Electronics II

Lecture 10
Multistage Amplifiers
Part 02

Muhammad Tilal
Department of Electrical Engineering
CIIT Attock Campus

Previous Lecture

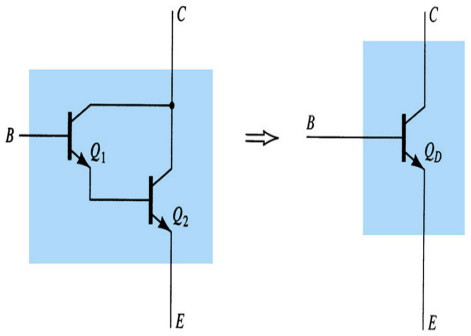
- Multistage Amplifiers
  - Cascade Connection.
  - Cascode Connection.

Session Overview

Topic	Multistage Amplifiers
Concepts	Darlington Pair.
Recommended Reading	Sections 12.4 & 12.9of [1].
Keywords	Darlington Pair, Differential Amplifier, Single Ended, Double Ended, Common Mode, Common Mode Rejection Ratio(CMRR).

Darlington Pair

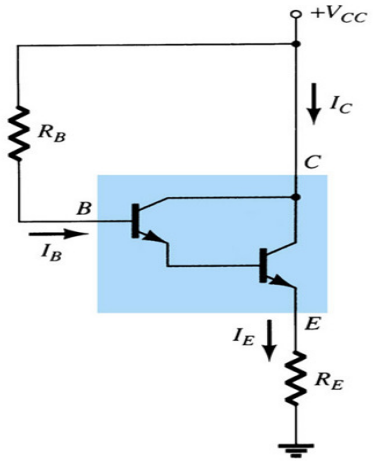
- Two BJTs coupled to act as a single amplifier.
- The current gain of Darlington pair is the product of the current gains of the two transistor
  - $\beta_D = \beta_1 * \beta_2$
- For matched transistors where $\beta 1 = \beta 2 = \beta$
  - $\beta_D = (\beta)^2$



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

Darlington Pair (DC Biasing)

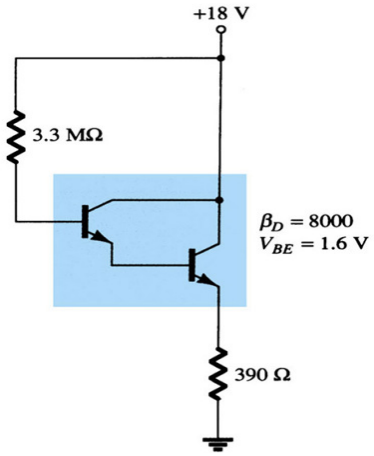
- $I_B = (V_{CC} - V_{BE})/(R_B + \beta_D R_E)$.
- $I_E = (1 + \beta_D) I_B \cong \beta_D I_B$.
- $V_E = I_E R_E$.
- $V_B = V_E + V_{BE}$.
- V_{BE} = ?



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

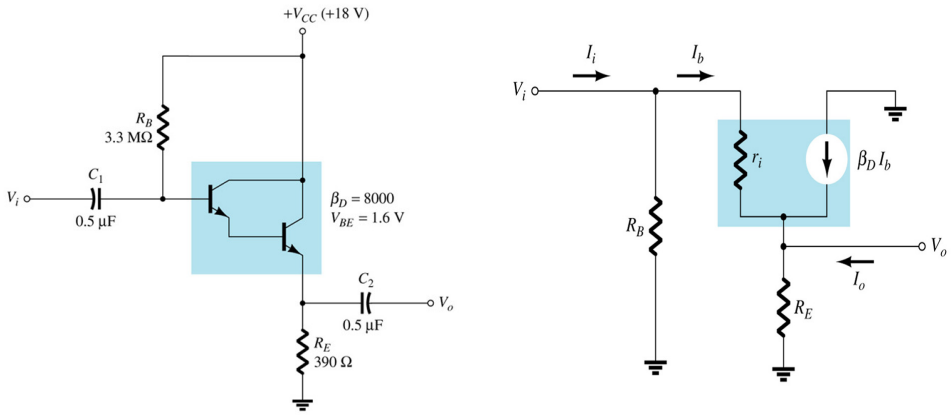
Darlington Pair (DC Biasing)

- *Example 12.6 (Boylestad):* Calculate DC bias voltages and currents for the given Darlington circuit.



