



SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

Accredited by NBA-AICTE and Accredited by NAAC – UGC with A++ Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai



23EET103 / ELECTRIC CIRCUITS AND ELECTRON DEVICES

UNIT 4- ELECTRONIC DEVICES AND APPLICATIONS

Bipolar Junction Transistors

- The transistor is a three-layer semiconductor device consisting of either two n- and one p-type layers of material or two p- and one n-type layers of material.
- The former is called an npn transistor, while the latter is called a pnp transistor
- So, there are two types of BJT-
 - i) pnp transistor
 - ii) npn transistor

Bipolar Junction Transistors

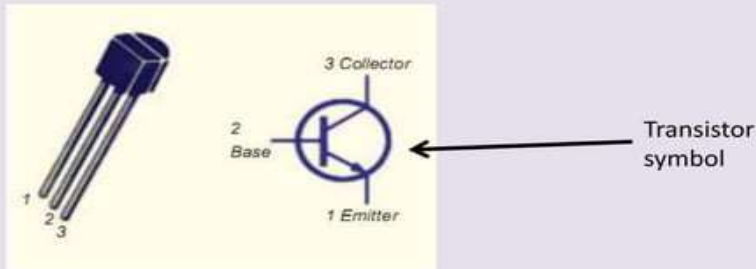


In each transistor following points to be noted-

- i) There are two junction, so transistor can be considered as two diode connected back to back.
- ii) There are three terminals.
- iii) The middle section is thin than other.

Naming of Transistor Terminals

- Transistor has three section of doped semiconductor.
- The section one side is called “emitter” and the opposite side is called “collector”.
- The middle section is called “base”.



Naming of Transistor Terminals

1) Emitter:

- The section of one side that supplies carriers is called emitter.
- Emitter is always forward biased wr to base so it can supply carrier.
- For “npn transistor” emitter supply holes to its junction.
- For “pnp transistor” emitter supply electrons to its junction.

Naming of Transistor Terminals

2) Collector:

- The section on the other side that collects carrier is called collector.
- The collector is always reversed biased wr to base.
- For “npn transistor” collector receives holes to its junction.
- For “pnp transistor” collector receives electrons to its junction.

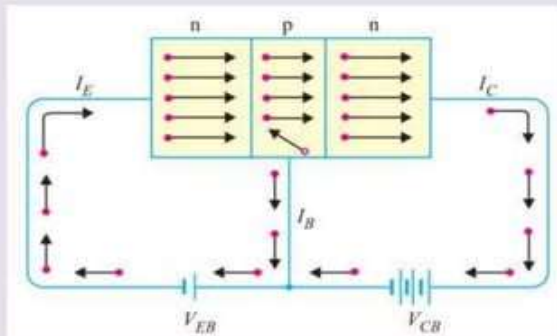
Naming of Transistor Terminals

3) Base:

→ The middle section which forms two pn junction between emitter and collector is called Base.

Transistor Operation

1) Working of npn transistor:

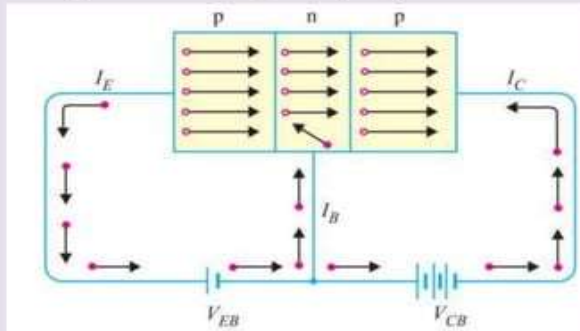


✓ Forward bias is applied to emitter-base junction and reverse bias is applied to collector-base junction.

