Design of a Microelectrode Array Preamplifier
ECE 6410 Advanced Electronic Instrumentation
Fall 2009
version 18 December 2009

A microelectrode array (see http://www.multichannelsystems.com/) is essentially a Petri dish with an array of microelectrodes plated onto the bottom of the dish. Neurons, grown on top of these electrodes, connect to one another to form biological neural networks. These electrodes are used to measure and stimulate the electrical activity of these neural networks to study the effects of pharmacological agents, network formation, learning mechanisms, etc. [1]

Neurons (and electrodes) are bathed in a solution necessary for neuron growth and function. A reference electrode placed in the solution is considered to be the signal ground. Electrodes enable measurement of extracellular voltages with respect to the reference node.

Assume that the electrode voltages are sinusoidal with peak-to-peak voltage $\leq 100\ \mu V$ with frequencies ranging from 30 Hz – 3 kHz. Also assume that electrodes can have a DC offset ranging from -100mV to 100mV. Your electrode preamplifier must provide a voltage gain of 50 V/V while blocking any DC component. Assume that the electrode can be modeled as a voltage source with an output resistance of 100 kΩ (see [2] for a more complete discussion of these values). The design must utilize a Linear Technology LT1167 instrumentation amplifier.

a. Based on the above description, develop a list of quantitative specifications for your preamplifier. What is your recommendation for an acceptable CMRR? You need not worry about the upper frequency of the amplifier pass-band; a later project will add a suitable low-pass filter.
b. Design your preamplifier around the LT1167 instrumentation amplifier (you will need to read the LT1167 datasheet).
c. Use only standard value components. You must use Digi-Key (digikey.com) as the parts provider. Provide a spreadsheet that lists all parts (description and Digi-Key part number), cost per part, and total cost for your design.
d. Use LTspice to test your design to insure that all specifications are met.
e. Evaluate the CMRR performance of your preamplifier using LTspice.
f. Prepare a report that summarizes your design and includes all requested information.

This project was inspired by previous work [3, 4].

Reminders

1. Projects are to be completed on an individual basis.
2. You may NOT use any references other than your text, references cited in the project description, or references cited in the syllabus to complete this project. If you use one of these sources, CITE the source!

References

[1] S. Marom and G. Shahaf, "Development, learning, and memory in large random networks of cortical neurons: lessons beyond anatomy," *Quarterly Review of Biophysics*, vol. 35, pp. 63-87, 2002.

[2] R. A. Blum, J. D. Ross, E. A. Brown, and S. P. DeWeerth, "An integrated system for simultaneous, multichannel neuron stimulation and recording," *IEEE Transactions on Circuits and Systems—I*, vol. 54, pp. 2608-2618, 2007.
[3] Y. Jimbo, N. Kasai, K. Torimitsu, T. Tateno, and H. P. C. Robinson, "A system for MEA-based multisite stimulation," *IEEE Transactions on Biomedical Engineering*, vol. 50, pp. 241-248, 2003.
[4] J. Stahl, *Dual Channel Low Noise Amplifier for Experiments in Neurophysiology*, Western Michigan University Master of Science in Electrical Engineering thesis, June 2009.