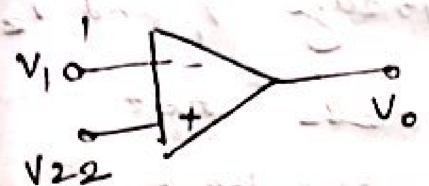
op. Amplifier



Depending upon whether input is applied to 1 input or 2 inputs op-Amp can have two or one inputs. Similarly output is also either single or double ended.

It has minimum five terminals.

1. inverting input terminals
2. non-inverting input terminal.
3. output terminal
4. positive bias supply terminal.
5. negative bias supply terminal.

− sign − represents inverting terminals
+ sign − " non-inverting ".

This means that a signal applied at negative input terminal will appear amplified but phase inverted at the output terminal. Similarly input signal applied to the positive terminal will appear amplified and inphase at the output.

③

The the +ve and -ve sign indicate phase reversal not the voltage V_1 and V_2. Also + and - sign does not indicate that +ve input voltage to be connected to + or -ve input signal to -. It can be reversed.

Op-Amp characteristics :

1) Op-Amp is operated without connecting to any resistor or capacitor from its output to any one of the inputs, it is said to be in the open-loop condition. The word open loop means there is no feedback.

2) Its open loop gain is A_V is infinite

$$A_V = -\infty$$

3) Its input resistance R_i is infinite

$$R_i = \infty \text{ ohm.}$$

4) Its output resistance R_o is zero

$$R_o = 0\ \Omega$$

5) It has got infinite bandwidth ie it has flat frequency response from dc to infinity.

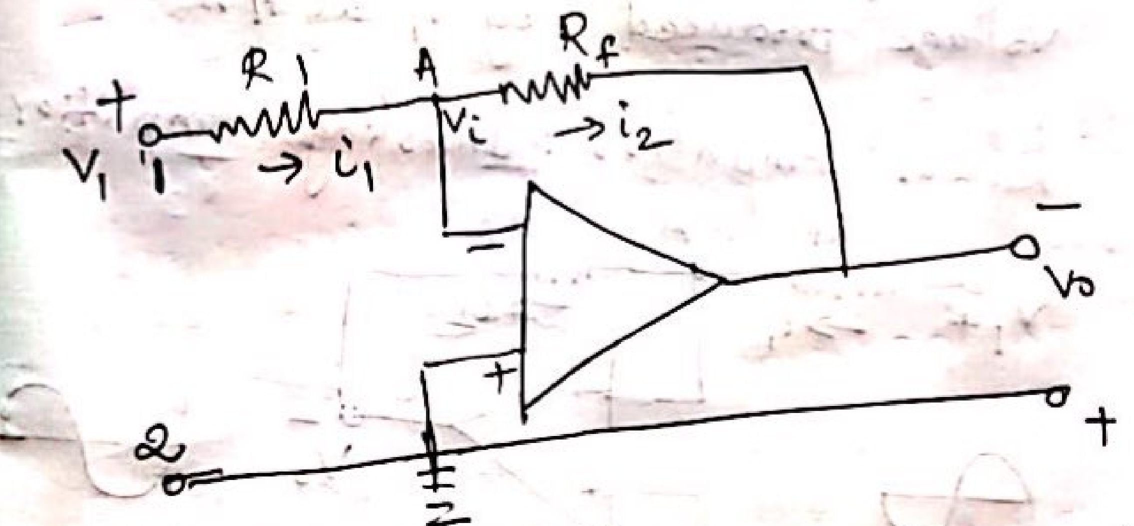
1) Infinite input resistance means the input current $i = 0$.
It is an voltage controlled device.

2) $R_0 = 0$ means, V_0 is not dependent on the load resistance connected across the output.

3) for an ideal op-Amp $A_V = \infty$ but actually it is very high. (10^6)
For input supply of $V_S = \mp 15V$, $A_V = 10^6$.
V_0 can be limited to $15/10^6 = 15\mu V$

$1\mu V$ can become $1V$.

