BASIC ELECTRONIC CIRCUITS

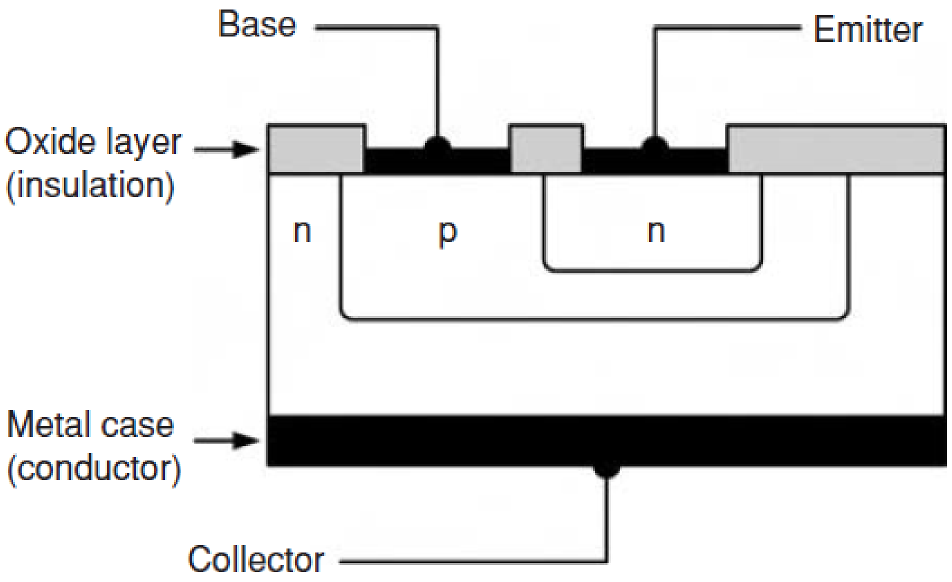
Bipolar Junction Transistor

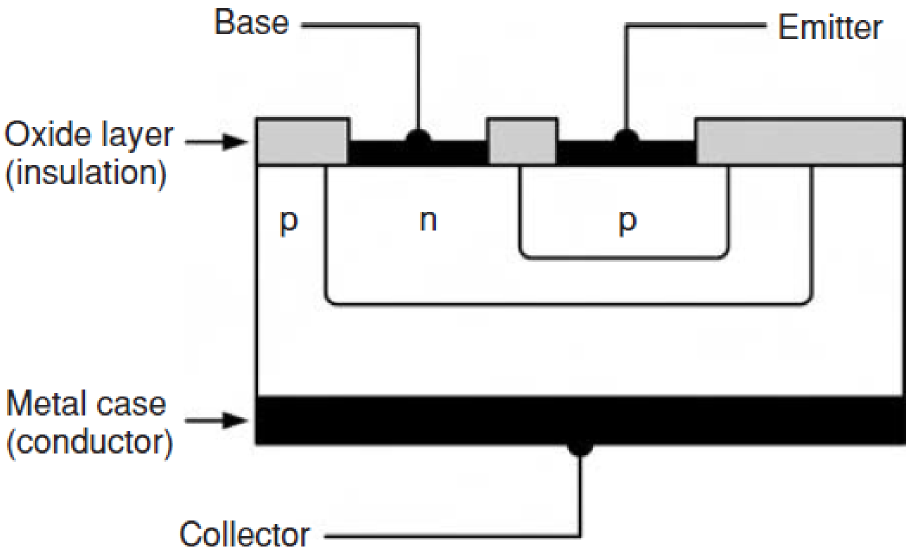
Contents

- Types of Transistors: Bipolar and field effect.
- Physical construction
- Modes of Operation
- Types of Configurations
- Input/output characteristics
- Application as an Amplifier

