



UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

Smart Bruxism Treatment Device

ECE 445 Presentation

Team 6

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Outline

Introduction

Subsystems

Challenges

Successes

Failures

Future Work

Conclusion



Introduction

Bruxism

- Commonly known as "tooth grinding"
- Affects up to 20% of adults and children [1]
- Causes other problems (chipped teeth, headaches, & more) [1]

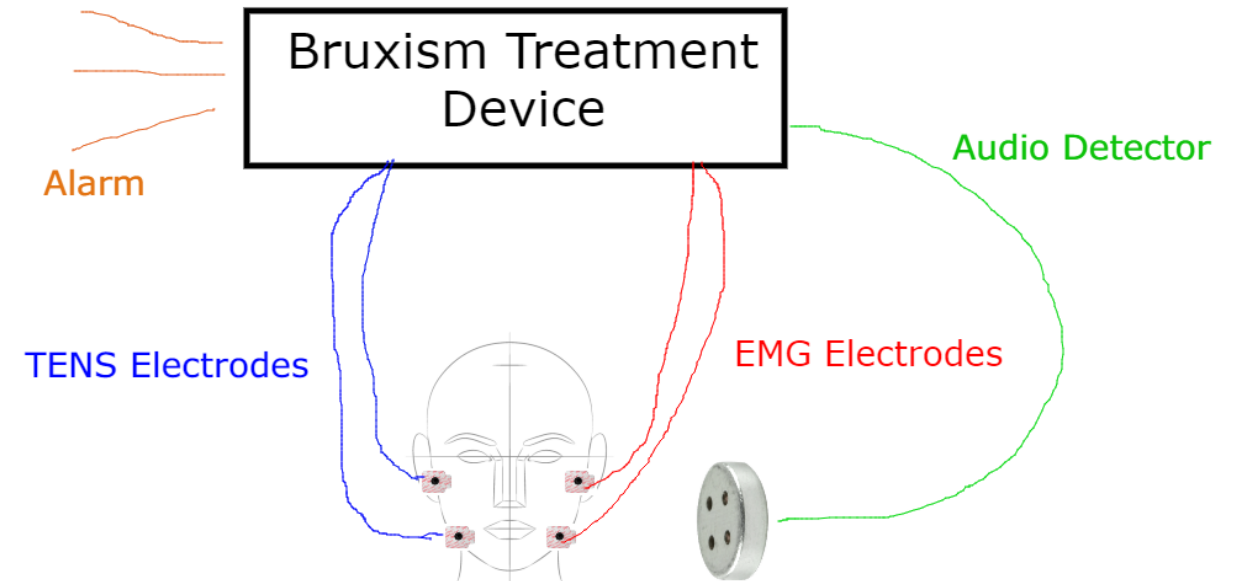


Mechanisms of bruxism [2]

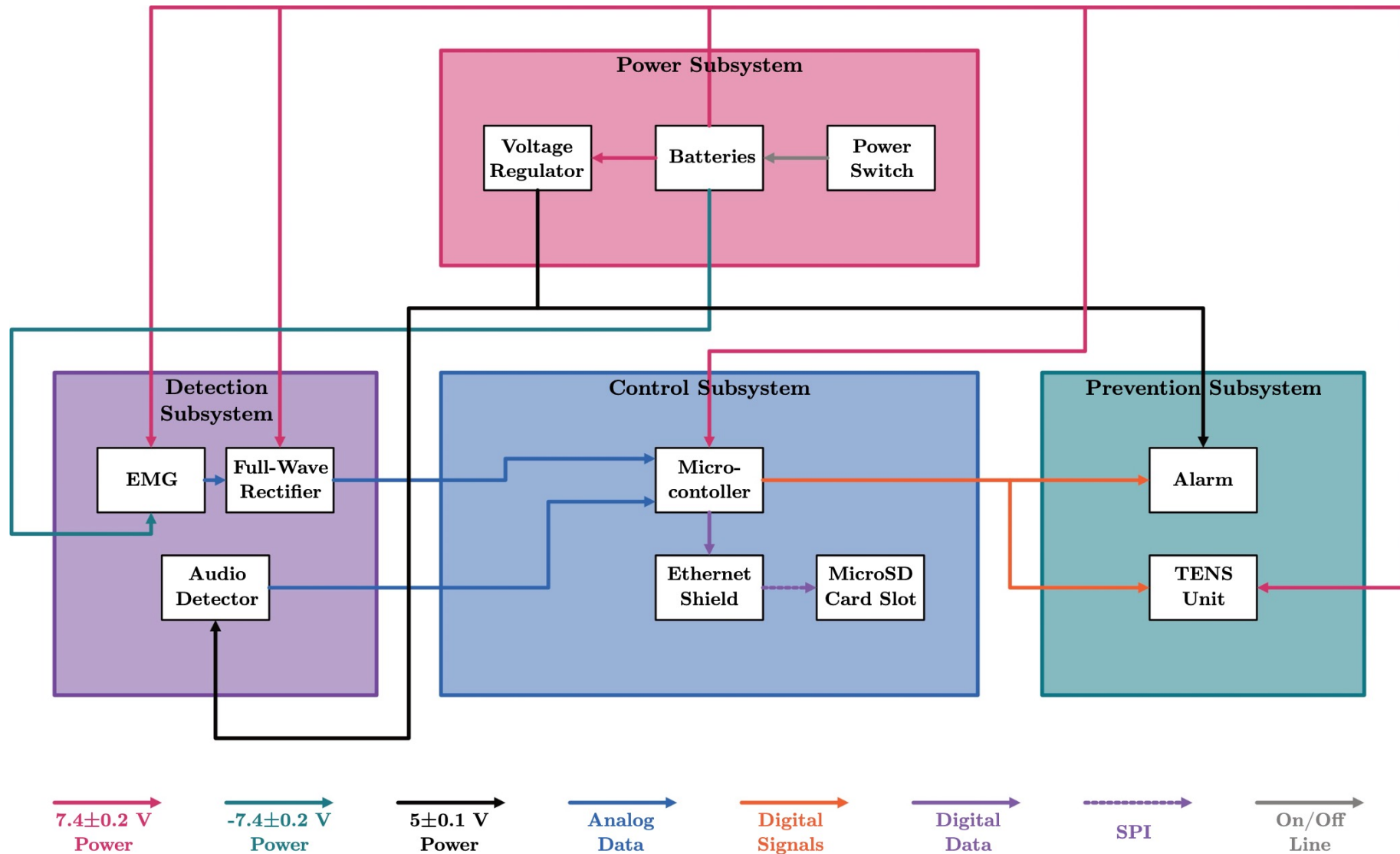


Proposed Solution

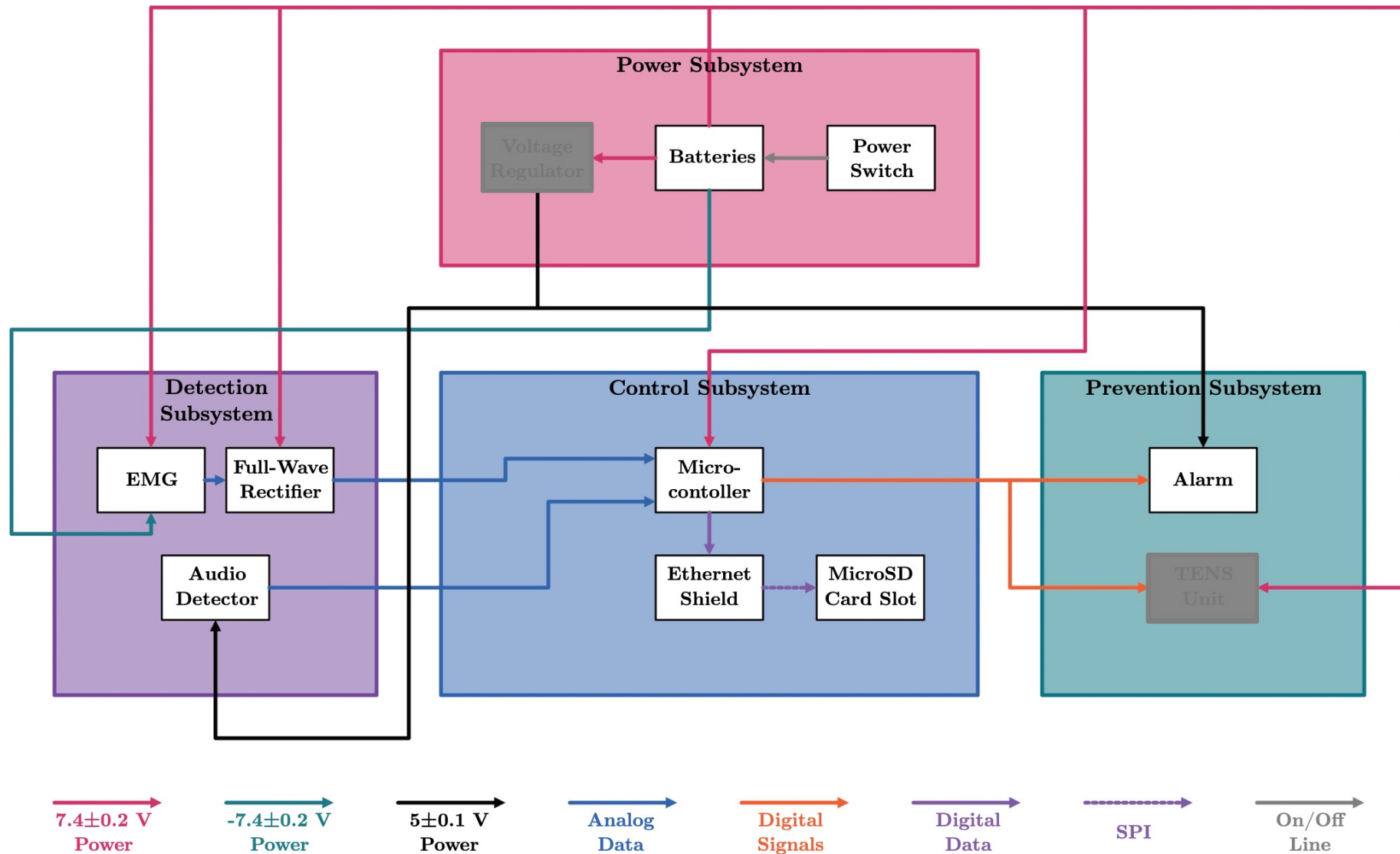
- Many current treatments aim to treat symptoms, not the causes
- Electric stimulation of the muscle
- Smart device that handles detection, data collection, and treatment administration



