Electronic Devices

Mid Term
Lecture - 07

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Reference book:
Electronic Devices and Circuit Theory (Chapter-3)
Robert L. Boylestad and L. Nashelsky , (11th Edition)

Objectives

- Become familiar with the basic construction and operation of the Bipolar Junction Transistor.
- Be able to apply the proper biasing to insure operation in the active region.
- Recognize and be able to explain the characteristics of a npn or pnp transistor.
- Become familiar with the important parameters that define the response of a transistor.
- Be able to test a transistor and identify the three terminals.

INTRODUCTION

- The basic of electronic system nowadays is semiconductor device.
- The famous and commonly use of this device is BJTs (Bipolar Junction Transistors).
- It can be used as amplifier and logic switches.
- BJT consists of three terminal:

  » collector : C (Lightly Doped)

  » base : B (Very lightly doped)

  » emitter : E (Heavily doped)

- Two types of BJT : p-n-p and n-p-n

TRANSISTOR CONSTRUCTION

- 3 layer semiconductor device consisting:
  - » two n- and one p-type layers of material = n-p-n transistor
  - » two p- and one n-type layers of material = p-n-p transistor
- The term bipolar reflects the fact that ***holes and electrons participate*** in the injection process into the oppositely polarized material.
- A single p-n junction has two different types of bias:
  - » forward bias
  - » reverse bias
- Thus, a two-p-n-junction device has four types of bias.

POSITION OF THE TERMINALS AND SYMBOL OF BJT

- Base is located at the middle and more thin from the level of collector and emitter.

- The emitter and collector terminals are made of the same type of semiconductor material, while the base of the other type of material.

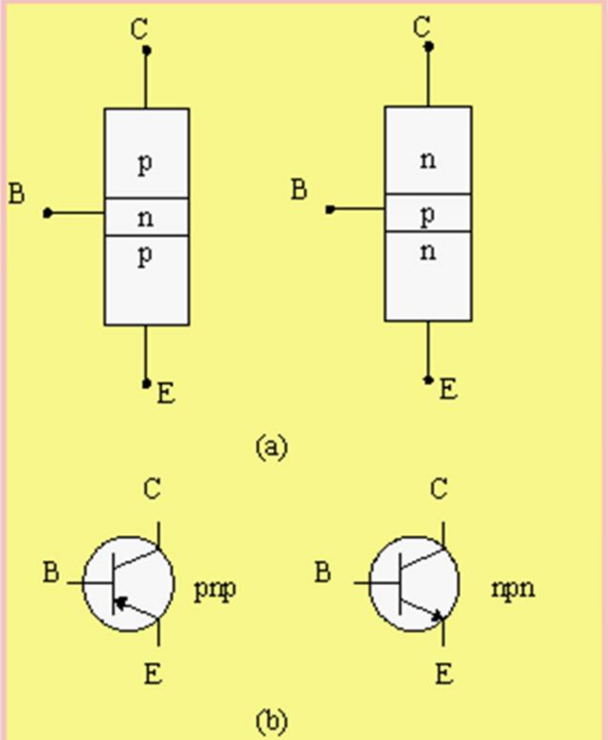


Fig. 4.1: (a) Position of terminals (b) Type of BJT

TRANSISTOR OPERATION

- The basic operation will be described using the p-n-p transistor.
- The operation of the n-p-n transistor is exactly the same if the roles played by the electron and hole are interchanged.
- One p-n junction of a transistor is reverse-biased, whereas the other is forward-biased.

