UNIT-1

FUNDAMENTALS OF OPERATIONAL AMPLIFIER

Applications of operational amplifier:

* Adder
* Subtractor
* Instumentation amplifier
* Integration
* I to V, V to I conversion
* Differentiator

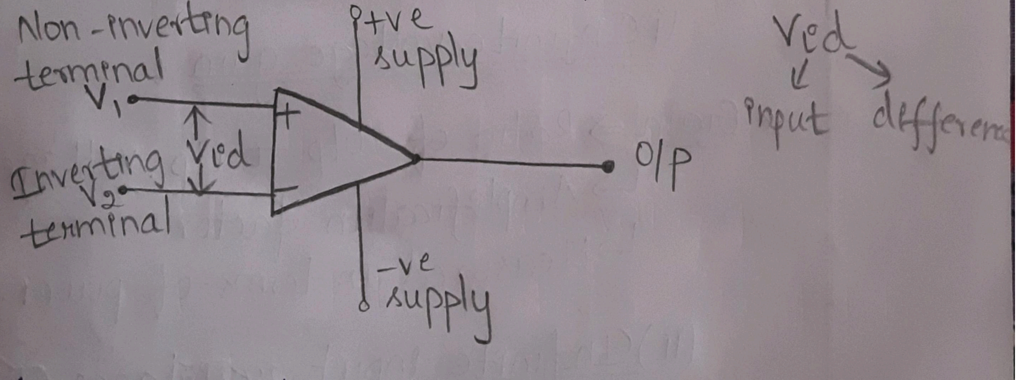
Amplifier:

* It is an electronic device that increases the magnitude of the signal [i.e current, voltage (or) power].

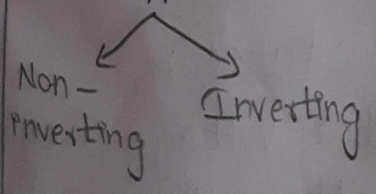
Applications:

* Wireless communication
* Signal broadcasting
* Audio equipment

Operational amplifier (Op-Amp):



* An operational amplifier is an analog circuit, its basic operation is to amplify and output the voltage difference between two i/p.



31/08/2023 * Linear Integrated Circuit ⇒ D. Roy Choudhry (5th edition)

* M. Morris Mano and Michael D. Ciletti ⇒ Digital Design (5th edition).

Ideal characteristics of op-Amp:

Op-Amp:

It has three terminals:

i) 2 - high impedance i/p (no current)

ii) 1 - Low impedance o/p

Impedance ⇒ How much voltage / current it can oppose.

Digital circuit ⇒ called as impedance

Analog circuit ⇒ called as resistance

* Op-Amp ⇒ IC 741.

Ideal characteristics of op-Amp:

(i) Infinite voltage gain:

* Gain ⇒ Ratio of o/p to i/p. voltage
  ↳ Amplification factor
  ↳ Measured in terms of power.

(ii) Infinite input resistance (R_i):

* Input resistance ⇒ Not drawing any current from any circuit which is connected to it.

(iii) Zero output resistance:

* It signifies that the voltage across the load (↳ device connected to o/p) will be same as the voltage output of op-Amp.

(iv) Zero output voltage (when i/p is zero):

(v) Infinite band width

↳ Zero to infinity value of frequency can be accepted. So, that any i/p signal can be amplified.

Band width ⇒ Band of frequency.

(vi) Infinite common mode rejection ratio (CMRR):

* CMRR ⇒ It is the measure of the capability of op-Amp to reject the signal i.e common to both i/p.

(vii) Infinite slew rate:

* Slew rate ⇒ Defined as the max rate of change of op-Amp output voltage. So, that the o/p changes occur with the i/p voltage change.