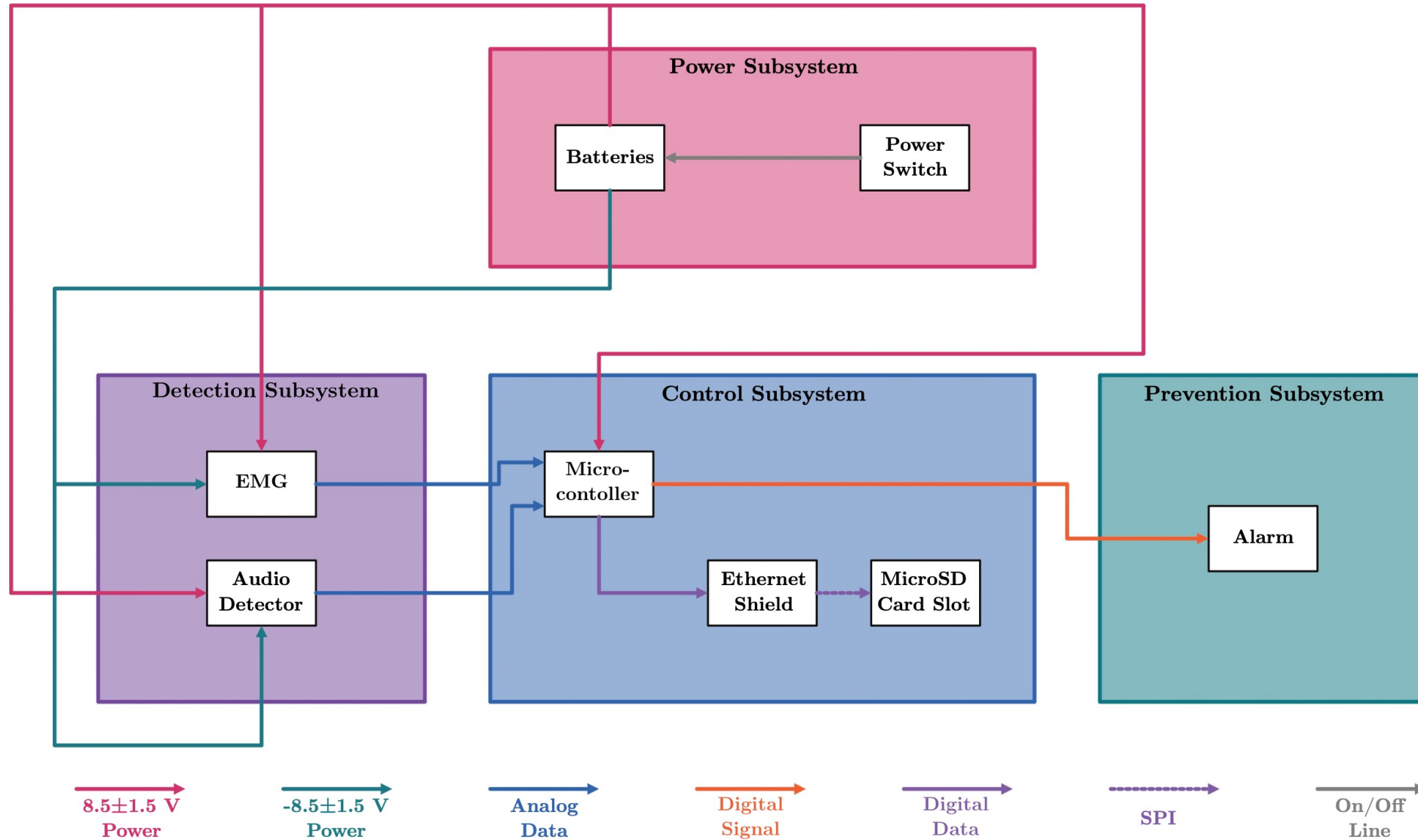
Original Block Diagram



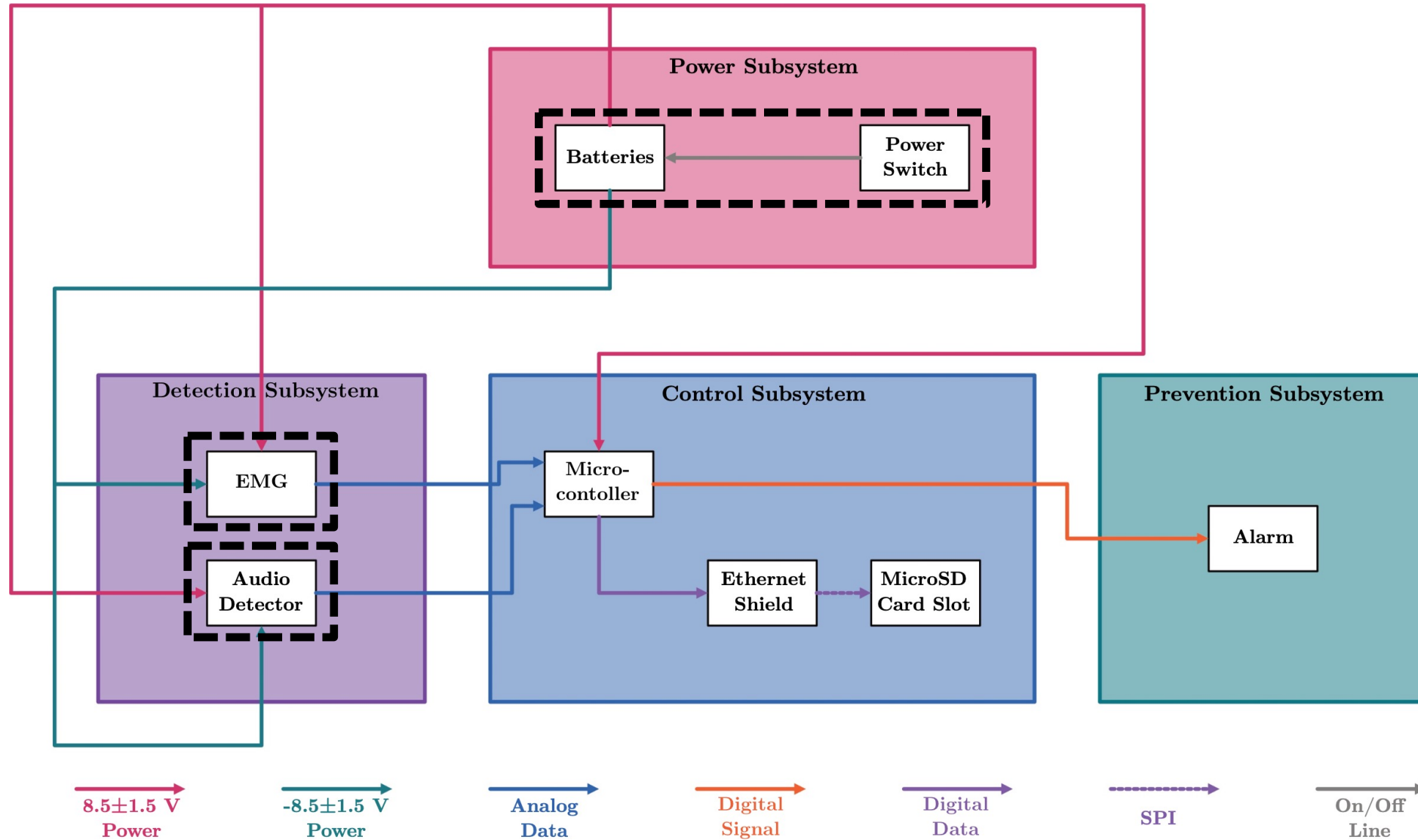
Original Block Diagram



Final Block Diagram



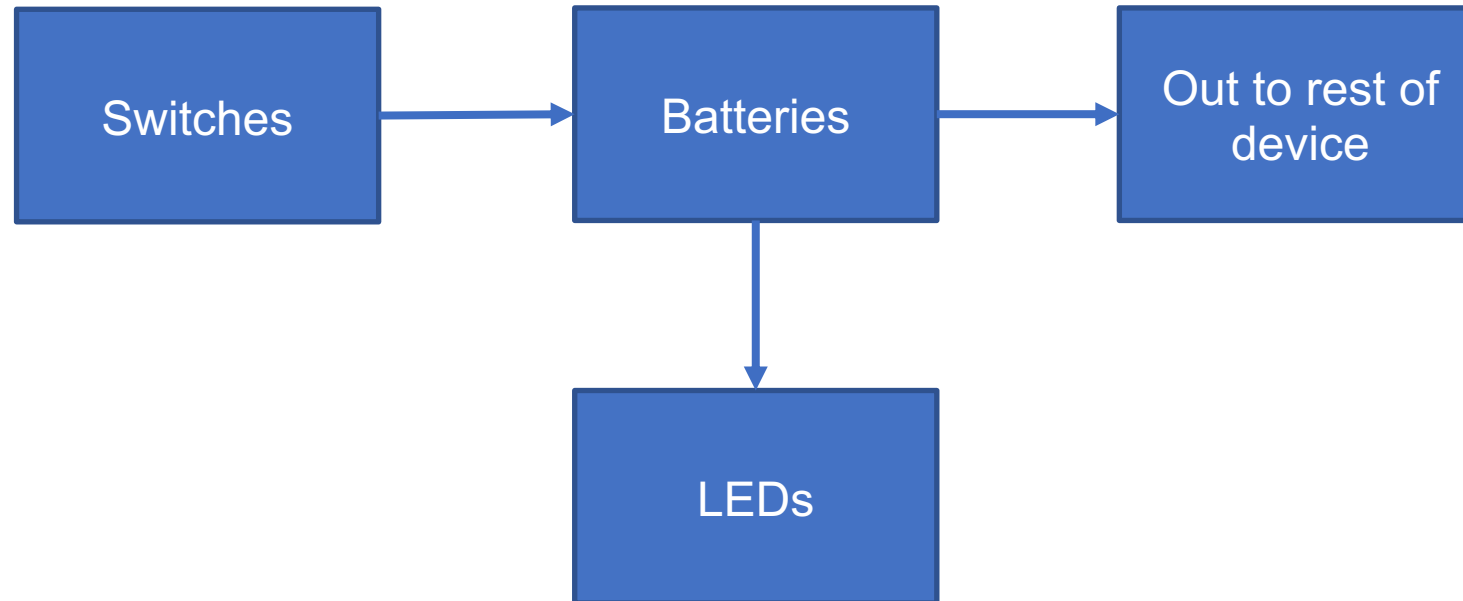
Final Block Diagram



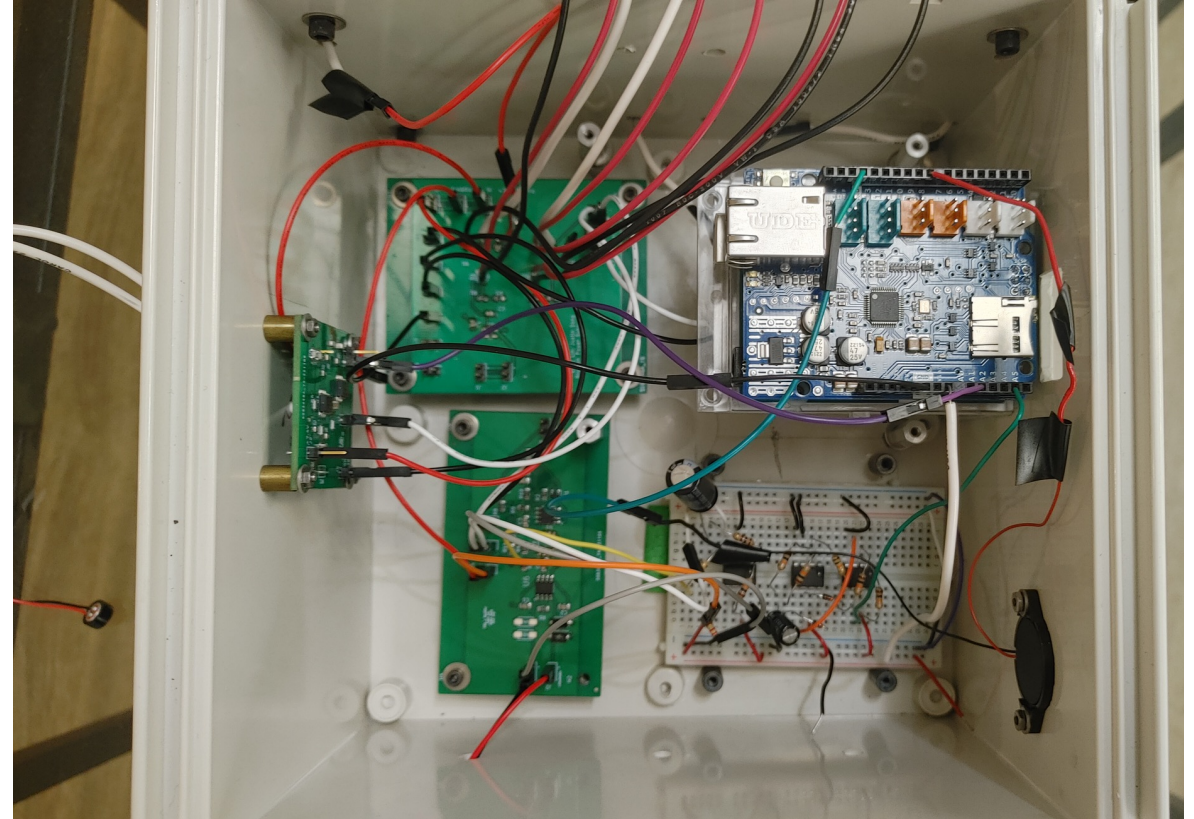


Power Subsystem

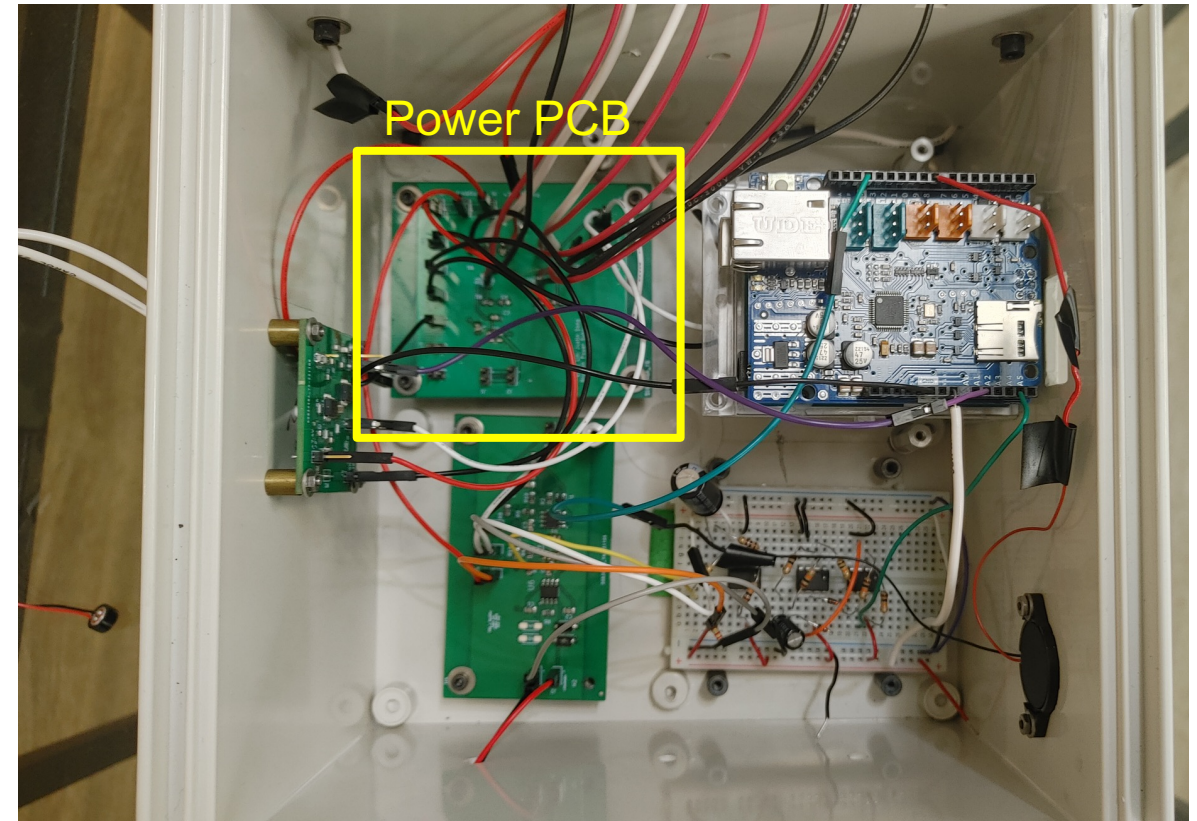
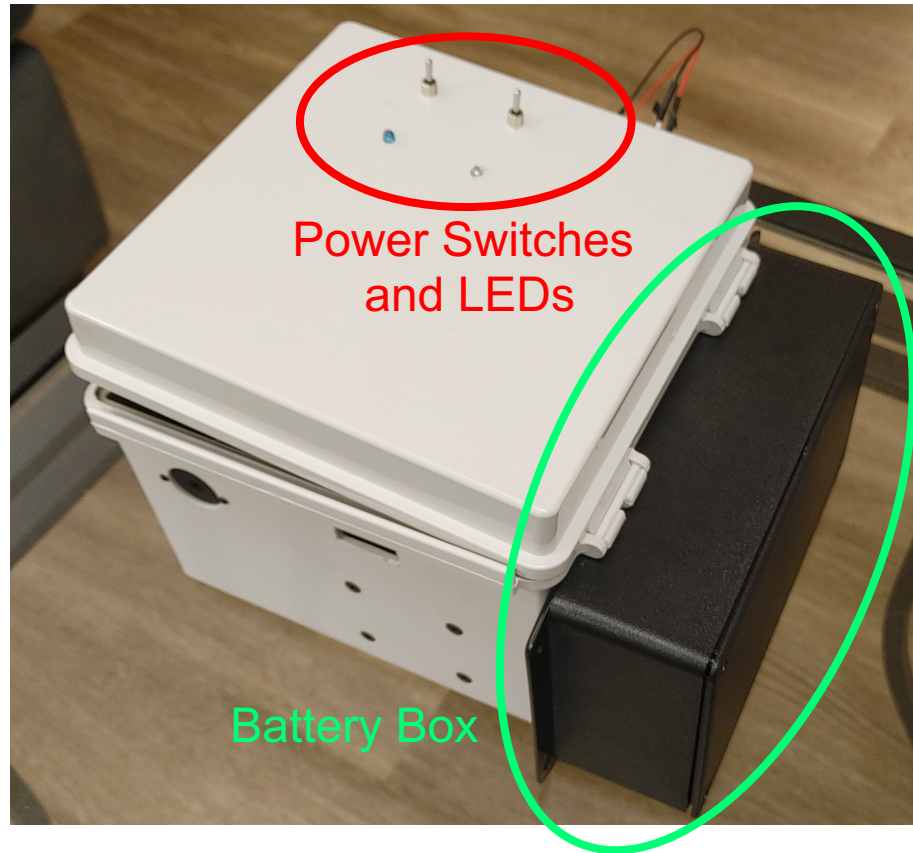
Focused Block Diagram



