

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
Department of Electrical and Computer Engineering

EXPERIMENT 4 – COMPARATORS AND SCHMITT TRIGGERS

OBJECTIVES

The purpose of this experiment is to familiarize the student with op-amp Comparators and Schmitt Triggers. Design methods and typical applications are investigated.

INTRODUCTION

Comparator circuits are used to compare an input voltage with a reference voltage. The output state is determined by the input voltage with respect to the reference voltage. For the comparator circuit shown in Figure 4-1, the output will be at its negative saturation value when the input is greater than the reference and at its positive saturation value when the input is less than the reference. One problem encountered with the simple comparator is the instability of its output resulting from noise when the input is in the neighborhood of V_r . The Schmitt trigger provides a method for dealing with this problem.

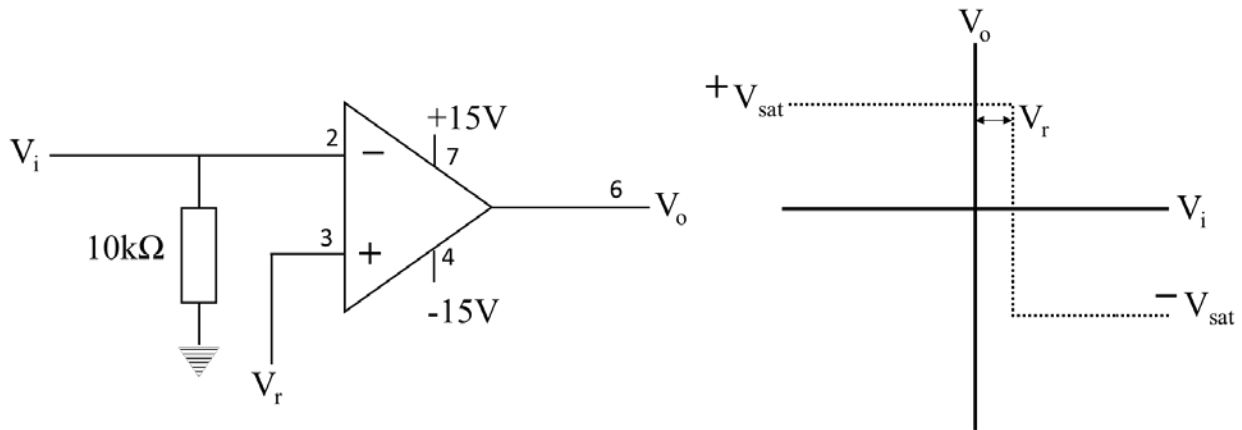


Figure 4-1 Comparator circuit and transfer characteristic

Schmitt Trigger circuits are designed with feedback that provides hysteresis in the transfer characteristic. Figure 4-2 shows a typical Schmitt trigger circuit along with its transfer characteristic. As the input voltage increases it reaches a threshold voltage (the upper threshold) at which the output voltage goes to negative saturation. As the input voltage decreases it reaches another threshold voltage (the lower threshold) at which the output voltage goes to positive saturation. With the voltage difference between V_u and V_l larger than the noise, the output remains stable.