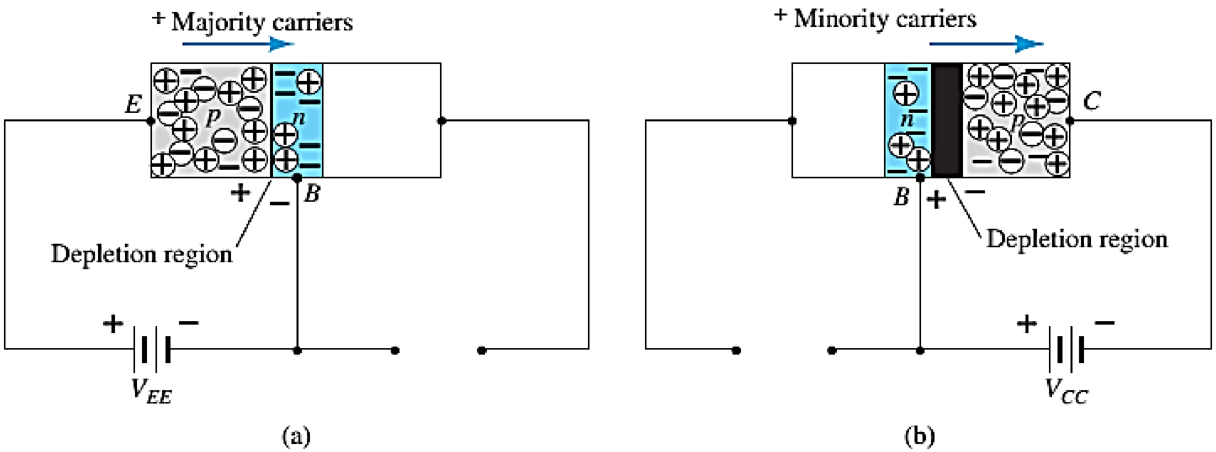


FIG. 3.4
Biasing a transistor: (a) forward-bias; (b) reverse-bias.

TRANSISTOR OPERATION

- Both biasing potentials have been applied to a p-n-p transistor and resulting majority and minority carrier flows indicated.
- Majority carriers (+) will diffuse across the forward-biased p-n junction into the n-type material.
- A very small number of carriers (+) will go through n-type material to the base terminal. Resulting I_B is typically in order of microamperes.
- The large number of majority carriers will diffuse across the reverse-biased junction into the p-type material connected to the collector terminal.

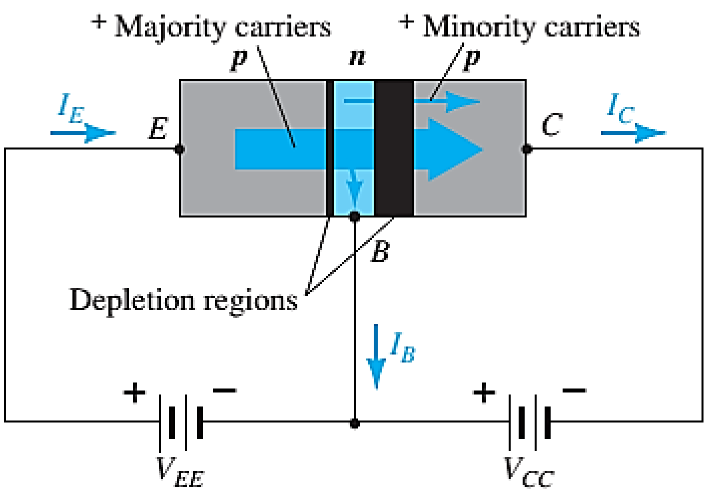


FIG. 3.5
Majority and minority carrier flow of a pnp transistor.

TRANSISTOR OPERATION

- Majority carriers can cross the reverse-biased junction because the injected majority carriers will appear as minority carriers in the n-type material.

- Applying KCL to the transistor :

$$\boxed{I_E = I_C + I_B}$$

- The collector current comprises of two components – the majority and minority carriers

$$\boxed{I_C = I_{C_{\text{majority}}} + I_{CO_{\text{minority}}}}$$

- I_{CO} = I_C current with emitter terminal open and is called ***leakage current.***

