

# Electronic Devices

## Mid Term Lecture - 08

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Reference book:

**Electronic Devices and Circuit Theory (Chapter-3)**

Robert L. Boylestad and L. Nashelsky , (11<sup>th</sup> Edition)

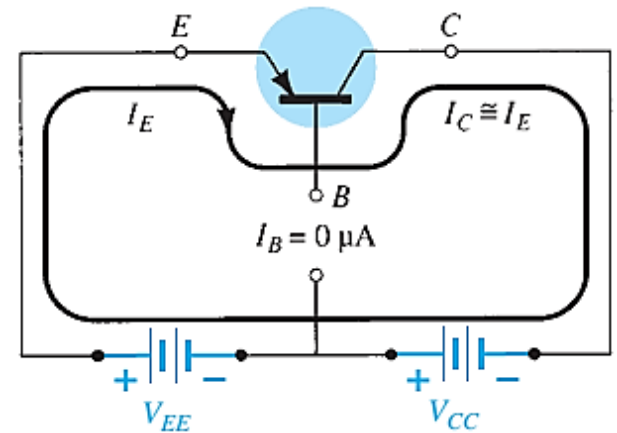


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# BIASING

- The proper biasing of the common-base configuration in the active region can be determined quickly using the approximation  $I_C \cong I_E$  and assuming for the moment that  $I_B \cong 0$  mA.
- The result is the configuration of Fig. 3.11 for the pnp transistor.
- For the npn transistor the polarities will be reversed.



**FIG. 3.11**

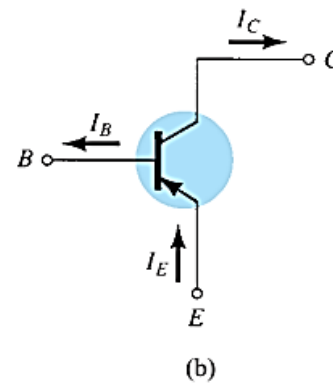
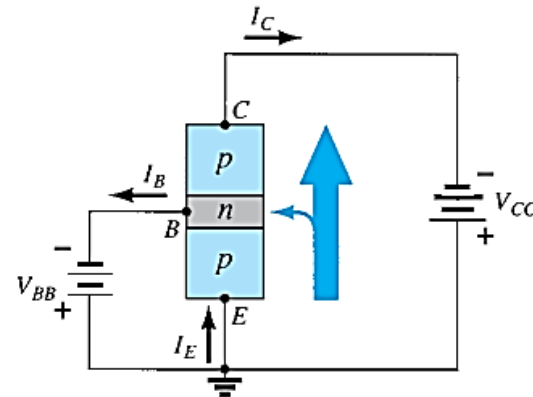
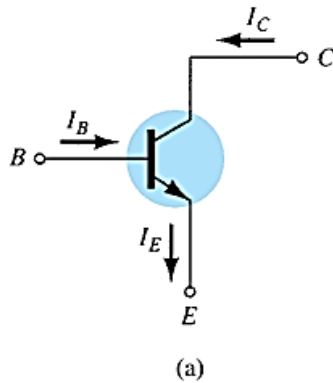
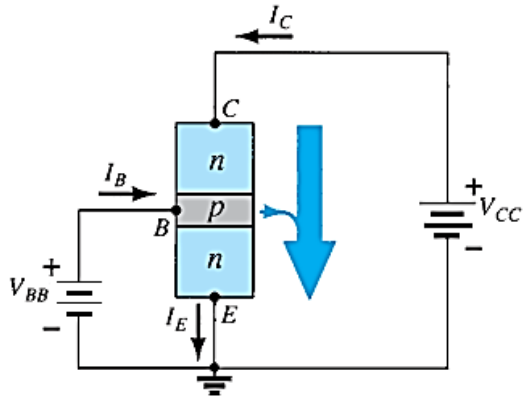
*Establishing the proper biasing management for a common-base pnp transistor in the active region.*

# COMMON-EMITTER CONFIGURATION

- It is called common-emitter configuration since :
  - emitter is common or reference to both input and output terminals.
  - emitter is usually the terminal closest to or at ground potential.
- Almost all amplifier design is using connection of CE due to the high gain for current and voltage.
- Two set of characteristics are necessary to describe the behavior for CE:
  - input (base terminal) and
  - output (collector terminal) parameters.



