جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

COLLEGE OF ENGINEERING AND TECHNOLOGIES

ALMUSTAQBAL UNIVERSITY

Electronics Fundamentals

CTE 204

Lecture 13

- Bipolar Junction Transistors (BJT) -

(2024 - 2025)

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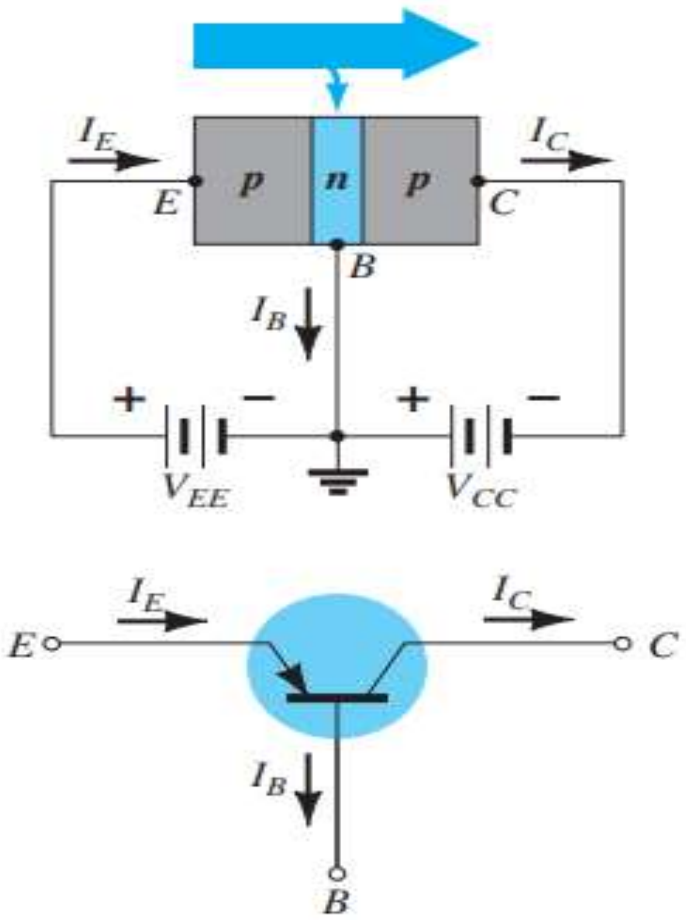
Introduction

- 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.

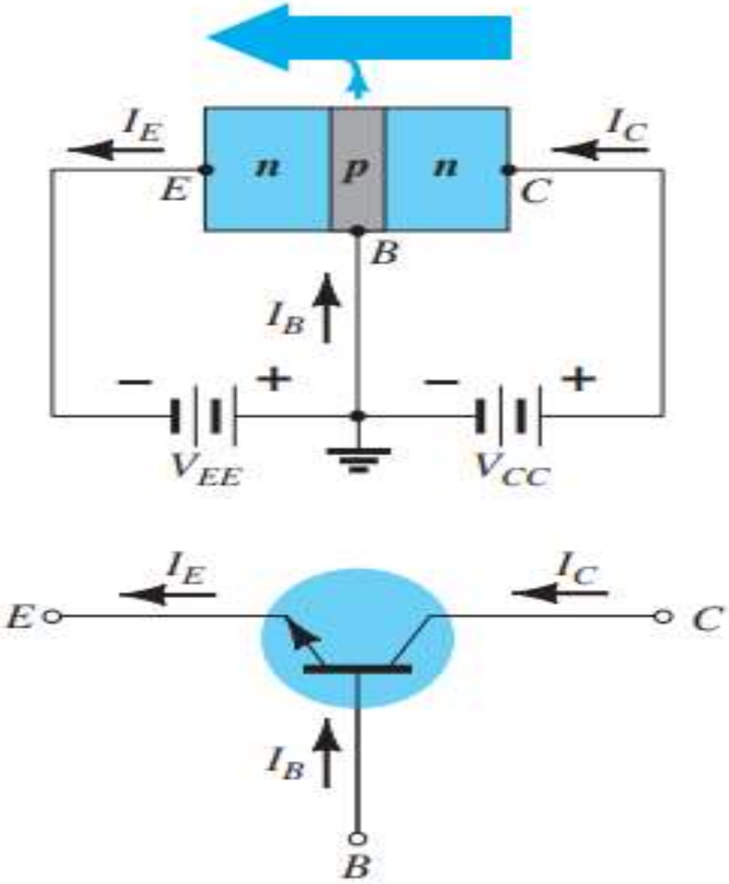
- The former is called an NPN transistor, while the latter is called a PNP transistor.

