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 , (11th Edition)

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.

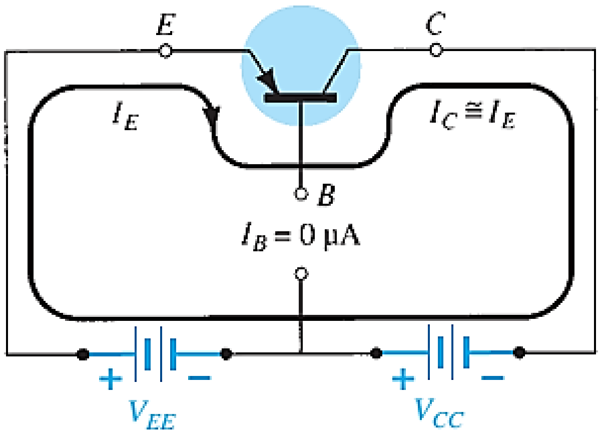


FIG. 3.11
Establishing the proper biasing management for a common-base pnp transistor in the active region.

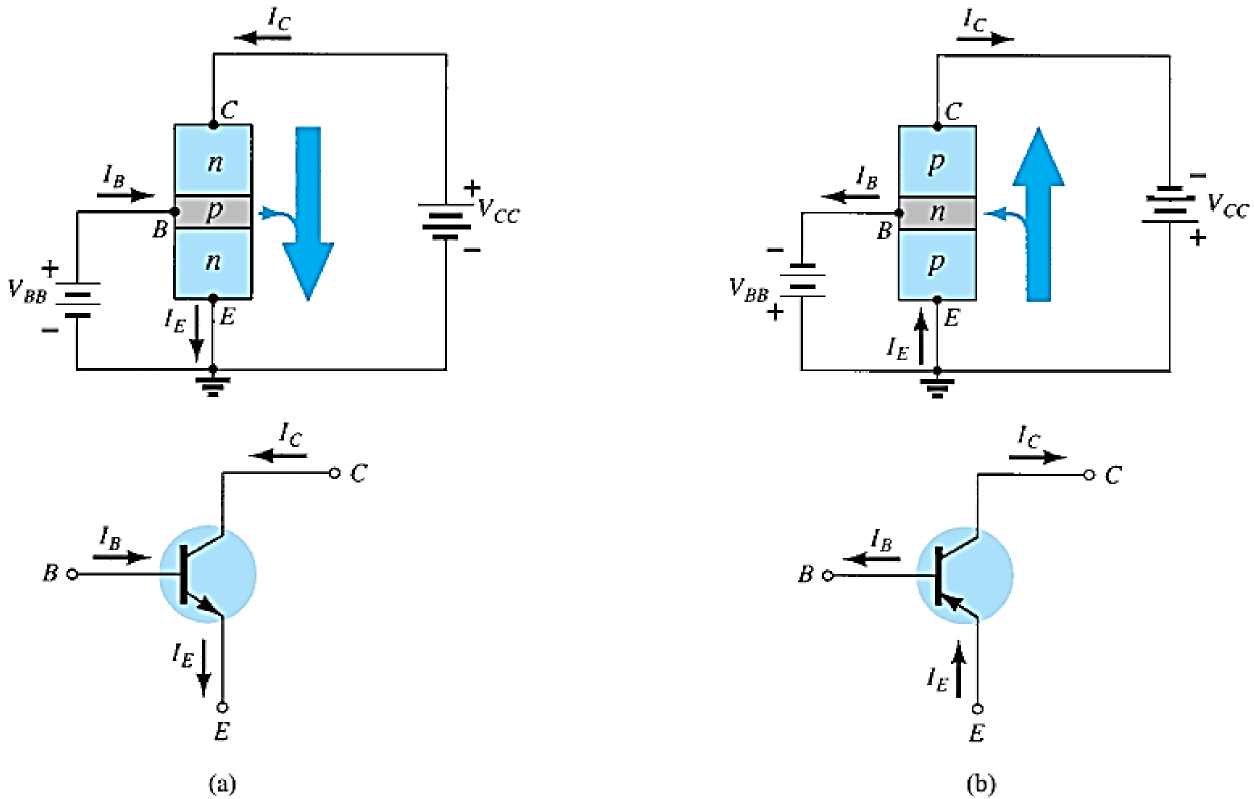
COMMON-EMITTER CONFIGURATION

- 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.

