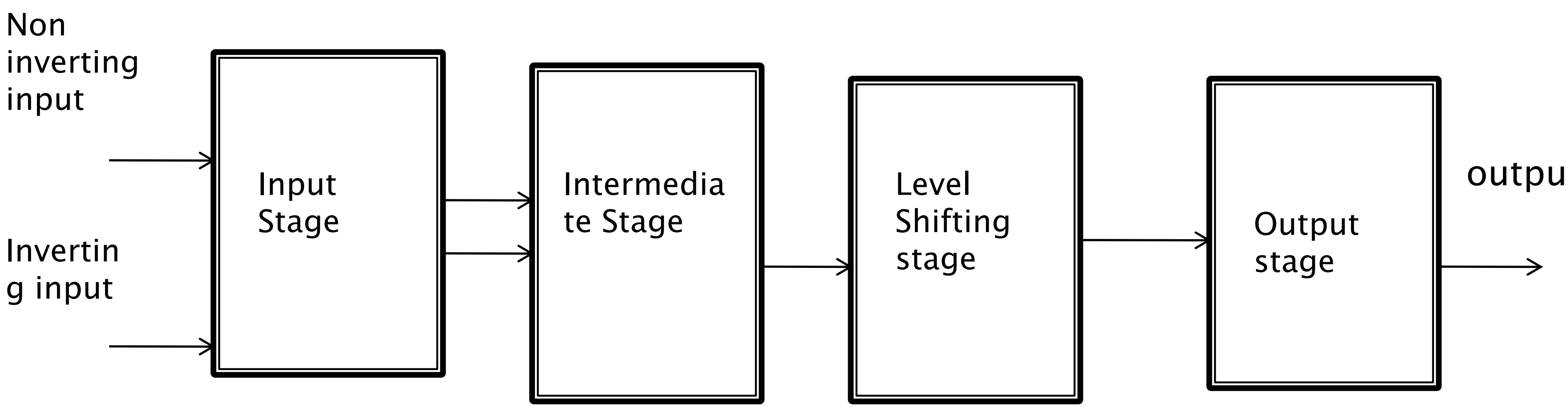
Operational Amplifier

Block Diagram of typical Op-amp

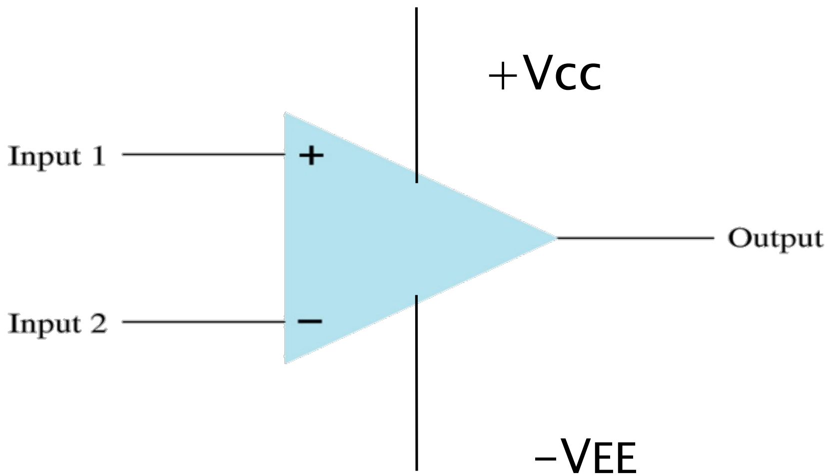


Dual-input Dual-input such as emitter
complementary
Balanced output unbalanced o/p follower using
symmetry push
Differential amp. Differential amp. Constant current
pull amplifier
source

