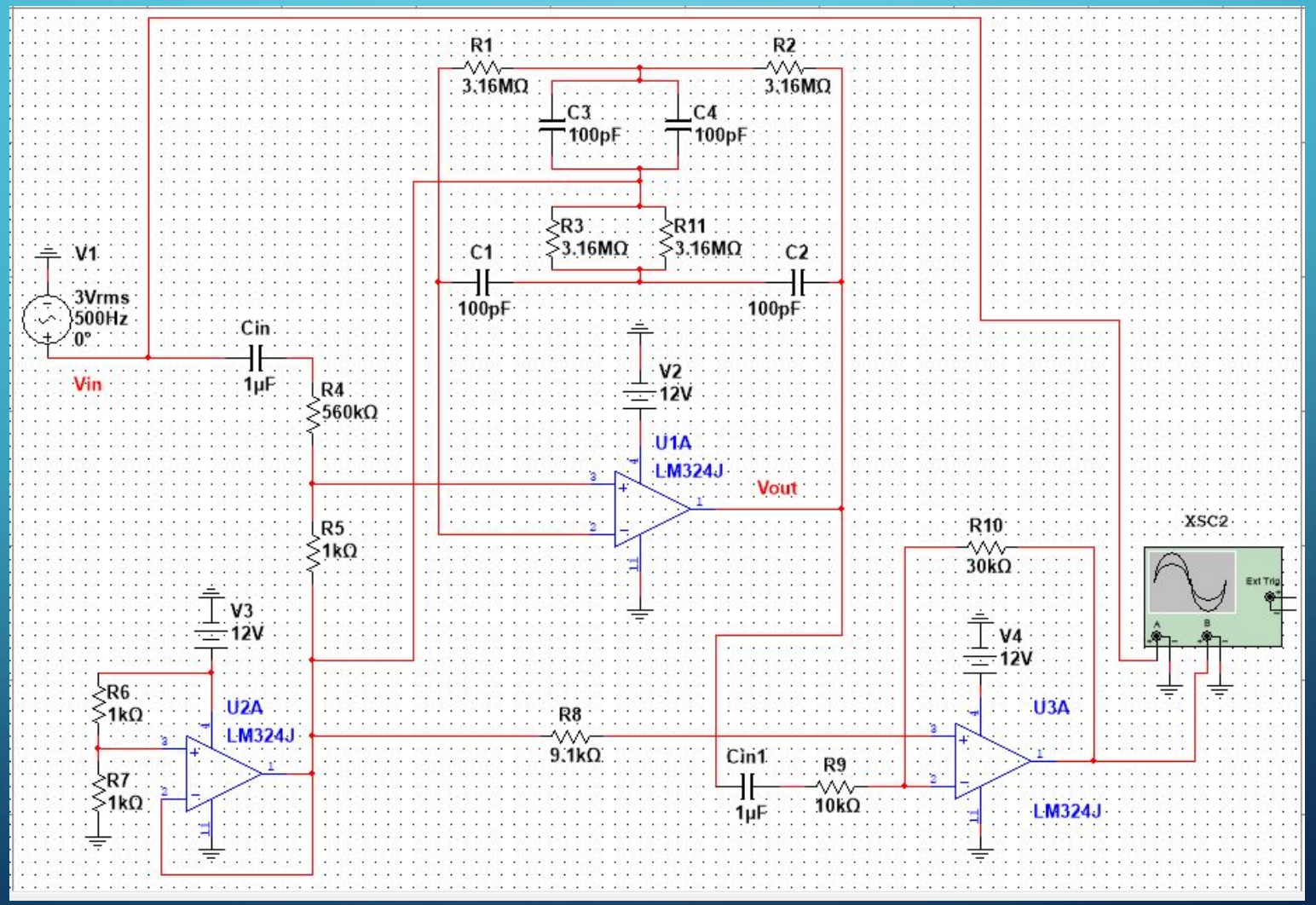


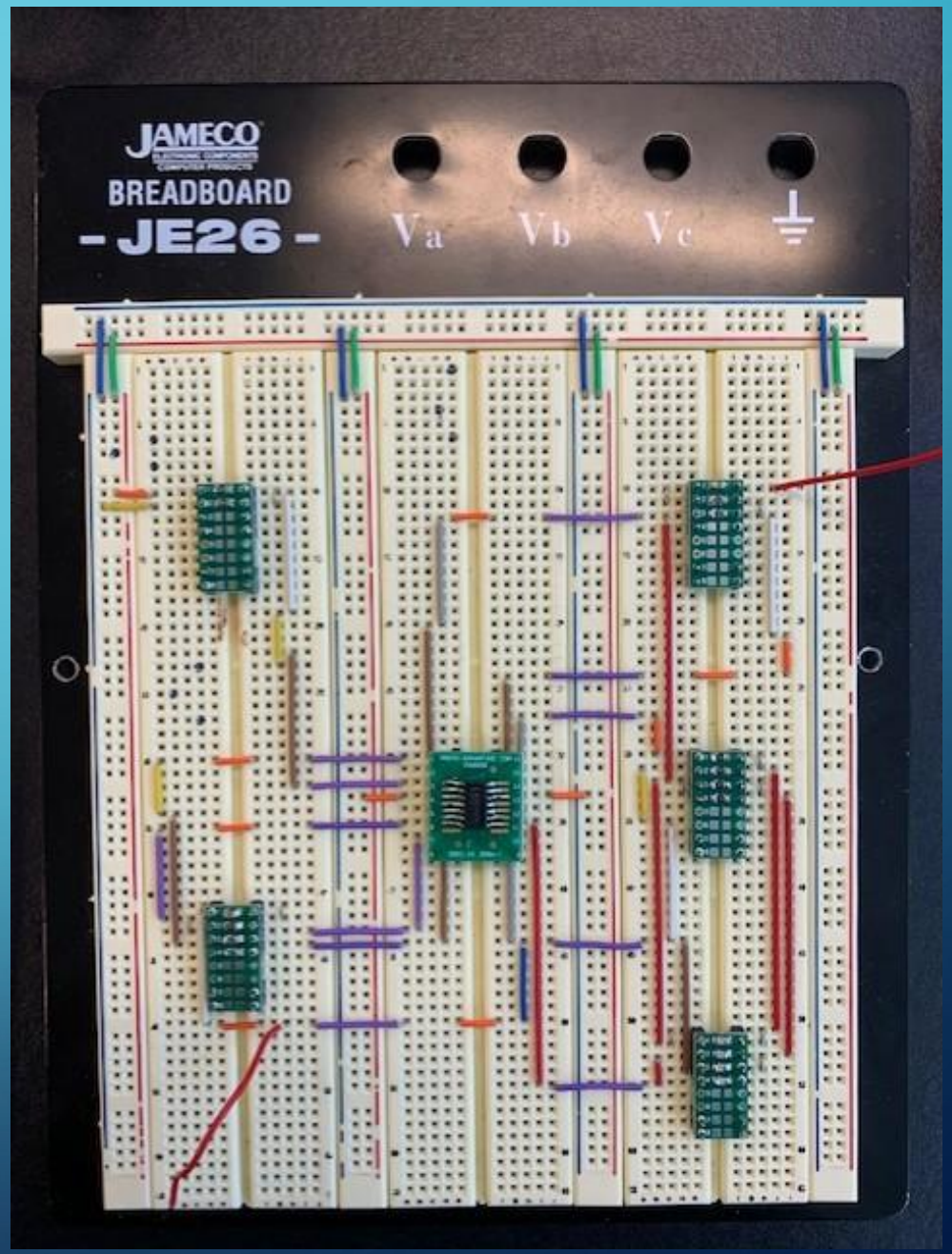
Figure 18. Single Op-Amp Twin-T Filter in Band-Pass Configuration

Texas Industries 'A Single-Supply Op-Amp Circuit Collection'