Implementation



Implementation





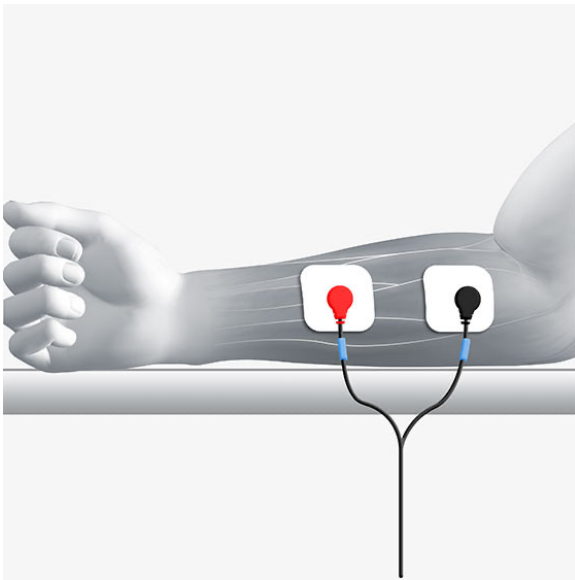
Detection Subsystem



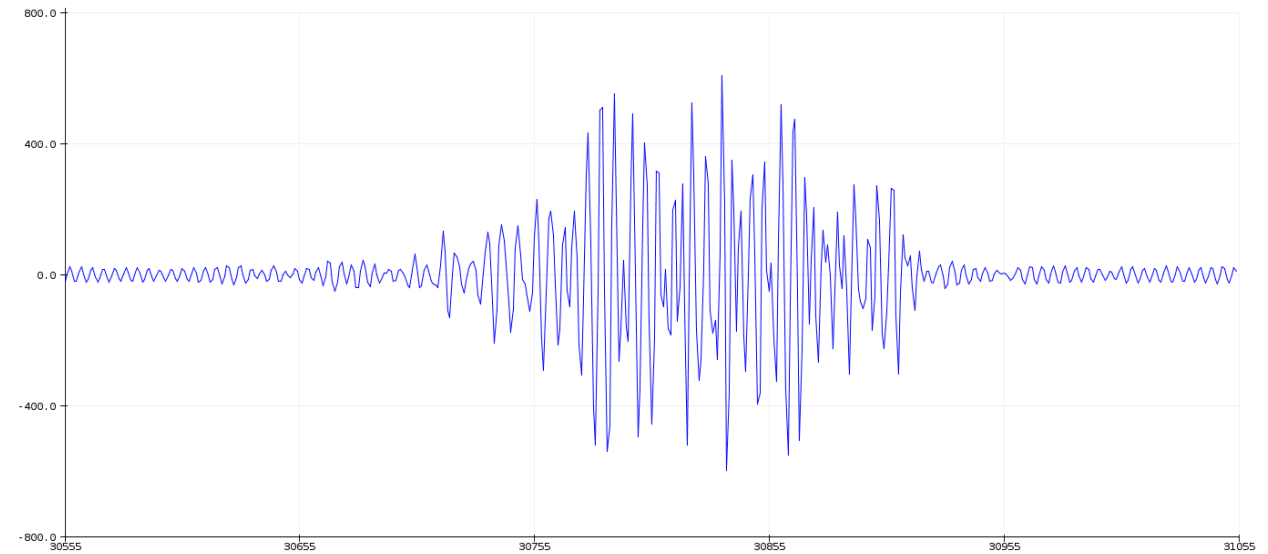
EMG

Overview

- **Electromyography**
- Detects electrical activity within muscles

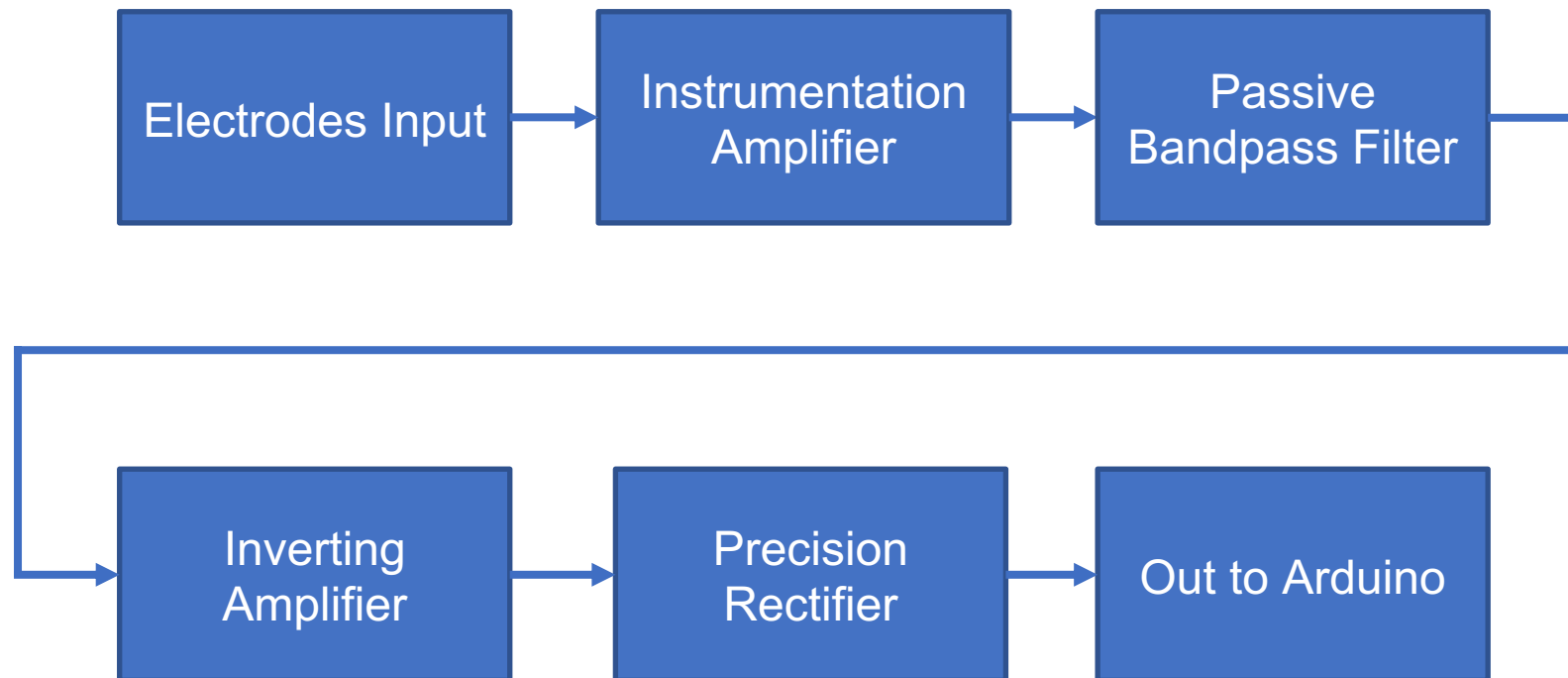


[9] EMG electrodes example

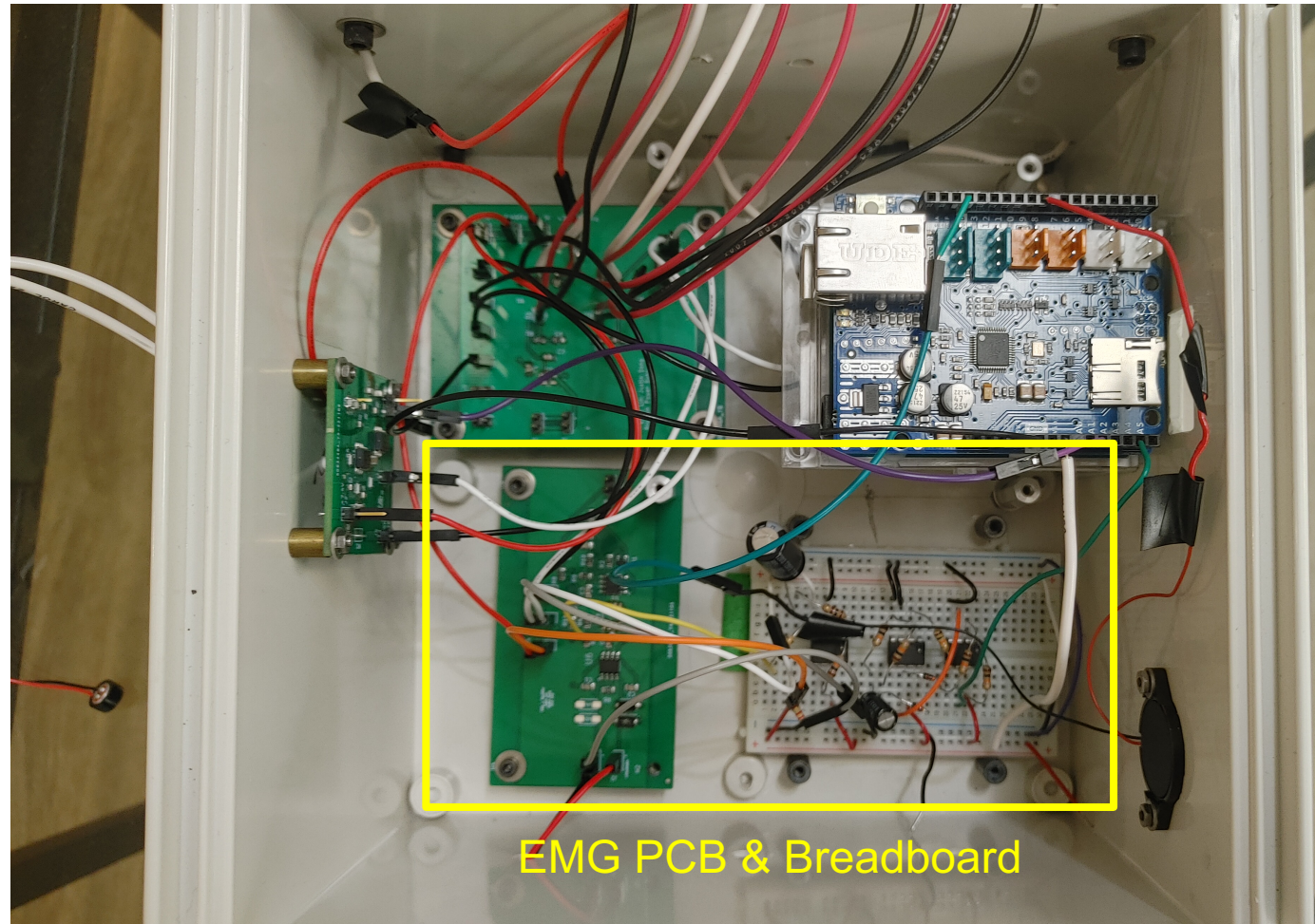


[8] EMG signal example

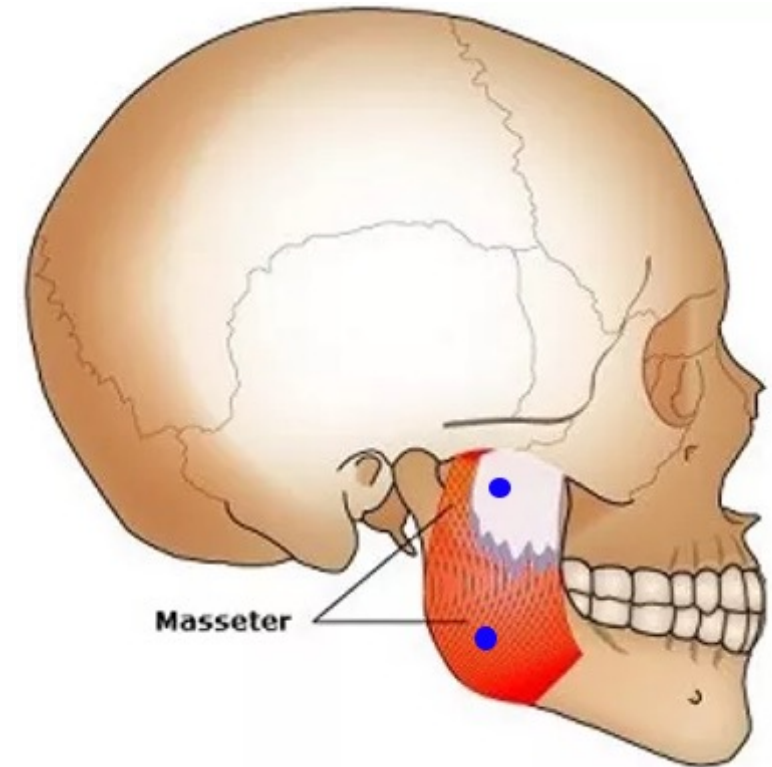
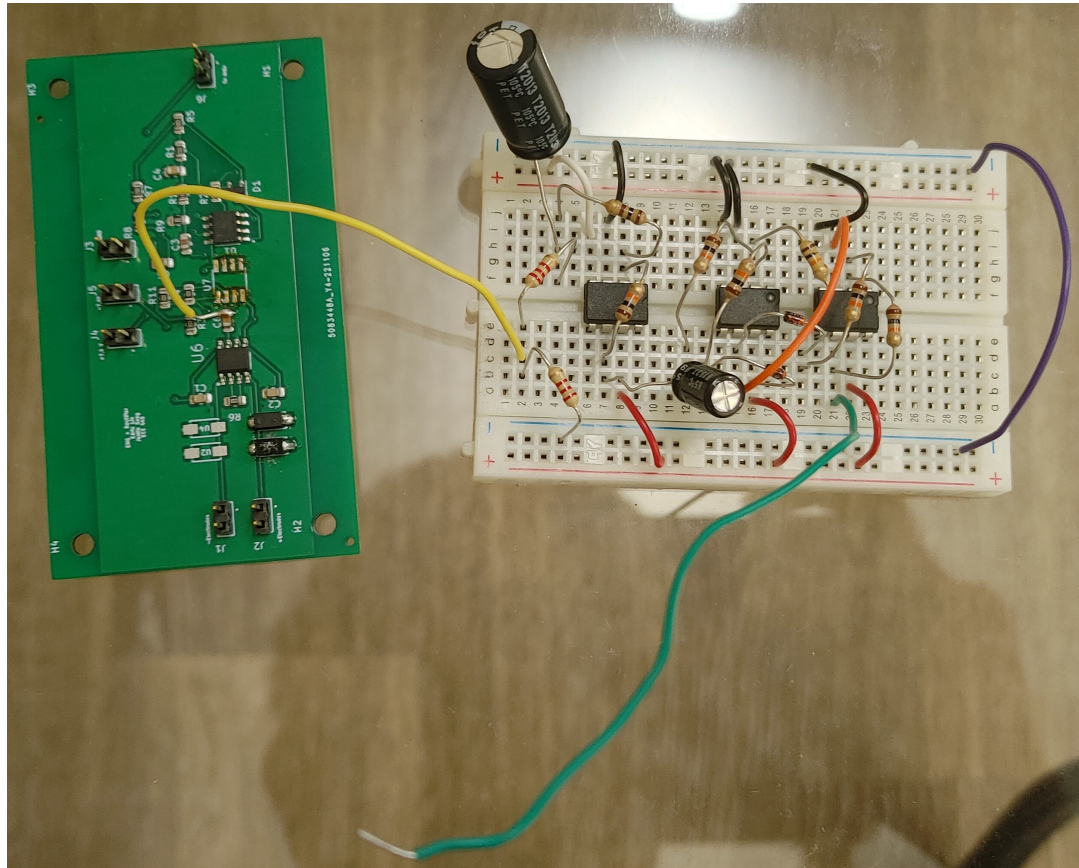
Focused Block Diagram



