Innovations in Closed-Loop Neural Prosthetics

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USC Viterbi School of Engineering

SHINE Summer High School Intensive in Next-Generation Engineering

Introduction & Impact of Professor's Research

Neural prosthetics are devices that can interface with the brain to restore lost sensory, motor, or cognitive functions:
The creation and examination of neural stimulation and recording circuits is the focus of Professor Sideris' research project. His research sought to provide insights to the field of closed-loop neural prosthesis chips for biomedical applications by examining key design parameters for safe and effective brain stimulation as well as accurate neural recording. The results of this project would be helpful to Professor Sideris's work in neural stimulation, particularly retinal stimulation, through implementing a constant current in order to generate different output current levels. (Fig. 4)
But what could these advancements mean for you?
This research could pave the groundwork for future developments in the field of neural biomedical applications, in order to more effectively restore lost sensory, motor, or cognitive functions for loved ones and even yourself.

Research & Learning Process

Before delving into my SHINE lab project in electrical engineering under Prof. Sideris, the research and learning process was slow, occasionally frustrating. As a circuitry beginner, I had to grasp fundamental concepts like KVL, KCL, and Ohm's Law for effective circuit analysis. Navigating LTspice (Fig. 1) and KiCAD (Fig. 2) demanded time and effort both in and out of the lab. Understanding operational amplifiers, MOSFETs, and other basics were crucial for my project. Despite challenges, this learning journey laid a solid foundation and equipped me to tackle more complex aspects of electrical engineering in SHINE.

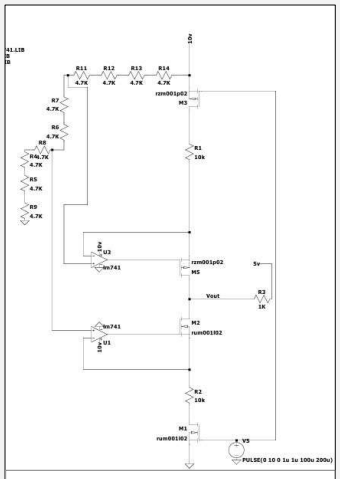

Figure 1: LTspice schematic for neural stimulator

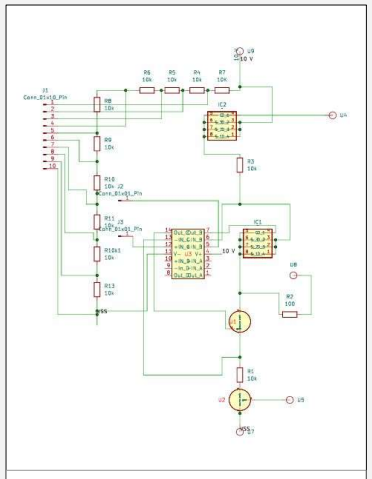

Figure 2: KiCAD schematic for neural stimulator

Methods & Results

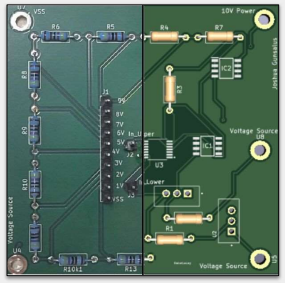

Figure 3: In our lab, my mentor and I developed a larger version of a neural stimulator with improved functionality. Through troubleshooting and some re-wiring, we were able to overcome initial challenges with the PCB (Printed Circuit Board) and obtain accurate measurements of the upper and lower regions of the circuit using an oscilloscope.

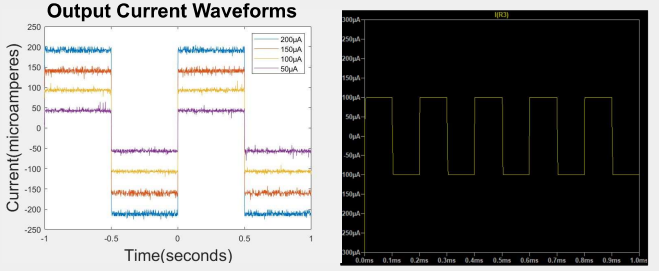

Figure 4: The figures above show the achieved objective of implementing a constant current in order to generate different output current levels. The left image is four examples of the different constant output current levels graphed in matlab using a .csv file taken from an oscilloscope. The right image is the simulation of one output current in LTspice.

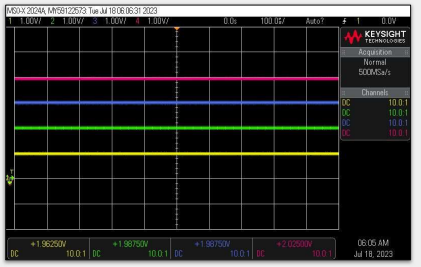

Figure 5: Four voltages of the sections between resistors in a ten resistor chain in series (Measured Using an oscilloscope. The different voltage levels provide different reference voltages in order to generate for different output current values.

Acknowledgements

I would like to thank Prof. Sideris for accepting me into his electrical engineering lab, Dr. Nguyen for mentoring me through the process of simulating, constructing, and then testing the circuit, and Monica Lopez and Marcus Gutierrez for helping this program be a fulfilling and fun experience.

Overview of Skills Learned

- LTspice(Circuit Simulation Program)
- Basic MatLab Training.
- Understanding Circuits Through KVL, KCL, and Ohm's Law
- KiCAD for Schematic Capture and PCB Layouts
- Learning the Components of a Circuit (Operational Amplifiers, MOSFETs, etc…)
- Soldering

References

Li J, Liu X, Mao W, Chen T, Yu H. Advances in Neural Recording and Stimulation Integrated Circuits. Front Neurosci. 2021 Aug 6;15:663204. doi: 10.3389/fnins.2021.663204. PMID: 34421507; PMCID: PMC8377741.

Next Steps for You OR Advice for Future SHINE Students

Although the program may feel overwhelming, keep in mind that your goal is to learn and develop. Even if everything seems new and daunting, trying your best will never hurt. The SHINE program challenges you to do your best, and if you're determined, you'll succeed. My learning process was long and uncertain due to the fact that I knew close to nothing about circuits, but simply accepting the learning process is where the genuine worth of the SHINE program lies.

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