# Diagnostic EEG for Viral-Induced Epilepsy

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## Problem Statement

Epilepsy is a common chronic neurological disease characterized by abiding recurrent seizures. Electroencephalogram (EEG) is the most widely used detection and analysis procedure for epilepsy, which records cortical electrical activity. However, EEG systems are very expensive, making it difficult for less-funded hospitals to afford. Additionally, tests are costly to perform on patients. Therefore, affordable EEG systems that can be rapidly and broadly deployed are in critical need. In this work, we show the development of an affordable diagnostic EEG system complete with ten channels, high temporal resolution, and a flexible 3D-printed head cap.

## Background

- 1 in 26 Americans develop Epilepsy.
- An Electroencephalogram (EEG) detects seizures.
- EEG placed on scalp to detect electrical impulses from brain.
- Medical-grade EEG systems expensive, upwards $10,000.
- Average price patient $200-3,000 [1].
- OpenBCI 8-channel system for $2,578 [2].
- 80% of epilepsy patients live in low- and middle-income countries [3].
    - No diagnostic access.
    - Have treatment options.


Figure 1: OpenBCI EEG Headset [4]


Figure 2: OpenBCI EEG Headband [5]

## Specifications

- Cost complete system under $100.
- Remain operational 3-4 years.
- Able to accommodate 10 channels.
- Head cap circumference between 50-65 cm.
- Head cap maintain landmark accuracy.
- Ear clip should score 10 or below on the Borg discomfort scale.
- Circuit samples at 1kHz with 12-bit resolution.
- Operating temperature under 40 ℃ and electrode sanitization for safety.

## Head Gear

**Head Cap**

- ~20g + 40g supports.
- ~$5 printed in TPU.
- Anatomically derived [6].
- S, M, L sizes: 50, 55, 60 cm head circumference.
- Adjustable for electrodes.
- Space for hair.

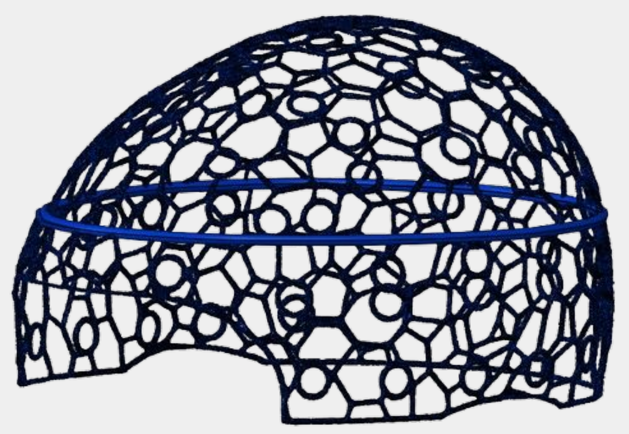
Figure 3: CAD model of the Headcap

**Ear Clip**

- Earclip for reference and driven right leg.
- ~1g ~$0.05.

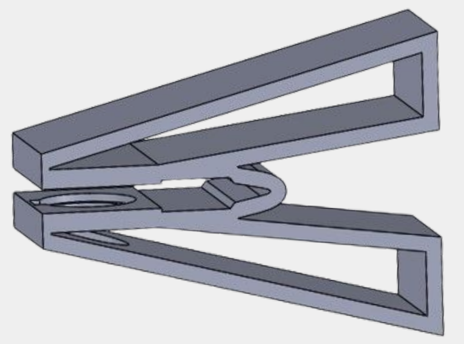
Figure 4: CAD model of the ear clip

## Embedded System

- Control MUX channel, amplification, and sampling rate.
- Send data to external computer.
- Future work: program gain, and send data to computer.
- Queue if data comes in too Quick.
- Based on code from Hunter Adams [7] and RP2040 SDK [8].

```
1 kHz Interrupt {
    Change to the next channel and
    read from that channel. Send this
    data to PC
}

Main {
    Initialize GPIO pins.
    Initialize gain.
    Initialize interrupt clock.

    Loop forever ()
}
```