Implementation



Implementation

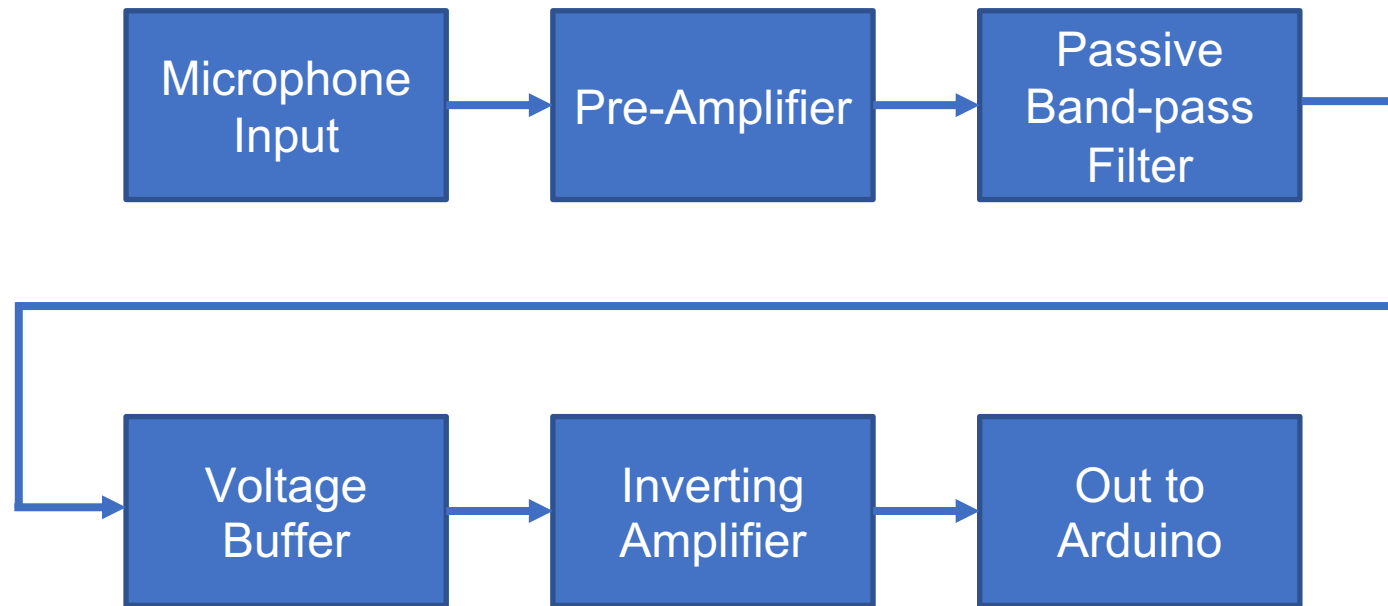


Targeted muscle and electrode placement [4]

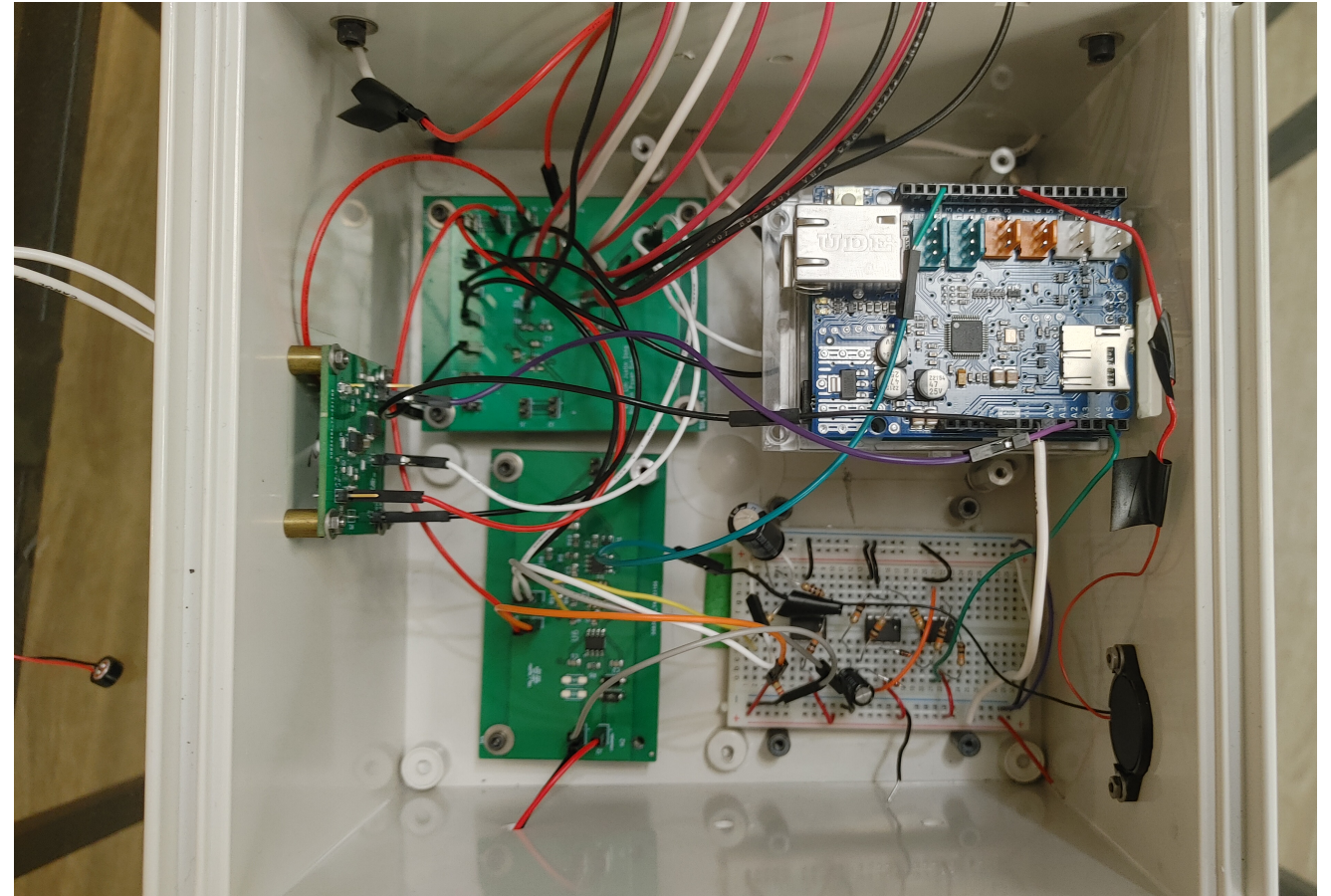
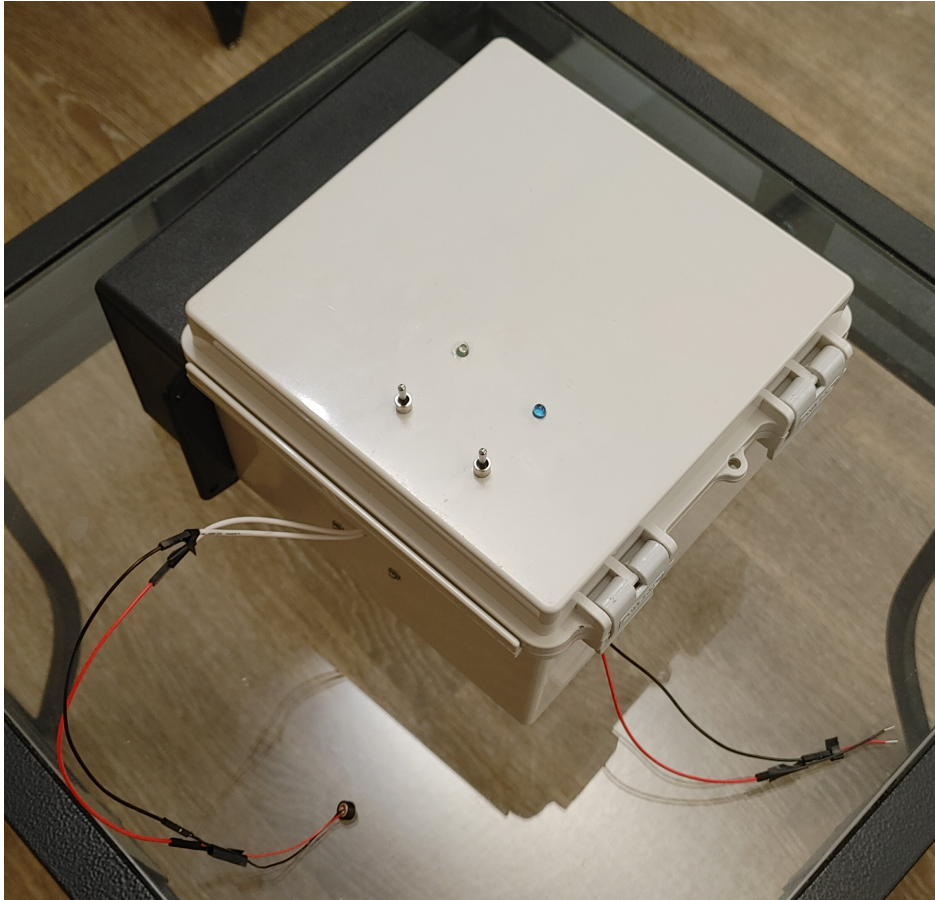