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

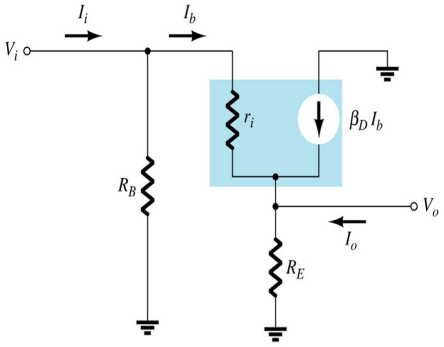
AC Equiv. Circuit (Darlington Pair)



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

AC Input Impedance (Darlington Pair)

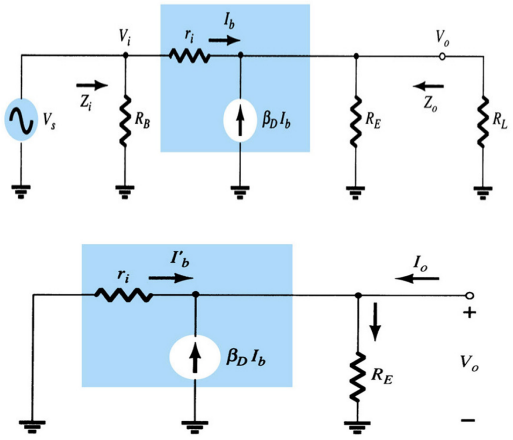
- $Z_i = R_B || (r_i + \beta_D R_E)$



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

AC Output Impedance(Darlington Pair)

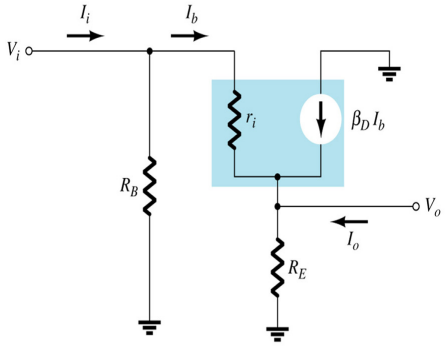
- $Z_o \cong r_i/\beta_D$



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

AC Current Gain(Darlington Pair)

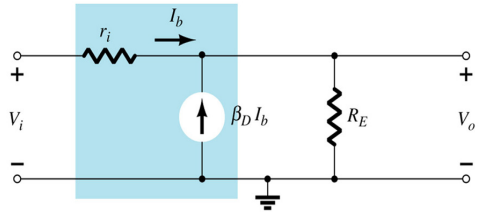
- $A_i = (\beta_D R_B)/(R_B + \beta_D R_E)$



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

AC Voltage Gain(Darlington Pair)

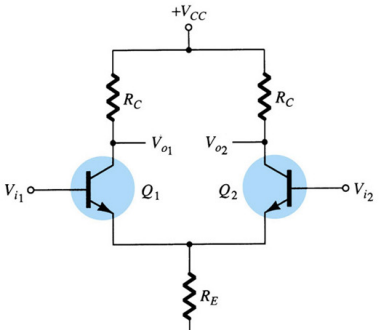
- $A_v \cong 1$

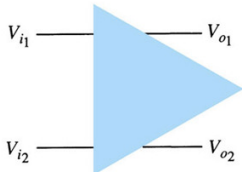


Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

Differential Amplifier

- Usually used in different Integrated Circuits (ICs).
- It has
  - Two separate Inputs.
  - Two Separate Outputs.
  - Single or two supplies.
- Different types of operation depending upon the combinations of the inputs
  - Single Ended Operation.
  - Double Ended Operation.
  - Common Mode Operation.