## Printed Circuit Board (PCB)

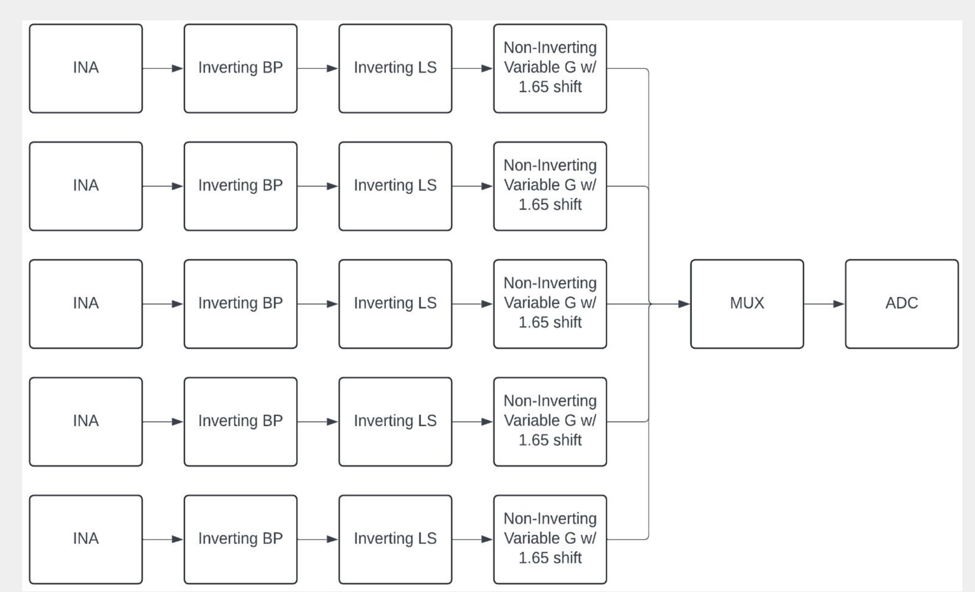

Figure 5: Block Diagram of Circuit 1

**Circuit 1: Minimize Switching Artifacts**

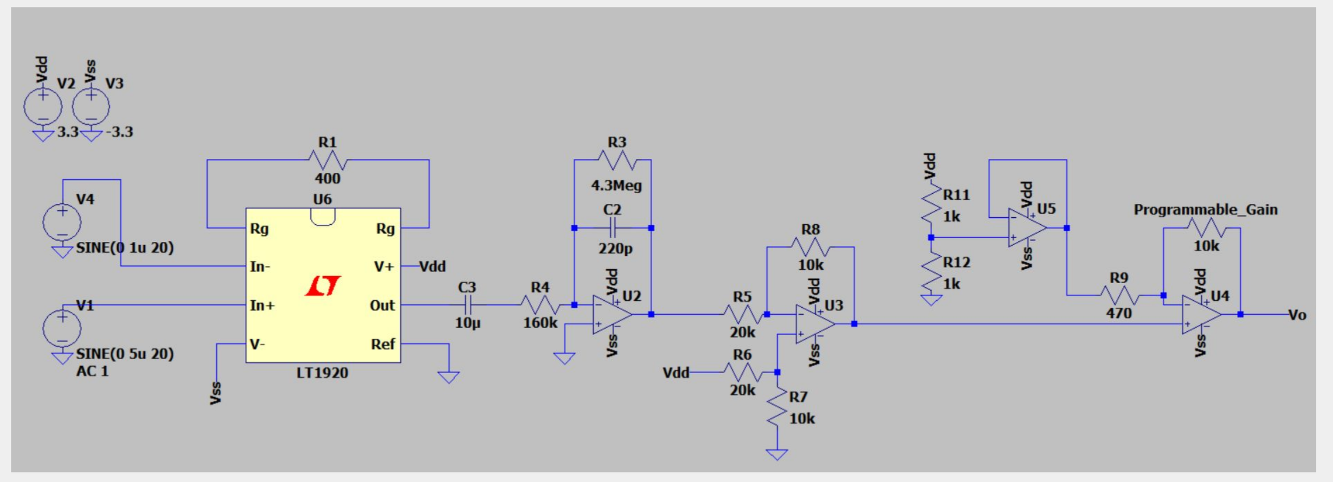
Figure 6: Schematic of Circuit 1

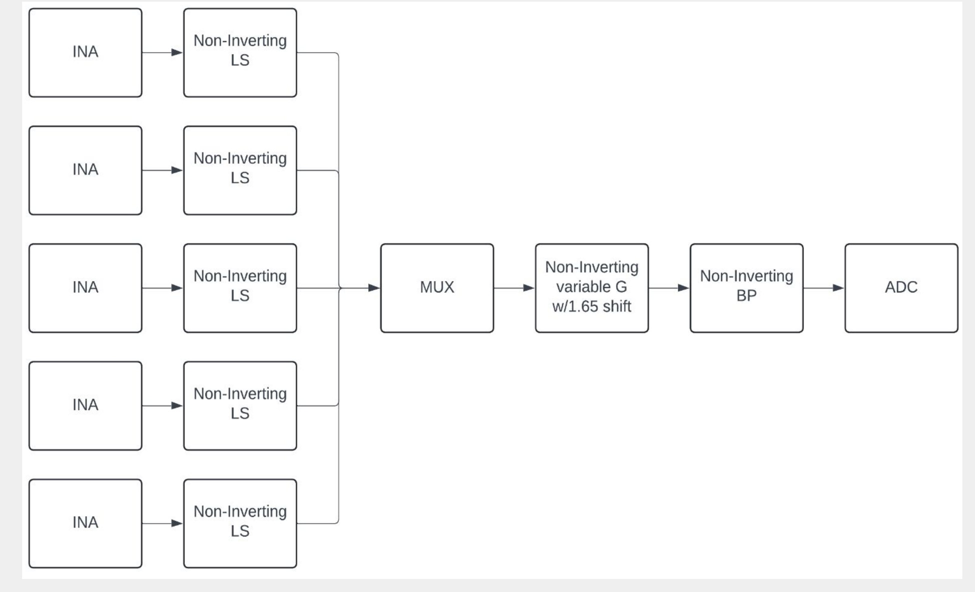

