AMPLIFIERS

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

Position of the terminals and symbol of BJT.

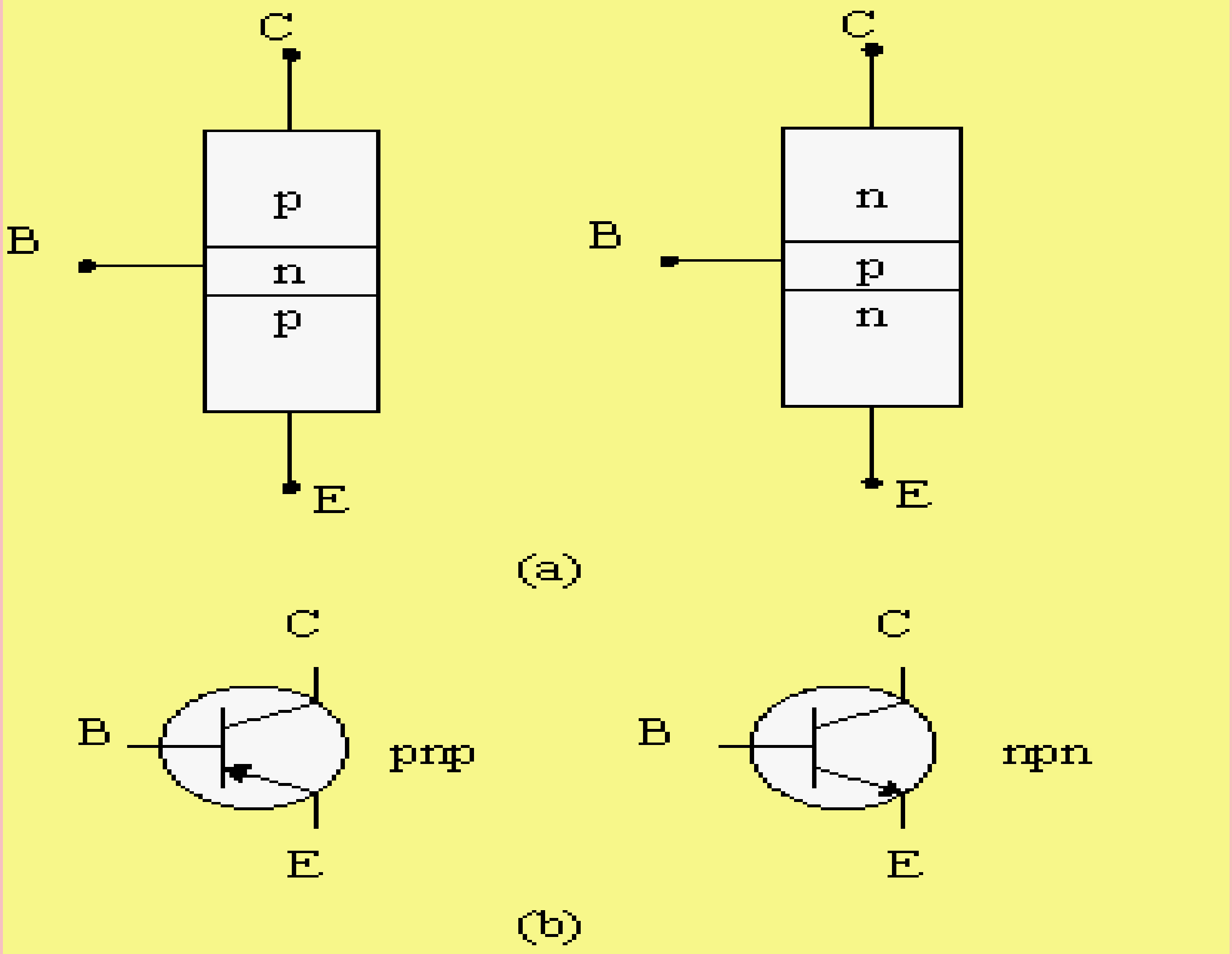
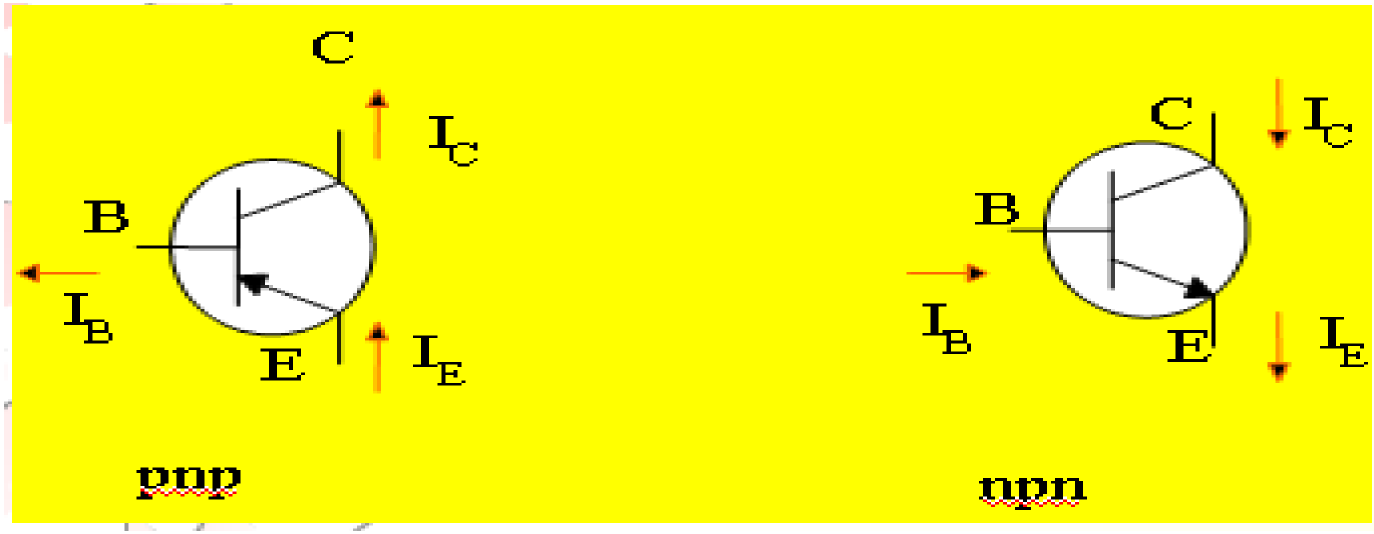


Fig. 4.1: (a) Position of terminals (b) Type of BJT

TRANSISTOR CURRENTS



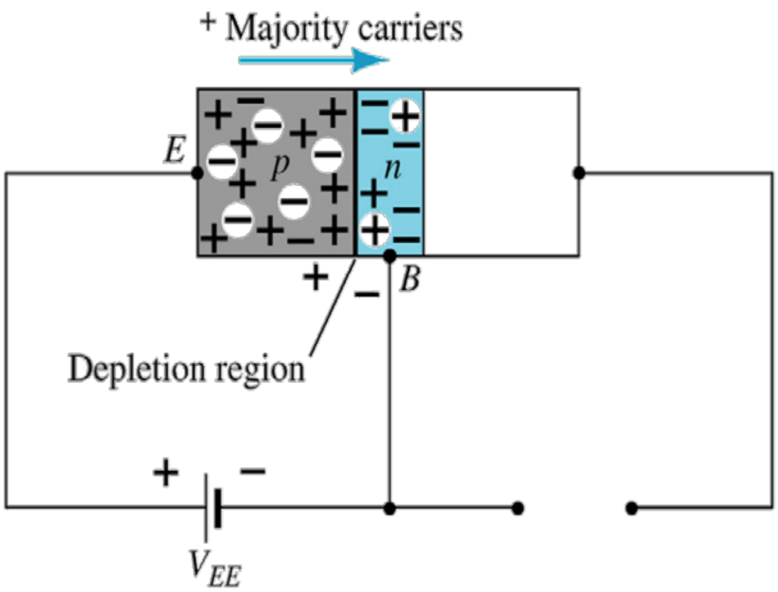
I_C=the collector current
I_B= the base current
I_E= the emitter current

