Wind Sensor:
Final Presentation
Advisor: Dr. Kuh

Creighton Chan • Jerry Wu • Scott Nishihara

Summary

- Motivation
- Project Overview
- Acoustic Wind Sensor
- Ultrasonic Wind Sensor
- Questions

Motivation

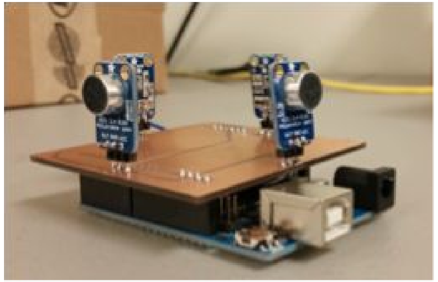
- Knowing the wind patterns (speed and direction) allows for predicting where buildings can be built so that there’s natural ventilation
- Traditional wind sensors are large, have moving parts, and are generally expensive
- We want something that is small, has no moving parts, and is inexpensive to manufacture, something that can be integrated with the weatherbox

Some examples of traditional wind sensors

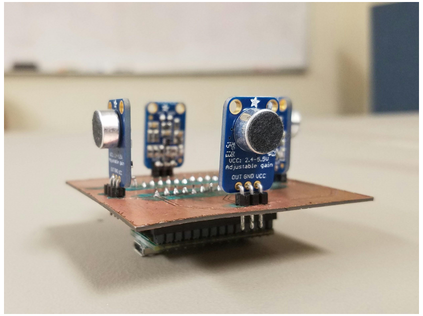
Project Overview

Objective: To build a small, static, and inexpensive, wind sensor that is able to:

- Gather accurate data in real-time on wind speeds and directions using microphones and signal processing
- Be integrated into a weatherbox design
- Recreate existing algorithm for acoustic wind sensor



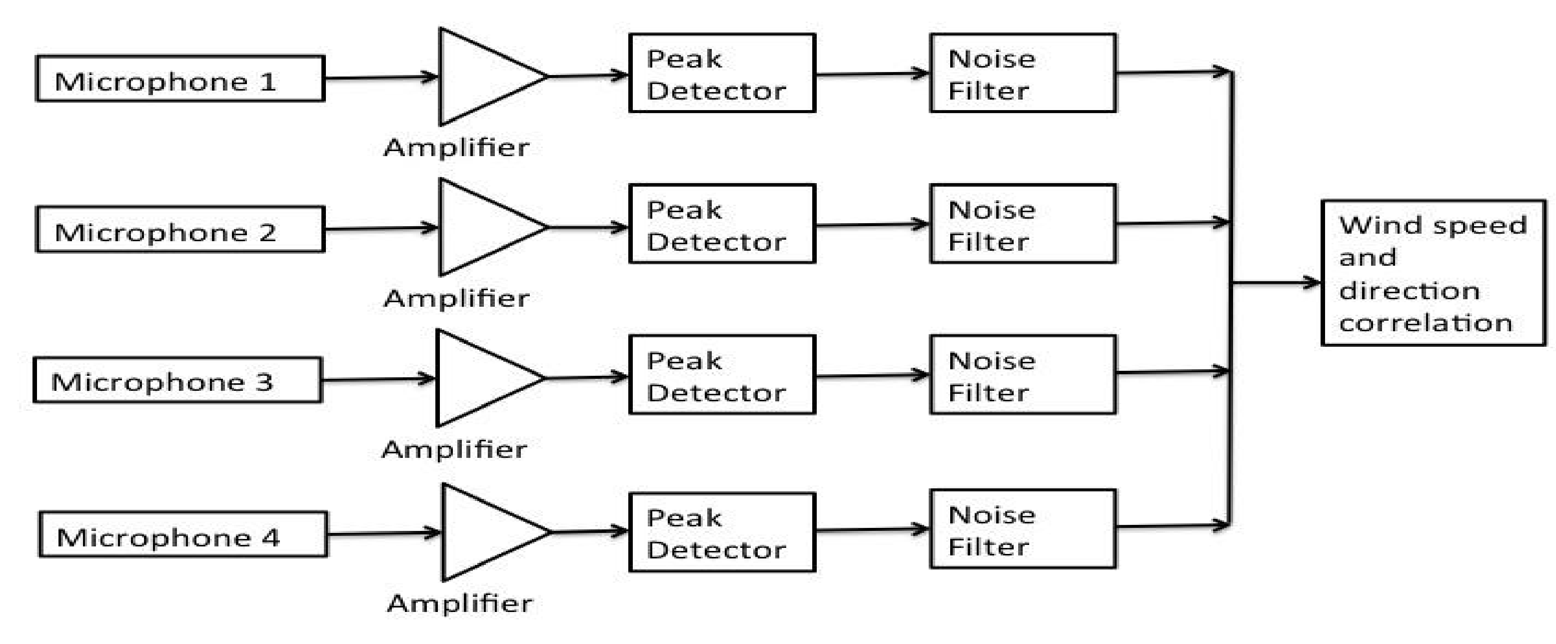
First iteration of the wind sensor using an Arduino and 4 omnidirectional microphones



