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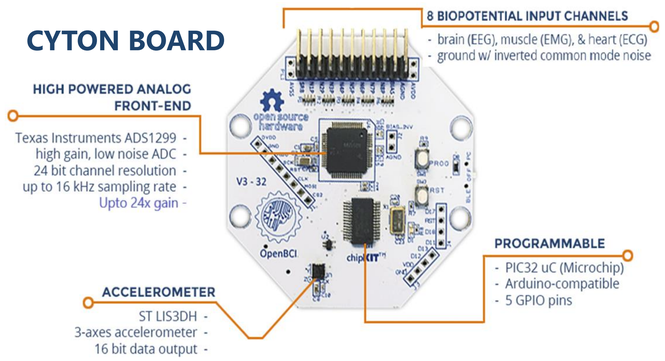
Improved Gain for a Brain-Computer Interface

Scope of Work

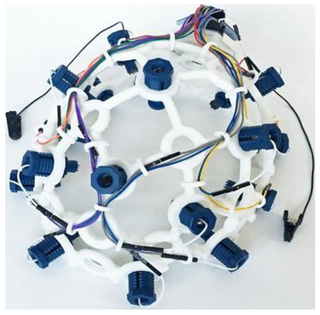
- Design a prototype acquisition board with the same functionality as the current OpenBCI Cyton board, but with a gain of 1000, a higher signal-to-noise ratio (SNR), and improved wireless communication capabilities.
- Develop a production ready printable circuit board (PCB) of the prototype.
- Provide detailed documentation of the prototype, including all calculations used, testing and failed designs.

Initial Conditions

The OpenBCI Cyton acquisition board is currently being used by our sponsor. Our acquisition board must be compatible with the Mark IV headset. Amplification is done in the ADS1299 chip.

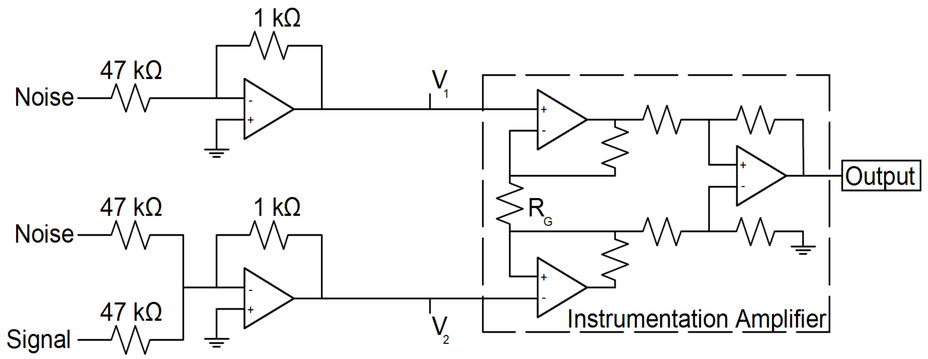


MARK IV EEG SYSTEM



Testing and Design

PROOF OF CONCEPT CIRCUIT SCHEMATIC

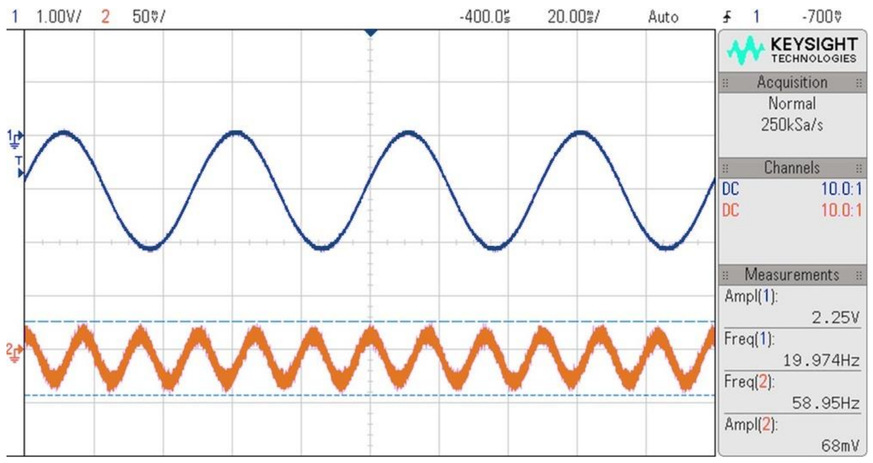


Acquisition Board: The purpose of the acquisition board is to measure voltages at the scalp which can be used to extrapolate the electrical activity occurring within the brain. The scalp voltages that are caused by brain activity are typically much smaller than the electrical noise that is present on the surface of the human body. The objective of this project is to improve the acquisition board's ability to amplify the relevant signals and reject noise.

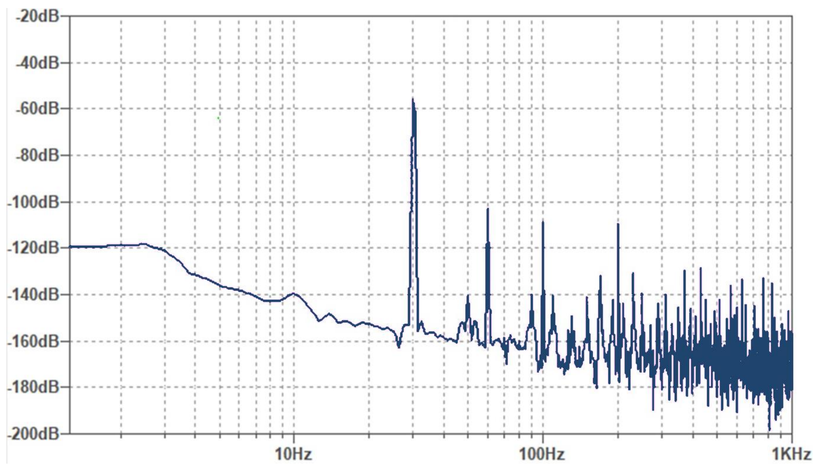
Proof of Concept: To simulate the acquisition board's task, we built a physical circuit to model the signals and noise in order to evaluate the performance of our prototype at a gain of 1052. The oscilloscope screenshot to the left shows the results of a test using such a circuit model. The orange signal shows a large amplitude noise signal with a very low amplitude sine wave hidden within it. The blue signal shows the output of our amplifier which removes the mock noise and amplifies the relevant 2.1mV signal.

Simulation: A computer simulation of the test circuit was created to have more flexible signal and noise inputs. The FFT graph below shows the response in dB for a 100µV signal at 30Hz.

PROOF OF CONCEPT RESULTS



SIMULATION FFT GRAPH



Design Process

Initial Conclusions and Future Work

- Separating the instrumentation amplifier from the ADC will allow for the desired gain. The desired frequency range will not be significantly distorted by these changes.
- Further testing will incorporate an ADC and microcontroller. A completed test circuit can then be tested with the Mark IV headset.
- A product prototype will be immediately usable by our client for research.
- The power consumption of the new acquisition board will be monitored so that it meets the sponsor's requirements of 1.5-2 hours minimum of run time.
- The acquisition board will be upgraded with wireless communication capabilities using Bluetooth 4.0 technology.
- Any product designs that result in superior performance over the existing Cyton board will likely be sent to OpenBCI for their consideration.

References

- Linear Technology. (1998). LT1167 Datasheet. Retrieved from http://cds.linear.com/docs/en/datasheet/1167fc.pdf
- OpenBCI. (2017). OpenBCI Hardware. Retrieved from http://docs.openbci.com/Hardware/01-OpenBCI_Hardware
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