Audio Detector

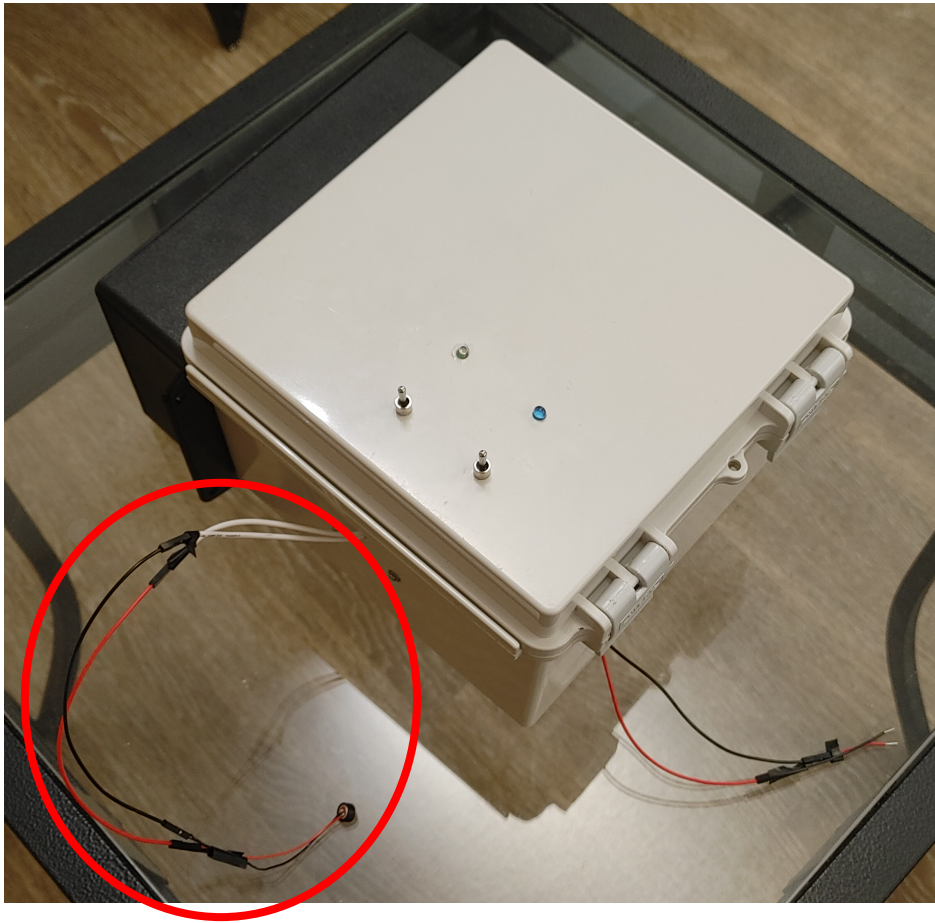
Focused Block Diagram



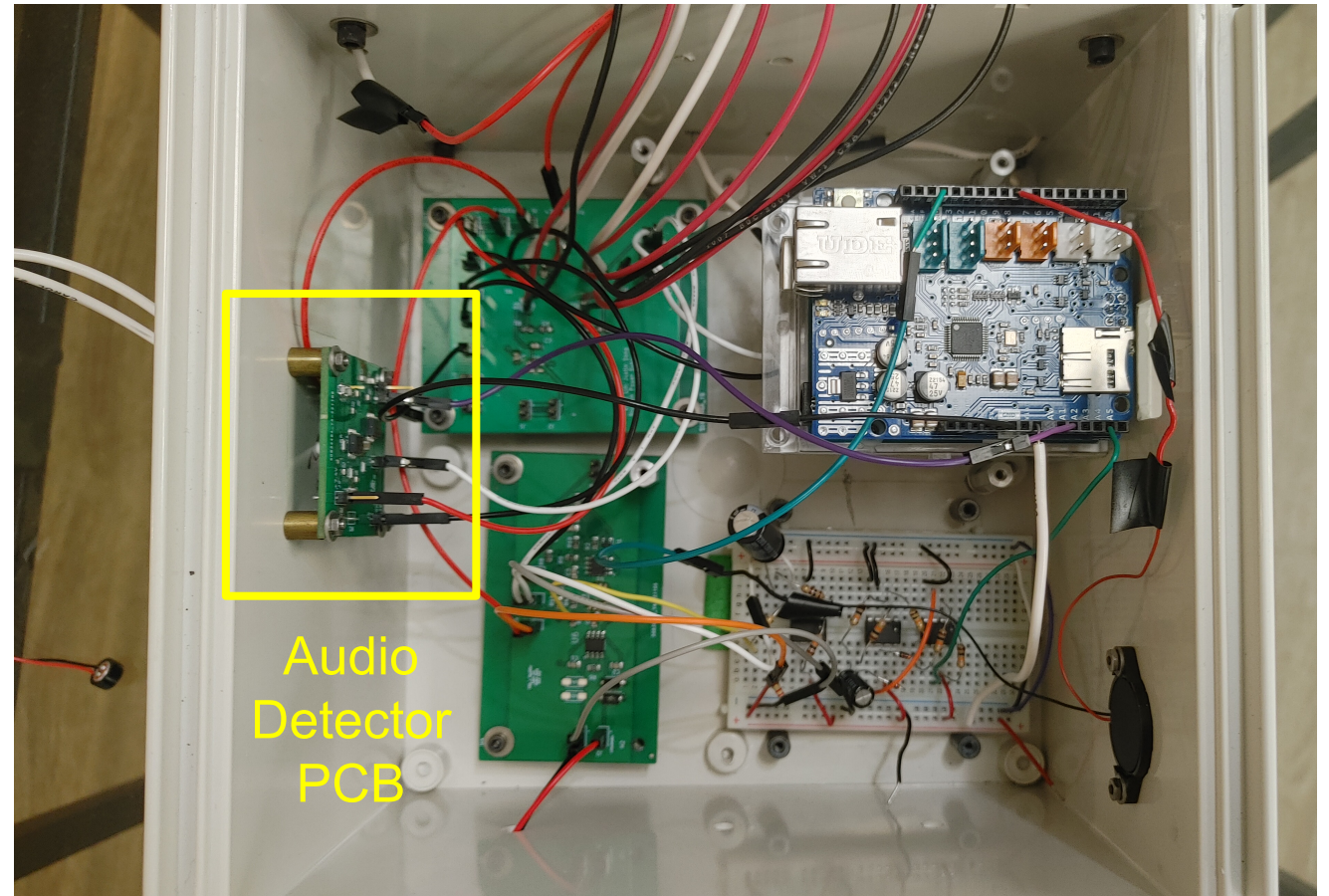
Implementation



Implementation



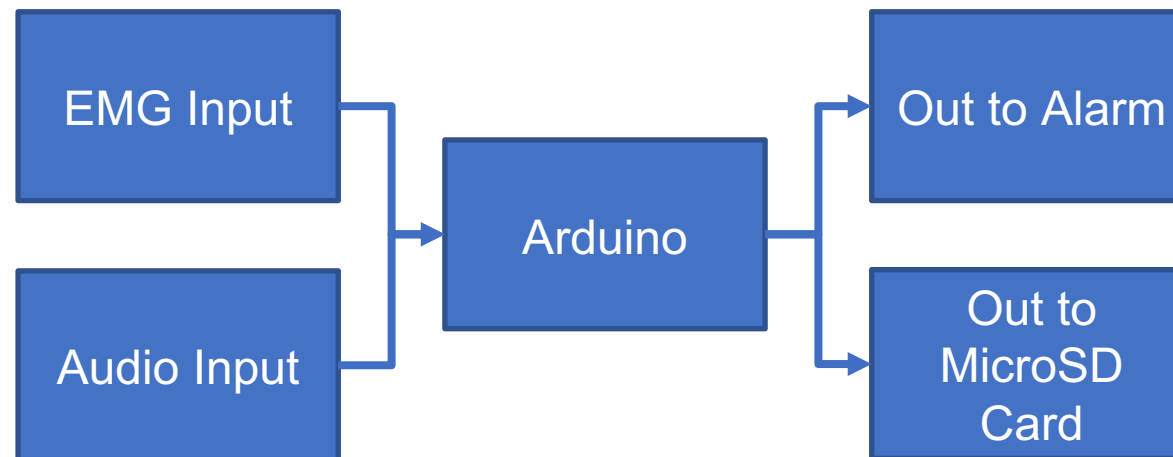
Microphone

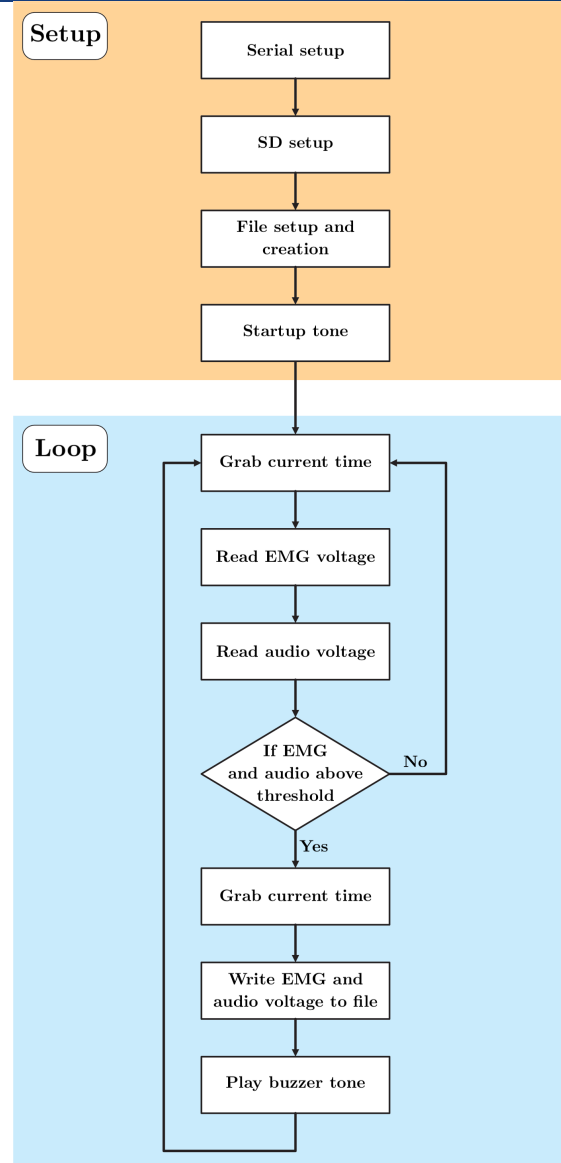


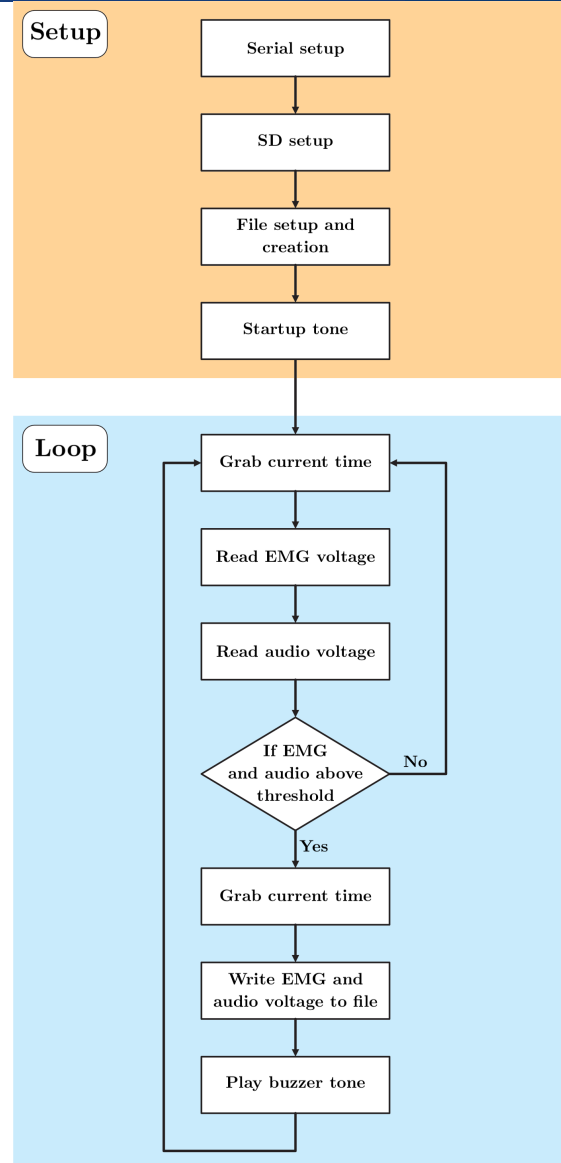


Control Subsystem

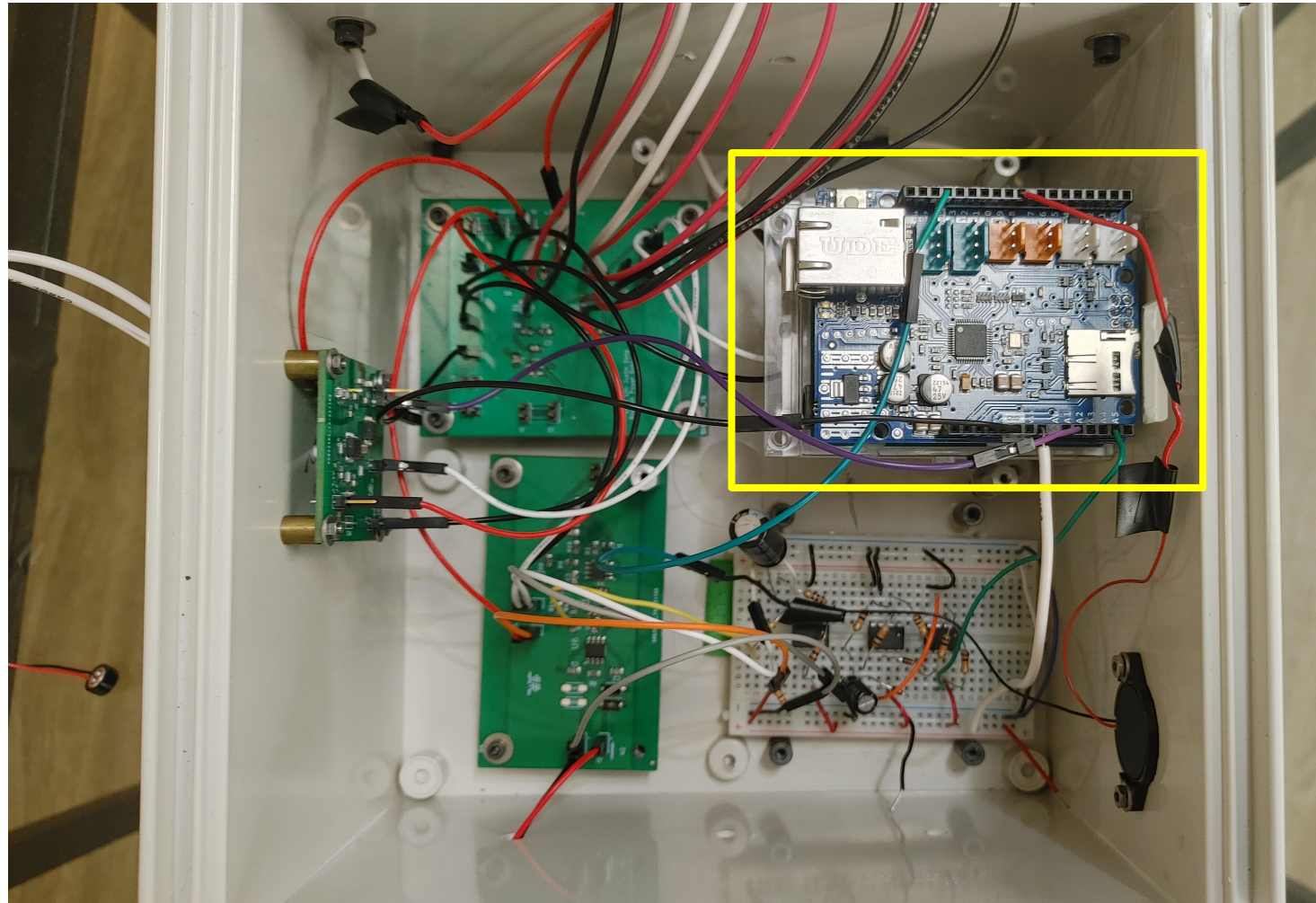
Focused Block Diagram







Implementation





Prevention Subsystem

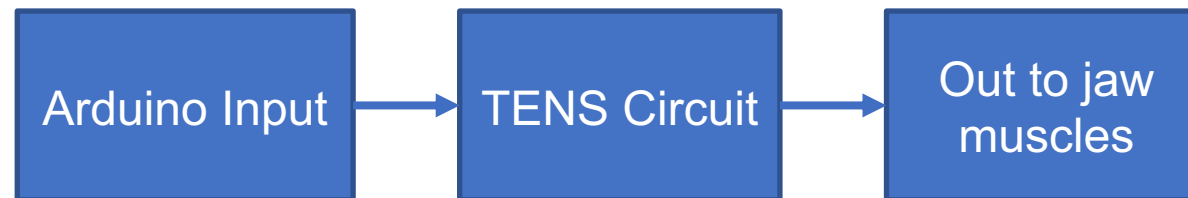


TENS Unit

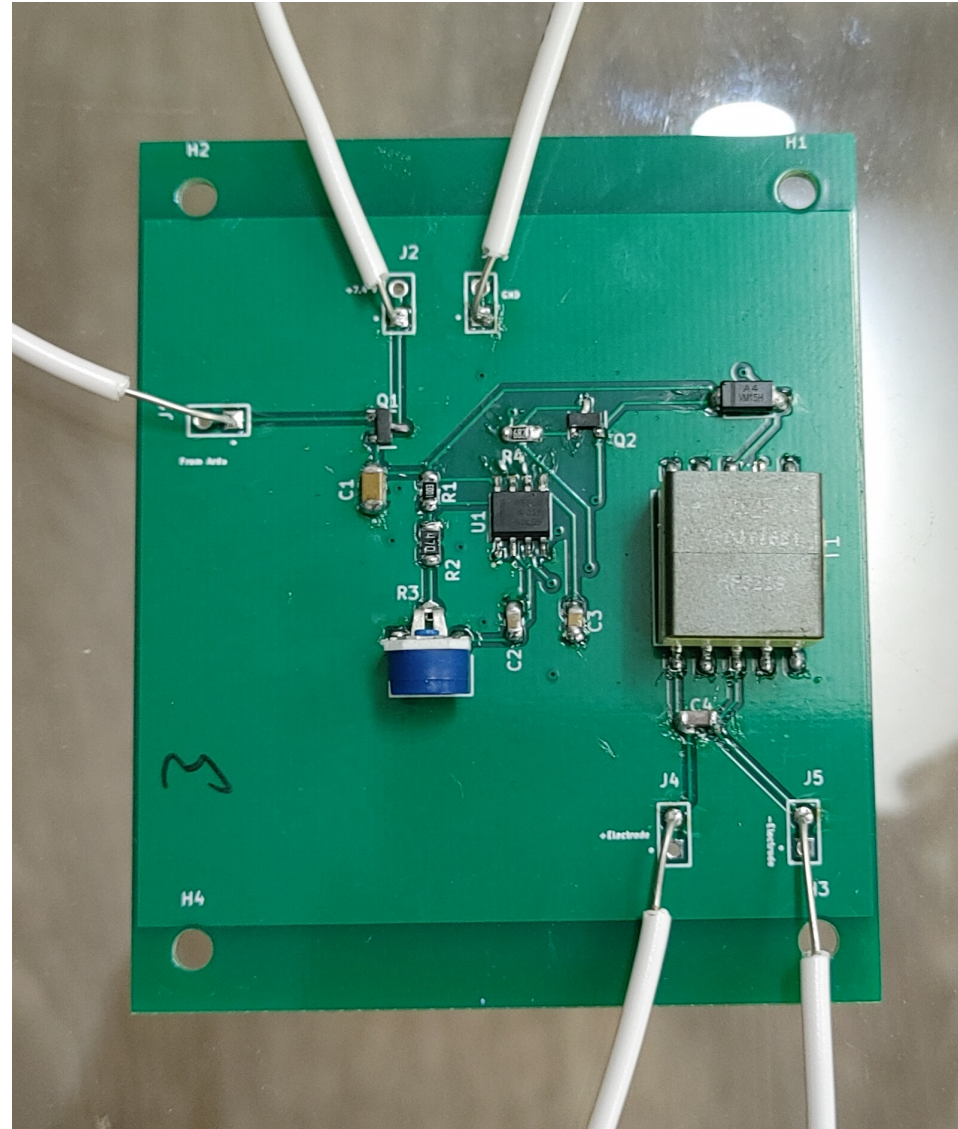
TENS Unit [6], [7]

