- **Comparator characteristics :-**

1. Speed of operation :
   - O/P of comparator must switch rapidly betⁿ saturation levels & also respond instantly to any change of conditions at its I/P.
   - i.e B/W should be high. ∴ B/W ↑, speed ↑.
   - By using positive f/b we can ↑ speed of operation.

2. Accuracy :-
   - Depends upon vtg. gain, CMRR, I/P offsets & thermal drift.
   - When vtg gain is high, less I/P is also cause the change in O/P saturation levels.
   - CMRR ↑, noise at I/Ps ↓. Hence false triggering is avoided.
   - To minimize offset problems, I_{io} & V_{io} must be negligible. Also changes in these offsets due to temp. variations should be very slight.
   - Comparator is one form of ADC.

3. Compatibility of O/P:

* **Limitations of op-amp as comparator :-**
  - As we have designed op-amps for amplification purpose, these are having high gain. Hence O/P is very high. & hence not compatible with a particular logic family such as TTL, which requires I/P vtgs as +5V or 0V. ∴ to keep O/P vtg swing within specified limits, we have to use extra

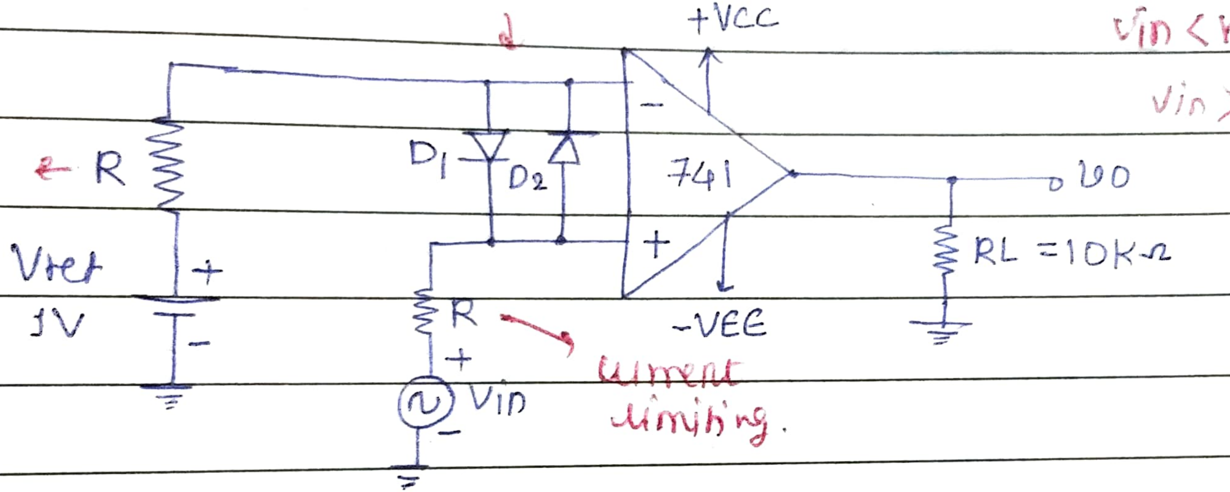
→ BASIC COMPARATOR :-

protection diodes from excess I/P vtg (Vid → clamped to ±0.7V → clamping diodes

