Electronics II

Lecture 11
Differential Amplifier

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Previous Lecture

- Darlington Pair
  - DC Biasing .
 - AC Equivalent Circuit and Related Parameters.

Session Overview

Topic	Differential Amplifier
Concepts	Introduction, Single Ended Operation, Double Ended Operation, Common Mode Operation.
Recommended Reading	Section 12.9 of [1]
Keywords	Single Ended, Double Ended, Common Mode.

Differential Amplifier

- Usually used in different Integrated Circuits (ICs).

- It has
  - Two separate Inputs.
  - Two Separate Outputs.
  - Emitters Connected Together.
  - Single or two supplies.

- Different types of operation depending upon the combinations of the inputs
  - Single Ended Operation.
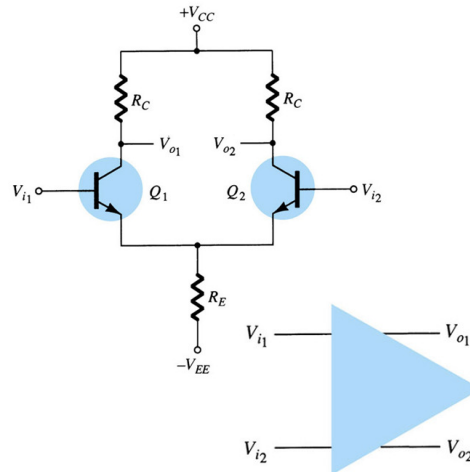 - Double Ended Operation.
  - Common Mode Operation.
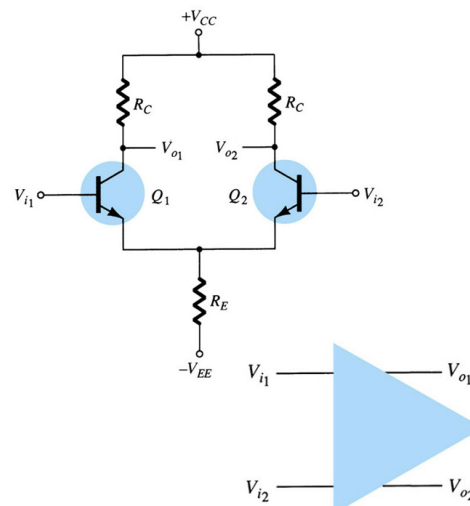
Robert L. Boylestad, *Electronic Devices and Circuit Theory,* 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

Modes of Operation
(Differential Amplifier)

- Single Ended Operation
  - Signal applied to one input terminal with other input terminal grounded.
  - Output from both collectors. (Why)

- Double Ended Operation
  - Two signal with opposite polarity applied to the two input terminals.
  - Output from both collectors according to the difference in inputs.

- Common Mode Operation.
  - Same signal applied to both input terminals.
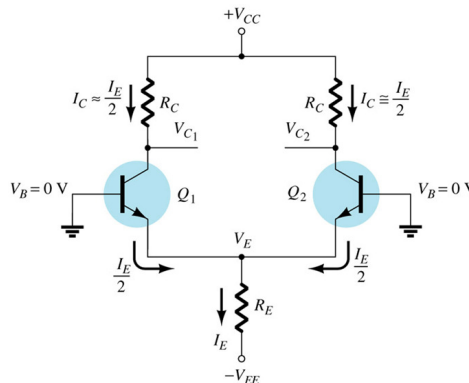 - Output from both collectors but net output is zero.

DC Biasing
(Differential Amplifier)

- DC Biasing

  - $V_E = V_B - V_{BE} = 0 - 0.7V = -0.7V$

  - $I_E = (V_E - (-V_{EE}))/R_E$
    $I_E = (V_{EE} - 0.7V)/R_E$

  - $I_{C1} = I_{C2} = I_E/2$

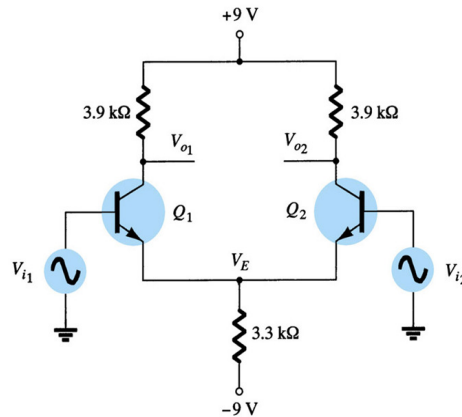 - $V_{C1} = V_{C2} = V_{CC} - I_C R_C = V_{CC} - (I_E/2) R_C$

DC Biasing
(Differential Amplifier)

- Example 12.18 (Boylestad): Calculate the DC voltages and currents in the given circuit.

