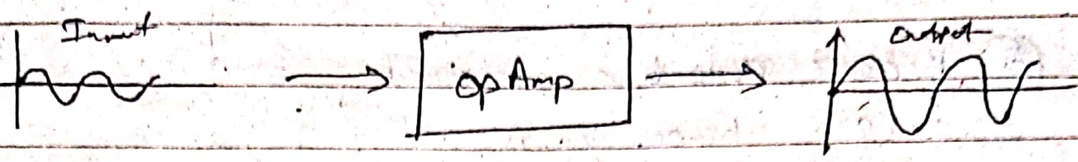
25th Jan 2022

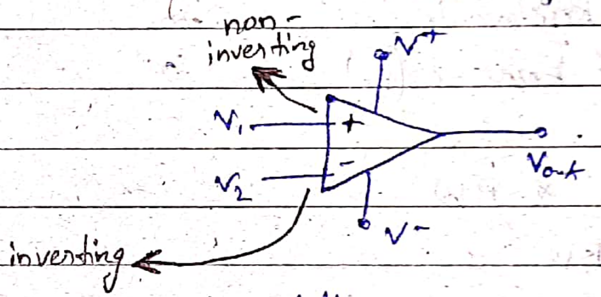
Operational Amplifier (Opamp)



- It is a very high gain differential amplifier with high input impedance and low output impedance.

- Could be used for performing ~~so~~ add, subs, mul, div, integration, diff. etc. Hence called Operational Amplifier.

Circuit ~~&~~ Symbol :-



$V_1, V_2 \rightarrow$ Input

$V_{out} \rightarrow$ Output

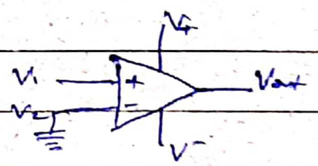
$V^+, V^- \rightarrow$ Biasing

$\boxed{V_{out} = A(V_1 - V_2)}$

the difference b/w V_1 and V_2 gets amplified.

where A is open loop gain of op-amp (without feedback).

(1) If $V_2 = 0$

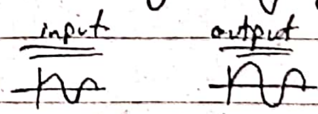


$V_{out} = A(V_1 - V_2)$

$= AV_1 \rightarrow$ thus non inverting.

($\because V_2$ is generally grounded $\Rightarrow V_2 = 0$)

$\hookrightarrow$ as



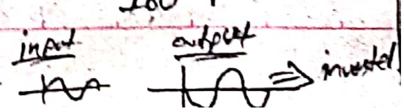
(2) $V_2 \neq 0$, $V_1 = 0$

$V_{out} = A(V_1 - V_2)$

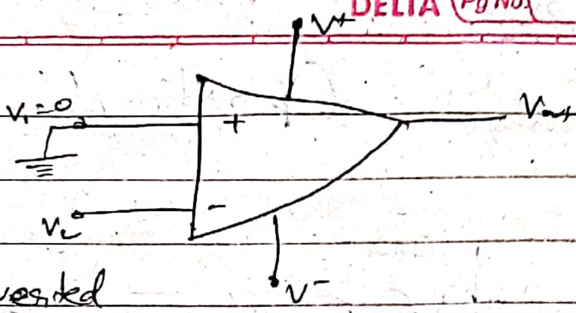
$= -AV_2$ (inverted)

180° phase shift

$\hookrightarrow$ as



2

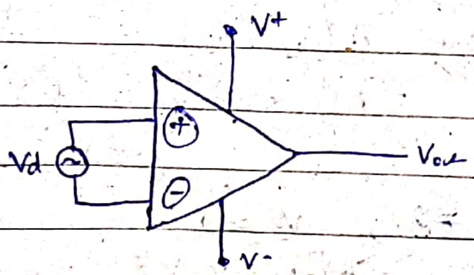


(*) Because output is inverted in (2), hence V_2 is called inverted ~~Xin~~ terminal.

Characteristic of OpAmp :-

	Char	Ideal	Practical
1	Voltage gain, (A_v)	∞	$10^5 - 10^6$
2	Input Resistance, (R_i)	∞	$1M\Omega$
3	Output Resistance, (R_o)	0	$10 - 100\Omega$
4 (*)	Gain * BW	∞	$10^6 Hz$
5	BW	∞	$10^6 Hz$ (gain = 1)
6	CMRR (common mode rejection ratio)	∞	10^6
7	Slew rate	∞	80 $\frac{Volt}{\mu sec}$ $\left(\frac{V}{\mu sec}\right)$ micro second

