

Research Migration Project

<https://esim.fossee.in/research-migration-project>



The Research Migration Project is an initiative of FOSSEE, IIT Bombay that promotes the use of eSim for reproducing published research circuits originally implemented using proprietary simulation tools. The objective is to migrate these validated designs to eSim to build an open source resource database.

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Title of the circuit : The Voltage-Amplifier Integrate-and-Fire (I&F) Neuron

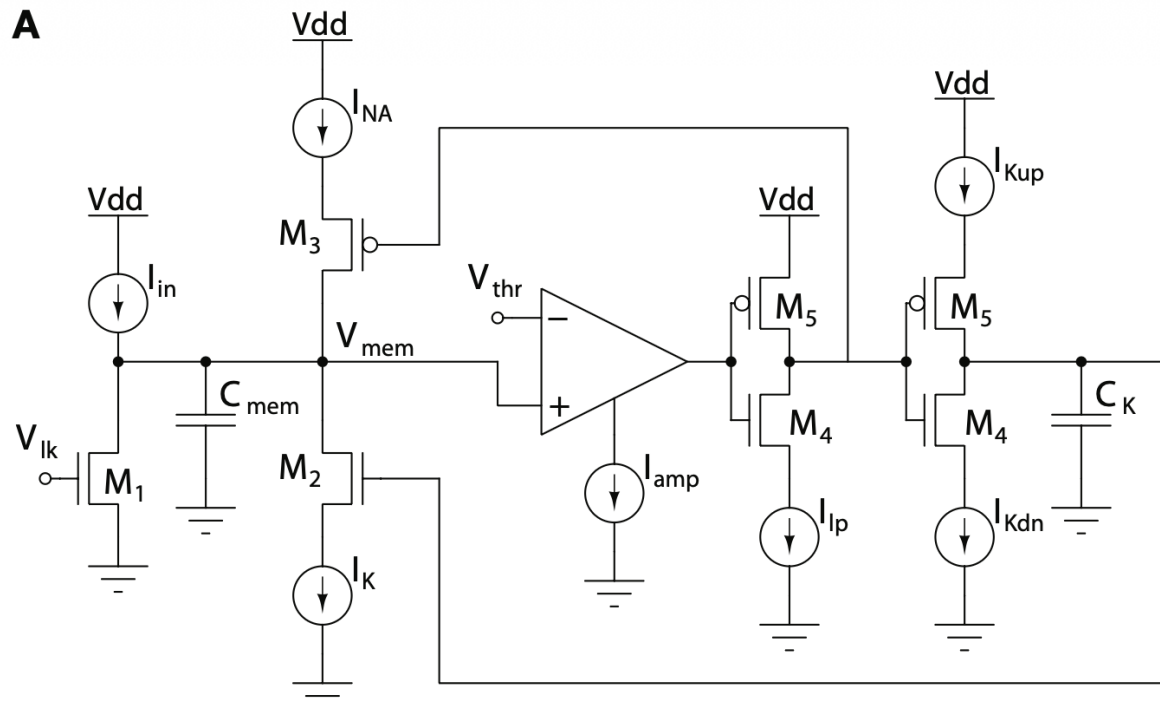
Theory/Description : Simulating a neuromorphic VLSI circuit that emulates biological action potentials using analog CMOS design. Based on the Axon-Hillock and Voltage-Amplifier topology, the circuit integrates an input current onto a membrane capacitor. Upon crossing a specific voltage threshold, a positive-feedback amplifier stage generates a discrete voltage spike and triggers a self-resetting mechanism. The simulation will utilise Ngspice transient analysis to observe the temporal spiking behaviour and inter-spike intervals under varying input currents.

Reason to reproduce with eSim : Transitioning existing simulation skills into a new open-source environment like eSim demonstrates software adaptability. Reproducing this circuit tests the limits of eSim's underlying Ngspice engine. It specifically challenges the software's ability to handle weak-inversion (sub-threshold) MOSFET modeling and precise transient analysis for positive-feedback loops.

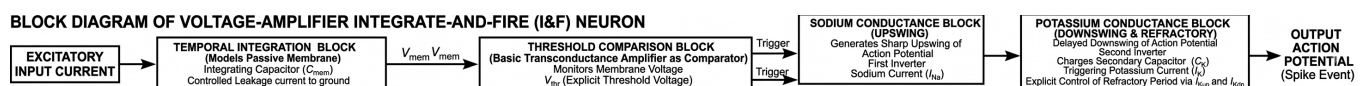
Expected Outcome/outputs : A complete, error-free schematic design of the Neuromorphic Voltage-Amplifier Integrate-and-Fire (I&F) Neuron, drafted within the eSim environment. Generation of Ngspice simulation plots demonstrating the biological action potential, specifically, the sawtooth integration of the membrane voltage V_{mem} and the sharp upswing triggered once the explicit threshold voltage V_{thr} is crossed. A full eSim project containing the schematic, netlist, SPICE models, and waveform plots.

Circuit Diagram(s) :

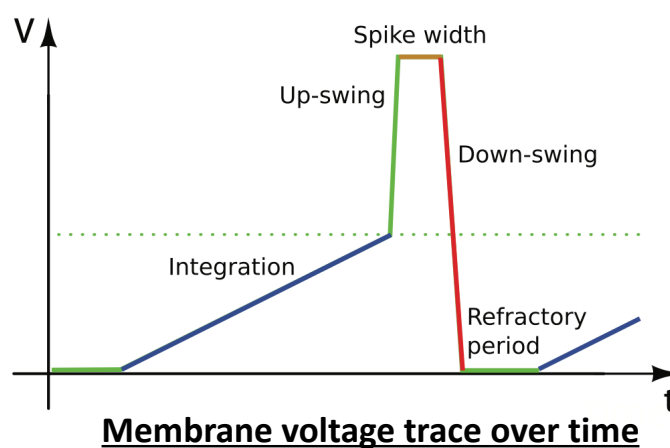
Schematic Diagram of Voltage-amplifier I&F neuron :-



Block Diagram (s) :



Expected Results (Input, Output waveforms and/or Multimeter readings) :



Research Paper/Journal/etc. :

Title : Neuromorphic Silicon Neuron Circuits

Author : Giacomo Indiveri, Bernabé Linares-Barranco, Tara Julia Hamilton, et al.

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Link : <https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2011.00073/full>

Source/Reference(s) :

- G. Indiveri et al., "Neuromorphic silicon neuron circuits," *Frontiers in Neuroscience*, vol. 5, p. 73, May 2011.
 - *Analog VLSI and Neural Systems* by C. A. Mead (1989).
 - *Analog VLSI: Circuits and Principles* by S.-C. Liu, J. Kramer, G. Indiveri, T. Delbrück, and R. Douglas (2002).
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