Op-amp based Schmitt trigger

Aim: To understand the operation of Schmitt trigger.

Schmitt trigger:

A Schmitt trigger circuit is a fast-operating voltage-level detector. When the input voltage arrives at the upper or lower trigger levels, the output changes rapidly. The circuit operates with almost any type of input waveform, and it gives a pulse-type output.

The input voltage V_{in} is applied to the inverting input terminal and the feedback voltage goes to the non-inverting terminal. This means the circuit uses positive voltage feedback instead of negative feedback. The output voltage will remain in a given state until the input voltage exceeds the reference voltage for that state. For instance, if the output is positively saturated, the reference voltage is $+\beta V_{sat}$. The input voltage V_{in} must be increased slightly above $+\beta V_{sat}$ to switch the output voltage from positive to negative. Once the output is in the negative state, it will remain there indefinitely until the input voltage becomes more negative than $-\beta V_{sat}$. Then, the output switches from negative to positive.

The feedback fraction, $\beta = R2 / (R1 + R2)$

When the output is positively saturated, the reference voltage applied to the non-inverting input is

$$V_{ref} = +\beta V_{sat}$$

When the output is negatively saturated, the reference voltage is

$$V_{ref} = -\beta V_{sat}$$

The trip points are defined as the two input voltages where the output changes states. The upper trip point (abbreviated UTP) has a value $UTP = +\beta V_{sat}$ and the lower trip point has a value $LTP = -\beta V_{sat}$

The difference between the trip points is the hysteresis H and is given as

$$H = +\beta V_{sat} - (-\beta V_{sat}) = 2\beta V_{sat}$$

The hysteresis is caused due to positive feedback. If there were no positive feedback, β would equal zero and the hysteresis would disappear, because the trip points would both equal zero. Hysteresis is desirable in a Schmitt trigger because it prevents noise form causing false triggering.

A Schmitt trigger is a comparator with hysteresis (see Fig. 1). When the input voltage is varied from low to high values, the output transition occurs at $V_i = V_{TH}$. When the input voltage is varied from high to low values, the output transition occurs at $V_i = V_{TL}$. Fig. 2 shows an op amp Schmitt trigger circuit. The diode arrangement at the output limits the output voltage to ± 6.3 V.

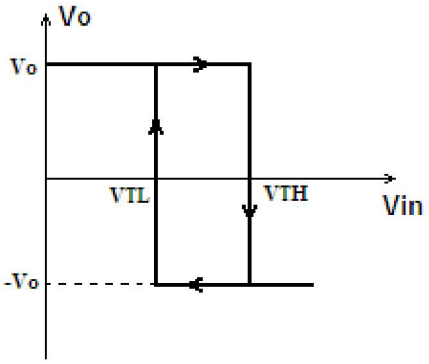

Figure 1: Schmitt trigger hysteresis

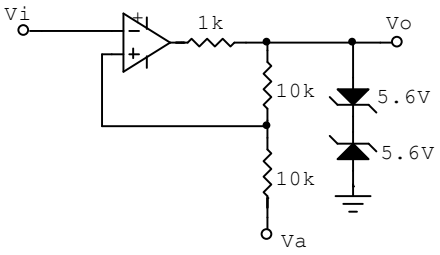

Figure 2: Schmitt trigger

Simulation asignment

1) Apply the input voltage V_{in} such that -10V < V_{in} < + 10V .
2) Simulate the given circuit with va = 0V and va = + 3V.
3) Change the value of resistors in the feedback network and observe the output waveform.