Single Ended Operation
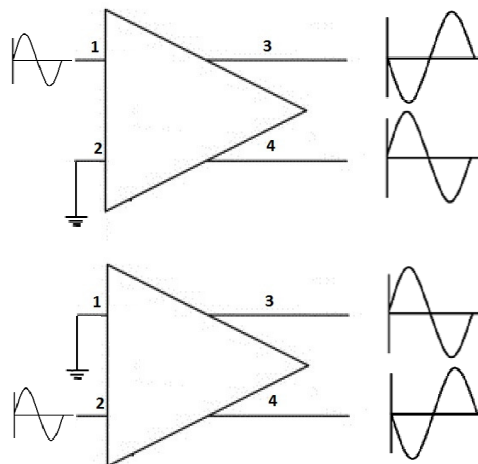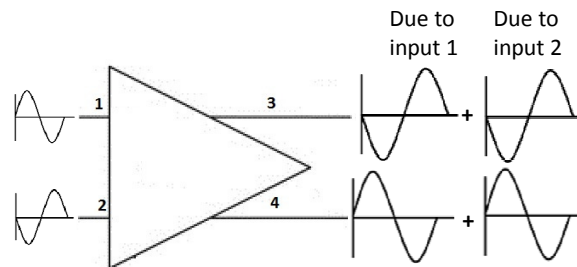# (Differential Amplifier)

- One input is grounded and the signal is applied to the other input.

- One output is amplified and inverted(w.r.t. input) signal.

- Other output is amplified and in phase(wr.t. input) signal.

Double Ended Operation
(Differential Amplifier)

- Two signals with opposite polarity are applied at two inputs.

- The resulting signals at both outputs are such that their peak value is twice as compared to that of single ended operation.

Common Mode Operation
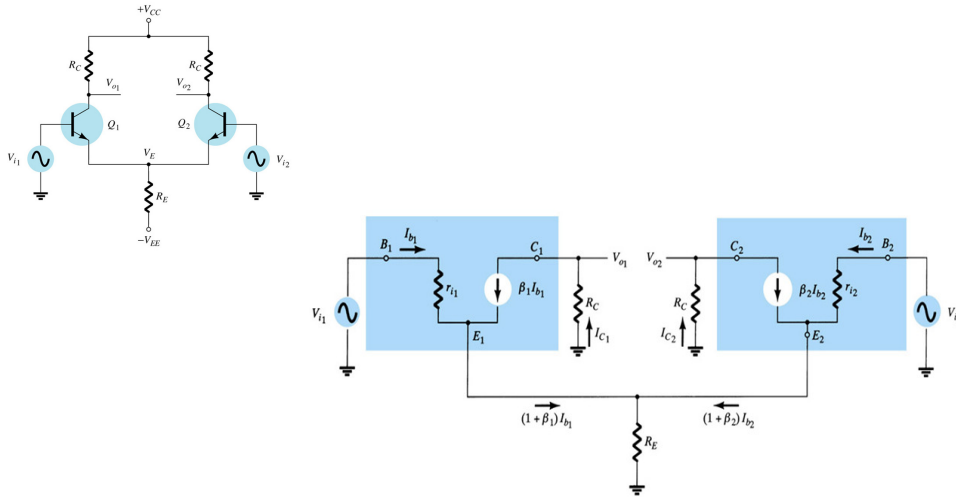# (Differential Amplifier)

- Two signals with same polarity or a same signal is applied at two inputs.
- The resulting signals at both outputs are such that their value is zero.
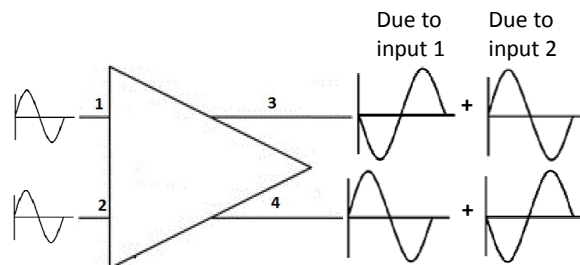
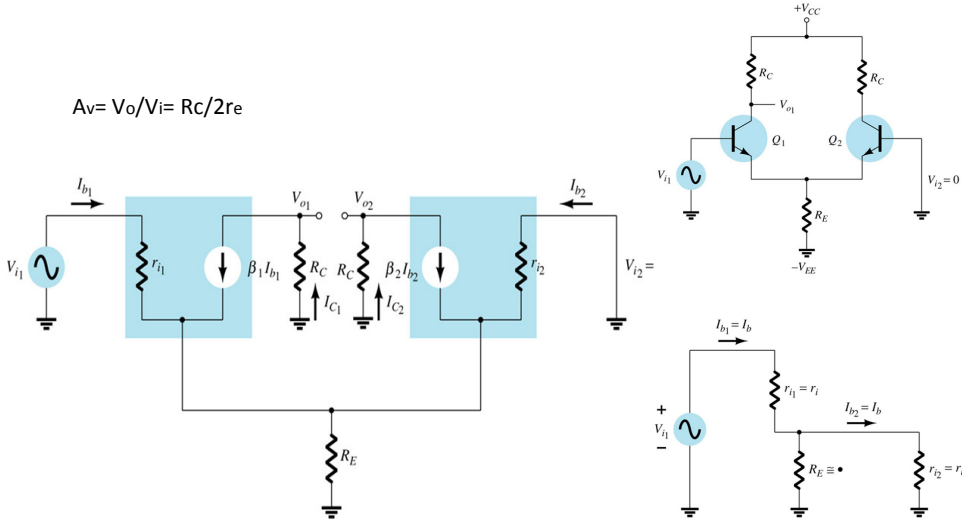**Task:** What is Common Mode Rejection Ratio (CMRR)?

