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 use as amplifier and logic switches.
- BJT consists of three terminal:
  - → collector : C
  - → base : B
  - → emitter : E
- Two types of BJT : pnp and npn

Transistor Construction

- 3 layer semiconductor device consisting:
  - 2 n- and 1 p-type layers of material → npn transistor
  - 2 p- and 1 n-type layers of material →pnp transistor
- The term bipolar reflects the fact that holes and electrons participate in the injection process into the oppositely polarized material
- A single pn junction has two different types of bias:
  - forward bias
  - reverse bias
- Thus, a two-pn-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

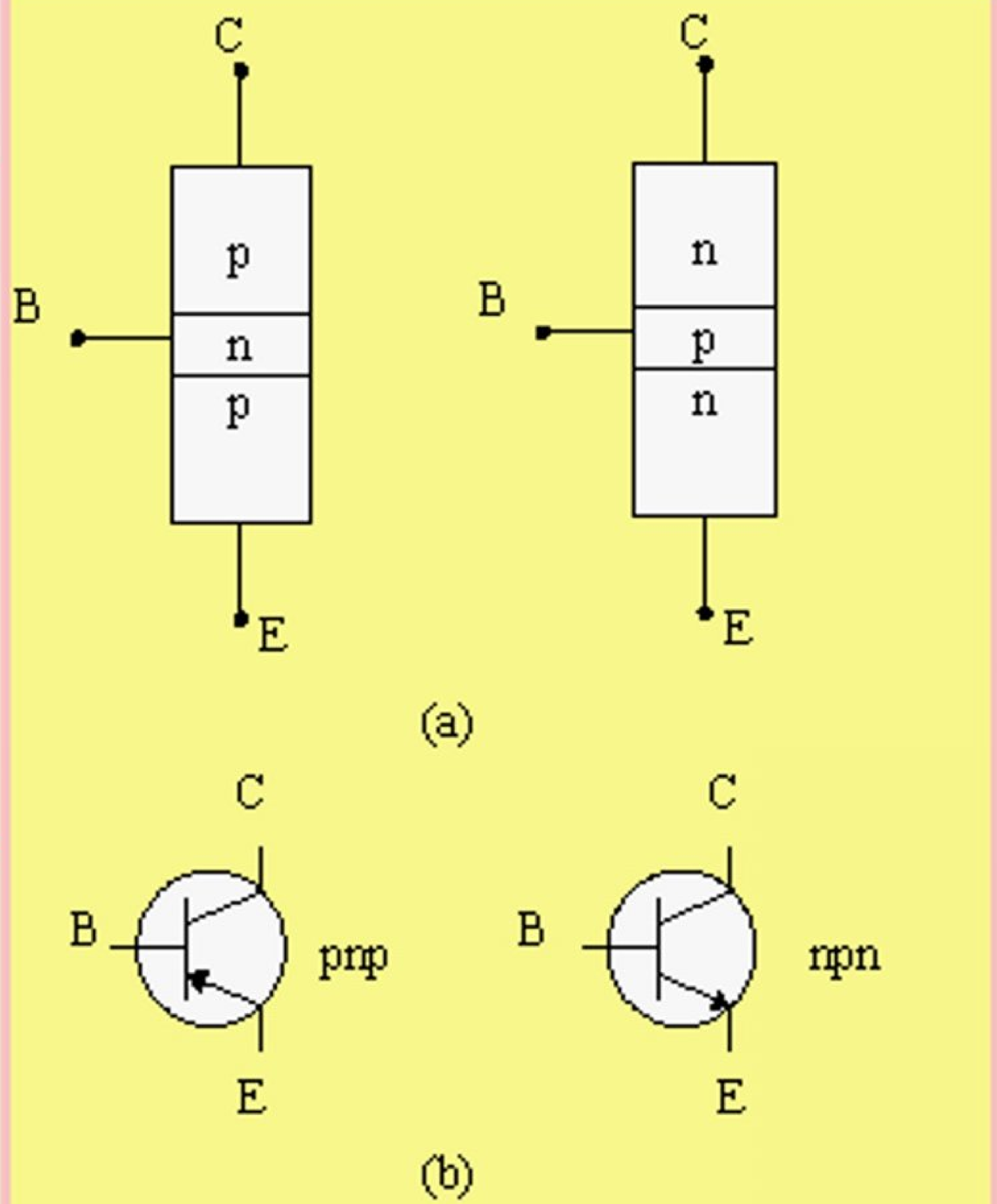


Fig. 4.1: (a) Position of terminals (b) Type of BJT

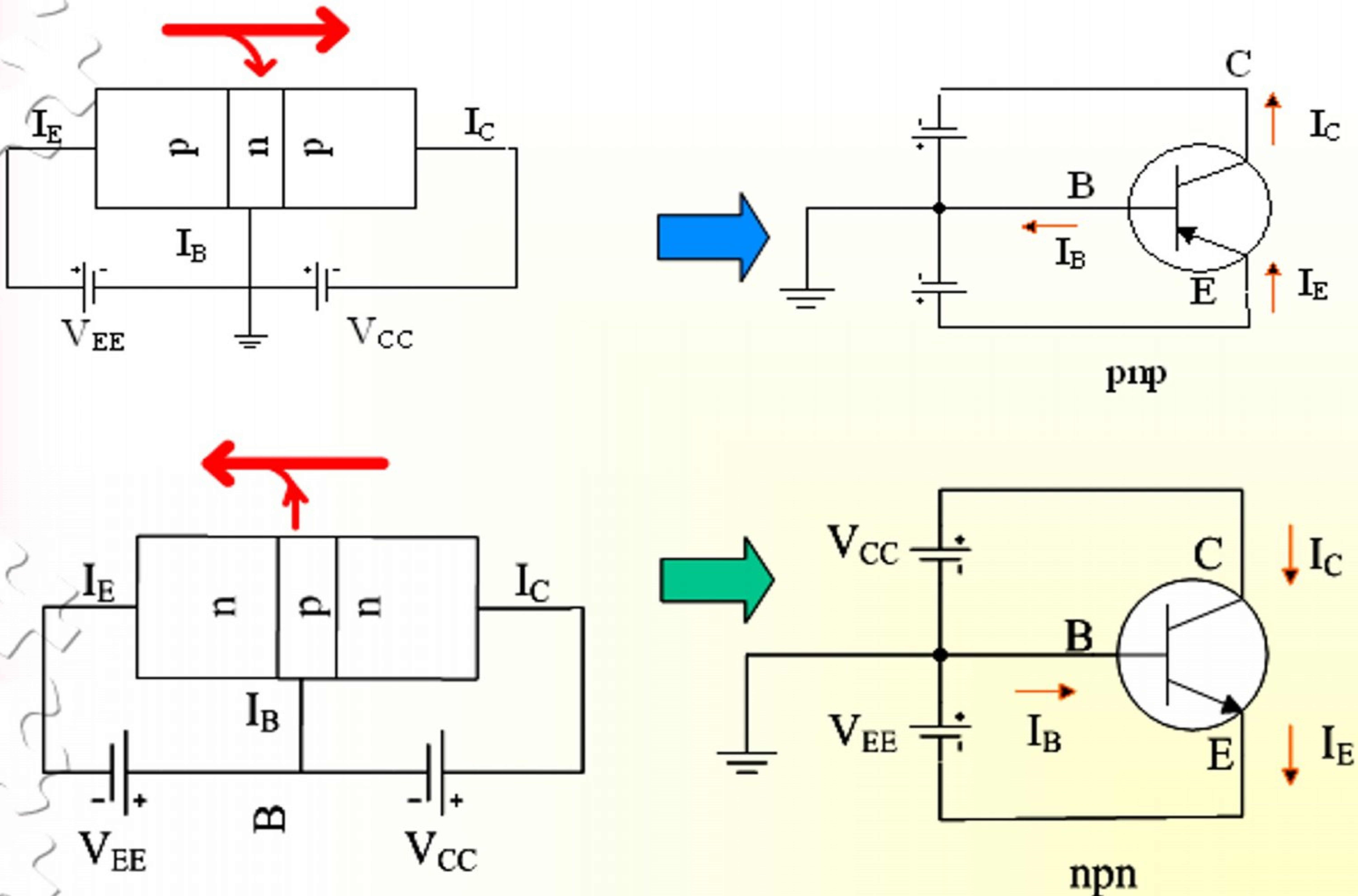
Common-Base Configuration

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

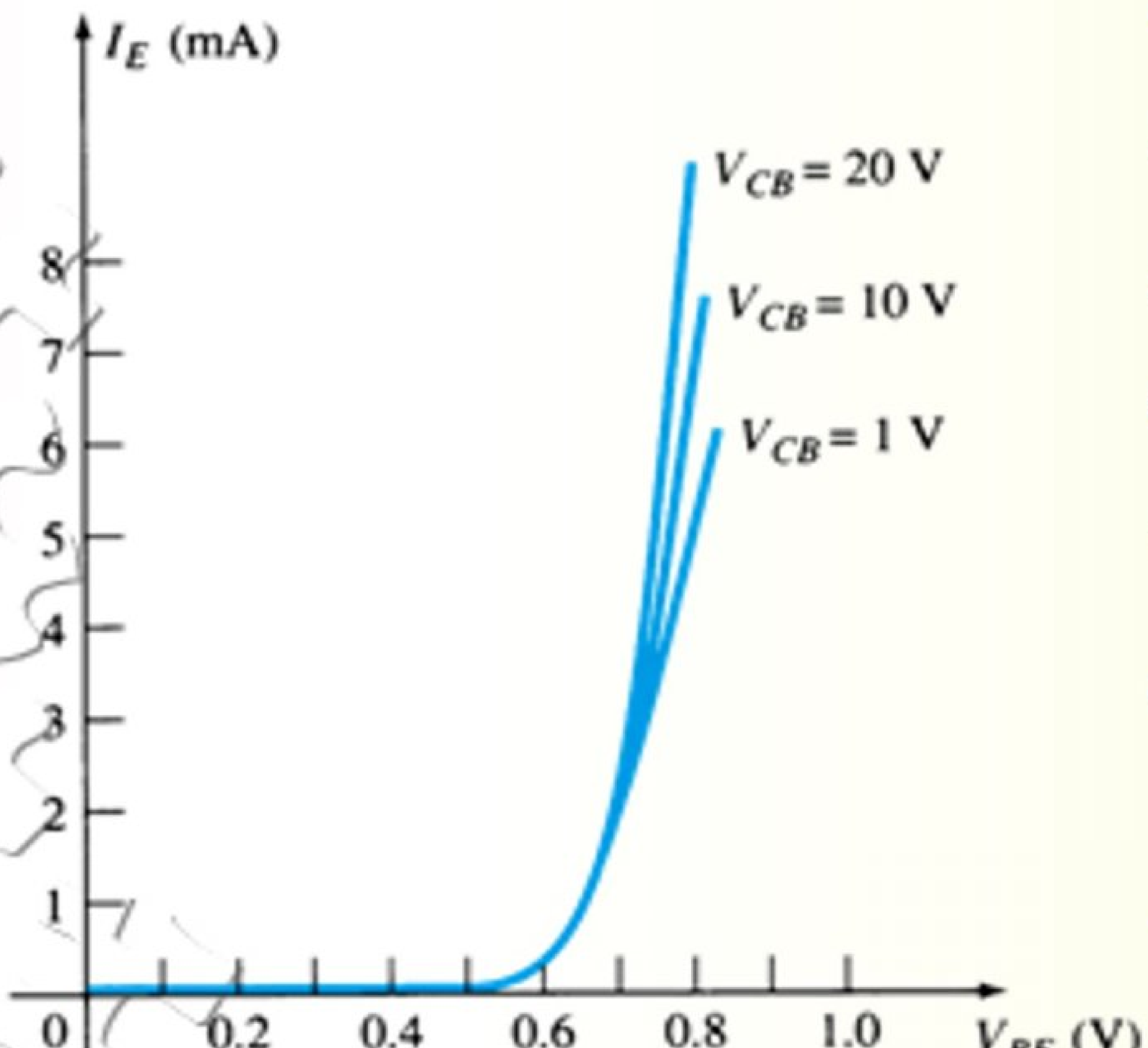
  - base is common to both input and output of the configuration.

