



Energy-Harvesting Piezoelectric Monitoring System for Memory Loss Patients

Paige Blackwood, Advisor: Professor Wayne Smith

Department of Electrical and Computer Engineering, University of New Hampshire

Introduction

The purpose of this project is to explore the feasibility of using piezoelectric technology to design and build a self-powered door monitoring system for memory loss patients. This approach aims to reduce reliance on batteries, lowering maintenance demands while improving reliability for caregivers.

Background

Approximately **60% of dementia patients wander at night**. A battery-less door alarm would help minimize maintenance for elderly primary caregivers who need to be alerted of these events.

- Piezoelectric sensors create a voltage when mechanically deformed
- Footsteps can be used as mechanical deformation to produce an electric signal:

$$V = \frac{d * F}{C}$$

V: Voltage produced
d: Piezoelectric charge coefficient (how efficiently the material converts stress to charge)
C: Capacitance of piezo element
F: Applied force

- Prior research has shown piezo systems can power low energy device

Methodology

Footstep pressure on pressure pad

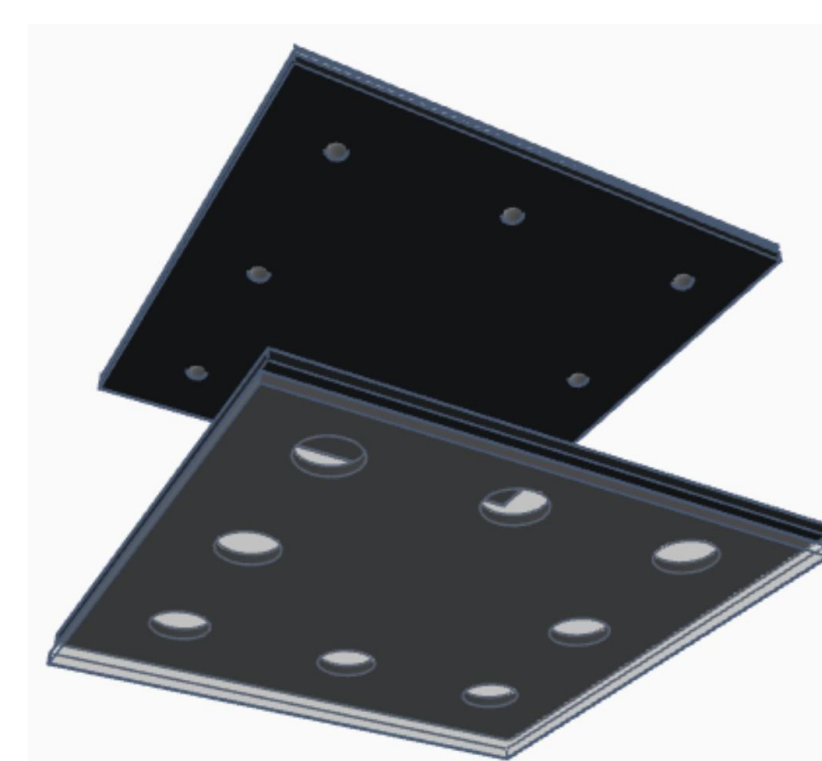
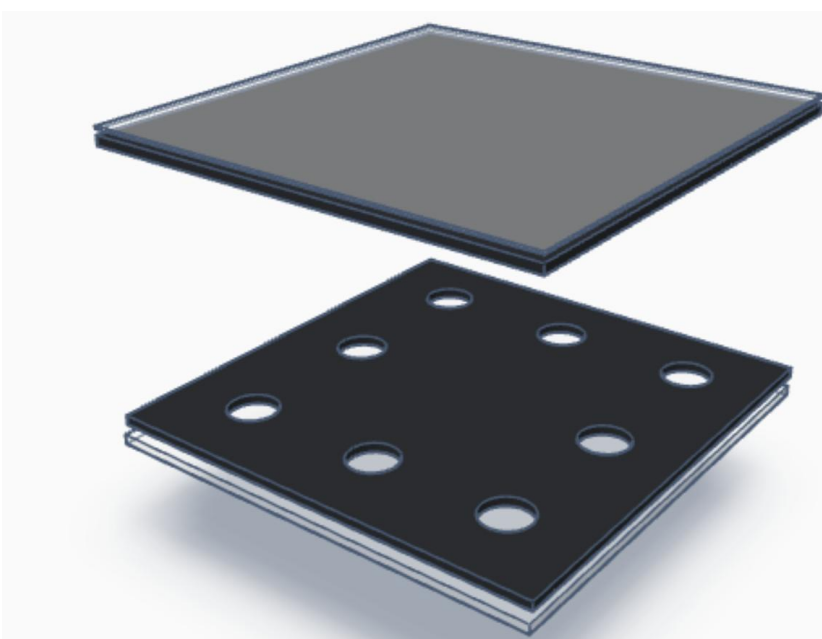
Piezo array generates AC Voltage