Simulations with Multisim

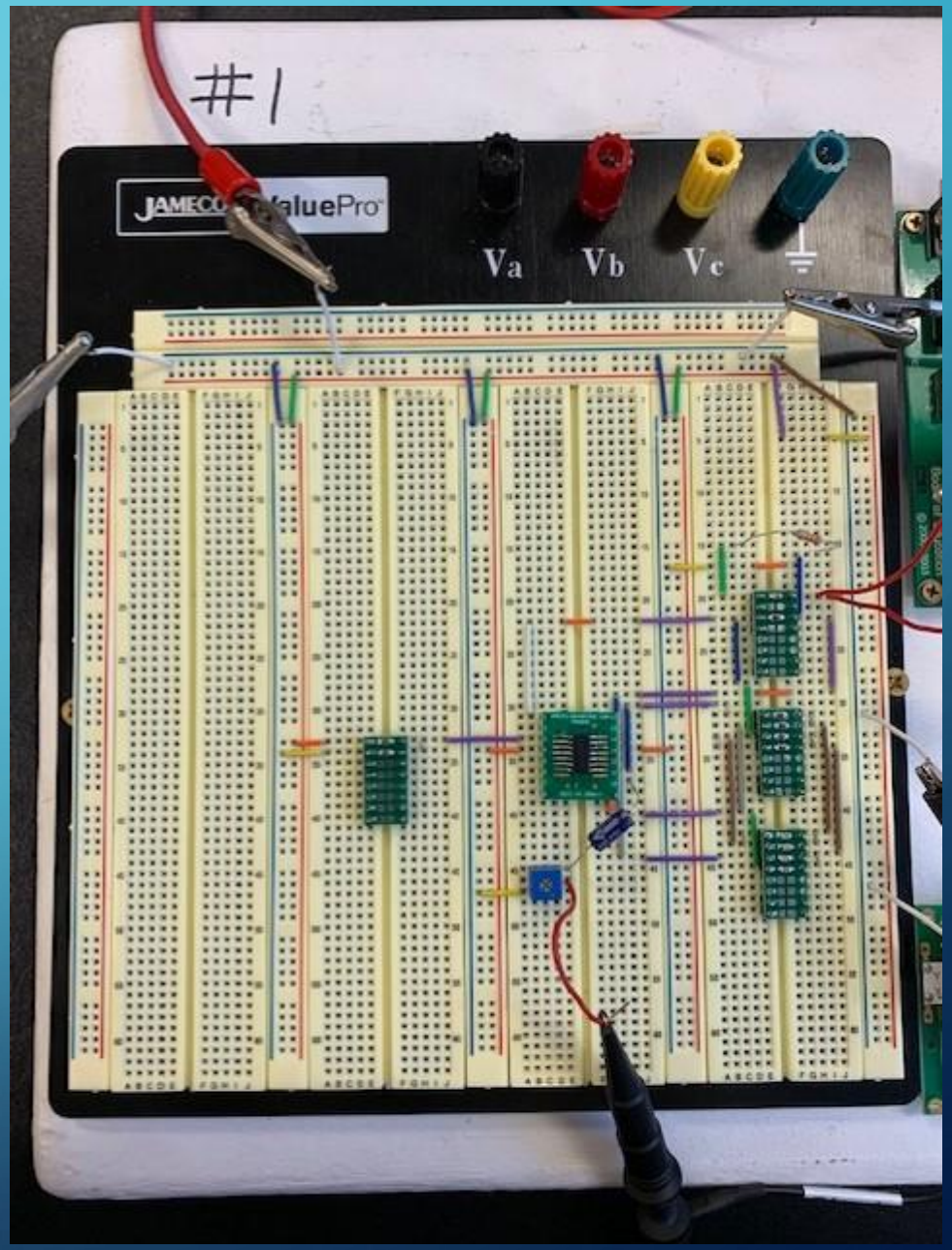


First Bread Board Design



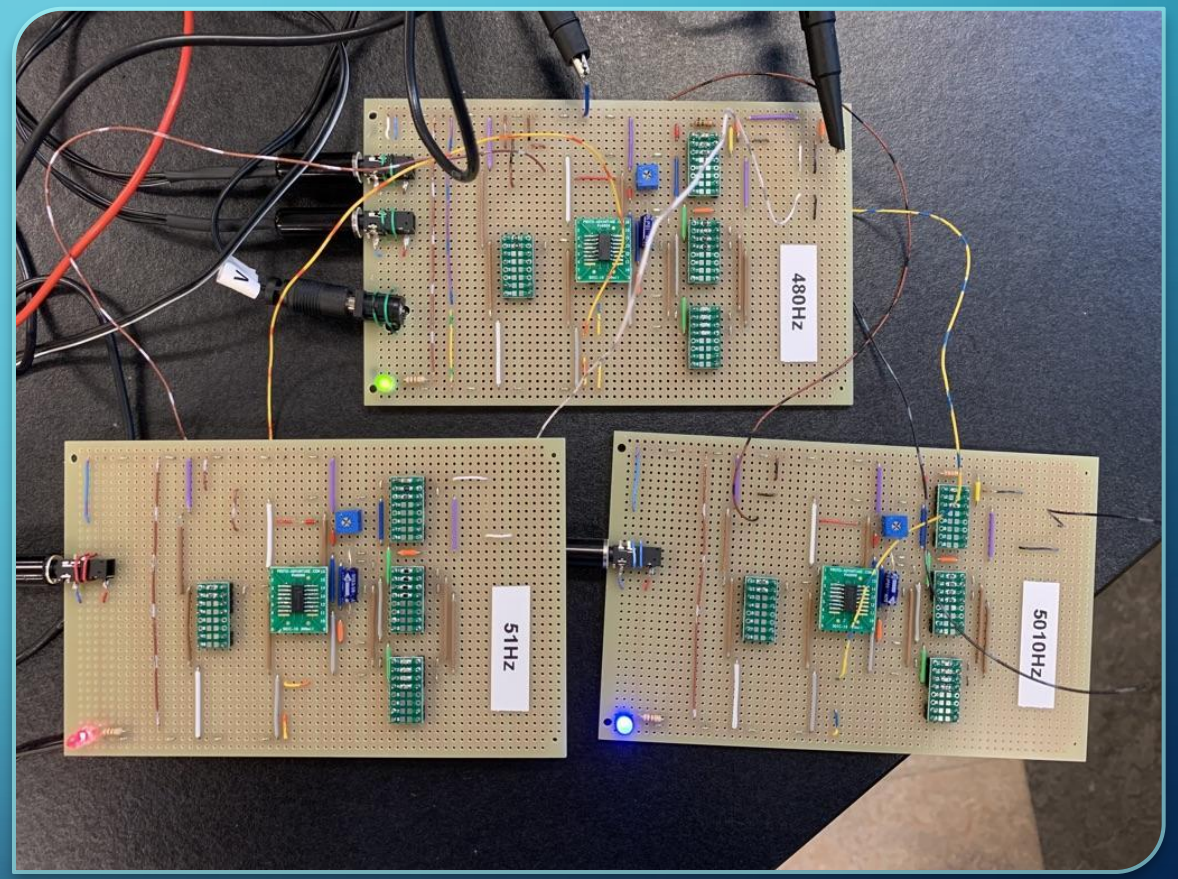
Final Bread Board Design

- Highly simplified
- No amplifier Required!
- Different resistors
- Potentiometer

