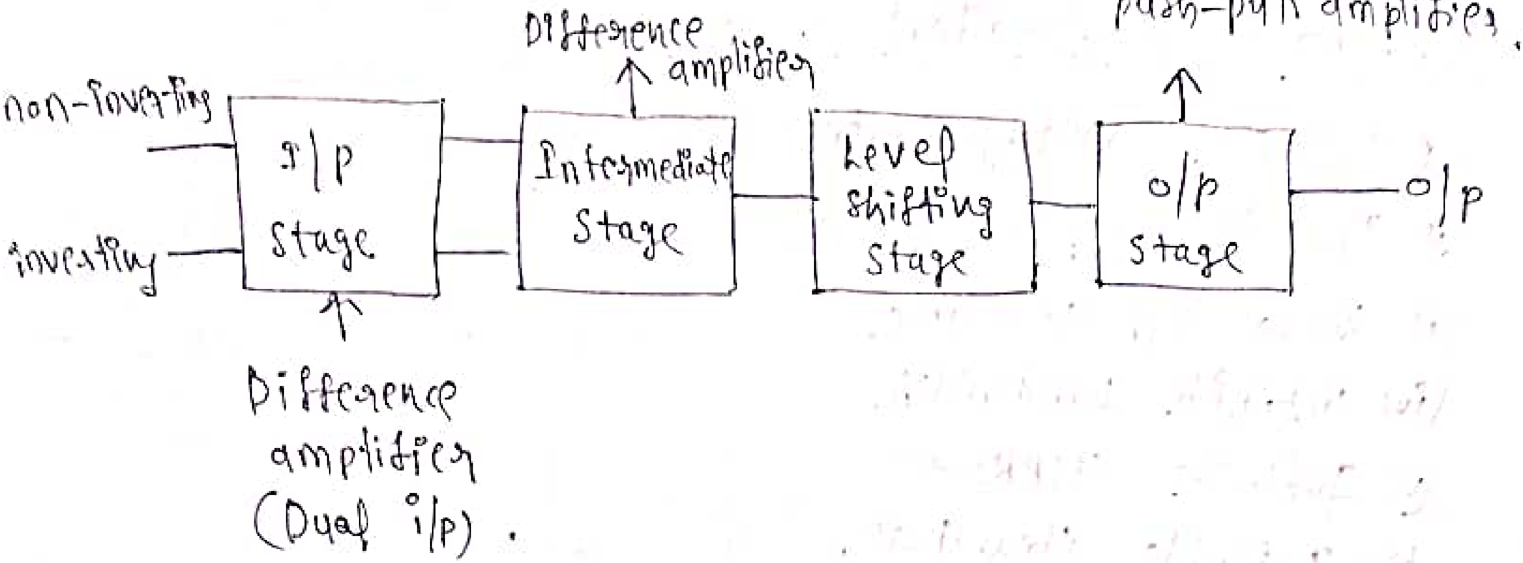
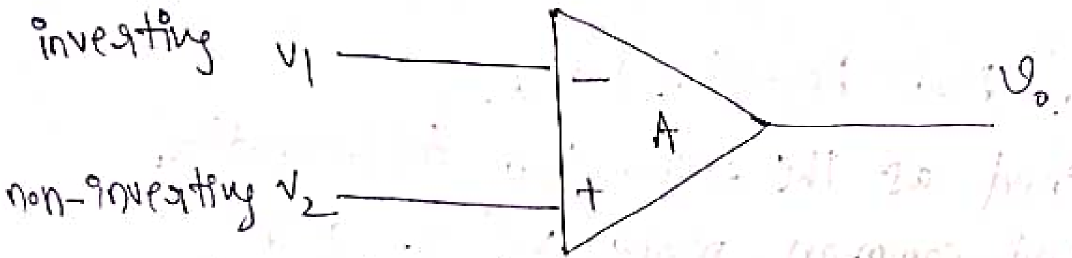
Operational Amplifier

29/Mar/2022.

Block diagram of op-amp :-

Op-amp means operational amplifiers.