Bridge rectifier converts to DC

Output signal triggers buzzer

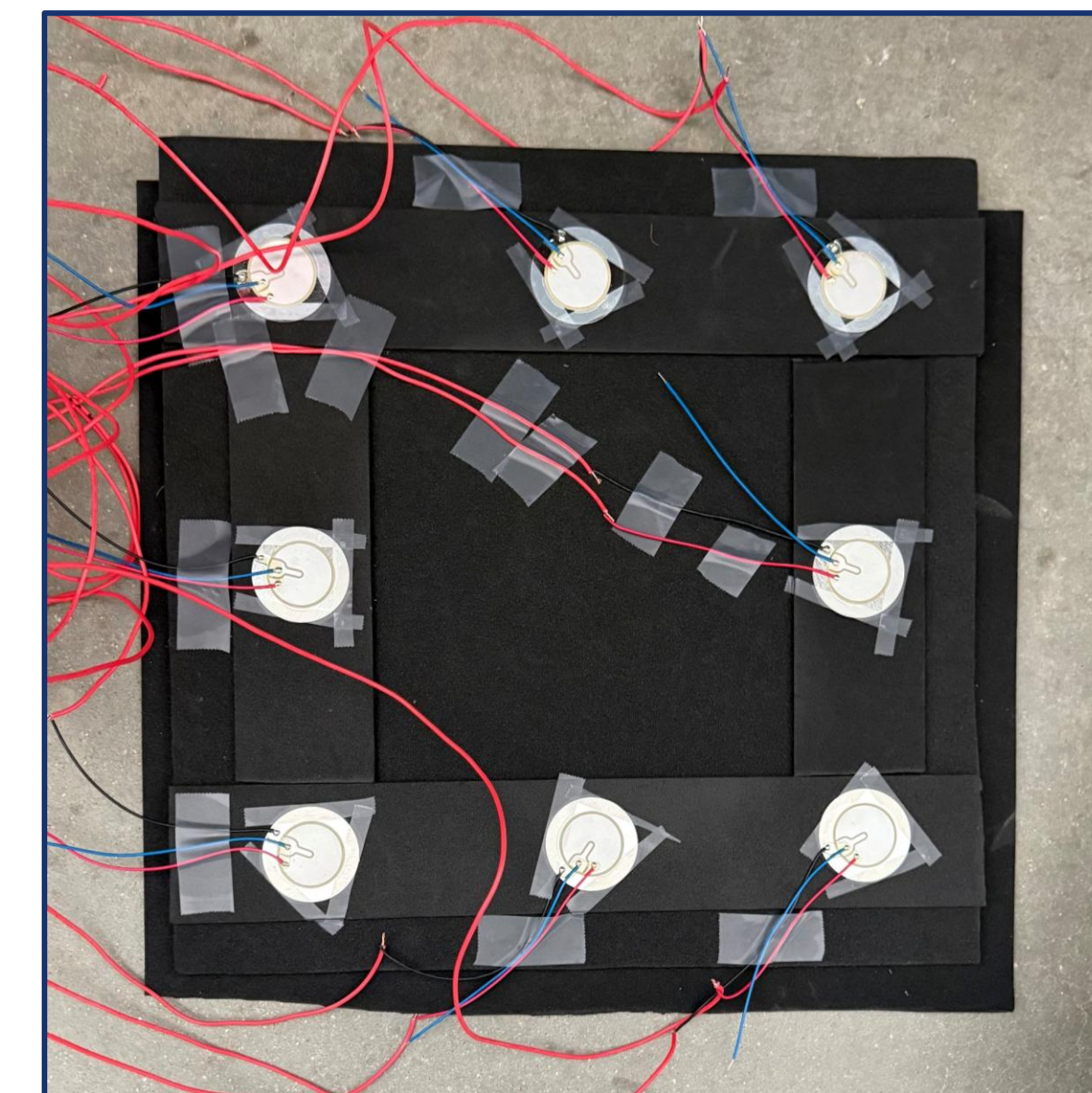
System Design

3D Mechanical Design of Footstep Pad

