COLLEGE OF ENGINEERING AND TECHNOLOGIES

ALMUSTAQBAL UNIVERSITY

# Electronics

## CTE 207

## Lecture 15

## - Bipolar Junction Transistors (BJT) II -

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# Introduction



- The transistor is a three-layer semiconductor device consisting of either two n- and one p-type layers of material or two p- and one n-type layers of material.

- The former is called an npn transistor, while the latter is called a pnp transistor.

- In Fig. below both biasing potentials have been applied to a pnp transistor, with the resulting majority- and minority-carrier flow indicated.

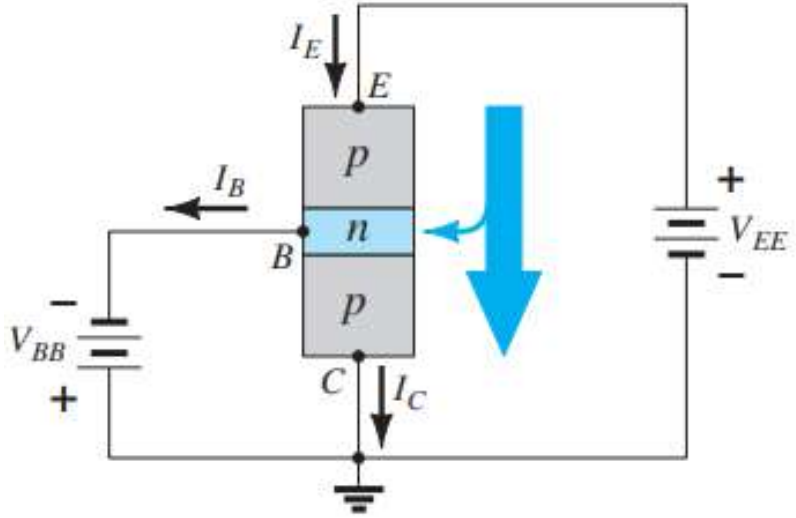
# Common-Emitter Configuration

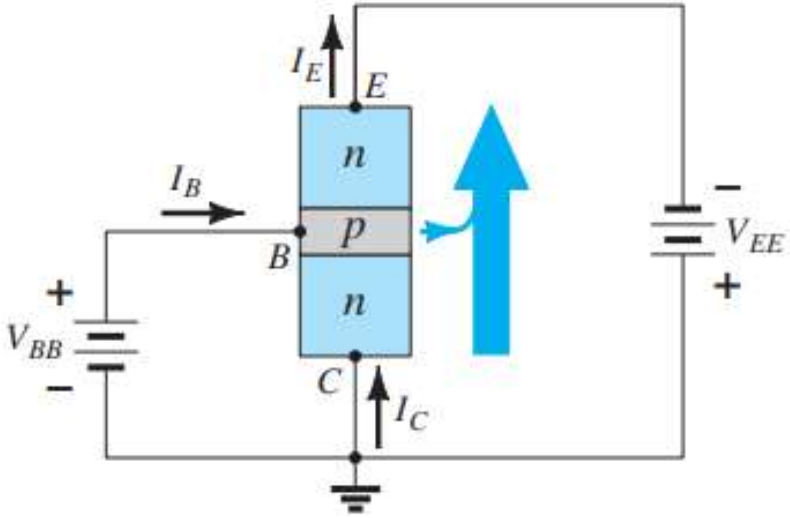


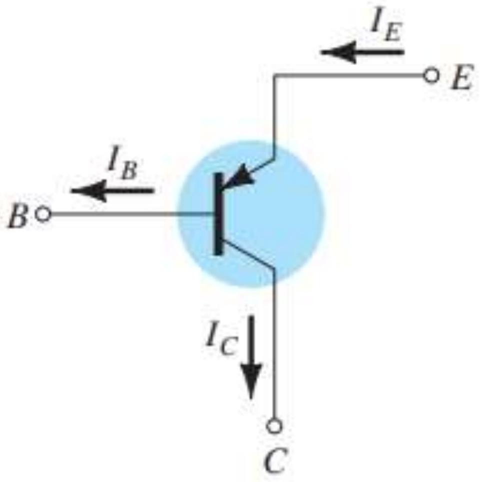
- The most frequently encountered transistor configuration appears in Figure below for the pnp and npn transistors.