Bipolar Junction Transistors

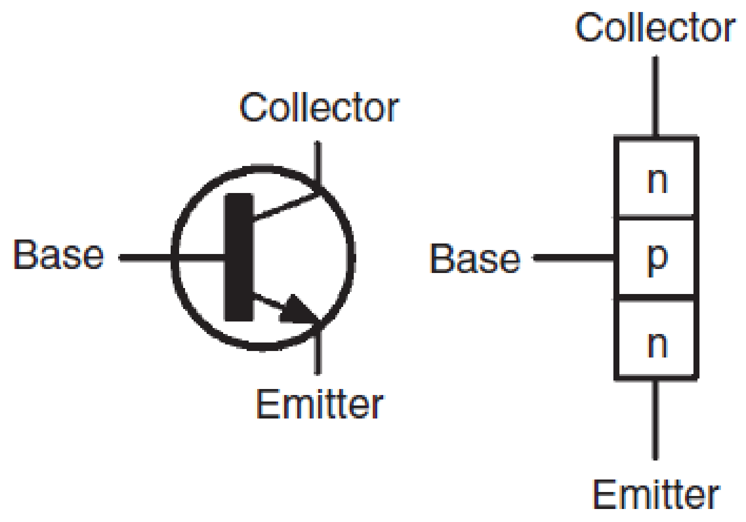
- Physical Construction

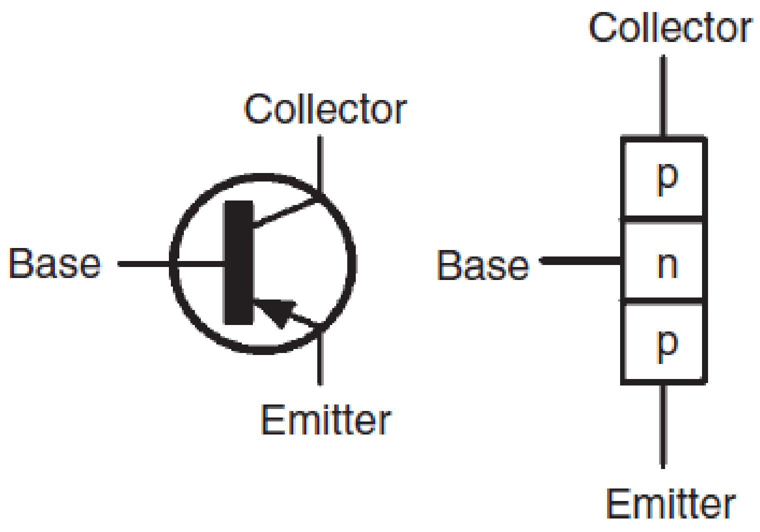




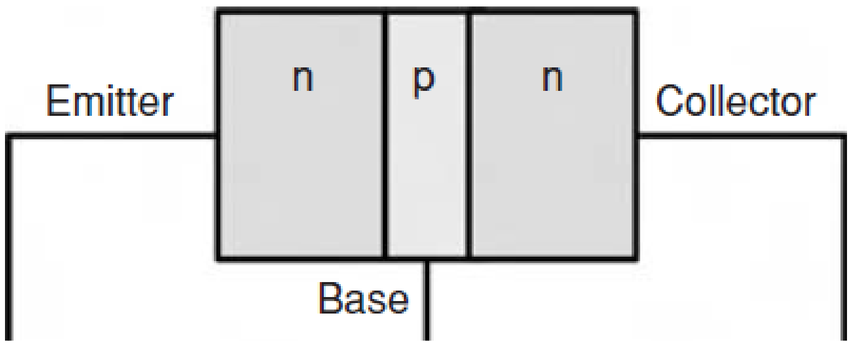
BJT: Symbols and junction models

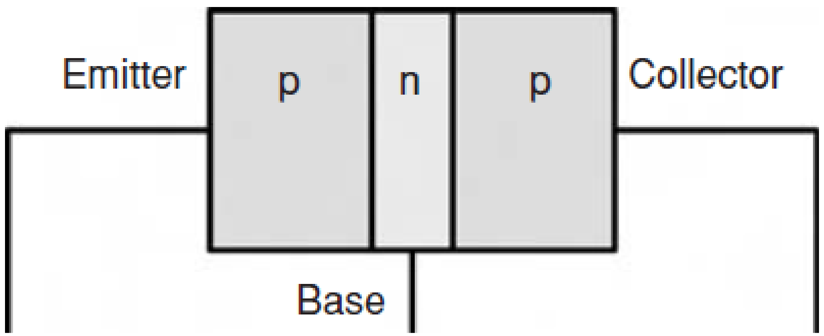
- Emitter – Medium sized and heavily doped, to inject majority carriers to collector through Base.
- Collector – Thick and lightly doped, designed to collect the majority carriers from emitter.
- Base – Thin and medium doped, control the flow of current between Emitter and Collector.





