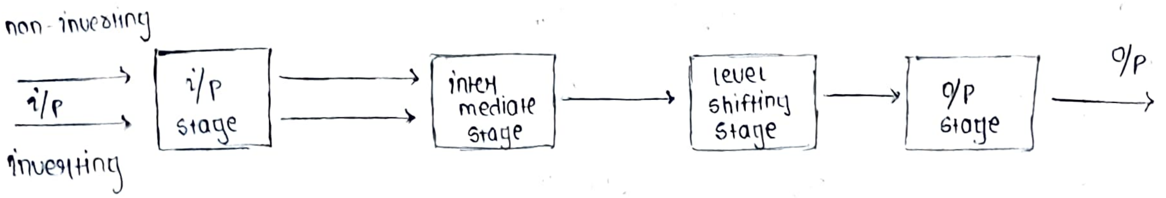
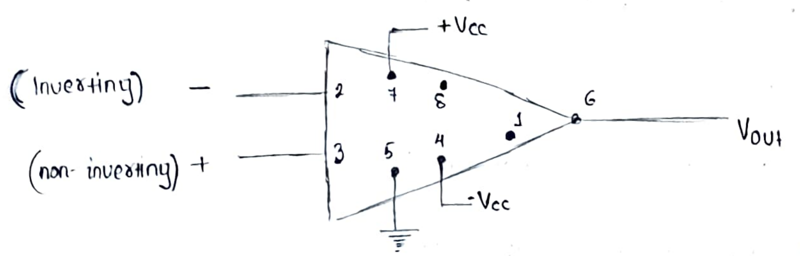
# OPERATIONAL AMPLIFIER [OP AMP]

* An operational amplifier is a direct coupled, high gain, amplifier with feedback. It is commonly known as 'opamp'. This is called so because of its ability to perform mathematical operations such as addition, int, diff, etc.

→ Block diag. of opamp :




opamp in diagram

* Input stage :

It is a dual i/p, double ended o/p differential amplifier. It has highest gain

* Intermediate stage :

It is a dual i/p, single ended o/p differential amplifier. It also provides some amplification

* Level shifting stage :

It is an emitter follower circuit. It shifts the o/p of intermediate stage to zero dc voltage wrt ground.

* Output stage :

It is a push pull complementary amplifier to raise the current supplying capacity , to increase O/p voltage ~~dur~~ shunt and to provide low O/p resistance

→ Properties of an ideal opamp :

* open loop voltage gain is infinity ($A_v = \infty$)
* A large voltage gain when operating without feedback
* Input impedence is infinity ($Z_{in} = \infty$)
* O/p impedence is zero ($Z_{out} = 0$)
* Bandwidth is infinity ($BW = \infty$)
* Common mode rejection ratio is infinity ($CMRR = \infty$)
* Slow rate is $\infty$
* Perfect balance is $V_0 = 0$ , when $V_1 = V_2$
* Characteristic do not vary with temperature.
* Voltage gain remains constant over a wide freq. range.

→ Slow rate of opamp :

It is defined as the max$^m$ rate of change of O/p voltage/~~unit~~ per unit of time . It is expressed in volts / microsecond.

$$SR = \left(\frac{dV_0}{dt}\right)_{max} \quad V/\mu sec.$$

→ Open loop gain of opamp :

open loop gain ($A_v$) of an opamp is the ratio of O/p voltage ($V_0$) to the differential I/p voltage ($V_{id}$) without feed back.

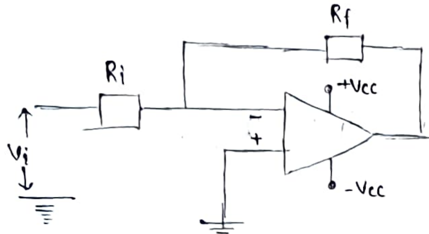
$$A_v = \frac{V_0}{V_{id}}$$

→ CMRR of an opamp :

It is a measure of ability of opamp to suppress the common mode signals. It is defined as ratio of differential mode gain to the common mode gain

$$\text{CMRR} = \frac{\text{Diff. mode gain}}{\text{Common mode gain}} = \frac{A_d}{A_{cm}}$$

→ Circuit diagram of an inverting amplifier and its o/p expression.




$$V_o = \frac{-R_f}{R_i} \cdot V_i$$

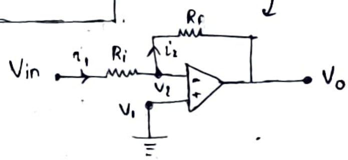
Gain of inverting amplifier :

$$\text{Gain} \quad A_{vf} = \frac{V_o}{V_i} = -\frac{R_f}{R_i}$$

where $R_f$ = feed back resistance

$R_i$ = i/p resistance

no i pass through opamp due to high resistance value.