INTRODUCTION

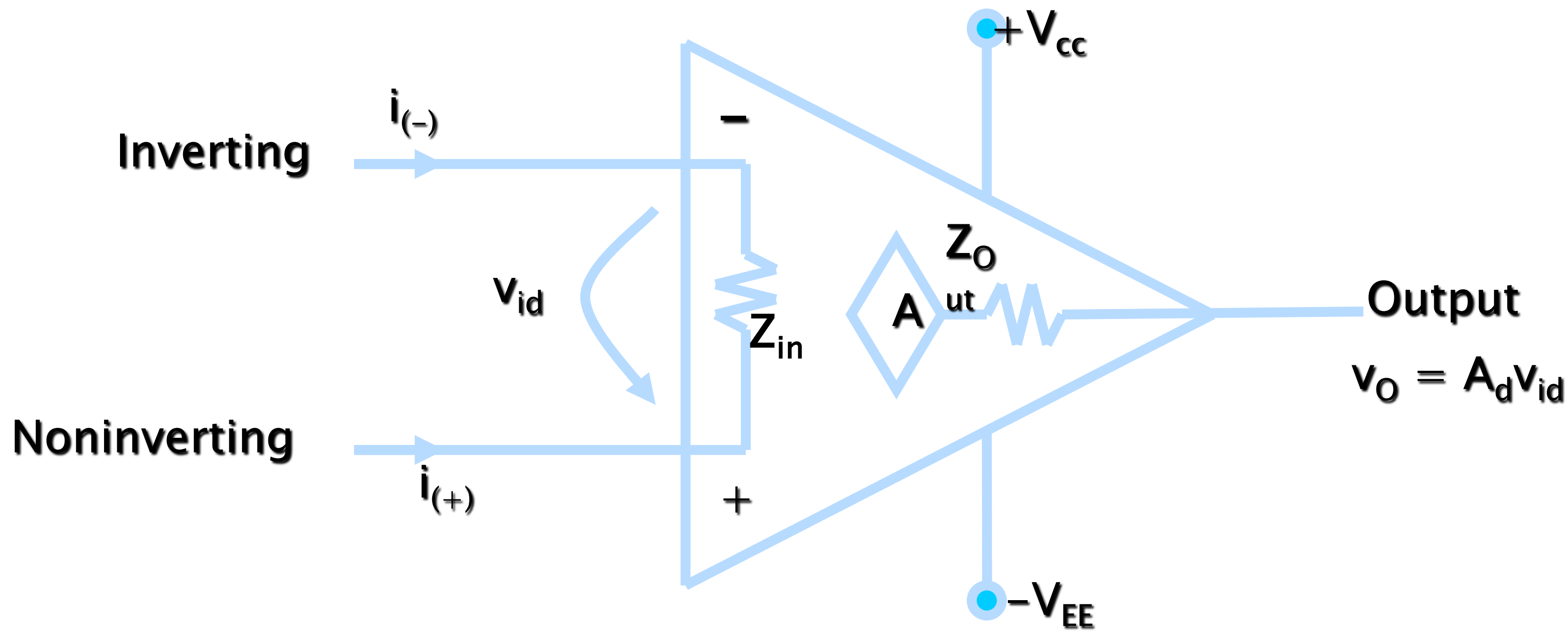
- An amplifier is a device that accepts a varying input signal and produces a similar output signal with a larger amplitude.
- Usually connected so part of the output is fed back to the input. (Feedback Loop)
- They are the basic components used to build analog circuits.
- The name “operational amplifier” comes from the fact that they were originally used to perform mathematical operations such as integration and differentiation.

Schematic Symbol



Input1– non inverting input (volts)
Input2– inverting input (volts)
Output– output voltage (volts)
A–Large signal voltage gain