<u>Op-Amp with Negative feedback:</u>



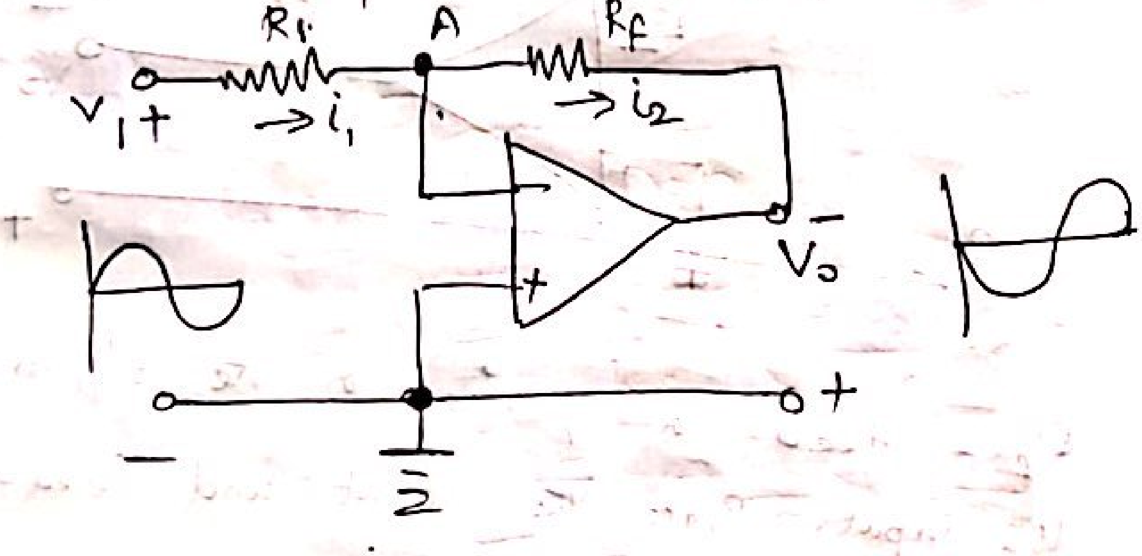
R_f - feed a portion of the o/p into the input. Since the input and feedbac currents are added at point A, It is called as summing point.

When V_1 is applied, point A attains some positive potential and at the same time V_0 is brought into existence. Due to the negative feedback, ~~some~~ fraction of the o/p voltage is feed back to the point A antiphase with the voltage V_1.

The algebric sum of the two voltages is almost zero $V_i = 0$.

Negative feed back voltage at A is exactly equal to the positive voltage produced by V_1 at A.

Linear Amplifier : Inverting Amplifier



Gain $i_1 = \frac{V_{in}}{R_1} = \frac{V_1}{R_1}$

$$i_2 = -\frac{V_0}{R_f}$$

$$i_1 - (-i_2) = 0 \; ; \; \frac{V_1}{R_1} + \frac{V_0}{R_f} = 0.$$

$$\frac{V_0}{R_f} - \frac{V_1}{R_1} \quad \text{or} \quad \frac{V_0}{V_1} = -\frac{R_f}{R_1}$$

$$A_V = -\frac{R_f}{R_1} \quad \text{or} \quad A_V = -K$$

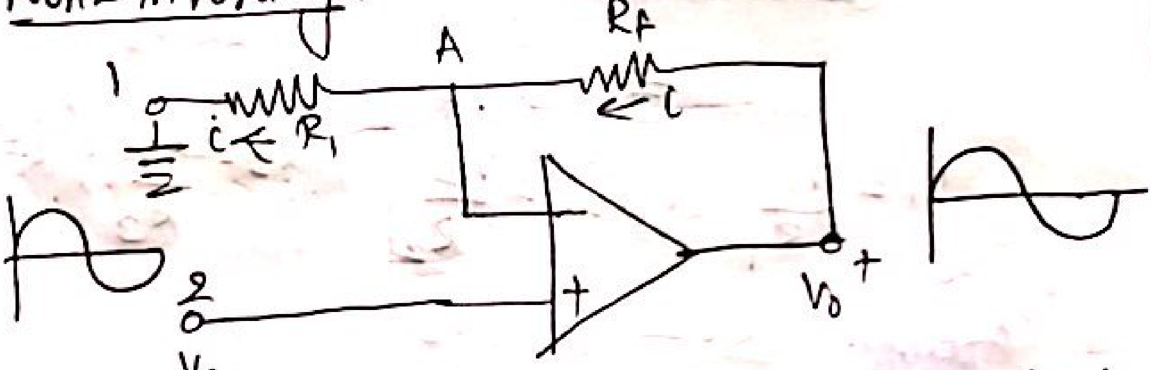
Also $V_0 = -KV_{in}$

K - constant

Voltage gain depends on R_1 and R_f - external resistors

Not on op Amp parameters.