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

Types of transistors



PNP



NPN

Transistor Construction

- The emitter layer is heavily doped, the base lightly doped, and the collector only lightly doped.

- The outer layers have widths much greater than the sandwiched p- or n-type material.

- From the Figure before, the terminals have been indicated by the capital letters E for Emitter, C for Collector, and B for Base.

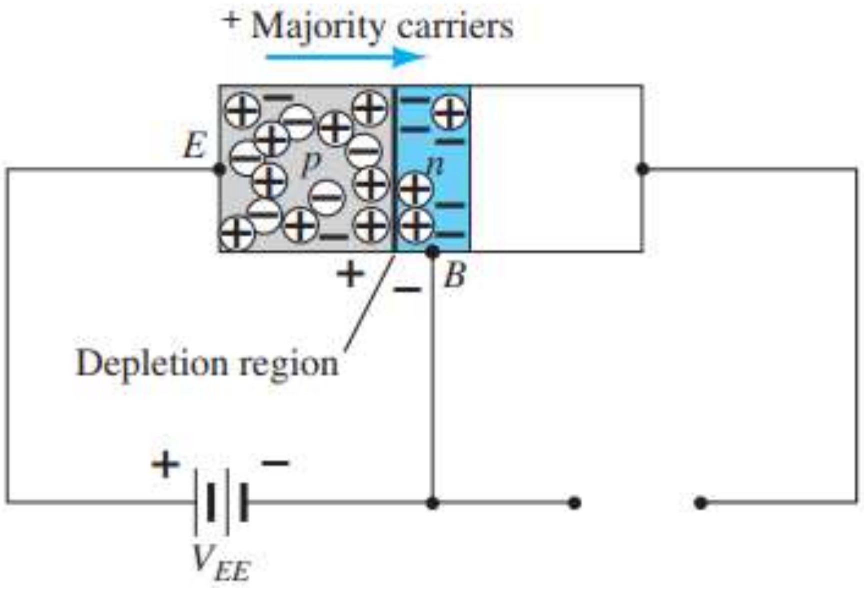
- The abbreviation BJT, from Bipolar Junction Transistor, is often applied to these three terminal devices.