-The arrow indicates the direction of the emitter current:

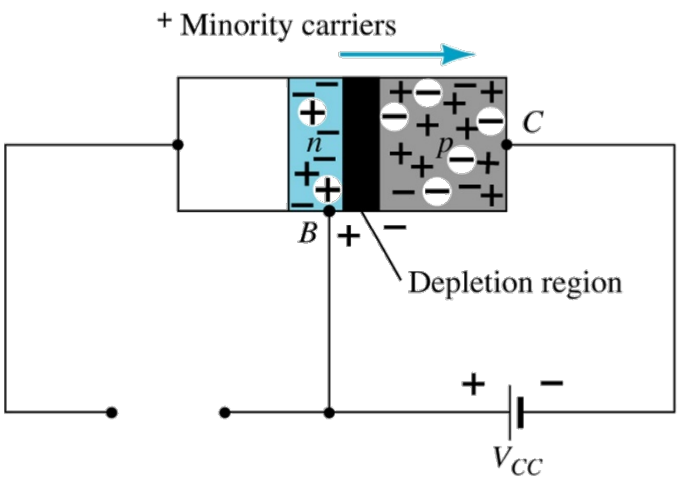
pnp:E→ B
npn: B→ E

TRANSISTOR OPERATION

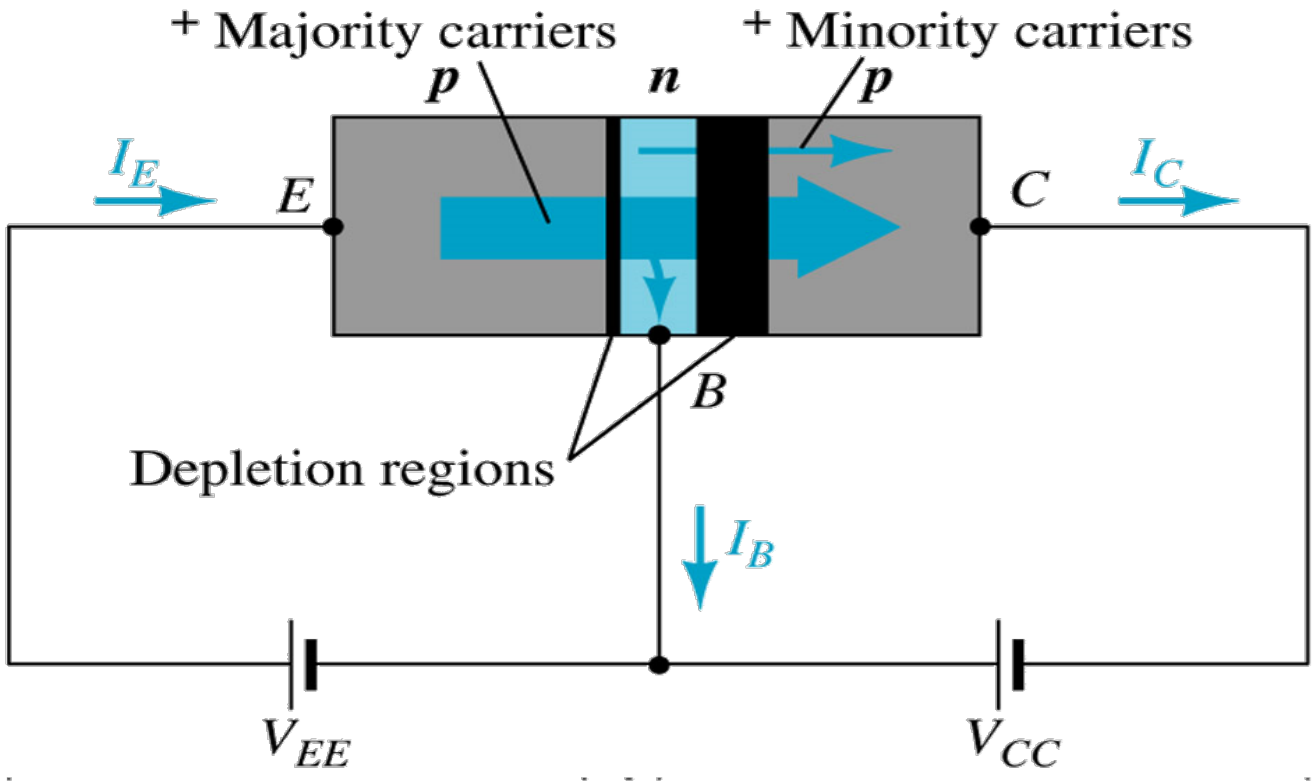
- One p-n junction of a transistor is reverse-biased, whereas the other is forward-biased.



Forward-biased junction of a pnp transistor



Reverse-biased junction of a pnp transistor



- **Both biasing potentials have been applied to a pnp transistor and resulting majority and minority carrier flows indicated.**

- 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 comprises of two components – the majority and minority carriers

$$I_C = I_{Cmajority} + I_{COminority}$$

I_{CO} – I_C current with emitter terminal open and is called leakage current.

ASSGINMENT QUESTION:

