CADENCE IMPLEMENTATION

LOW POWER SCHMITT TRIGGER

Designing a Schmitt trigger in Cadence aimed to create a circuit with strong noise immunity and stable switching characteristics, crucial for applications requiring signal conditioning and noise suppression. The Schmitt trigger design focused on achieving robust hysteresis to improve signal stability.

Objective: The primary goal was to achieve reliable hysteresis by optimizing transistor sizing and implementing effective design techniques within the Cadence environment.

Design Approach:

Parameter Optimization: Transistor sizing was adjusted to ensure a balance between hysteresis width and reliable performance.

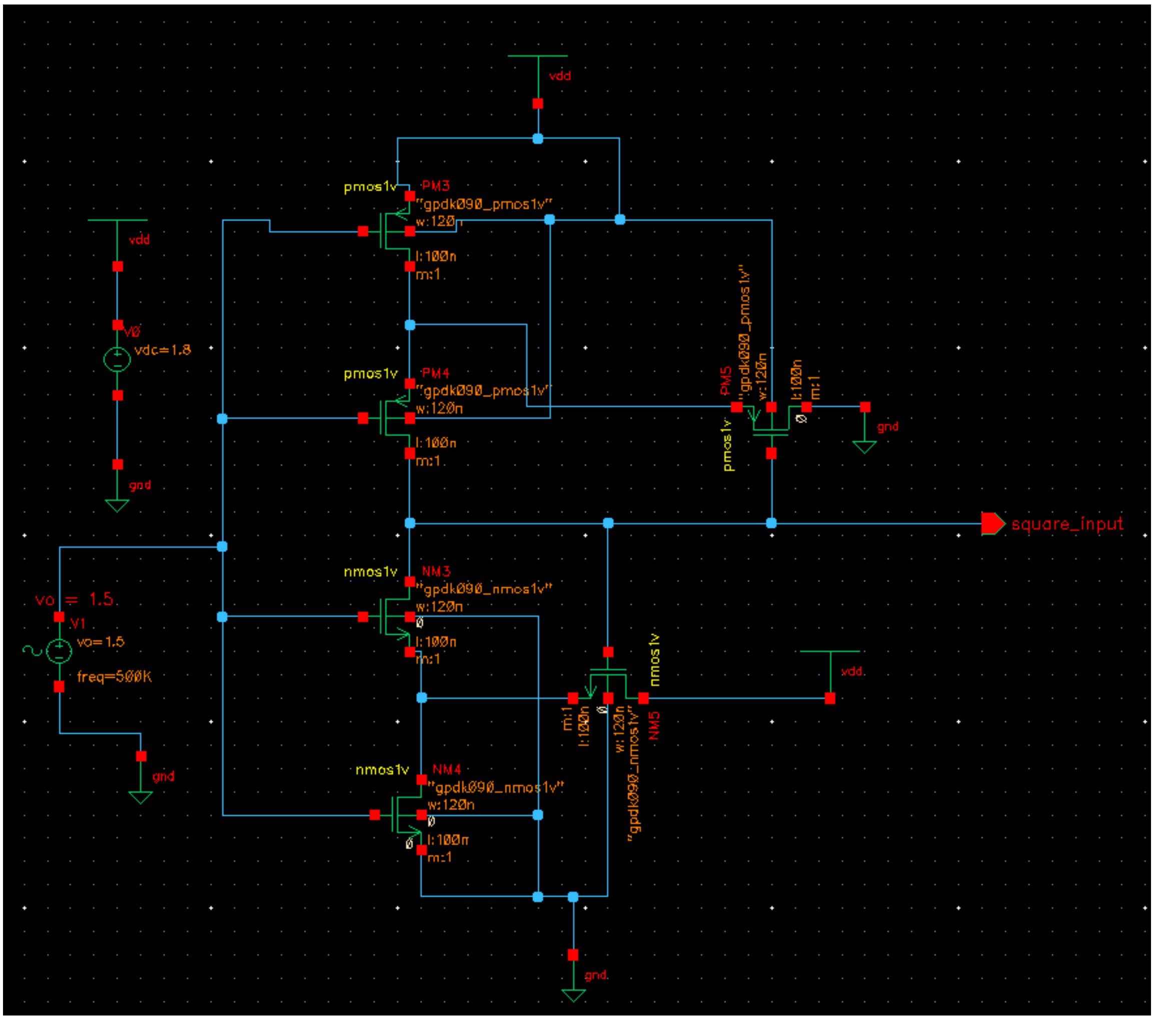
Simulation: Multiple simulations were run in Cadence to verify noise immunity, stability, and correct threshold levels across a range of input conditions.