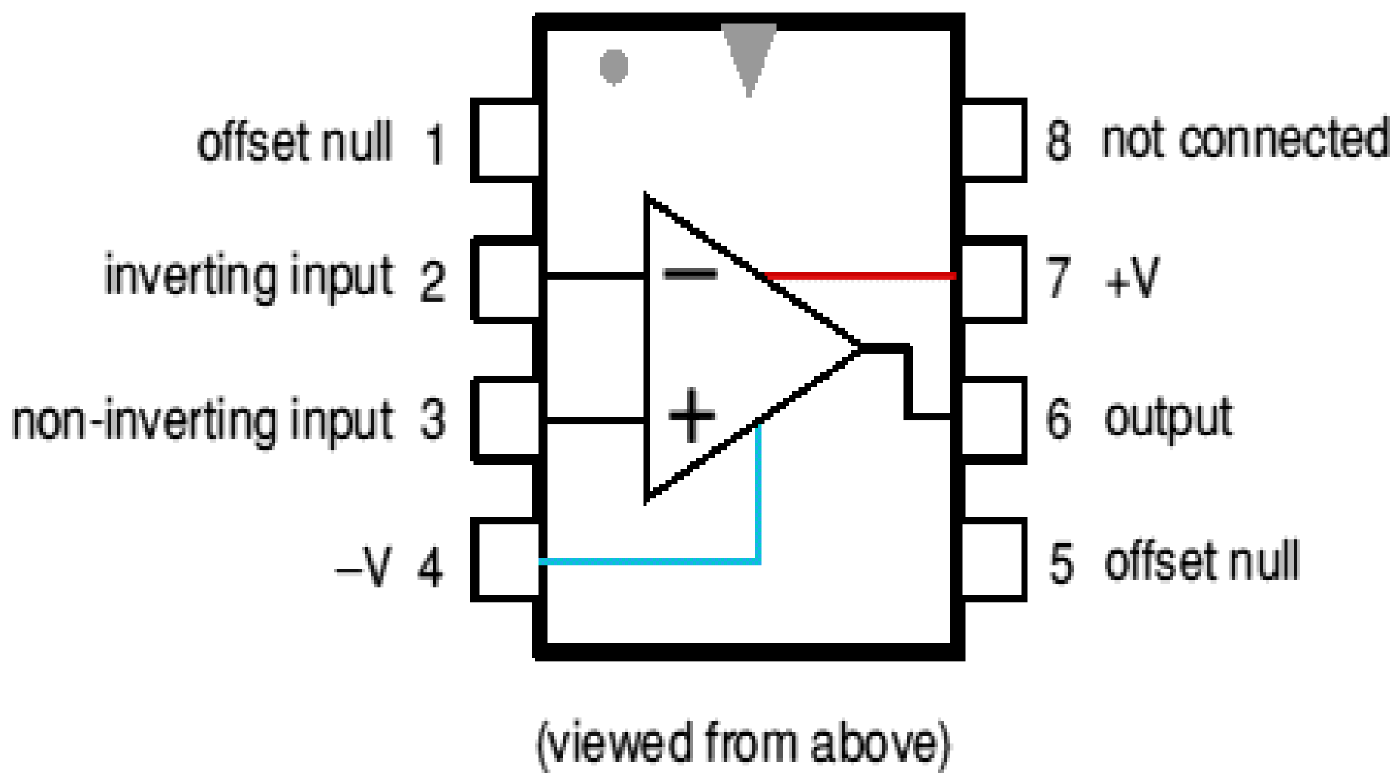
Output= A (input1–input2)