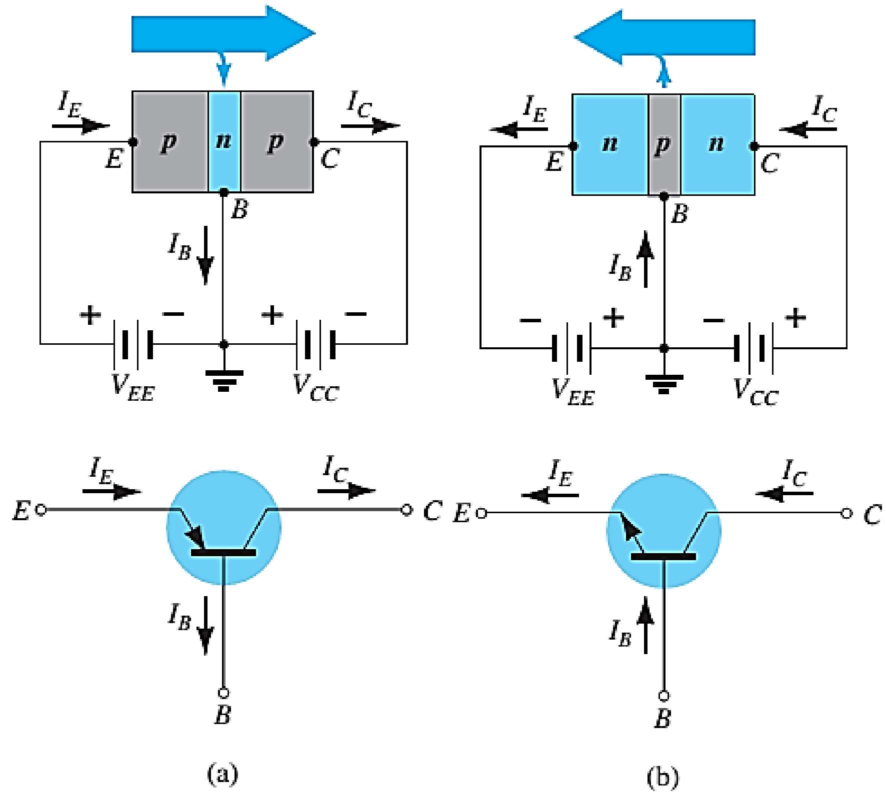
COMMON-BASE CONFIGURATION

- Common-base terminology is derived from the fact that the :

  - base is common to both input and output of the configuration.

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

- All current directions will refer to conventional (hole) flow and the arrows in all electronic symbols have a direction defined by this convention.
- Note that the applied biasing (voltage sources) are such as to establish current in the direction indicated for each branch.



COMMON-BASE CONFIGURATION

- To describe the behavior of common-base amplifiers requires two set of characteristics:
  - Input or driving point characteristics.
  - Output or collector characteristics

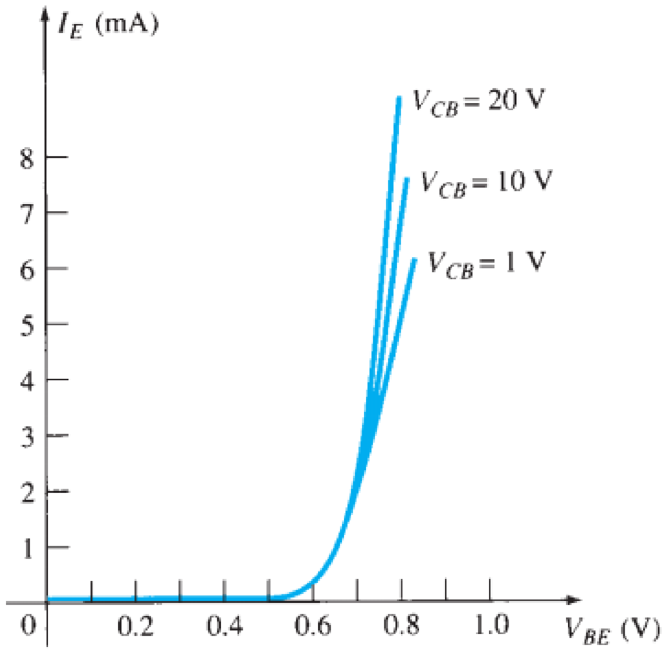


FIG. 3.7
Input or driving point characteristics for a common-base silicon transistor amplifier.

COMMON-BASE CONFIGURATION

- The output characteristics has 3 basic regions:
  - Active region – defined by the biasing arrangements
  - Cutoff region – region where the collector current is 0A
  - Saturation region- region of the characteristics to the left of V_{CB} = 0V