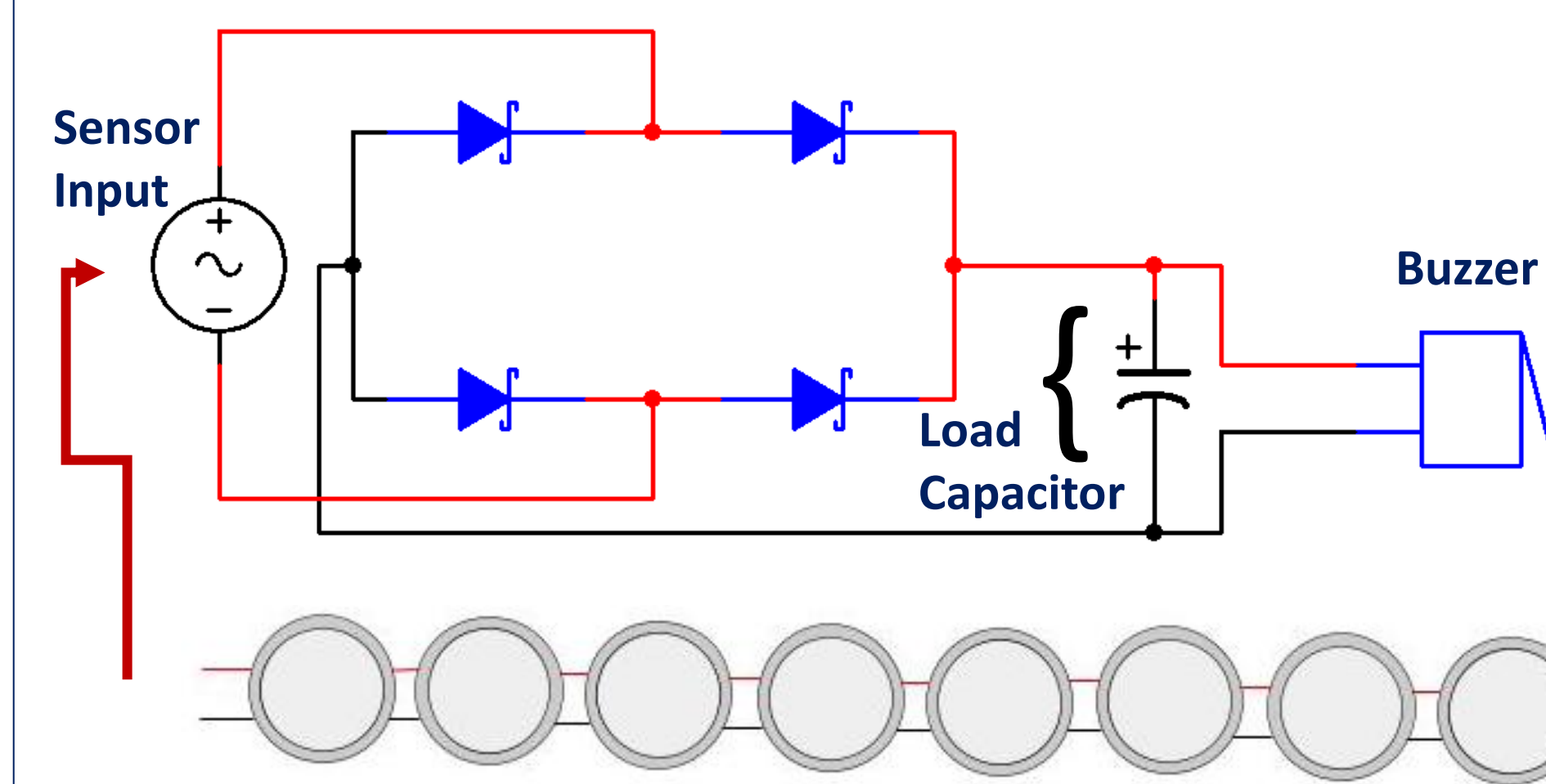


- 12"x12" acrylic sheets
- Neoprene foam
- 10mm x 3mm silicone bumpers
- 35mm piezo discs
- Schottky diodes
- Active piezo buzzer