Second iteration of the wind sensor using a Teensy and 4 omnidirectional microphones

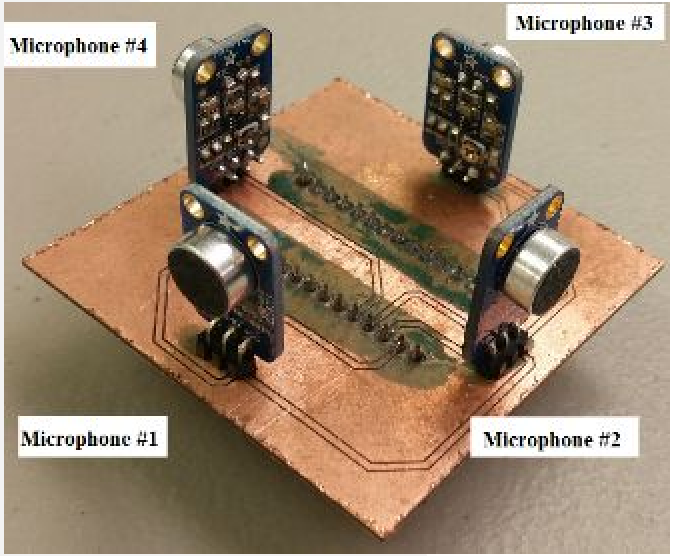
Acoustic Wind Sensor

Block Diagram



Block diagram for the acoustic wind sensor

Overall Design

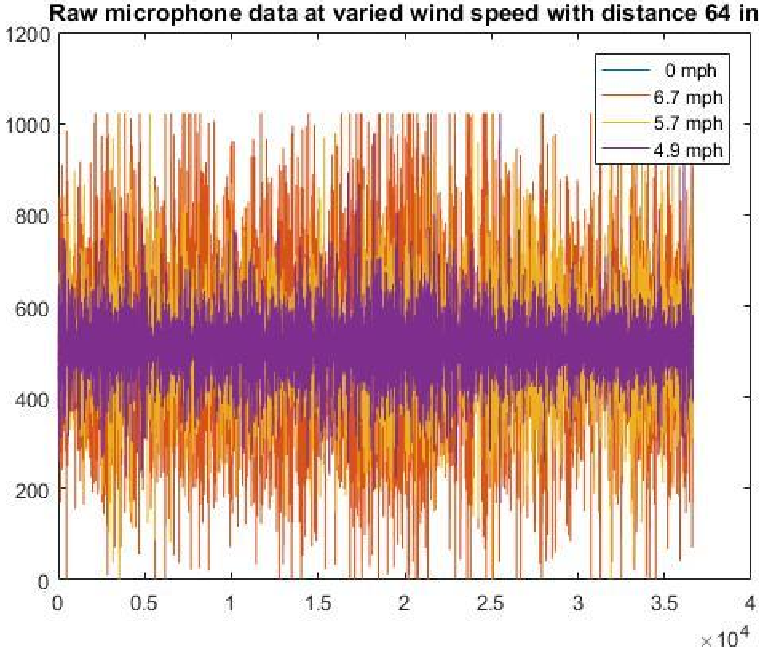


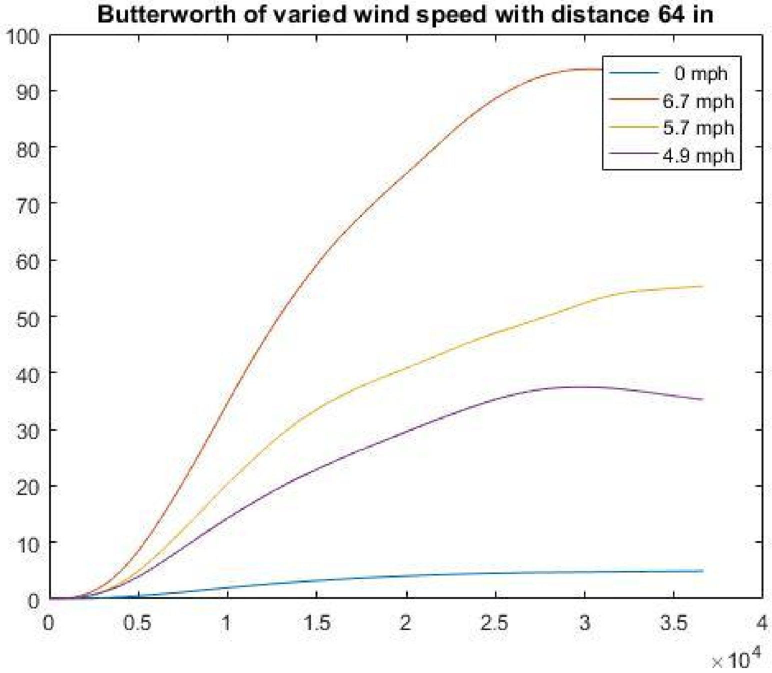
Second iteration of the wind sensor using a Teensy and 4 omnidirectional microphones

- Uses the amplitudes from the four microphones and our developed algorithms to get the wind speed and direction
- Algorithms:
    - Peak Detector
    - Butterworth filter

- **Costs:**
    - 4 x $6.95 for microphone and amplifier breakout board = $27.80
    - 1 Teensy 3.2 = $19.95
    - Total cost = $47.75
    - Other: Cortex M4 ($5), RMS Chip

