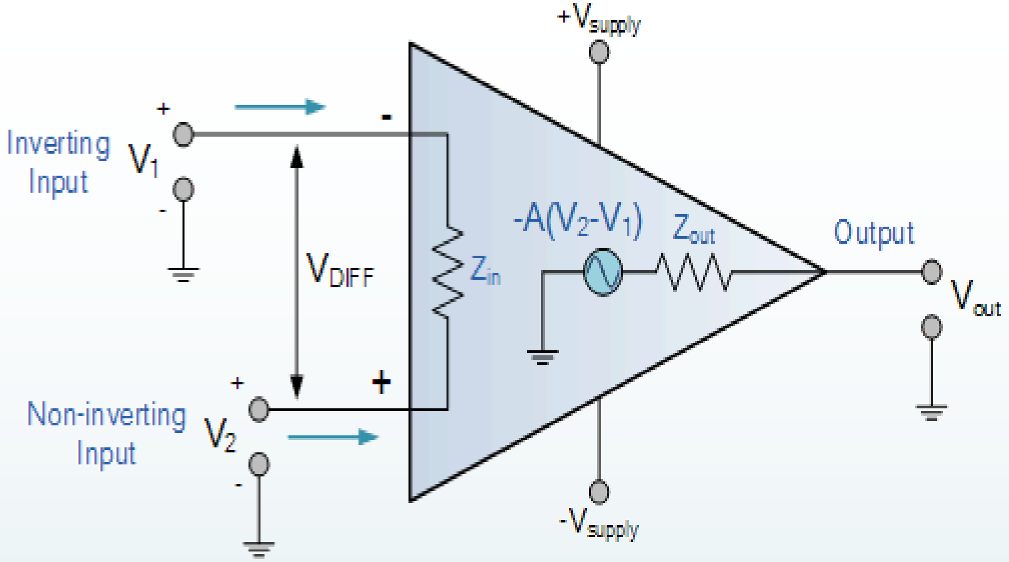
Op Amplifier

Contents

The Op-Amp Gain

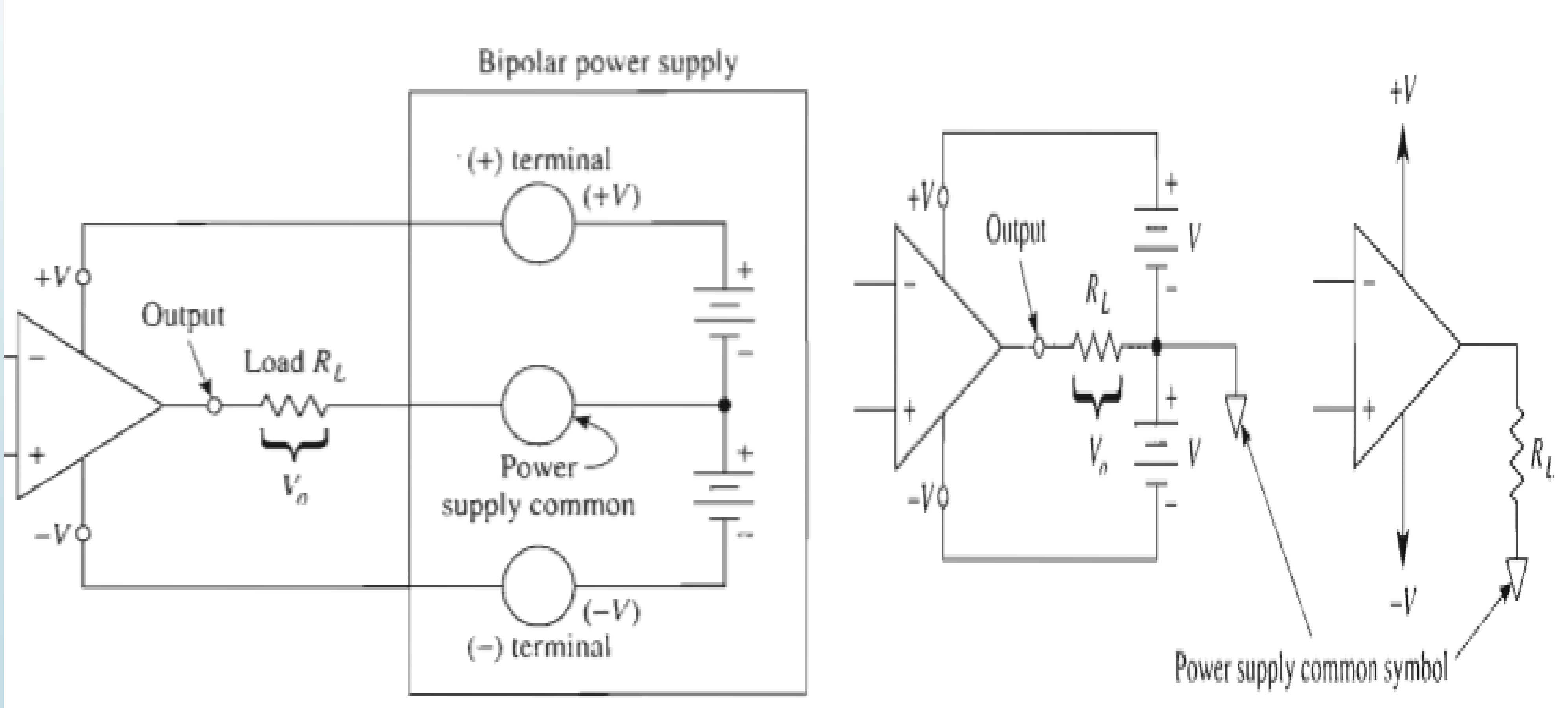


A : The gain of the amplifier

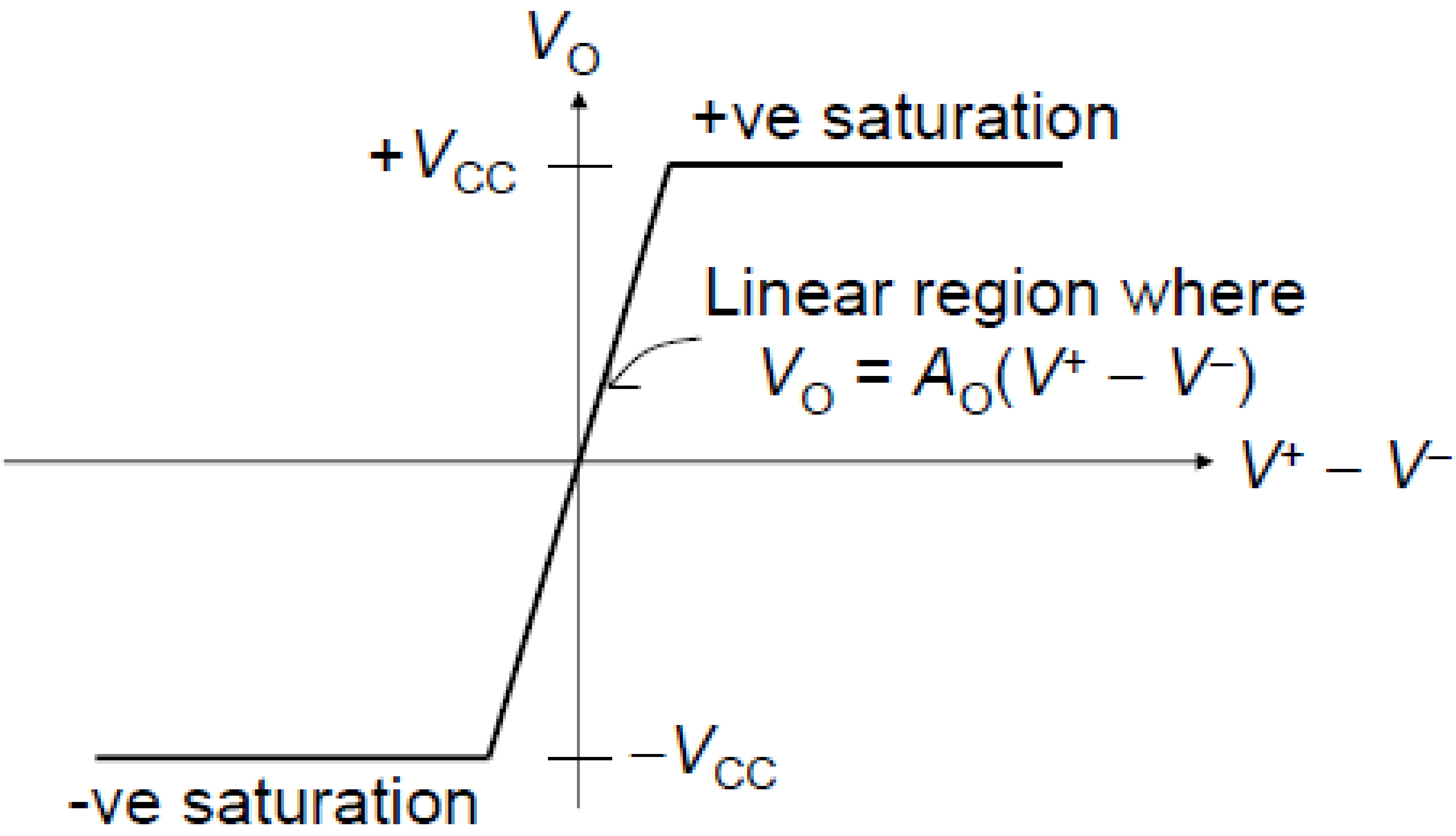
$Vo=A(V_2-V_1)$

- Op-Amps has a very high gain.
- They can be connected open-loop or closed-loop.
- **Open-loop** refers to a configuration where there is no feedback from output back to the input.
- In the open-loop configuration the gain can exceed 10,000.
- **Closed-loop** configuration reduces the gain. In order to control the gain of an op-amp it must have feedback.
- This feedback is a negative feedback.
- A negative feedback reduces the gain and improves many characteristics of the op-amp.