Vin < Vref, Vo = -Vsat

Vin > Vref, Vo = + Vsat

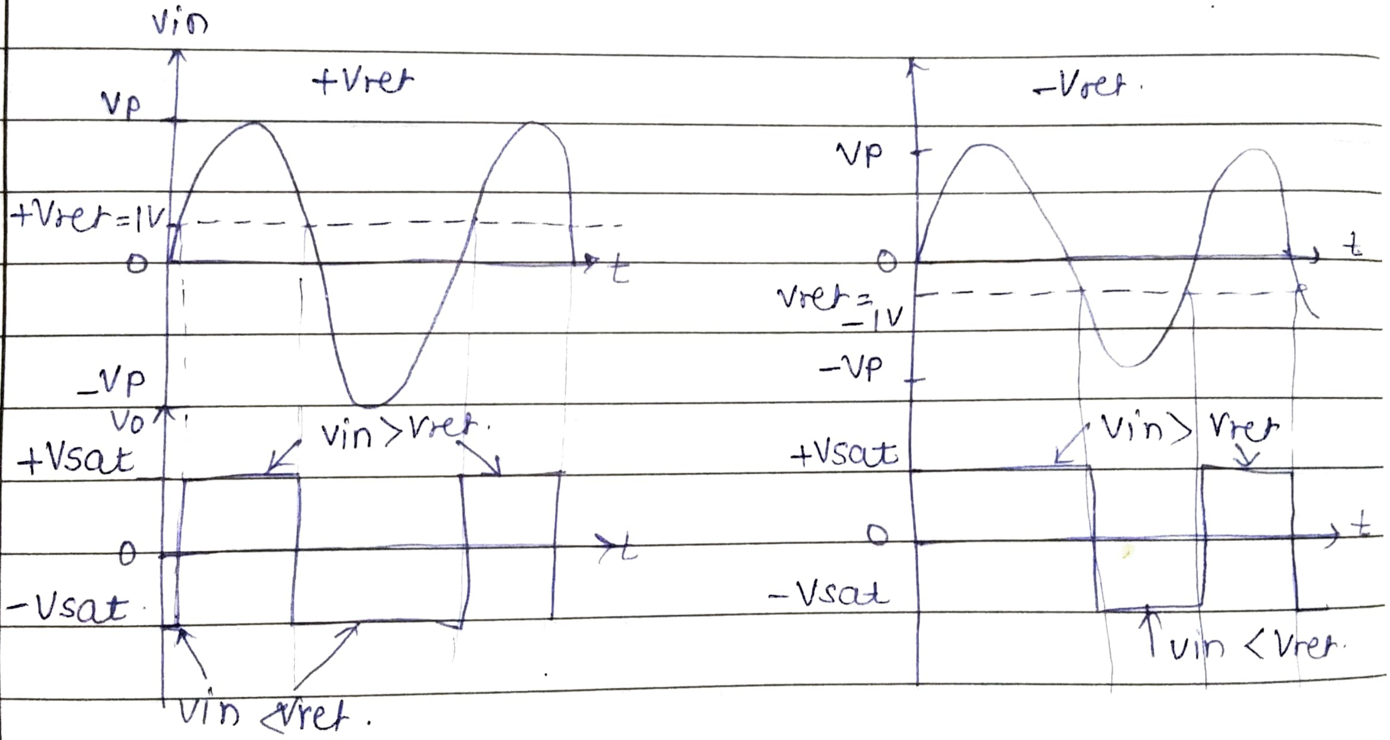
offset ← Rom minimizing



current limiting.

- op-amp is used as a comparator.
- A fixed ref. vtg. Vref of 1V is applied to the (-) I/P & AC I/P is applied at (+) I/P.
- Hence ckt. is called as non-inv ~~amp~~r. comparator.

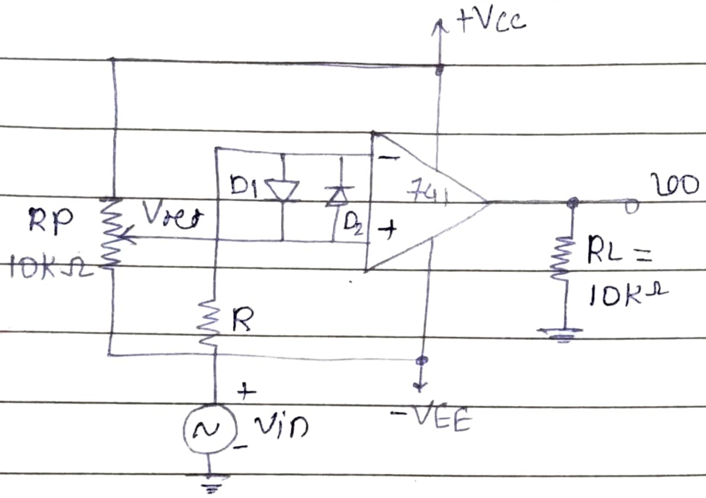
- when vin is less than Vref, the O/P vo is at $-V_{sat}$ ($\cong -V_{CC}$) because the vtg. at the (−) input is higher than that at the (+) input.
- when vin is greater than vref, the (+) input becomes +ve w.r.t the (−) input, the vo goes to $+V_{sat}$ ($\cong +V_{CC}$).
- Thus vo changes from one saturation level to another whenever $V_{in} \cong V_{ref}$.
- In short, Comparator is a type of ADC.
- comparator sometimes called as a voltage-level detector because, for a desired value of Vref, the vtg. level of the I/P vin can be detected.



- Diodes D1 & D2 protect the op-amp from damage due to excessive I/P vtg. vin. Because of these diodes, the difference I/P vtg. Vid of the op-amp is clamped to either 0.7V or −0.7V. Hence diodes are called as clamping diodes.
- R in series with vin is used to limit the current thr' D1 & D2.

