

Electronic Devices

Course Teacher
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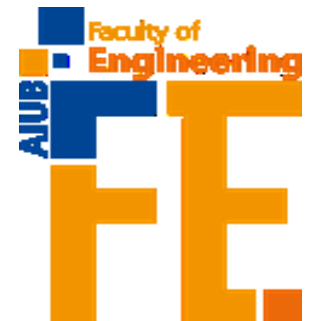
Reference book:

Electronic Devices and Circuit Theory (Chapter-3)

Robert L. Boylestad and L. Nashelsky , (11th Edition)



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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

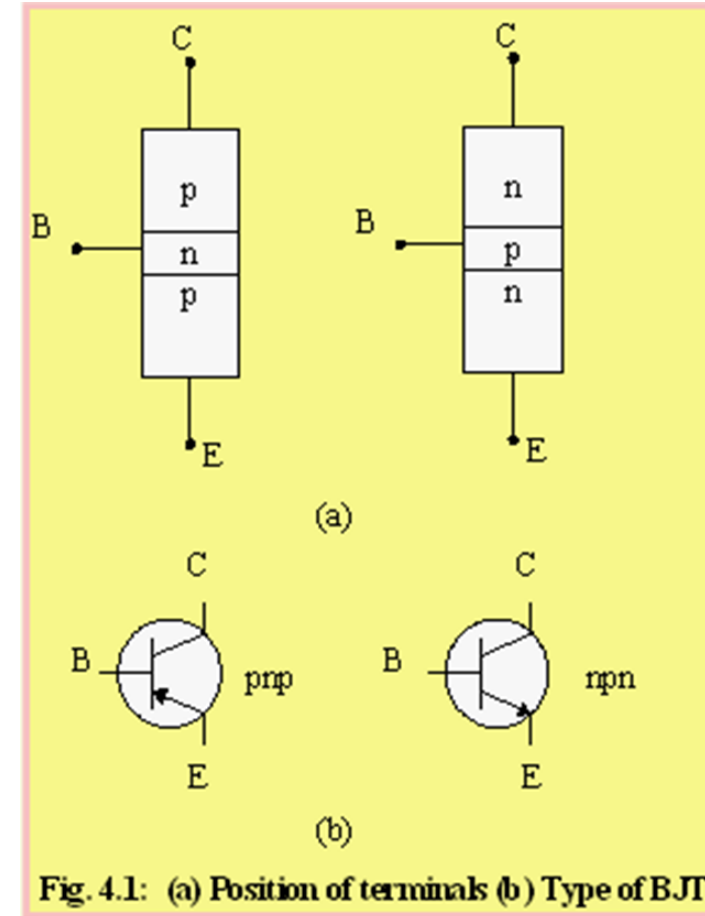


TRANSISTOR CONSTRUCTION

- 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.



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.