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

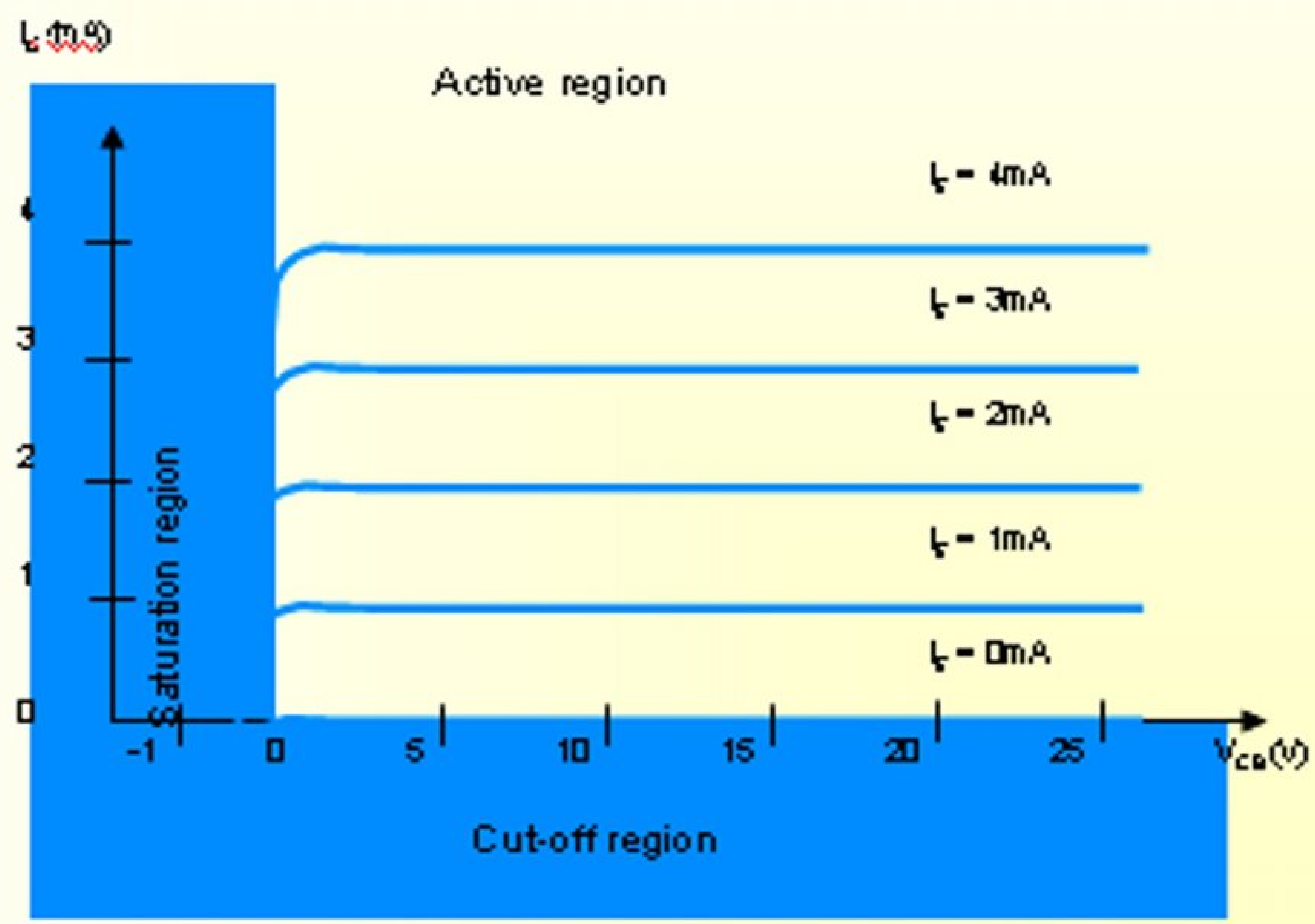
- All current directions will refer to conventional (hole) flow and the arrows in all electronic symbols have a direction defined by this convention.
- Note that the applied biasing (voltage sources) are such as to establish current in the direction indicated for each branch.