∴ KCL : $i_1 = i_2$

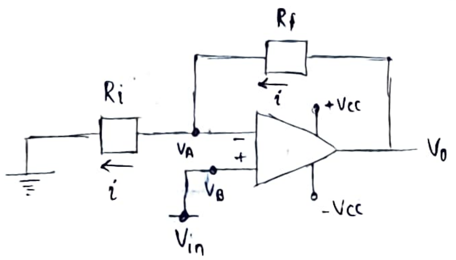
$$\frac{V_{in} - V_2}{R_i} = \frac{V_2 - V_o}{R_f}$$

$V_1 = V_2 = 0$ (Due to ground $V_1$ is zero, due to opamp $V_2$ is zero)

$$\frac{V_i}{R_i} = \frac{-V_o}{R_f}$$

$$\frac{V_o}{V_i} = -\frac{R_f}{R_i}$$

→ Circuit diag. of a non-inverting amplifier :




$$V_o = \left(1 + \frac{R_f}{R_i}\right) \cdot V_i$$

Gain expression : $A_{vf} = \dfrac{V_o}{V_i} = 1 + \dfrac{R_f}{R_i}$

$V_{in} = V_A = V_B$ , $i = \dfrac{V_o - V_A}{R_f} = \dfrac{V_o - V_{in}}{R_f}$

$i = \dfrac{V_A - 0}{R_i}$ $\quad$ ∴ $i = i$

$$\frac{V_o}{R_f} - \frac{V_{in}}{R_f} = \frac{V_{in}}{R_i} \Rightarrow \frac{V_o}{R_f} = V_{in}\left[\frac{1}{R_f} + \frac{1}{R_i}\right] \Rightarrow V_o = \left[1 + \frac{R_f}{R_1}\right] V_{in}$$

| Inverting | Non - inverting |
| --- | --- |
| * input voltage is applied to inverting terminal of opamp through $R_i$ | * Input voltage is directly applied to non- inverting terminal of opamp. |
| * Voltage shunt feedback in used | * Voltage series feedback is used |
| * The o/p is phase reversed. | * The o/p is inphase with the i/p |
| * Gain : $A_{vf} = -\frac{R_f}{R_i}$ | * Gain : $A_{vf} = \left(1+\frac{R_f}{R_i}\right)$ |

⇒ Draw the ckt diagram of non- inverting amplifier with a feedback gain of 30

Sol$^n$

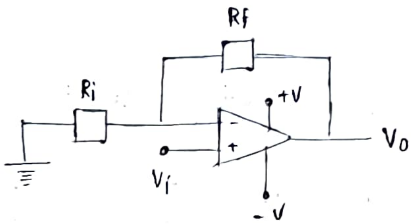
$A_{vf} = 30$

$1+\frac{R_f}{R_i} = 30$

$R_f = 29 R_i$

Assume, $R_1 = 10\,K\Omega$

$R_f = 290\,K\Omega$.

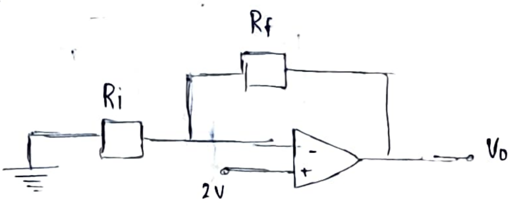



⇒ Design a ckt using opamp to get an o/p of 6V from an i/p of 2V

Sol$^n$

$V_o = 6V, \quad V_i = 2V$.

$R_f = ?$




for non - inverting amplifier.

$V_o = \left(1+\frac{R_f}{R_i}\right) \cdot V_i$

$R_f = 2 R_i$

Assume, $R_i = 10\,K\Omega$

$R_f = 20\,K\Omega$