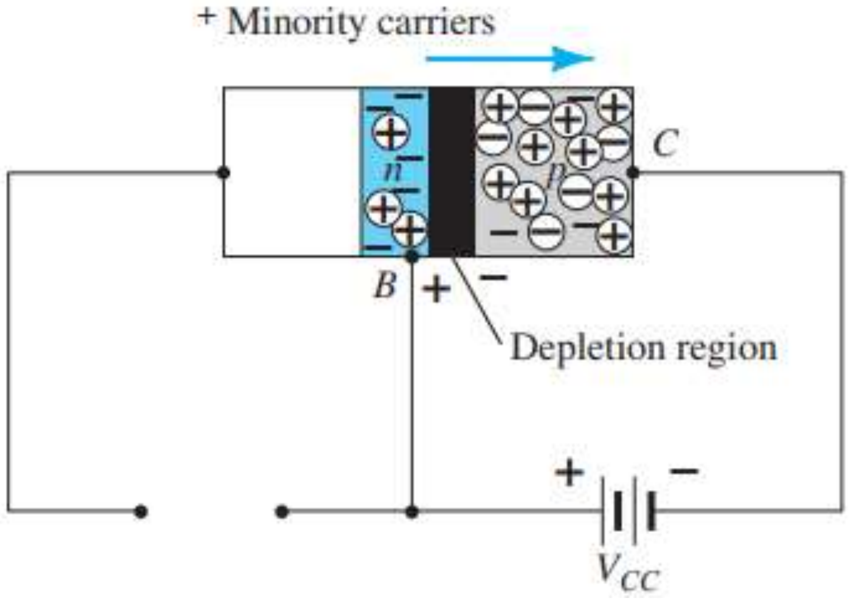
Transistor Operation

- The basic operation of the transistor will now be described using the PNP transistor.
- The operation of the NPN transistor is exactly the same if the roles played by the electron and hole are interchanged.
- In the Figure below, the PNP transistor has been redrawn without the base-to-collector bias.
- Note the similarities between this situation and that of the forward-biased diode.

Transistor Operation

- The depletion region has been reduced in width due to the applied bias, resulting in a heavy flow of majority carriers from the p- to the n-type material.





Transistor Operation

- Let us now remove the base-to-emitter bias of the PNP transistor as shown in Figure before, Consider the similarities between this situation and that of the reverse-biased diode.

- The flow of majority carriers is zero, resulting in only a minority-carrier flow, as indicated in the Figure before.

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

- Note in Figure below the widths of the depletion regions, indicating clearly which junction is forward-biased and which is reverse-biased.

Transistor Operation

- As indicated in Figure below, a large number of majority carriers will diffuse across the forward-biased p-n junction into the n-type material.

- Since the sandwiched n-type material is very thin and has a low conductivity, a very small number of these carriers will take this path of high resistance to the base terminal.

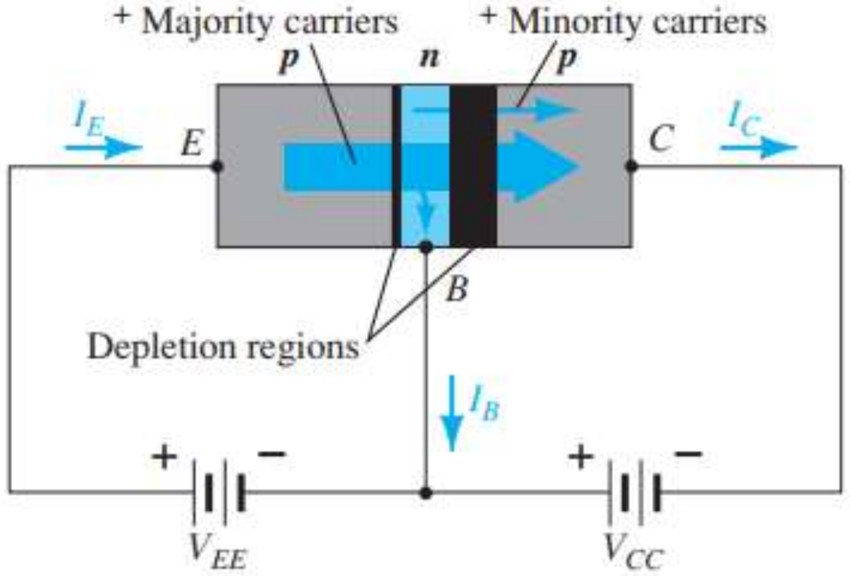
- The magnitude of the base current is typically on the order of microamperes as compared to milliamperes for the emitter and collector currents.

Transistor Operation

- The larger number of these majority carriers will diffuse across the reverse-biased junction into the p-type material connected to the collector terminal as indicated in Figure below.

- Applying Kirchhoff current law to the transistor of Figure below as if it were a single node, we obtain:

$$I_E = I_C + I_B$$



Common – Base Configuration (CB)

- The notation and symbols used in conjunction with the transistor are indicated in the Figure below, for the common-base configuration with PNP and NPN transistors.

- The common-base terminology is derived from the fact that the base is common to both the input and output sides of the configuration.