Power supply for OP AMP

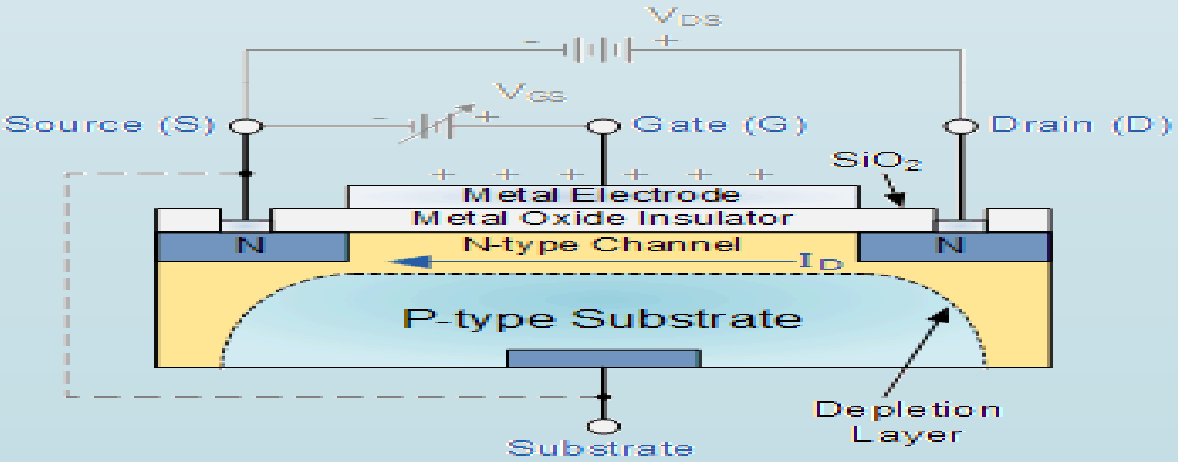


The Op-Amp Transfer Curve

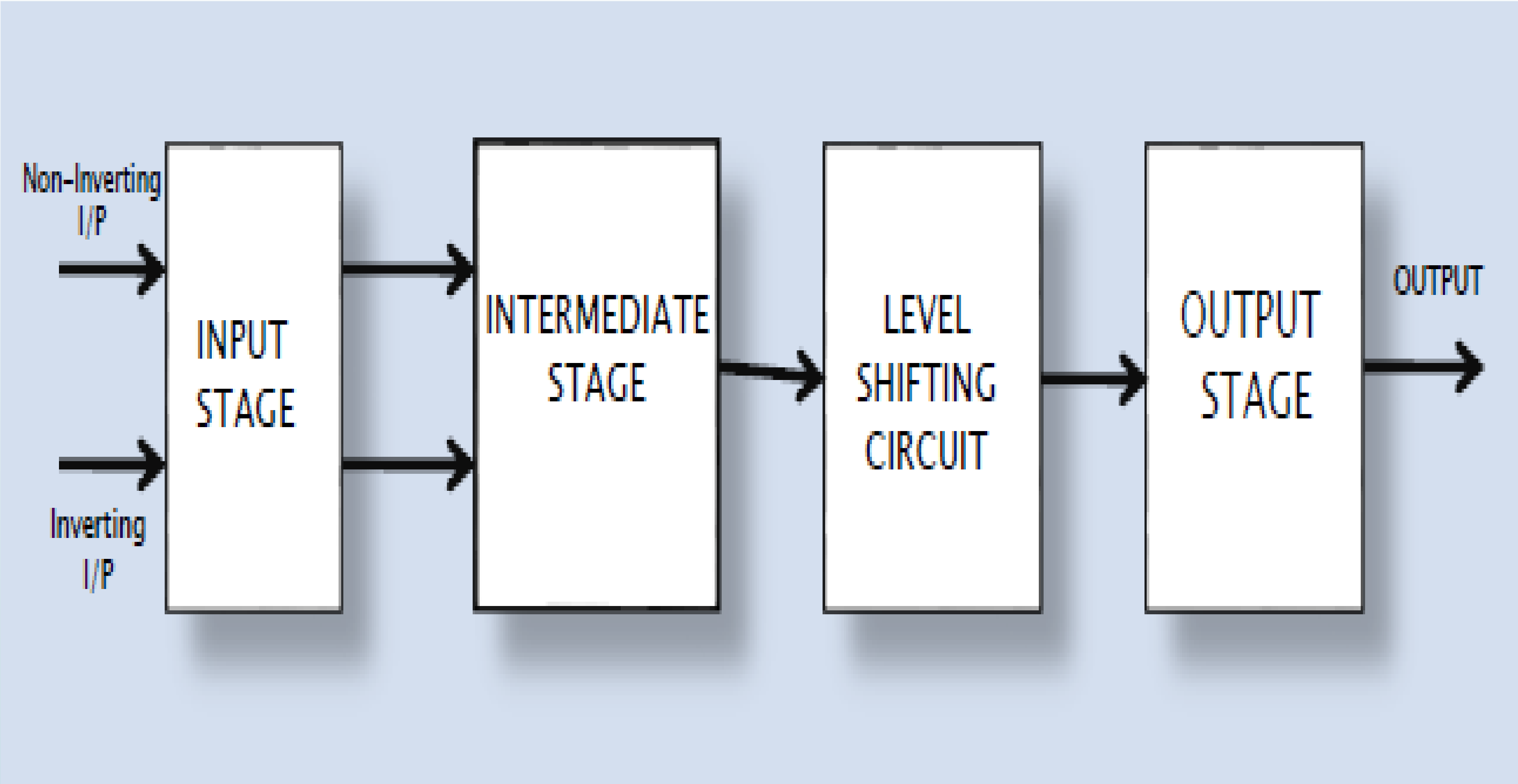


Concept of Saturation voltage

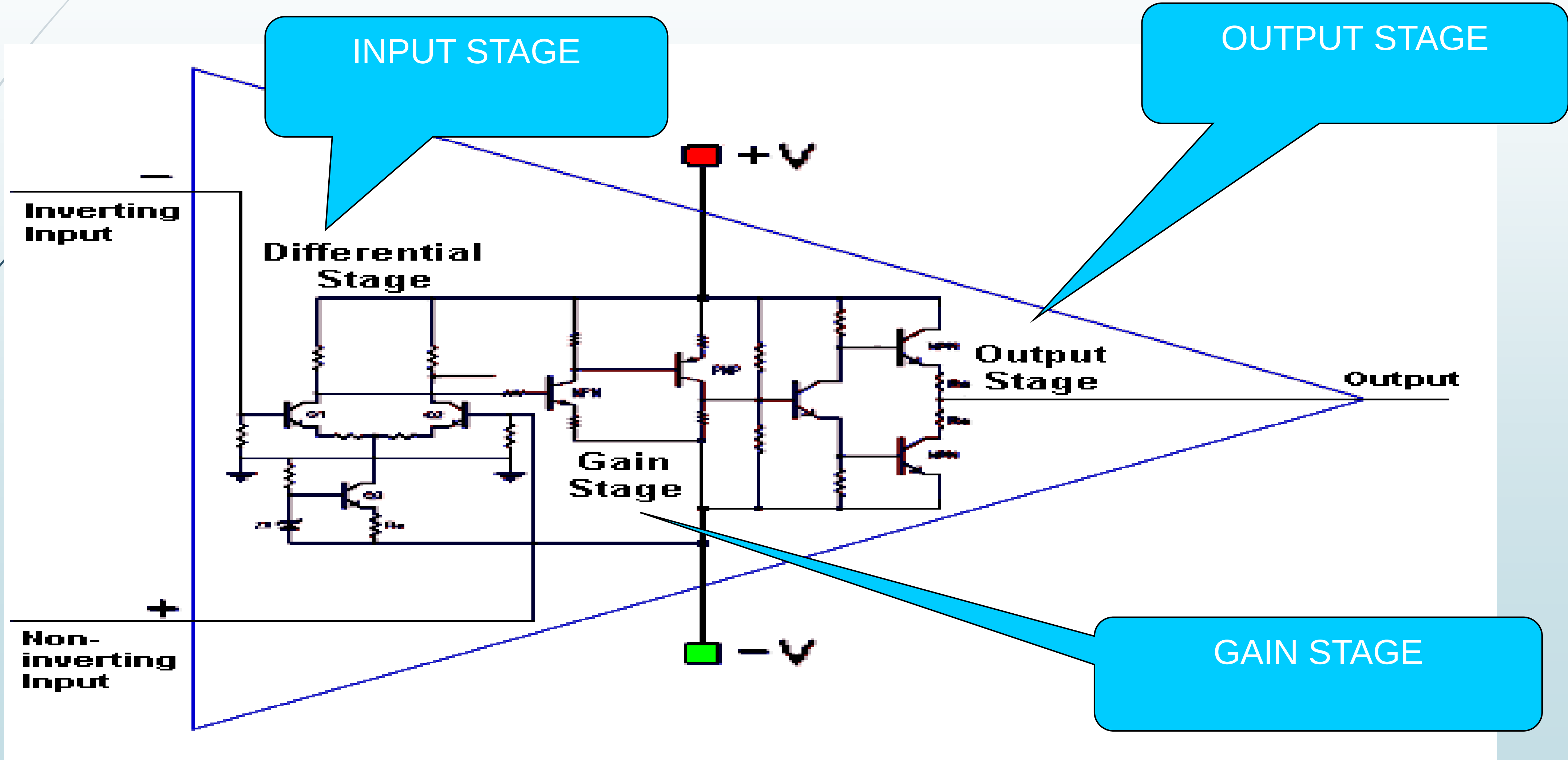
- The OP amp has single output terminal and output voltage V_0 varies whose value depend upon the bipolar supply.
- The transistors at output stage require 1-2 V to act as amplifier .
- So the output terminal voltage rises to +1 Volt and drops to within 2V of –V.
- The upper limit of V_0 is called +ve saturation voltage
- The lower limit of V_0 is known as –ve saturation voltage.
- For a +15 Volt DC supply the V_{sat} varies from +13V to -13 V.
- Now a days transistors are replaced by MOS devices.