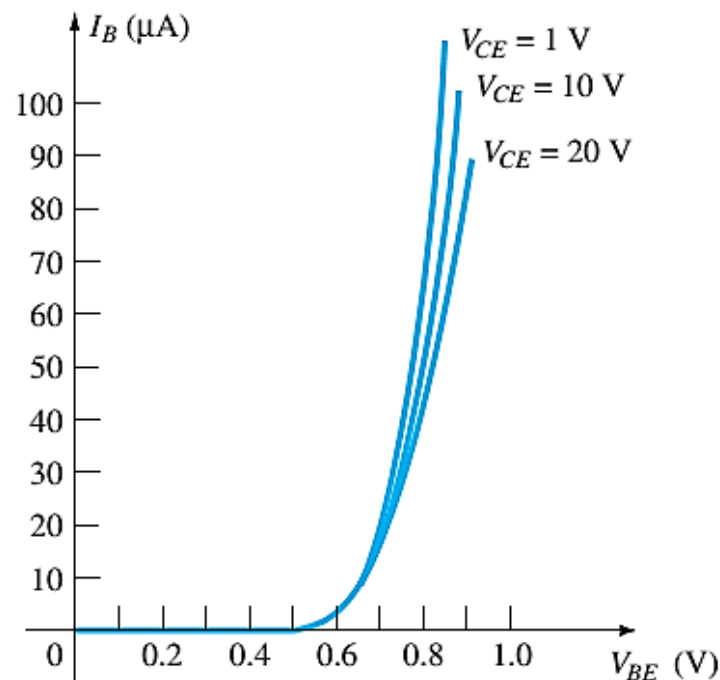
# COMMON-EMITTER CONFIGURATION



# COMMON-EMITTER CONFIGURATION

- $I_B$  is micro-amperes compared to milli-amperes of  $I_C$ .
- $I_B$  will flow when  $V_{BE} > 0.7V$  for silicon and  $0.3V$  for germanium
- Before this value  $I_B$  is very small.
- Base-emitter junction is forward bias
- Increasing  $V_{CE}$  will reduce  $I_B$  for different values.

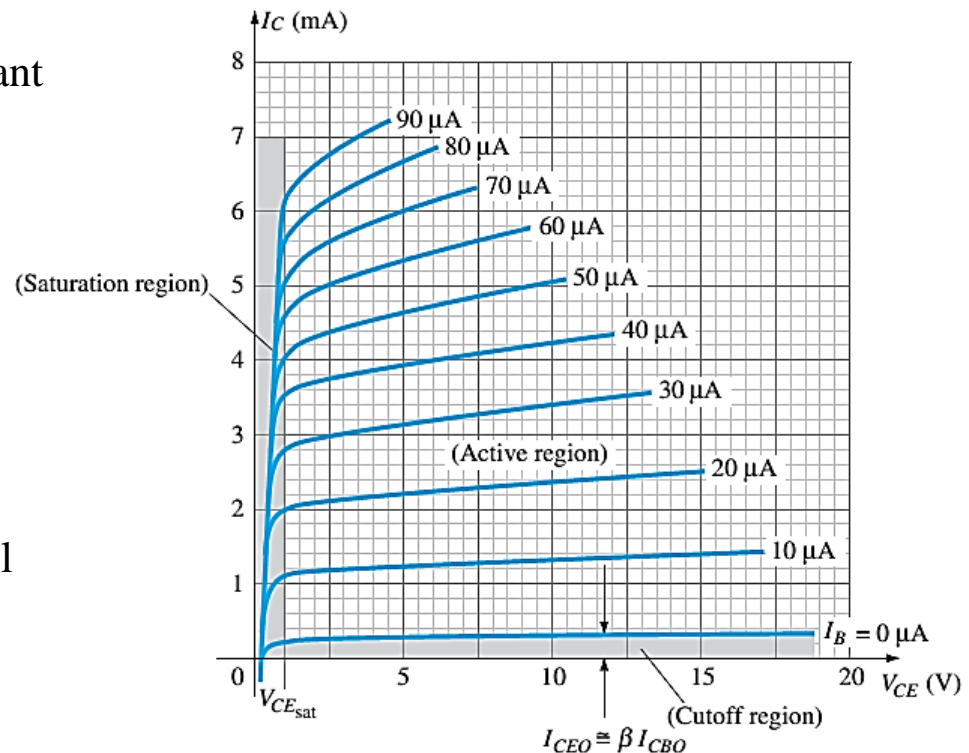
## Input characteristics for a common-emitter n-p-n transistor



# COMMON-EMITTER CONFIGURATION

- For small  $V_{CE}$  ( $V_{CE} < V_{CEsat}$ ,  $I_C$  increase linearly with increasing of  $V_{CE}$
- $V_{CE} > V_{CEsat}$ , Independent of  $V_{CE} \rightarrow$  constant  $I_C$
- $I_B(\mu A)$  is very small compare to  $I_C$  (mA). Small increase in  $I_B$  cause big increase in  $I_C$
- $I_B=0 A \rightarrow I_{CEO}$  occur.
- Noticing the value when  $I_B=0A$ . There is still some value of current flows.

