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 : DESIGN AND SIMULATION OF A CMOS SCHMITT TRIGGER USING ESIM FOR HYSTERESIS-BASED SIGNAL CONDITIONING

Theory/Description :

A Schmitt Trigger is a comparator circuit with hysteresis, used to convert noisy or slowly varying input signals into clean digital output signals. It introduces two distinct threshold voltages: the Upper Threshold Voltage (UTP) and Lower Threshold Voltage (LTP), thereby preventing false triggering due to noise.

The circuit is typically implemented using an operational amplifier such as the LM741 Operational Amplifier or comparator IC. Positive feedback is applied through a resistor network, which creates hysteresis. When the input signal exceeds the upper threshold, the output switches to a high state, and when it drops below the lower threshold, the output switches to a low state.

This hysteresis behavior makes the Schmitt Trigger highly effective in applications such as signal conditioning, waveform shaping, debouncing circuits, and analog-to-digital interfacing.

Reason to reproduce with eSim :

The Schmitt Trigger circuit is highly suitable for implementation using the eSim platform due to the following reasons:

- **Open-source environment allowing cost-free simulation and accessibility**
- **Integration with Ngspice enables accurate analog circuit simulation**
- **Educational value for understanding comparator behavior and hysteresis**
- **Ease of modification to analyze different resistor values and threshold levels**

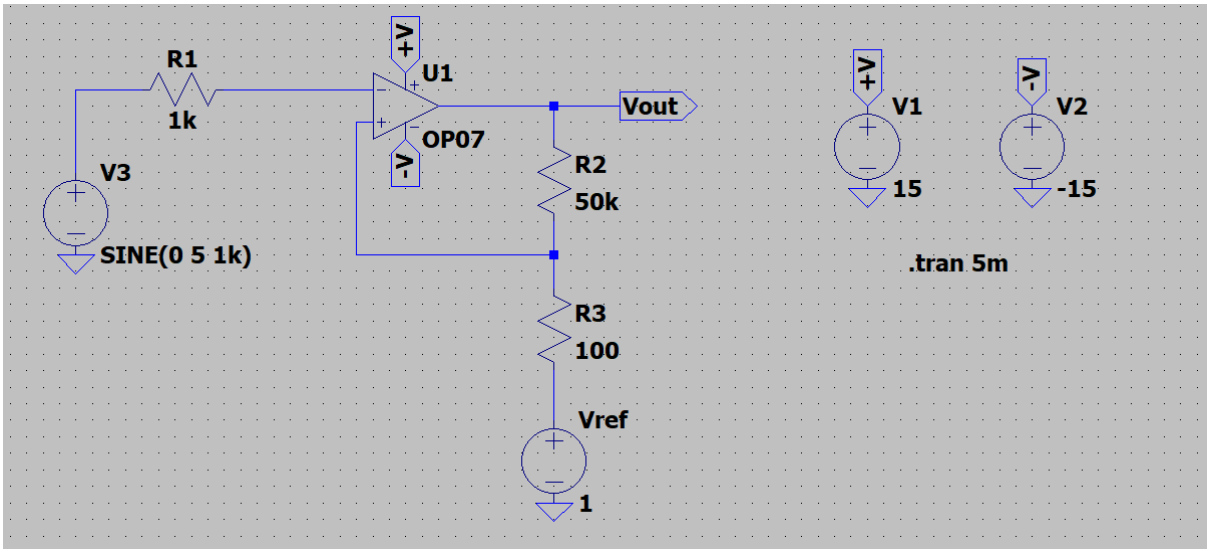
- **Verification of theoretical results through waveform visualization**
- **Bridges theory and practical implementation for VLSI and embedded systems students**

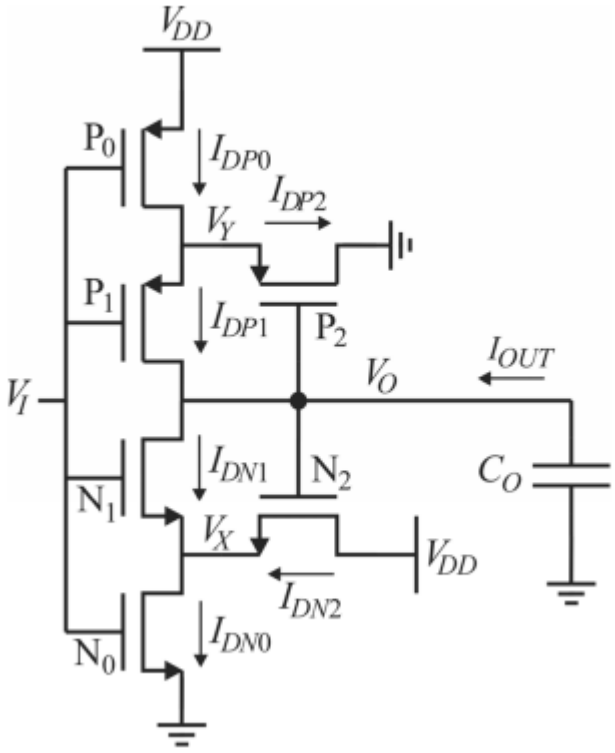
Using eSim, the circuit can be simulated before hardware implementation, reducing errors and improving design efficiency.