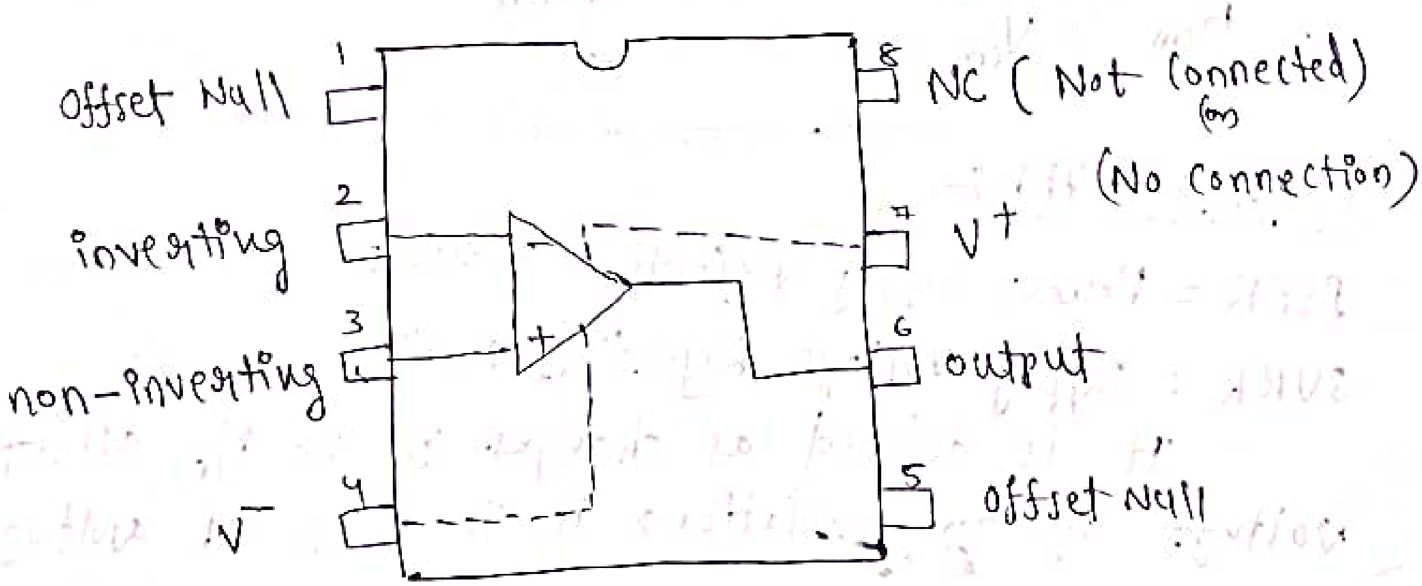




Symbol for op-amp.

A = Gain of the amplifier.

Pin configuration of 741 op-amp :-



Offset Null ① ⑤ :-

The voltage applied to get o/p zero.

MOS = Metal Oxide Semi conductor

Characteristics of ideal op-amp :-

(i) Infinite voltage gain.

(ii) Infinite i/p resistance.

(iii) zero o/p resistance.

(iv) infinite bandwidth.

(v) Infinite CMRR

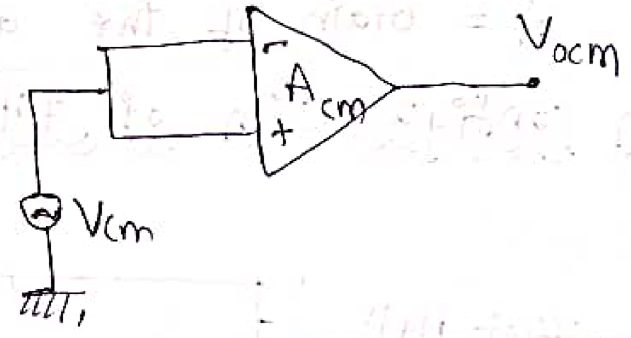
(vi) Infinite Slew-Rate.

CMRR :-

CMRR = Common Mode Rejection Ratio.

It is defined as the ratio b/w differential voltage gain and common mode voltage gain.

$$CMRR = \frac{A_d}{A_{cm}}$$



$$A_{cm} = \frac{V_{ocm}}{V_{cm}}$$

PSRR (or) SVRR :-

PSRR = Power supply Rejection Ratio.

SVRR = supply voltage Rejection Ratio.

It is defined as changes in the i/p offset voltage due to variations in the supplied voltage.

$$PSRR = \frac{\Delta V_{io}}{\Delta V}$$

V_{io} = input offset voltage.

Offset voltage వలన తక్కువగా ఉంటే అంత మంచిది.

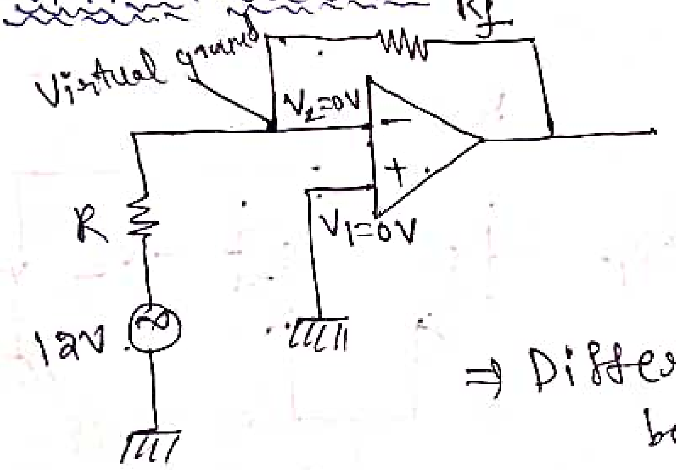
Slew Rate:-

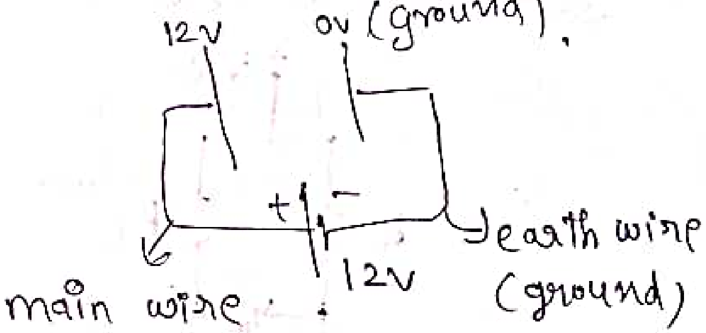
It is defined as maximum rate of change of o/p voltage per unit of time. It is measured in volts / microsecond.

$$SR = \left.\frac{dV_o}{dt}\right|_{max} \quad \text{in } V/\mu s.$$

741 op-amp's slew rate = 0.5 V/μs.