Results and Observations:

The final design successfully demonstrated stable hysteresis characteristics and effective noise rejection, achieving reliable switching performance.

Conclusion: This Schmitt trigger design serves as an effective solution for circuits that require stable signal switching, underscoring the utility of Cadence for analog design.

Schematic



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pmos1v
gnd
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nmos1v
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m:1
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vo=1.5
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gnd
nmos1v
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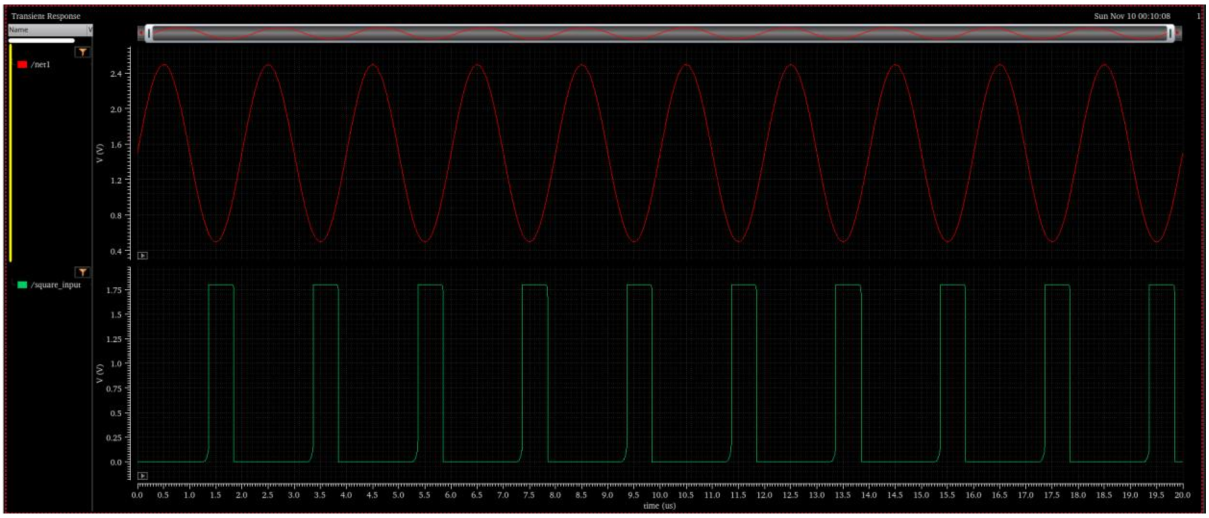
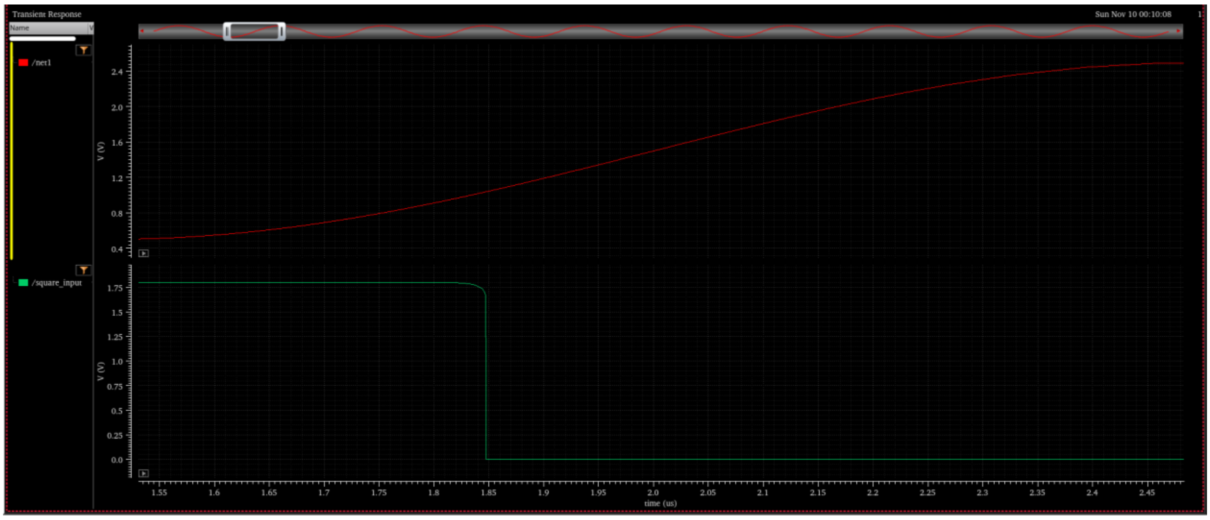
l:100n
m:1
gnd