✓ The forward bias in the emitter-base junction causes electrons to move toward base. This constitutes emitter current, I_E

Transistor Operation

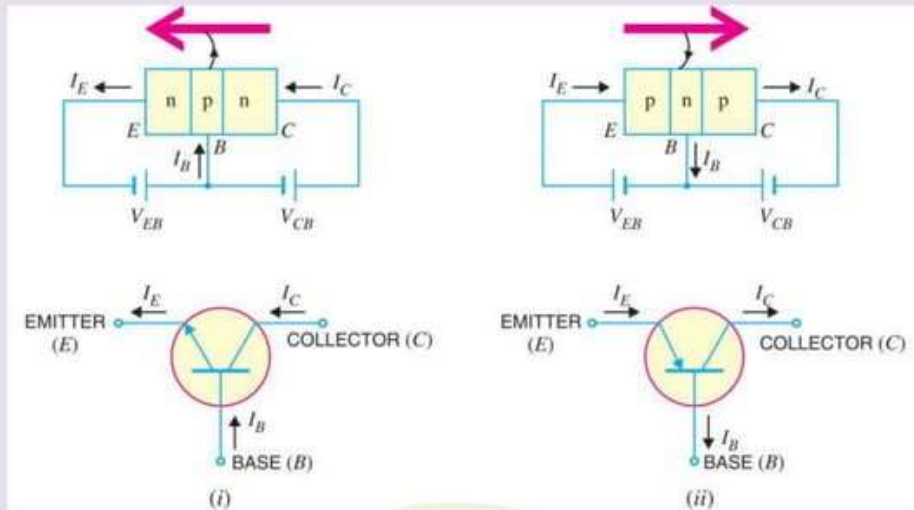
2) Working of pnp transistor:



✓ Forward bias is applied to emitter-base junction and reverse bias is applied to collector-base junction.

✓ The forward bias in the emitter-base junction causes holes to move toward base. This constitutes emitter current, I_E

Transistor Symbol



Transistor Operating Modes

- Active Mode
 - Base- Emitter junction is forward and Base-Collector junction is reverse biased.
- Saturation Mode
 - Base- Emitter junction is forward and Base-Collector junction is forward biased.
- Cut-off Mode
 - Both junctions are reverse biased.

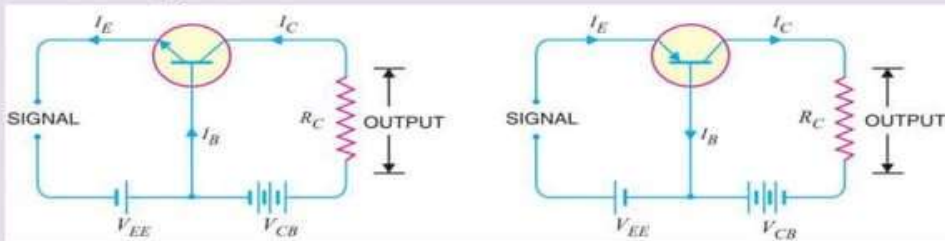
Transistor Connection

- Transistor can be connected in a circuit in following three ways-

- 1) Common Base
- 2) Common Emitter
- 3) Common Collector

Common Base Connection

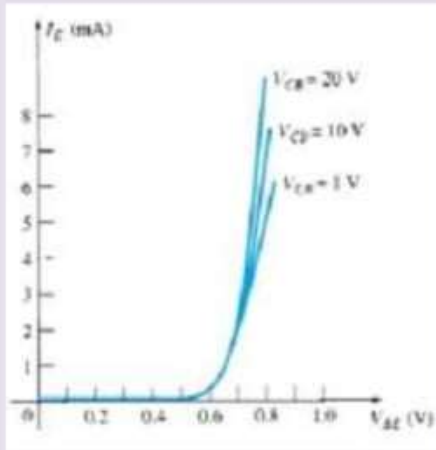
- The common-base terminology is derived from the fact that the base is common to both the input and output sides of the configuration.



- First Figure shows common base npn configuration and second figure shows common base pnp configuration.