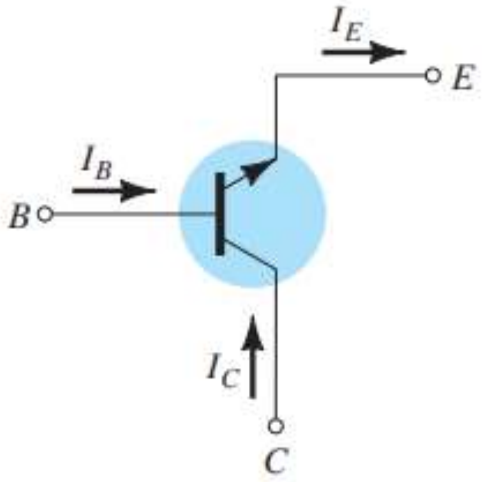
- It is called the common emitter configuration since the emitter is common or reference to both the input and output terminals (in this case common to both the base and collector terminals).

# Common-Emitter Configuration



# Common-Emitter Configuration



- For the common-emitter configuration, the output characteristics are a plot of the output current (IC) versus output voltage (VCE) for a range of values of input current (IB ).

- The input characteristics are a plot of the input current (IB) versus the input voltage (VBE) for a range of values of output voltage (VCE).

# Common-Emitter Configuration

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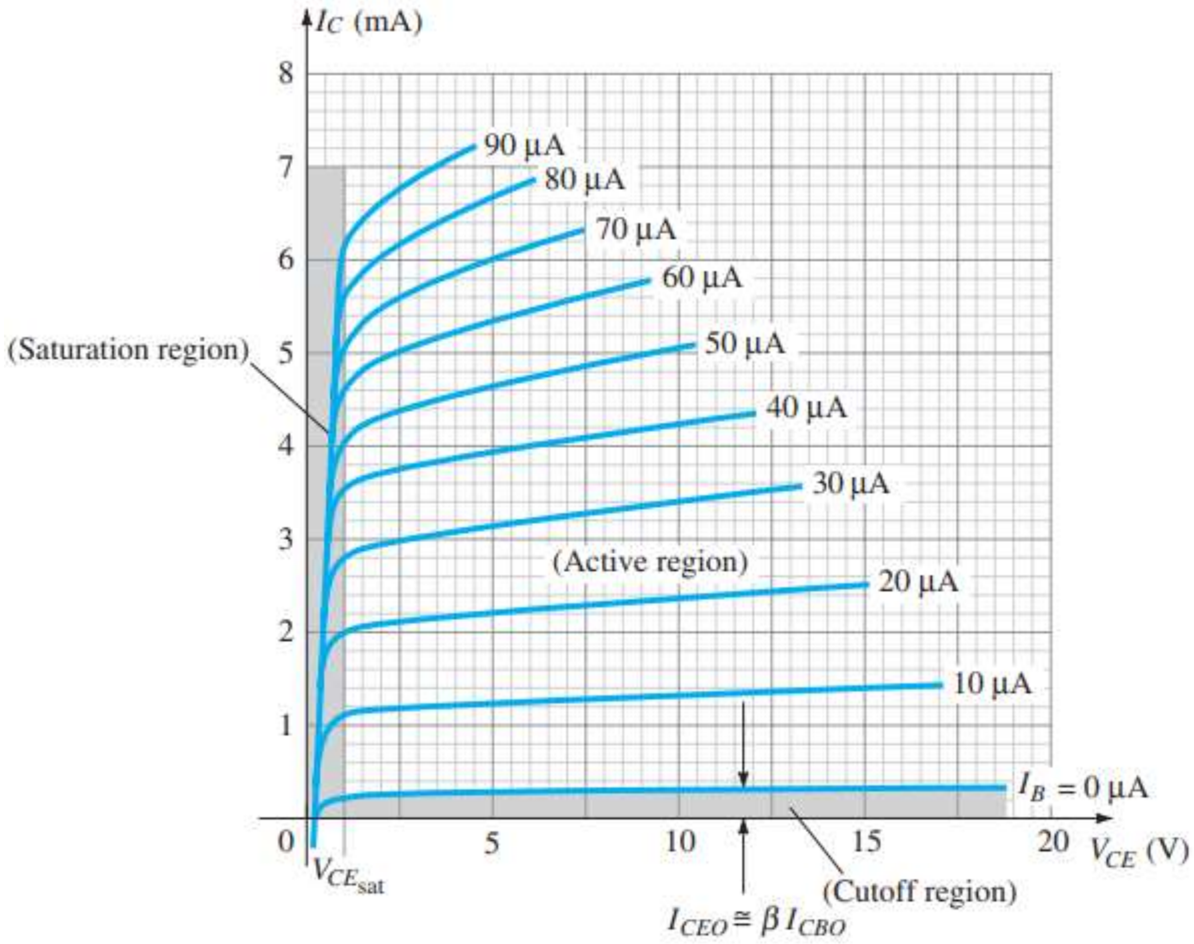
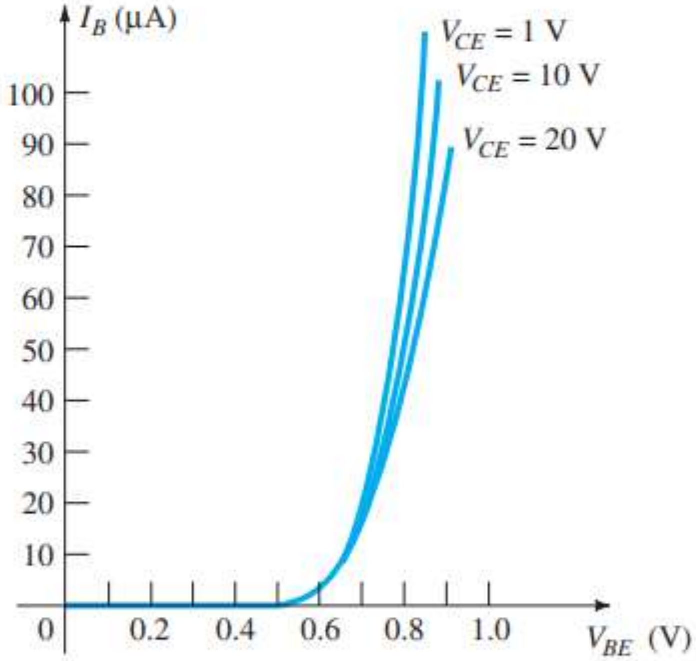