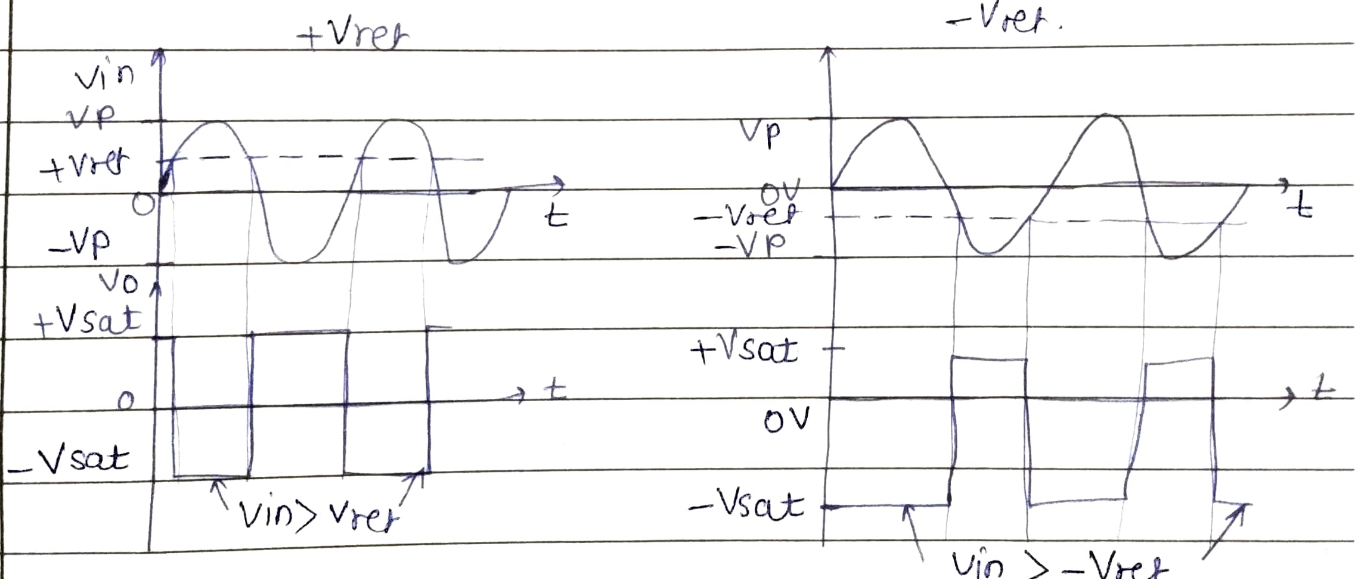
- To reduce offset problems, a resistance $R_{OM} \cong R$ is connected betn the (-) input & Vref.
- If Vref is -ve, o/p is as shown in fig.
  i.e when vin > Vref, Vo is at +Vsat & when vin < Vref, vo is at -Vsat.
- Hence to take switching action, vin must be large enough.

⇒ **Inverting comparator :-**



D1 & D2 are protecting diodes.

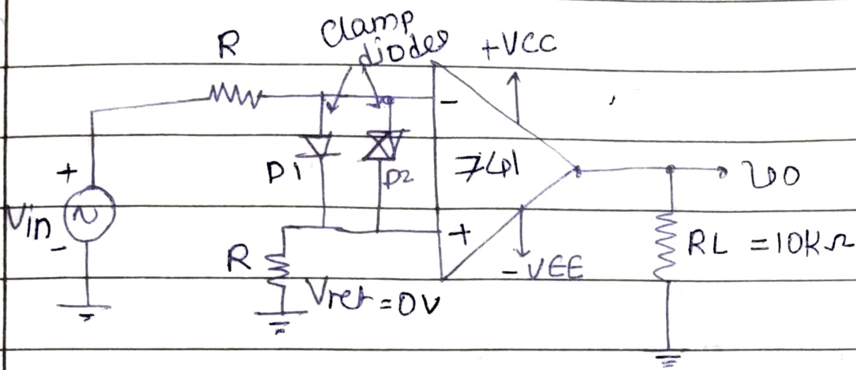
Vin < Vref , Vo = +Vsat
Vin > Vref , vo = - Vsat

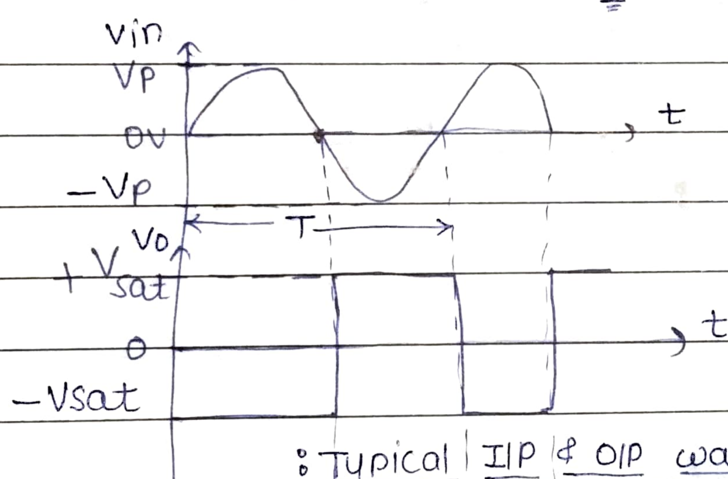


- Vref is obtained by using a 10kΩ pot that forms a vtg. divider with the dc supply vtgs +Vcc & -VEE & the wiper connected to the (+) input.
- As the wiper is moved toward -VEE, Vref becomes more -ve, while if it is moved toward +Vcc, Vref becomes

