Lab 5: Schmitt Trigger and Relaxation Oscillator

UC Davis Physics 116B
Rev 1/11/2019

Introduction

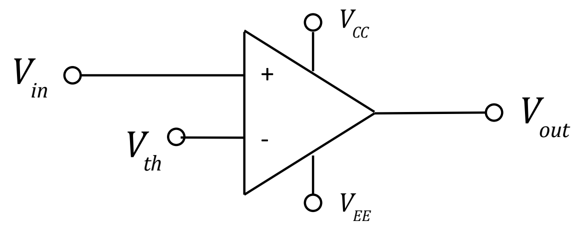

Figure 1: An open loop op-amp as a comparator

An open loop op-amp can be thought of as a comparator, as shown in Figure 1, with the following behavior:

$$V_{in} > V_{th} \rightarrow V_{out} = V_{CC}$$
$$V_{in} < V_{th} \rightarrow V_{out} = V_{EE}$$

As we discussed in class, this circuit can be unstable for inputs near the threshold.

A Schmitt Trigger uses feedback to change the threshold depending on the output state, in order to improve its stability.

Schmitt Trigger

The Schmitt trigger circuit is shown in Figure 2. Build this circuit using an LM741, with ± 15V power supplies. Use $R_1 = R_2 =$10kΩ, and R_3=100kΩ. Drive the circuit with a 1kHz triangle wave, with a 20V peak-to-peak amplitude. Verify the transition threshold for both the rising and filling slopes and verify that they match the prediction of:

$$V_{th} = \frac{R_1||R_2||R_3}{R_2} V_{bb} + \frac{R_1||R_2||R_3}{R_3} V_{out}$$

For your lab report, include images of the scope traces, including a close up on both the rising and falling transition.

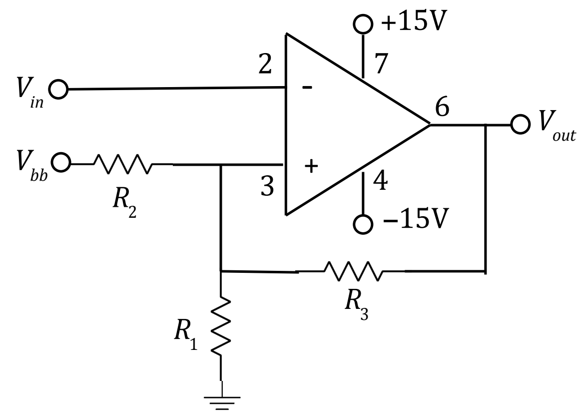

Figure 2: A Schmitt Trigger

Simulated Noisy Source

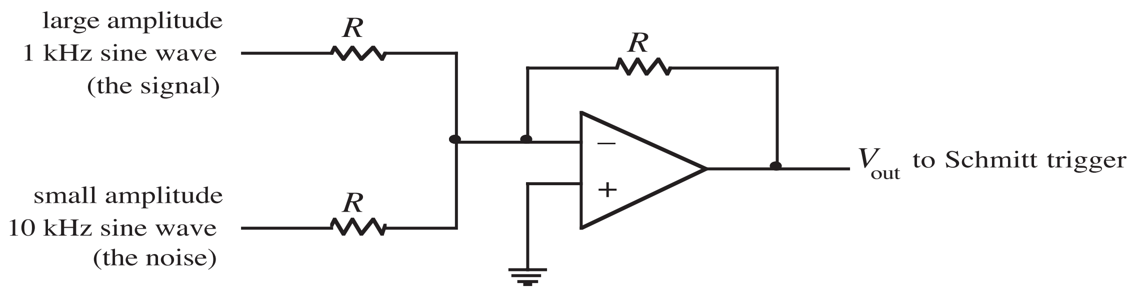

Figure 3: A simulated noise source.

To see how a Schmitt trigger might be useful, we will construct a source with some fake noise introduced into it. Figure 3 shows how to do this using two function generators and a second 741 op-amp, used as a summing amplifier. Build this circuit and use it as the input to your Schmitt trigger. Make all resistors equal, with values of a few kΩ. Regard the 1kHz sign wave as the "signal" and the 10 kHz sine wave as the "noise". For your lab report, include a picture of the scope trace showing both the input and the outpu, being careful to show each time the input crosses a Vth and what the output does in response. Determine the amplitude of the "noise" signal that will cause multiple transitions on the rising edge of the signal. Include an image of this in your report.

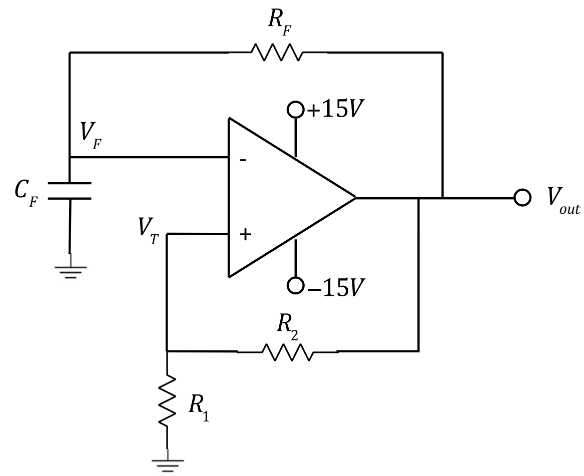

Figure 4: Relaxation oscillator.

Relaxation Oscillator

Construct the relaxation oscillator shown in Figure 4. Use $R_1 = R_2 = R_F = 10\text{k}\Omega$ and C_F=10nF. Verify that the period of the oscillation is

$$T = 2R_F C_F \ln\left(\frac{2R_1 + R_2}{R_2}\right)$$

as we derived in class.

For your lab report, include a picture of the output waveform.