In the dc mode the levels of $I_C$ and $I_B$ are related by a quantity called beta and defined by the following equation:

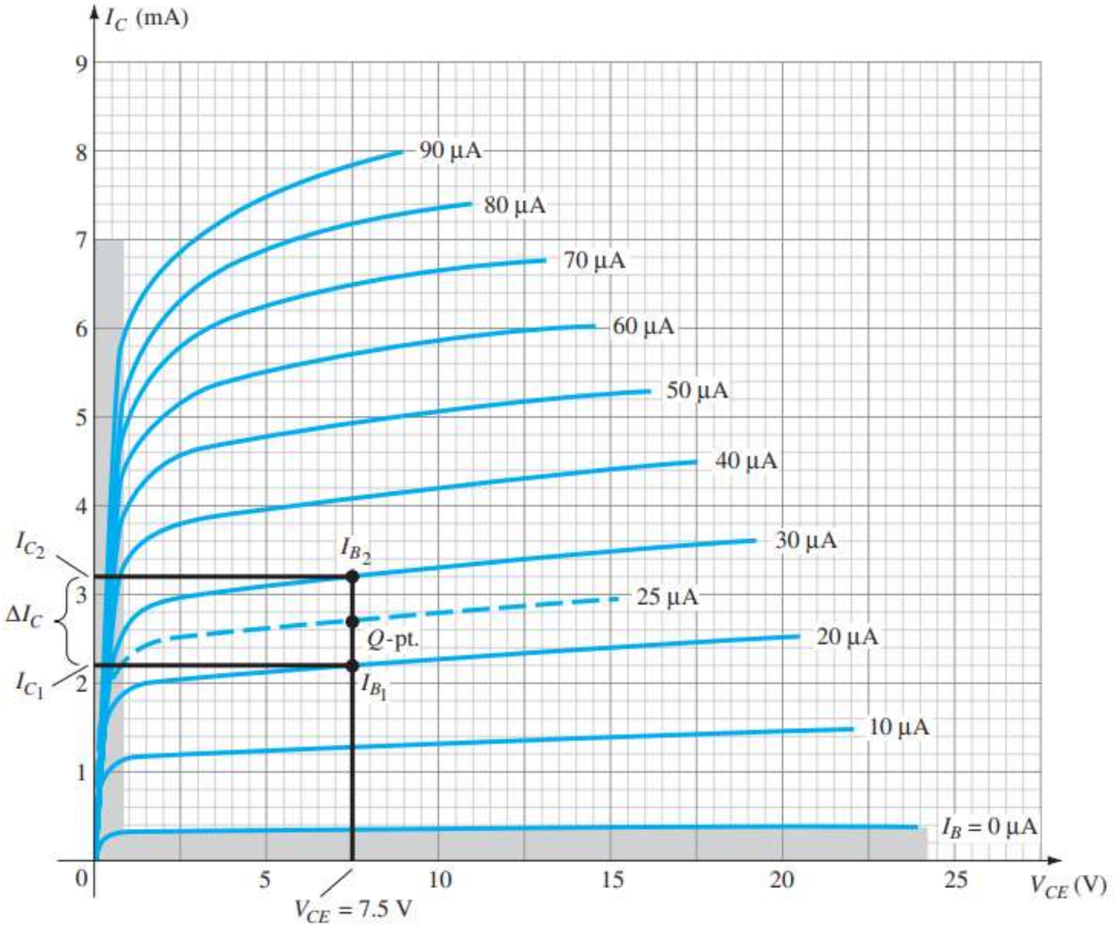
$$\beta_{dc} = \frac{I_C}{I_B}$$

For practical devices the level of typically ranges from about 50 to over 400, with most in the midrange.

A relationship can be developed between $\beta$ and $\alpha$ using the basic relationships introduced thus far. Using $\beta = I_C/I_B$ we have $I_B = I_C/\beta$, and from $\alpha = I_C/I_E$ we have

# Example

*Determining $\beta_{ac}$ and $\beta_{dc}$ from the collector characteristics.*




$$\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=\text{constant}}$$

$$\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=\text{constant}} = \frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}}$$

$$= \frac{3.2\text{ mA} - 2.2\text{ mA}}{30\ \mu\text{A} - 20\ \mu\text{A}} = \frac{1\text{ mA}}{10\ \mu\text{A}}$$