- Transcutaneous Electrical Nerve Stimulation
- Designed for pain relief and muscle stimulation/relaxation using electrical impulses
- Deployed through electrodes
- Widely regarded to be safe
 - Several devices on the market have FDA approval

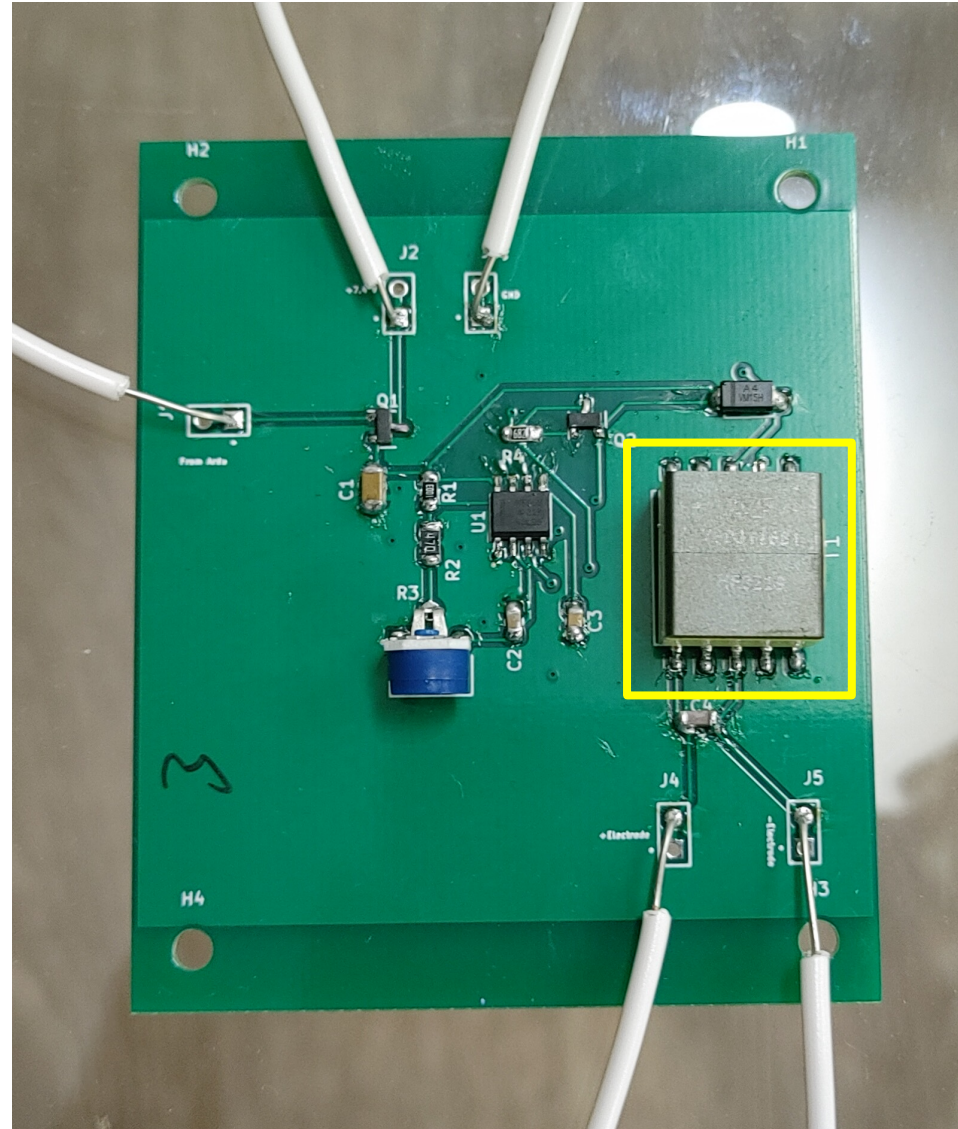
Focused Block Diagram



Implementation



Implementation

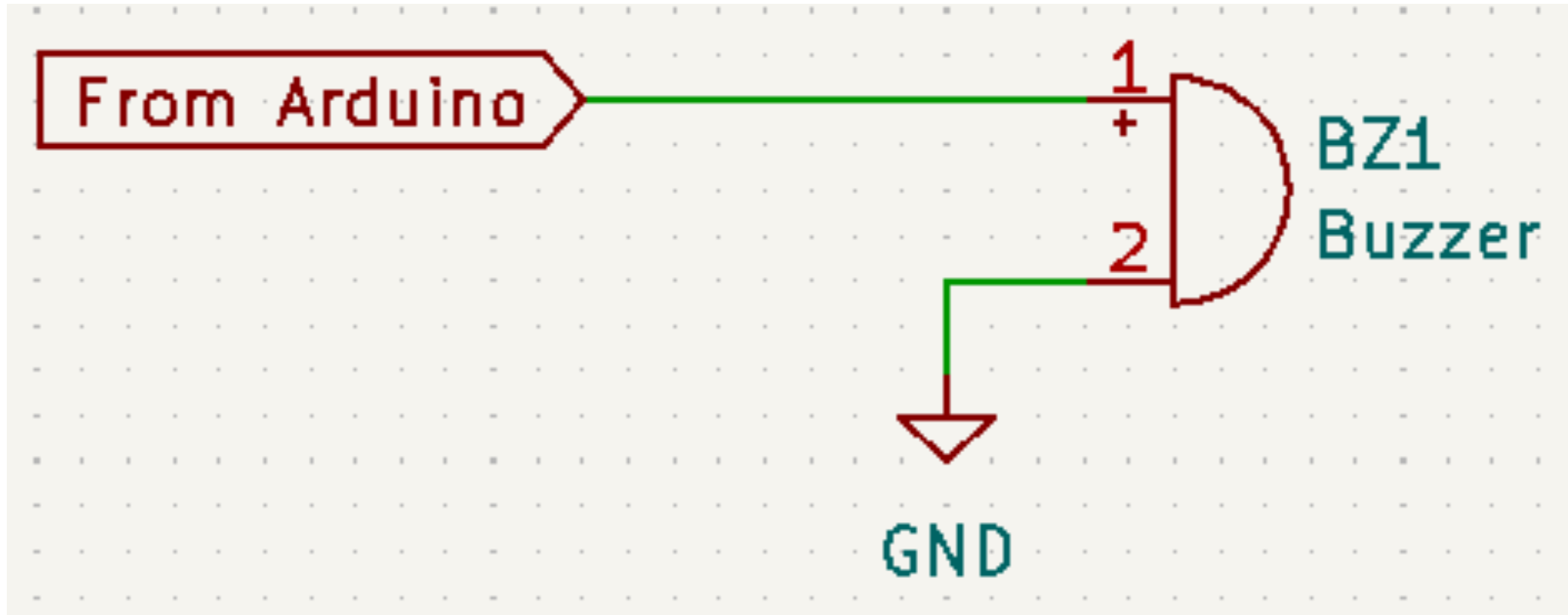


Risk Mitigations

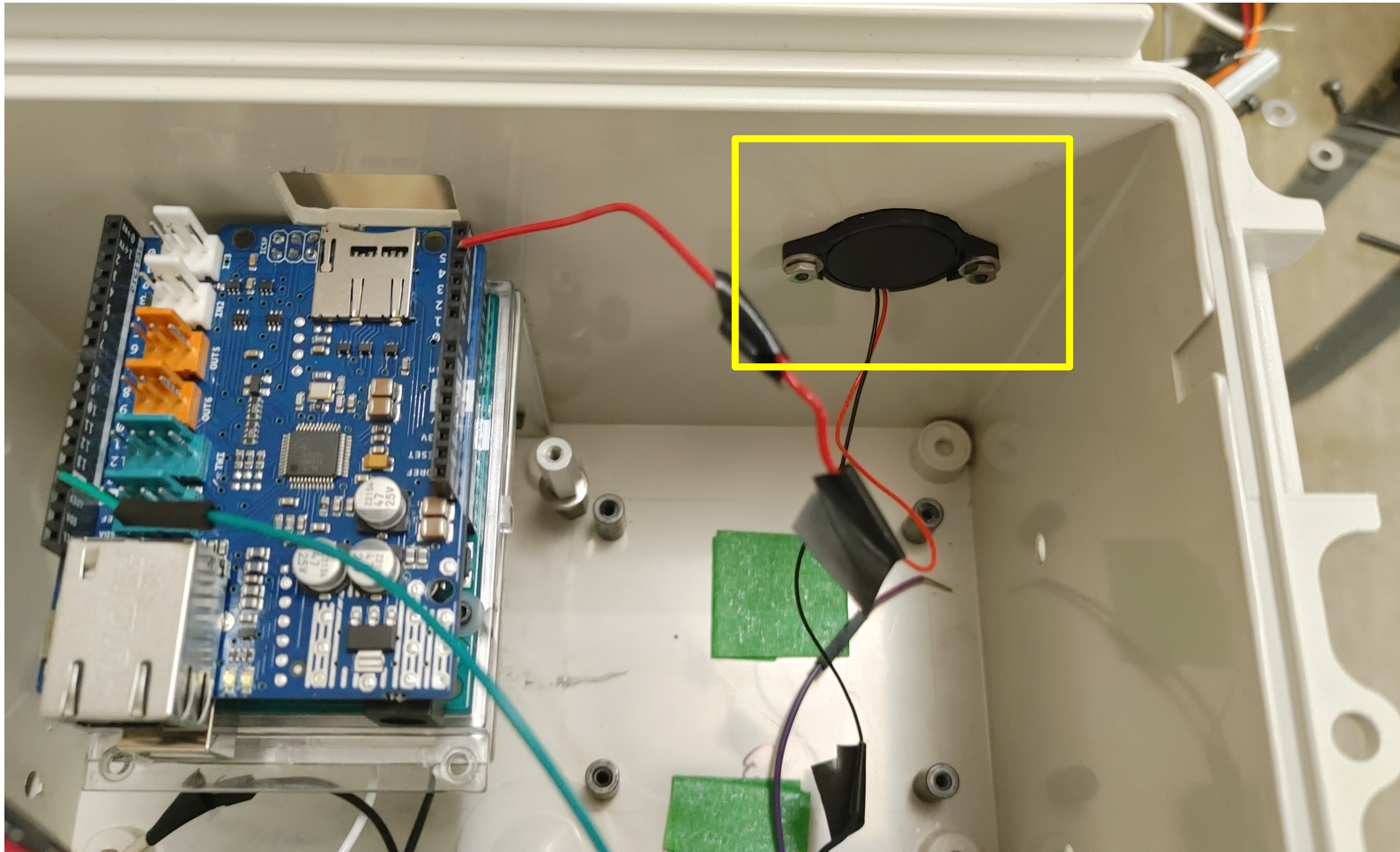
- All human testing with the TENS would have been conducted on ourselves
- Any data collected would not be shared without consent
 - No WiFi Design



Buzzer



Implementation





Challenges



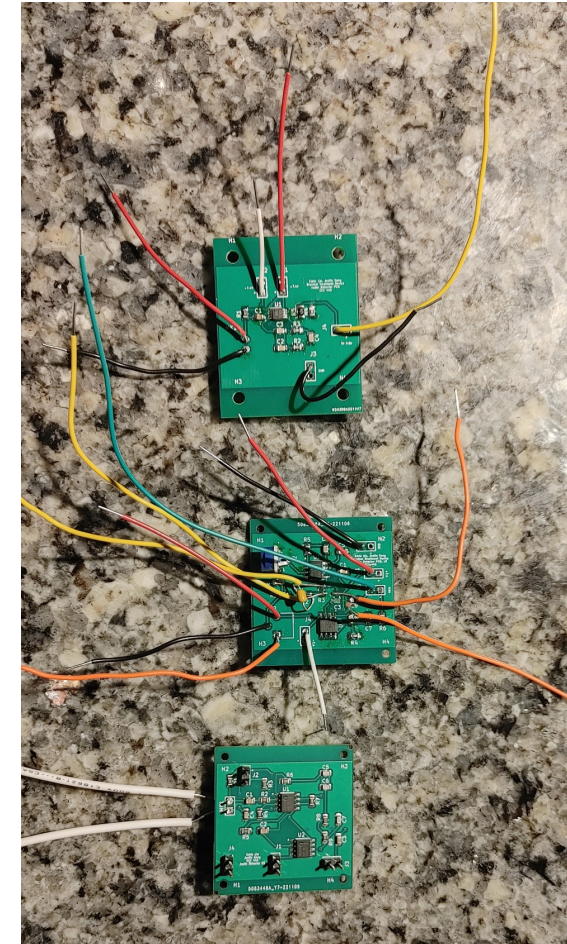
Audio Detector

Development Issues

- Initial design failed
- Second design was space costly
 - Physical dimensions of container already determined
- Third design mostly worked as intended

Passive Bandpass filter

- Spectrum analyzer had pass range 1 kHz – 2 kHz
 - Frequency range of crunchy sounds (according to research)
- Empirical testing had pass range 1 kHz – 3.5 kHz
 - Settled for this range in the end