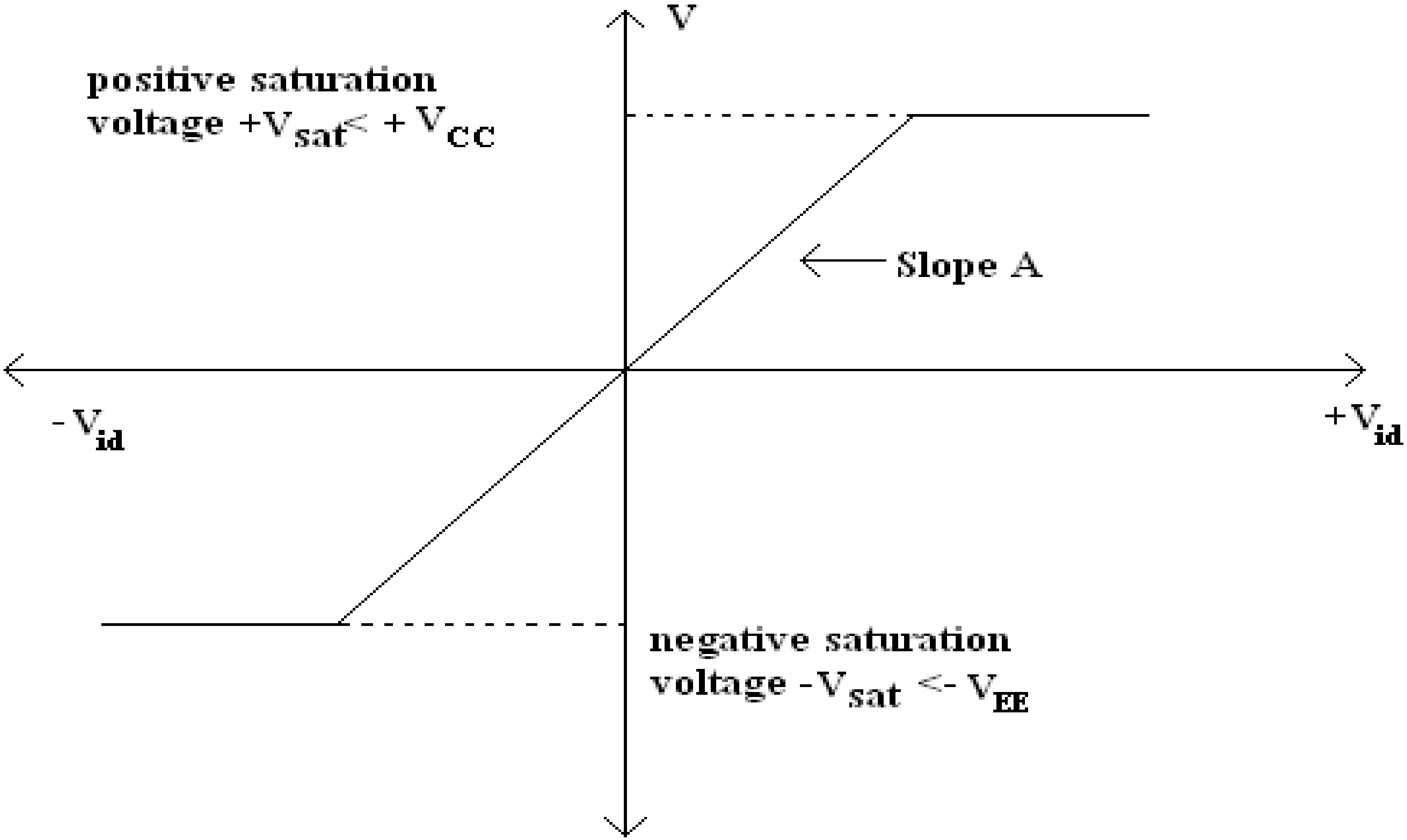
Equivalent circuit of an op-amp

- $i_{(+)}$, $i_{(-)}$: Currents into the amplifier on the inverting and noninverting lines respectively
- v_{id} : The input voltage from inverting to non-inverting inputs
- $+V_{cc}$, $-V_{EE}$: DC source voltages, usually +15V and -15V
- Z_{in} : The input resistance, ideally infinity
- A : The gain of the amplifier. Ideally very high, in the $1x10^{10}$ range.
- Z_{Out}: The output resistance, ideally zero
- v_O: The output voltage; $v_O = A_{OL}v_{id}$ where A_{OL} is the open-loop voltage gain
- $V_{id:}$ Difference input voltage