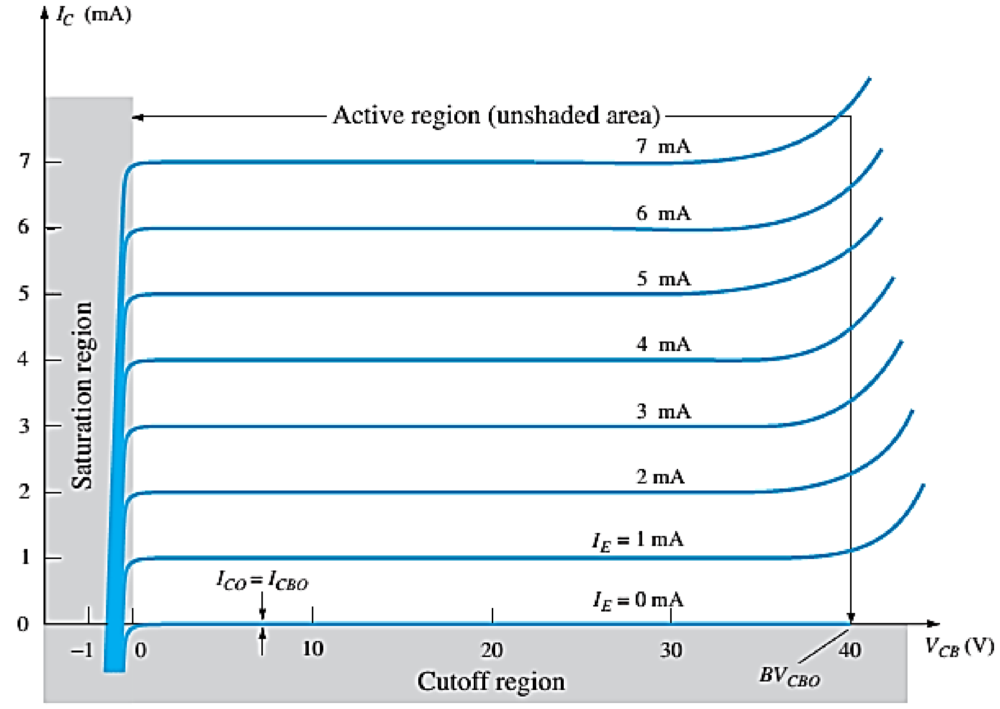


FIG. 3.8
Output or collector characteristics for a common-base transistor amplifier.

COMMON-BASE CONFIGURATION

ACTIVE REGION	SATURATION REGION	CUTOFF REGION
I_E increased, I_C increased		
BE junction reverse biased and CB junction reverse biased	BE and CB junctions are forward biased	BE and CB junction are reverse biased
$I_C \approx I_E$		No current flow at collector, only leakage current
I_C does not depend on V_{CB}	Small change in V_{CB} will cause big difference in I_C	
Suitable region for the transistor to work as an amplifier	The allocation for this region is to the left of the V_{CB} = 0 V	Region below the line of I_E = 0

COMMON-BASE CONFIGURATION

- The curves (output characteristics) clearly indicate that a first approximation to the relationship between I_E and I_C in the active region is given by

$$\mathbf{I_C \approx I_E}$$

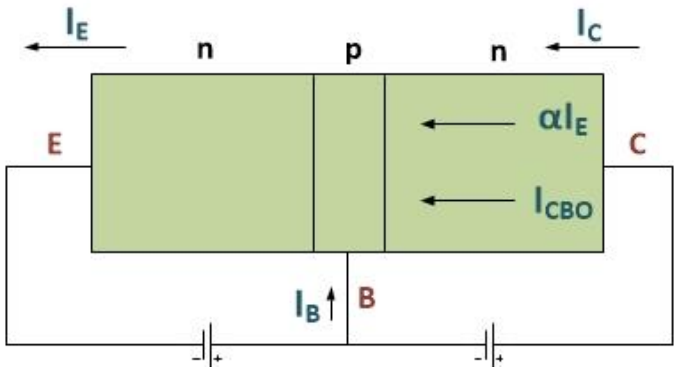
- Once a transistor is in the 'on' state, the base-emitter voltage will be assumed to be

$$\mathbf{V_{BE} = 0.7V}$$

- In the dc mode the level of I_C and I_E due to the majority carriers are related by a quantity called alpha

$$\alpha = \frac{I_C}{I_E} \qquad\qquad I_E = I_C + I_B$$

$$I_C = \alpha I_E + I_{CBO}$$



COMMON-BASE CONFIGURATION

- It can then be summarized to $I_C = \alpha I_E$(ignore I_{CBO} due to small value)

- For ac situations where the point of operation moves on the characteristics curve, an ac alpha defined by

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

- Alpha a common base current gain factor that shows the efficiency by calculating the current percent from current flow from emitter to collector. The value of α is typical from 0.9 ~ 0.998.

Thank You