Expected Outcome/outputs :

1. **The circuit should convert a noisy analog input signal into a clean square wave output**
2. **Two distinct switching thresholds (UTP and LTP) will be observed**
3. **Output will toggle between saturation levels (+Vcc and –Vcc or 0–Vcc depending on configuration)**
4. **The hysteresis loop can be verified by plotting input vs output**
5. **Improved noise immunity compared to a simple comparator**

Circuit Diagram(s) :





The circuit consists of:

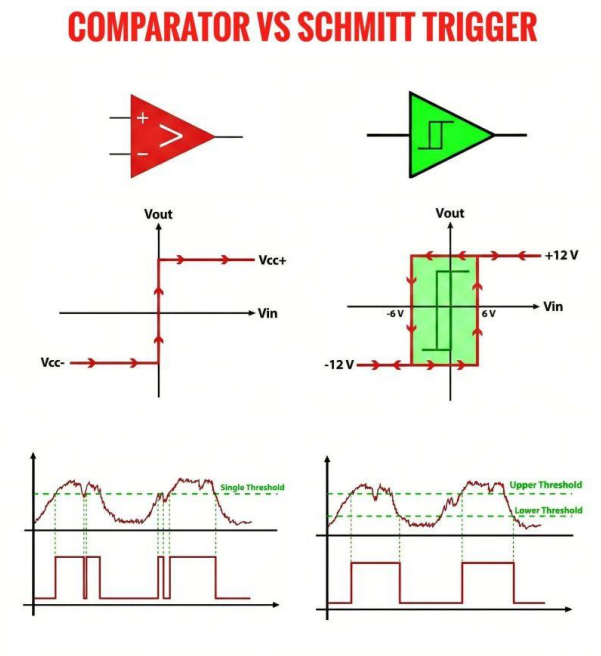
- **Operational Amplifier (e.g., LM741)**
- **Feedback resistor network (R1, R2)**
- **Input resistor**
- **Power supply (+Vcc and –Vcc or single supply)**
- **Input signal source**

Block Diagram (s) :

Blocks:

1. **Input Stage (VI)**
2. **PMOS Pull-Up Network (P0, P1, P2)**
3. **NMOS Pull-Down Network (N0, N1, N2)**
4. **Feedback Network (P2 & N2)**
5. **Output Node (VO with load capacitor CO)**

Signal Flow:
Input → Switching Network → Feedback → Output



Blocks include:

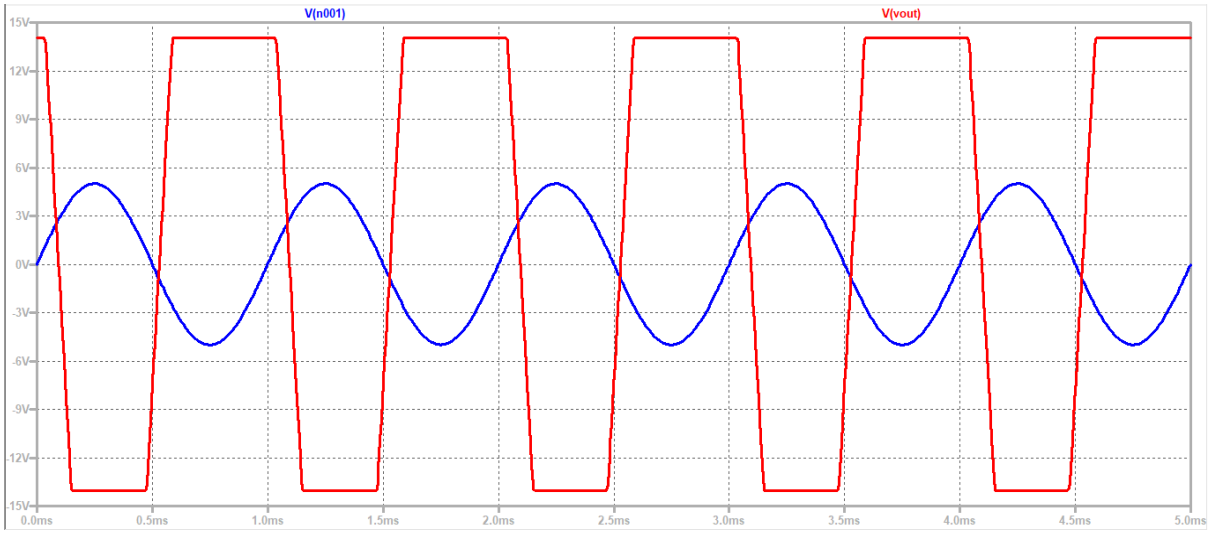
1. **Input Signal Source**
2. **Comparator with Positive Feedback**
3. **Threshold Generation Network**
4. **Output Signal (Digital waveform)**

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

- **Input Signal:**
    1. **Sine wave / noisy signal**
    2. **Voltage range: e.g., ±2V**
- **Output Signal:**
    1. **Square wave**
    2. **Sharp transitions at threshold voltages**
- **Waveform Observations:**
    1. **Output switches only at UTP and LTP**

2. **No multiple transitions due to noise**
3. **Clear hysteresis loop in transfer characteristics**

- **Multimeter Readings:**
  1. **Output High ≈ +Vcc**
  2. **Output Low ≈ –Vcc (or 0V for single supply)**
  3. **Threshold voltages depend on resistor ratio**



Research Paper/Journal/etc. :

Title : Analysis and Design of the Classical CMOS Schmitt Trigger in Subthreshold Operation

Author: L. A. P. Melek et al.

Page No. : 1

Link :

https://lci.ufsc.br/pdf/Analysis%20and%20Design%20of%20the%20Classical%20CMOS%20Schmitt-Trigger%20in%20Melek%20TCAS-I%202017.pdf?utm_source=chatgpt.com

Source/Reference(s) :

1. **Microelectronic Circuits**
2. **Design of Analog CMOS Integrated Circuits**
3. **eSim documentation**
4. **Op-amp datasheet for LM741 Operational Amplifier**
5. **NPTEL lectures on Analog Circuits**