Characteristics of common base configuration

- Input Characteristics:



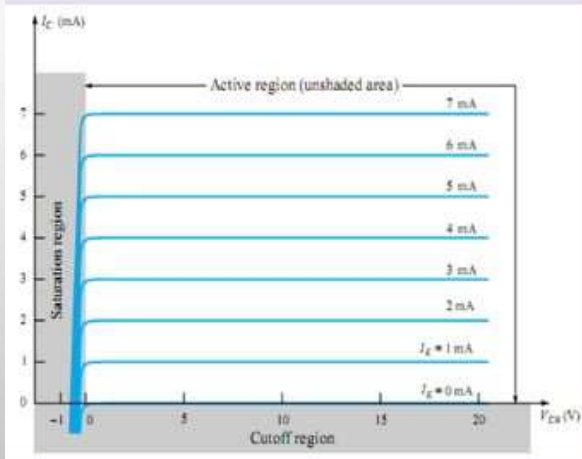
→ V_{BE} vs I_E characteristics is called input characteristics.

→ I_E increases rapidly with V_{BE} . It means input resistance is very small.

→ I_E almost independent of V_{CB} .

Characteristics of common base configuration

Output Characteristics:



→ V_{BC} vs I_C

characteristics is called output characteristics.

→ I_C varies linearly with V_{BC} , only when V_{BC} is very small.

→ As, V_{BC} increases, I_C becomes constant.

Input and Output Resistance of common base conf.

- Input Resistance: The ratio of change in emitter-base voltage to the change in emitter current is called Input Resistance.

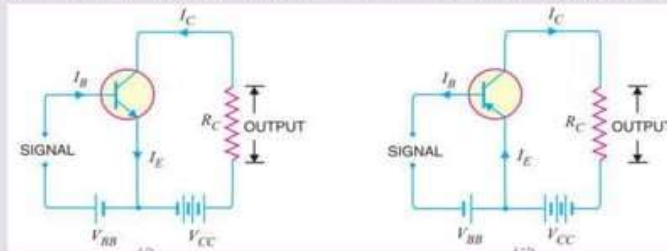
$$r_i = \frac{\Delta V_{BE}}{\Delta I_E}$$

- Output Resistance: The ratio of change in collector-base voltage to the change in collector current is called Output Resistance.

$$r_o = \frac{\Delta V_{BC}}{\Delta I_C}$$

Common Emitter Connection

- The common-emitter terminology is derived from the fact that the emitter is common to both the input and output sides of the configuration.



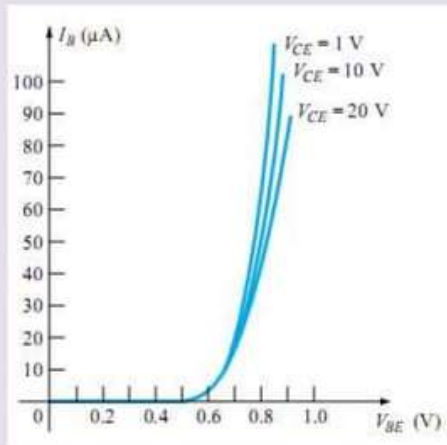
- First Figure shows common emitter npn configuration and second figure shows common emitter pnp configuration.

Common Emitter Connection

- Base Current amplification factor (β) :
- In common emitter connection input current is base current and output current is collector current.
- The ratio of change in collector current to the change in base current is known as base current amplification factor, β .
$$\beta = \frac{\Delta I_C}{\Delta I_B}$$
- Normally only 5% of emitter current flows to base, so amplification factor is greater than 20. Usually this range varies from 20 to 500.

Characteristics of common emitter configuration

- Input Characteristics: $\rightarrow V_{BE}$ vs I_B characteristics is called input characteristics.