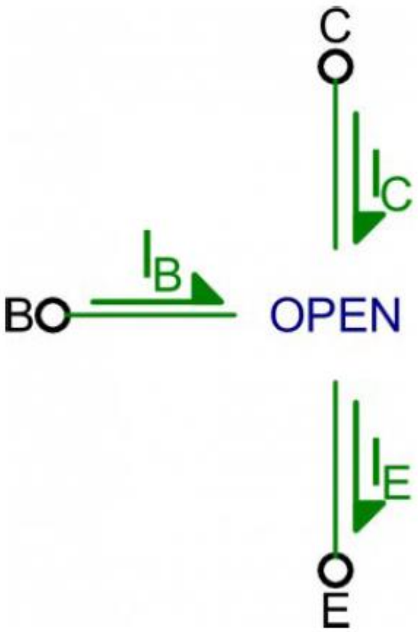
BJT: Modes of Operation

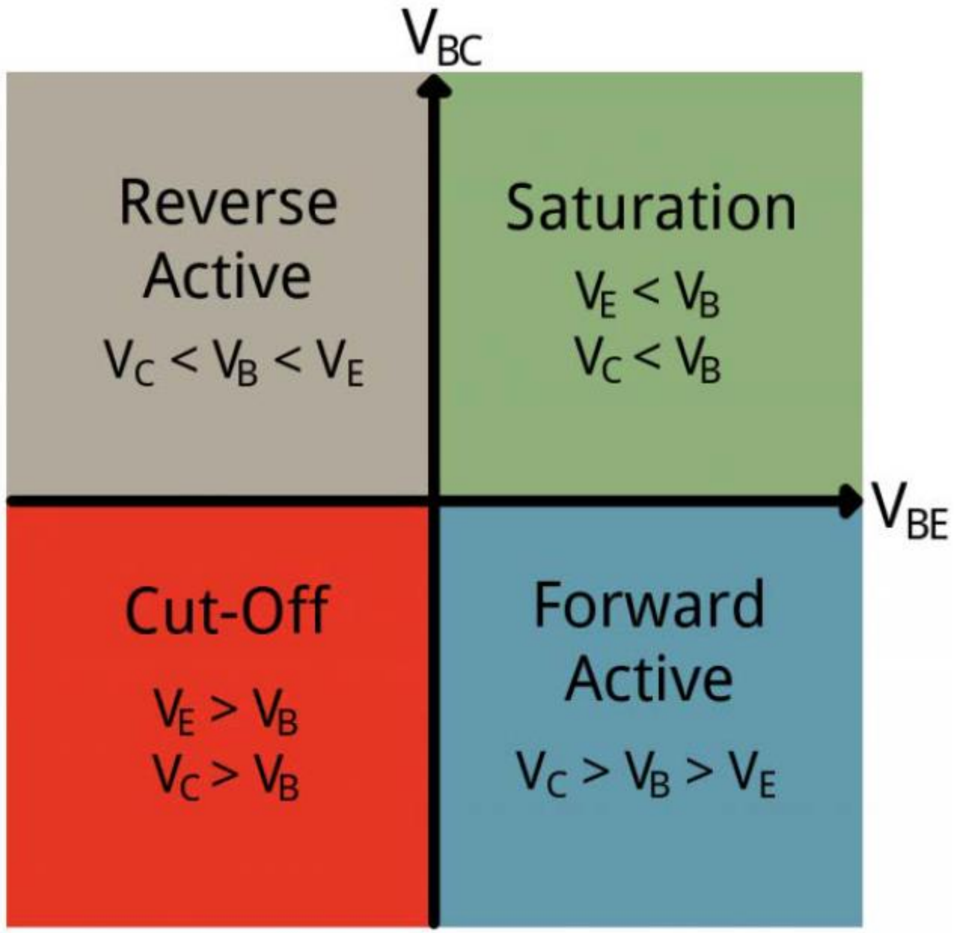




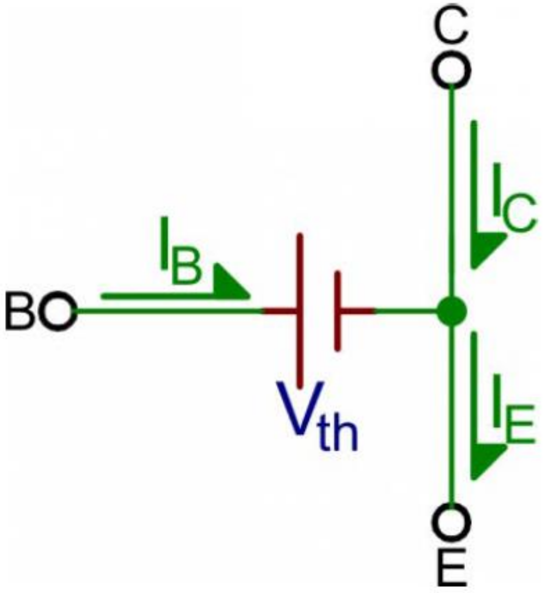
S. No.	Mode	Emitter-Base Junction	Collector Base Junction	Action	Application
1	Cut-off	Reverse	Reverse	Open	Switch
2	Saturation	forward	forward	Short	
3	Active	Forward	Reverse		Amplifier
4	Reverse active	Reverse	Forward		

- Cut-off Mode:
- No collector current and no emitter current.
- Very much like a open circuit





