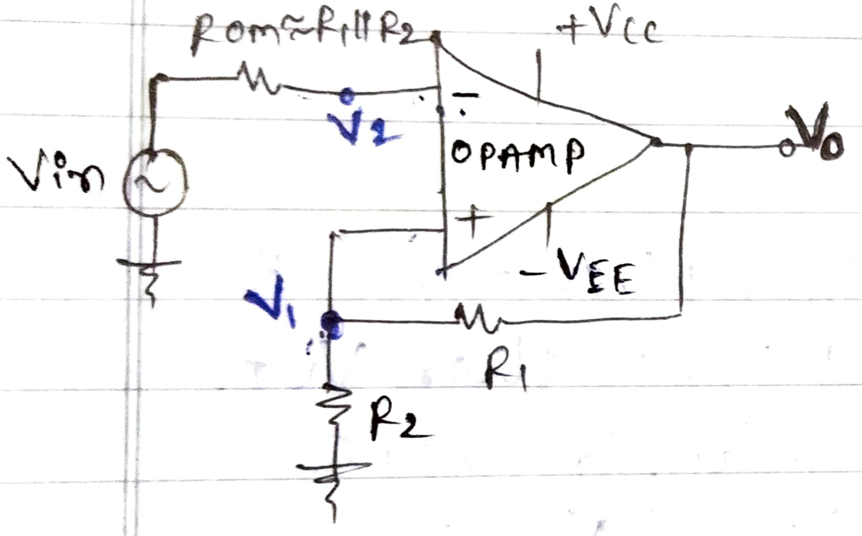
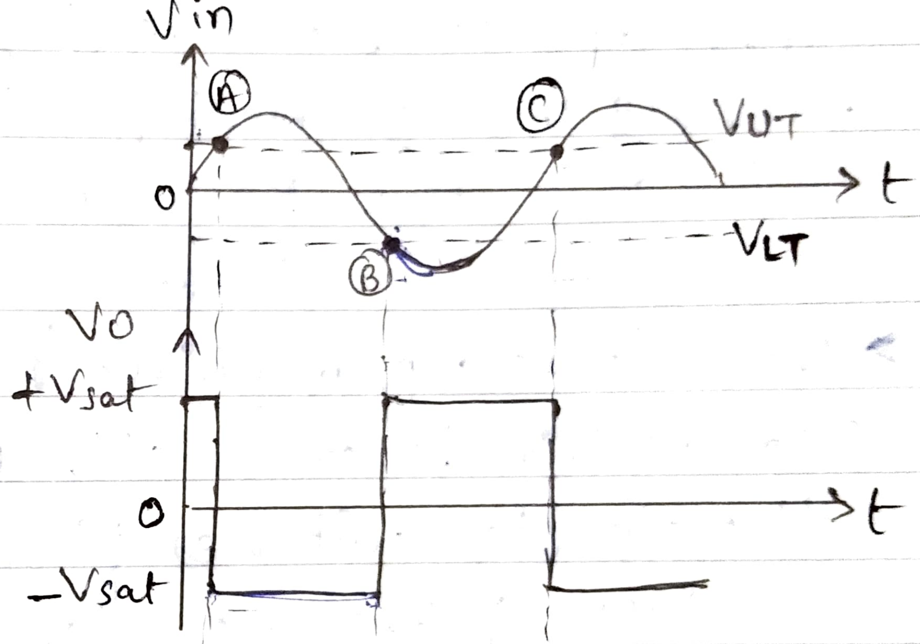
→ Schmitt trigger





> It is inverting schmitt trigger as i/p is applied to inverting terminal. & resistance divider formed by R_1 & R_2 connected between o/p & non-inv terminal.

> It is basically inverting comparator with +ve or regenerative f/b ∴ it is called as regenerative comparator.

> R_{om} is called as offset minimizing resistor & is equal to parallel combination of R_1 & R_2.

