UNIT-3 MPHYECC-5

OP-AMP CIRCUITS

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Op-Amp-Applications: A circuit is said to be linear, if there exists a linear relationship between its input and the output. Similarly, a circuit is said to be non-linear, if there exists a non-linear relationship between its input and output.

Op-amps can be used in both linear and non-linear applications. The following are the basic applications of op-amp −

Inverting Amplifier

Non-inverting Amplifier

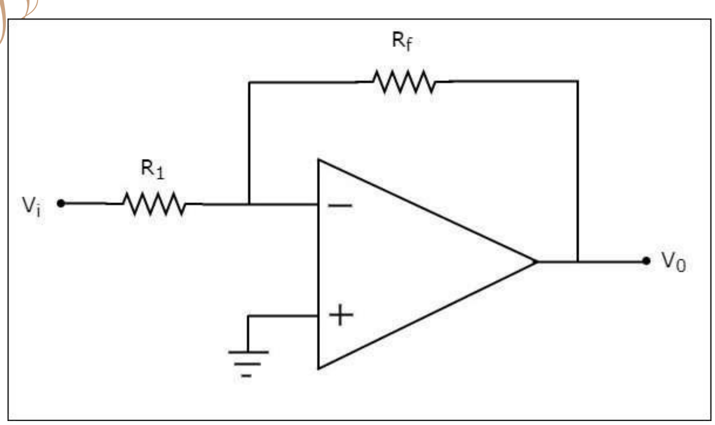
Voltage follower

In this notes you will find these basic applications in detail.

Inverting Amplifier

An inverting amplifier takes the input through its inverting terminal through a resistor R1, and produces its amplified version as the output. This amplifier not only amplifies the input but also inverts it (changes its sign).

The **circuit diagram** of an inverting amplifier is shown in the following figure −



Note that for an op-amp, the voltage at the inverting input terminal is equal to the voltage at its non-inverting input terminal. Physically, there is no short between those two terminals but **virtually**, they are in **short** with each other. In the circuit shown above, the non-inverting input terminal is connected to ground. That means zero volts is applied at the non-inverting input terminal of the op-amp.
According to the **virtual short concept**, the voltage at the inverting input terminal of an op-amp will be zero volts.
The **nodal equation** at this terminal's node is as shown below –

$$\frac{O - Vi}{R1} + \frac{0 - V0}{Rf} = 0$$

$$=> \frac{-Vi}{R1} = \frac{V0}{Rf}$$

$$=> V0 = \left(-\frac{Rf}{R1}\right) Vt$$

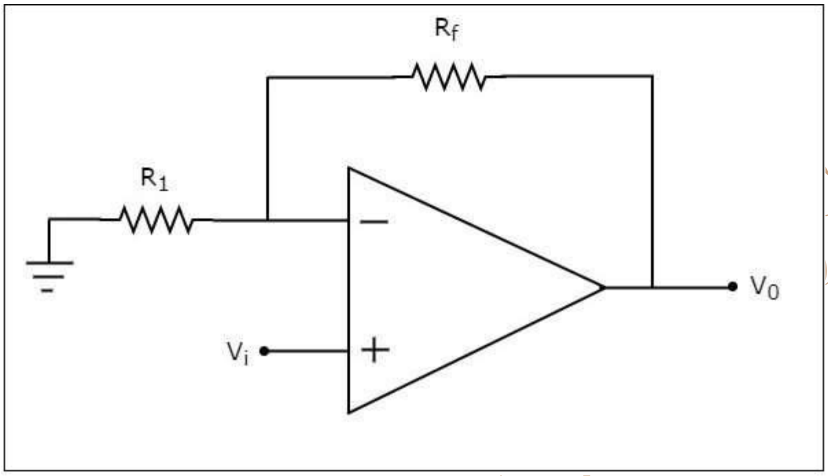
$$=> \frac{V0}{Vi} = \frac{-Rf}{R1}$$

The ratio of the output voltage V0 and the input voltage Vi is the voltage-gain or gain of the amplifier. Therefore, the **gain of inverting amplifier** is equal to $\frac{-Rf}{R1}$.
Note that the gain of the inverting amplifier is having a **negative sign**. It indicates that there exists a 180^0 phase difference between the input and the output.