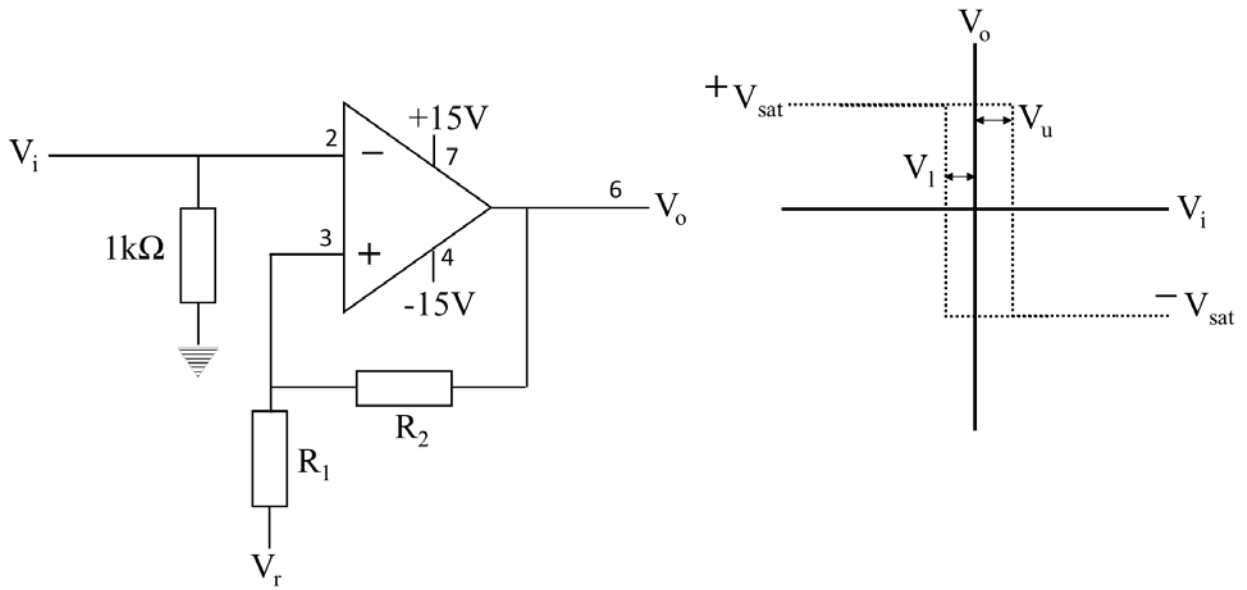


Figure 4-2 Schmitt trigger circuit and transfer characteristic

PRELAB

1. For the Schmitt trigger of Figure 4-2, use any method (including simulations) to determine values of V_r , R_1 , and R_2 that will give upper and lower trigger voltages of +1V and -0.5V for V_u and V_l , respectively. Assume the saturation voltages ($+V_{sat}$ and $-V_{sat}$) to be $\pm 14V$.

PROCEDURE

Comparator Circuit with DC Input

1. Connect the circuit of Figure 4-1. Set V_r to zero by grounding pin 3.
2. Provide a DC input to the comparator with the signal generator. This is done by reducing the AC amplitude to its minimum, bypassing the AC input to ground through a capacitor (e.g. 100 μF), and enabling the DC offset.
3. Observe the output with the oscilloscope set on DC coupling. Change the input DC offset up and down, crossing 0v, while observing the output. In addition to the output swing, approximately from +14V to -14V, what do you observe at the output when the input is set very close to zero?

Comparator Circuit with AC Input

4. Apply a 1 kHz, 5V_{p-p} AC voltage to the input of the comparator circuit (Figure 4-1) of the previous part. In this case set the DC offset disabled or adjusted to zero, and the AC signal coupled to the input through a 0.1 μF capacitor (connected in series with the output of the signal generator).
5. Again set V_r to zero by grounding pin 3.
6. With the oscilloscope in the dual trace mode simultaneously observe the input and output voltages. The oscilloscope should be DC coupled and both channels ground referenced set for a center line trace. Record these waveforms.

Schmitt Trigger Circuit

7. Modify your current setup to match the circuit of Figure 4-2 using the values of V_r , R_1 , and R_2 determined in the Pre-Lab.
8. Provide a DC input with the signal generator. This is done by reducing the AC amplitude to its minimum, bypassing the input to ground through a capacitor (e.g. 100 μF), and enabling the DC offset.
9. Set the oscilloscope in the dual trace mode, observe the input and output voltages simultaneously.
10. The input channel will need to be on a scale sensitive enough to accurately observe V_u and V_l . Record these values of input voltage at which the output changes from positive saturation to negative saturation and vice-versa.

POST-LAB

Post-Lab questions must be answered in each experiment's laboratory report.

1. Discuss the results obtained from the comparator circuit with DC input. In particular comment on the limitations of this comparator in a noisy environment.
2. Discuss the results from the comparator circuit with AC input including how it could work as part of a zero-crossing detector. Also, during your discussion think about how changing the value of V_r would allow for using this circuit for other applications.
3. Discuss the results obtained from the Schmitt Trigger circuit. Be sure to comment on how the Schmitt trigger is able to reduce instabilities due to noise. Compare your measured trigger voltages with the design values.