PIN CONFIGURATION



Ideal Voltage transfer curve



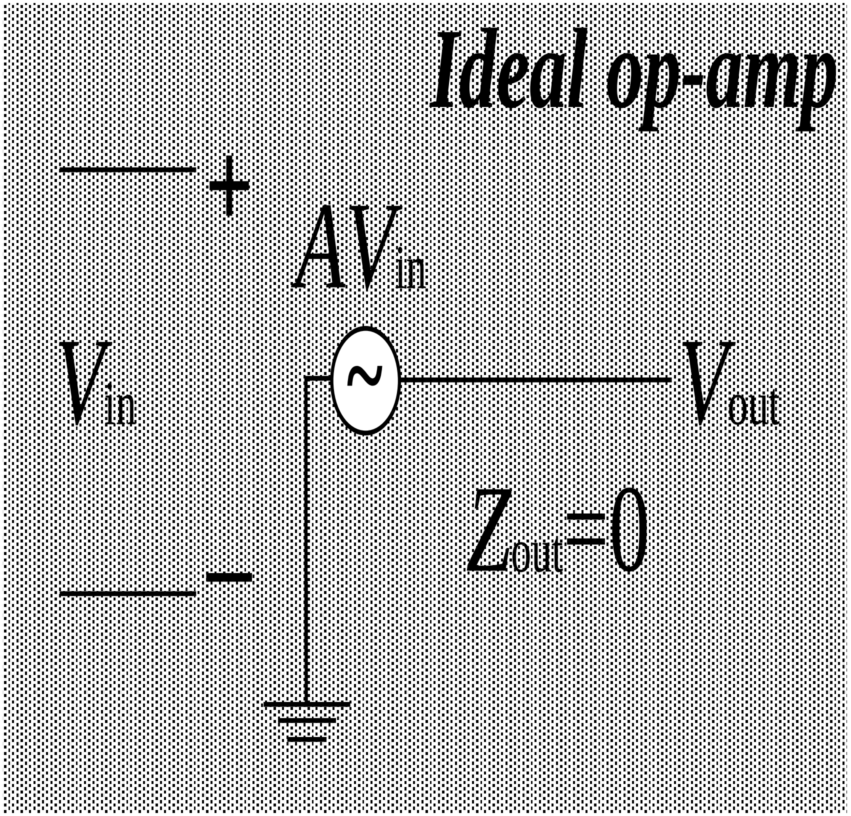
- $v_O = A_{OL}v_{id}$ This is the basic op-amp equation in which the output offset voltage is assumed to be zero.

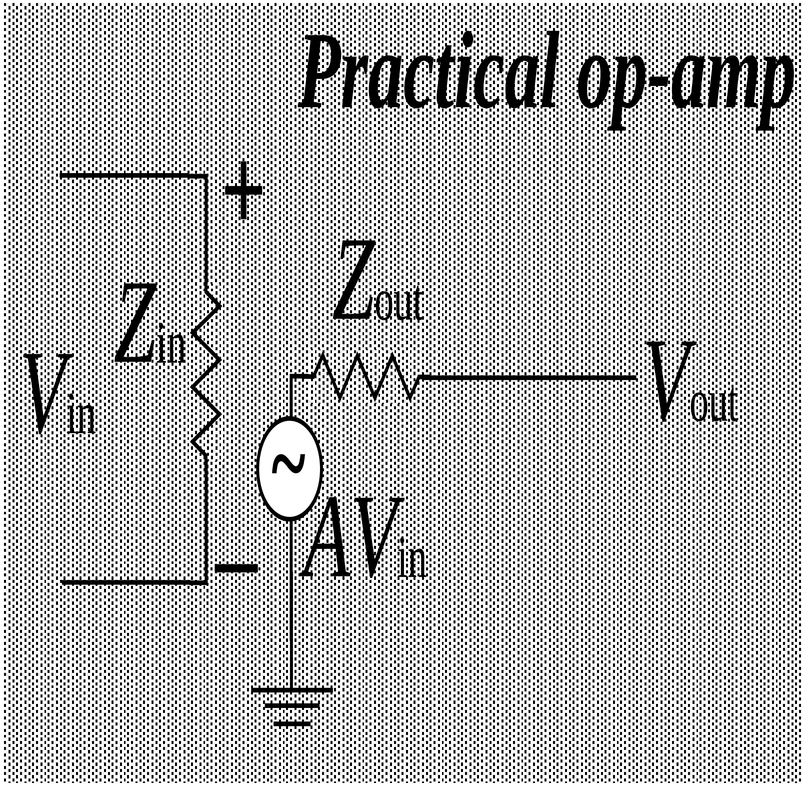
- The graphic representation of this equation is shown; where the output voltage ,Vo is plotted against input difference voltage Vid,keeping gain A constant.

- The output voltage cannot exceed the positive and negative saturation voltage.

- The output voltage is directly proportional to the input difference voltage until it reaches the saturation voltages and thereafter the output voltage remains constant.

- This curve is called ideal voltage transfer curve.