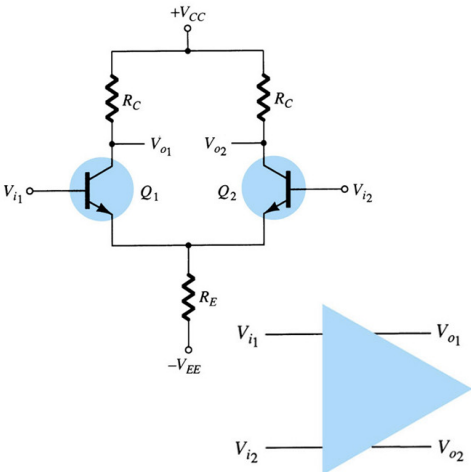




Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

Modes of Operation (Differential Amplifier)

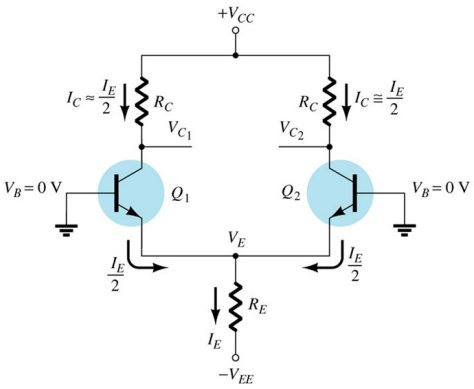
- Single Ended Operation
  - Signal applied to one input terminal with other input terminal grounded.
  - Output from both collectors. (Why)
- Double Ended Operation
  - Two signal with opposite polarity applied to the two input terminals.
  - Output from both collectors according to the difference in inputs.
- Common Mode Operation.
  - Same signal applied to both input terminals.
  - Output from both collectors but net output is zero.



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

DC Biasing (Differential Amplifier)

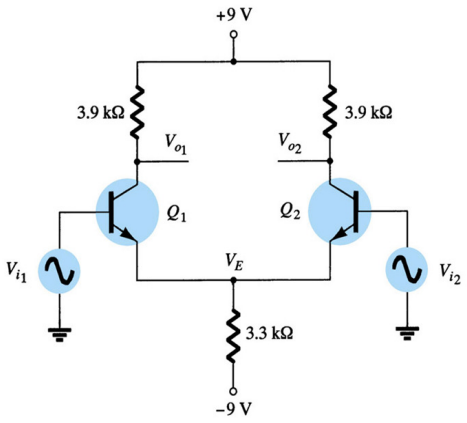
- DC Biasing
  - $V_E = V_B - V_{BE} = 0 - 0.7V = -0.7V$
  - $I_E = (V_E - (-V_{EE}))/R_E$
    $I_E = (V_{EE} - 0.7V)/R_E$
  - $I_{C1} = I_{C2} = I_E/2$
  - $V_{C1} = V_{C2} = V_{CC} - I_C R_C = V_{CC} - (I_E/2) R_C$



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

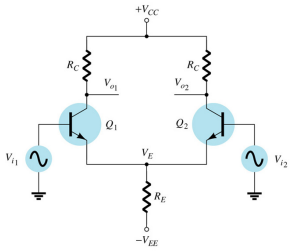
DC Biasing (Differential Amplifier)

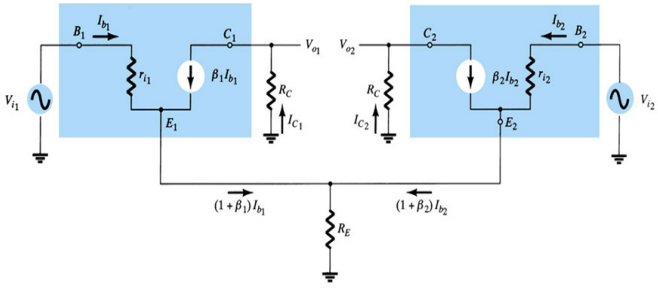
- Example 12.18 (Boylestad): Calculate the DC voltages and currents in the given circuit.



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

AC Opertaion (Differential Amplifier)





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.