Picture of Developed Prototype

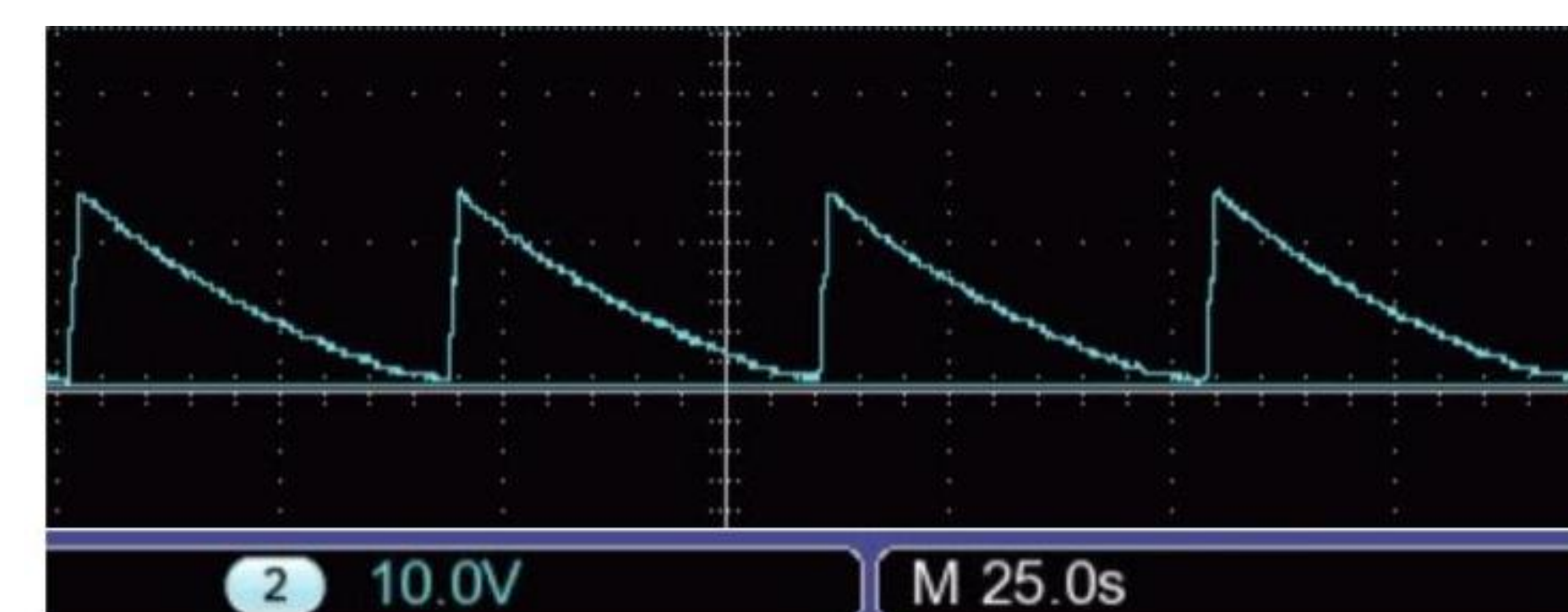


Circuit Diagram