Gain ↑ BW ↓
and,
BW ↑ Gain ↓

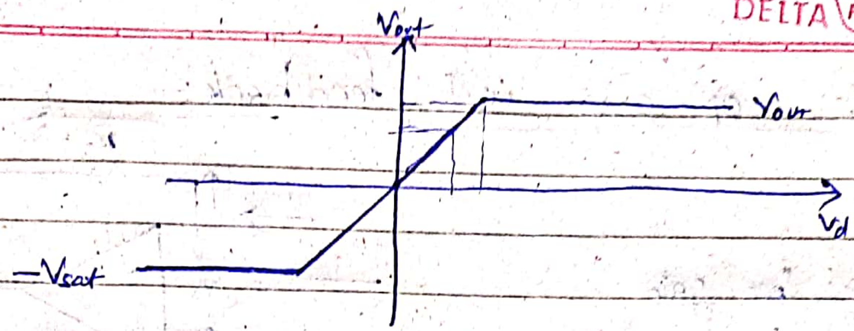


$V_1 - V_2 = V_d$

$A = 10^5$

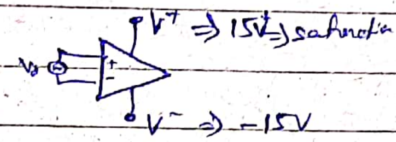
$V_d = 1mV$

$V_{out} = A * V_d = 10^5 * 1mV = \boxed{100V}$



$\Rightarrow$ ~~Vou~~

$V_{saturation} \Rightarrow$ decided by the Biasing.

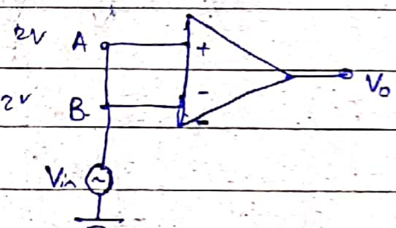


$\Rightarrow \quad V_{out} = +15V$

(A) V_{out} can never be above than $V_{saturation}$ i.e. Biasing voltage.

Common mode Operation :-

$\rightarrow$ Results in 0 output (ideally).



$\Rightarrow$ Amplify the difference signal while neglecting the common signal out the two inputs.

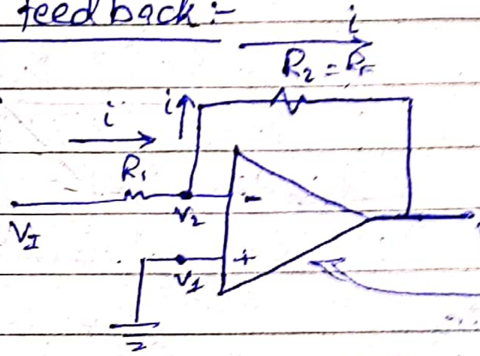
$\Rightarrow$ common signal.
$C + B_1 \Rightarrow$ of A
$C + B_2 \Rightarrow$ of B_2

$\Rightarrow$ Noise is generally common to both inputs (A and B), hence will get neglected.

V_{out} (Amplified)
$= \cancel{C} + B_1 - \cancel{C} - B_2$
$= (B_1 - B_2)$

(A) Hence the common signal neglected.

Basic op-amp with feedback:-



*Resistance of op-amp is ∞ so all current passes through $R_2 = R_F$

Closed loop gain

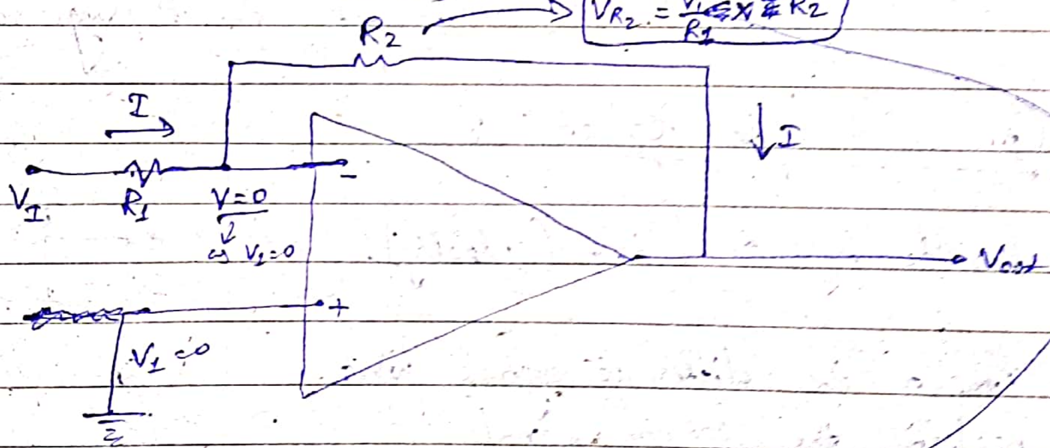
$$G_r = \frac{V_{out}}{V_I}$$

$$V_{out}\, \cancel{G_r} = A(V_2 - V_1)$$

$$V_2 - V_1 = \frac{V_{out}}{A} = 0$$

∵ $\boxed{V_2 = V_1}$ ⇒ virtually short circuit b/w input terminals and $V_1 = 0$ (as grounded), so $V_1 = V_2 = 0$

$\boxed{V_{R_2} = \frac{V_I}{R_1} \times R_2}$



$$I_1 = \frac{V_I - 0}{R_1} = \frac{V_I}{R_1}$$

By KVL,

$$V_{out} = -\left(\frac{V_I}{R_1} \times R_2\right) \Rightarrow$$

$$\boxed{\frac{V_{out}}{V_I} = -\left(\frac{R_2}{R_1}\right)}$$

↳ gain (closed loop)

(Inverted)

↳ as V_{out} is (−ve).