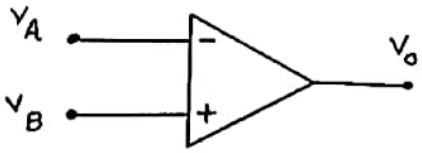
Characteristics of an ideal op-amp

An ideal op-amp exhibits the following characteristics

1. Infinite voltage gain
2. Infinite input impedance
3. Zero output impedance
4. Zero input offset voltage
5. Zero input offset current
6. Infinite CMRR
7. Infinite Slew rate
8. Infinite Bandwidth.

Concept of virtual ground



Let V_A and V_B be the voltage at the input terminals. We know that

$$V_o = A_v(V_A - V_B)$$

The A_V is the differential voltage gain and its ideal value is infinity

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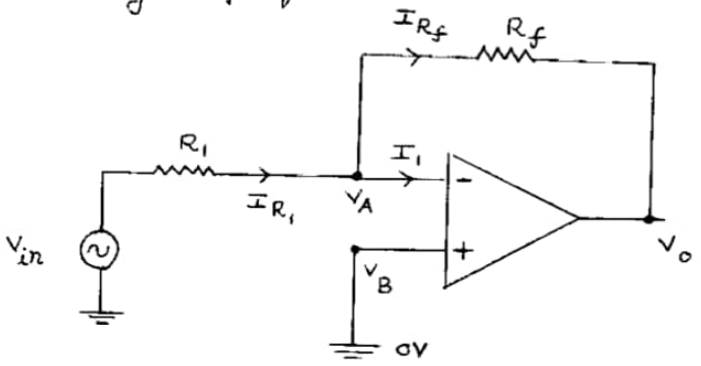
$$A_V = \infty = \frac{V_o}{V_A - V_B}$$

$$\Longrightarrow \quad V_A - V_B = 0$$

This concept is called as virtual ground.

Op-amp as an inverting amplifier

An inverting amplifier is a circuit whose output is amplified and inverted with respect to the input. Figure below shows the circuit diagram of an inverting amplifier.



By the concept of virtual ground, we have

$$V_A - V_B = 0$$

Since V_B is grounded, $V_B = 0V$. Thus we have,

$$V_A = 0V$$

Since the op-amp has infinite input impedance, it does not draw any current. Hence $I_1 = 0$

Hence $$I_{R_1} = I_{R_f}$$

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

Substituting $V_A = 0V$ we have

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

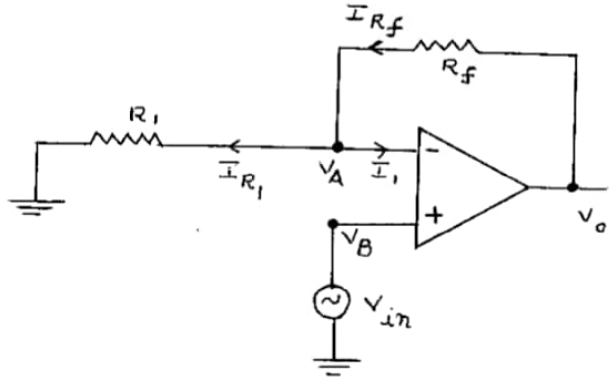
$$\therefore \boxed{V_o = -\left(\frac{R_f}{R_1}\right) V_{in}}$$

The term (R_f/R_1) is called the gain of the inverting ampl

The negative sign indicates that the output is inverted with respect to the input.

Op-amp as a non inverting amplifier :-

Figure below shows the circuit diagram of a non inverting amplifier.



By the Concept of virtual ground we have

$$V_A - V_B = 0$$

Since V_B is maintained at a voltage V_{in} we have

$$V_A = V_B = V_{in}$$

Since the op-amp has infinite input impedance, it does not draw any current. Hence $I_1 = 0$.

Hence

$$I_{R_f} = I_{R_1}$$

$$\frac{V_o - V_A}{R_f} = \frac{V_A - 0}{R_1}$$

$$\frac{V_o}{R_f} = \frac{V_A}{R_f} + \frac{V_A}{R_1} = V_A \left[\frac{1}{R_f} + \frac{1}{R_1}\right]$$

Substituting $V_A = V_{in}$ we have

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

$$\therefore \quad V_o = V_{in}\left(1 + \frac{R_f}{R_1}\right).$$

The term $\left(1 + \frac{R_f}{R_1}\right)$ is called gain of the non inverting amplifier.