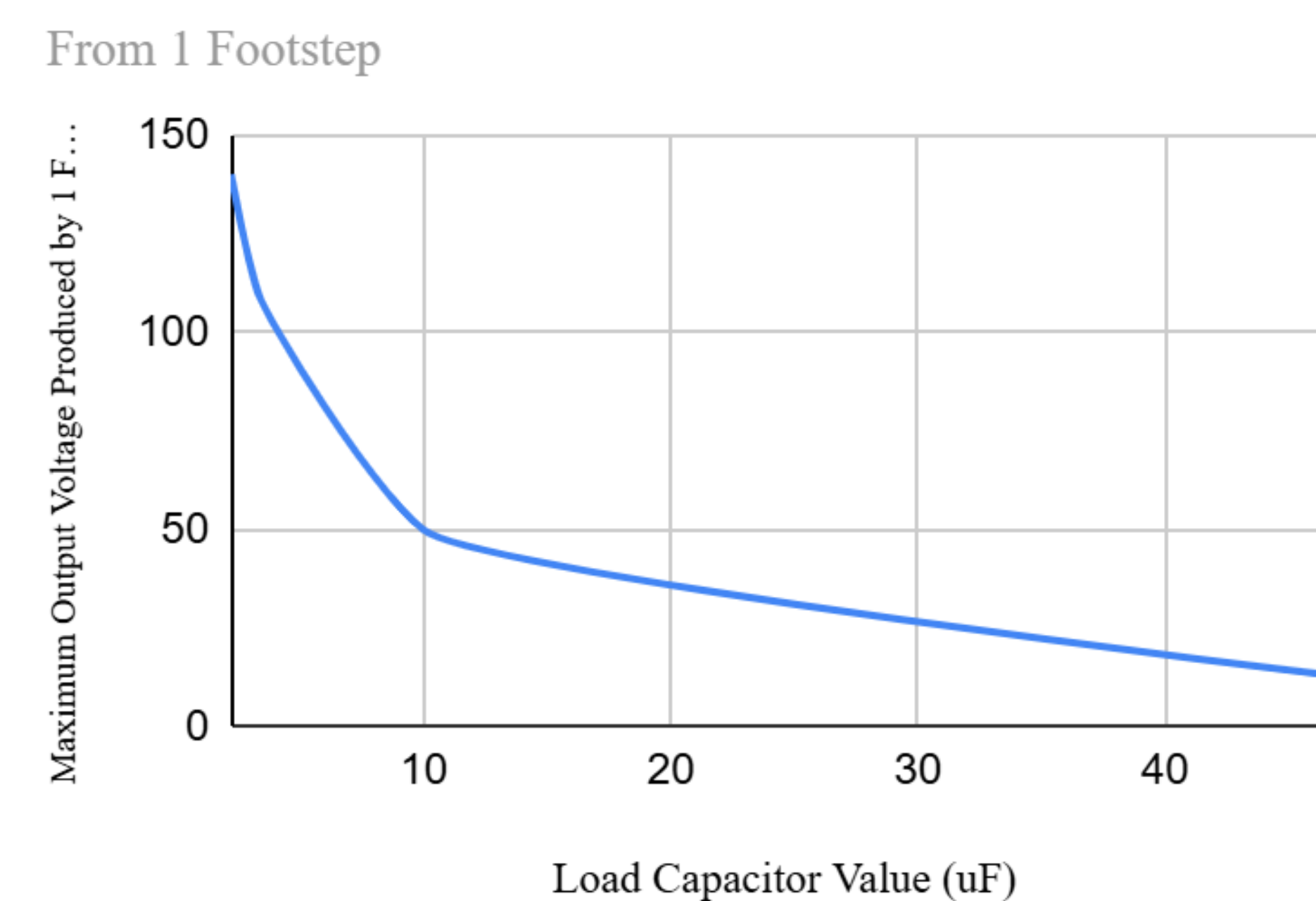


Results

Voltage Across 47uF Load Capacitor with Footsteps