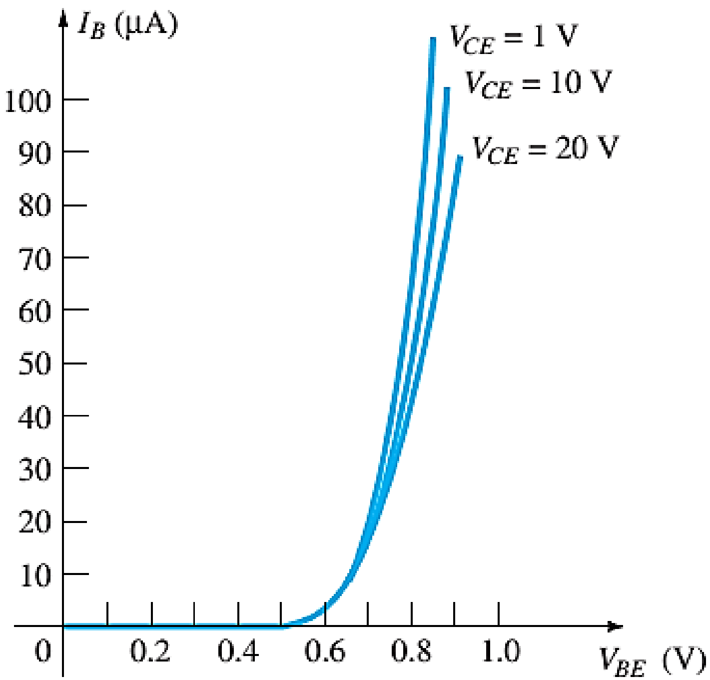
COMMON-EMITTER CONFIGURATION



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.

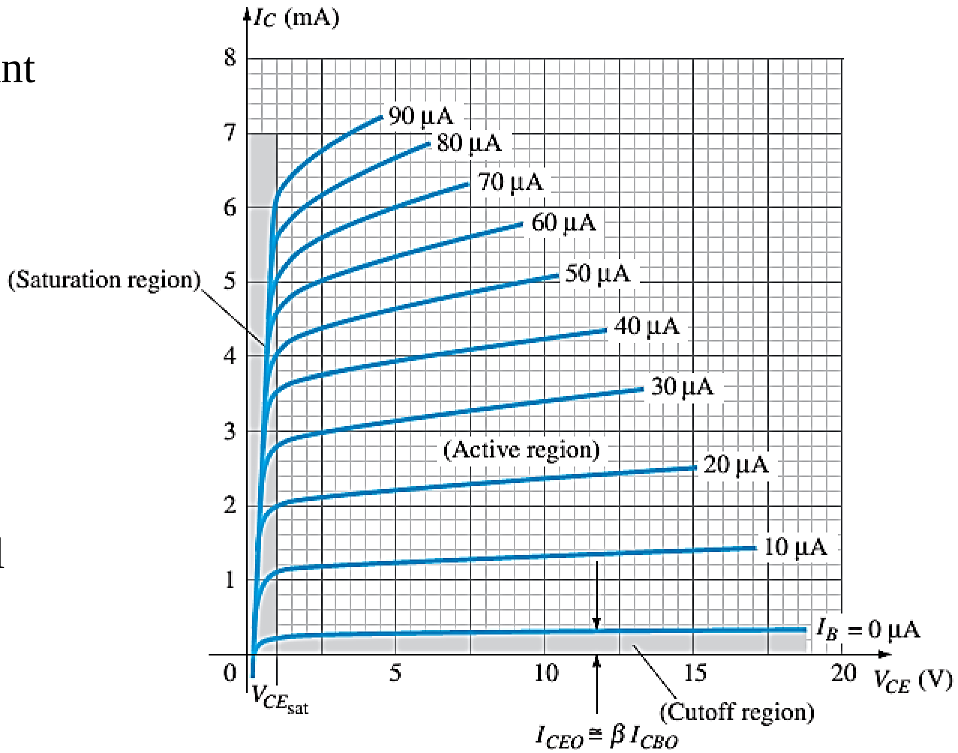
Input characteristics for a common-emitter n-p-n transistor



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} → constant I_C
- I_B(uA) is very small compare to I_C (mA). Small increase in I_B cause big increase in I_C
- I_B=0 A → 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



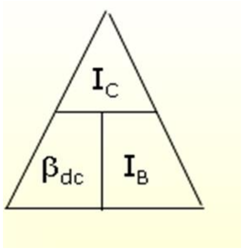
COMMON-EMITTER CONFIGURATION

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 $I_B = 0$ µA 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 e employed for voltage, current and power amplification	Suitable region when the transistor is used 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 (β) OR AMPLIFICATION FACTOR

- The ratio of dc collector current (I_C) to the dc base current (I_B) is dc beta (β_{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 α AND β