## Output characteristics for a common-emitter n-p-n transistor



# COMMON-EMITTER CONFIGURATION

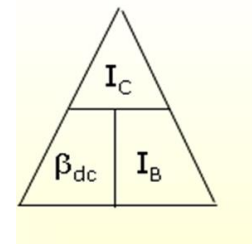
| ACTIVE REGION  | SATURATION REGION   | CUTOFF REGION  |
|--|---|--|
| BE junction is forward biased                                | BE and CB junctions are forward biased, thus the values of $I_B$ and $I_C$ is too big | Region below $I_B = 0 \mu A$ is to be avoided if an undistorted output signal is required                                  |
| CB junction is reverse biased                                | The value of $V_{CE}$ is too small  | BE junction and CB junctions are reverse biased  |
| Can be employed for voltage, current and power amplification | Suitable region when the transistor is used as a logic switch                         | $I_B = 0$ , $I_C$ not zero, during this condition $I_C = I_{CEO}$ where this is the current flow when BE is reverse biased |
|  | NOT and avoid this region when the transistor as an amplifier                         |  |



# BETA ( $\beta$ ) OR AMPLIFICATION FACTOR

- The ratio of dc collector current ( $I_C$ ) to the dc base current ( $I_B$ ) is dc beta ( $\beta_{dc}$ ) which is dc current gain where  $I_C$  and  $I_B$  are determined at a particular operating point, Q-point (quiescent point).
- It's defined by the following equation:

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



- On data sheet,  $\beta_{dc} = h_{FE}$  with h is derived from ac hybrid equivalent circuit. FE are derived from forward-current amplification and common-emitter configuration respectively.
- For ac conditions an ac beta has been defined as the changes of collector current ( $I_C$ ) compared to the changes of base current ( $I_B$ ) where  $I_C$  and  $I_B$  are determined at operating point.
- It can be defined by the following equation:

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





## RELATIONSHIP ANALYSIS BETWEEN $\alpha$ AND $\beta$

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  $I_E = I_C/\alpha$ . Substituting into