more -ve, while if it is moved toward +Vcc, Vref becomes more +ve. Thus a Vref of a desired amplitude & polarity can be obtained by simply adjusting the 10kΩ pot.

⇒ ZERO-CROSSING DETECTOR :→



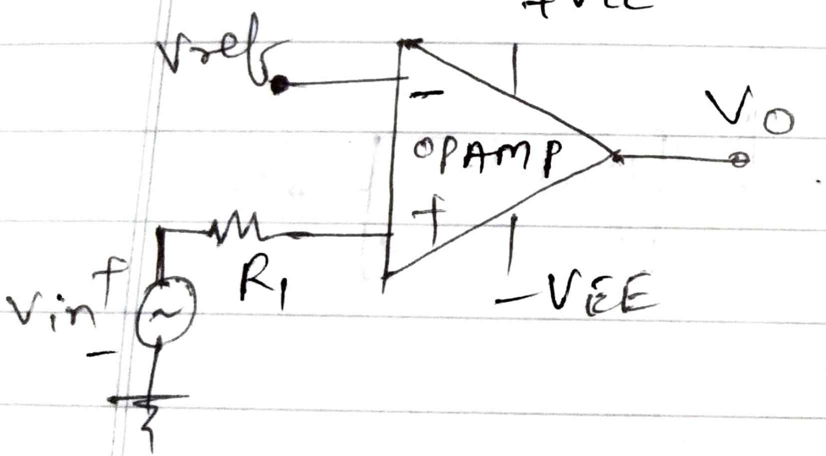


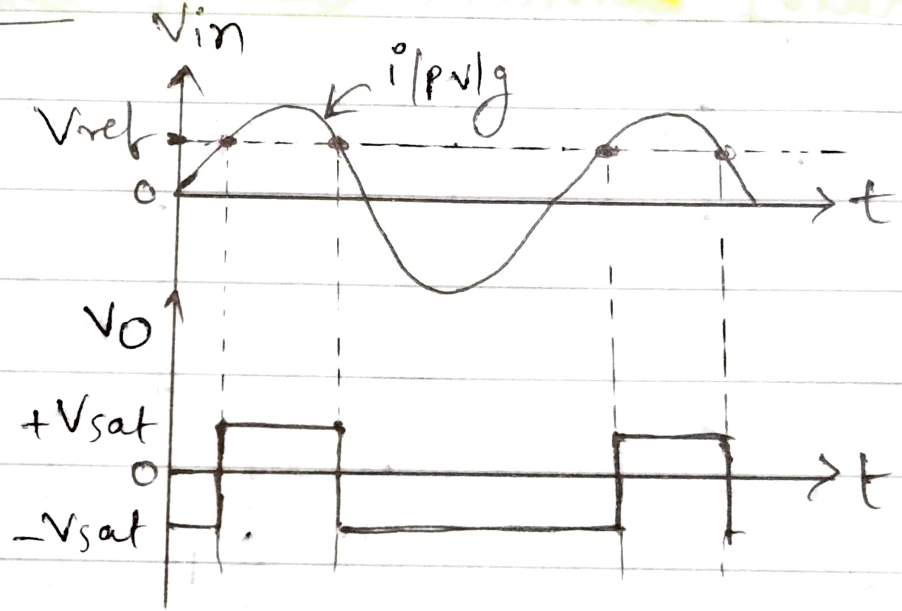
: Typical I/P & O/P waveforms :

- This is the application of comparator. Also called as sine wave to square wave converter.
- For this Vref = 0.
- vo is driven into -ve saturation when vin passes through zero in the positive direction.
- When vin passes thr' zero in the -ve direction, the O/P vo switches & saturates +vely.

- Regenerative or +ve f/b :-
- Used to change faster & eliminate any false output transitions due to noise signals at the input.

→ Non-Inv Comparator





➤ Here positive dc v/g is applied to inv. terminal & ac s/g is applied to non-inv. terminal.

I/p v/g $V_d = V_{in} - V_{ref}$.