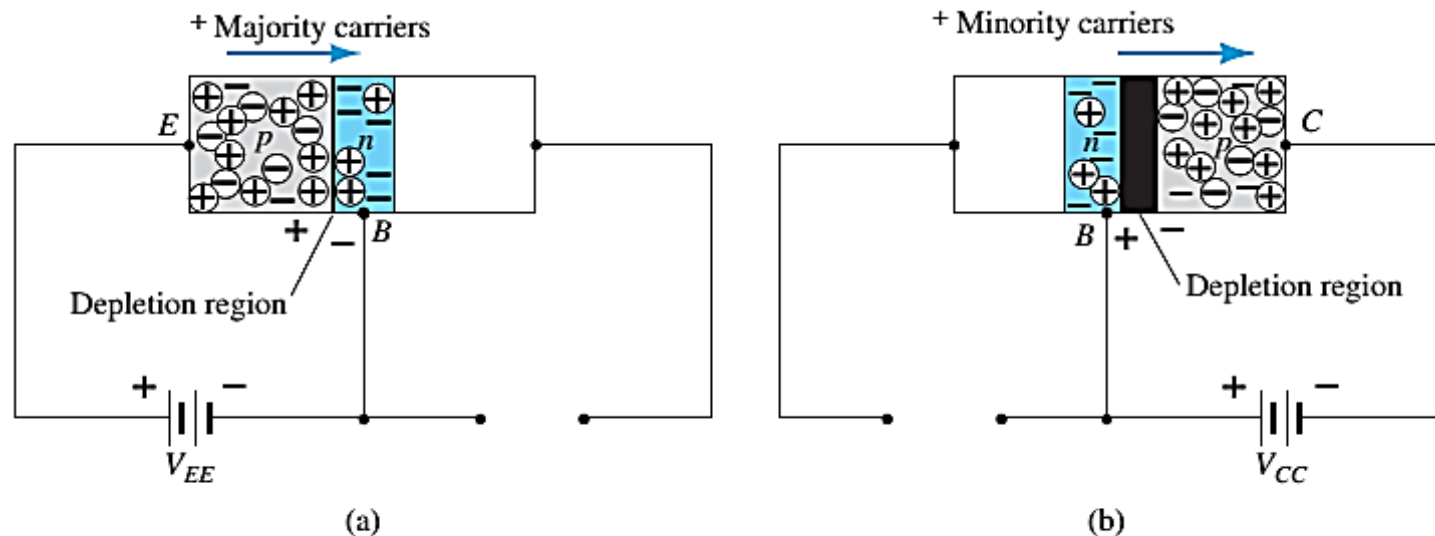


FIG. 3.4

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.

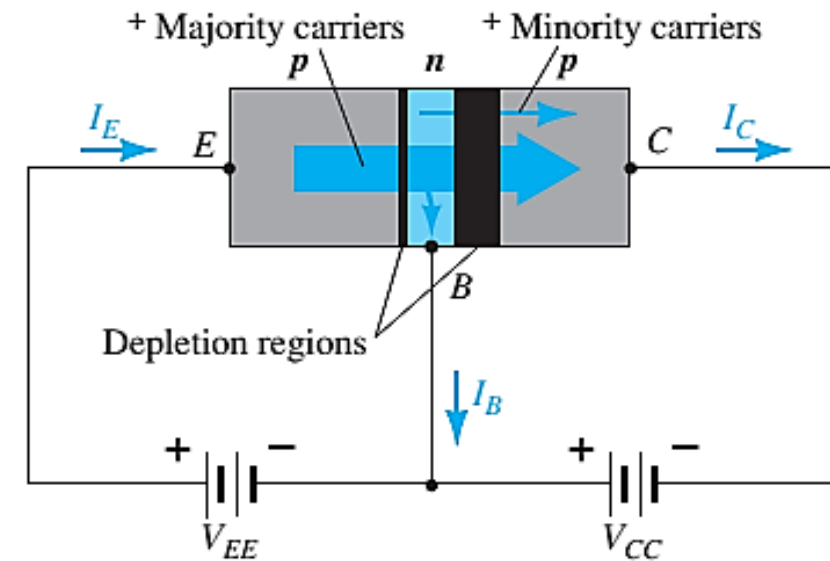


FIG. 3.5

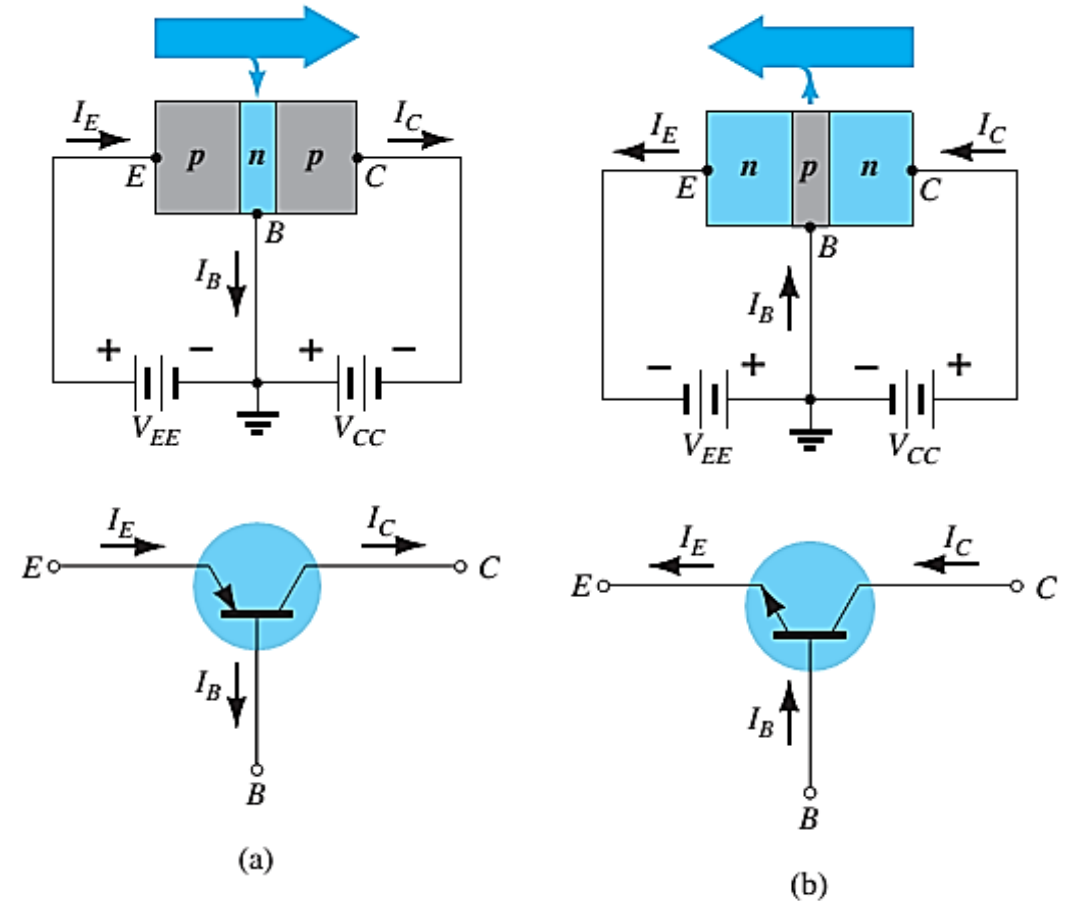
Majority and minority carrier flow of a pnp transistor.