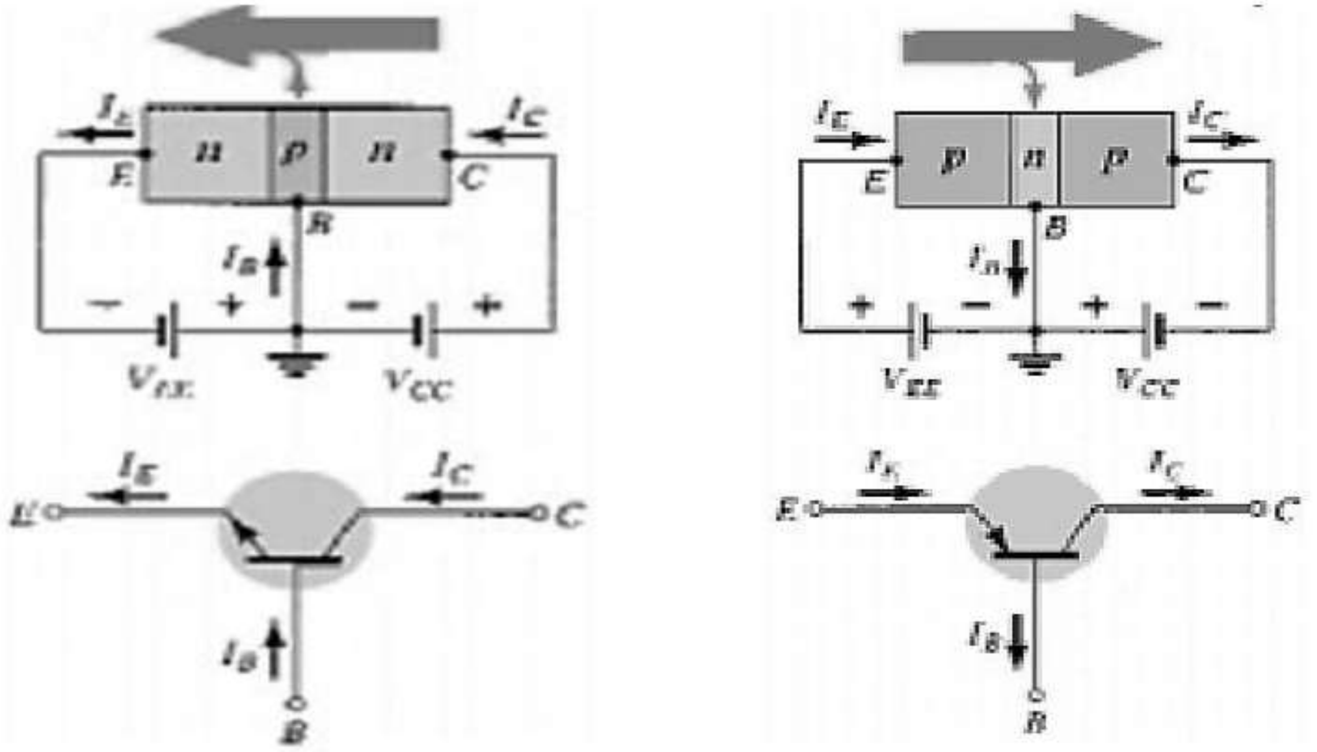
- In addition, the base is usually the terminal closest to, or at, ground potential.

Common – Base Configuration (CB)

- All the current directions appearing in the Figure below, are the actual directions as defined by the choice of conventional flow.