> In schmitt trigger reference v/g is V_1, which is developed across R_2, $V_1 = \frac{R_2}{R_1+R_2} V_o$

> There are two different triggering v/gs are defined,

i) Upper threshold v/g is the value of Vin which forces transition from +Vsat to -Vsat in o/p v/g.

ii) lower threshold v/g is the value of Vin which force the o/p v/g from -Vsat to +Vsat.

$$V_{UT} = \frac{R_2}{R_1+R_2}(+V_{sat})$$

$$V_{LT} = \frac{R_2}{R_1+R_2}(-V_{sat})$$

> Initially assume that o/p v/g is +Vsat, & if i/p is applied to inverting i/p of OPAMP, then ref. v/g V_1 is given by,

$$V_1 = \frac{R_2}{R_1+R_2}(+V_{sat})$$

> V_o = +Vsat upto point 'A', i/p v/g $V_{in} = V_{UT}$. As soon as Vin becomes slightly higher than **V_{UT}**, the o/p v/g switches from +Vsat to -Vsat.

Now V_1 becomes, $V_1 = \frac{R_2}{R_1+R_2}(-V_{sat})$

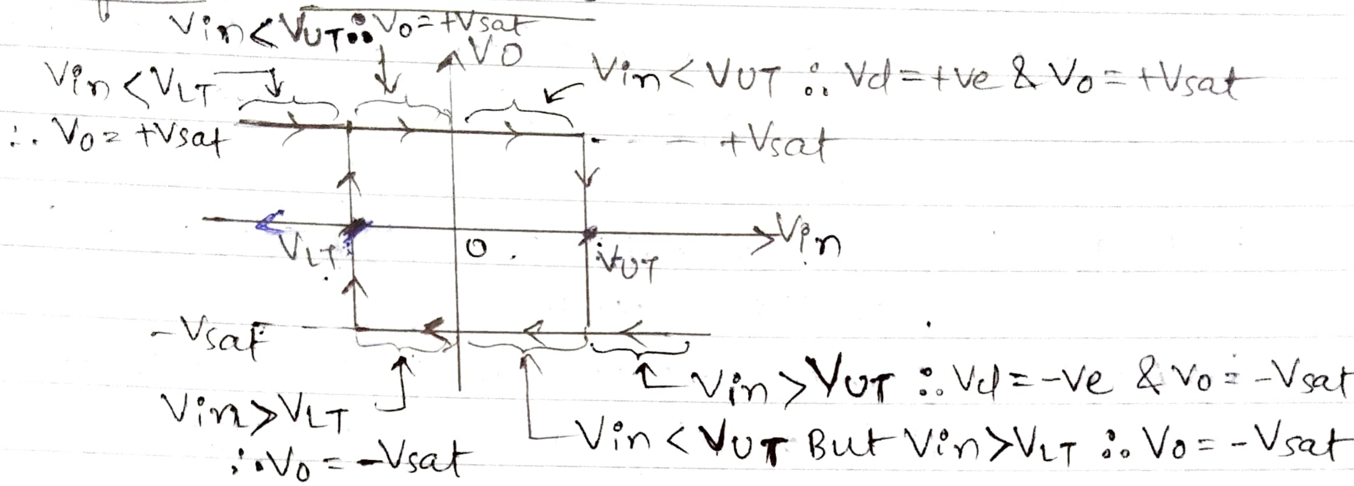
> o/p v/g remains -Vsat between point A & B. At point 'B', the i/p v/g crosses V_{LT} & becomes more -ve than V_{LT} ∴ o/p switches to +Vsat.

Chintamani Tattva

& V_1 becomes, $V_1 = \frac{R_2}{R_1+R_2}(+V_{sat})$

Again it remains equal to +Vsat till point 'c'.

→ **Transfer characteristics**



> It is the graph of 'Vin' versus 'Vo'.

Hysteresis v/g equal to difference between V_{UT} & V_{LT} & it is called the hysteresis width.

> The interval $V_{LT} < V_{in} < V_{UT}$ is called as deadzone or dead band because the variation of Vin in this band does not change the o/p v/g at all.

Hysteresis v/g $V_{HV} = V_{UT} - V_{LT} = \frac{R_2}{R_1+R_2}\left[+V_{sat} - (-V_{sat})\right]$

$$V_{HV} = \frac{R_2}{R_1+R_2} \times 2V_{sat}.$$

→ **Application**

- To convert sinewave into square wave.
- In over v/g & over c/n protection ckt.
- In ON/OFF type temperature controller.

