VIDEO#35: Electronic Basics #35: Schmitt Trigger and when to use them

Schmitt Triggers

Operational Amplifier as a Comparator

An operational amplifier (op-amp) can be used as a comparator by connecting a reference voltage (e.g., 2.5V) to its inverting input and a triangle wave signal (0-5V) to its non-inverting input. The output of the op-amp will then produce a square wave. This behavior follows the first golden rule of op-amps, which states that the op-amp will do anything to make the voltage difference between its inputs zero. Since there is no feedback in this configuration, the output either swings to the positive supply voltage when the non-inverting input is higher than the inverting input or swings to zero volts when the inverting input is higher. This makes the op-amp function as a comparator, which is useful for voltage monitoring applications such as activating an alarm when a voltage crosses a threshold.

Limitations of a Basic Comparator

Although comparators are useful, they are not perfect. When observing the output while the monitored voltage crosses the reference voltage, there are multiple unwanted pulses rather than a single, clean transition. This noise-related issue can cause instability in practical applications.

Introduction to Schmitt Triggers

Schmitt triggers solve the noise issue associated with basic comparators. A Schmitt trigger introduces hysteresis, which means it has two threshold values: a high threshold and a low threshold. The output only switches to high when the input exceeds the high threshold and switches to low when the input falls below the low threshold. This prevents multiple transitions within the hysteresis range and ensures a stable output.

Types of Schmitt Triggers

1. **Non-Inverting Schmitt Trigger**: The output is high when the input is above the high threshold and low when the input is below the low threshold.
2. **Inverting Schmitt Trigger**: Works similarly but reverses the output states for the high and low threshold values.

Designing a Schmitt Trigger with an Op-Amp

A Schmitt trigger can be built using an op-amp and a couple of resistors. The resistor configuration determines the threshold voltages and the hysteresis range.

Schmitt Trigger IC: 74HC14

Instead of building Schmitt triggers with op-amps, it is common to use dedicated ICs like the 74HC14 Hex Inverting Schmitt Trigger. This IC consists of six Schmitt triggers and operates with a supply voltage of 5V. The datasheet provides details about its characteristics, including its threshold voltages.

Experimental Observation of Threshold Voltages By using an oscilloscope and varying the input voltage, we can determine the threshold voltages of the 74HC14. Practical measurements show threshold voltages around 2.1V (low) and 3.1V (high), which match the datasheet specifications.

Applications of Schmitt Triggers

1. **Debouncing Push Buttons**
    - When using a mechanical push button as an input, noise occurs due to bouncing.
    - A Schmitt trigger, combined with an RC filter, ensures a smooth transition.
    - However, microcontrollers like Arduino already incorporate Schmitt trigger behavior in their digital inputs, meaning only an RC network is required for debouncing.
2. **Relaxation Oscillators**
    - A capacitor and resistor can be added to a Schmitt trigger circuit to create a simple relaxation oscillator.
    - The hysteresis voltage causes continuous charging and discharging of the capacitor, generating a stable square wave output.
    - By using a potentiometer, the frequency can be adjusted within the kilohertz range.

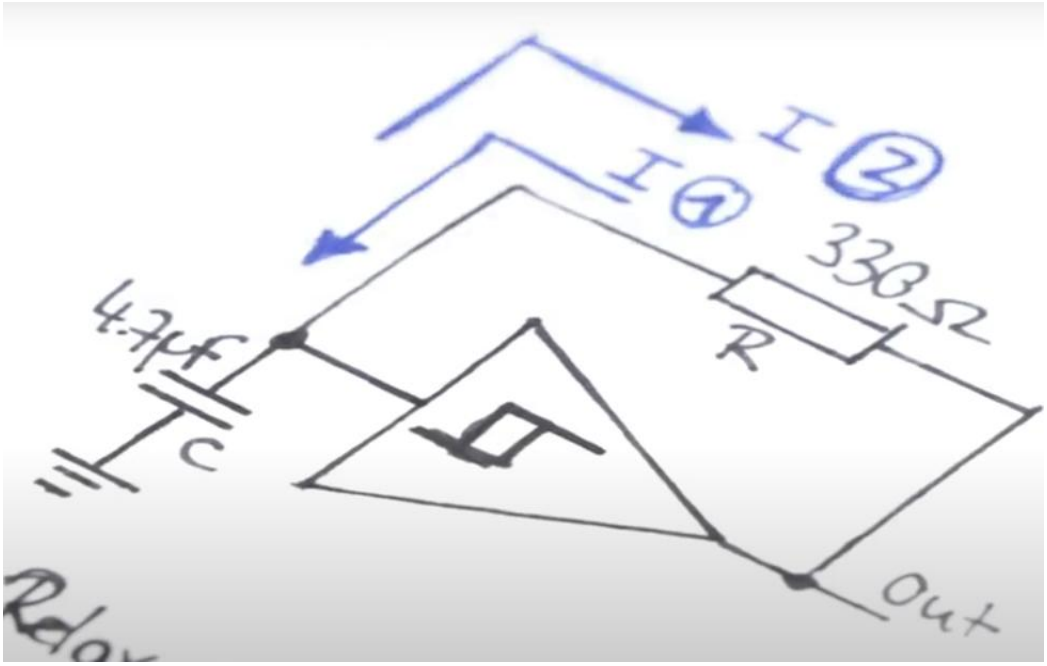

FIG: **Relaxation Oscillators**

3. **Signal Conditioning**
    - Schmitt triggers can clean up noisy or degraded digital signals.
    - By reshaping signals with well-defined transitions, they improve data integrity in digital circuits.

Schmitt triggers are essential components in electronics, providing noise immunity and signal stability. They are widely used in debouncing, oscillators, and signal conditioning. Understanding their working principles helps in designing efficient circuits that require clean and reliable switching behavior.