- Saturation mode: on state
- Acts like a short circuit between the collector and emitter.
- Both the junctions are forward biased, V_B must be at higher potential than V_C and V_E.
- V_C must be slightly greater than V_E.
- V_{CE} = 0.2 V.



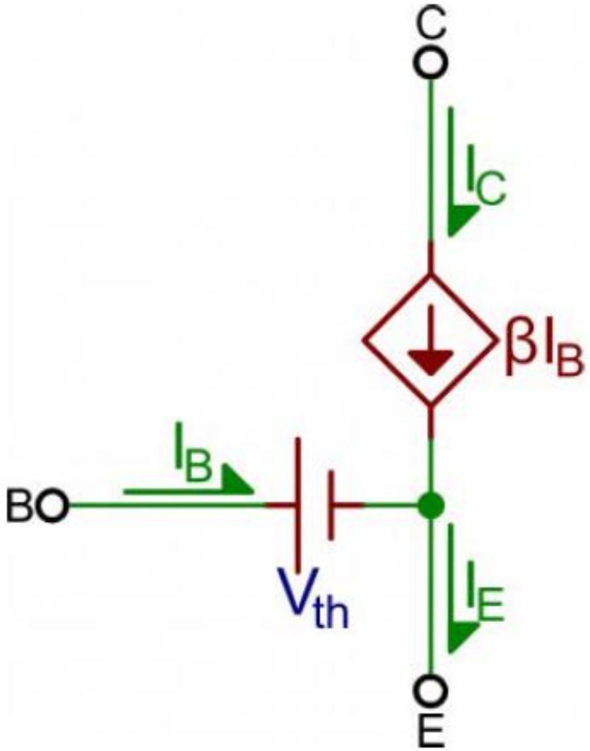
- Active Mode:
- V_{BE} must be positive and V_{CB} must be negative. $V_C > V_B > V_E$.
- Gain (amplification factor) – β
- Common base current gain - α