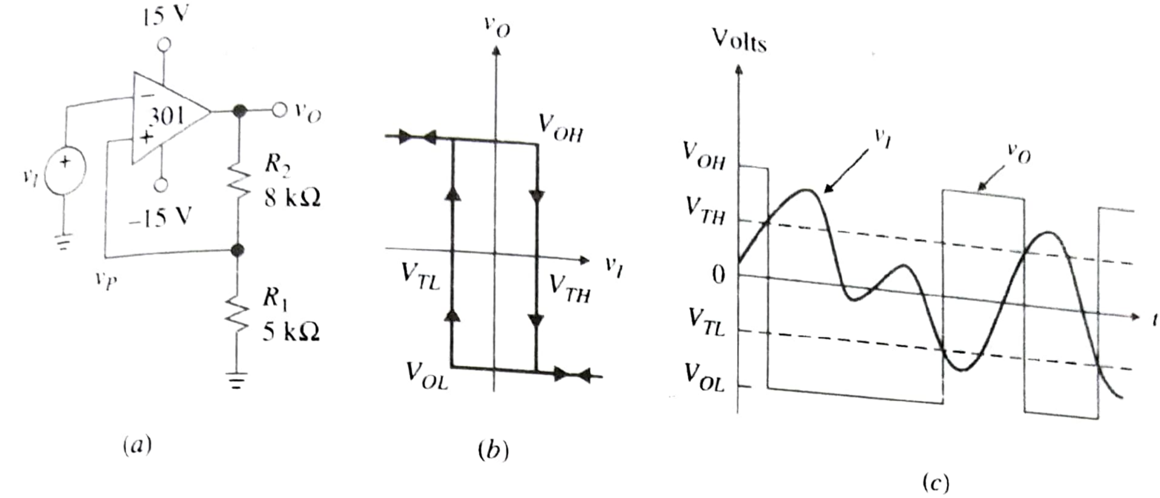


FIGURE 9.20
Inverting Schmitt trigger, VTC, and sample waveforms.

to snap from V_{OH} to V_{OL} as fast as the amplifier can swing. This, in turn, causes v_P to snap from V_{TH} to V_{TL}, or from +5 V to −5 V. If we wish to change the output state again, we must now lower v_I all the way down to $v_P = V_{TL} = -5$ V, at which juncture v_O will snap back to V_{OH}. In summary, as soon as $v_N = v_I$ approaches $v_P = V_T$, v_O and, hence, v_P, snap away from v_N. This behavior is opposite to that of negative feedback, where v_N tracks v_P!

Looking at the VTC of Fig. 9.20*b*, we observe that when coming from the left, the threshold is V_{TH}, and when coming from the right it is V_{TL}. This can also be appreciated from the waveforms of Fig. 9.20*c*, where it is seen that during the times of increasing v_I the output snaps when v_I crosses V_{TH}, but during the times of decreasing v_I it snaps when v_I crosses V_{TL}. Note also that the horizontal portions of the VTC can be traveled in either direction, under external control, but the vertical portions can be traveled only *clockwise*, under the regenerative effect of positive feedback.

A VTC with two separate tripping points is said to exhibit *hysteresis*. The hysteresis *width* is defined as

$$\Delta V_T = V_{TH} - V_{TL} \tag{9.9}$$

and in the present case can be expressed as

$$\Delta V_T = \frac{R_1}{R_1 + R_2}(V_{OH} - V_{OL}) \tag{9.10}$$

With the component values shown, $\Delta V_T = 10$ V. If desired, ΔV_T can be varied by changing the ratio R_1/R_2. Decreasing this ratio will bring V_{TH} and V_{TL} closer together until, in the limit $R_1/R_2 \to 0$, the two vertical segments coalesce at the origin. The circuit is then an inverting zero-crossing detector.