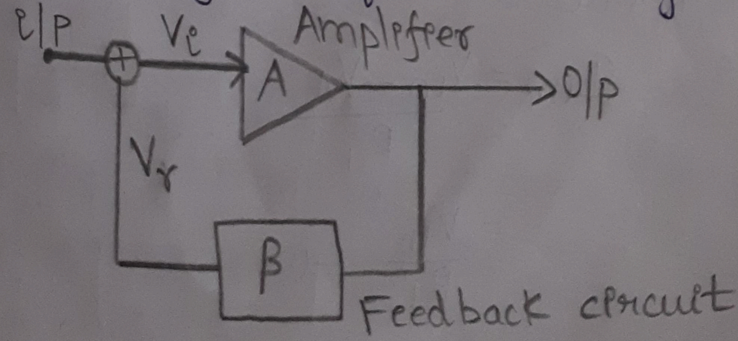
(viii) Zero offset voltage:

* Offset voltage ⇒ Defined as the differential voltage that must be applied b/w the i/p terminals to bring its o/p voltage zero.

Feedback in Op-Amp:

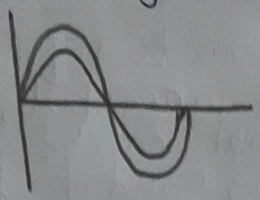
* Feedback is when a fraction of o/p signal is fed back into i/p.

* To improve gain, feedback is given.

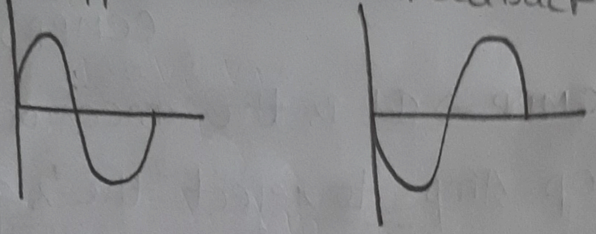


Types:

i) +ve Feedback (Regenerative) ⇒ Sum ⇒ Both in same phase
↓
e/p + feedback



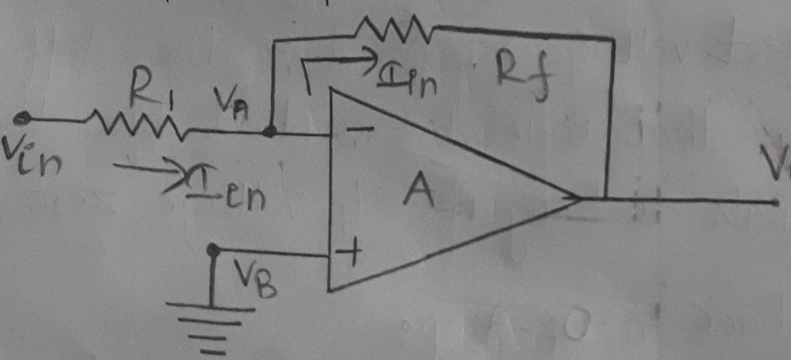
(ii) -ve Feedback (Degenerative) ⇒ Subtract ⇒ out of phase



* Op-Amp is used with -ve feedback.
  -ve feedback provides gain stability.
  ↳ Reduces the Noise level.

04/09/2023 Inverting amplifier:

* In inverting amplifier input is applied to inverting terminal (-).
* Graph ⇒ outphase.



Rf = Feedback resistor

Assume

$V_A = V_B$ V_B is connected to ground

$V_A = 0$

At e/p side

$$I_{in} = \frac{V_{in} - V_A}{R_1} \qquad \left[I = \frac{V}{R}\right]$$

$$= \frac{V_{in}}{R_1} \rightarrow (1)$$

At o/p side,

$$I_{in} = \frac{V_A - V_O}{R_f}$$

$$= \frac{-V_O}{R_f} \rightarrow ②$$

Equate ① & ②,

$$\frac{V_{in}}{R_1} = \frac{-V_O}{R_f}$$

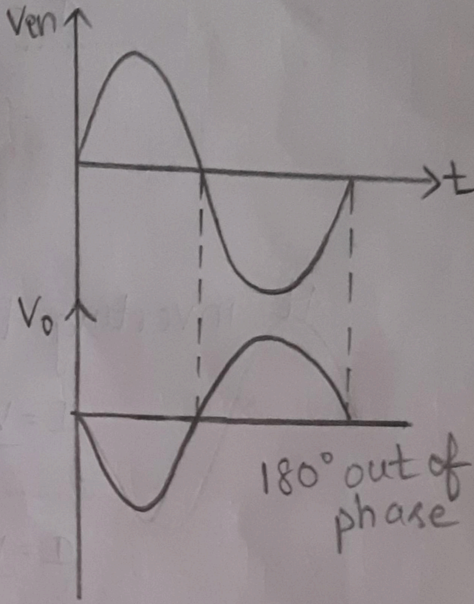
$$\frac{V_{in}}{V_O} = \frac{-R_1}{R_f}$$