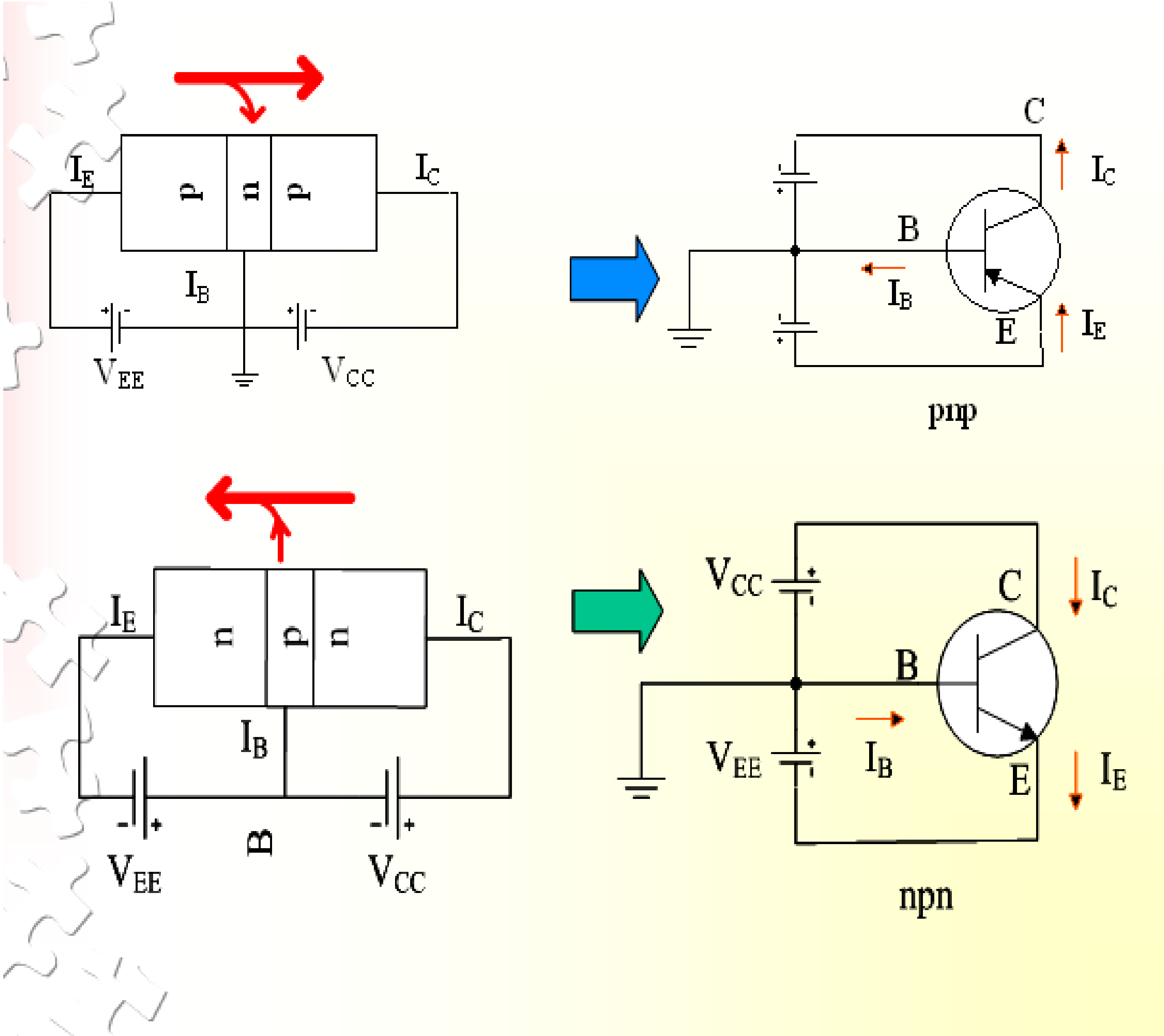
- Explain transistor as an amplifier.
- Why common emitter configuration is mostly used?

COMMON-BASE CONFIGURATION

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

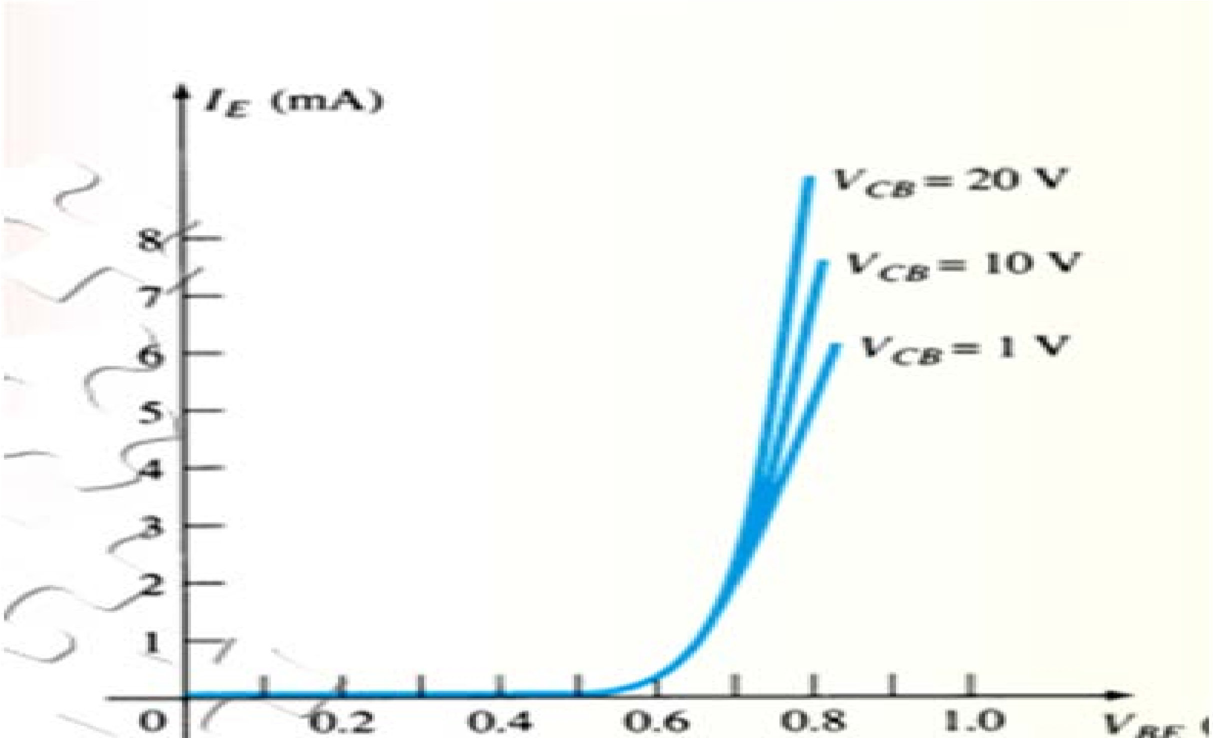
  - base is common to both input and output of the configuration.

- All current directions will refer to conventional (hole) flow and the arrows in all electronic symbols have a direction defined by this convention.



