Analog Implementation of the Hodgkin-Huxley Model Neuron

Zach D. Mobille[1,2*], George H. Rutherford[1], Jordan Brandt-Trainer[1], Rosangela Follmann [1,3], Epaminondas Rosa, Jr. [1,4]

[1]*Department of Physics, Illinois State University, Normal, IL 61761*
[2]*Department of Mathematics, Illinois State University, Normal, IL 61761*
[3]*Department of Information Technology, Illinois State University, Normal, IL 61761*
[4]*School of Biological Sciences, Illinois State University, Normal, IL 61761*

zdmobil@ilstu.edu

Neurons, the building blocks of neurological systems, are complex cells capable of decoding, encoding and transmitting information. There has been much progress in the realms of analyzing neurons physiologically, but also modeling them mathematically. In this study, we focus on the classical model introduced by Alan Hodgkin and Andrew Huxley in 1952. By performing both computer simulations of their model and constructing an electronic circuit that accurately mimicks the dynamics of the Hodgkin-Huxley neuron, we are working toward an understanding of neurons on two fronts. The implementation of the mathematical model is well-suited for comprehending the cells from a dynamical systems perspective, often leading to qualitative insights in regards to the wide array of possible behaviors demonstrated by biological neurons. The electronic neuron is a physical realization of the Hodgkin-Huxley dynamics in the form of a circuit that allows for real-time parameter adjustment. In this presentation we provide some theoretical background to the Hodgkin-Huxley model, discuss the design of the electronic neuron, and present data from the associated circuit which suggest that its dynamics are indeed analogous to the Hodgkin-Huxley model. Lastly, we compare our results to experimental recordings performed on real neurons.