Applications of OPAMP as Comparator and Schmitt Trigger

Objectives:

(i) Study of OPAMP as comparator

(ii) Study of OPAMP as Schmitt trigger

(i) Comparator

Theory

When the feedback signal (voltage) is applied to the inverting (-) input of the op-amp then the feedback is negative. Negative feedback tends to reduce the difference between the voltages at the inverting and non-inverting terminals and make linear circuits. Without negative feedback the op-amp output is highly sensitive to the input, which can be used to design *switching* or *nonlinear* circuits. The voltage *comparator* is a device which uses no feedback; then saturation is the desired result. In this circuit we want a simple yes-no answer to be signified by either positive saturation or negative saturation of the output.

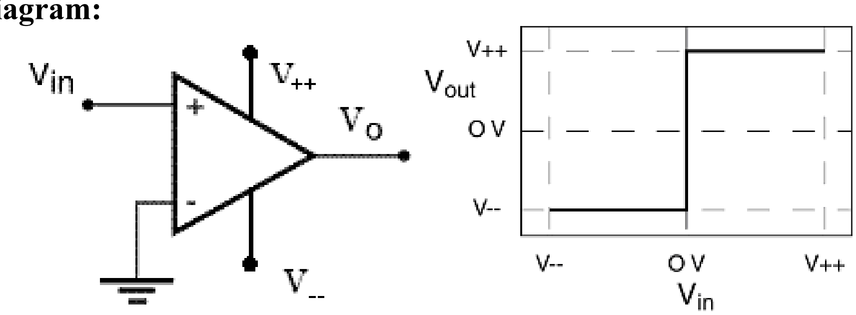
In the circuit diagrams shown below, for Fig.(i), if $V_{in} > 0$, $V_o \approx V_{++}$ and if $V_{in} < 0$, $V_o \approx V_{--}$.The output is no longer linearly related to the input– it's more like a digital signal, high or low depending on how V_{in} compares to ground (0 V). Needless to mention that, if V_{in} is applied at the inverting terminal with respect to a grounded non-inverting terminal, the output will switch to low when $V_{in} > 0$. Figure (ii) shows a small modification, allowing the circuit to switch its output when V_{in} crosses a certain preset voltage level, often called the **threshold voltage**, V_{th}.

Typical applications of this circuit are crossover detectors, analog to digital converters or counting applications where one wants to count pulses that exceed a certain voltage level.

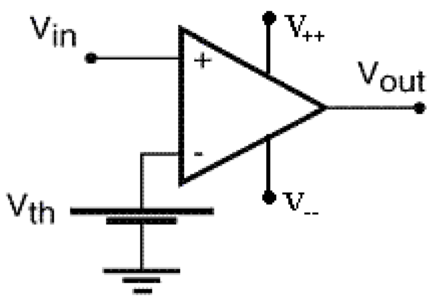
Components/Equipments:

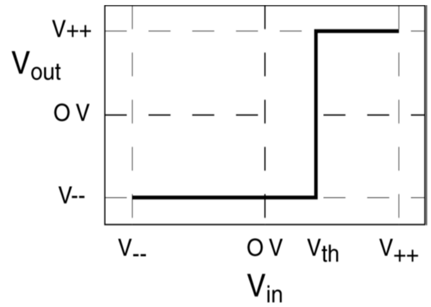
(i) OPAMP (IC-741) chip, (ii) A D.C. power supply, (iii) A digital multimeter (DMM), (iv) A digital storage oscilloscope (DSO), (v) Connecting wires, (vi) Breadboard

Circuit Diagram:



(i)





(ii)

Procedure:

1. Construct the comparator circuit on the breadboard as shown in the circuit diagram. Take care to give proper connections at the desired pins of the IC.
2. Use terminal **C** of the d.c. power supply (denoted by V_+ and V_- knobs) to provide power supply to IC. Connect the 0Vterminal to ground.
3. Connect terminal A of the d.c. power supply (0-30V) at the input. Use terminal B (5V) to provide threshold voltage V_{th} for circuit shown in Fig. (ii).
4. Vary the input from a negative value to a positive value through 0.
5. Using the DMM, measure and tabulate V_{in} and V_{out}. You can also look at the output using a DSO by coupling the output to it in DC mode.
6. Make a plot of V_{out} vs V_{in} for each circuit. Estimate V_{th} from graph for Fig. (ii) and compare with the V_{th} value actually applied. You can repeat the same procedure for different values of threshold.
7. Repeat the entire procedure described above with input at the inverting terminal and the non-inverting terminal being grounded w/o and with the threshold voltage connected to it.