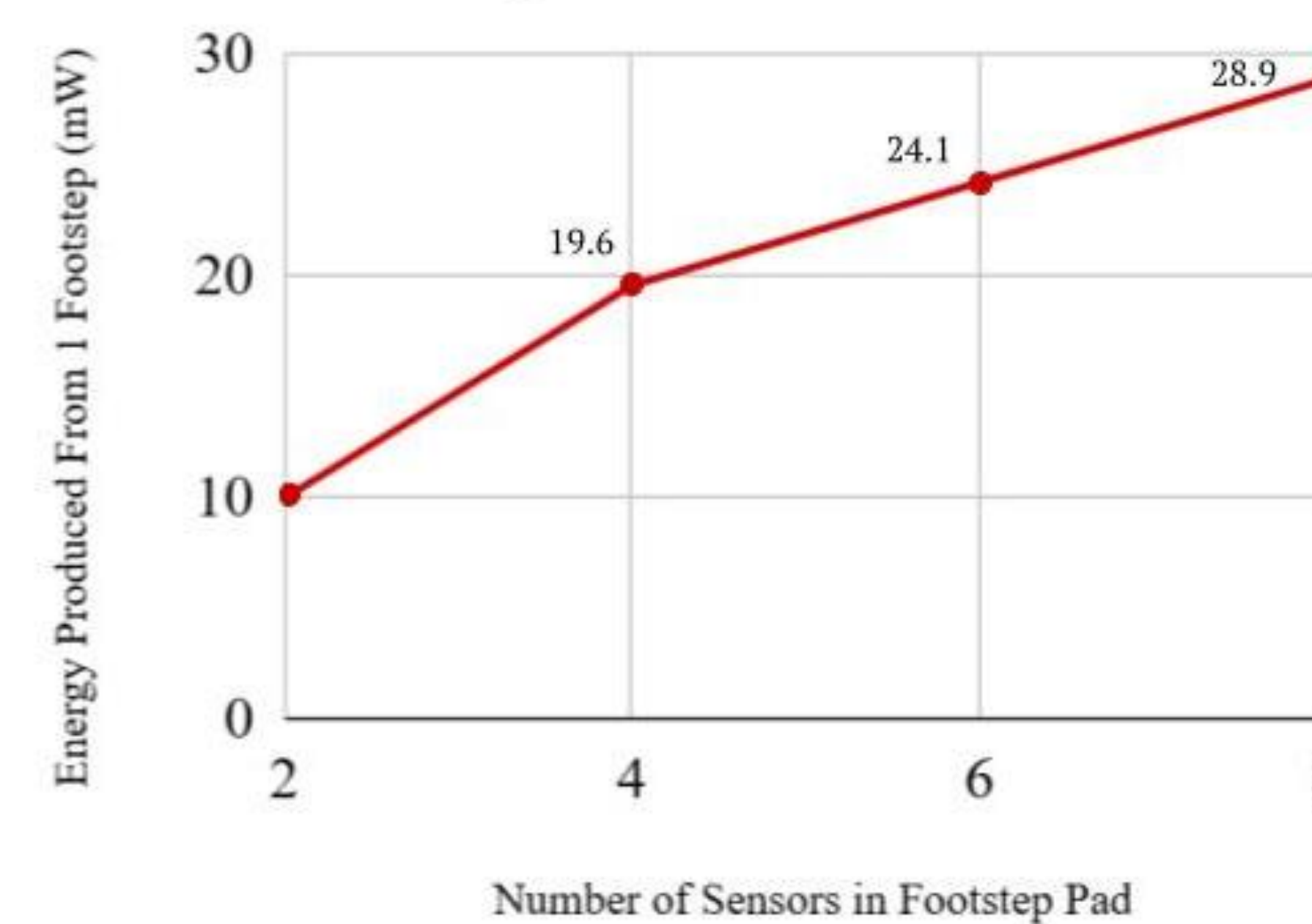
Effects of Load Capacitor Value on Maximum Output Voltage