I_E
p
n
p
I_C
I_B
V_{EE}
V_{CC}
C
I_C
B
I_B
E
I_E
pnp
I_E
n
p
n
I_C
I_B
V_{EE}
B
V_{CC}
V_{CC}
C
I_C
B
V_{EE}
I_B
E
I_E
npn

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



Input characteristics for a common silicon transistor



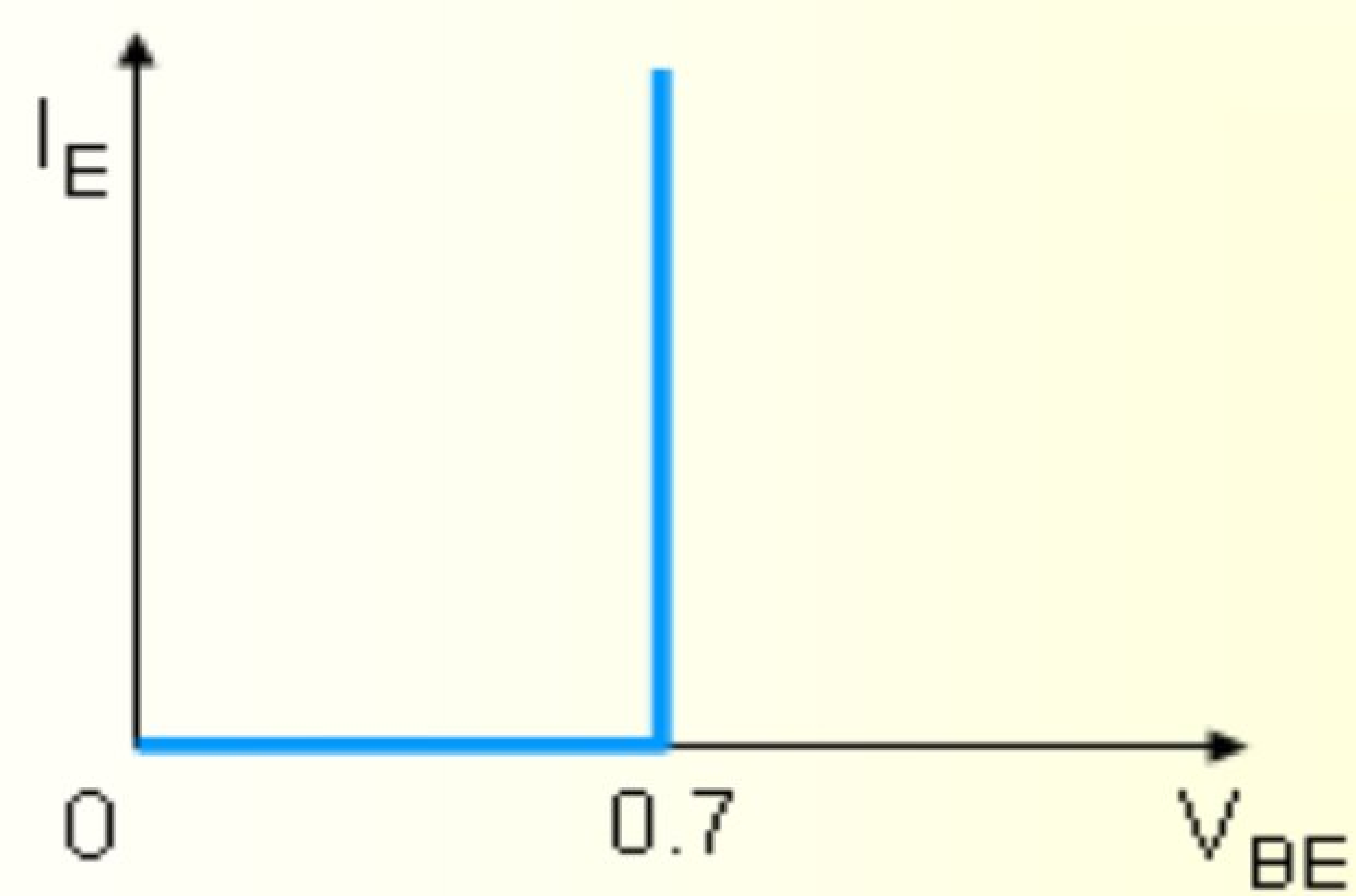
Output of collector characteristics for common-base transistor amplifier

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

$$I_C \approx IE$$

- 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

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

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

- It can then be summarize 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.

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 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.