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 : $I_E = I_C + I_B$
- The collector current comprises of two components – the majority and minority carriers
$$I_C = I_{C_{\text{majority}}} + I_{CO_{\text{minority}}}$$
- $I_{CO} = I_C$ 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. (the relationship between the input voltage and the input current at the base of the transistor, while keeping the output voltage constant.)
 - Output or collector characteristics

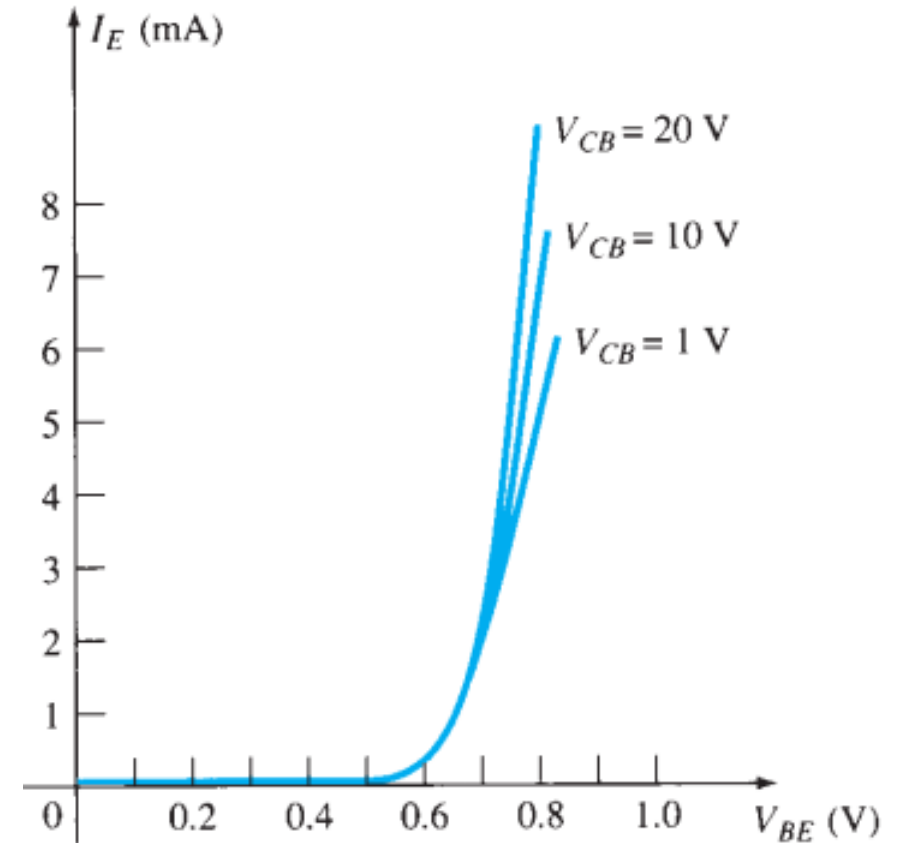


FIG. 3.7

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 $V_{CB} = 0V$

