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Modelling Fundamental Spiking Neural Network (SNN) Components Using Memristors

SNNs are the next generation neural networks with the ability to perform complex brain-like computations with very low power. SNNs use discrete ON/OFF signals called action potentials or spikes for data communication and processing.

In this project, you will simulate various building blocks of SNNs including the Hodgkin-Huxley Neuron, Leaky Integrate and Fire Neuron and its variants using memristors. You will also demonstrate concepts like Spike Time Dependent Plasticity (STDP), long term potentiation (LTP), long term depression (LTD) with memristive synapses.

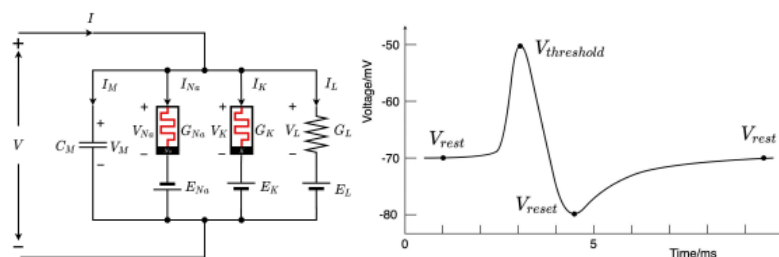


Figure 1: (a) Memristive Hodgkin Huxley (HH) Model circuit (b) the action potential of the memristive HH model [1]

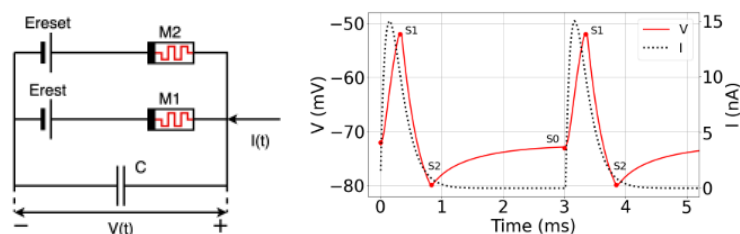


Figure 2: (a) Memristive Leaky Integrate and Fire Model circuit (b) action potential[1]

You will also build feed forward spiking neural networks using these basic components. These circuits will be behaviourally implemented in MATLAB and then implemented in cadence virtuoso circuit simulator.

Softwares: MATLAB and Cadence Virtuoso

Courses: Electronic Circuits (044137)

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Reference:

- [1] S. M. Kang et al., "How to Build a Memristive Integrate-and-Fire Model for Spiking Neuronal Signal Generation," IEEE Transactions on Circuits and Systems I: Regular Papers, Vol. 68, No. 12, pp. 4837–4850, December 2021.