# Neuromorphic Circuit Design: Integrate-and-Fire Neuron with STDP Synapse

SANA
Department of Electronics and Communication Engineering
BVRIT Hyderabad College of Engineering for Women's
Sana20041712@gmail.com

## Objective / Aim:

The objective of this project is to design and simulate a neuromorphic circuit that replicates the biological behavior of an Integrate-and-Fire (I&F) neuron combined with a Spike- Timing-Dependent Plasticity (STDP) synapse using eSim. The circuit aims to model basic learning and spiking mechanisms found in neural systems for use in low-power brain- inspired computing architectures.

## Circuit Schematic:

The proposed circuit consists of two main sub-blocks: 1. STDP Synapse – Modulates the synaptic weight based on timing between pre- and post synaptic spikes. It uses MOSFET switches and capacitors to emulate synaptic learning. 2. Integrate-and-Fire Neuron – Integrates input current over a capacitor (membrane potential). When the voltage exceeds a threshold, the neuron "fires", producing an output spike, and resets.

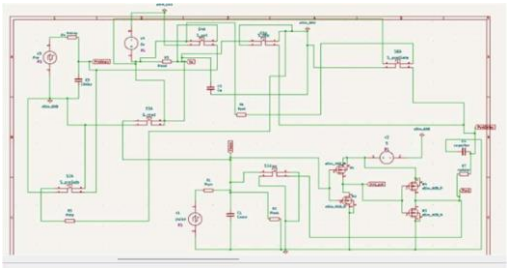
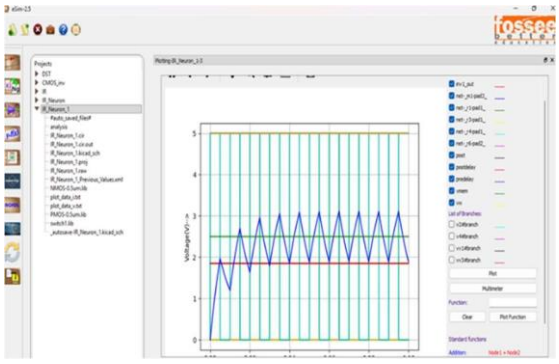


Figure 1: eSim schematic of the Integrate-and-Fire Neuron with STDP Synapse.

## Simulation Results:

The circuit was simulated using Ngspice in eSim. The plotted waveforms represent: - Vmem (blue): Membrane potential integrating over time. - Post (green): Post-synaptic spike output. - Predelay / Postdelay (yellow, red): Timing control for STDP learning behavior. - The results confirm neuron-like spiking activity and demonstrate temporal correlation between pre- and post-synaptic events.



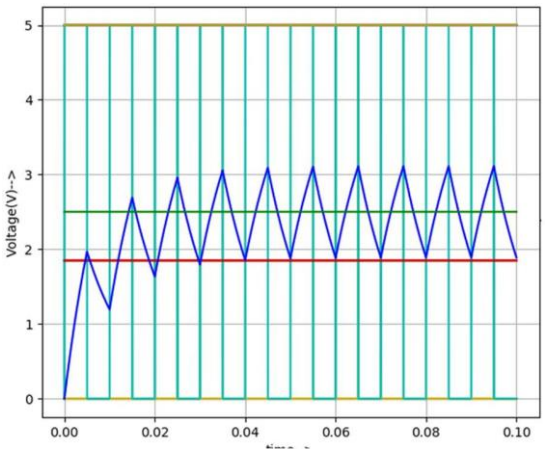



Figure 2: Simulation results showing voltage variations (spike generation and STDP timing).

## Conclusion:

The designed neuromorphic circuit successfully models integrate-and-fire behavior with an adaptive STDP learning mechanism. This validates eSim as a capable open-source tool for analog neuromorphic circuit design and testing. The work serves as a foundation for scalable neuromorphic architecture.

## GitHub Repository link:

https://github.com/sana20041/NeuromorphicNeuron_eSim

## Short README Description:

This repository contains all design and simulation files for the project "Neuromorphic Circuit Design: Integrate-and-Fire Neuron with STDP Synapse." It includes eSim schematic files (.sch, .cir), Ngspice simulation data, waveform plots, and the final PDF report. The project demonstrates neuromorphic spiking behavior and plasticity using MOSFET-based circuits on the eSim platform.

## License:



## References:

1. eSim FOSSEE Project – https://esim.fossee.in
2. Mead, C. "Neuromorphic Electronic Systems," Proceedings of the IEEE, 1990.