$$V_O = \frac{-R_f V_{in}}{R_1}$$

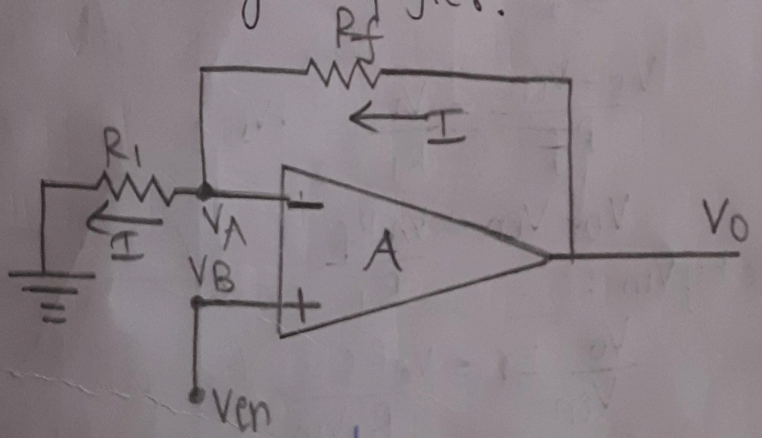
$$\frac{V_O}{V_{in}} = \frac{-R_f}{R_1}$$

$$\boxed{A = \frac{-R_f}{R_1}}$$

O/P waveform



Non-inverting amplifier:



* Non inverting op-Amp is an op-Amp circuit with an output voltage that is inphase with an input voltage.
* In this configuration, the i/p signal is given to the non-inverting (+) terminal and the inverting terminal is connected to the ground.
* There are two assumptions,

(i) Current will not flow through the i/p terminal of Op-Amp. So the V_o produces the current 'I' from V_o terminal to V_A.

(ii) $V_A = V_B$

$$V_A = V_{in}$$

At o/p side,

$$I = \frac{V_o - V_A}{R_f}$$

$$= \frac{V_o - V_{in}}{R_f} \rightarrow ①$$

At inverting terminal,

$$I = \frac{V_A - 0}{R_1}$$

$$I = \frac{V_A}{R_1} \rightarrow ②$$

Equate ① & ②,

$$\frac{V_o - V_{in}}{R_f} = \frac{V_A}{R_1}$$

$$V_o - V_{in} = \frac{V_A R_f}{R_1}$$

Divide by 'V_{in}' :

$$\frac{V_o}{V_{in}} - 1 = \frac{V_A R_f}{R_1 V_{in}}$$

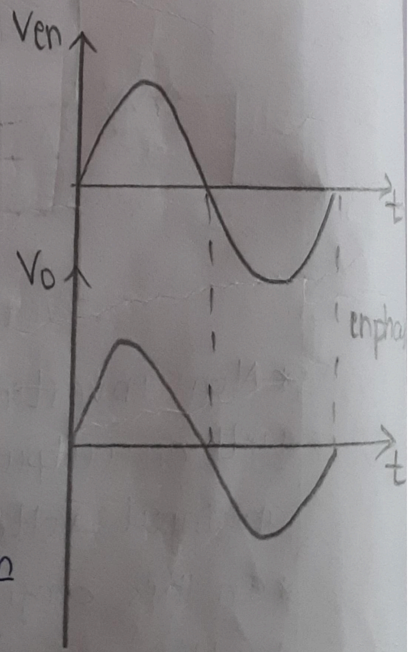
$$\frac{V_o}{V_{in}} = \frac{V_A R_f}{R_1 V_{in}} + 1$$

$$\frac{V_o}{V_{in}} = \frac{V_A R_f + R_1 V_{in}}{R_1 V_{in}}$$

$[V_A = V_{in}]$ $$V_o = \frac{V_{in} R_f + V_{in} R_1}{R_1}$$

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

O/p waveform



$$\frac{V_o}{V_{en}} = \frac{R_f + R_1}{R_1}$$

$$\boxed{A = 1 + \frac{R_f}{R_1}}$$