High and sufficient voltage
Low current draw

Resulted in:
Buzzer indication but brief and quiet

Number of Sensors vs. Power Produced From 1 Footstep



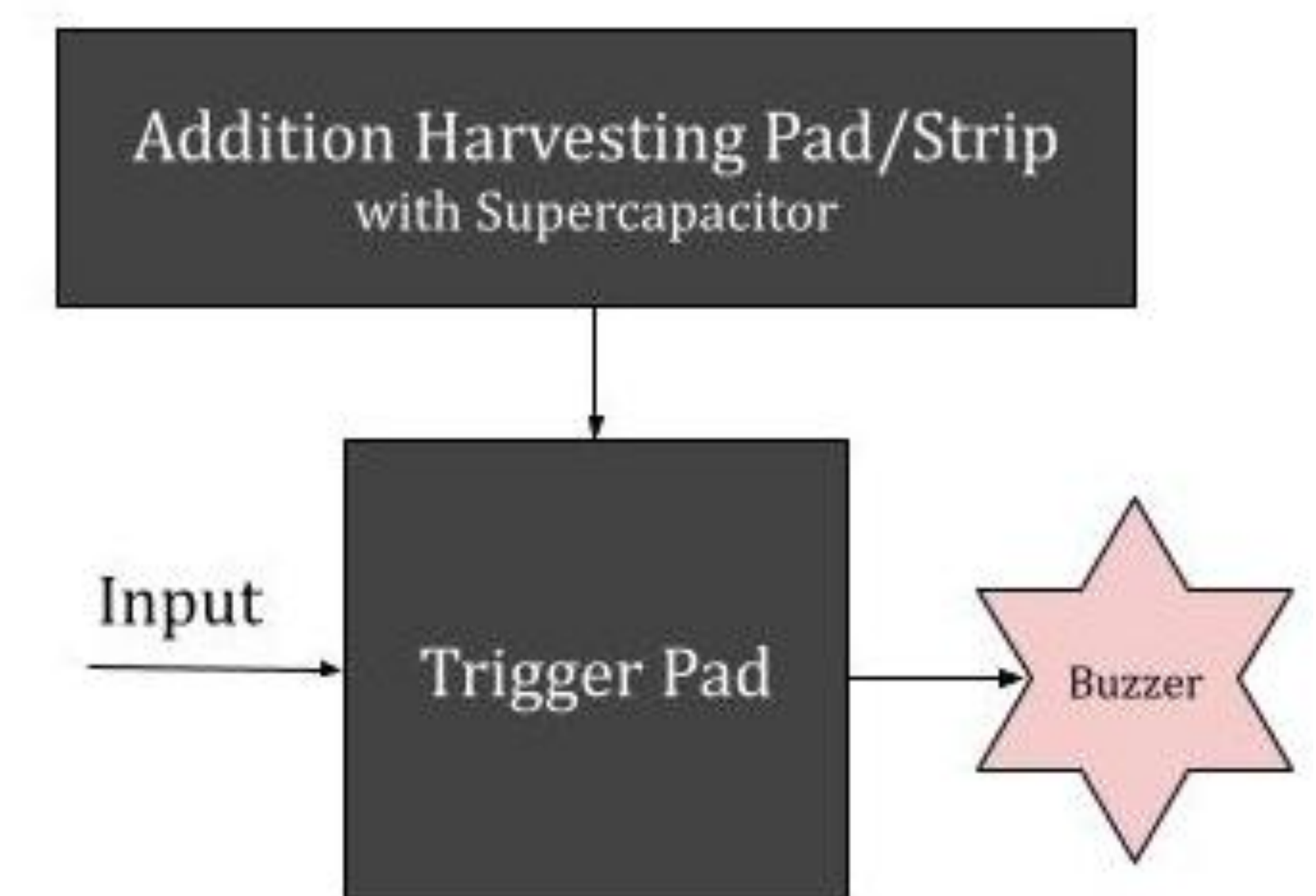
Ideal capacitor value found to be **47 uF**
Ideal sensor count found to be **8 sensors**

- Resulted in:
- Target voltage to trigger buzzer
 - Increased buzzer length
 - Maximum amount of volume achieved

Conclusions

The system successfully demonstrated immediate triggering from a single footstep. However, the generated energy was insufficient to produce a loud enough or sustained audible alert to wake caregivers. While piezoelectric harvesting can support detection, it is limited in its ability to deliver sufficient power for a loud output alert. As a result, this approach showed is not fully practical for reliable nighttime alerting in its current form.

Future Improvements



Acknowledgements

I would like to thank Professor Wayne Smith for his guidance and advising work as well as the UNH ECE department for providing testing equipment and development space to explore this project.

References

- [1] Selim, Kyrillos K., et al. "Piezoelectric sensors pressed by human footsteps for Energy Harvesting." *Energies* vol. 17, no. 10, 10 May 2024, p. 2297, <https://www.mdpi.com/1996-1073/17/10/2297>.
- [2] Anusha, K.B., et al. "Energy harvesting from ambient vibrations using piezoelectric materials: A sustainable approach to powering IOT devices." *International Journal of Environmental Sciences*, vol. 11, 1 Sept. 2025, pp. 1-9, <https://doi.org/10.64252/ij5evd585>.
- [3] Amri, Chaymae, et al. "Optimizing and enhancing piezoelectric energy harvesting devices." *E3S Web of Conferences*, vol. 601, 2025, p. 00019, <https://doi.org/10.1051/e3sconf/202560100019>.
- [4] ALZRA. Alzheimer's Research Association, alzra.org. Accessed 2 Apr. 2026.