A relationship can be developed between β and α 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

$$I_E = I_C + I_B$$

we have

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

and dividing both sides of the equation by I_C results in

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

or

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

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

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

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

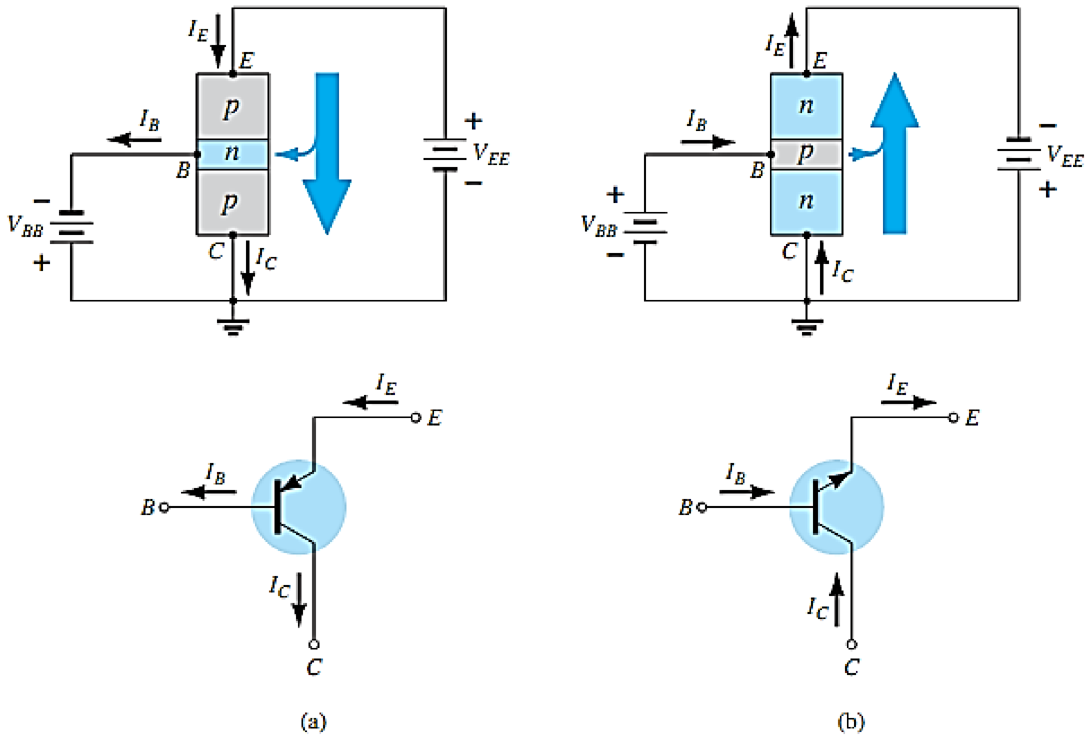


FIG. 3.20

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

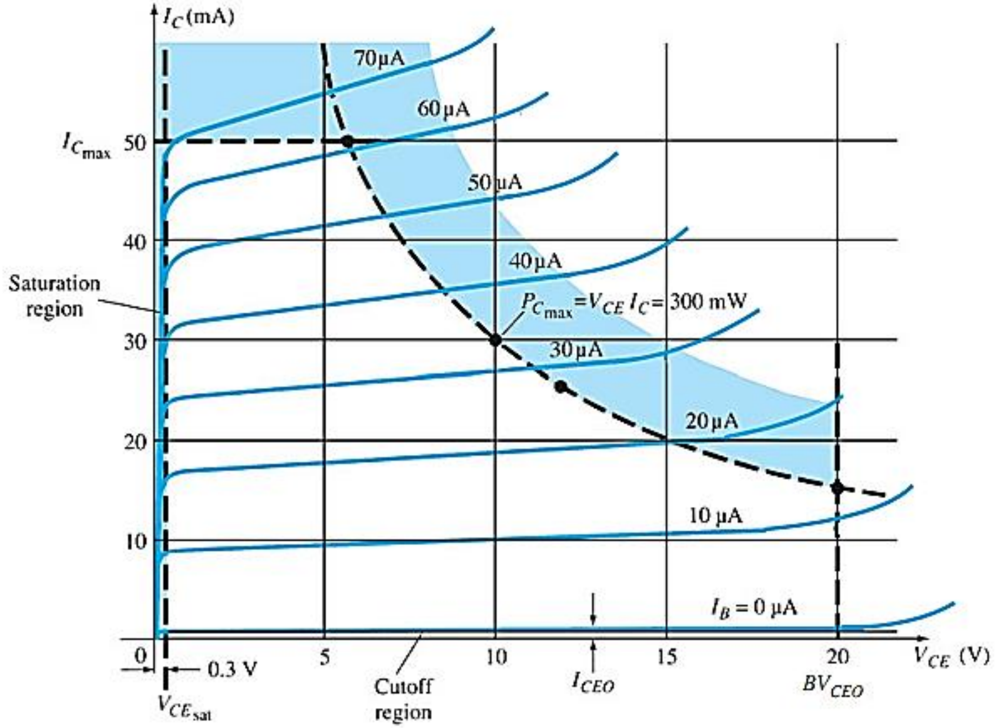


FIG. 3.22

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 ($V_{CE\ max}$ = V_{CEsat} = V_{CEO}) in the saturation region. The transistor operates in the active region between saturation and cutoff

Thank You