Virtual Ground:-



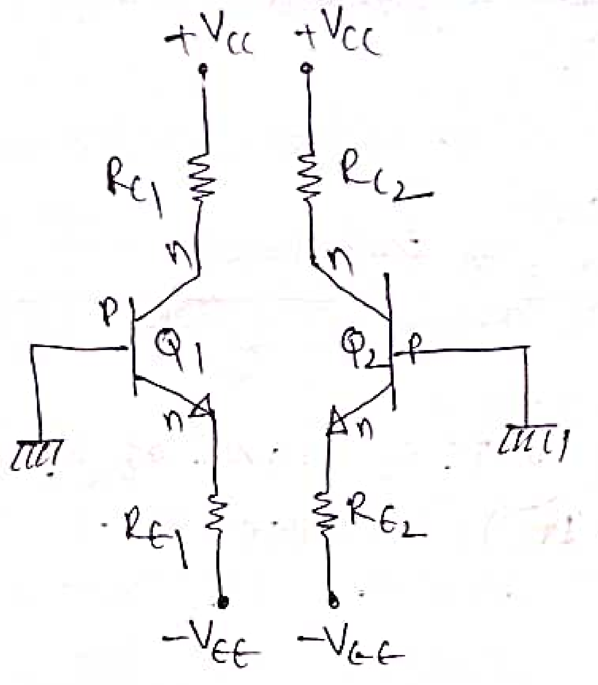


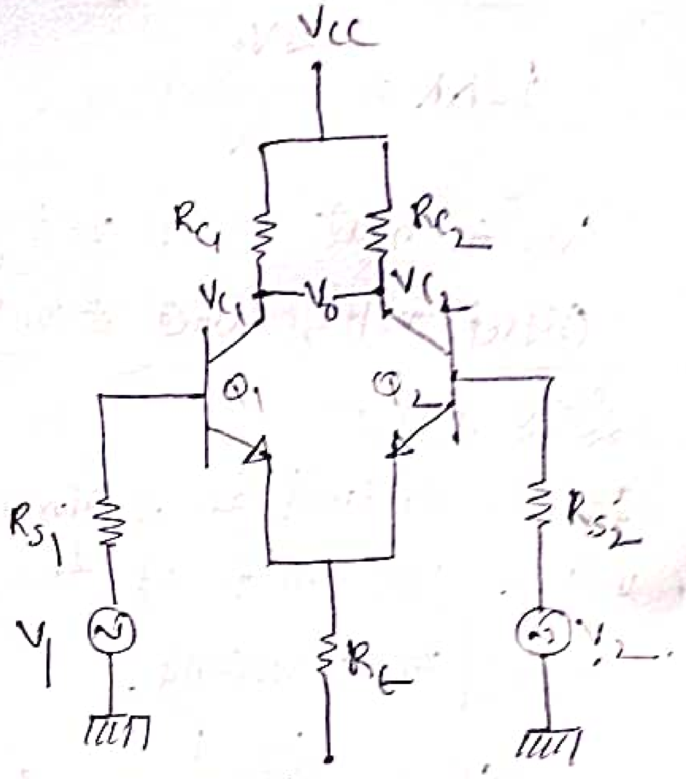
⇒ Difference in i/p voltages must be zero.

$V_1 - V_2 = 0 \Rightarrow V_1 = V_2.$

if $V_1 = 0$, $V_2 = 0$

Differential Amplifier Configurations:-

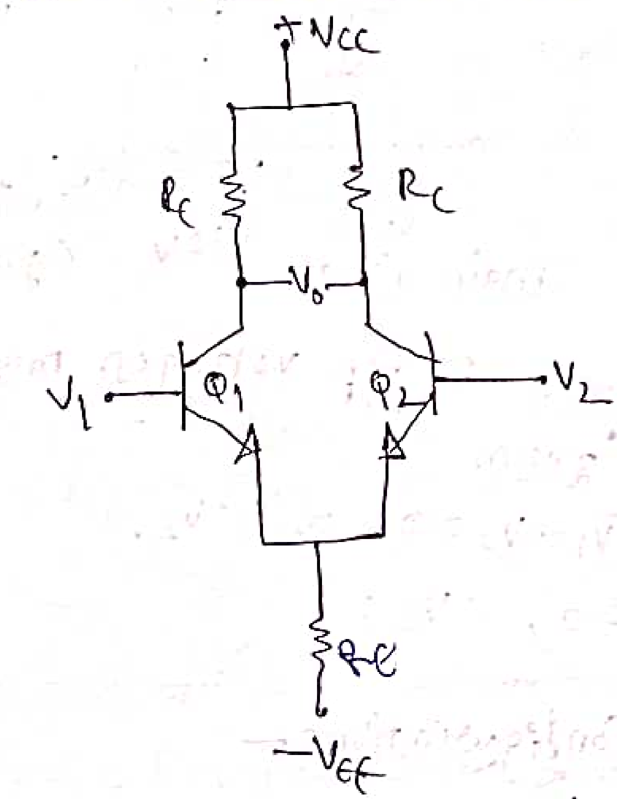




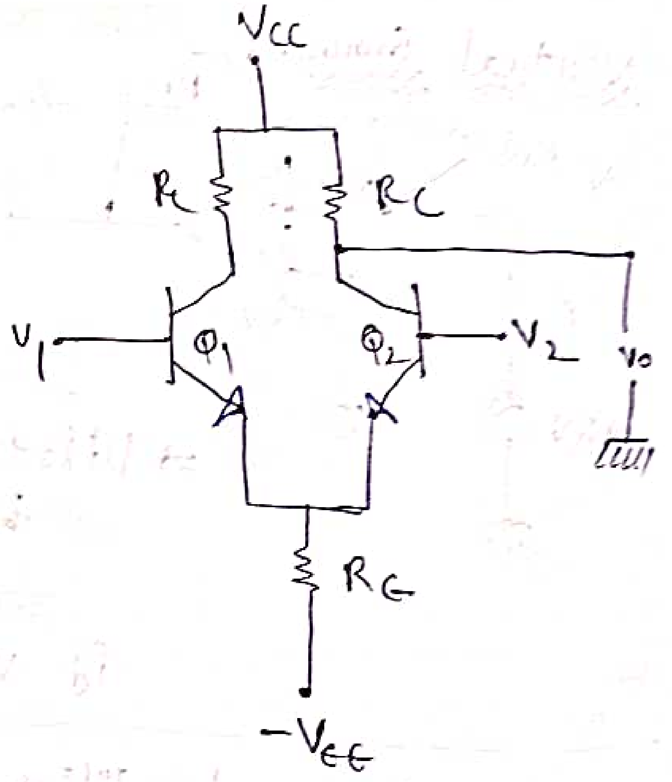
⇒ if $V_1 > V_2$ then V_0 = +ve(positive)