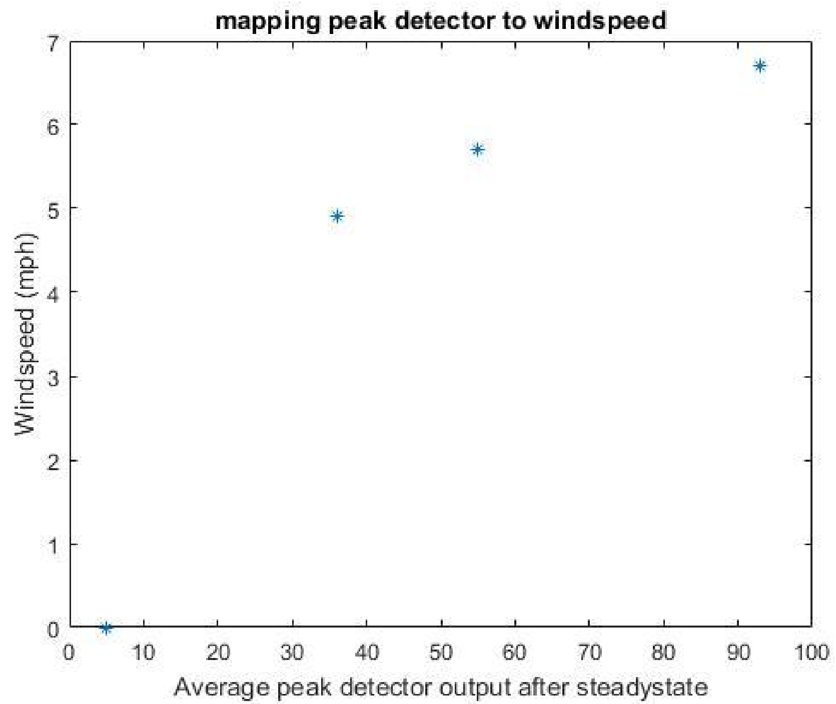
Methods

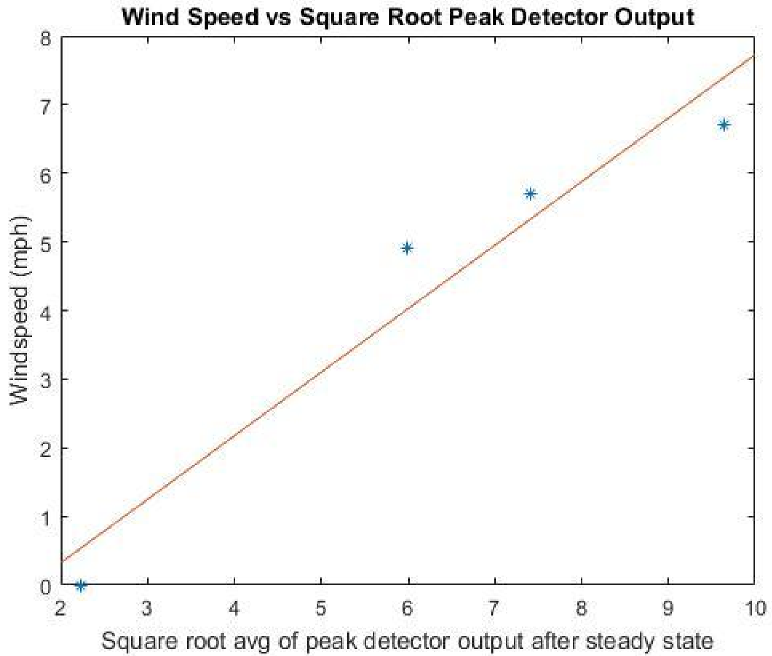




Peak Detector: alpha = 0.0001
Butter: Order 2, wn = 0.0001