$$I_C = \beta I_B$$

$$I_C = \alpha I_E$$

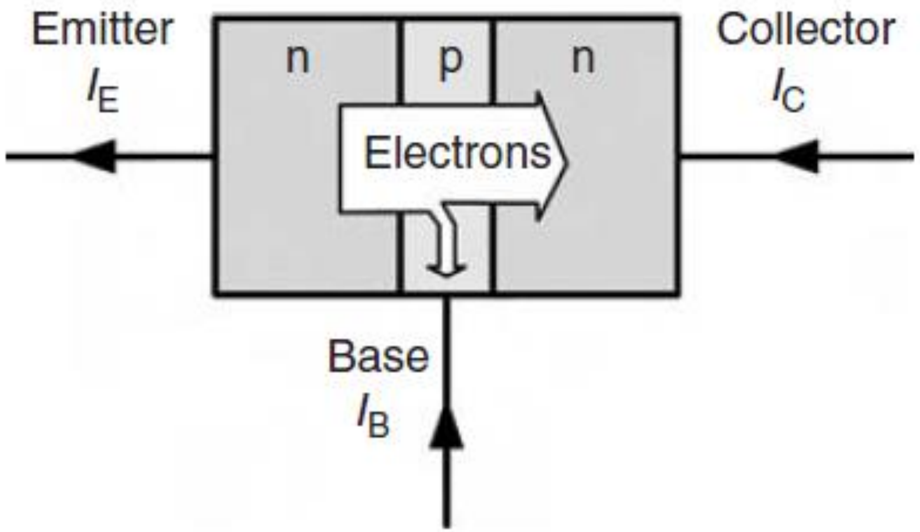
$$\beta = \frac{\alpha}{(1-\alpha)}$$

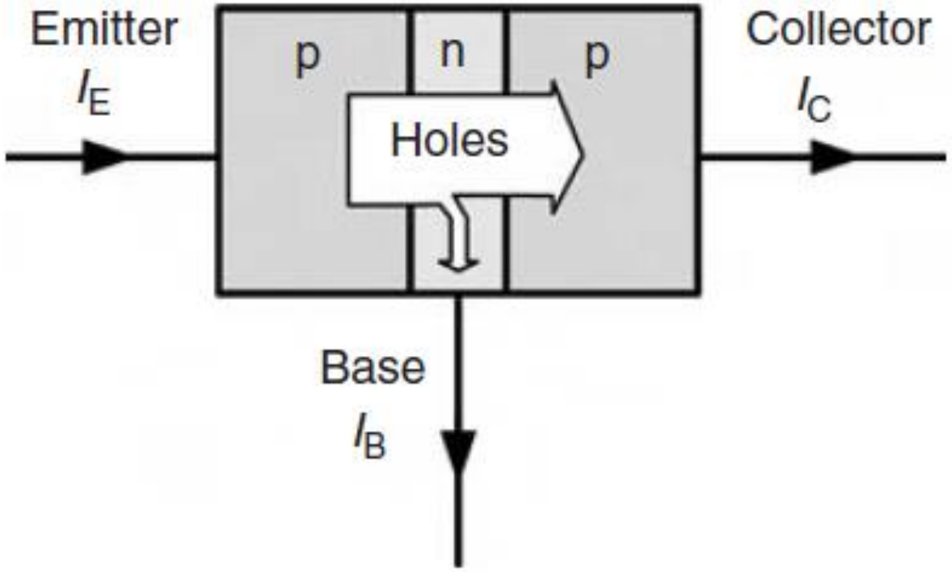
$$\alpha = \frac{\beta}{\beta+1}$$