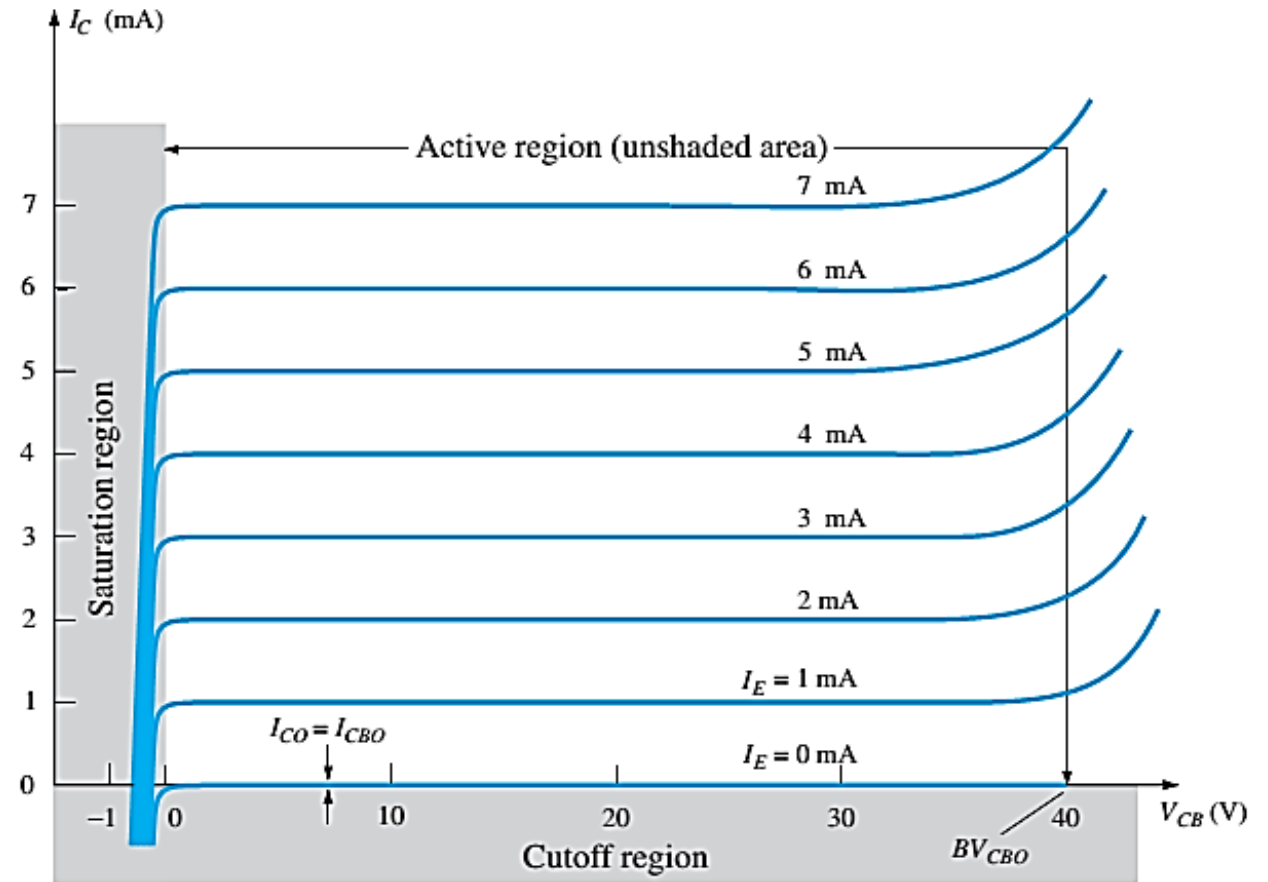


FIG. 3.8

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 forward 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

$$I_C \approx I_E$$

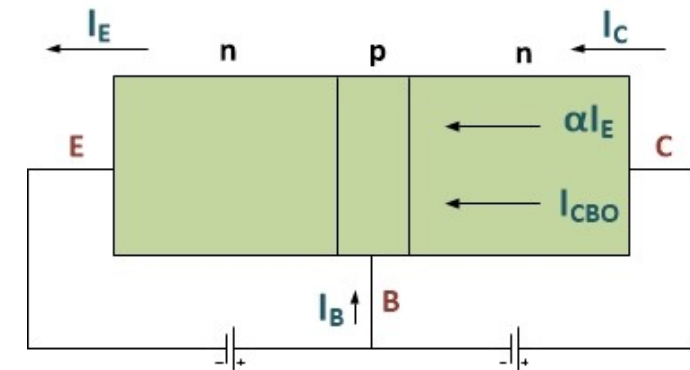
- Once a transistor is in the 'on' state, the base-emitter voltage will be assumed to be

$$V_{BE} = 0.7V$$

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

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

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



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 $0.9 \sim 0.998$.

Thank You