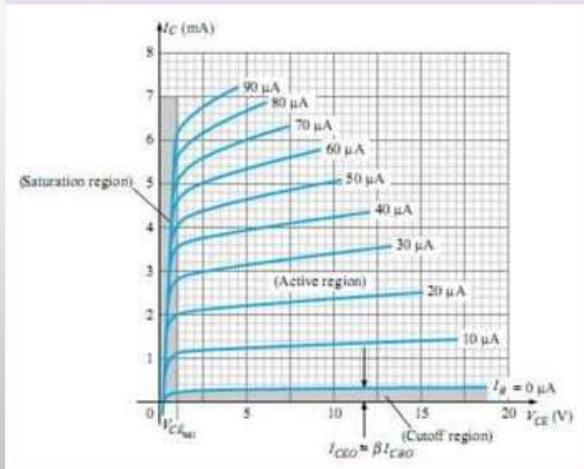
$\rightarrow I_B$ increases rapidly with V_{BE} . It means input resistance is very small.

$\rightarrow I_E$ almost independent of V_{CE} .

$\rightarrow I_B$ is of the range of micro amps.

Characteristics of common emitter configuration

- Output Characteristics:



→ V_{CE} vs I_C

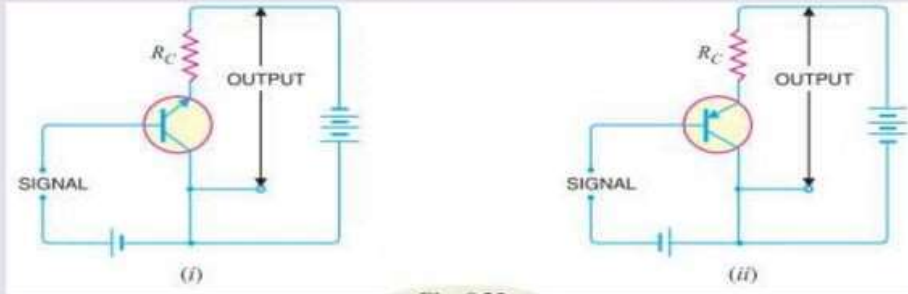
characteristics is called output characteristics.

→ I_C varies linearly with V_{CE} , only when V_{CE} is very small.

→ As, V_{CE} increases, I_C becomes constant.

Common Collector Configuration

- The common-collector terminology is derived from the fact that the collector is common to both the input and output sides of the configuration.



- First Figure shows common collector npn configuration and second figure shows common collector pnp configuration.

Common Collector Configuration

- Current amplification factor (γ) :
- In common emitter connection input current is base current and output current is emitter current.
- The ratio of change in emitter current to the change in base current is known as current amplification factor in common collector configuration.

$$\gamma = \frac{\Delta I_E}{\Delta I_B}$$

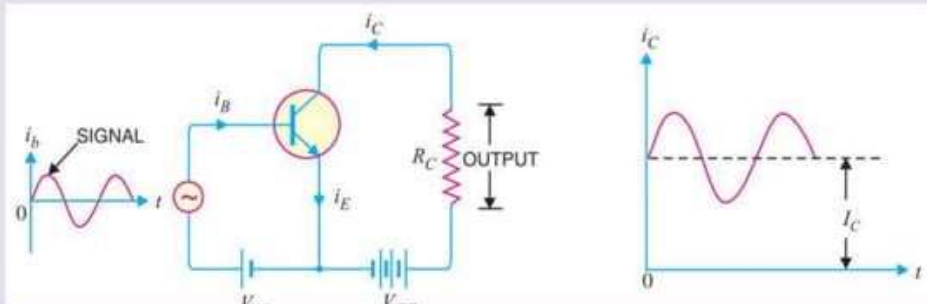
- This circuit provides same gain as CE configuration as,

$$\Delta I_E \approx \Delta I_C$$

Comparison of Transistor Connection

S. No.	Characteristic	Common base	Common emitter	Common collector
1.	Input resistance	Low (about 100 Ω)	Low (about 750 Ω)	Very high (about 750 k Ω)
2.	Output resistance	Very high (about 450 k Ω)	High (about 45 k Ω)	Low (about 50 Ω)
3.	Voltage gain	about 150	about 500	less than 1
4.	Applications	For high frequency applications	For audio frequency applications	For impedance matching
5.	Current gain	No (less than 1)	High (β)	Appreciable

Transistor as an amplifier in CE conf.