Non-inverting:



Negative ~~Positive~~ feed back is given the output is multiplied by a positive scalar.
→ constant

Since V_2 is applied to non-inverting terminal called as non-inverting amplifier

V_o and V_2 = +ve

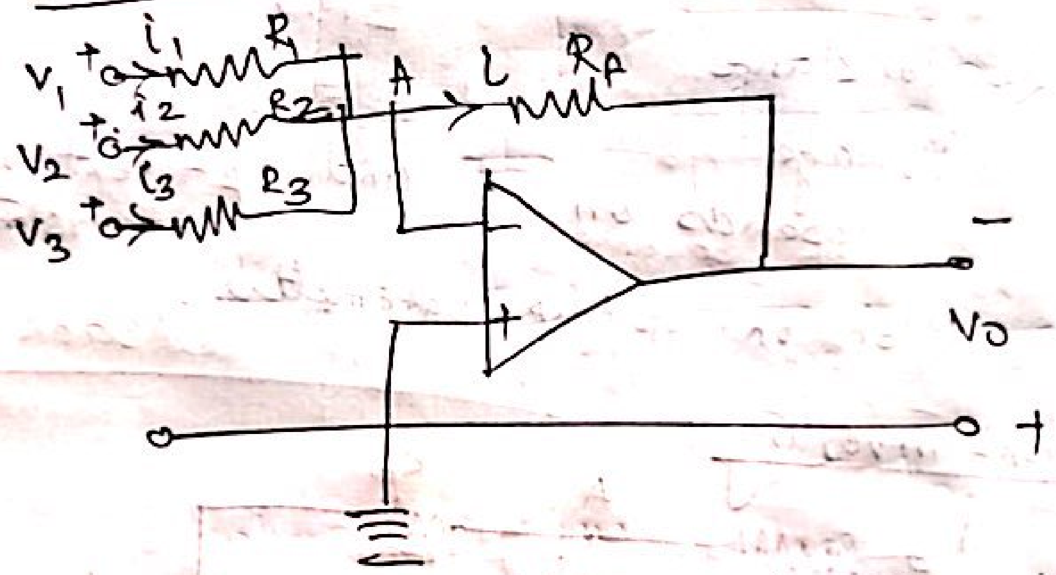
Voltage across R_1 is the input voltage V_2

$$V_{in} = V_2 = iR_1 ; \quad V_o = i(R_1 + R_f)$$

$$A_v = \frac{V_o}{V_{in}} = \frac{i(R_1 + R_f)}{iR_1}$$

$$A_v = \frac{R_1 + R_f}{R_1} = 1 + \frac{R_f}{R_1}$$

Adder or summer:



$$i_1 = \frac{V_1}{R_1} , \quad i_2 = \frac{V_2}{R_2} , \quad i_3 = \frac{V_3}{R_3} , \quad i = \frac{-V_o}{R_f}$$

Applying KCL

$$i_1 + i_2 + i_3 + (-i) = 0.$$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} - \left(\frac{-V_o}{R_f}\right) = 0.$$

$$V_o = -\left[\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right]$$

Scanned with CamScanner

$V_o = -(k_1 V_1 + k_2 V_2 + k_3 V_3)$

$-$ sign - inverting the i/p terminal

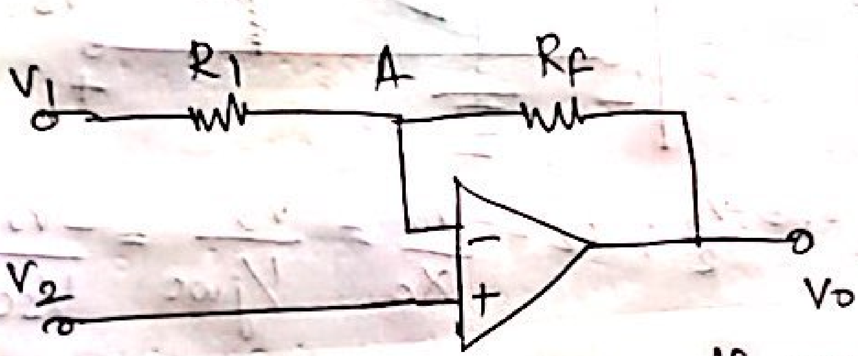
$$R_1 = R_2 = R_3 = R$$

$$\therefore V_o = \frac{-R_f}{R}(V_1 + V_2 + V_3)$$

$$= -k(V_1 + V_2 + V_3)$$

Algebric sum of the input voltages.