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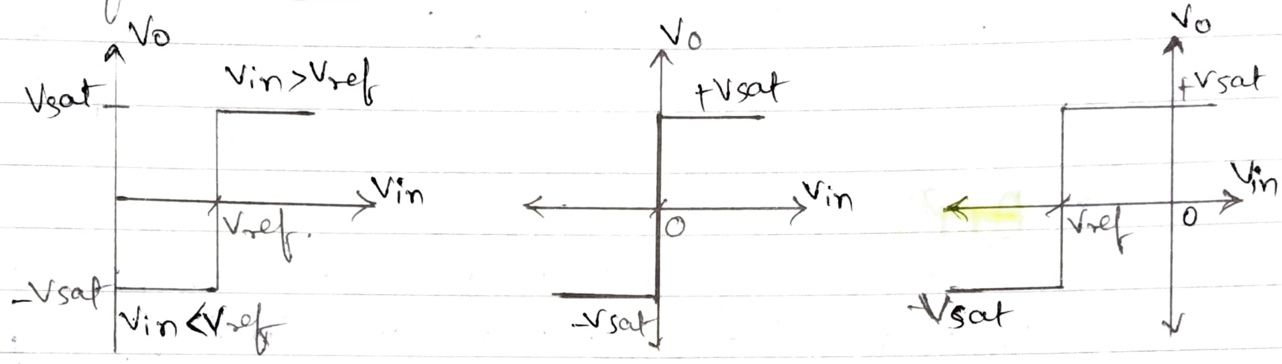
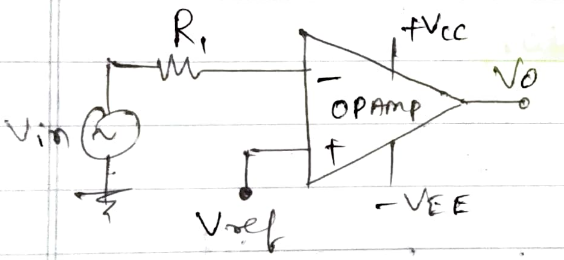
- when Vin is less than Vref, inv. terminal is at higher potential than non-inv. terminal. ∴ 'Vd' is -ve & OPAMP o/p will swing to -Vsat volts.
- when Vin is greater than Vref, non-inv terminal is at higher potential than inv. terminal. ∴ 'Vd' is +ve & the OPAMP o/p will swing to +Vsat volts.

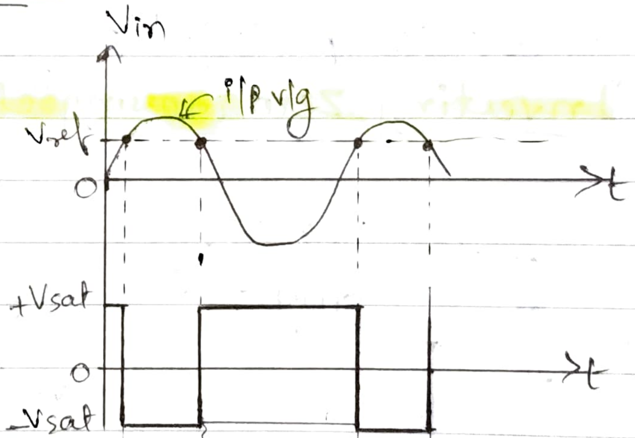
→ **Transfer characteristics**



For +ve ref. · Vref = 0. Vref = -Ve

→ **Inverting Comparator**

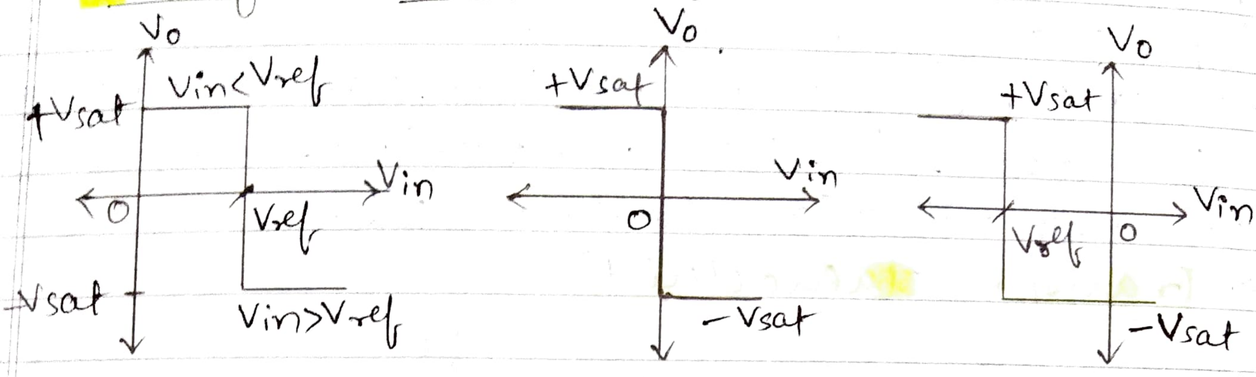




- Here differential i/p v/g Vd = Vref - Vin.
Also here i/p is applied to inv. terminal & reference v/g is applied to non-inv. terminal.
- when Vin is less than Vref, v/g at non-inv. terminal is higher than v/g at inv. terminal. This makes 'Vd' +ve & OPAMP o/p will swing to +Vsat.
- when Vin is greater than Vref, v/g at non-inv terminal is less than v/g at inv. terminal. This makes 'Vd'

−ve & opamp o/p will be −Vsat.