Ideal op-amp
+
AVin
Vin
~
Vout
Zout=0
–


Practical op-amp
+
Zout
Zin
Vin
Vout
~
AVin
–

Ideal Vs Practical Op-Amp

	Ideal	**Practical**
Open Loop gain *A*	$\propto$	10^5
Bandwidth *BW*	$\propto$	10-100Hz
Input Impedance Z_{in}	$\propto$	>1MΩ
Output Impedance Z_{out}	0 Ω	10-100 Ω
Output Voltage V_{out}	Depends only on $V_d = (V_+ - V_-)$ Differential mode signal	Depends slightly on average input $V_c = (V_+ + V_-)/2$ Common-Mode signal
CMRR	$\propto$	10-100dB

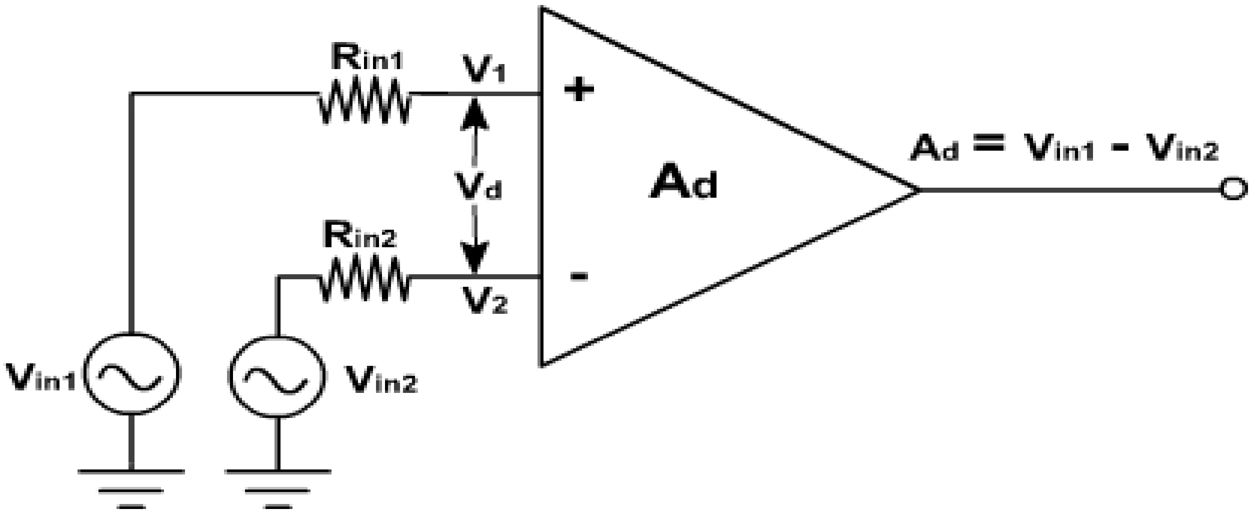
Open loop op-amp configuration

When connected in open loop configuration, there are 3 open loop op amp configuration:

1) Differential amplifier
2) Inverting amplifier
3) Non inverting amplifier

These configuration are classed according to number of inputs used and the terminal to which input as applied when a single input is used.