$V_{C_1} - V_{C_2} = V_0$.

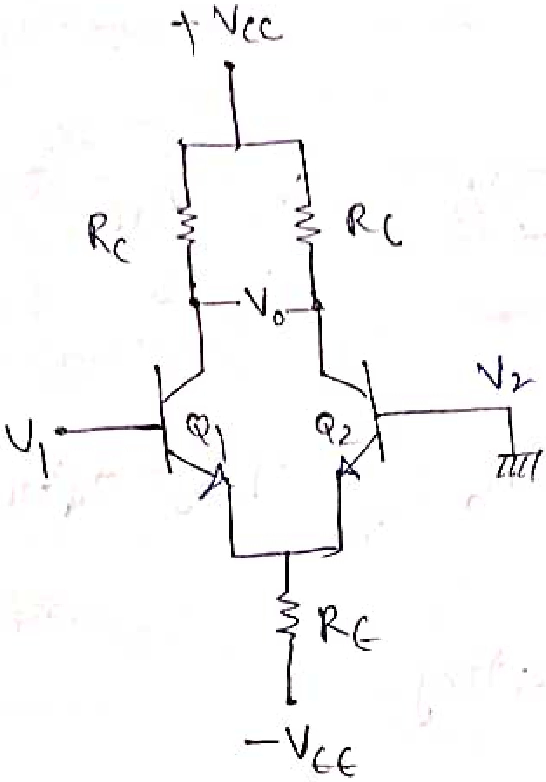
Different configurations:-



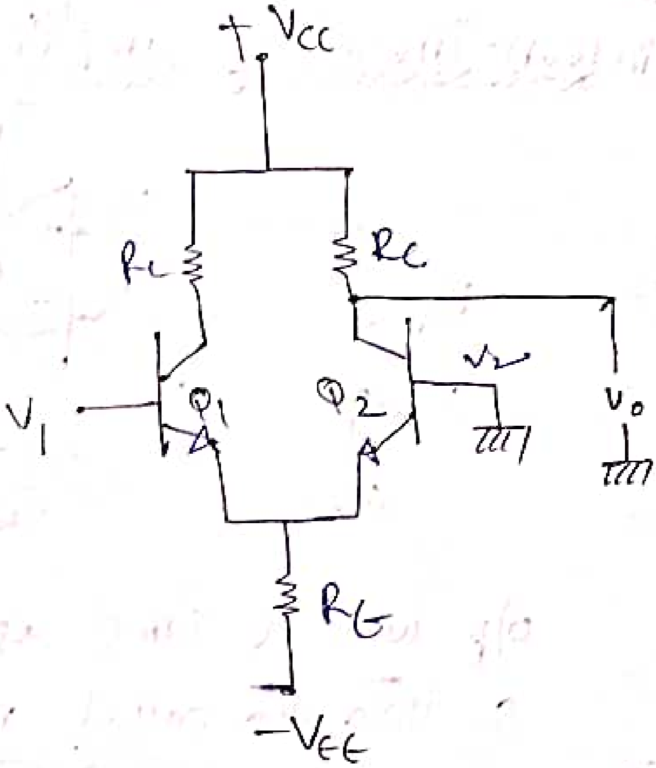
(i) Dual input balanced o/p differential amplifier.



(ii) Dual i/p unbalanced o/p differential amplifier.



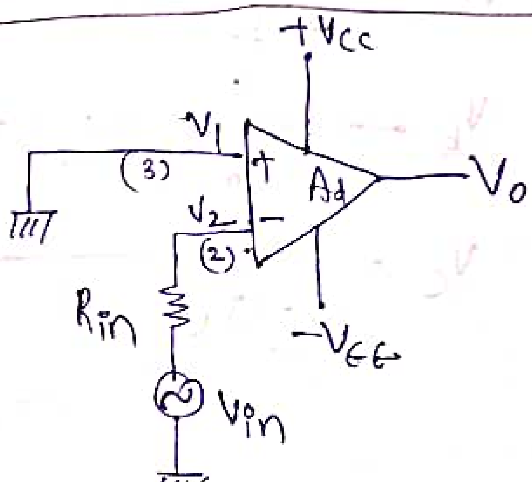
(iii) Single i/p balanced o/p differential amplifier.



(iv) Single i/p unbalanced o/p differential amplifier.

Amplifications of op-amp :-

(i) Inverting amplifier :-



V_{in} → i/p voltage

R_{in} → i/p resistance

A_d = gain of amplifier.

V_o = o/p voltage.