→ **Transfer Characteristics**



$V_{ref} = +Ve$ $V_{ref} = 0$ $V_{ref} = -Ve$

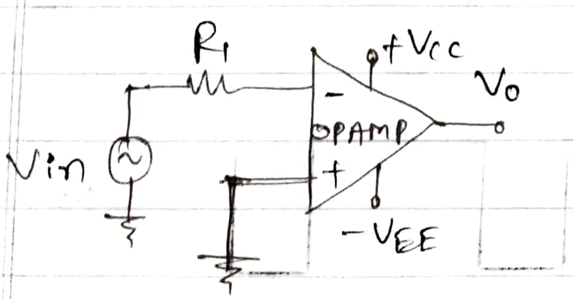
→ **Appⁿ**

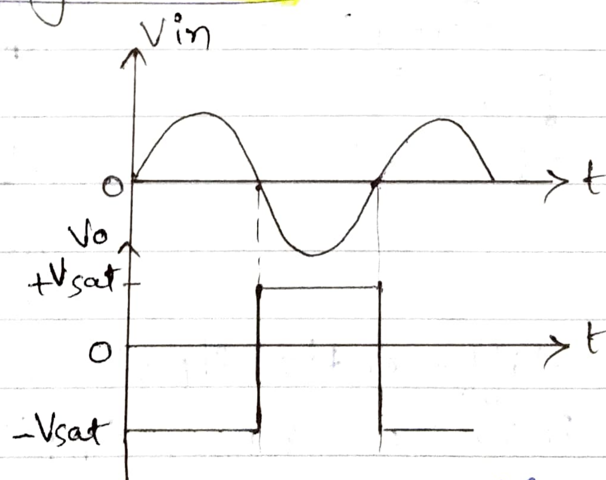
Zero crossing detector, window comparator, level detector, phase detector, schmitt trigger, peak detector.

→ **Zero Crossing Detector**

This is nothing but the comparator in which we are comparing i/p v/g with $V_{ref} = 0V$.

→ **Inverting Zero crossing detector**



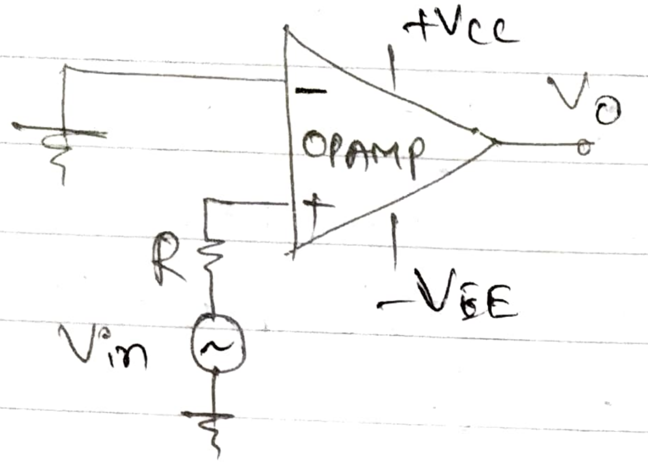


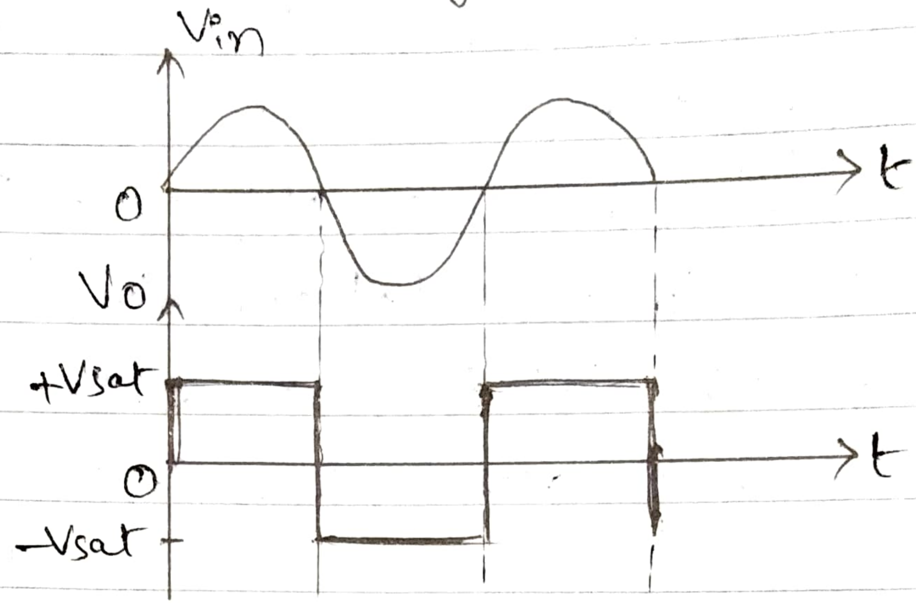
> Here i/p v/g is applied to inv. terminal & non-inv. terminal is connected to ground.