- Note in each case that:

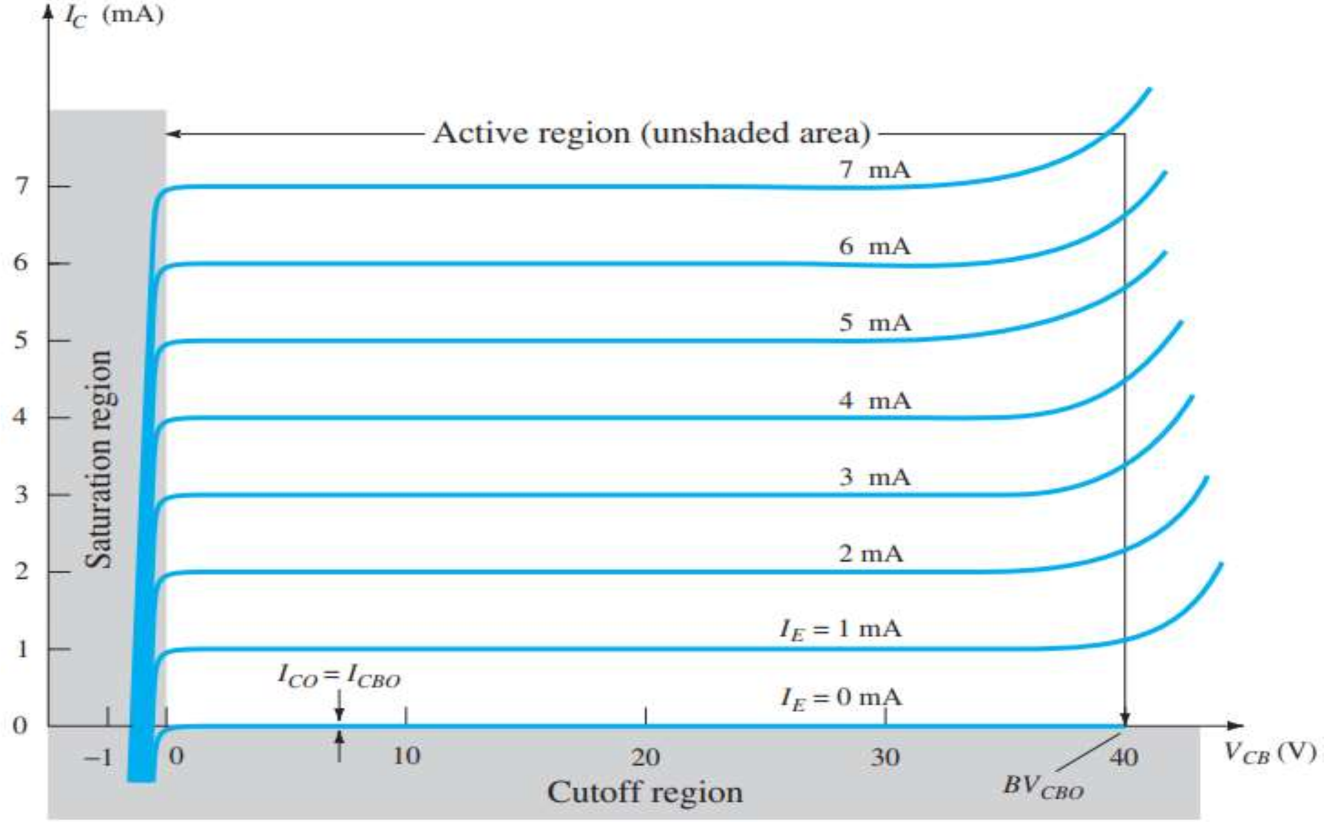
$$I_E = I_C + I_B$$



Common – Base Configuration (CB)

- The output or collector set of characteristics has three basic regions of interest, as indicated in Figure below:

- The active
- Cutoff
- Saturation regions



Common – Base Configuration (CB)

- In the active region the collector-base junction is reverse-biased, while the base-emitter junction is forward-biased.

- In the cutoff region the collector-base and base-emitter junctions of a transistor are both reverse-biased.

- In the saturation region the collector-base and base-emitter junctions are forward-biased.

Common – Base Configuration (CB)

- The emitter current increases above zero, the collector current increases to a magnitude essentially equal to that of the emitter current, the curves clearly indicate that a first approximation to the relationship between I_E and I_C in the active region is given by:

$$I_E \sim I_C$$

- The second approximation is, that once a transistor is in the ON state, the base-to-emitter voltage will be assumed to be the following:

$$V_{BE} = 0.7V$$