Output of Schmitt Trigger





LIF MODEL FOR SPIKING NEURAL NETWORK

The Leaky Integrate-and-Fire (LIF) neuron model was designed to emulate spiking neural activity, incorporating a Schmitt trigger, integrate module, reset, and refractory circuits. This design aimed to simulate biological neuron behavior accurately by generating spikes in response to input signals while controlling spike timing and frequency.

1. Objective: The goal was to create a biologically-inspired neuron model that could capture essential spiking dynamics, including threshold-based firing, resetting after each spike, and a refractory period to prevent immediate reactivation.

2. Design Approach:

- Schmitt Trigger: Employed to introduce a sharp firing threshold, mimicking the neuron's response when membrane potential reaches a critical level.

- Integrate Module: Implemented to accumulate input signals, which gradually increase the simulated membrane potential until it reaches the firing threshold.

- Reset and Refractory Circuit: Designed to reset the membrane potential after each spike and introduce a refractory period, preventing the neuron from firing again immediately.

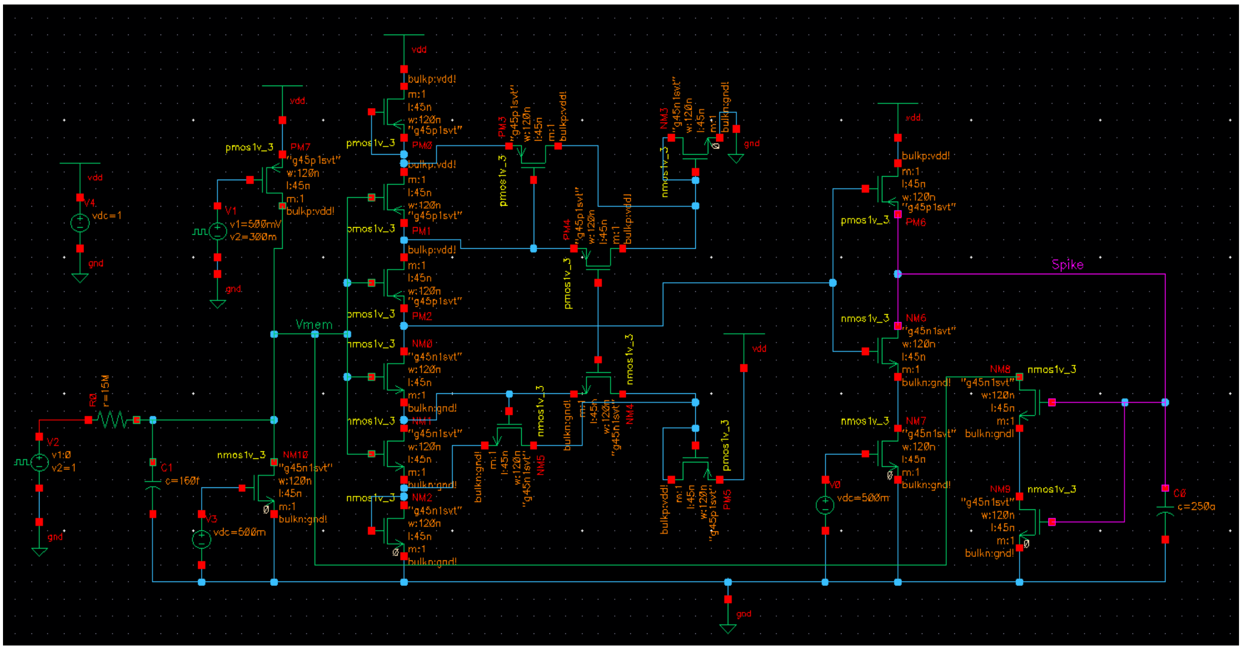
3. Results and Observations:

- The LIF neuron model successfully produced distinct spiking behavior, with the Schmitt trigger ensuring precise threshold crossing and the reset and refractory circuits maintaining accurate spike timing.