- Figure shows CE amplifier for npn transistor.
- Battery V_{BB} is connected with base in-order to make base forward biased, regardless of input ac polarity.
- Output is taken across Load R

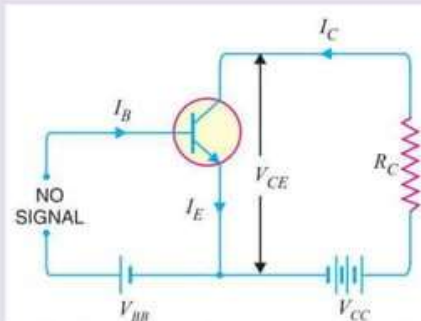
Transistor as an amplifier in CE conf.

- During positive half cycle input ac will keep the emitter-base junction more forward biased. So, more carrier will be emitted by emitter, this huge current will flow through load and we will find output amplified signal.
- During negative half cycle input ac will keep the emitter-base junction less forward biased. So, less carrier will be emitted by emitter. Hence collector current decreases.
- This results in decreased output voltage (In opposite direction).

Transistor Load line analysis

- In transistor circuit analysis it is necessary to determine collector current for various V_{CE} voltage.
- One method is we can determine the collector current at any desired V_{CE} voltage, from the output characteristics.
- More conveniently we can use load line analysis to determine operating point.

Transistor Load line analysis



→ Consider common emitter npn transistor ckt shown in figure.

→ There is no input signal.

→ Apply KVL in the output ckt-

$$V_{CE} = V_{CC} - I_C R_C$$

(i) When the collector current $I_C = 0$, then collector-emitter voltage is maximum and is equal to V_{CC} i.e.

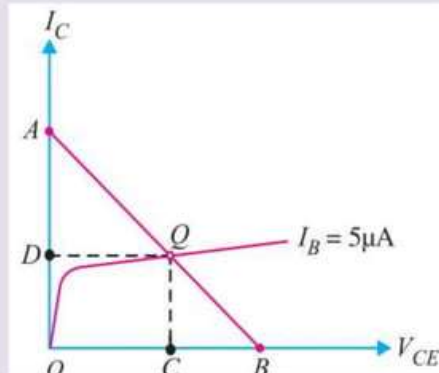
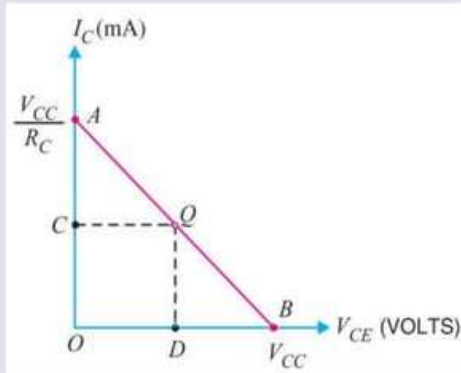
$$\begin{aligned} \text{Max. } V_{CE} &= V_{CC} - I_C R_C \\ &= V_{CC} \quad (\because I_C = 0) \end{aligned}$$

When collector-emitter voltage $V_{CE} = 0$,

$$\begin{aligned} V_{CE} &= V_{CC} - I_C R_C \\ 0 &= V_{CC} - I_C R_C \end{aligned}$$

$$\text{Max. } I_C = V_{CC} / R_C$$

Transistor Load line analysis



Operating Point

The zero signal values of I_C and V_{CE} are known as the **operating point**.

→ It is called operating point because variation of I_C takes place about this point.

→ It is also called quiescent point or Q-point.