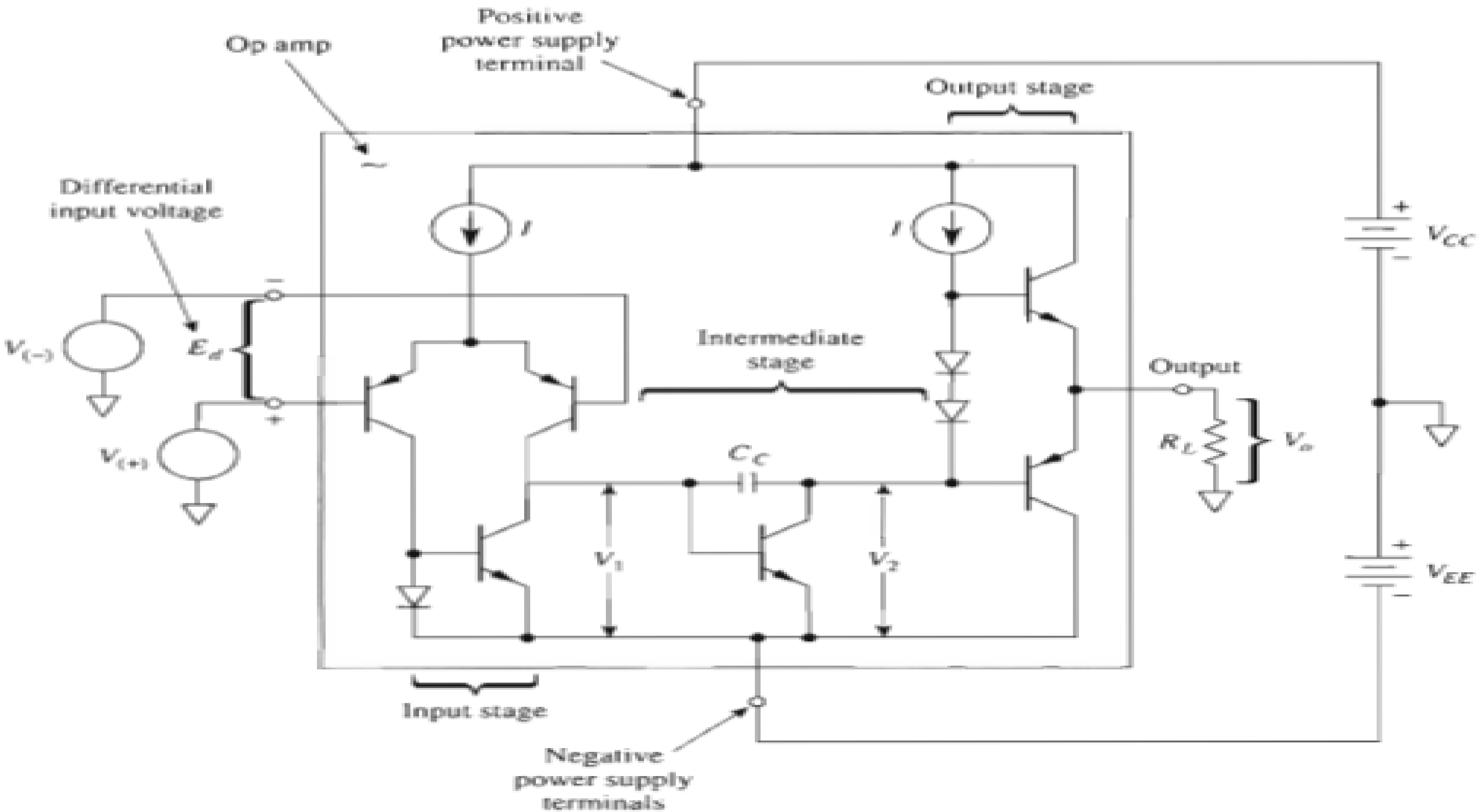
Block Diagram of OP AMP



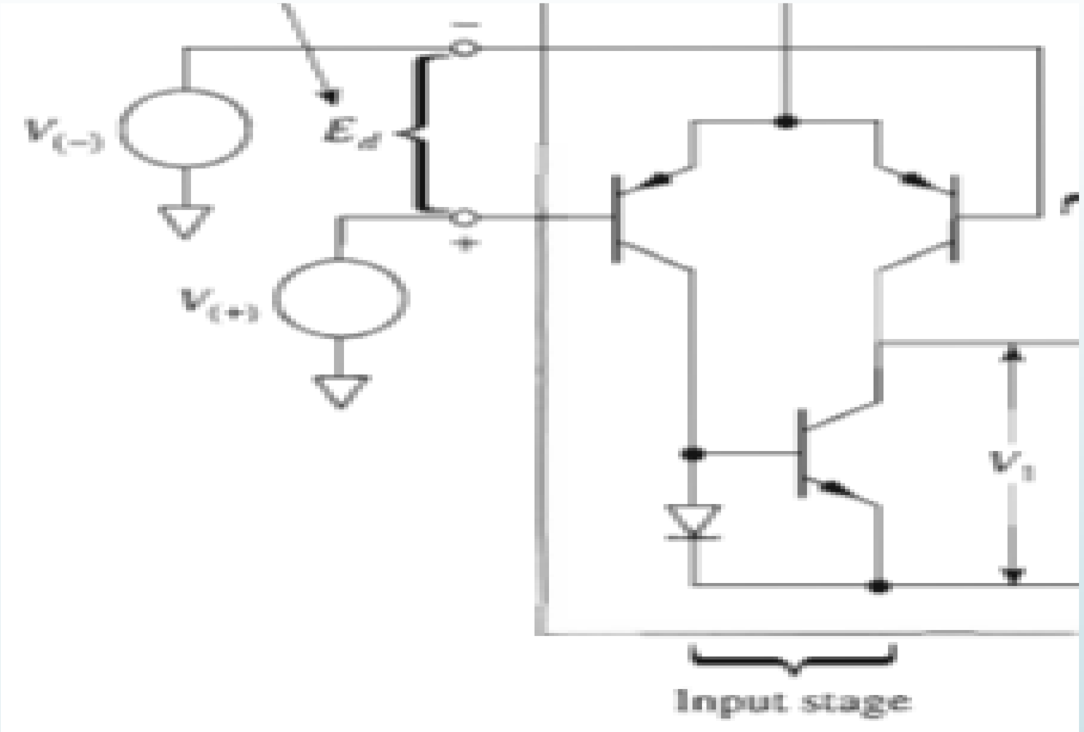
EQUIVALENT CIRCUIT



Stages of OP Amp

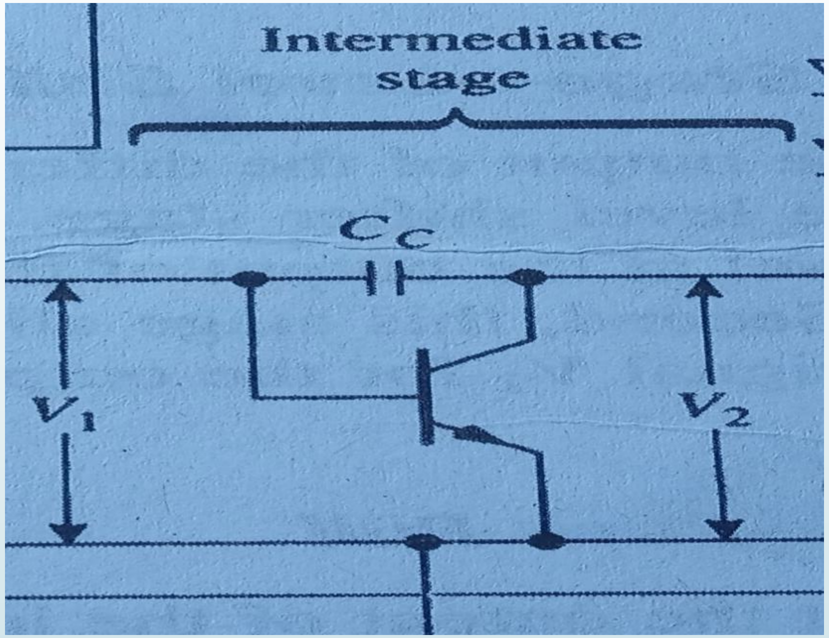


Input Stage



