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In Pursuit Of A Good Night's Rest. Steps Towards Improving Electroencephalogram (Eeg) Accessibility And Affordability

Niyant Vora
Illinois Wesleyan University

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Niyant Vora, Thushara Perera*
Illinois Wesleyan University Department of Physics, Bloomington, IL 61704

Introduction:

EEGs are a key pillar of sleep studies, but as a result, their limitations affect those studies. These largest of these is the setting: Sleep studies don't take place in a person's natural sleeping environment. Despite the creation of some commercial EEG headsets, however, most of these headsets are not capable of being used for sleep studies. By modifying the EEG circuit design to use easily available parts, we can improve the affordability as well as accessibility of EEGs. This is done by utilizing *active, dry electrodes*. Active electrodes are a newer direction in EEG technology. They allow the micro-voltages produced by the brain to be amplified at the electrode site, enabling better noise reduction, while also allowing for the biopotentials to be picked up without utilizing the conductive gel normally used in passive electrodes. Therefore, as a proof-of-concept we created an EEG circuit using the aforementioned easily available parts, and utilized LabVIEW to record the digital output. As a benefit, this circuit lends itself to being miniaturized into an ergonomically good electrode device for future use and work.

Circuit Design:

The schematic to the right shows the current design of the EEG.

1. The input signals (Electrodes 1 & 2) enter into the instrumentation amplifier (Blue circle), where they are referenced against the ground electrode and then amplified to ~90 times the input voltage.
2. This amplified signal is then sent through a 60 Hz notch filter (Red circle) which removes induced voltages caused by electricity (e.g. lights) in the room and devices around us, which run on 60 Hz, AC.
3. This filtered signal is then sent through a 7 Hz Highpass filter (Green circle) which attenuates all signals below 7 Hz—because of noise concerns below 7 Hz.
4. The output from the 7 Hz highpass filter was then sent into a 31 Hz Lowpass filter (Purple circle) which attenuated all signals above 31 Hz, as we don't want to look at brainwave signals above Beta waves (see Table 1 below).
5. The output of the Lowpass filter was then sent through a variable gain amplifier (Orange Circle), which is capable of amplifying the given signal between 90 and 455 times.
6. The output of this amplifier was then sent into another 60 Hz notch filter (Red Circle) to remove more of the noise from the electrical environment around the system.

One point of note: several of the brainwaves present during sleep cycles (such as Theta and Delta waves) are very weak using the current circuit set-up (Please see the below table). These waveforms are not present because the current design is merely meant to prove that such an EEG circuit acting as an electrode could work. In the future, the circuit will be further modified so that it can detect all frequencies below 31 Hz. Gamma brainwaves are not important for sleep, and so we are not concerned with detecting such frequencies.

Brainwave Type	Frequency (Hz)
Gamma	31-100
Beta	16-30
Alpha	8-15
Theta	4-7
Delta	0.1-3

Future Work:

From the current state of the EEG device, there are several key future goals to consider:

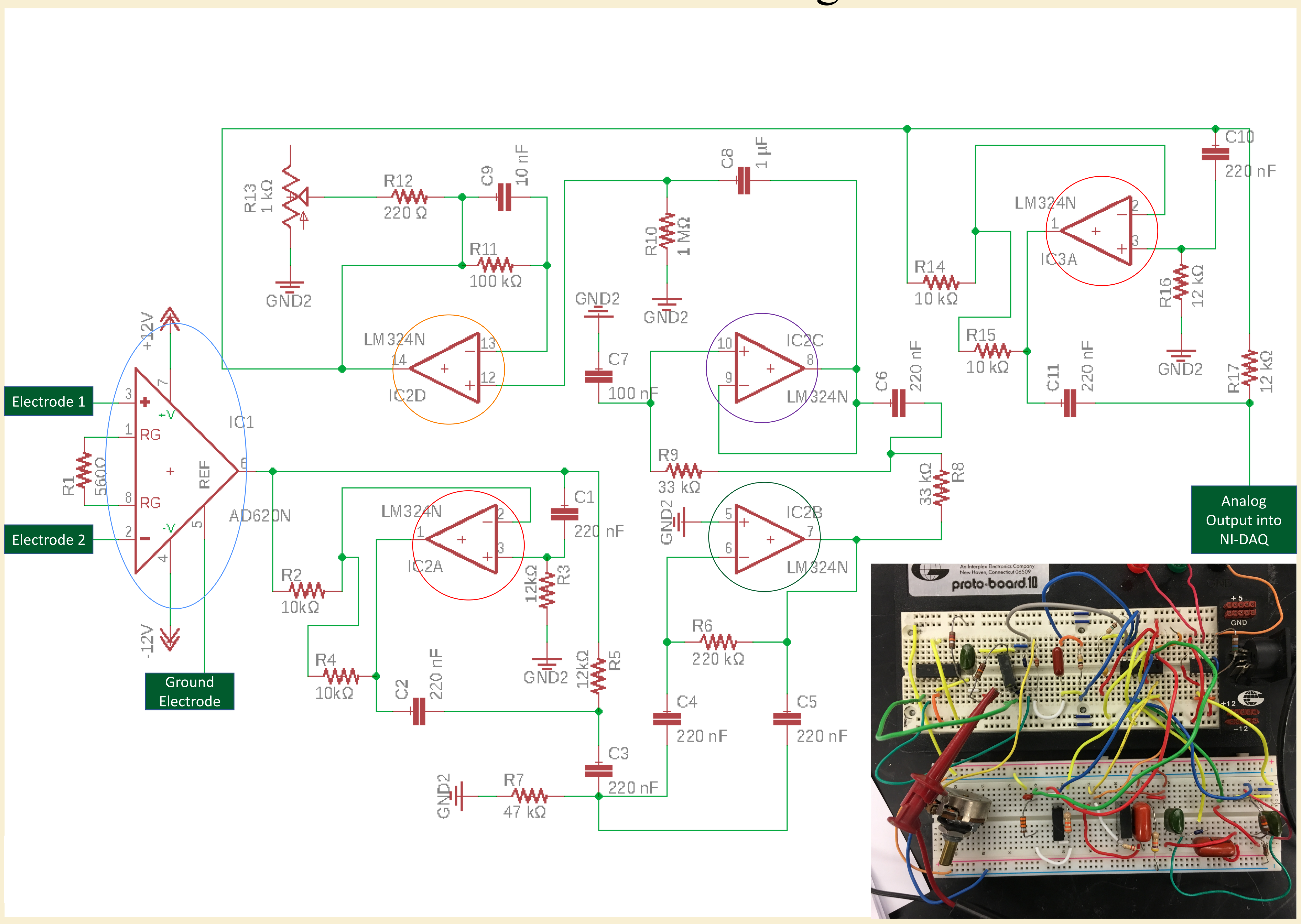
During the coming weeks:
1. Ensure that EEG data is properly connected and works in conjunction with the National Instruments—Data Acquisition (NI-DAQ) device.
2. Design a Printed Circuit Board (PCB) and test it