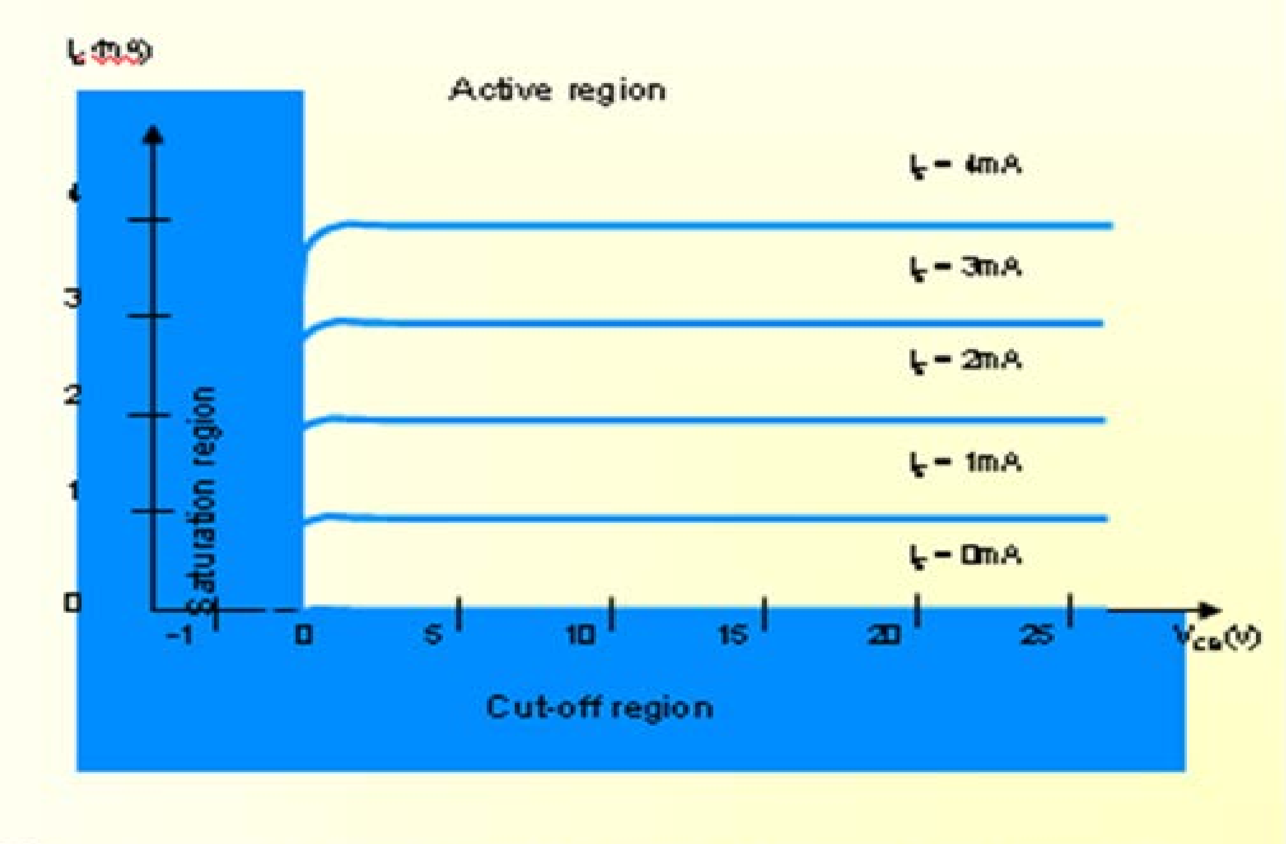
I_E
p
n
p
I_C
I_B
V_{EE}
V_{CC}
C
I_C
B
I_B
E
I_E
pnp
I_E
n
p
n
I_C
I_B
V_{EE}
B
V_{CC}
V_{CC}
C
I_C
B
I_B
V_{EE}
E
I_E
npn

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



Input characteristics for a common silicon transistor

The output characteristics has 3 basic regions:



(V) Output of collector characteristics for common-base transistor amplifier

Active region	Saturation region	Cut-off region
• I_E increased, I_C increased • BE junction forward bias and CB junction reverse bias • Refer to the graf, $I_C \approx I_E$ • I_C not depends on V_{CB} • Suitable region for the transistor working as amplifier	• BE and CB junction is forward bias • Small changes in V_{CB} will cause big different to I_C • The allocation for this region is to the left of V_{CB}= 0 V.	• Region below the line of I_E=0 A • BE and CB is reverse bias • no current flow at collector, only leakage current

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

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

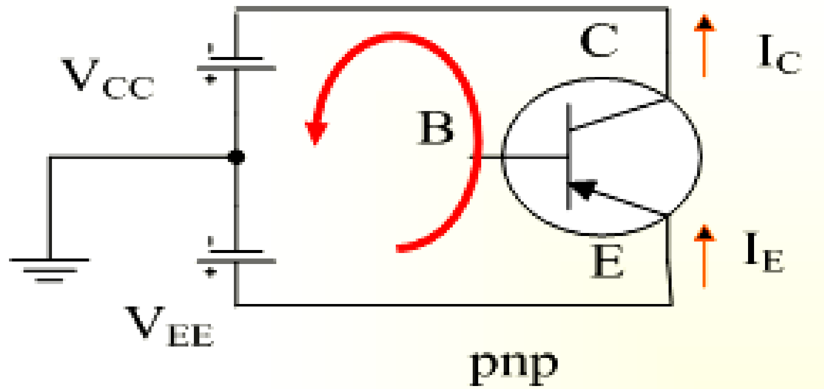
$$I_C = \alpha I_E + I_{CBO}$$

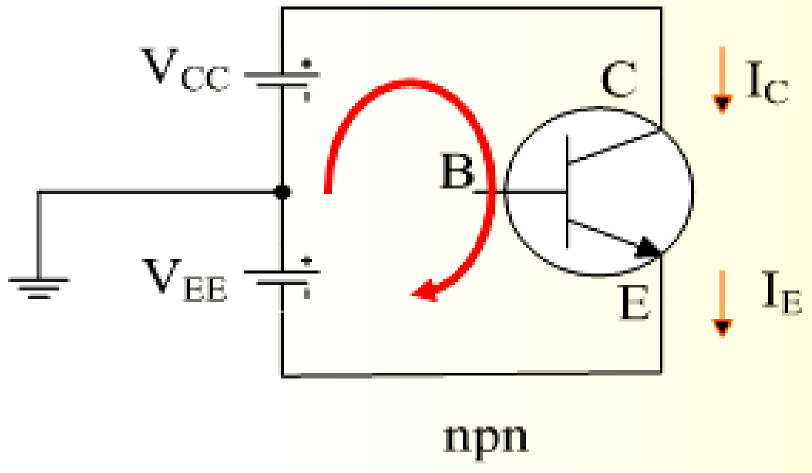
- It can then be summarize to $I_C = \alpha I_E$ (ignore I_{CBO} due to small value)
- For ac situations where the point of operation moves on the characteristics curve, an ac alpha defined by

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

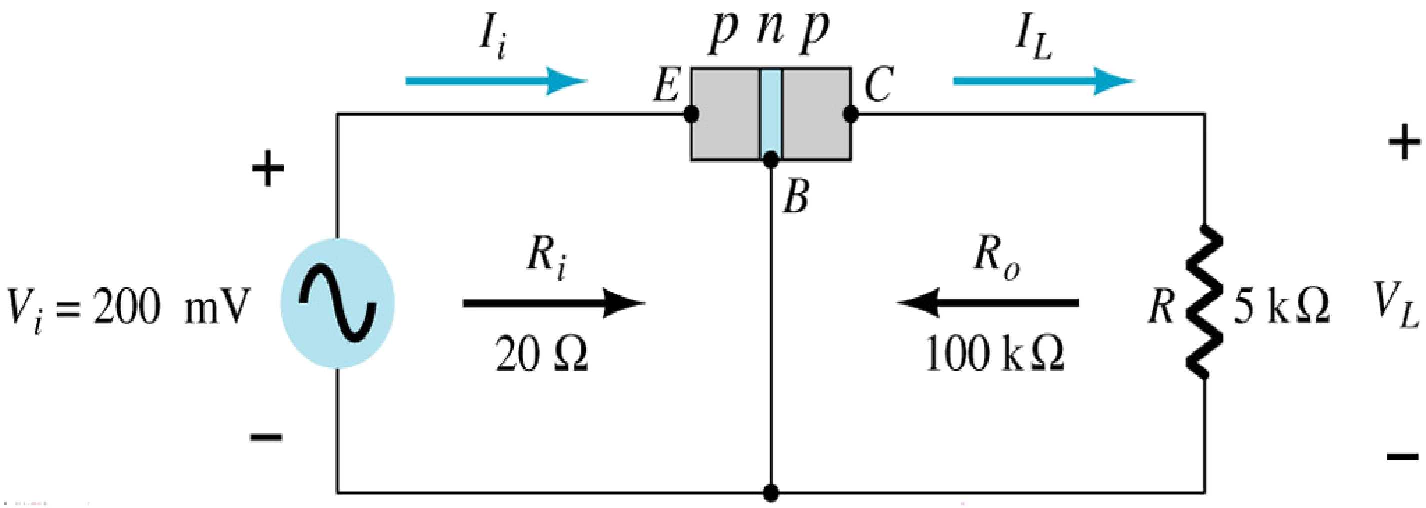
BIASING

- Proper biasing CB configuration in active region by approximation $I_C \approx I_E$ ($I_B \approx 0$ uA)