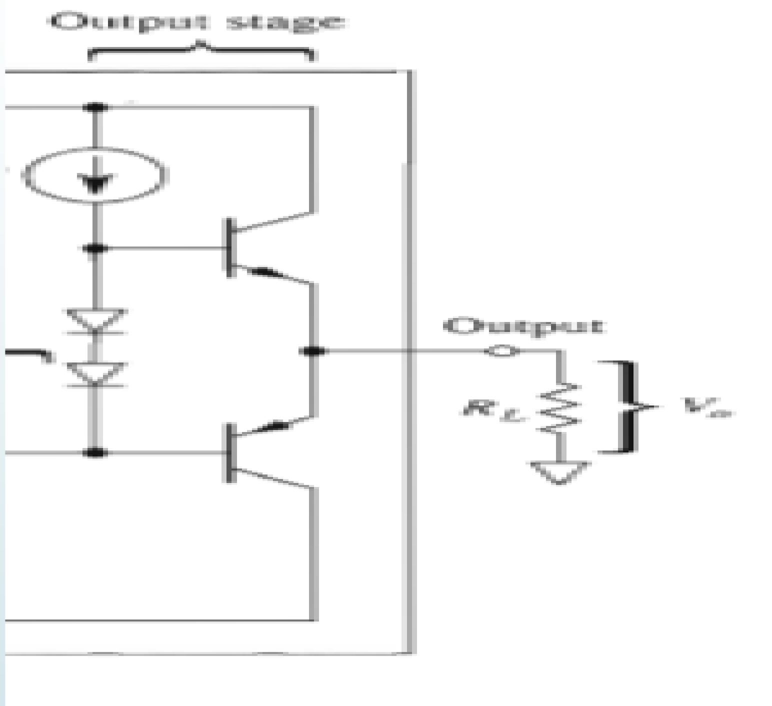
- The Input Stage is a dual input balanced output differential amplifier which provides most of the voltage gain of amplifier and also establishes the input resistance of op-amp.

Intermediate stage



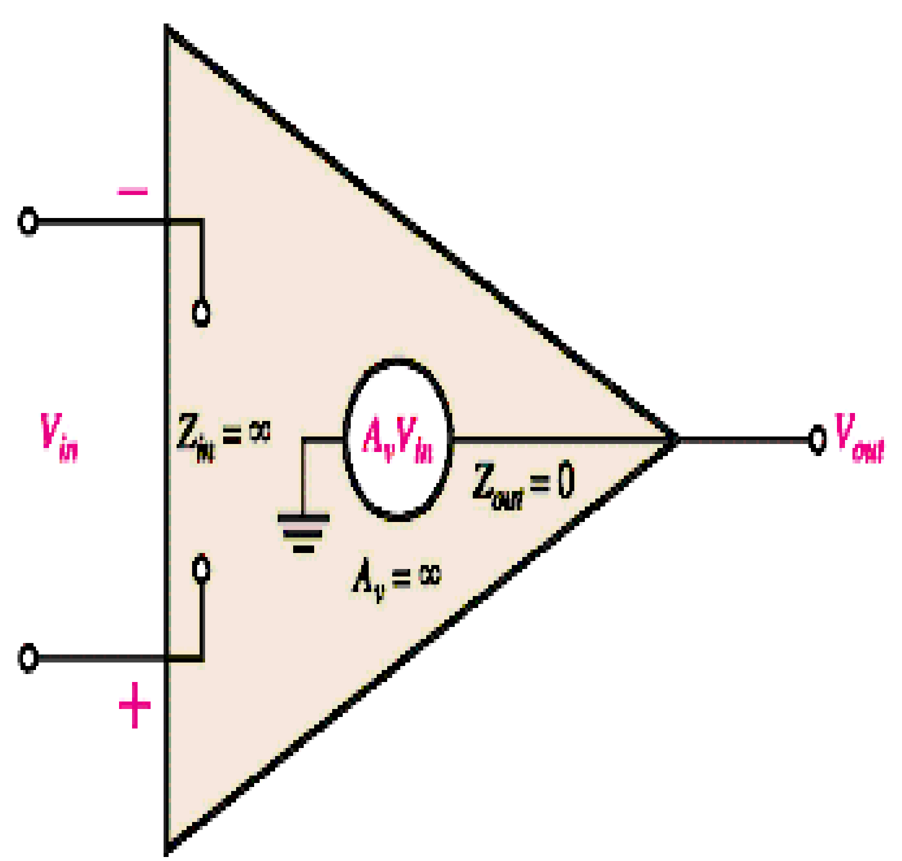
- In this stage direct coupling is used, which makes the dc voltage at the output of the intermediate stage above ground potential.

Output stage



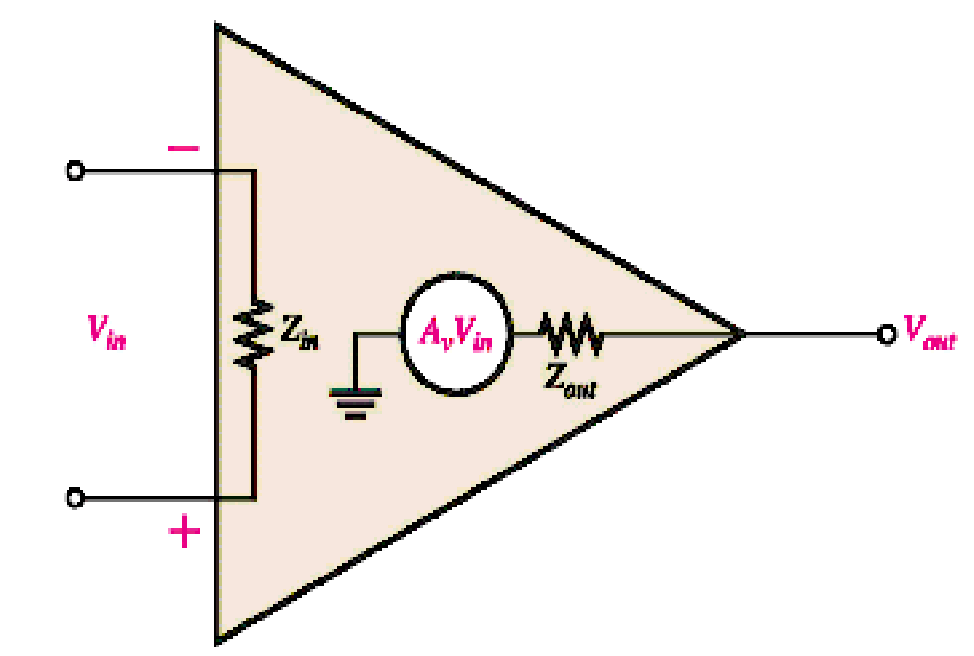
- The main purpose of the **output stage** of an **operational amplifier** is to deliver a certain amount of signal power into a load with acceptably low levels of signal distortion.
- In a low-voltage low-power environment, this has to be achieved by efficiently using the supply voltage as well as the supply current.

Ideal Op-Amp



- High open-loop gain, ($A_{OL}= \infty$).
- High input impedance, ($R_i = \infty$).
- Low output impedance, ($R_o = 0$).
- Output saturation voltage, $\pm V_o$(sat) is equal to input
- supply voltage, $\pm V_{CC}$.
- High CMRR (∞).
- High bandwidth, (BW = ∞).

Practical OP AMP

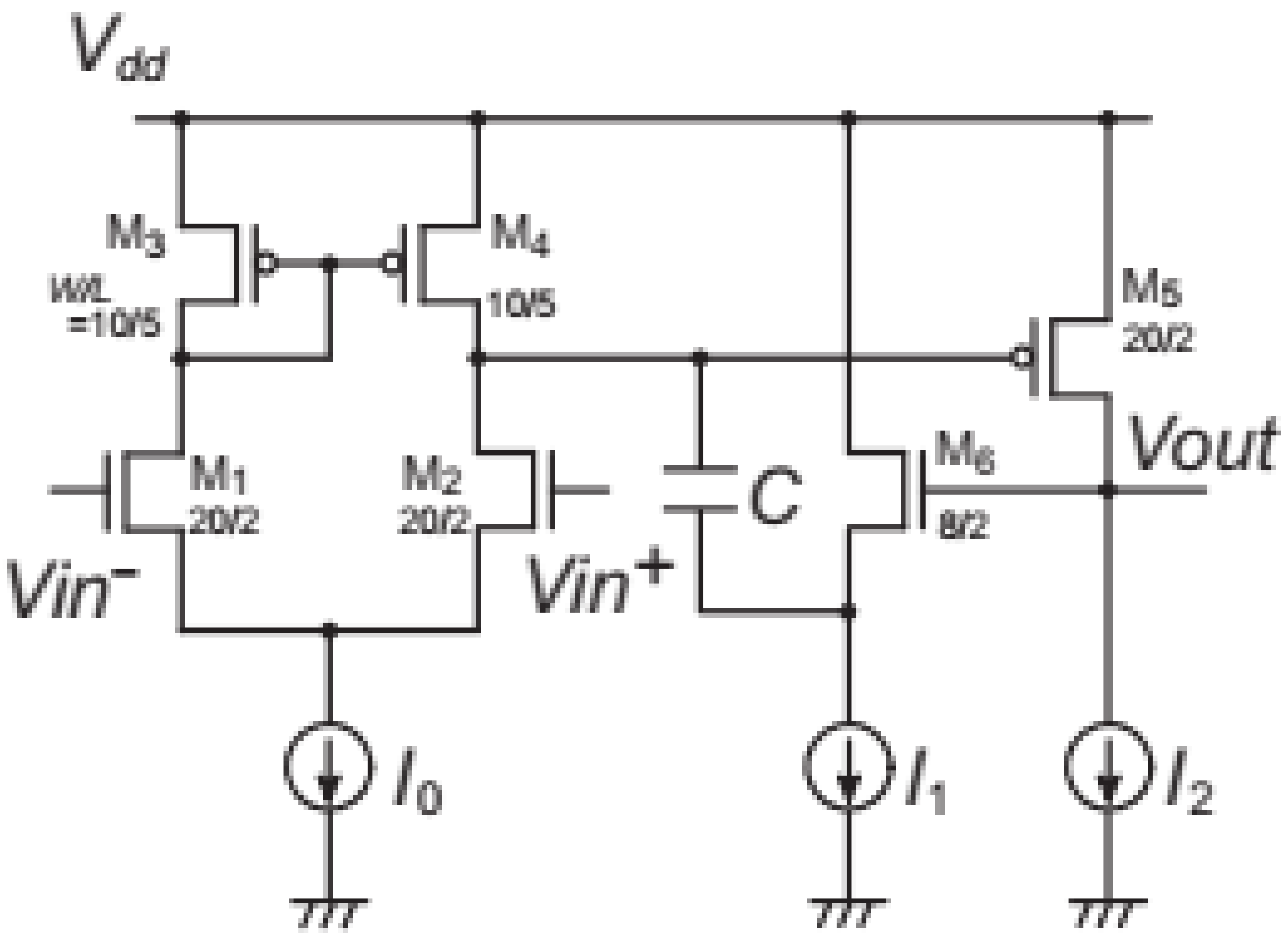


- Input impedance 500k-2MΩ
- Output impedance 20-100 Ω
- Open-loop gain (20k to 200k)
- Bandwidth limited (a few kHz)
- Has noise contribution
- Non-zero DC output offset

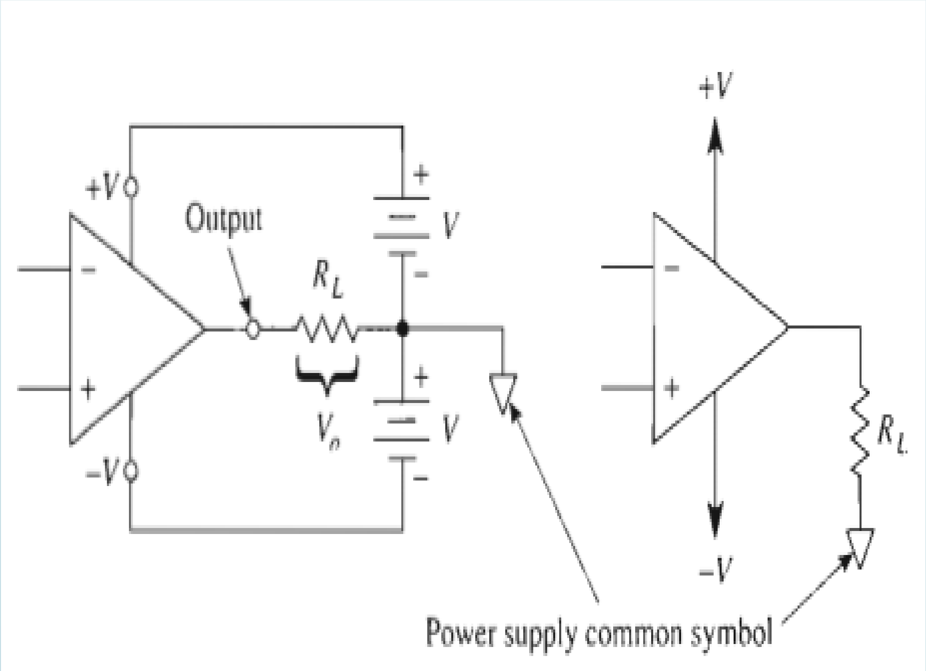
Op-Amp Advantages

- No external element is needed for stability.
- Gain value varies with feedback to one of the inputs.
- AC signal can be amplified without biasing.
- Output nearly zero when input is zero.
- Output can be in phase or 180 degree out of phase with input.