Methods (cont.)





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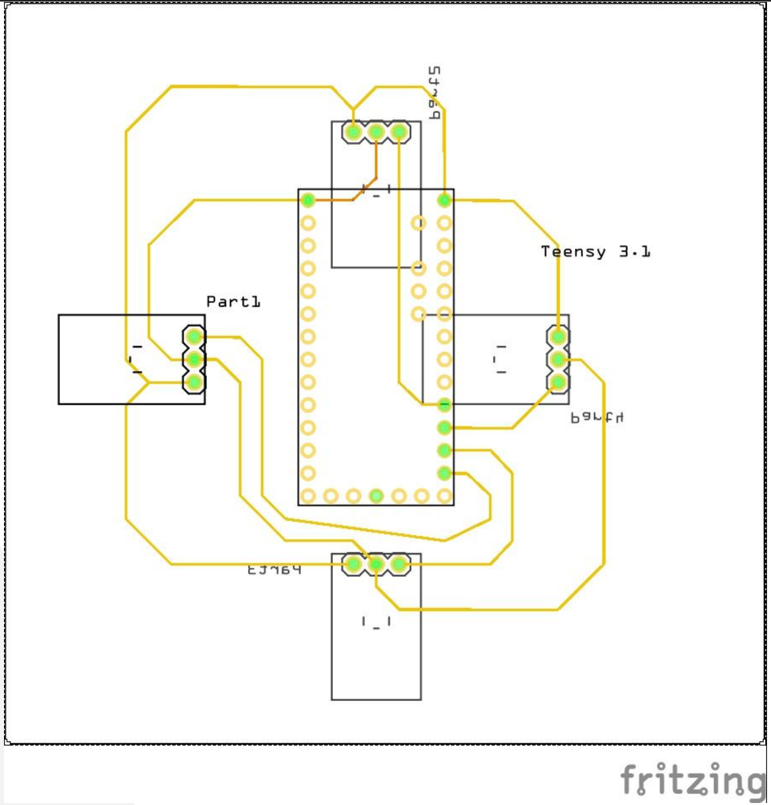
PCB Design