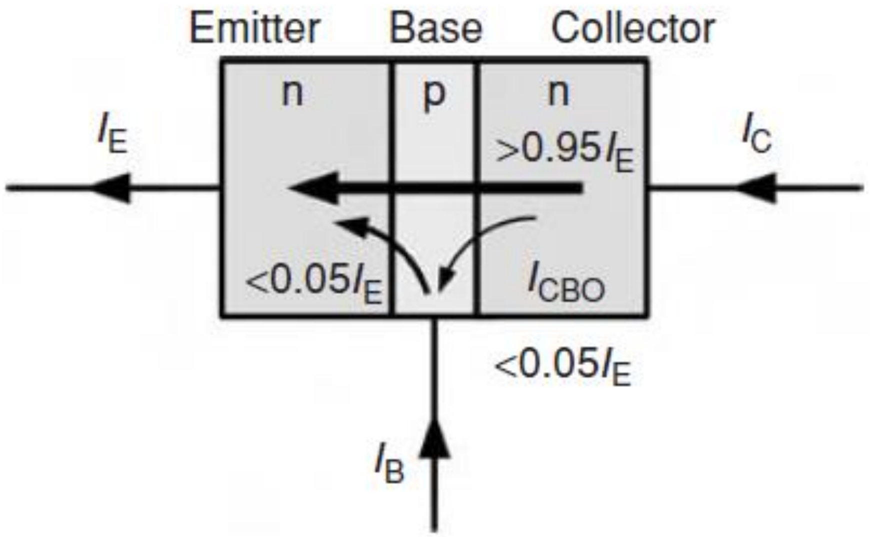
Transistor Action: Active mode

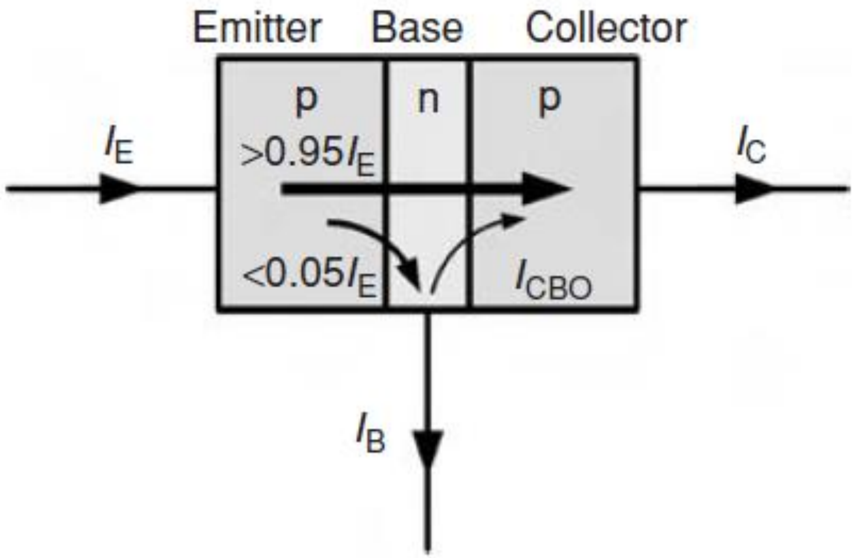
- Emitter-Base junction is Forward Biased, Collector-Base junction is Reverse Biased