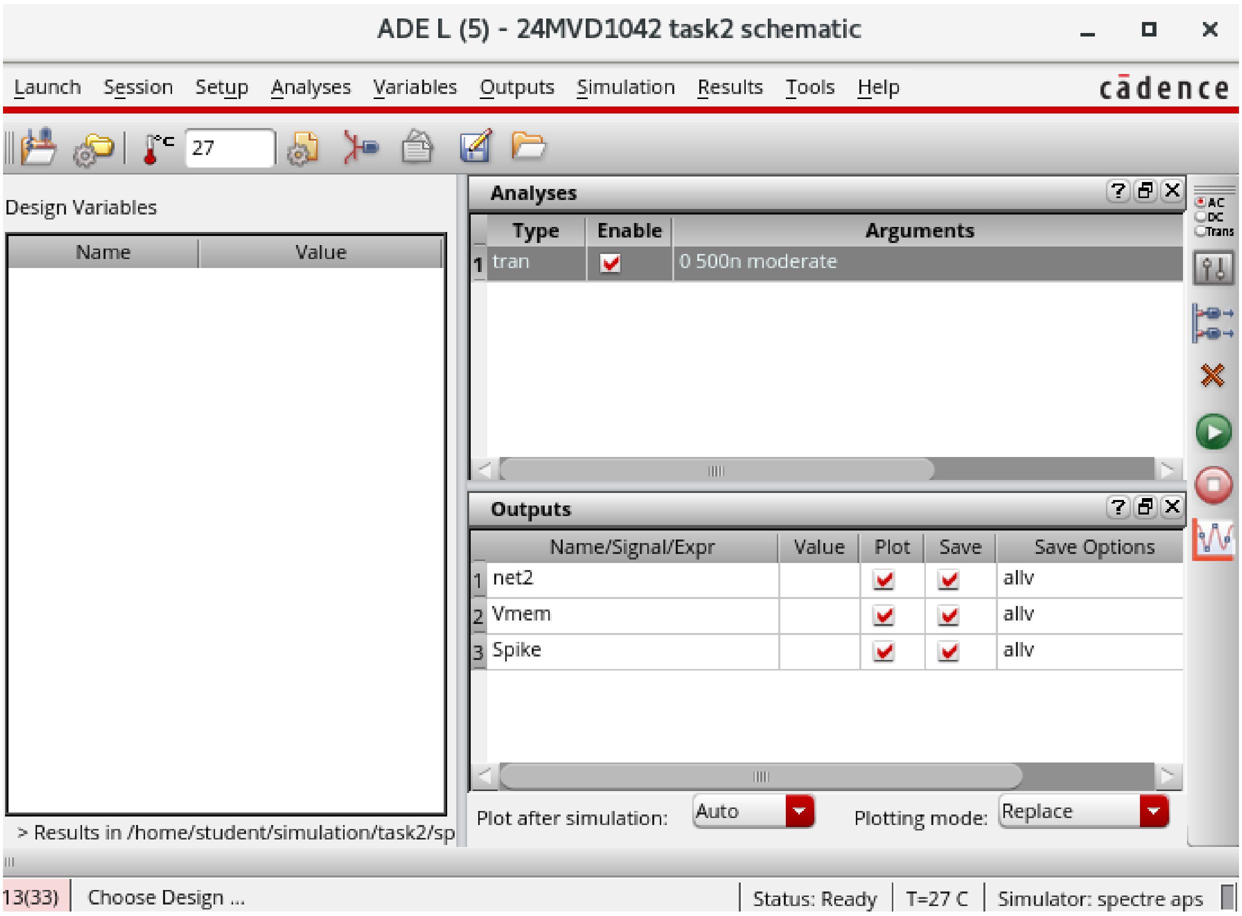
- The model demonstrated realistic neural responses, including predictable firing rates based on input magnitude and effective control over the spike frequency.

4. Conclusion: This LIF neuron model, utilizing a Schmitt trigger and refractory circuit, provides a robust platform for simulating spiking neuron activity in neuromorphic systems, supporting applications in neural networks and bio-inspired computing.