Figure 7: Block Diagram of Circuit 2

**Circuit 2: Minimize Component Cost**

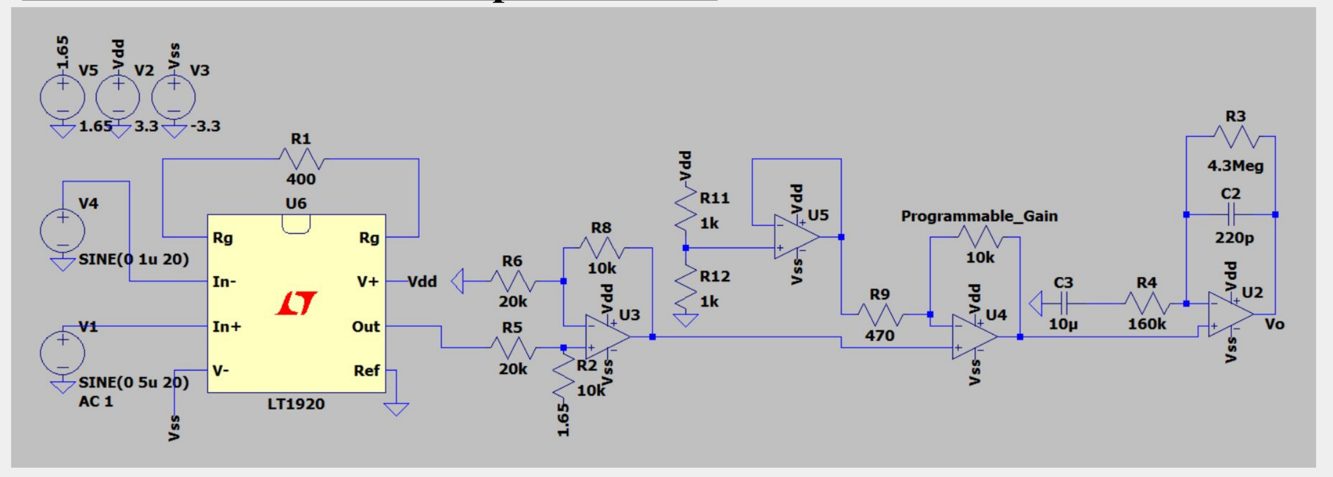
Figure 8: Schematic of Circuit 2

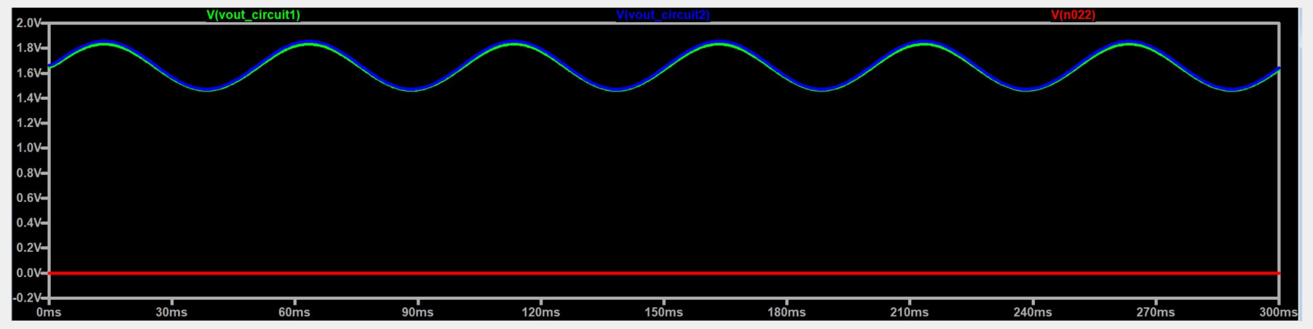
Figure 9: SPICE Simulation of the Circuits