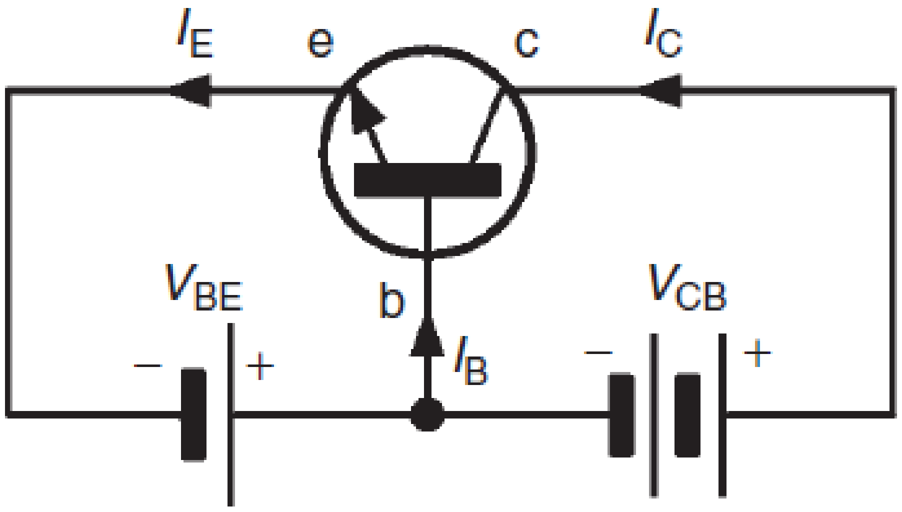
Leakage Current



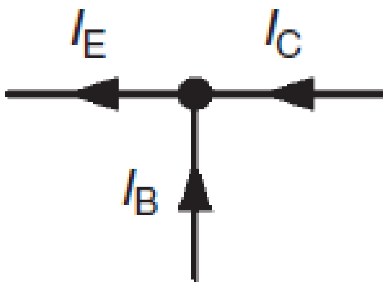


BJT: Bias and Current Flow

- For linear amplification, BE junction is forward bias and CE junction is reverse biased.
- Base region is made very small such that the carriers are swept across it from emitter to collector.

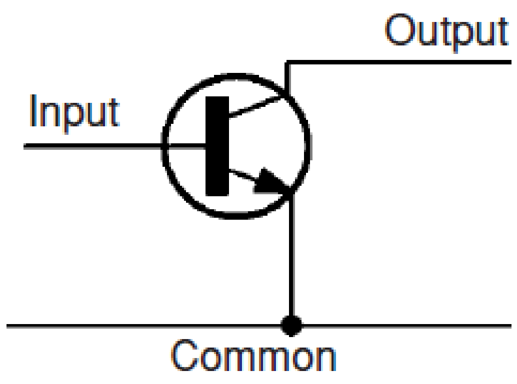


$$I_E = I_B + I_C$$

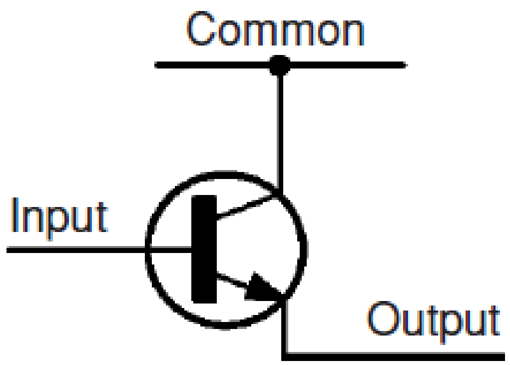


BJT: operating Configurations

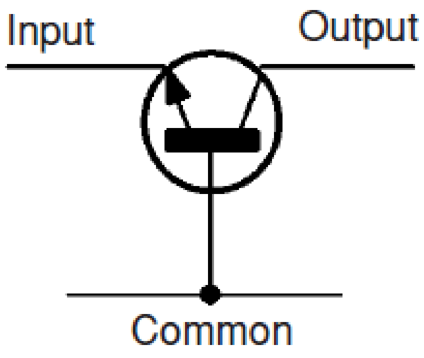
- Symbols and simplified junction models