During Summer/Fall 2018:
1. Modify the current single-channel EEG circuit to a multi-channel EEG circuit.
2. Obtain data from that modified circuit
3. Design a second PCB

Finally, it is worth noting, that although this preliminary test was done as an EMG, all subsequent tests will be conducted using EEG for both standard electrode placement—any place on the head for electrodes 1 and 2, generally following the International 10-20 system—and ground electrode placement (on the mastoid bone behind either ear)

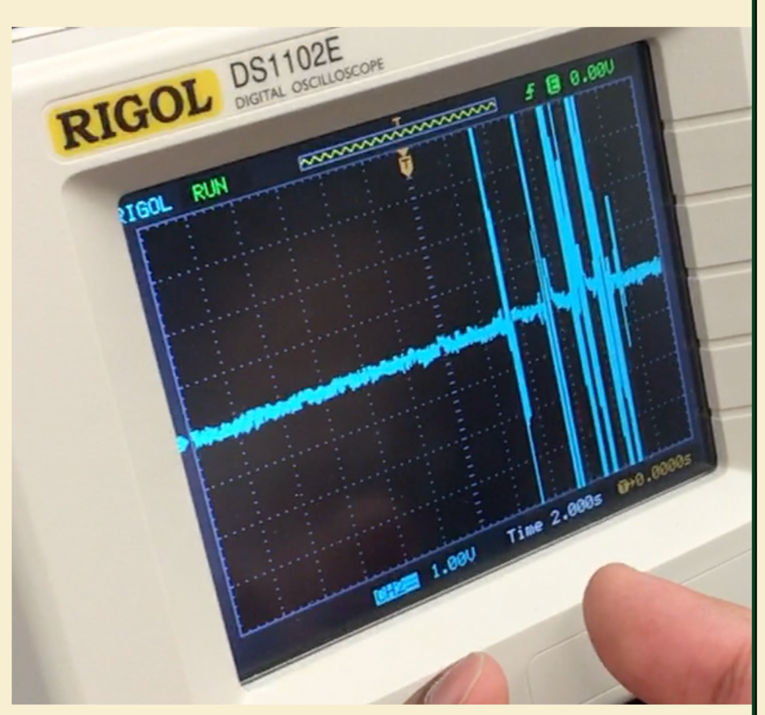
PCB Size (4 inches)

Current Circuit Design



Preliminary Testing: Measuring EMG signals

- The above version of the EEG device was tested via measuring Electromyographic signals.
- This is possible, because an EEG circuit/device can also act as any sort of biopotential device, in this case as an Electromyograph (EMG).
- The importance of such a preliminary test is the ease of testing involved with EMG measurements allows us to determine the viability of the EEG circuit, and proceed to EEG tests.
- In order to do so, 2 disposable passive BIOPAC® electrodes were obtained and placed at strategic places on the arm. One electrode was placed at the rightmost part of the inner forearm (nearest to the wrist)—this was Electrode 1. The other electrode was placed at the top left position of the inner forearm (nearest the elbow)—this was Electrode 2. A ground electrode was unnecessary here.
- Once this was accomplished, the oscilloscope was set to a time/epoch measurement of 2.000 seconds. I then kept my right forearm as still as possible (flat line seen on oscilloscope). Next I clenched an unclenched my hand several times. Doing so created spikes in detected voltages. This indicates that the muscles and associated motor neurons are working appropriately.
- The smallest spike, at the furthest right of the oscilloscope screen, is caused by a slight clenching of the hand, which helps demonstrate the difference between a tightly clenched hand before it, and the lack of muscle movement/motor neuron firing after it.



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