Proper Biasing common-emitter configuration in active region

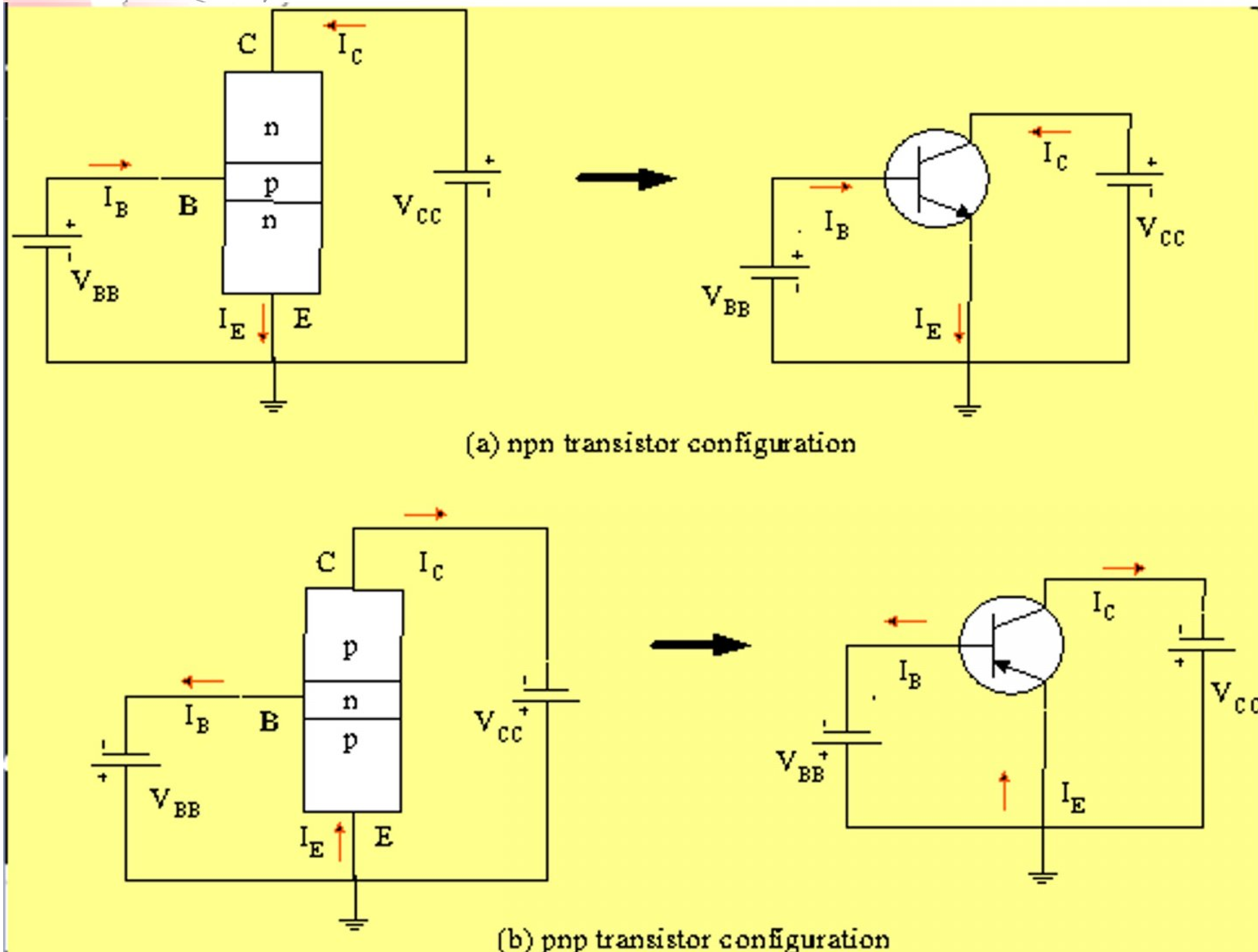
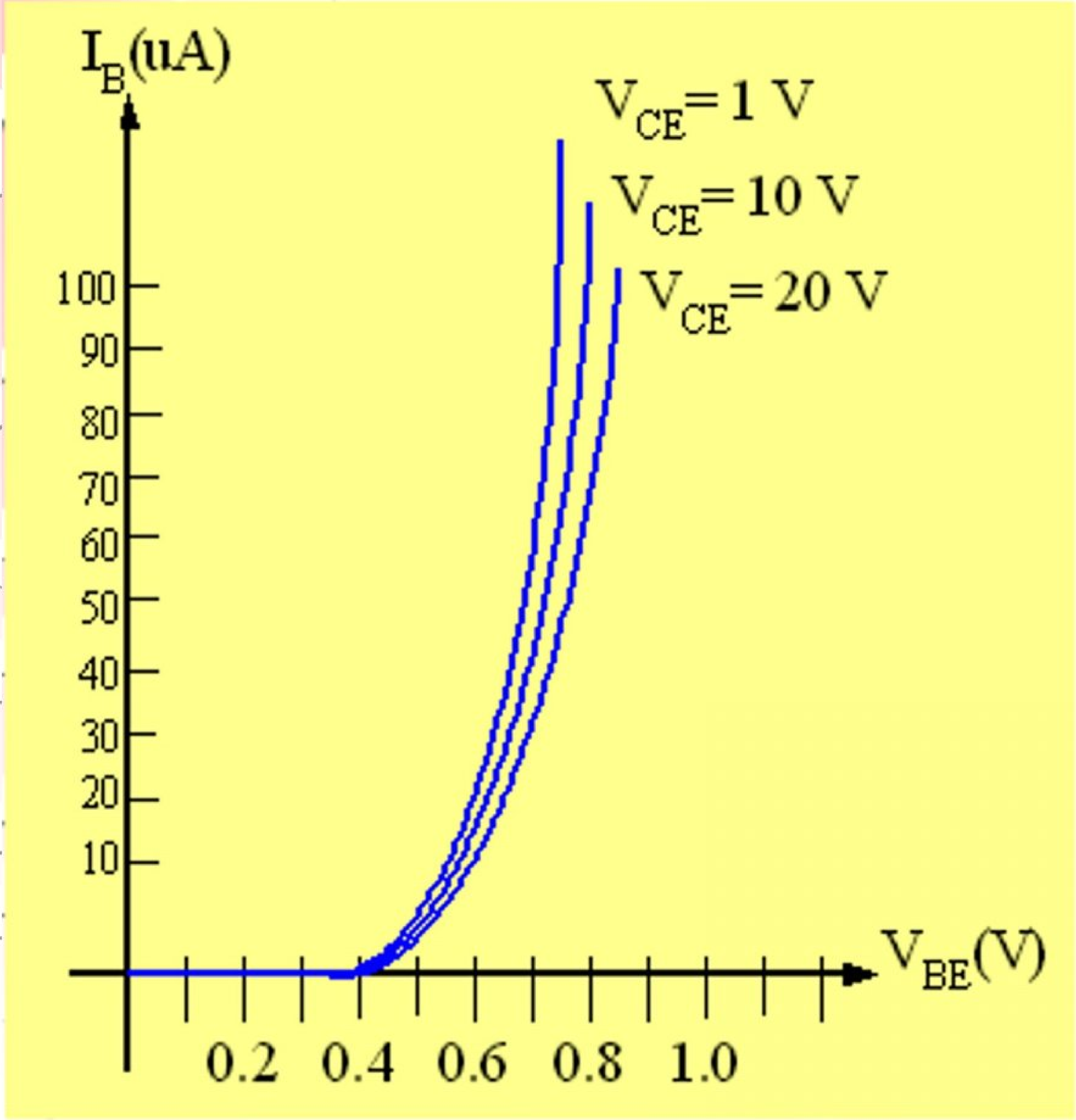