Observations:

For Fig. (i)

Obs.No	V_i (V)	V_o (V)
1		
..		
..		

For Fig. (ii)

V_{th} = ----- V

Obs.No	V_i (V)	V_o (V)
1		
..		
..		

Disscusions:

Discuss the graphs you obtained.

Precautions:

(ii) Schmitt trigger

The Schmitt trigger is a variation of the simple comparator which has hysteresis, that is, it has a toggle action. It uses a positive feedback. When the output is high, positive feedback makes the switching level higher than it is when the output is low. A little positive feedback makes a comparator with better noise immunity.

Now, to understand what causes the hysteresis let's analyze the circuit diagram given below, using the same rules as in the previous section for the comparator. The key in understanding this circuit will again be in calculating the voltages that cause its output to switch. If V_+ and V_- are the actual voltages at the non-inverting and inverting terminals of the OPAMP, then the output will be the following, considering that $V_-=0$:

$$\text{if} \quad V_+ > 0, \qquad V_{out} \approx V_{++}$$
$$\& \ \text{if} \quad V_+ < 0, \qquad V_{out} \approx V_{--}.$$

Since V_{out} changes its state whenever V_+ crosses 0V, we need to find what value of V_{in} results in $V_+ = 0$. The two values of V_{in} for which the output switches are called the trip points. V_+ acts as a voltage divider formed by R_1 and R_2 between V_{in} and V_{out}. Thus the trip points of a noninverting Schmitt trigger are:

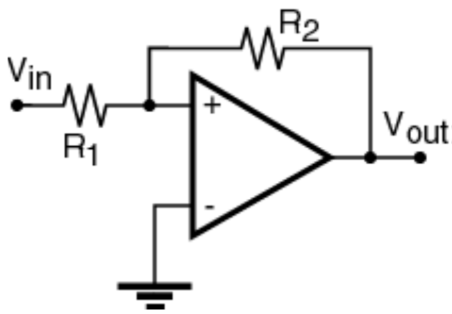
$$\mathbf{V_{in} = -V_{out}\,(R_1/R_2)} \ \ \textbf{(Lower trip point, LTP)}$$
$$\mathbf{= +\,V_{out}\,(R_1/R_2)} \ \ \textbf{(Upper trip point, UTP)}$$

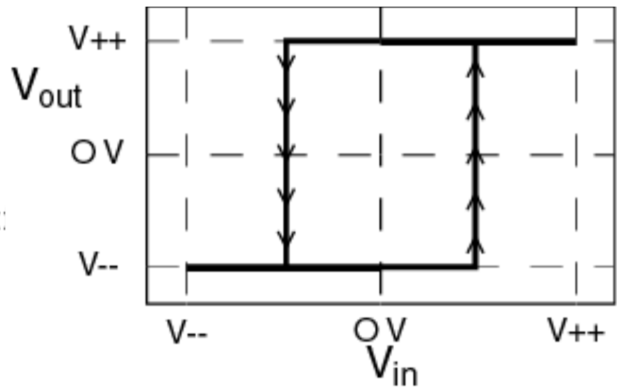
Choosing suitable ratios of R_1 to R_2, enough hysteresis can be created in order to prevent unwanted noise triggers.

Components/Equipments:

(i) OPAMP (IC-741) chip
(ii) A D.C. power supply
(iii) A digital multimeter
(iv) Connecting wires
(v) Breadboard
(vi) Digital storage oscilloscope (DSO)

Circuit Diagram:





Procedure:

1. Construct the schmitt trigger circuit on the breadboard as shown in the circuit diagram.
2. Connect the d.c. power supply at the input. Vary the input from a negative value to a positive value through 0.
3. Using the DMM, measure and tabulate V_{in} and V_{out}.
4. Make a plot of V_{out} vs V_{in}. Estimate the trip points from the graph and compare with the computed value, i.e. $\mathbf{V_{in} = \pm V_{out} R_1/R_2}$
5. You can also look at the output using a DSO by coupling the output to it in DC mode.

Observations:

Obs.No	V_i (V)	V_o (V)
1		
..		
..		

Disscusions:

Analyze the graph you obtained. Discuss the switching action.

Precautions: