



Electronics II

Lecture 12 Operational Amplifiers- Introduction

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Previous Lecture

- Differential Amplifier
 - Basics of Differential Amplifier.
 - DC Biasing.
 - Single Ended Operation.
 - Double Ended Operation.
 - Common Mode Operation.



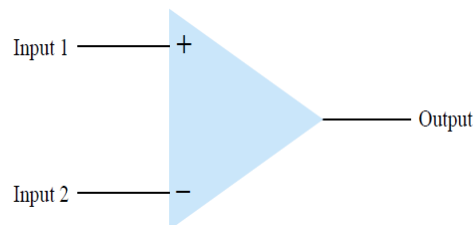
Session Overview

| | |
|----------------------------|---|
| Topic | Operational Amplifiers (Op Amp) |
| Concepts | Op Amp Basics, Modes of Operation. |
| Recommended Reading | Section 13.1, 13.2 & 13.4 of [1] Section 8-2 of [2]. |
| Keywords | Op Amp, Single Ended, Double Ended, Common Mode. |



Operational Amplifiers (Op Amp)

- An ideal op- amp has
 - Infinite gain.
 - Infinite bandwidth.
 - Infinite input impedance.
 - Zero output impedance.
- Op amp is a differential amplifier with
 - Very high gain.
 - High input impedance.
 - Low output impedance.
- An op amp have large number of differential amplifier stages connected together to achieve a high voltage gain.
- Usually op amp has two inputs and one output, but double ended output is also possible.
- Typical applications include oscillators, filter circuits and instrumentation circuits.

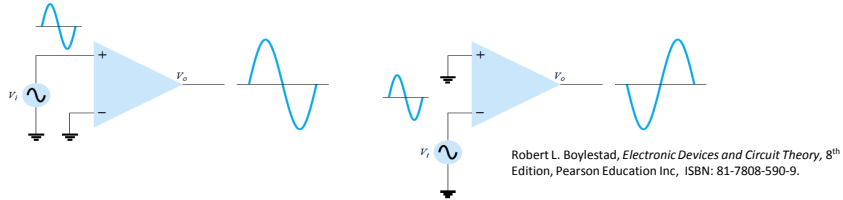


Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

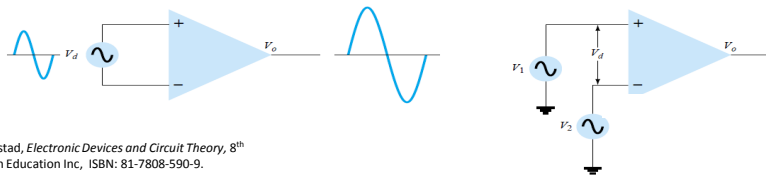


Op Amp Modes of Operation

- Single Ended Input

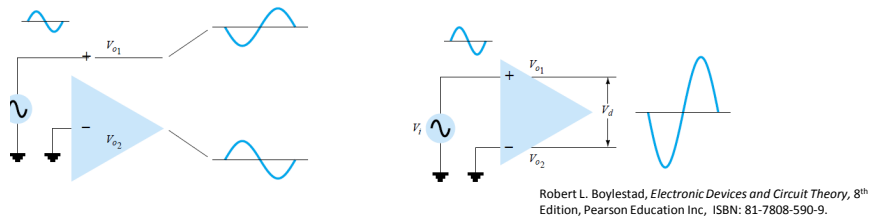


- Double Ended (Differential) Input

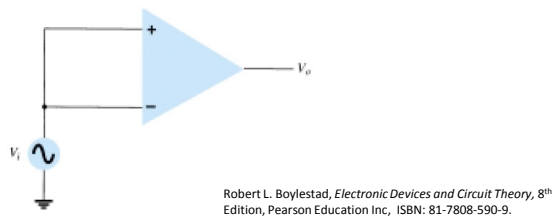


Op Amp Modes of Operation

- Double Ended Output



- Common Mode Operation





Differential & Common Mode Operation

- Differential Inputs
 - $V_d = V_{i1} - V_{i2}$.
- Common Inputs
 - $V_c = \frac{1}{2}(V_{i1} + V_{i2})$ How?
- Output Voltage
 - $V_o = A_d V_d + A_c V_c$.
- Opposite Polarity Inputs
 - If $V_{i1} = -V_{i2} = V_s$
 - $V_d = 2V_s$.
 - $V_c = 0$.
 - $V_o = 2A_d V_s$.
- Same Polarity Inputs
 - If $V_{i1} = V_{i2} = V_s$.
 - $V_d = 0$.
 - $V_c = V_s$.
 - $V_o = A_c V_s$.
- $CMRR = A_d/A_c$.
- $CMRR(\log) = 20 \log_{10}(A_d/A_c)$.
- $V_o = A_d V_d (1 + (V_c / (CMRR * A_d)))$.



References

- [1] Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.
- [2] Theodore F. Bogart, Jeffery S. Beasley, Guillermo Rico, *Electronics Devices and Circuits*, 6th Edition, Pearson Education Inc, ISBN: 978-81-775-8887-3