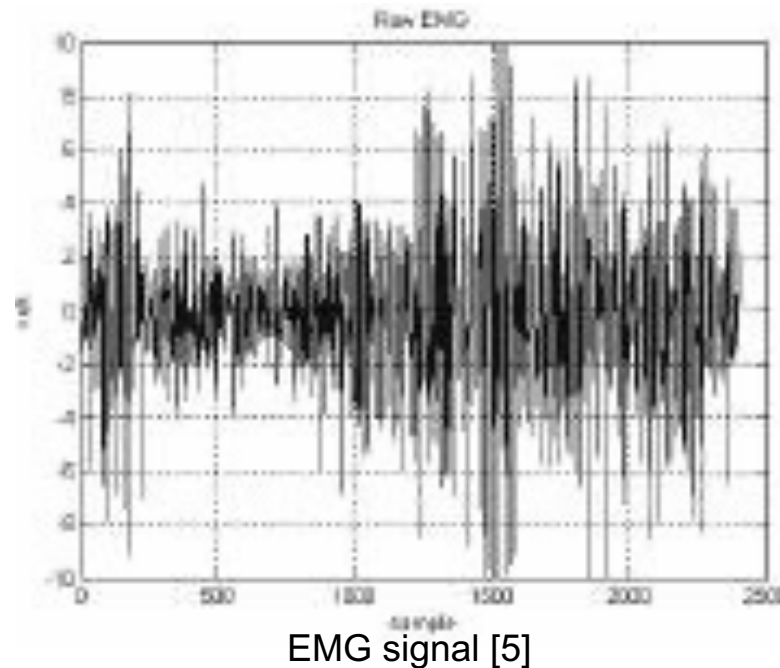
Obsolete Audio
Detector PCBs



EMG

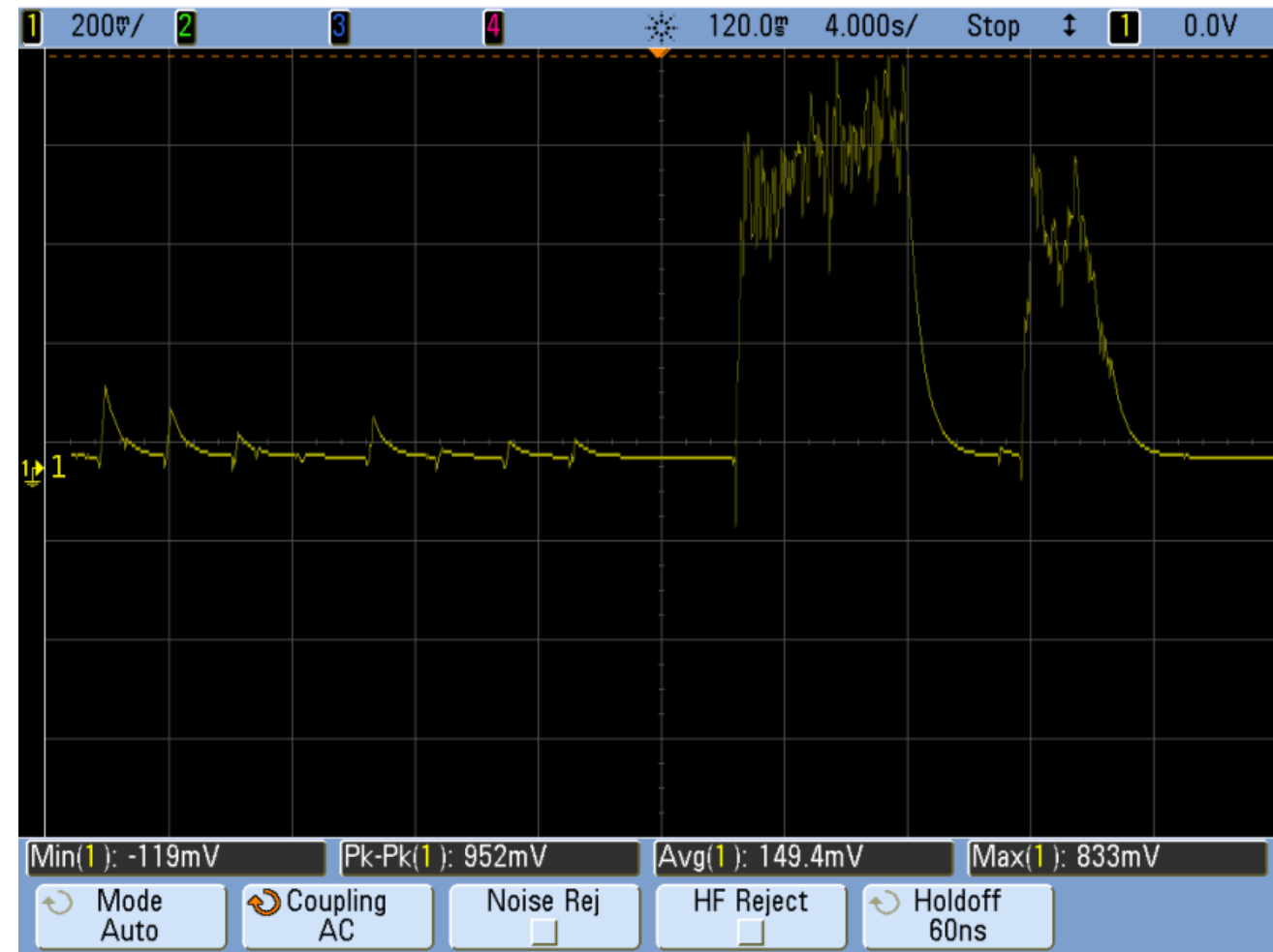
Development Issues

- Peak voltage from jaw muscles unknown
 - Research said that EMG signals are within 5-15 mV range
- Shape of voltage signal from jaw muscles unknown
 - Research said that it would be very noisy



Development Issues

- Empirical testing suggested very different EMG signal characteristics
 - Magnitude of signal: 0.1 – 10 μV
 - Looked closer to a step function



Raw EMG signal amplified by 1,000,000

Development Issues

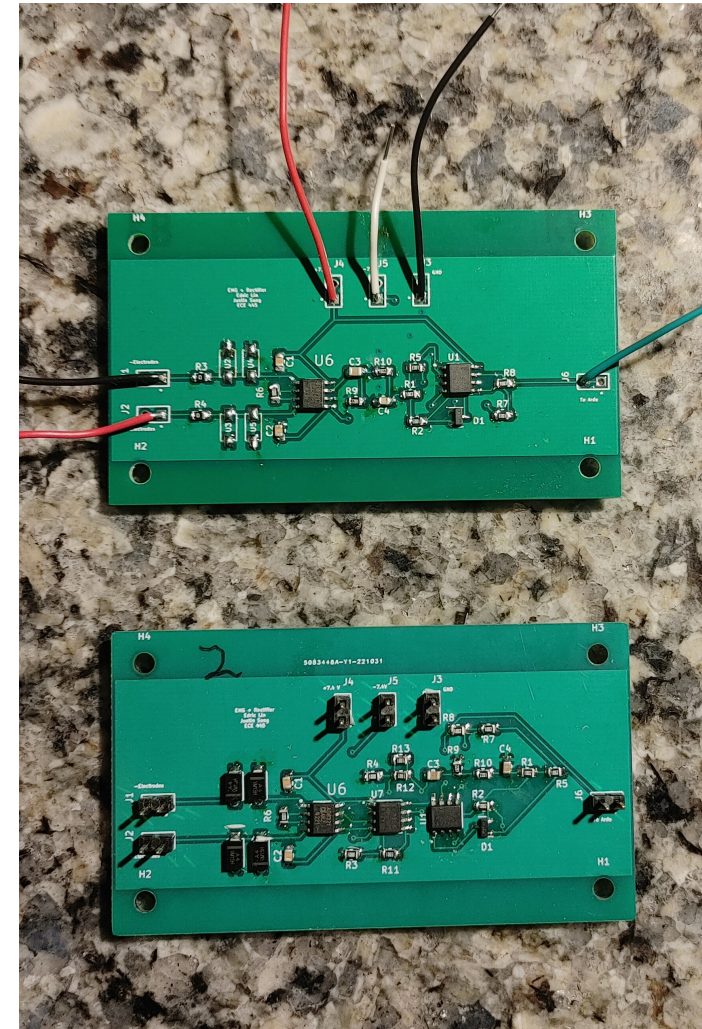
- Empirical testing suggested very different EMG signal characteristics
 - Magnitude of signal: 0.1 – 10 μV
 - Looked closer to a step function



Raw EMG signal amplified by 1,000,000

Development Issues

- Initial design failed
 - Not enough gain (~ 495)
- Second design failed
 - Needed capacitors to block DC outputs of Op Amps
- Third design failed
 - Non-inverting amplifiers vs. Inverting amplifiers
- Fourth design worked
 - Improvised PCB/Breadboard hybrid



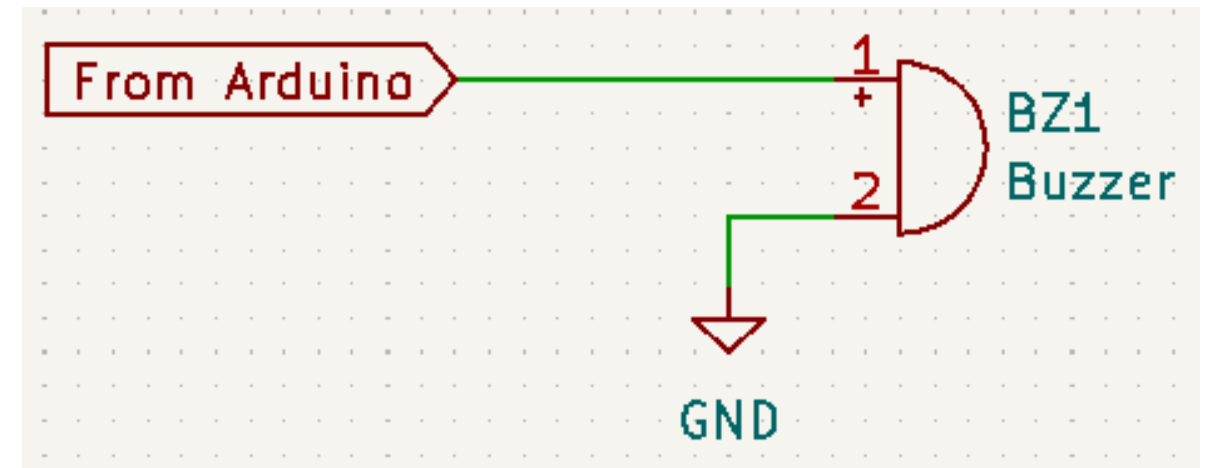
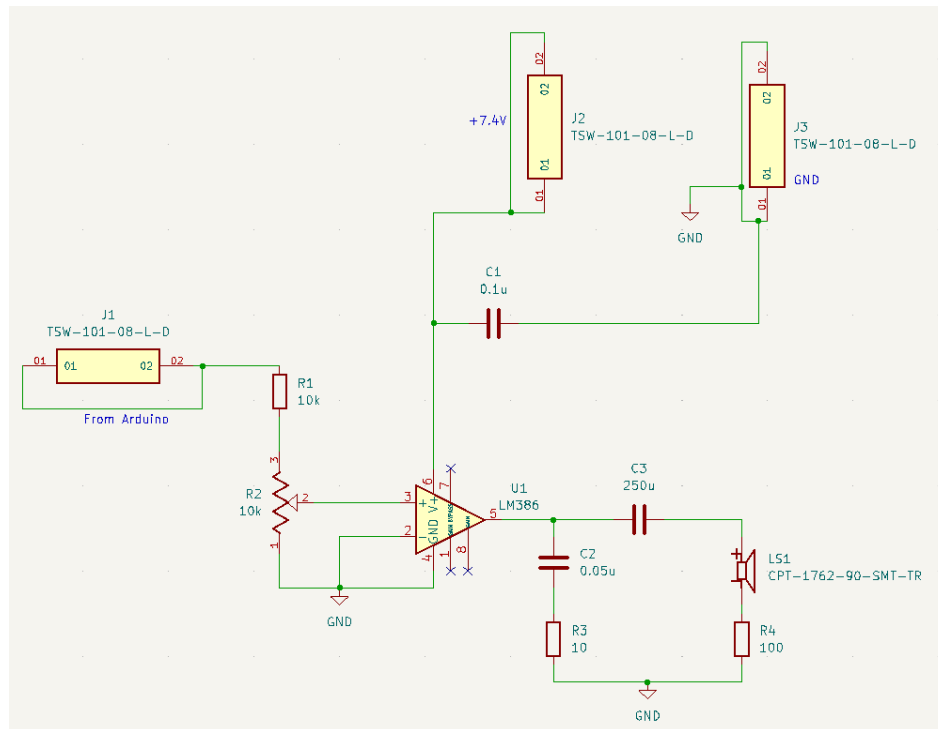
Obsolete EMG PCBs



Successes

Alarm/Buzzer

- Alarm system was vastly simplified
 - Learned how buzzers worked



Others

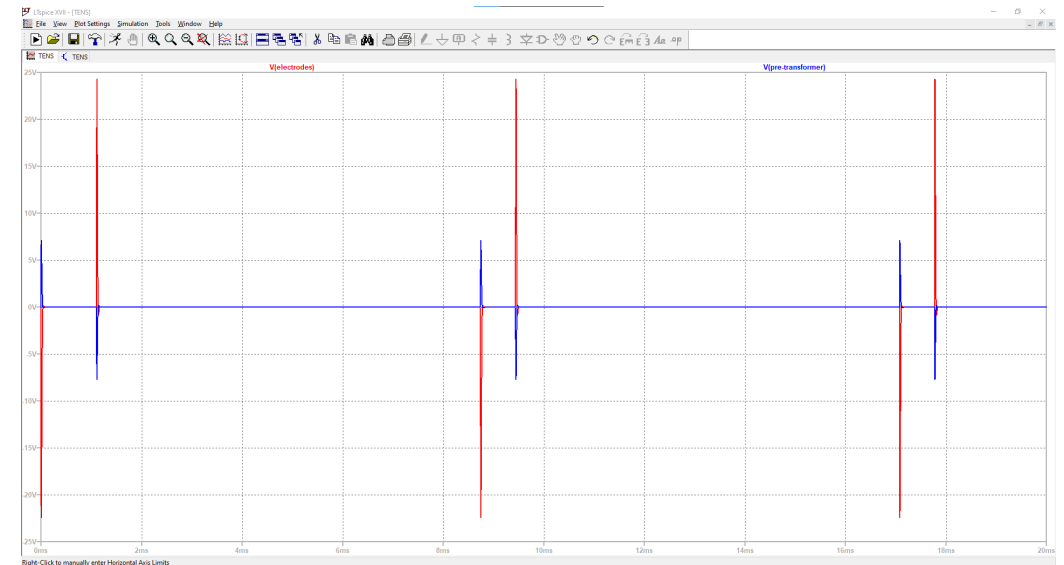
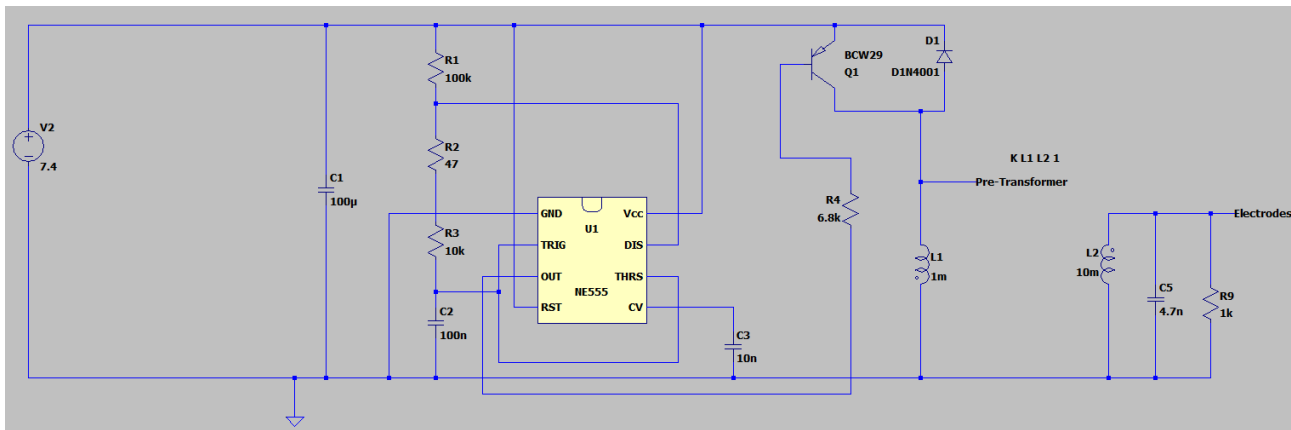
- Power PCB functioned as expected
 - Simplified as well
- Microcontroller functioned as needed
- Audio Detection circuit eventually worked
- EMG eventually worked