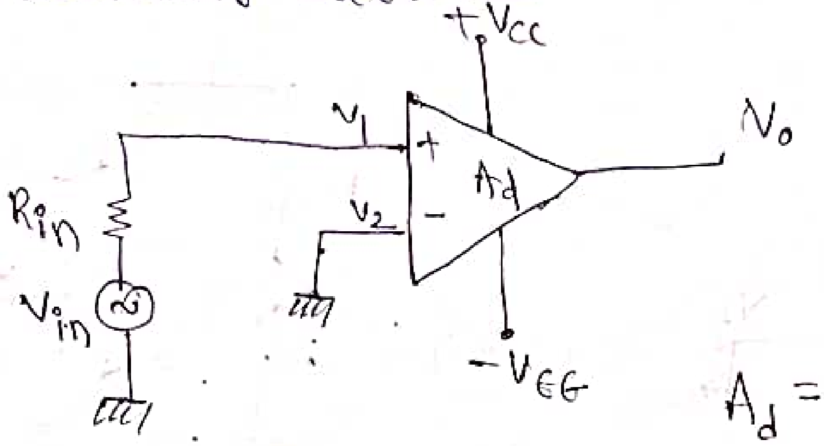
$A_d = \frac{V_{o/p}}{V_{i/p}}$

$V_2 = V_{in}$, $V_1 = 0$.

$A_d = \frac{-V_o}{V_{in}}$ $\quad V_o = -A_d V_{in}$.

⇒ o/p will be -ve of the i/p. So this is called inverting amplifier.

(ii) Non-inverting amplifiers



$V_1 = V_{in}$

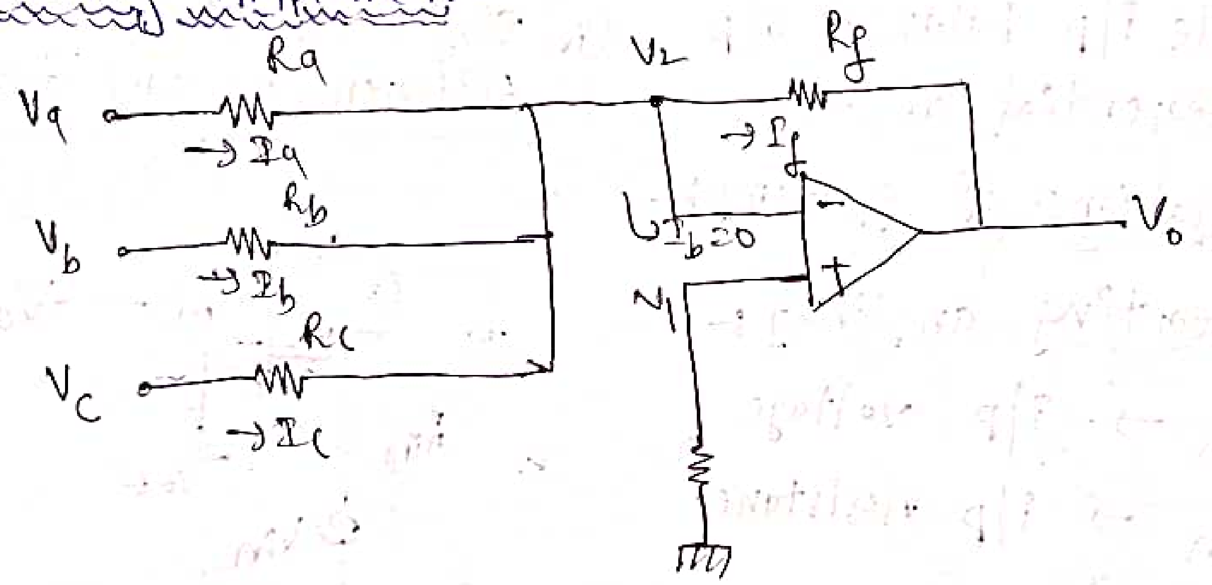
$V_2 = 0$

$A_d = \frac{V_o}{V_{in}} \Rightarrow V_o = A_d V_{in}$.

o/p will be same as i/p.

So this is called non-inverting.

(iii) Summing Amplifiers



I_f = feed back current.

by applying KCL at V_2 node

$$I_a + I_b + I_c = I_f + I_b$$

$$I_b = 0 \Rightarrow I_a + I_b + I_c = I_f$$

$$\frac{V_a}{R_a} + \frac{V_b}{R_b} + \frac{V_c}{R_c} = \frac{-V_o}{R_f}$$

$$V_o = -R_f\left(\frac{V_a}{R_a} + \frac{V_b}{R_b} + \frac{V_c}{R_c}\right).$$

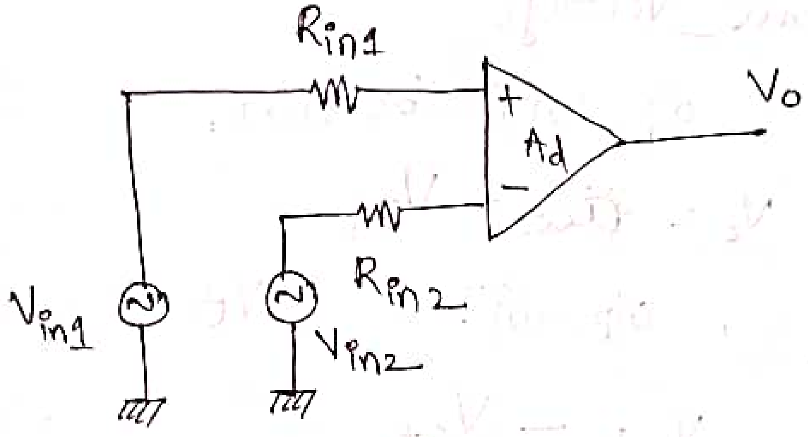
Let $R_a = R_b = R_c = R$

$$V_0 = -R_f \left(\frac{V_a + V_b + V_c}{R} \right).$$

$\frac{R_f}{R}$ is the gain of the amplifier.

if $\frac{R_f}{R} = 1$ then $V_0 = -(V_a + V_b + V_c)$ //.