AC Opertaion
(Differential Amplifier)

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

Single Ended AC Voltage Gain

$A_v = V_o/V_i = R_c/2r_e$

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

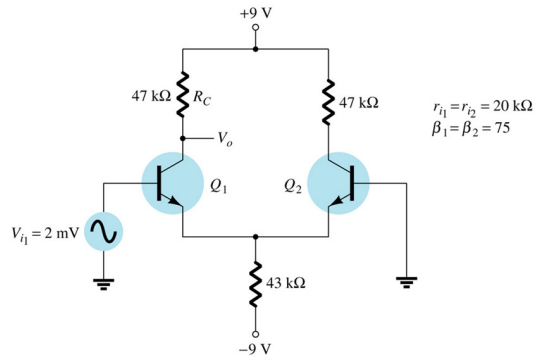# Single Ended AC Voltage Gain

- Example 12.19 (Boylestad): Calculate the single ended output voltage for the given circuit.
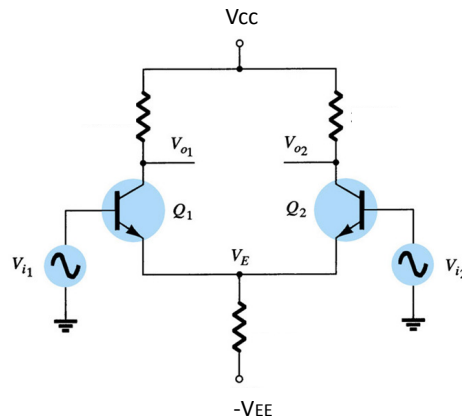

$r_{i_1} = r_{i_2} = 20\ k\Omega$
$\beta_1 = \beta_2 = 75$

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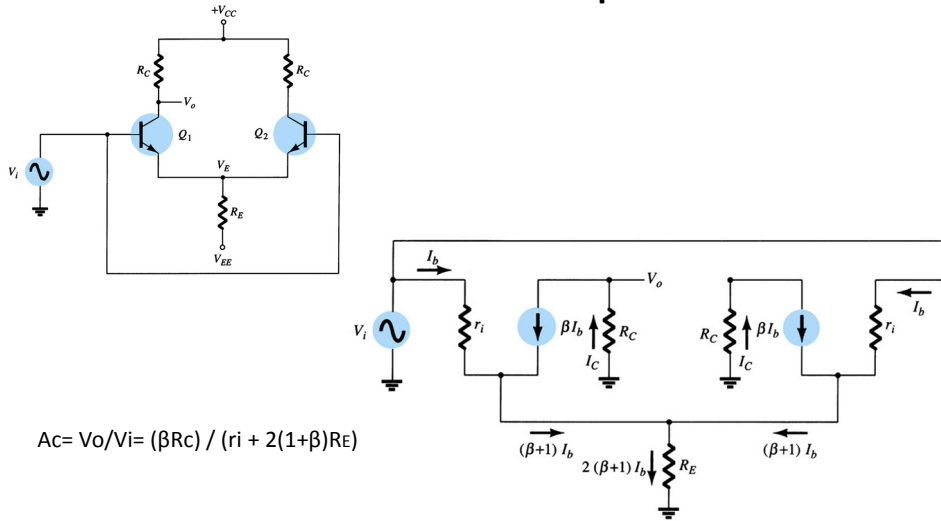
Double Ended AC Voltage Gain

- Ad= Vo/Vd= βRc/2ri

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

Common Mode Operation

$Ac= Vo/Vi= (\beta Rc) / (ri + 2(1+\beta)R_E)$

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

References

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