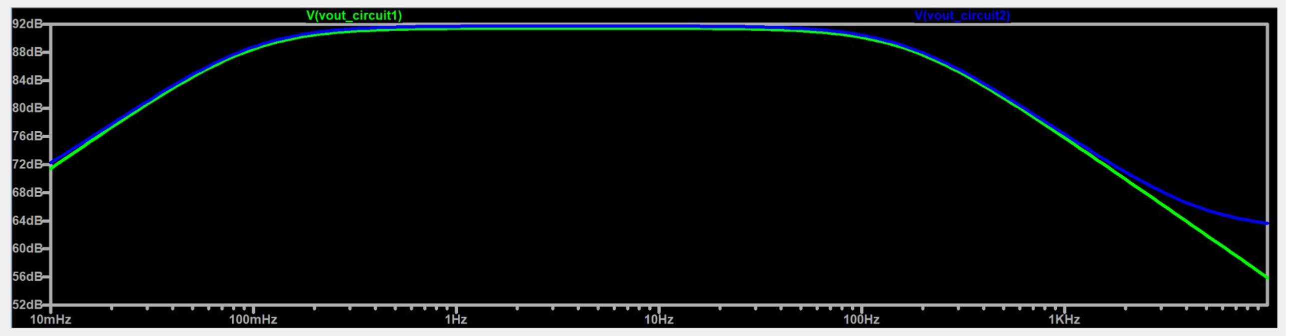
Figure 10: Bode Plot of the Circuits

## Results

**Head Cap**

- Mean 6-7% placement error, 2-13% standard deviation.
- Measured expected and actual electrode placement for 10-20 layout from nasion to inion.

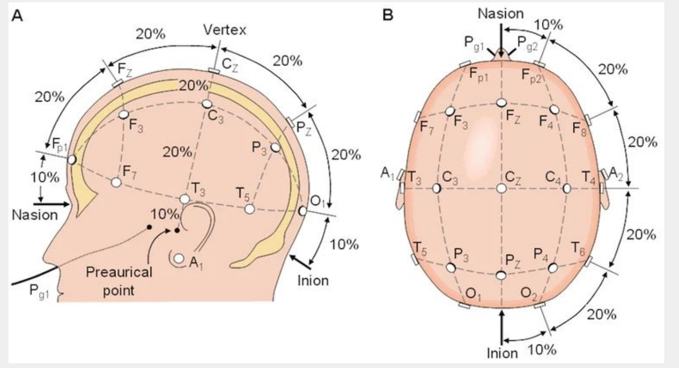
Figure 11: 10-20 EEG Placement System [9]

**Ear Clip**

- Mean Borg discomfort value after 10 minutes of 9.75 with a standard deviation of 1.09.

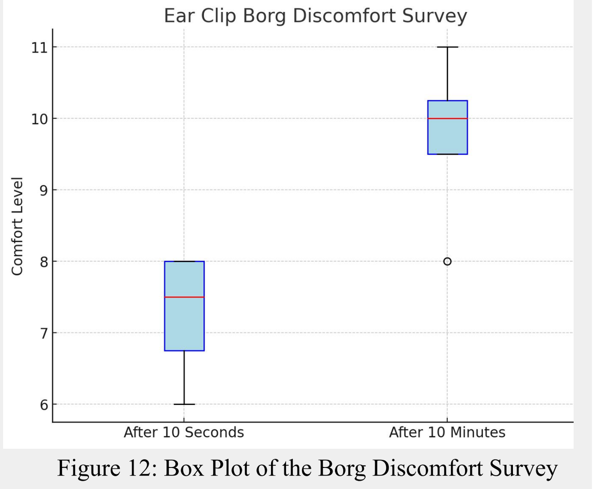

Figure 12: Box Plot of the Borg Discomfort Survey

## Conclusion

**Head Cap**

- Improve placement reliability.
- Electrode cable management.

**Ear Clip**

- Improve durability.

**Embedded System**

- Communicate and write to python GUI on PC.

**PCB**

- Common mode rejection ratio, power supply rejection ratio, and ground truth testing.
- Identify points to improve.

## References

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