Non-Inverting Amplifier

A non-inverting amplifier takes the input through its non-inverting terminal, and produces its amplified version as the output. As the name suggests, this amplifier just amplifies the input, without inverting or changing the sign of the output.

The **circuit diagram** of a non-inverting amplifier is shown in the following figure –



In the above circuit, the input voltage Vi is directly applied to the non-inverting input terminal of op-amp. So, the voltage at the non-inverting input terminal of the op-amp will be Vi.

By using **voltage division principle**, we can calculate the voltage at the inverting input terminal of the op-amp as shown below –

$$=> Vi = V0\left(\frac{R1}{R1 + Rf}\right)$$

According to the virtual short concept, the voltage at the inverting input terminal of an op-amp is same as that of the voltage at its non-inverting input terminal.

$$V1 = Vi$$

$$=> V0\left(\frac{R1}{R1 + Rf}\right) = Vi$$

$$=> \frac{V0}{Vi} = \frac{R1 + Rf}{R1}$$

$$=> \frac{V0}{Vi} = 1 + \frac{Rf}{R1}$$

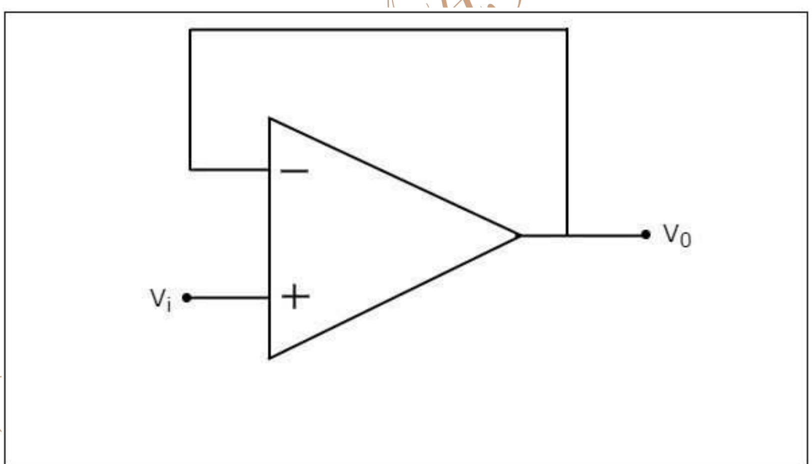
Now, the ratio of output voltage V0 and input voltage Vi or the voltage-gain or gain of the non-inverting amplifier is equal to $1 + \frac{Rf}{R1}$

Note that the gain of the non-inverting amplifier is having a positive sign. It indicates that there is no phase difference between the input and the output.

Voltage follower

A voltage follower is an electronic circuit, which produces an output that follows the input voltage. It is a special case of non-inverting amplifier.

If we consider the value of feedback resistor, Rf as zero ohms and (or) the value of resistor, 1 as infinity ohms, then a non-inverting amplifier becomes a voltage follower. The circuit diagram of a voltage follower is shown in the following figure –



In the above circuit, the input voltage Vi is directly applied to the non-inverting input terminal of the op-amp. So, the voltage at the non-inverting input terminal of op-amp is equal to Vi. Here, the output is directly connected to the inverting input terminal of op amp. Hence, the voltage at the inverting input terminal of op-amp is equal to V0.

According to the virtual short concept, the voltage at the inverting input terminal of the op-amp is same as that of the voltage at its non-inverting input terminal.

$$=> V0=Vi$$

So, the output voltage V0 of a voltage follower is equal to its input voltage Vi. Thus, the gain of a voltage follower is equal to one since, both output voltage V0 and input voltage Vi of voltage follower are same.