Noninverting Schmitt Trigger

The circuit of Fig. 9.21*a* is similar to that of Fig. 9.20*a*, except that v_I is now applied at the noninverting side. For $v_I \ll 0$, the output will saturate at V_{OL}. If we want v_O

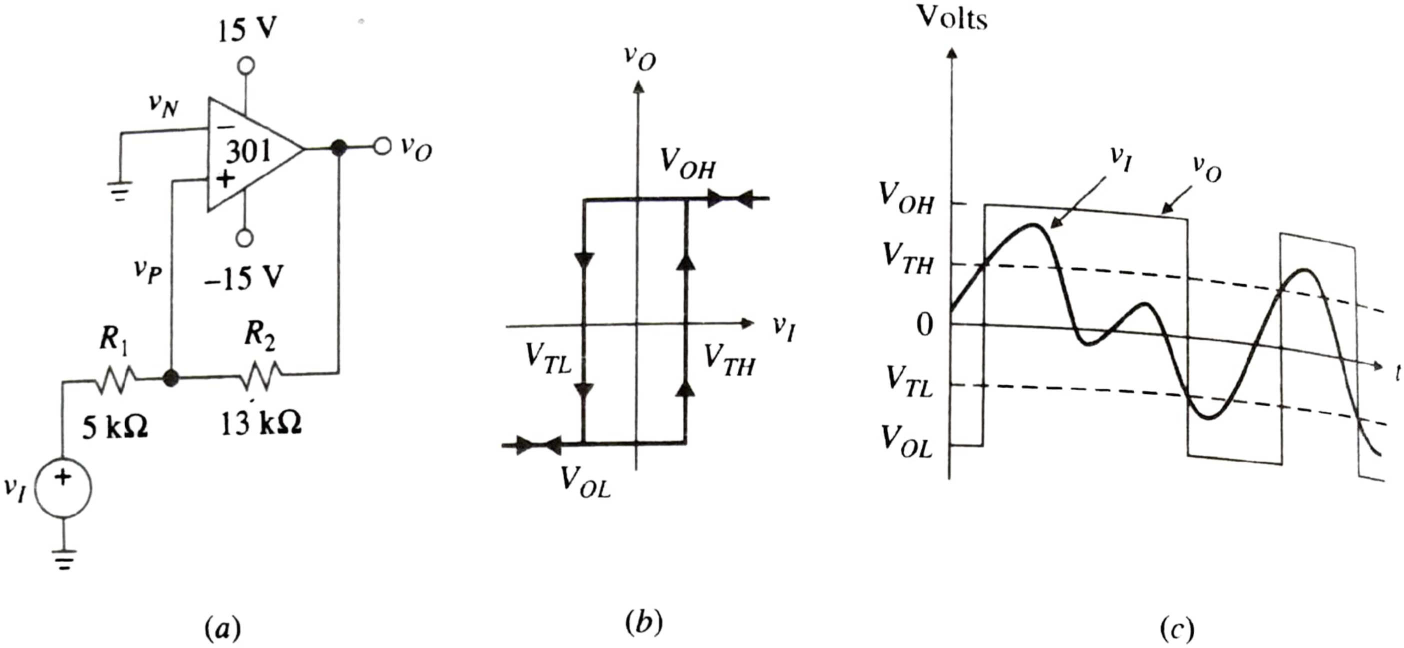


FIGURE 9.21
Noninverting Schmitt trigger, VTC, and sample waveforms.

to switch state, we must raise v_I to a high enough value to bring v_P to cross $v_N = 0$, since this is when the comparator trips. This value of v_I, aptly denoted as V_{TH}, must be such that $(V_{TH} - 0)/R_1 = (0 - V_{OL})/R_2$, or

$$V_{TH} = -\frac{R_1}{R_2} V_{OL} \tag{9.11a}$$

Once v_O has snapped to V_{OH}, v_I must be lowered if we want v_O to snap back to V_{OL}. The tripping voltage V_{TL} is such that $(V_{OH} - 0)/R_2 = (0 - V_{TL})/R_1$, or

$$V_{TL} = -\frac{R_1}{R_2} V_{OH} \tag{9.11b}$$

The resulting VTC, shown in Fig. 9.21*b*, differs from that of Fig. 9.20*b* in that the vertical segments are traveled in the *counterclockwise* direction. The output waveform is similar to that of the inverting Schmitt trigger, except for a reversal in polarity. The hysteresis width is now

$$\Delta V_T = \frac{R_1}{R_2}(V_{OH} - V_{OL}) \tag{9.12}$$

and it can be varied by changing the ratio R_1/R_2. In the limit $R_1/R_2 \to 0$ we obtain a noninverting zero-crossing detector.