TRANSISTOR AS AN AMPLIFIER



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**

Proper Biasing common-emitter configuration in active region

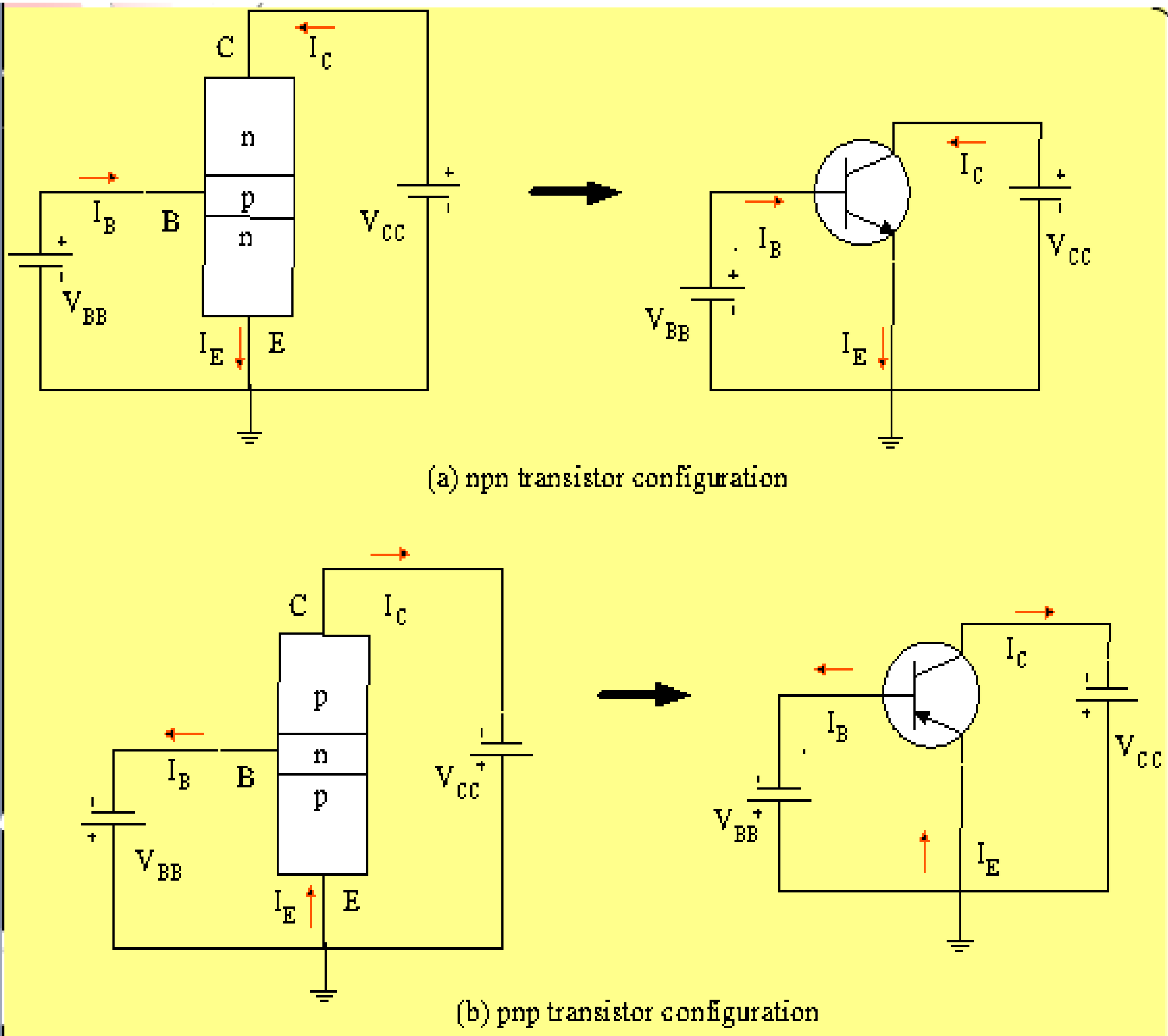
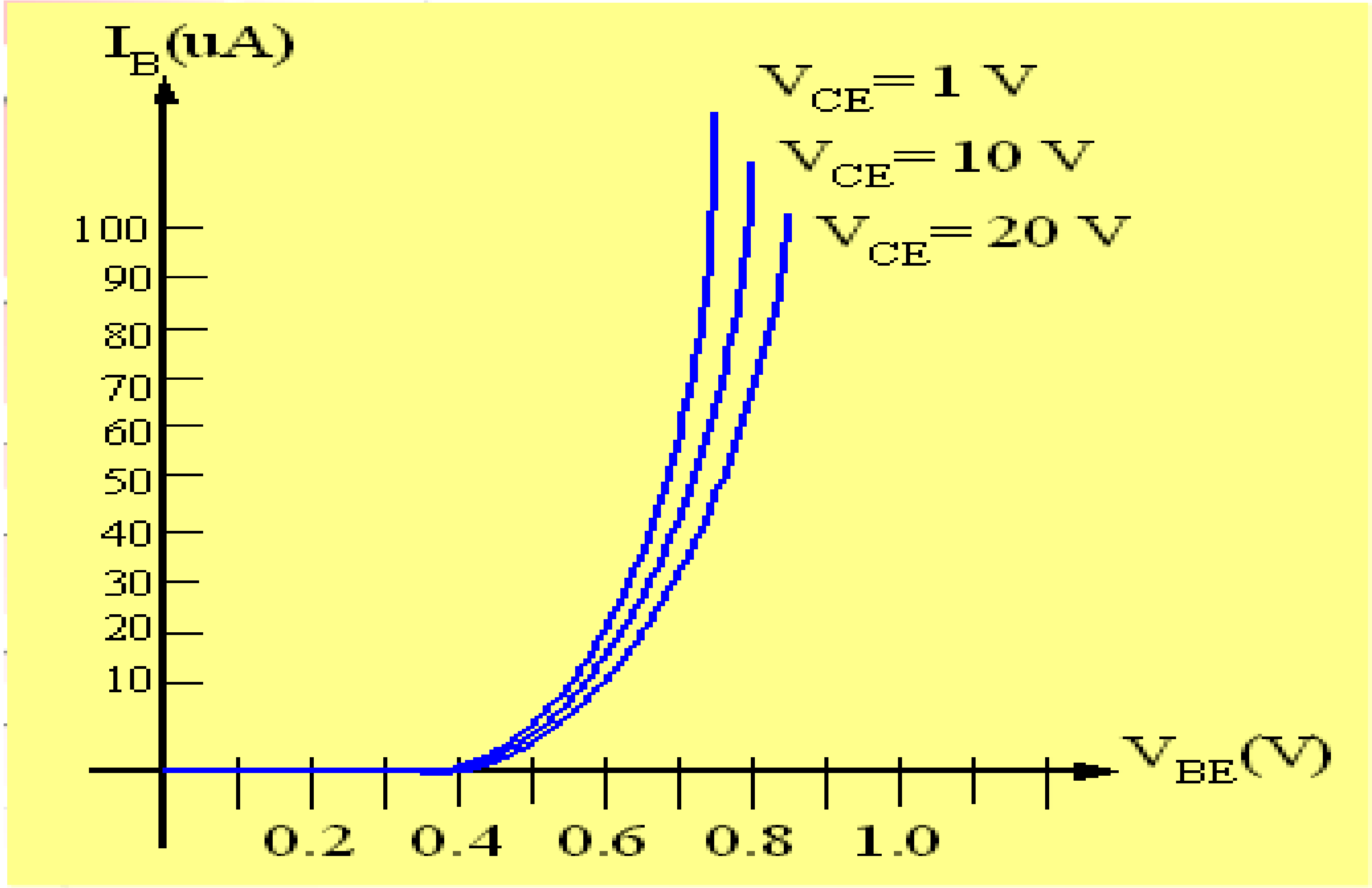