we have

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

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

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

or

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

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

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

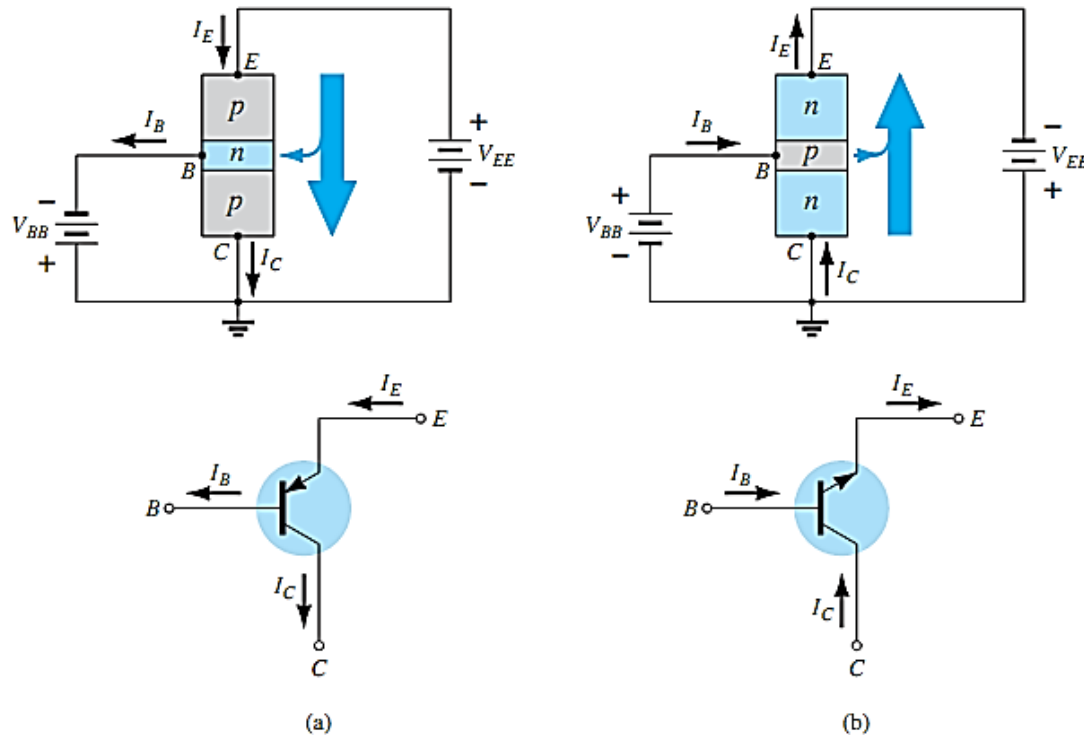


# COMMON-COLLECTOR CONFIGURATION

- Also called emitter-follower (EF).
- It is called common-emitter configuration since both the signal source and the load share the collector terminal as a common connection point.
- The output voltage is obtained at emitter terminal.
- The input characteristic of common-collector configuration is similar with common-emitter configuration.
- Common-collector circuit configuration is provided with the load resistor connected from emitter to ground.
- It is used primarily for impedance-matching purpose since it has high input impedance and low output impedance.



# COMMON-COLLECTOR CONFIGURATION



**FIG. 3.20**

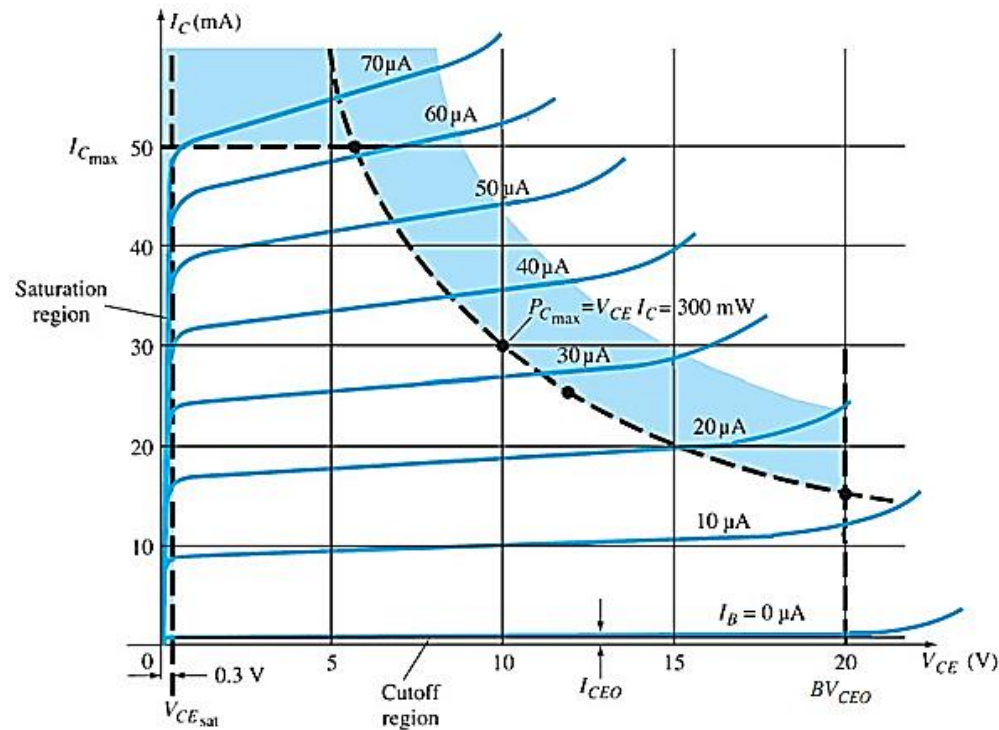
Notation and symbols used with the common-collector configuration: (a) pnp transistor; (b) npn transistor.

# LIMITS OF OPERATION

- Many BJT transistor used as an amplifier. Thus it is important to notice the limits of operations.
- At least 3 maximum values is mentioned in data sheet.
- There are:
  - a) Maximum power dissipation at collector:  $P_{Cmax}$  or  $P_D$
  - b) Maximum collector-emitter voltage:  $V_{CEmax}$  ;sometimes named as  $V_{(BR)CEO}$  or  $V_{CEO}$ .
  - c) Maximum collector current:  $I_{Cmax}$
- There are few rules that need to be followed for BJT transistor used as an amplifier. The rules are:
  - i. transistors need to operate in active region!
  - ii.  $I_C < I_{Cmax}$
  - iii.  $P_C < P_{Cmax}$



# LIMITS OF OPERATION



**FIG. 3.22**

*Defining the linear (undistorted) region of operation for a transistor.*

**Note:**  $V_{CE}$  is at maximum and  $I_C$  is at minimum ( $I_{Cmax}=I_{CEO}$ ) in the cutoff region.  $I_C$  is at maximum and  $V_{CE}$  is at minimum ( $V_{CEmax} = V_{CEsat} = V_{CEO}$ ) in the saturation region. The transistor operates in the active region between saturation and cutoff

# Thank You



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