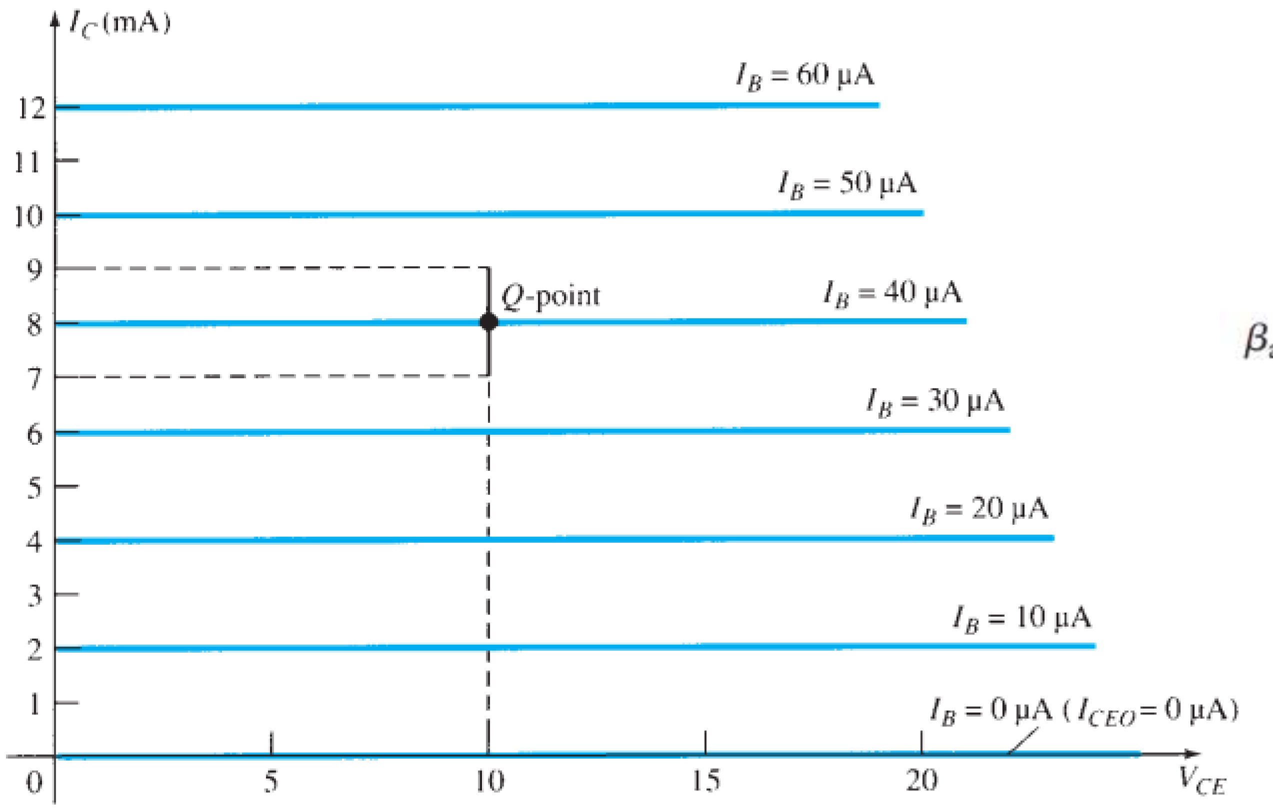
$$= \mathbf{100}$$

$$\beta_{dc} = \frac{I_C}{I_B} = \frac{2.7\text{ mA}}{25\ \mu\text{A}} = \mathbf{108}$$

# Example



*Determining $\beta_{ac}$ and $\beta_{dc}$ from the collector characteristics.*




$$\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=\text{constant}}$$

$$\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=\text{constant}} = \frac{9\text{ mA} - 7\text{ mA}}{45\ \mu\text{A} - 35\ \mu\text{A}} = \frac{2\text{ mA}}{10\ \mu\text{A}} = \mathbf{200}$$

$$\beta_{dc} = \frac{I_C}{I_B} = \frac{8\text{ mA}}{40\ \mu\text{A}} = \mathbf{200}$$

# Common-Emitter Configuration



$I_E = I_C/\alpha$. Substituting into

$$I_E = I_C + I_B$$

we have

$$\frac{I_C}{\alpha} = I_C + \frac{I_C}{\beta}$$

*and dividing both sides of the equation by* $I_C$ will result in

$$\frac{1}{\alpha} = 1 + \frac{1}{\beta}$$

or

$$\beta = \alpha\beta + \alpha = (\beta + 1)\alpha$$

so that

$$\alpha = \frac{\beta}{\beta + 1}$$

or

$$\beta = \frac{\alpha}{1 - \alpha}$$

# Common-Emitter Configuration

$$I_C = \beta I_B$$

and since

$$I_E = I_C + I_B$$

$$= \beta I_B + I_B$$

we have

$$I_E = (\beta + 1) I_B$$

# Common-Collector Configuration

- The common-collector configuration is used primarily for impedance-matching purposes since it has a high input impedance and low output impedance, opposite to that of the common-base and common-emitter configurations.

# Common-Collector Configuration



- For all practical purposes, the output characteristics of the common collector configuration are the same as for the common-emitter configuration.

- For the common-collector configuration the output characteristics are a plot of IE versus VCE for a range of values of IB.

- The input current, therefore, is the same for both the common-emitter and common-collector characteristics.

# Common-Collector Configuration