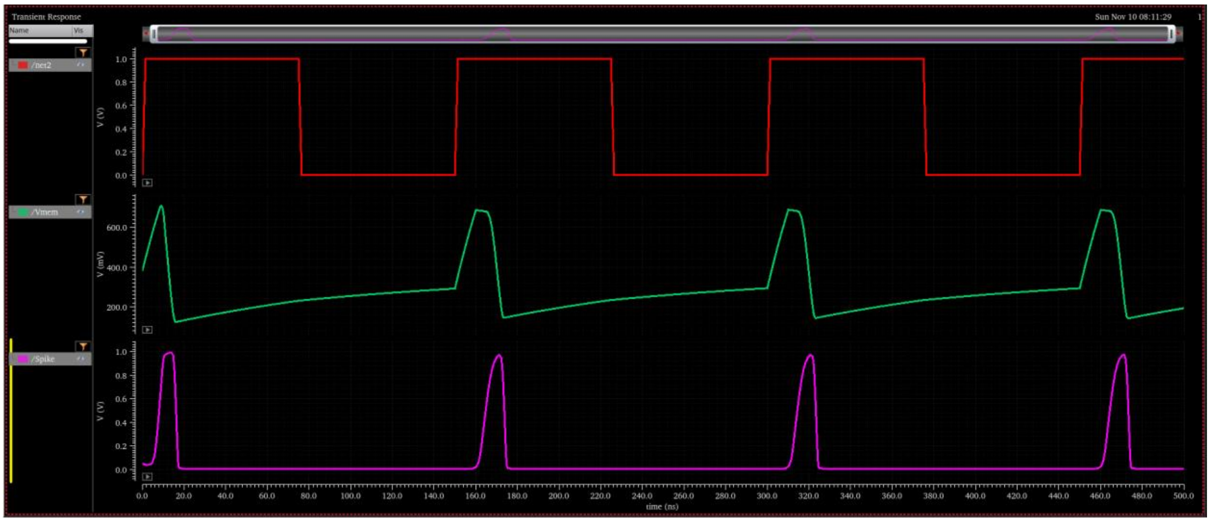
Schematic for LIF



ADE L Values for Transient Analysis



OUTPUT



INFERENCE

1. **Low-Power CMOS Implementation**: The paper proposes a CMOS-based Leaky Integrate-and-Fire (LIF) neuron model with low energy consumption, utilizing only 524.415aJ per spike.

2. **Biological Inspiration:** The model emulates biologically plausible tonic and burst spiking behavior by incorporating mechanisms such as leaky integration, dynamic refractory periods, and spike frequency modulation.

3. **Schmitt Trigger Integration:** A Schmitt trigger-based comparator is used, which improves noise immunity, increases switching speed, and reduces energy usage, enhancing model efficiency.

4. **Dynamic Control:** Spike frequency and refractory period are dynamically controlled by adjusting membrane capacitance and reset circuitry, allowing flexible neuron behavior simulation.

5. **High Simulation Accuracy:** The model, simulated on Cadence Virtuoso using 45 nm technology, produces precise spike pulse widths (1.867 ns) and refractory periods (0.2 ns).

6. **Efficiency in Neuromorphic Computing:** With its reduced power consumption and biologically realistic spiking patterns, this neuron model supports low-power neuromorphic computing, beneficial for applications in AI and bio-inspired computing.

7. **Advantages over Conventional Models:** The proposed model is more power-efficient than conventional LIF neuron models, making it suitable for next-generation neuromorphic systems with minimized energy requirements.

8. **Insights into Design Trade-offs**: The paper explores how spike width, frequency, and energy consumption are influenced by design parameters, offering insights for future low-power neural circuit designs.

APPLICATIONS

1. **Medical Devices for Real-Time Neural Signal Processing**: The low-power, biologically realistic spiking behaviour can be useful in implantable or portable medical devices for real-time processing of neural signals, potentially aiding in treatments like brain-computer interfaces or prosthetics.

2. **High-Speed Data Analysis for Big Data**: The model's efficient spike-based processing is suitable for applications in data centres or big data processing units, where fast, energy-efficient analysis of streaming data is required.

REFERENCES

1. Biologically Inspired Tonic and Bursting LIF Neuron Model for Spiking Neural Network: A CMOS Implementation
2. https://neuronaldynamics.epfl.ch/online/Ch1.S3.html
3. https://youtu.be/OPMqKXwaJ5U?si=9Ob5XbhlUDKxsr6L
4. https://youtu.be/_f5fR7NXg7k?si=yeKK0mEj9umqWL3-

RESULT

In summary, this model delivers energy-efficient, high-speed, and biologically accurate neuron behavior, which can greatly enhance the performance of next-generation neuromorphic hardware, making it ideal for low-power AI and neuromorphic applications.