Subtractor:



Applying super position theorem.

$$V_o = V_o' + V_o''$$

V_o' : o/p produced by V_1

V_o'' : o/p produced by V_2

$$V_o' = \frac{-R_f}{R_1} V_1 \quad ; \quad V_o'' = \left(1 + \frac{R_f}{R_1}\right) V_2$$

$$\therefore V_o = \left(1 + \frac{R_f}{R_1}\right) V_2 - \frac{R_f}{R_1} V_1$$

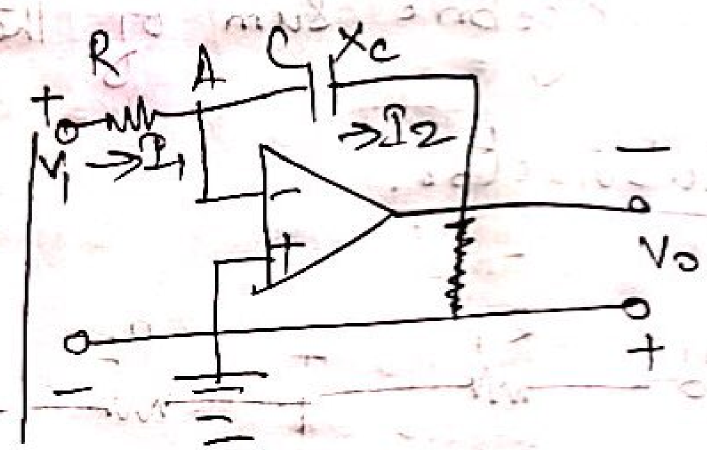
$R_f = R_1$ and $R_f/R_1 = 1$

$$V_o = \frac{R_f}{R_1}(V_2 - V_2) = k(V_2 - V_1)$$

If $R_F = R_1$

$$V_o = (V_2 - V_1)$$ – diff of two i/p voltages.

<u>Integrator</u>



$$i_1 = \frac{V_1}{R};\ i_2 = \frac{-V_o}{X_c} = \frac{V_o}{1/j\omega C} = \frac{-V_o}{1/sC}$$

$$-sCV_o.$$

where $s = j\omega$ Laplace notation

$$i_1 = i_2$$

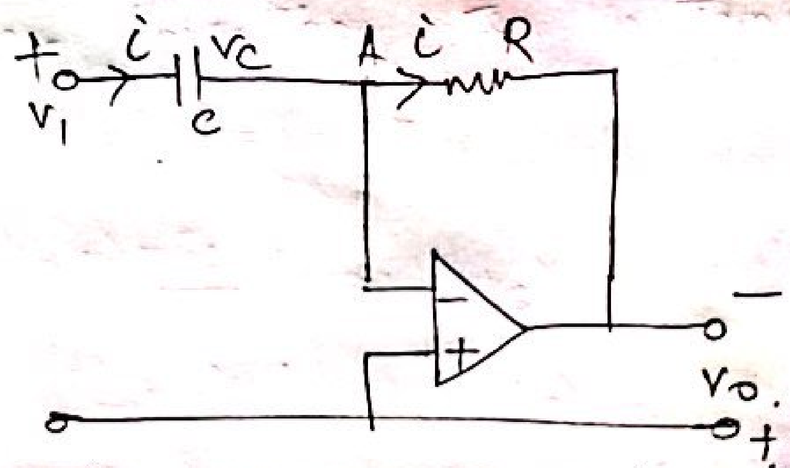
$$\frac{V_1}{R} = -sCV_o$$

$$\frac{V_o}{V_{in}} = \frac{V_o}{V_1} = \frac{-1}{sCR}.$$

$$A_V = -\frac{1}{sCR}$$

$$V_o(t) = -\frac{1}{\ldots} \int V_1(t)\,dt$$

Differentiator :



Differentiator circuit can be obtained by interchanging the resistor and capacitor of the integrator circuit.

i = rate of change of charge $= \frac{dq}{dt}$

$$q = CV_c$$

$$i = \frac{d}{dt}(CV_c) = C\frac{dv_c}{dt}$$

A – virtual ground.

$$V_o = -iR = -\left[C \cdot \frac{dV_c}{dt}\right]R$$

$$V_o = -iR = -CR\frac{dv_c}{dt}$$

O/P is proportional to the derivative of the input voltage. $-CR$ is constant.