(iv). Difference Amplifier:-



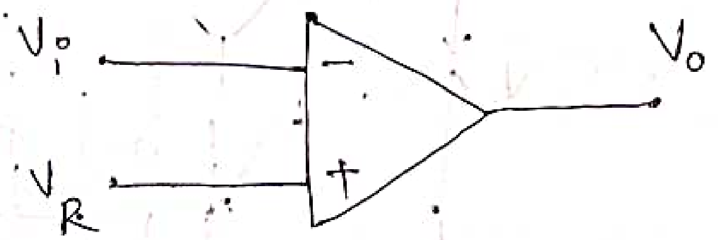
Applications:-

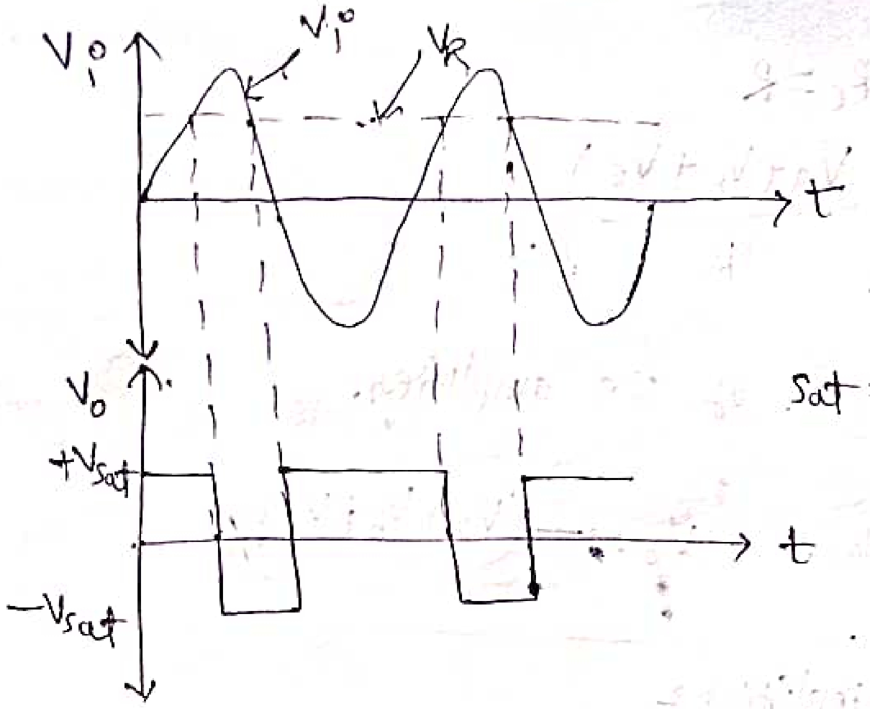
$$V_0 = A_d (V_{in1} - V_{in2})$$

$$A_d = \frac{o/p \text{ voltage}}{i/p \text{ voltage}} = \frac{V_{o/p}}{V_{i/p}}.$$

A_d = differential gain.

(v). Comparator:-





Sat = Saturation.