Failures

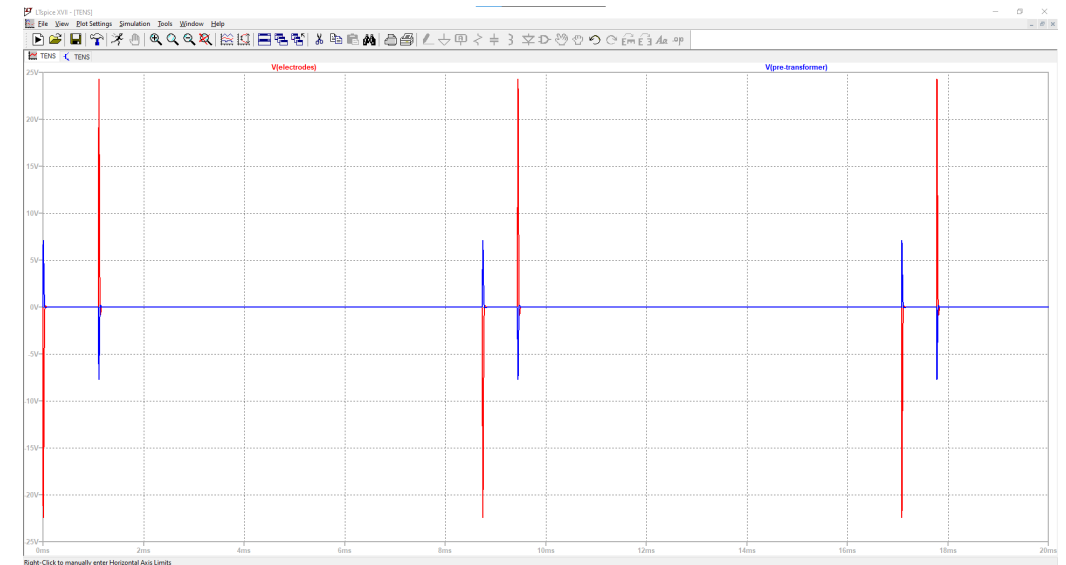
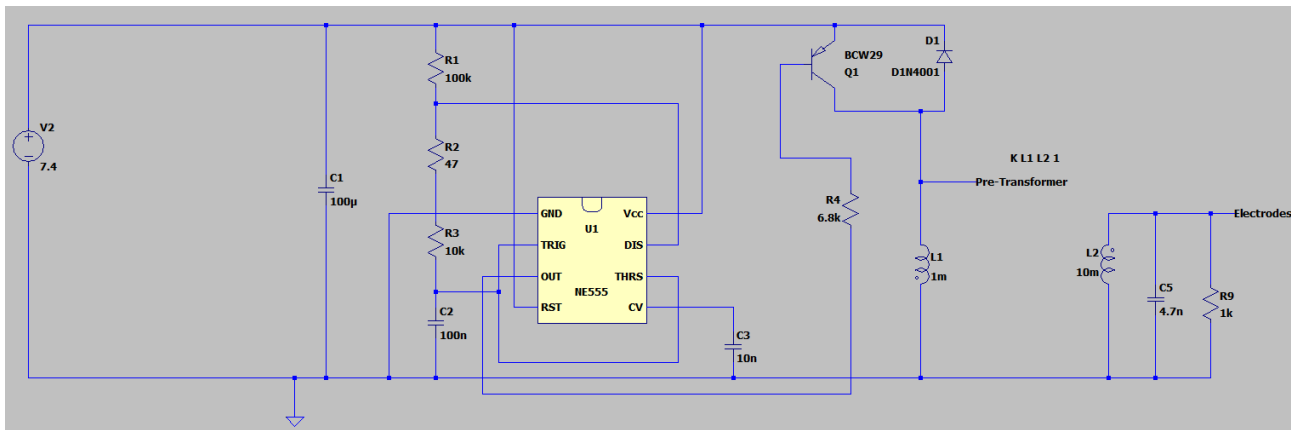
TENS Unit

- Initial LTSpice simulations seemed promising



TENS Unit

- Initial LTSpice simulations seemed promising

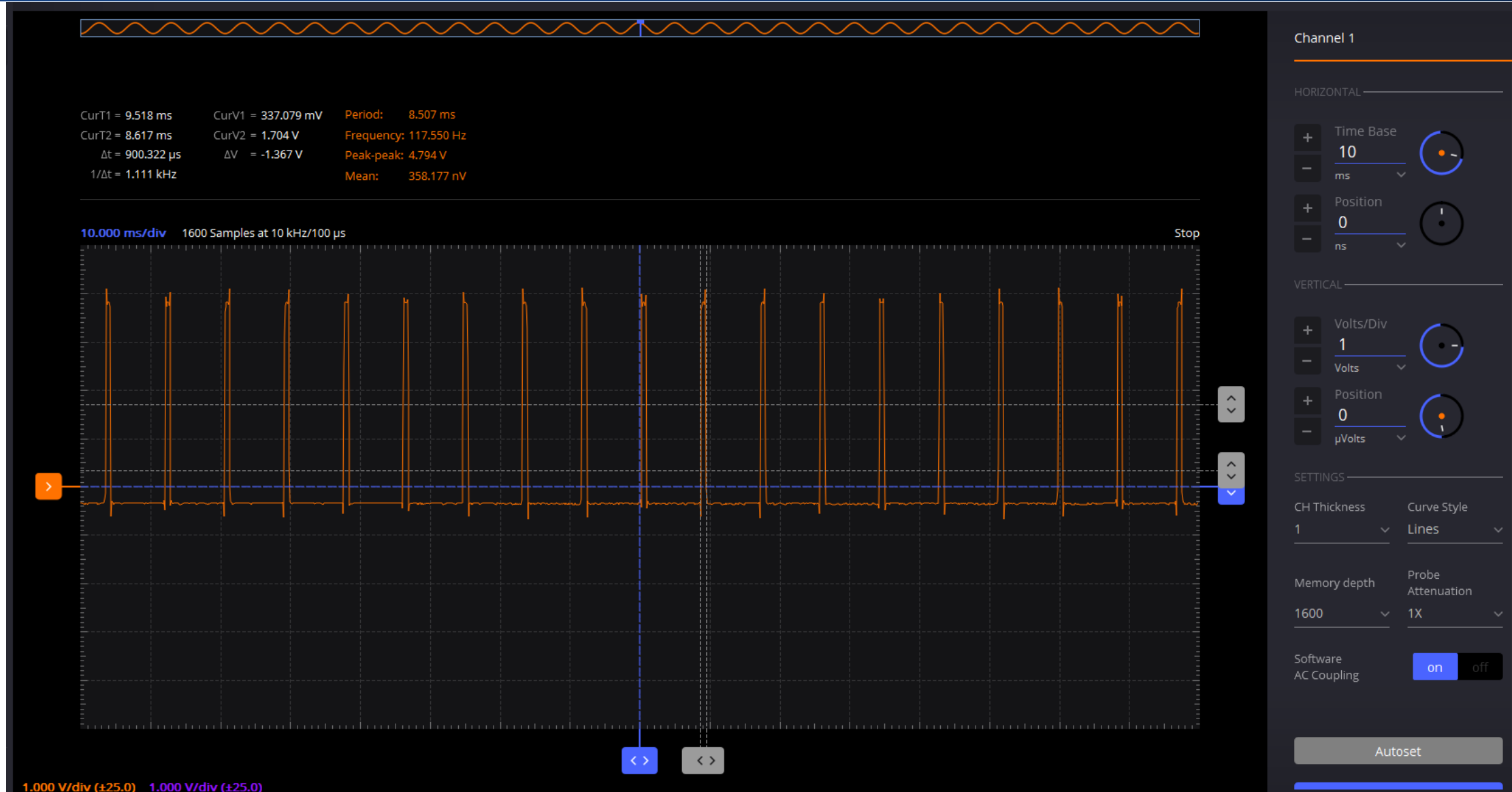


TENS Unit

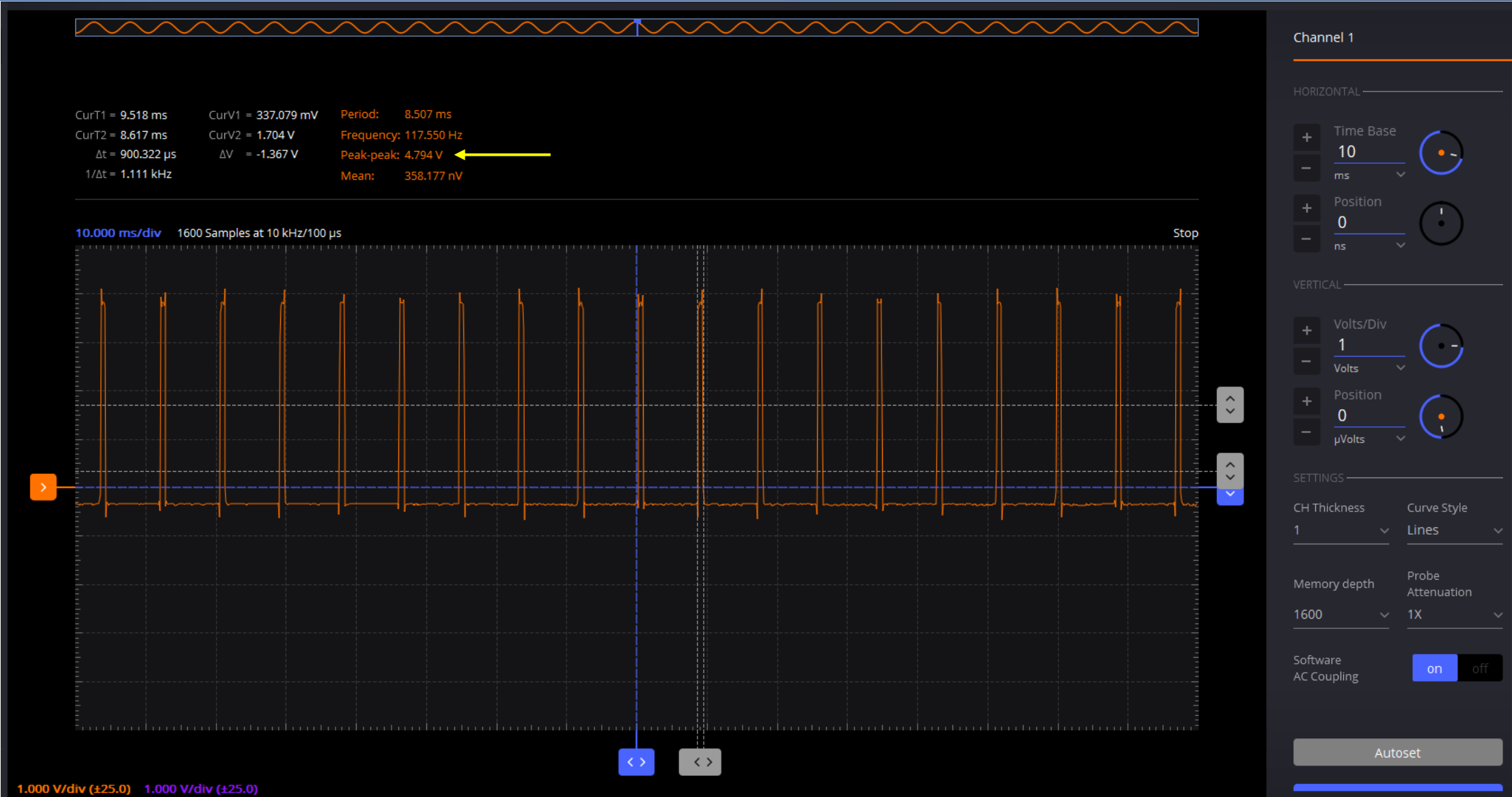
- Initial LTSpice simulations seemed promising



Physical TENS Unit Output (Pre-Transformer)



Physical TENS Unit Output (Pre-Transformer)



TENS Unit

- Problem: Transformer not to needed specifications
 - Cannot operate below 10 kHz frequencies
- Solution: Line frequency transformer

TENS Unit

- Problem: TENS unit's electrodes overlaps EMG's electrodes
- Solution:
 - Explore non-skin contact alternatives to EMG for detection
 - Explore non-skin contact alternatives to the TENS unit
 - Therapeutic Ultrasound?





Future Work

Potential Improvements

- Optional Ethernet or WiFi capabilities
- User adjustments via mechanical knobs
- Alternative to TENS device
- Integration with smartphone application
- More detailed statistics
- Wall powered
- Further downsizing



Conclusion

Summary

- Device detects movement of jaw muscles
- Device detects sounds within "crunch" frequency range
- Device is battery powered by four 3.7V 2500 mAh batteries
 - 4V in reality
- Device stores EMG and audio signals' magnitude
- Device gives warning buzz when Bruxism is detected
- Device does not give electric pulses to counter muscle movement

What we've learned

- Have contingency plans
 - Ordering delays of PCBs and parts
 - Breadboard circuit working, but PCB circuit failing
- Improvising PCBs when needed
 - Soldering jumper wires
- Specific analog circuit oddities

Acknowledgements

We would like to thank:

- Mingjia Huo (our TA) for her support and attentiveness to our project
- Professor Joseph Irudayaraj (Professor in BIOE) for early advice
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- Professor Andrew Stillwell (Professor in ECE) for transformer advice
- Gregory Bennet & Skee Aldrich (Machine Shop) for building our container
- The rest of the ECE 445 Staff for running the course

Citations

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Thank You



Questions?



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