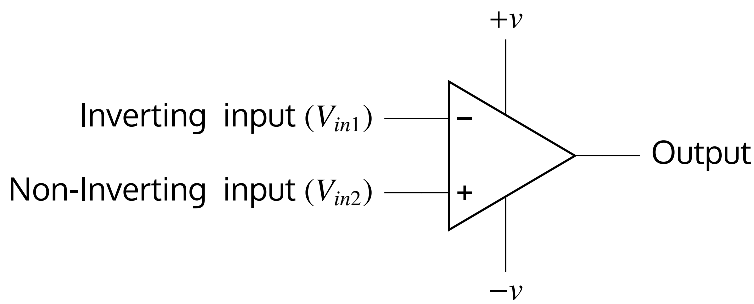
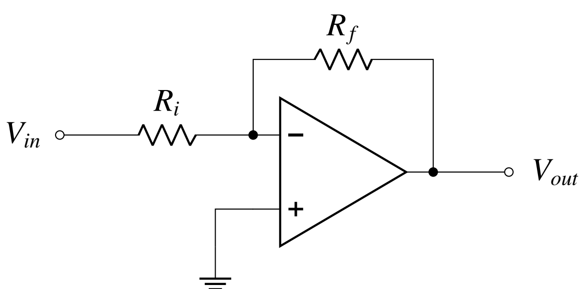
Operational Amplifier (Op-Amp)



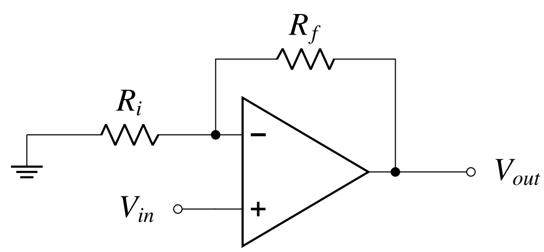
Input signal mode: Single Ended Mode

Single-ended input operation results when the input signal is connected to one input with the other input connected to ground.



Inverting Amplifier

$$Av = -\frac{R_f}{R_i}$$

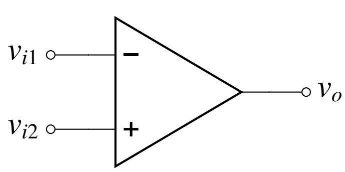


Non-Inverting Amplifier

$$Av = 1 + \frac{R_f}{R_i}$$

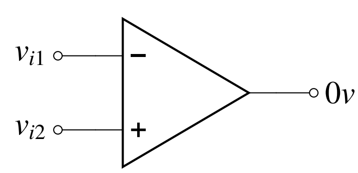
Input signal mode: Differential Mode

When separate inputs are applied to the op-amp, the resulting difference signal is the difference between the two inputs i.e $v_d = v_{i1} - v_{i2}$ and output voltage is $v_o = A_d v_d$.



Input signal mode: Common Mode

When two input signals voltages of same phase, frequency and magnitude are applied are applied to both inputs, they tend to cancel each other resulting in a zero-output voltage. This action is called common mode rejection.



Common Mode Rejection Ratio (CMRR)

Unwanted signals or noise appearing with same polarity on both lines of input are common mode signals and are cancelled by the op-amp. The measure of the op-amp's ability to reject common mode signals is expressed in terms of common mode rejection ratio (CMRR). It is defined as

$$CMRR = \frac{A_d}{A_c}$$

Maximum Output Voltage Swing

The output voltage never excess the DC voltage supply $(-v \text{ to } +v)$ of the Op-Amp.

Terminology

Input Offset Voltage: The input offset voltage (V_{iO}) is defined as the voltage that must be applied between the two input terminals of the op amp to obtain zero volts at the output.

Input Bias Current: Ideally no current flows into the input terminals of op-amp. But in practice, a small amount of current flows into the input terminals. These currents are called bias current.

Input Offset Current: The difference between these two input bias currents are called input offset current.

Input Impedance: The input impedance in the differential mode is the total resistance between inverting and noninverting inputs.

Output Impedance: The output impedance is the resistance viewed from the output terminal of the op-amp.

Slew rate: The slew rate is defined as the maximum rate of output voltage change per unit time.

$$\text{Slew rate} = \frac{\Delta V_{out}}{\Delta t}$$

An ideal op-amp exhibits the following characteristics

Infinite voltage gain, Infinite input impedance, Infinite CMRR, Infinite slew rate, Infinite Bandwidth, Zero output impedance, Zero input offset voltage, Zero input offset current.

Virtual Ground

The voltage at that particular node is almost equal to ground voltage $(0V)$, even though it is not physically connected to ground.

Let $A_v = \infty$, then $(v_1 - v_2) = \frac{V_{out}}{A} = \frac{V_{out}}{\infty} = 0$

$\therefore v_1 = v_2$. If any one is connected to the ground, another one is also $0V$

Voltage Follower

A voltage follower (also called a unity-gain amplifier, a buffer amplifier) is a op-amp circuit which has a voltage gain of 1. Therefore, $V_{out} = V_{in}$

From, $V_{out} = AV_{in} \Rightarrow V_{out} = 1.V_{in} \Rightarrow V_{out} = V_{in}$

Output voltage remains the same as the input voltage.