Differential Amplifier

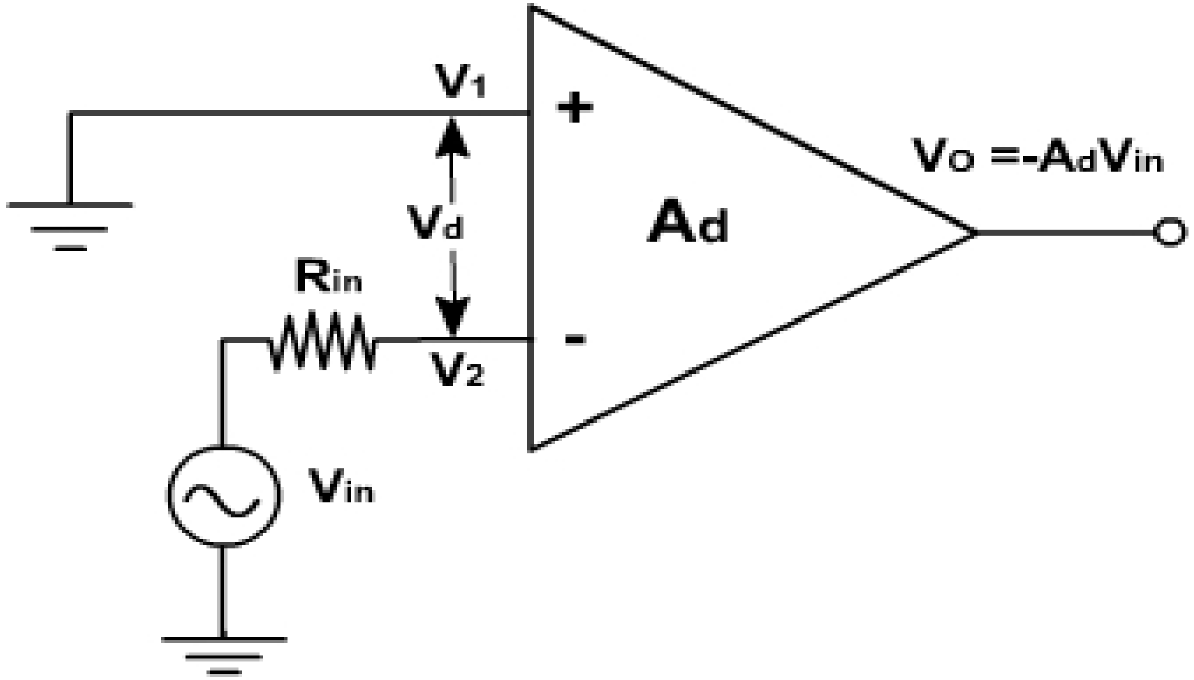


$v_1 = v_{in1}$ and $v_2 = v_{in2}$.

$$v_o = A_d\,(v_{in1} - v_{in2})$$

- where, A_d is the open loop gain.

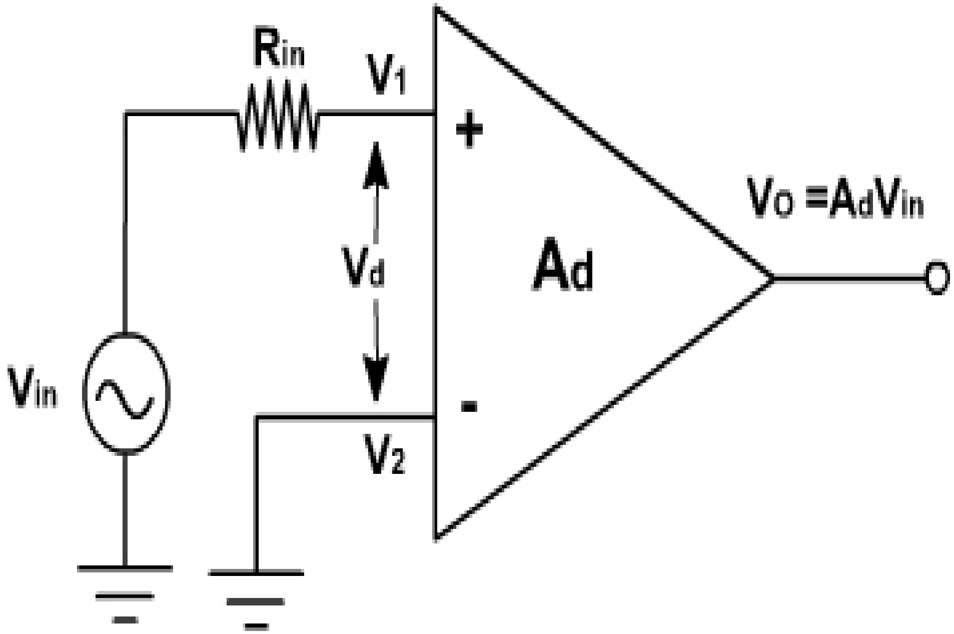
Inverting Amplifier



$v_1 = 0,\ v_2 = v_{in}.$

$v_o = -A_d\ v_{in}$

Non-inverting Amplifier



$v_1 = +v_{in}$ $v_2 = 0$

$$v_o = +A_d\, v_{in}$$