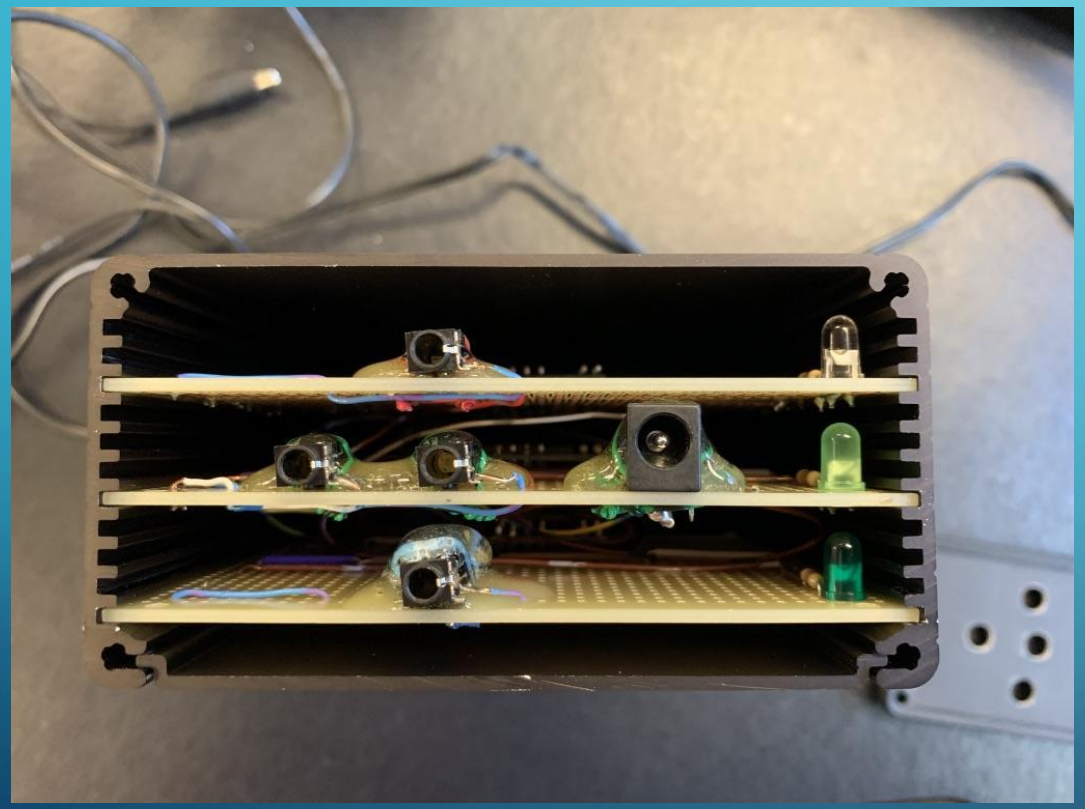


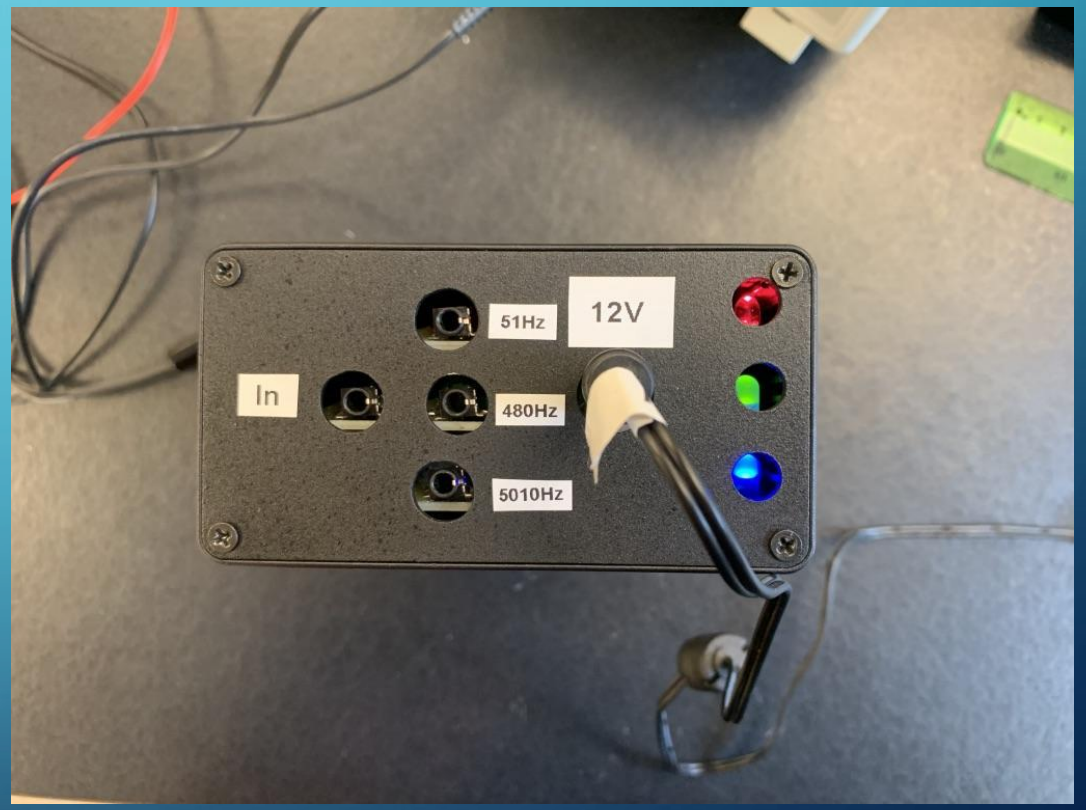
Circuit Boards

- Shockingly it worked on my first try!
- My favorite part of the process

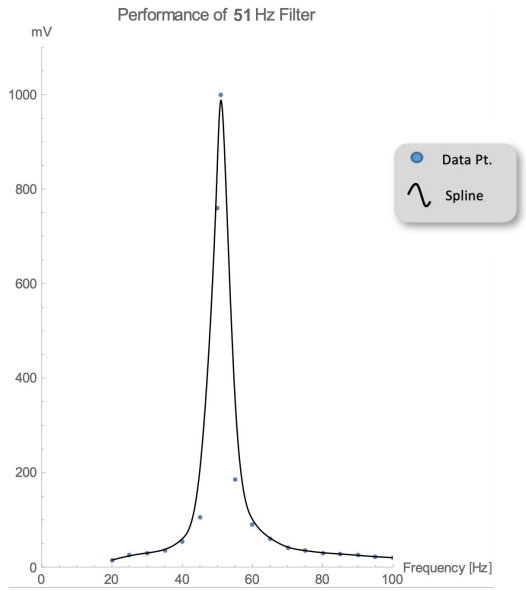


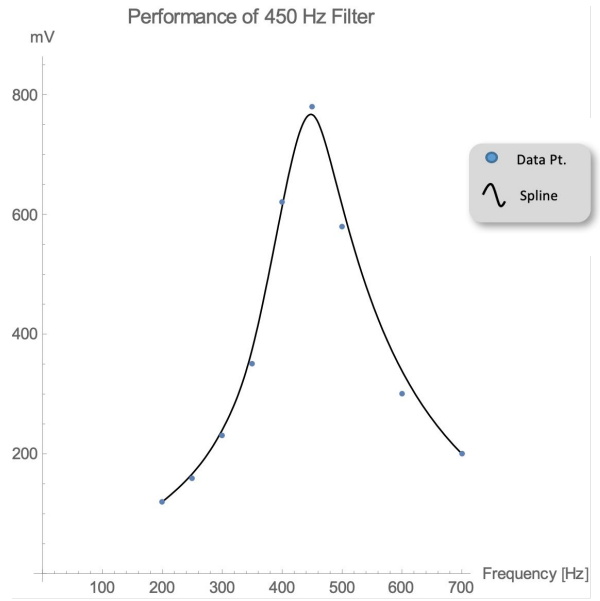
Filter Bank

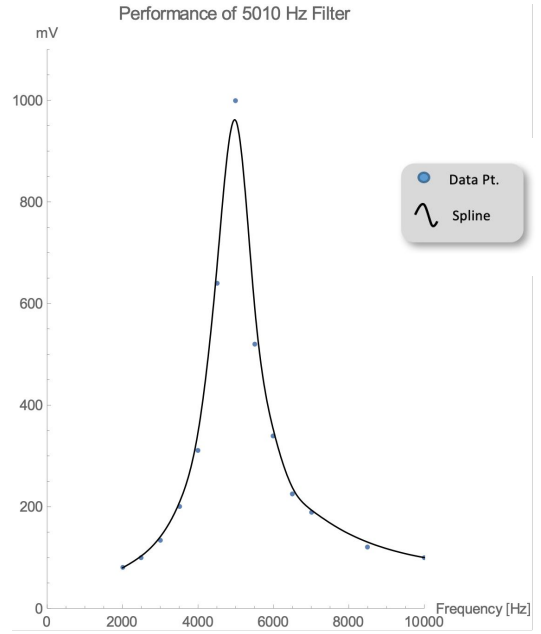




Final Look







Performance

Future Work

- Develop a neural network using AI that can determine signal quality
- Make a sound generator to be heard by the pseudo ear
- Develop means to measure antenna orientation
- Field testing: baseline controls, reading refraction measurements and gathering data
- Secondary methods for comparison data

Long Term Goal

- Making a model that shows the relation of the index of refraction to atmospheric pollutants
- With this information we could determine what harmful chemicals are in the air

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Acknowledgements

- My advisor Peter Conwell
- The Gore Math and Science Endowment