Low-Cost Extracellular Voltage Amplifier for Neural Signal Acquisition

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Cost Barriers in Neurobiological Experiments

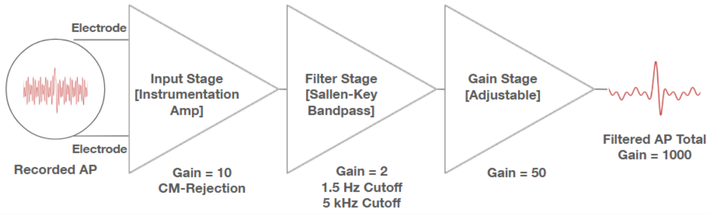
Extracellular voltage-amplifiers are necessary for measuring action potential (AP) signals in neurobiological experiments. Commercial amplifiers can cost from $500 to $1000 per device-channel. By designing a **low-cost extracellular voltage amplifier** that has comparable functionality to the commercial devices available this provides additional access to studying neural signals in both educational and *limited* resource research settings.

Amplifier Design Goals

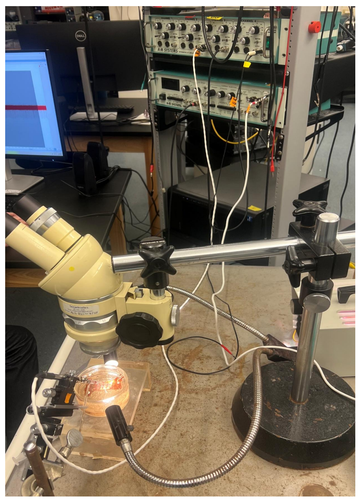
Designing Based on A-M 1700 Differential AC Amplifier:

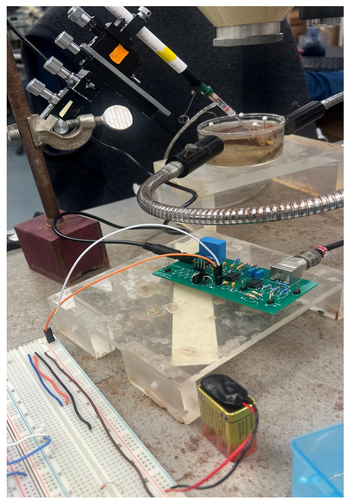
1. Simple Enough Design for DIY (Low Cost
2. Gain (Adjustable): 100 & 1000
3. Frequency Response: 1.5 Hz to 5 kHz
4. High Common-Mode-Rejection-Ratio (CMRR)
5. High Signal-to-Noise Ratio (SNR)
6. High Input Impedance
7. Powered using 9V-battery → Minimal power consumption
8. Minimal Sizing and Area