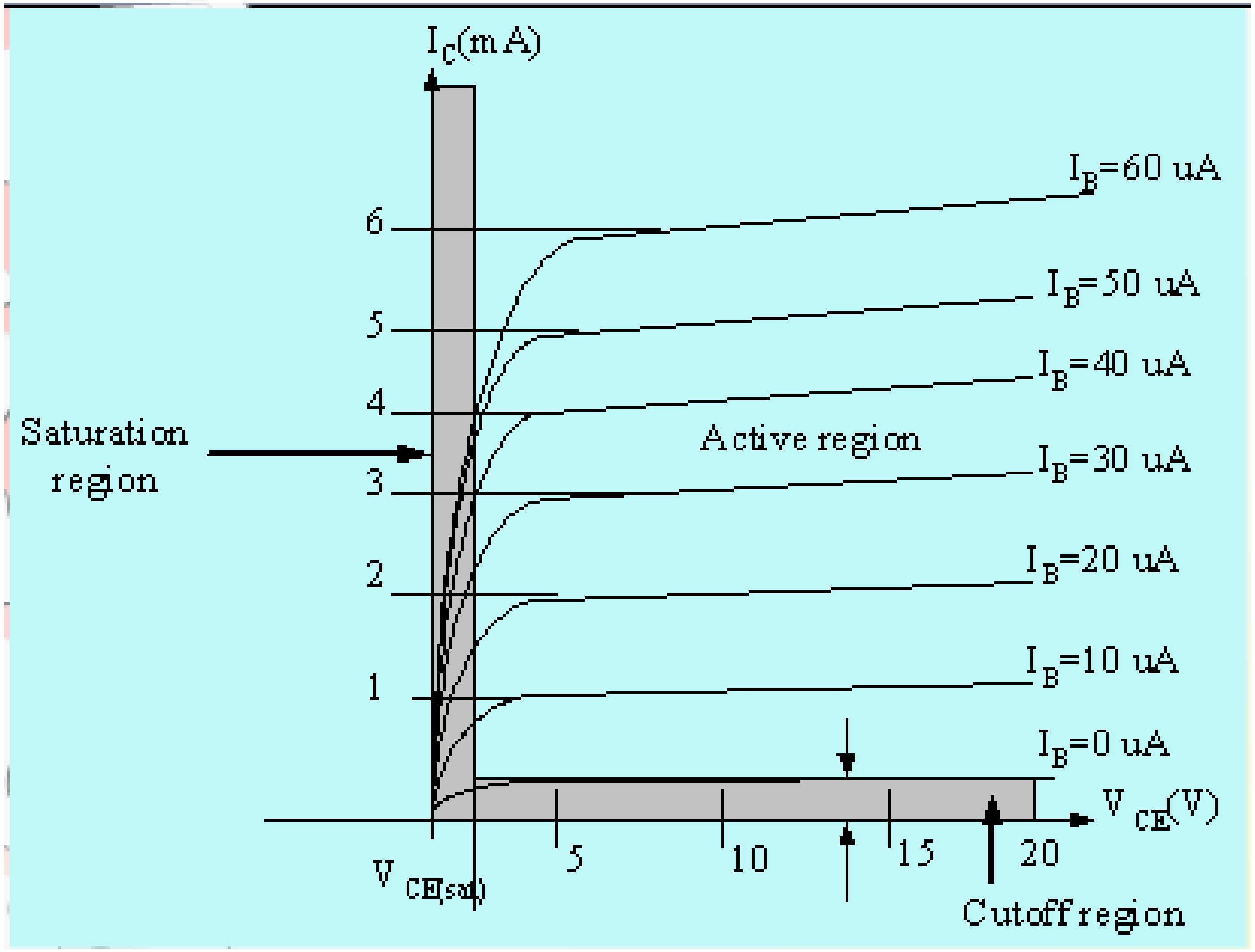
Fig 4.7 : Common-emitter configuration

$$I_E = I_C + I_B$$



Input characteristics for a common-emitter NPN transistor

Output characteristics for a common-emitter npn transistor



RELATIONSHIP ANALYSIS BETWEEN A AND B

CASE 1

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

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

$$I_E = (\beta + 1) I_B$$

CASE 2

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