Problems and Solutions

- Problem: Anemometer screen and data acquisition didn’t work
  - Solution: Ordered a new one with working data acquisition software
- Problem: Everyone unfamiliar with the project and direction
  - Solution: Reached out to Andy & Daisy for mentoring
- Problem: Old PCB didn’t work
  - Solution: Checked connections and now it works
- An ultrasonic approach seemed feasible
  - Solution: Work on both approaches in parallel

Final Status & Remaining Problems

Final Status:

- Verified Andy’s results with one microphone implementation
- Conducted tests with four-microphone setup

Remaining Problems:

- Teensy processed data differs from breadboard and arduino data

Future Improvements

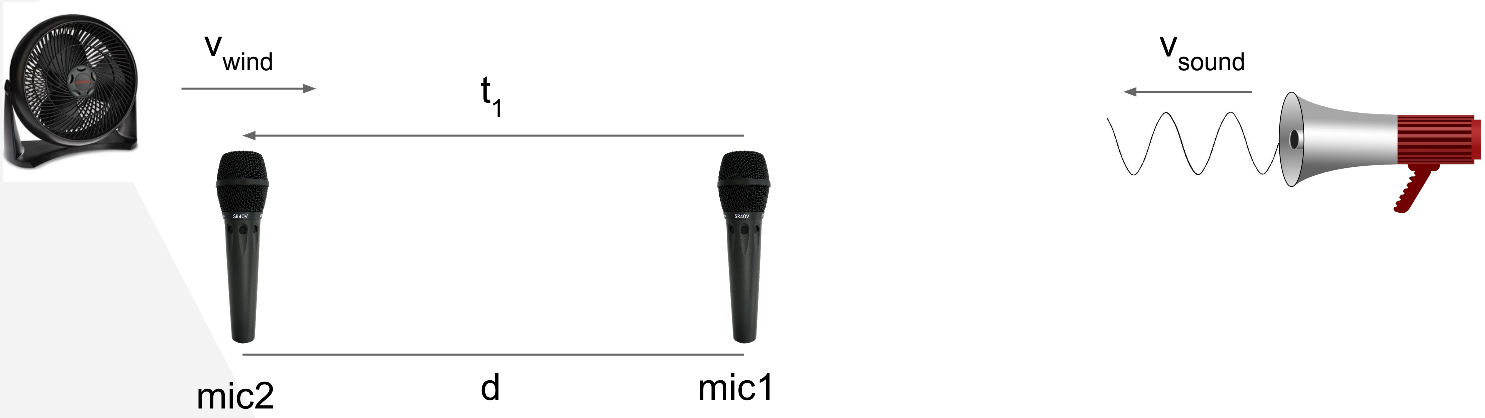
- Use an RMS to DC converter chip in hardware for improved efficiency
- Build housing
- Look more into frequency domain
- Filter random outdoor noise
- Power source
- Wireless transmission of data
- Implement Cortex M4 microprocessor

Ultrasonic Wind Sensor

The Idea

1. With no wind present, propagation time from mic1 to mic2 is t_0 seconds

The Idea



1. With no wind present, propagation time from mic1 to mic2 is t_0 seconds
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The Idea

1. With no wind present, propagation time from mic1 to mic2 is t_0 seconds
2. Wind **blowing against** the propagation of sound will decrease sound wave velocity and **increase propagation time**, $t_1 > t_0$
3. Wind **blowing in the same direction** as the sound wave will increase sound wave velocity and **decrease propagation time**, $t_2 < t_0$