V_R = Reference Voltage

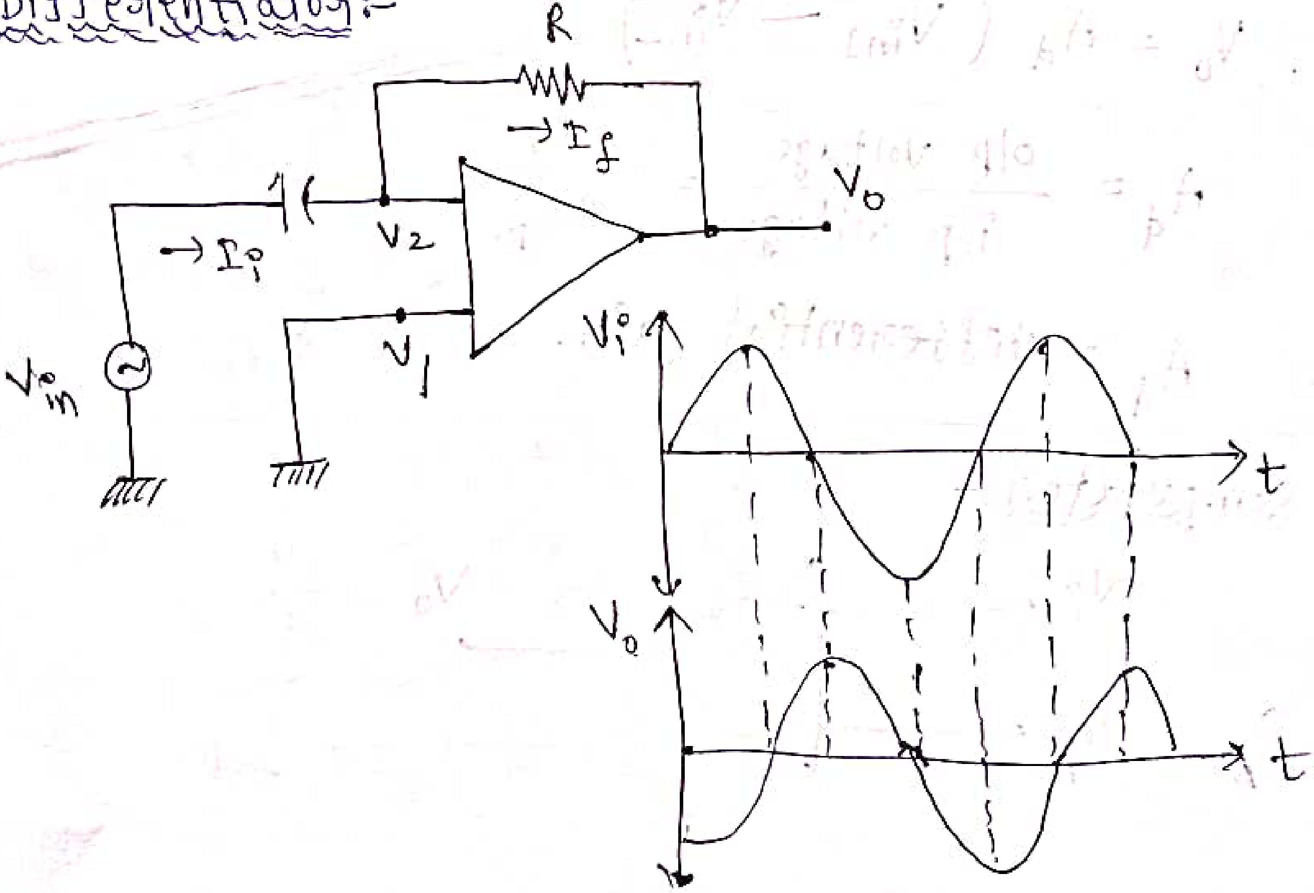
(i) if $V_i < V_R$, o/p will be +ve,

$V_o = + V_{sat}$.

(ii) if $V_i > V_R$, o/p will be -ve

$V_o = - V_{sat}$.

(vi) Differentiator:-



$\Rightarrow I_1 = I_f$ $\qquad$ $I_1 = I_b + I_f$

Here, $I_b = 0$

wkt, $I = C \cdot \frac{dV}{dt}$.

$$I_1 = I_f$$

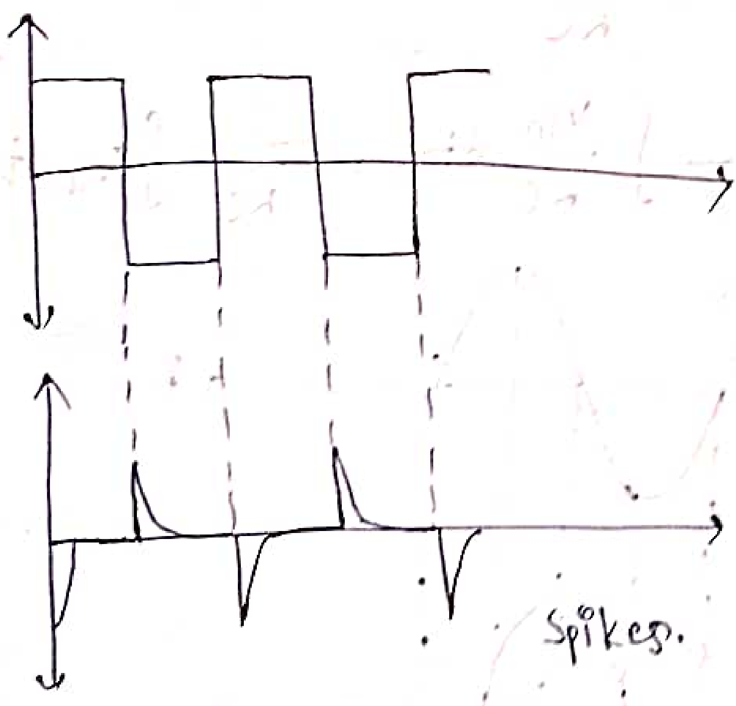
$$C \cdot \frac{d}{dt}(V_{in} - V_2) = \frac{V_2 - V_0}{R}$$

But $V_2 = 0$ ↓ virtual ground.

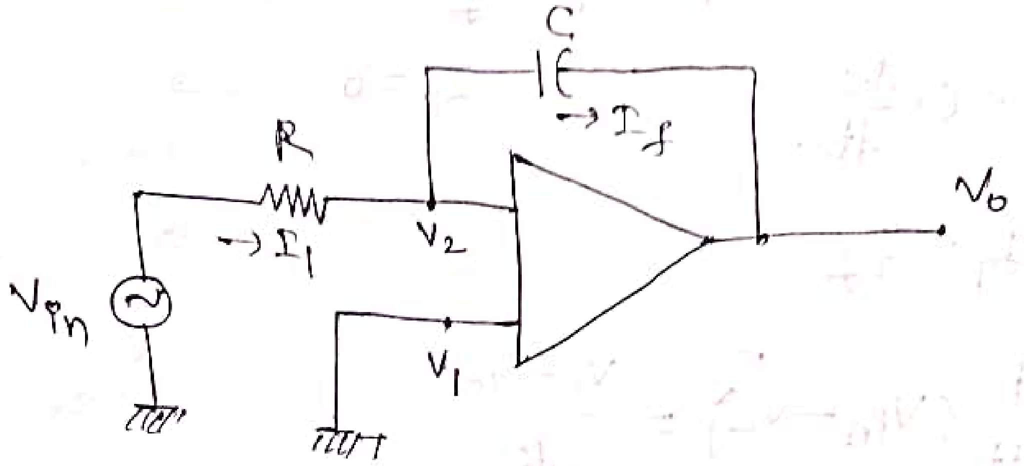
$$C \cdot \frac{d}{dt} V_{in} = \frac{-V_0}{R}$$

$$V_0 = -RC \frac{d}{dt}(V_{in}).$$

RC = Time Constant.