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

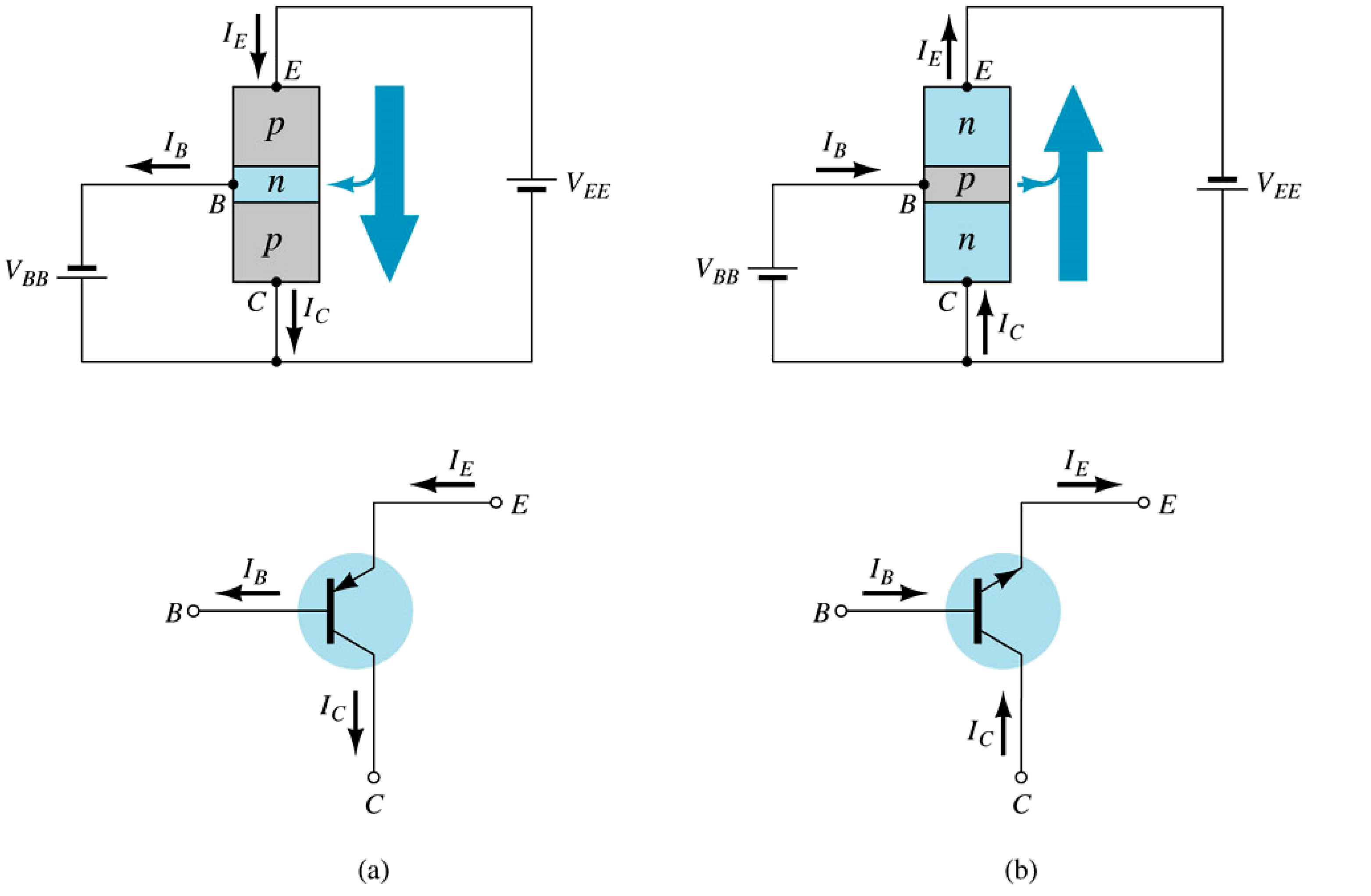
subtitute (2) and (3) into (1) we get,

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

COMMON – COLLECTOR CONFIGURATION

- 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.



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

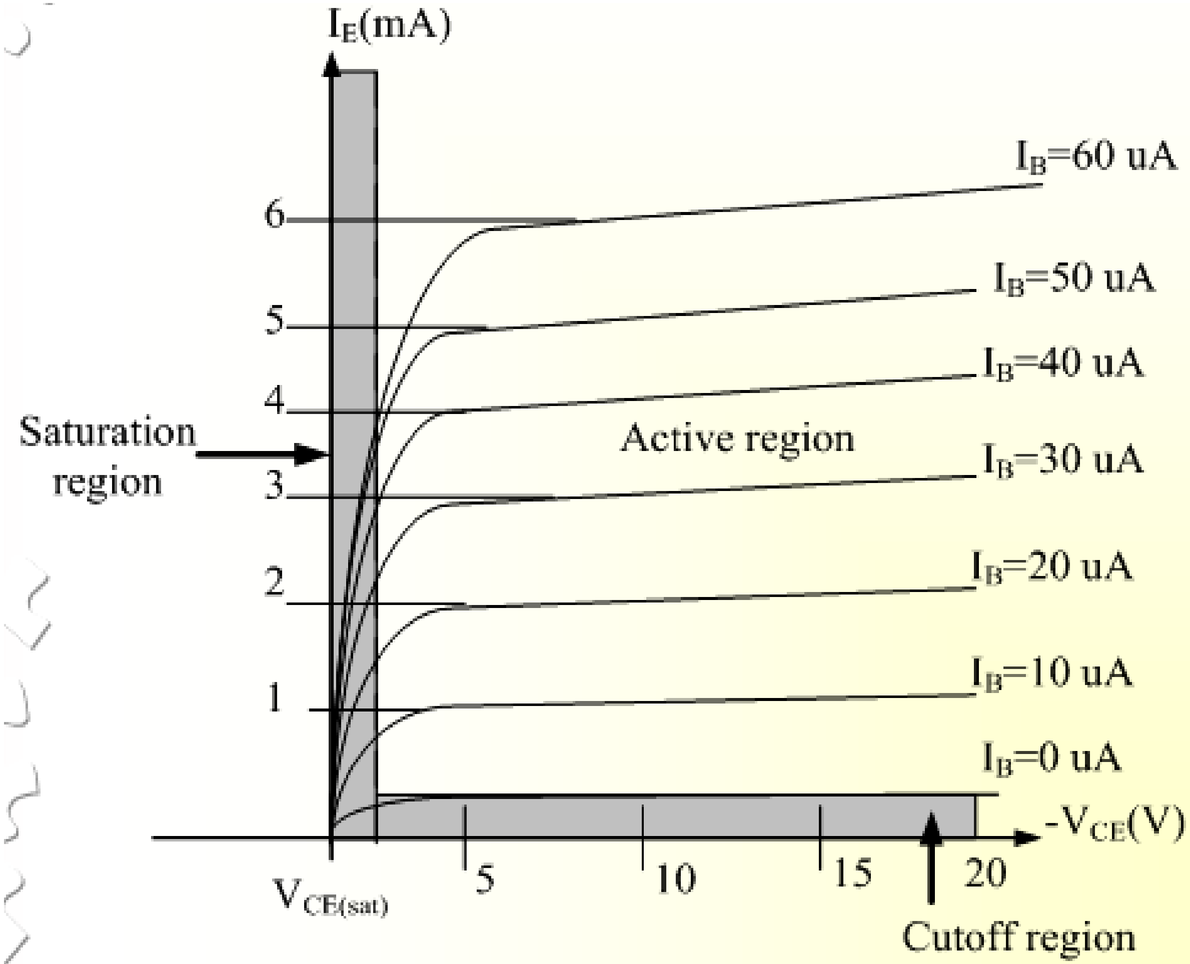
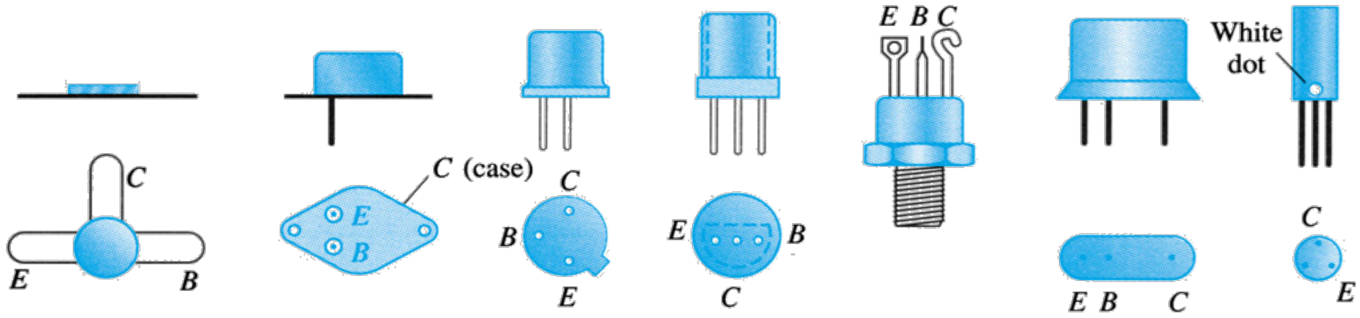
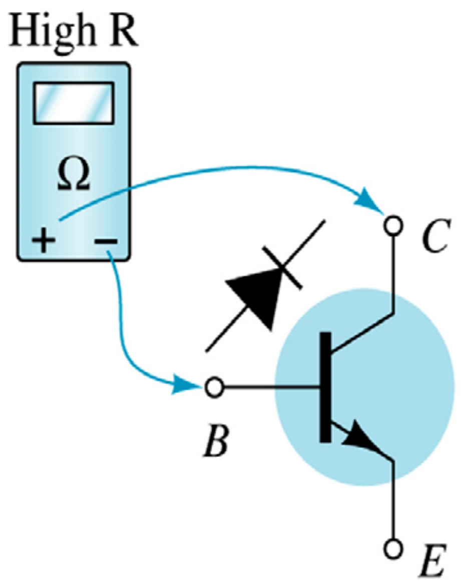