> when Vin > 0 then v/g at inv. terminal is more than non-inv. & o/p is swings −Vsat.

> when Vin < 0 ie crosses zero then v/g at inv. terminal becomes less than non-inv. & o/p swing to +Vsat.

Non-Inv. ~~comparator~~ Zero Crossing detector:



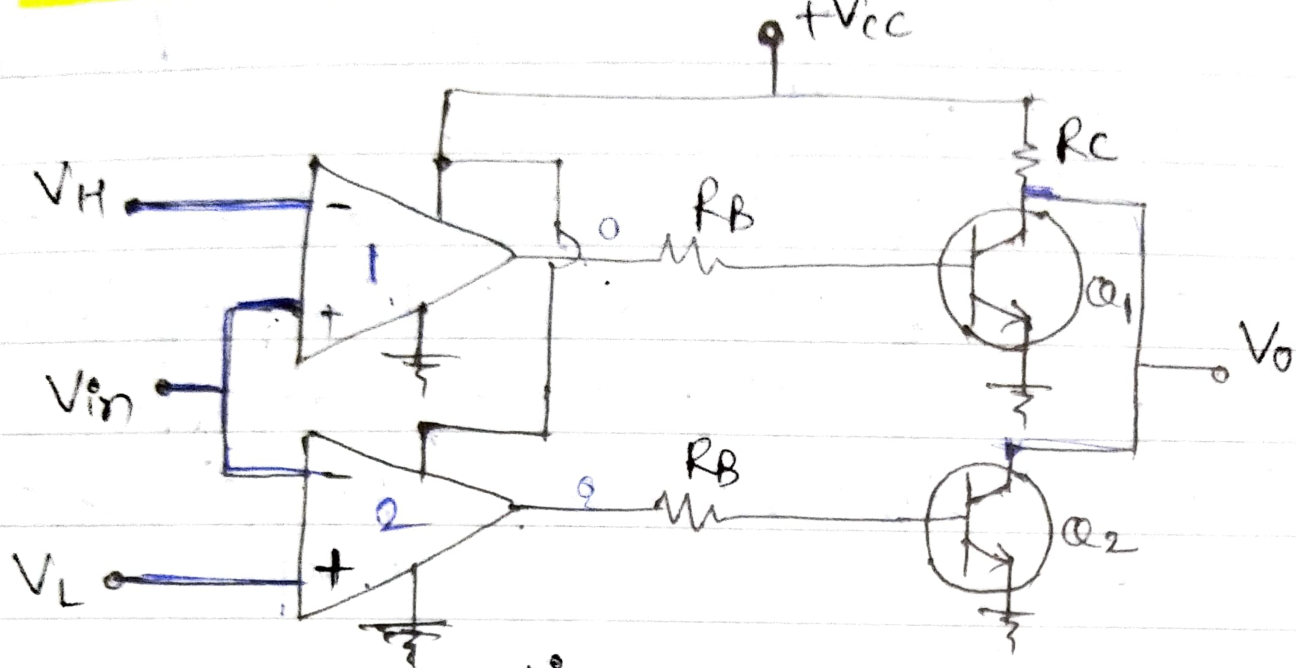


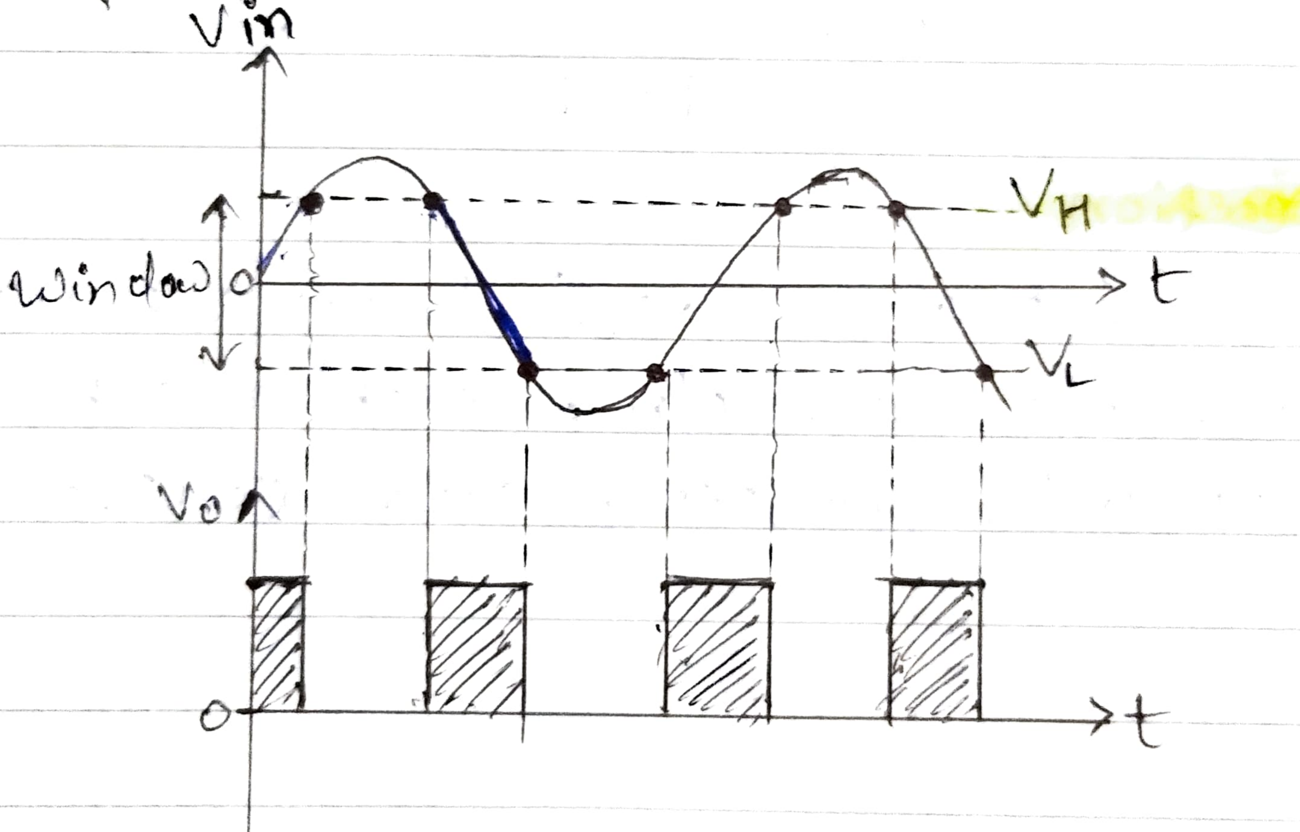
- In this i/p v/g is applied to non-inv. terminal & inv. terminal is connected to ground.
- When Vin > 0 then v/g at non-inv terminal is more than inv. terminal & o/p swings to +Vsat.
- When Vin < 0 ie. when it crosses zero then v/g at non-inv. terminal becomes less than inv. & o/p swings to −Vsat.

Applications

Synchronizing circuit, Square wave generator.

Window Detector





- V_H & V_L are two reference v/g's with $V_H > V_L$ & V_{in} as i/p v/g. The o/p of two comparators are applied to two transistors which operate as a switches. The o/p v/g is obtained at common collector terminal of two Transistor.

- If Vin is between two ref. v/g i.e. $V_L < V_{in} < V_H$ then o/p of both comparators will be low. So both the transistor will remain in off state. So the collector v/g i.e. o/p v/g will be equal to +Vcc.

$$\therefore V_o = +V_{cc} \text{ for } V_L < V_{in} < V_H.$$

- If Vin is less than V_L, the o/p of comparator '1' will be low & comparator 2 will be high. This will turn off 'Q_1' but saturate Q_2 & o/p v/g will be $V_{CE(sat)}$ i.e. low.

$$\therefore V_o = V_{CE(sat)} = \text{low for } V_{in} < V_L.$$

- If Vin is greater than V_H, then o/p of comparator '1' will be high & comparator 2 will be low. Thus Q_1 will saturate & Q_2 will remain off. The o/p v/g will be $V_{CE(sat)}$ i.e. low

$$\therefore V_o = V_{CE(sat)} = \text{low For } V_{in} > V_H.$$

From these cases we can say that we will get high v/g when i/p v/g is within window, where as low o/p v/g indicates that i/p v/g is out of window.

Application

- Level detector
- Industrial alarm.
- Digital Computers
- Bar-graph indicators
- Speed indicator