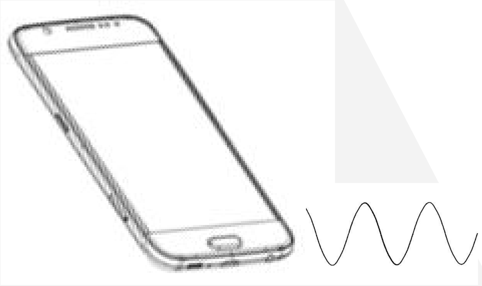
Calculating Timing Resolution Needed

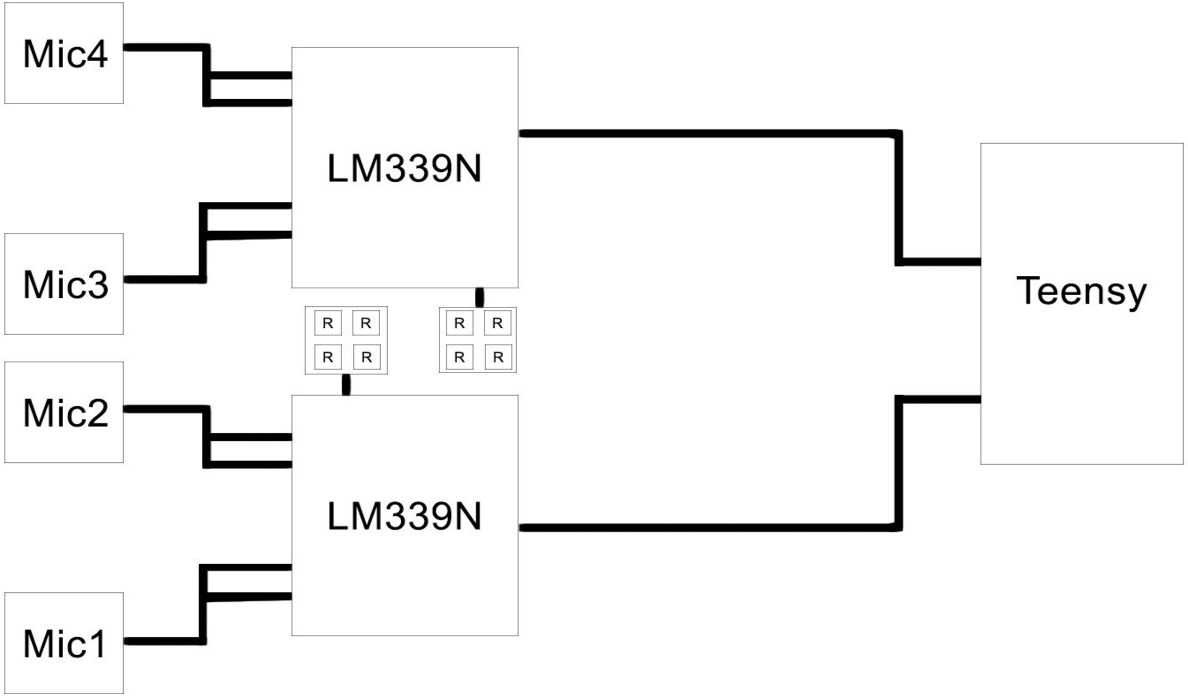
1. With **no wind present**, propagation time is d/v_{sound} = **232.55814 us**
2. With wind **blowing against sound propagation**, time is $d/(v_{sound} - v_{wind})$ = **232.86075 us**
3. With wind **blowing in direction of sound wave**, time is $d/(v_{sound} + v_{wind})$ = **232.256314 us**
4. Thus, **minimum timing resolution** needed is about **0.30261 us**

Main Goal

- To produce an **accurate** and **precise** measurement for the propagation time