Device Block Diagram



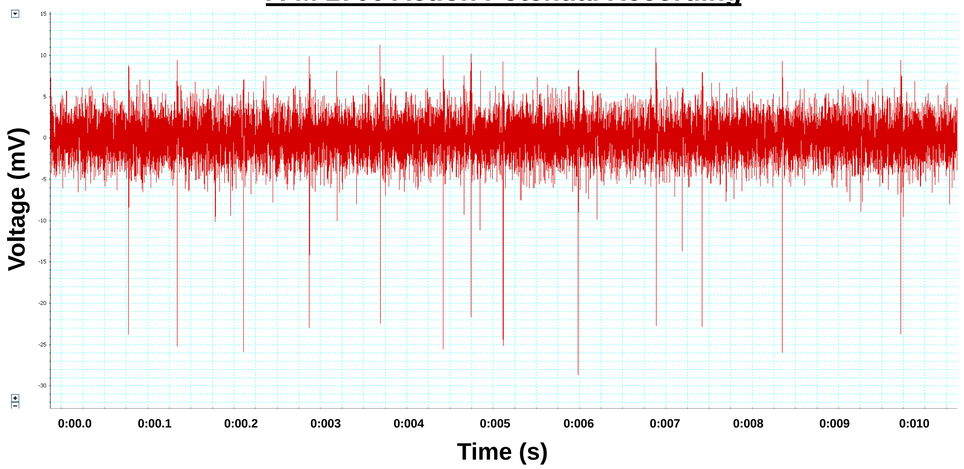
Crawdad Lab Experiment Setup



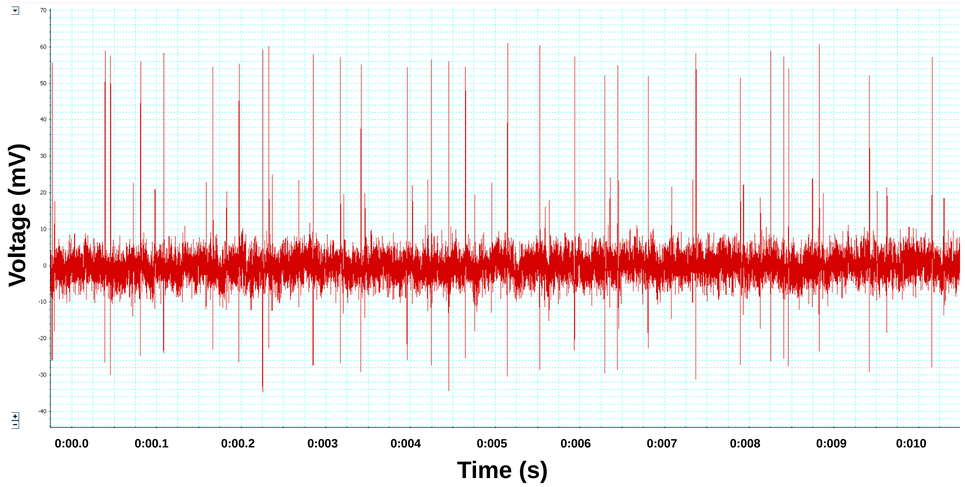


Crawdad Motor Nerve Recording: Comparable to Commercial Amplifier

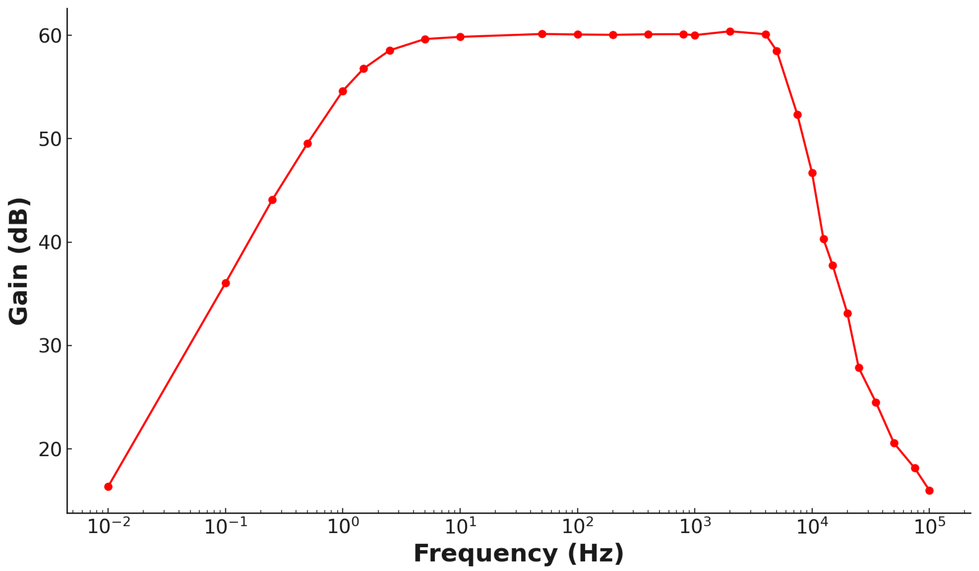
A-M 1700 Action Potential Recording



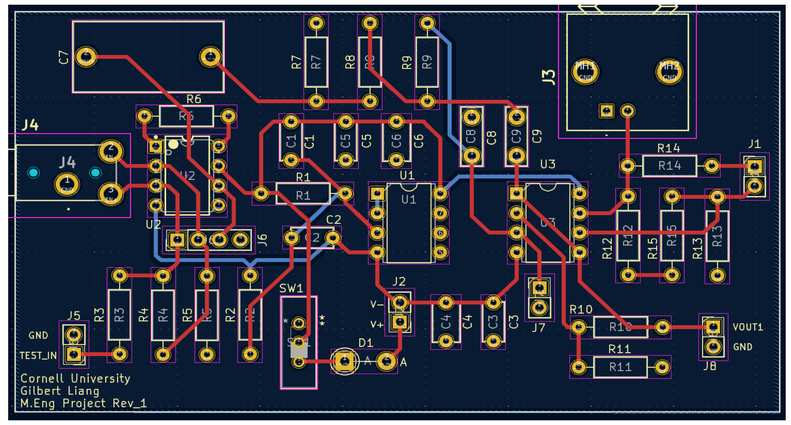
M.Eng Voltage Amplifier Action Potential Recording



M.Eng Voltage Amplifier Bode-Diagram w/ Gain set to 1000



Amplifier PCB Layout



Size: 92.4mm x 72.21mm x 19.56mm

Comparing Device Functionality

	A-M 1700 Spec.	M.Eng PCB Spec.
Gain (Adjustable):	100 | 1000 | 10,000*	100 | 1000
Frequency Response:	300Hz - 5kHz*	1.5Hz - 5kHz
Signal-to-Noise Ratio (SNR)	~ 3.5:1 (avg)	~ 4.25:1 (avg)
Input Impedance	100G Ω	1T Ω
Power Consumption	-	1.8mA @ 9V (16.2mW)
Cost	$3130 (4-Channels)	$32 (1-Channel)

Conclusion & Next Steps

A functional extracellular voltage amplifier was designed and tested in a lab experiment, recording the action potential signals from a stimulated motor nerve. When compared to the $782.5 (per device-channel) A-M 1700, the **$32 single-channel device** can provide the same gain at the defined cut-off frequencies with similar SNR while powered by a 9V battery.

Next steps:

1. Design metal-enclosure for PCB-assembly
2. Increase low cut-off frequency to 300Hz to stabilize noise floor recording
3. Add adjustable frequency functionality and multi-channel output

References

[1] B. R. Land, R. A. Wyttenbach, and B. R. Johnson, "Tools for teaching neurophysiology: The Backyard Brains SpikerBox and other projects," *J. Neurosci. Methods*, vol. 106, no. 1, pp. 47–55, Jan. 2001, doi: 10.1016/S0165-0270(01)00341-6.

[2] B. R. Johnson, "Crawdad Lab 2: Motor nerve recording," *Emory University Crawdad Lab Manual*, [Online]. Available: https://faculty.college.emory.edu/sites/wyttenbach/crawdad/2.NerveRecording.html.

[3] A-M Systems, "Model 1700 Differential AC Amplifier," *Biomedical Instruments Trading*, [Online]. Available: https://www.biomedical-instruments-trading.com/products/electrophysiology/amplifiers/differential-extracellular/84-a-m-systems-model-1700.

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