MOSFET based OP AMP



Q1. In Figure assume +v=15 Volt and -v=-15 Volt with $+V_{sat}$=13 Volt and $-V_{sat}$=-13 Volt. Gain has value of 10,000. Find the theoretical Magnitude and Polarity of V_0 for voltage at inverting input is -10 microvolt and voltage at non inverting is +15 microvolt.

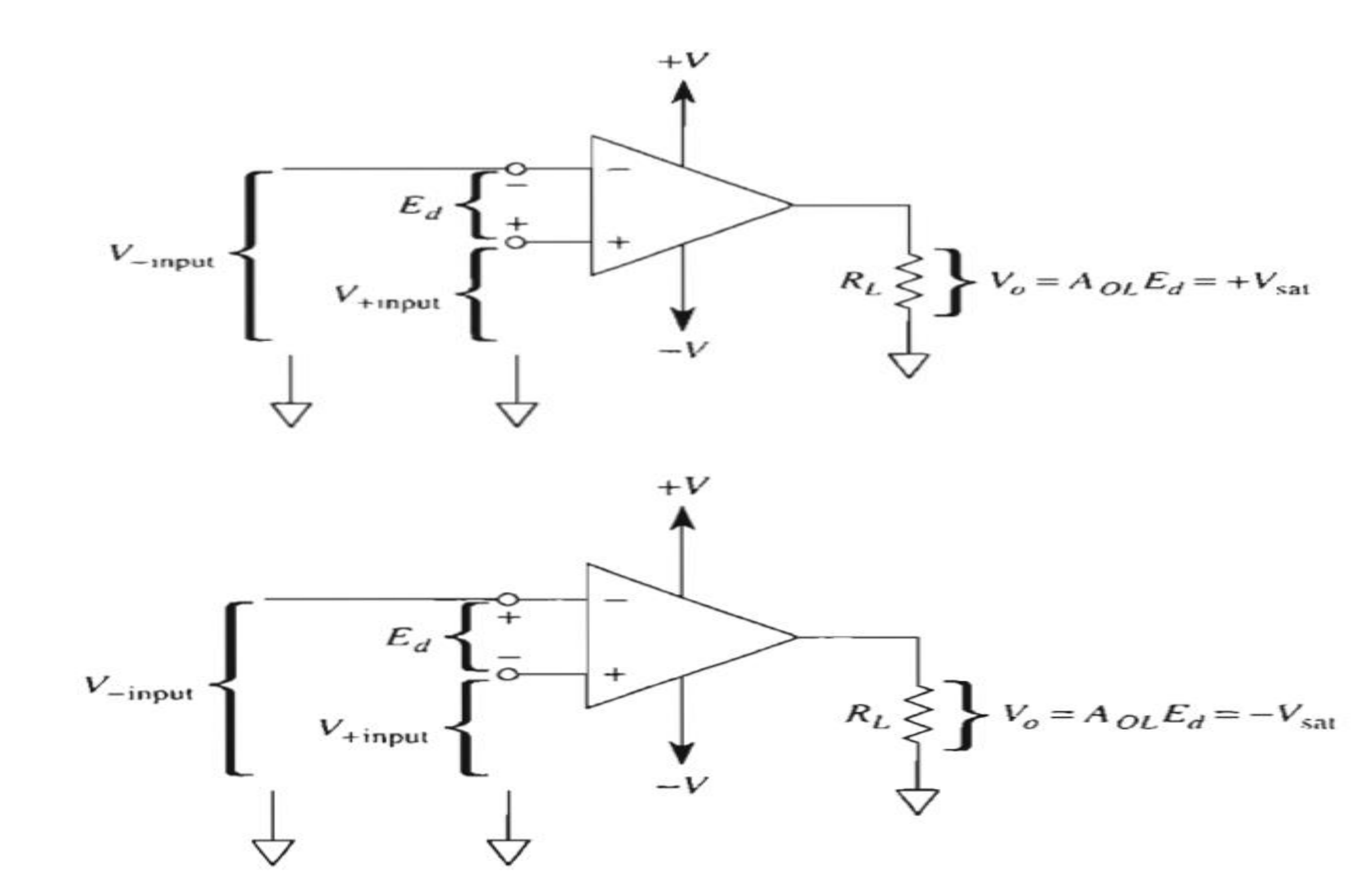


Solution

- **Case 1:** $E_d=V_1-V_2=15-(-10)=25$ microVolt
- $V_0=A*Ed=10,000*25=250000$ microvolt=2.5 Volt
- Actual Voltage $V_0=+13$ Volt

- **Case 2:** If $V_1=-15$ and $V_2=10$
- Then $E_d=V_1-V_2=-15-10=-25$ microvolt
- $V_0=A*Ed=10,000*-25=-250000$ microvolt=-2.5 Volt
- Then Actual Voltage $V_0=-13$ volt

Contd..



+V
E_d
−
+
$V_{-\text{input}}$
$V_{+\text{input}}$
−V
R_L
$V_o = A_{OL}E_d = +V_{sat}$
+V
E_d
+
−
$V_{-\text{input}}$
$V_{+\text{input}}$
−V
R_L
$V_o = A_{OL}E_d = -V_{sat}$

References

- *Coughlin, R.F., Operational Amplifiers and Linear Integrated Circuits, Pearson Education (2006).*
- *Gayakwad, R.A., Op-Amp and Linear Integrated Circuits, Pearson Education (2002).*
- Franco, S., Design with Operational Amplifier and Analog Integrated circuit, McGraw Hill (2016).
- *Terrell, D., Op Amps Design Application and Troubleshooting, Newness (1996).*