Low Cost Extracellular Voltage Amplifier

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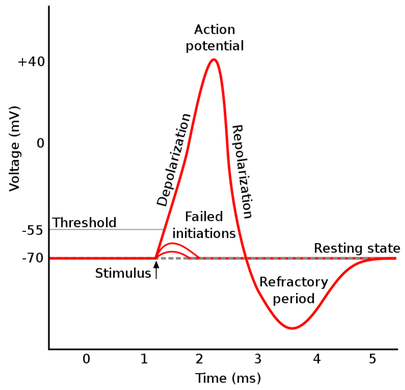
BIO SIGNALS ARE TINY…

Action potentials are electrical signals that propagate through nerve cells across various parts of any living organisms body. These signals are worth recording due to how they are the medium of communication between cells for bodily functions and comprehensive thought to occur.



But these signals are small! Extracellular voltage recording is a method of examining these signals for study, by bringing electrodes very close to a cell with propagating action potentials and recording the voltage transient. These signals are attenuated by a factor of 10-100 due to being outside the cell.

…BUT MEASURING THEM IS EXPENSIVE!

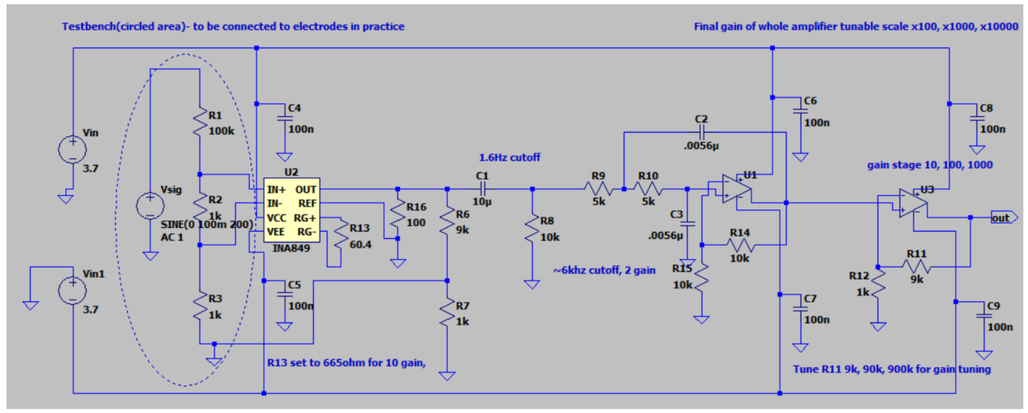
Since these signals are so small, when recording we must amplify them for more detailed examination. This amplification requires a frequency bandwidth to handle frequencies up to 3kHz, and apply tunable gains of 100-10,000 for the various sized action potentials for different applications. Additionally, 60Hz current noise from the environment is a huge factor due to the nature of extracellular recording and these small signals being particularly susceptible. Commercial amplifiers that take all these considerations into account go for up to $1000 per channel!

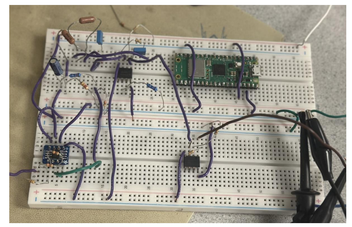
Extracellular voltage recording of a crawfish

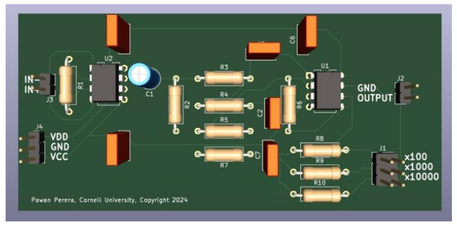
LOWER THE COST

We aimed to develop an amplifier for use in student lab environments, much like the neurophysiology lab in Cornell's Comstock Hall run by Professor Bruce Johnson, that can perform all the capabilities detailed for extracellular voltage recording and report the transient via Bluetooth, but with a fraction of the cost.

SCHEMATIC DESIGN AND PCB LAYOUT



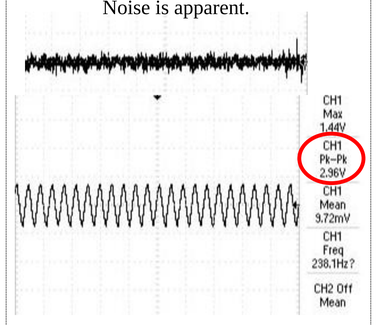




DESIGN MEETS SPEC

Used 3mV input sine wave in testing.

Noise is apparent.



At gain of 1000 tested output gives appropriate 3V peak-to-peak output

Final testing with real ECG output. Well formed action potentials are visible

250ms slice

100ms slice

LOW COST ACHIEVED

The established specs and functionality have all been met, detecting voltage impulses on the level of the smallest of action potentials while minimizing noise in the transient. Furthermore, our price point comes in at less than ~$50, much less than the $1000 benchmark comparison used in Cornell labs today. Extracellular voltage amplifiers are vital implements in being able to examine action potentials in many different applications, from ECG to EEG to simpler motor nerve cells, the tunable gain format and noise suppression allows for these varied capabilities. By developing such a staple implement of biological studies in an easy to assemble, cost reductive way, we produce a significant impact on all student biological research labs alike.

ACKNOWLEDGEMENTS & REFERENCES:

B. R. Land, R. A. Wyttenbach, and B. R. Johnson, "Tools for physiology labs: An inexpensive high-performance amplifier and electrode for extracellular recording," *Journal of Neuroscience Methods*, vol. 106, no. 1, pp. 47–55, Mar. 2001. doi:10.1016/s0165-0270(01)00328-4

"Physiological AC Preamplifier -- Version 2," Student preamplifier, https://people.ece.cornell.edu/land/PROJECTS/preamp2/index.html.

"Action potential," Wikipedia, https://en.wikipedia.org/wiki/Action_potential.