Block Diagram

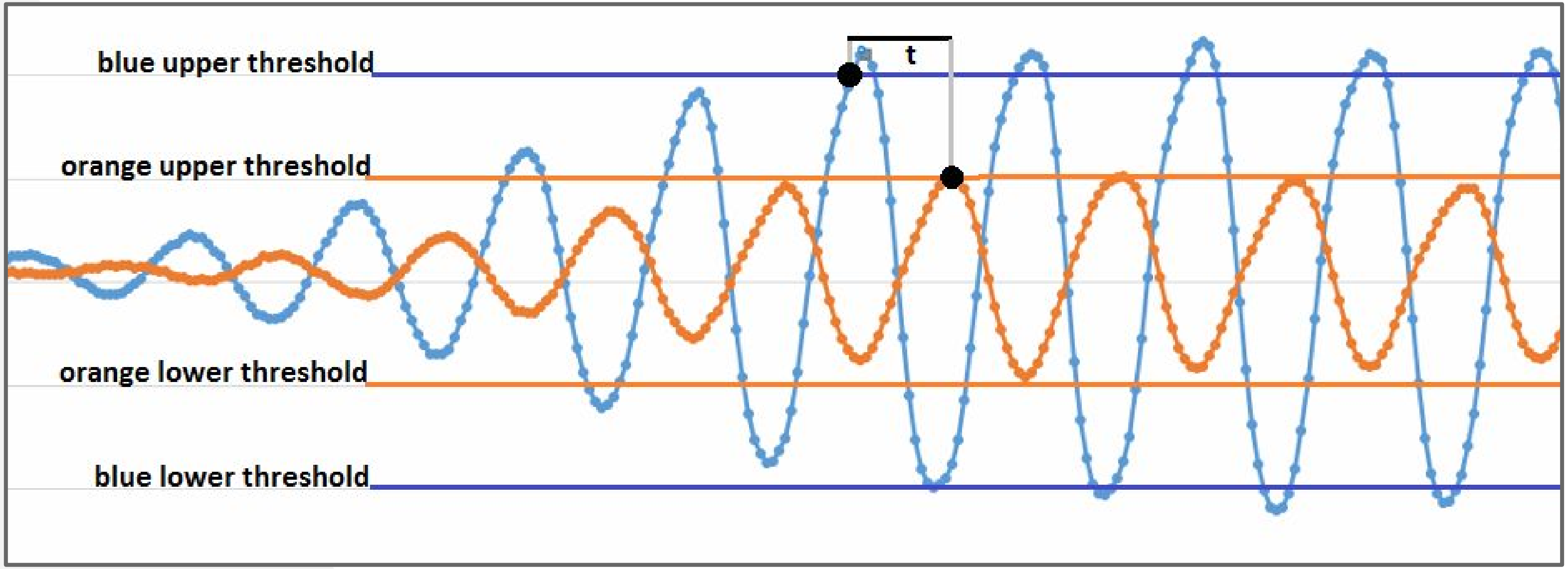




Block diagram for the ultrasonic wind sensor

Current Design Problems

1 kHz signal is too slow



Sample transient response of microphone 1 (blue) and microphone 2 (orange)

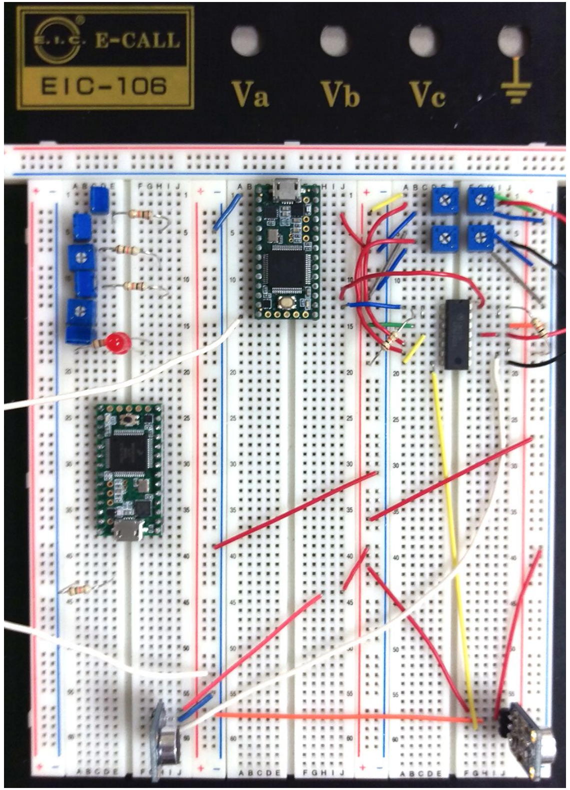
Progress

- Solution to slow frequency signal is to use a faster signal
  - Ordered 40 kHz transducers

- Read up on other designs and their techniques
  - Cross correlation (sample and check)
    - Teensy’s ADC is too slow
  - Thresholding (trigger based on a threshold)
    - Current implementation
  - **Phase shift (difference in transmitted & received signal phases)**
    - Has potential, currently exploring this

Outstanding Tasks

1. Implement measuring phase difference implementation
2. Integrate 40kHz transducers once they arrive
3. Integrate a hardware filter to filter out all other frequencies (for outdoor use)
4. Work on using multiple sensors to measure wind direction
5. Transfer our design to a PCB



The end.

Any questions?

Backup Slides

Undefined Zone