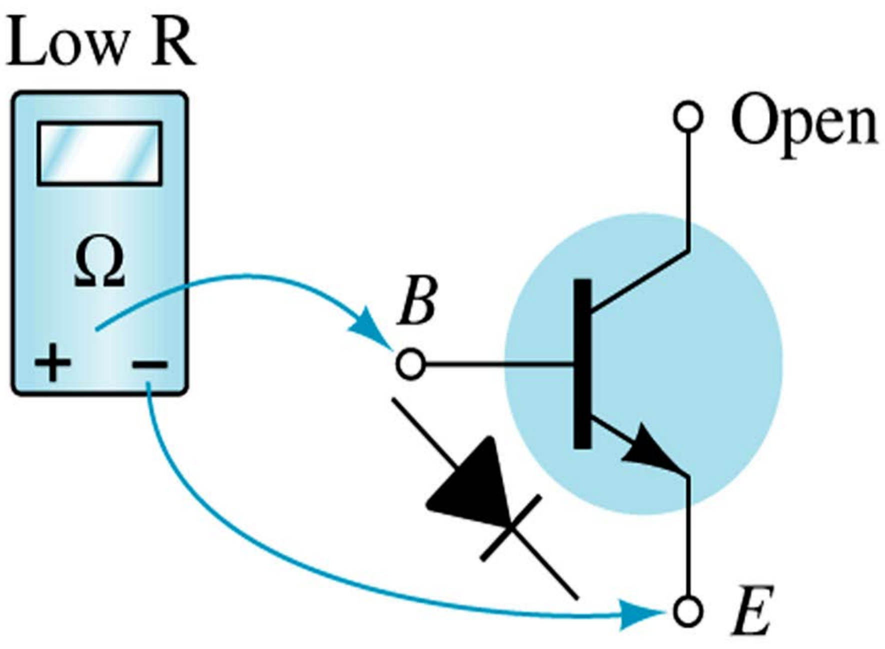
Fig 4.9 : Output characteristic in CC configuration for npn transistor

TRANSISTOR TERMINAL IDENTIFICATION

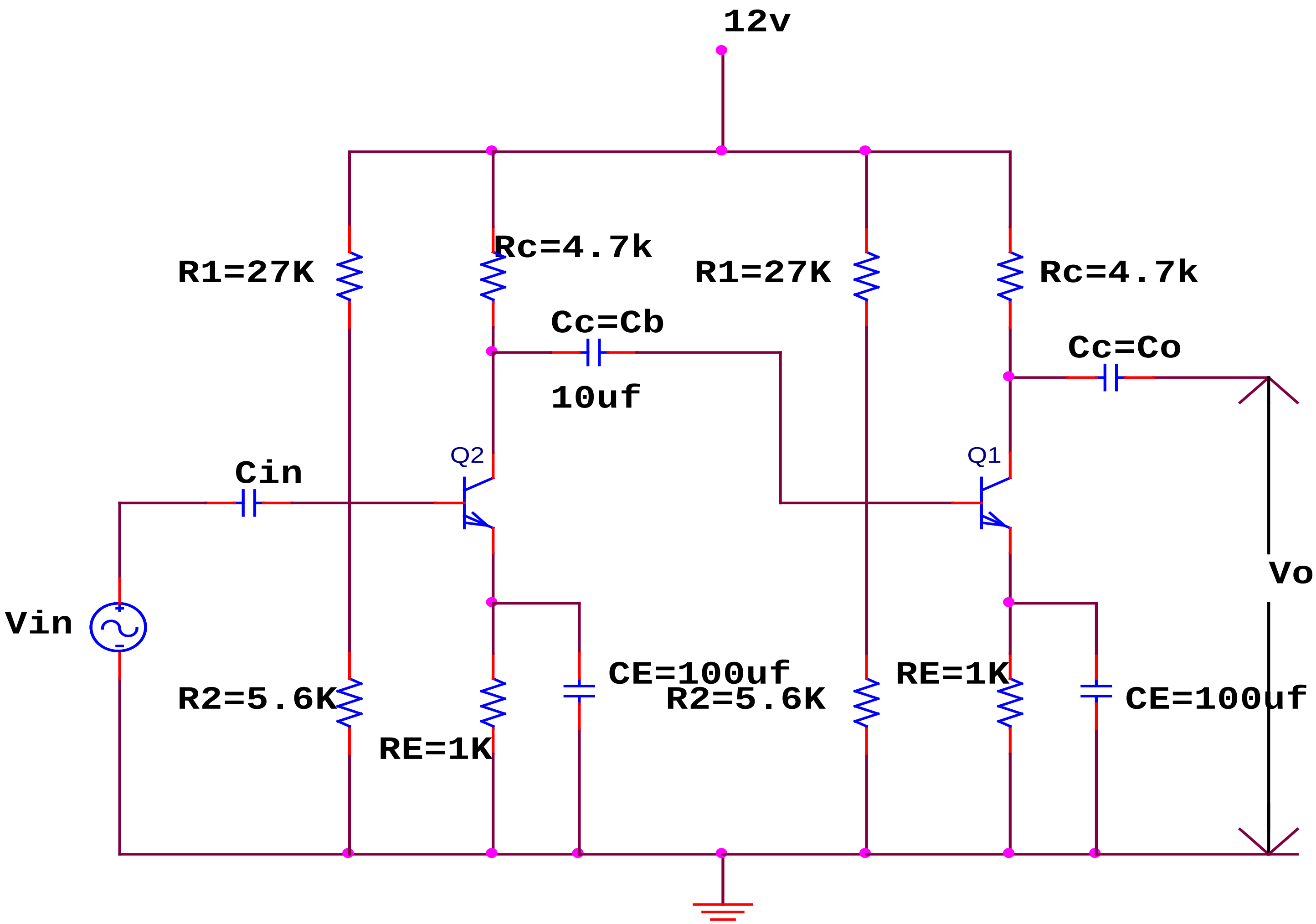


TRANSISTOR TESTING





R-C COUPLED AMPLIFIERS



RC COUPLED AMPLIFIER

FREQUENCY RESPONSE of R-C COUPLED AMPLIFIERS