(vii) Integration:



$$I_1 = I_f$$

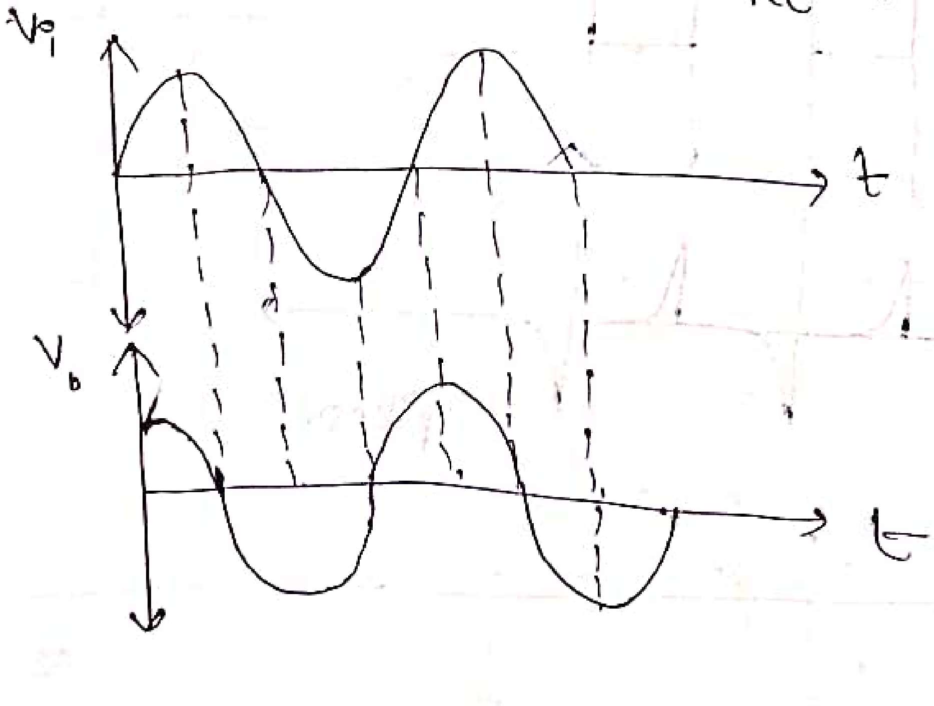
$$\frac{V_{in} - V_2}{R} = C\frac{d}{dt}(V_2 - V_o)$$

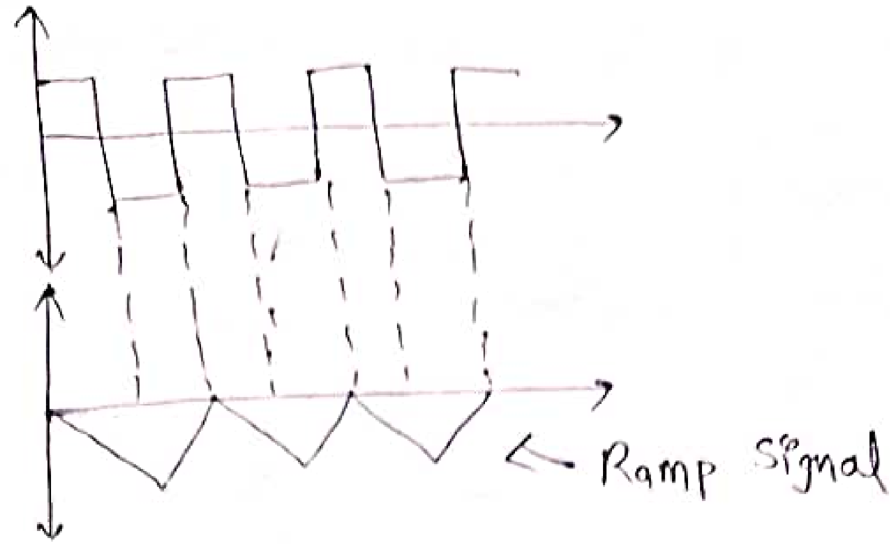
$$\Rightarrow V_2 = 0.$$

$$\frac{V_{in}}{R} = C \cdot \frac{d}{dt}(-V_o)$$

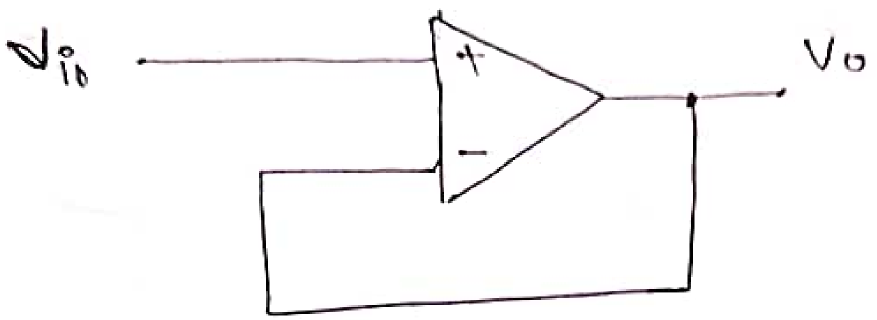
$$-\frac{d}{dt} V_o = \frac{V_{in}}{RC}$$

$$V_o = -\int \frac{V_{in}}{RC}\, dt = \frac{-1}{RC}\int V_{in}\, dt.$$





(viii) Voltage Follower:-



-ve feedback.

A_d = Gain = Unity = 1.

$V_o = A_d V_{in}$. ↓ $A_d = 1$

$$\boxed{V_o = V_{in}}$$