

Lab 10: Schmitt Trigger

U.C. Davis Physics 116B (Rev. 05)

Reference: *Bobrow*, pp. 704-710

Prelab Problem: Prove Equation 1 (include in your lab notebook).

INTRODUCTION

Like the Wien bridge oscillator in 116A, the Schmitt trigger is an application of positive feedback. This circuit is a voltage comparator with hysteresis. A voltage comparator will give as its output one of two voltages:

$$V_{\text{out}} = \begin{cases} +15\text{ V} & \text{for } V_{\text{in}} > V_{\text{th}} \\ -15\text{ V} & \text{for } V_{\text{in}} < V_{\text{th}} \end{cases}$$

where V_{th} is a threshold voltage. A voltage comparator with hysteresis will have a different V_{th} for rising input voltages than for falling input voltages.

In this lab, we will build a Schmitt trigger using the 741 op amp, our analog circuit workhorse. We will measure V_{th} and verify the circuit's operation as a voltage comparator.

1. SCHMITT TRIGGER

The Schmitt trigger circuit is shown in figure 1. Build this circuit at least twice, each time with a different set of resistors. Some recommended values are 10k Ω , 10k Ω , 100k Ω ; or 10k Ω , 10k Ω , 1M Ω ; or 10k Ω , 22k Ω , 100k Ω . Use the variable voltage supply for V_{in} and measure it with the voltmeter. Measure V_{out} with the oscilloscope and note how fast the output switches from +15V to -15V. For each set of resistors, record V_{th} for both positive and negative transitions. See how close they are to the predicted values:

$$V_{\text{th}} = \frac{R_1 \parallel R_2 \parallel R_3}{R_2} V_{\text{bb}} + \frac{R_1 \parallel R_2 \parallel R_3}{R_3} V_{\text{out}} \quad (1)$$

For your lab report, report these measured and predicted voltages and draw them on a V_{out} vs V_{in} curve showing the hysteresis loop. (Make a separate drawing for each set of R 's.)

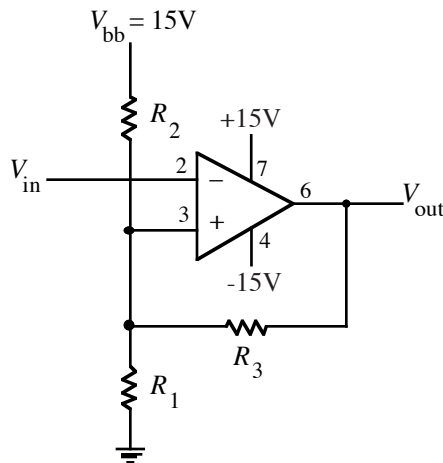


Fig 1: Schmitt trigger circuit.

For each set of resistor values, apply a sine wave or a triangle wave to the input and sketch the output. For your lab report, sketch these waveforms, showing the input voltages where the output switches and compare these to the V_{th} 's you measured with the voltmeter.

2. SIMULATED NOISY SOURCE

To see how a Schmitt trigger might be useful, we will construct a source with some fake noise introduced into it. Figure 2 shows how to do this using two function generators and a second op amp, used as a summing amplifier. Build this circuit and use it as the input to your Schmitt trigger. Regard the 1 kHz sine wave as the "signal" and the 10 kHz sine wave as the "noise". For your lab report, sketch the input and output waveforms, being careful to show each time the input crosses a V_{th} and what the output does in response. Try to determine approximately how much hysteresis is required to filter out a given amount of noise.

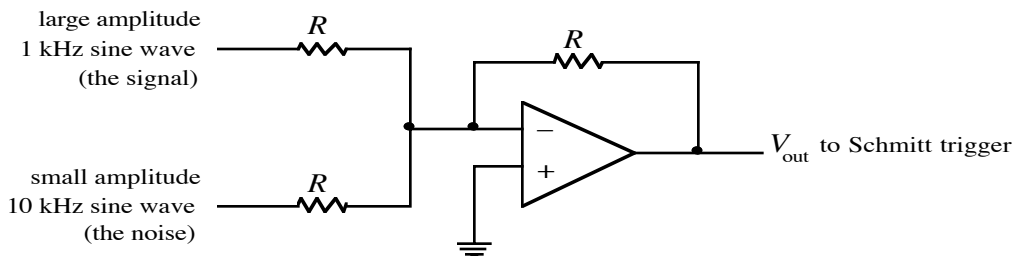


Fig 2: Simulated noisy source.

Notes on Lab 10 (Schmitt Trigger)

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- I. Be sure to set the +15 V and -15 V power supplies to the proper values before connecting them to the rest of the circuit.
- II. If available, use an LF411 op amp instead of the LM741 for the Schmitt trigger. The LF411 has a maximum slew rate of 10 V/ μ s, much faster than the 741 (0.5 V/ μ s). Use a 741 for the summing amplifier (speed is not an issue here).
- III. The breadboards have only two variable voltage sources, which are in use for the ± 15 V op amp supplies. You can use the 10 k Ω pot to produce a variable voltage for the Schmitt trigger V_{in} . One end of the pot resistor should go to +15 V and the other to -15 V. The center connection then provides the variable voltage. **Caution:** *do not* use the 1 k Ω pot. It would dissipate too much power and burn out.

Alternatively, you can use a triangle wave input for V_{in} and simultaneously observe V_{in} (Ch. 1) and V_{out} (Ch. 2) on the oscilloscope (you are asked to do this anyway). Trigger on Ch. 1. You can then measure the values of V_{in} when the output switches and the time required for the output to switch.

You can also use the x-y display feature of the oscilloscope (in the “horizontal” menu) to display V_{out} (y, Ch 2) vs. V_{in} (x, Ch. 1). This is the hysteresis loop diagram (excitation curve).