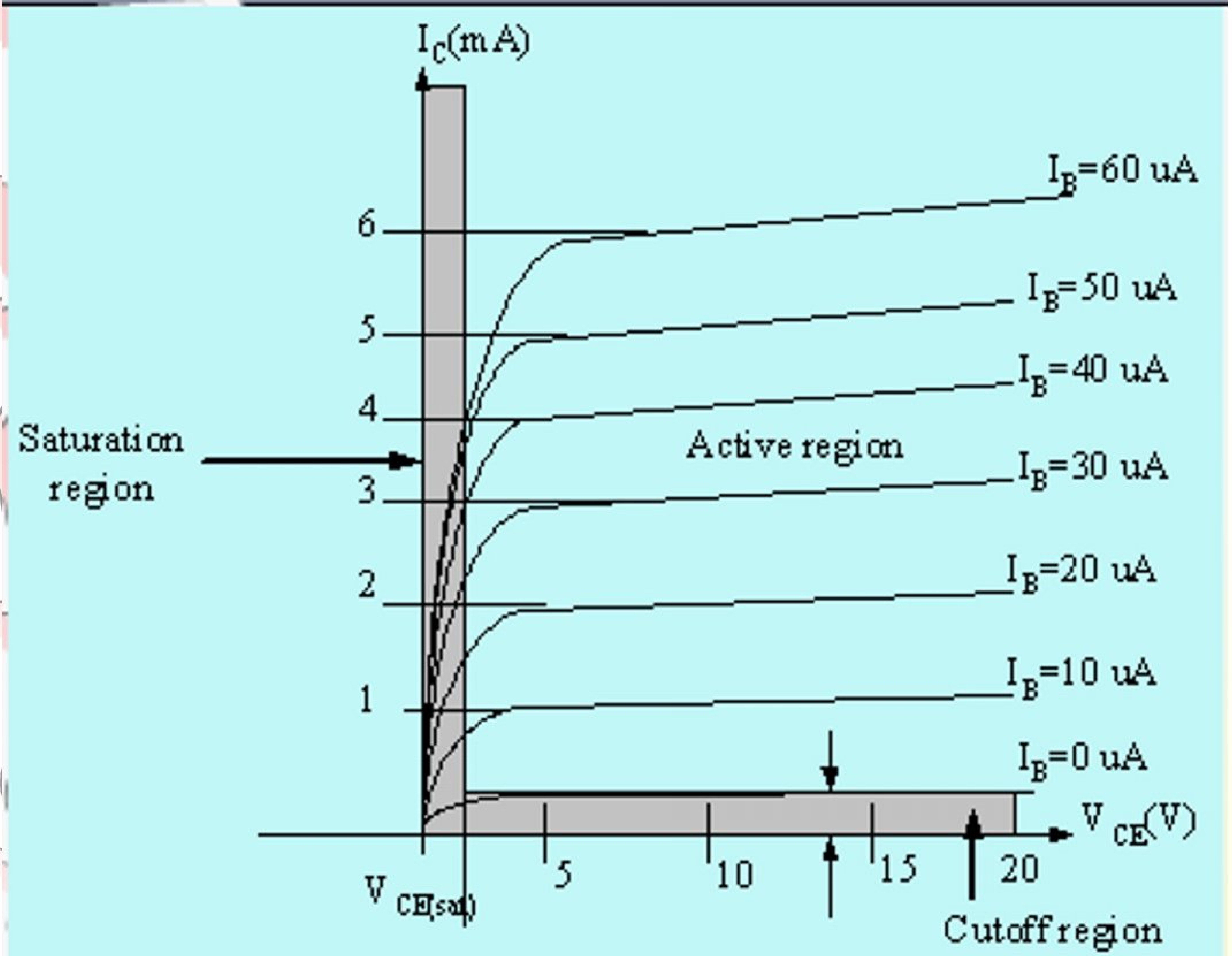
Fig 4.7 : Common-emitter configuration

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



Input characteristics for a common-emitter NPN transistor

- I_B is microamperes compared to miliamperes 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 and no I_B.
- Base-emitter junction is forward bias
- Increasing V_{CE} will reduce I_B for different values.



Output characteristics for a common-emitter npn transistor

- For small V_{CE} ($V_{CE} < V_{CESAT}$, I_C increase linearly with increasing of V_{CE}
- $V_{CE} > V_{CESAT}$ I_C not totally depends on 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_C=0A. There is still some value of current flows.

Relationship analysis between α and β

CASE 1

$$I_E = I_C + I_B \qquad (1)$$

subtitute equ. $I_C = \beta I_B$ into (1) we get

$$\underline{\underline{I_E = (\beta + 1) I_B}}$$

CASE 2

known $: \alpha = \dfrac{I_C}{I_E} \Rightarrow I_E = \dfrac{I_C}{\alpha} \qquad (2)$

known $: \beta = \dfrac{I_C}{I_B} \Rightarrow I_B = \dfrac{I_C}{\beta} \qquad (3)$

subtitute (2) and (3) into (1) we get,

$$\underline{\underline{\alpha = \frac{\beta}{\beta + 1}}} \qquad \text{and} \qquad \underline{\underline{\beta = \frac{\alpha}{1 - \alpha}}}$$

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.