(a) Common emitter

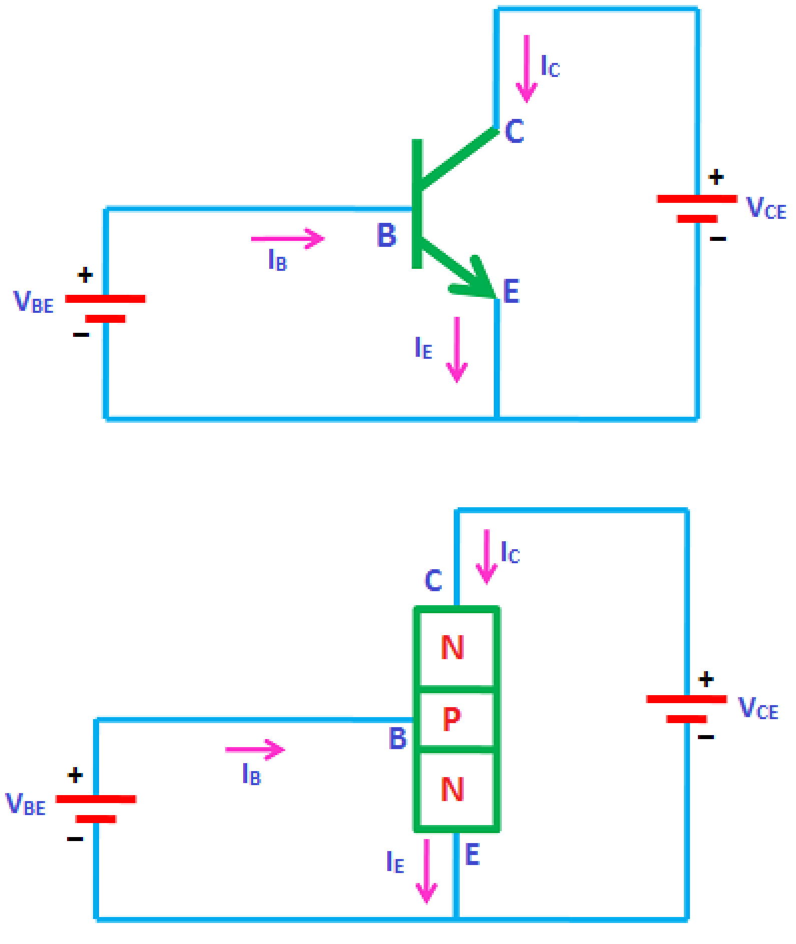


(b) Common collector

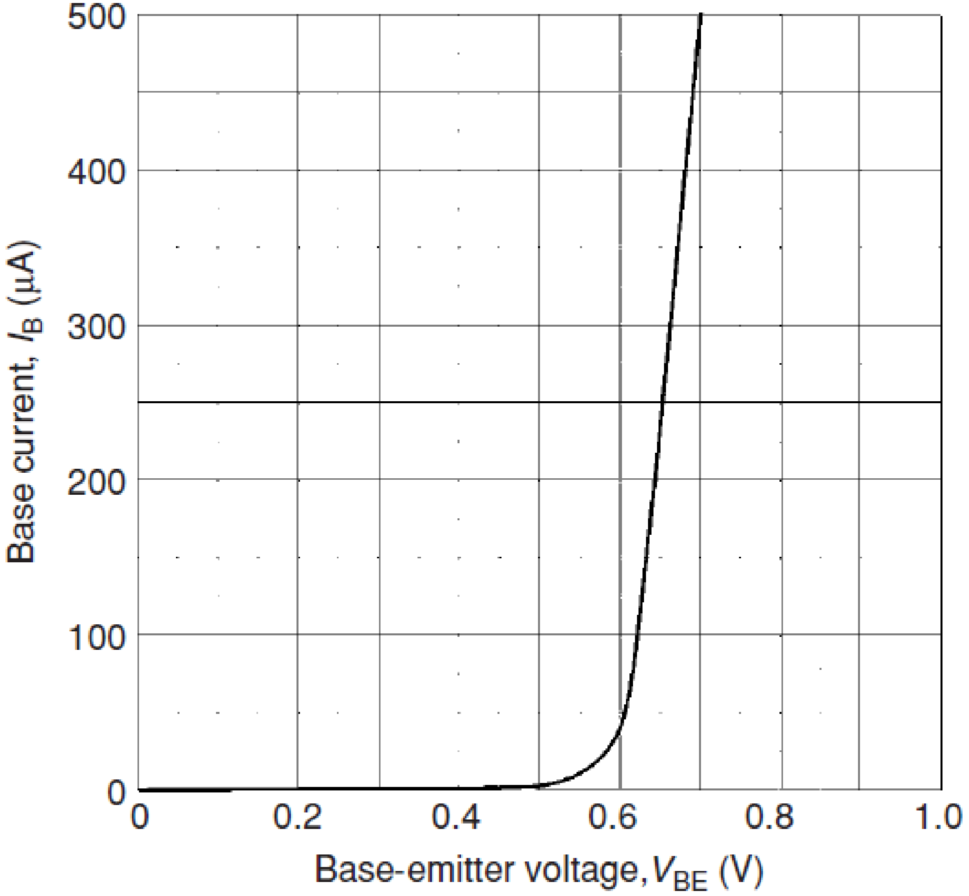


(c) Common base

Common Emitter: Input Characteristics



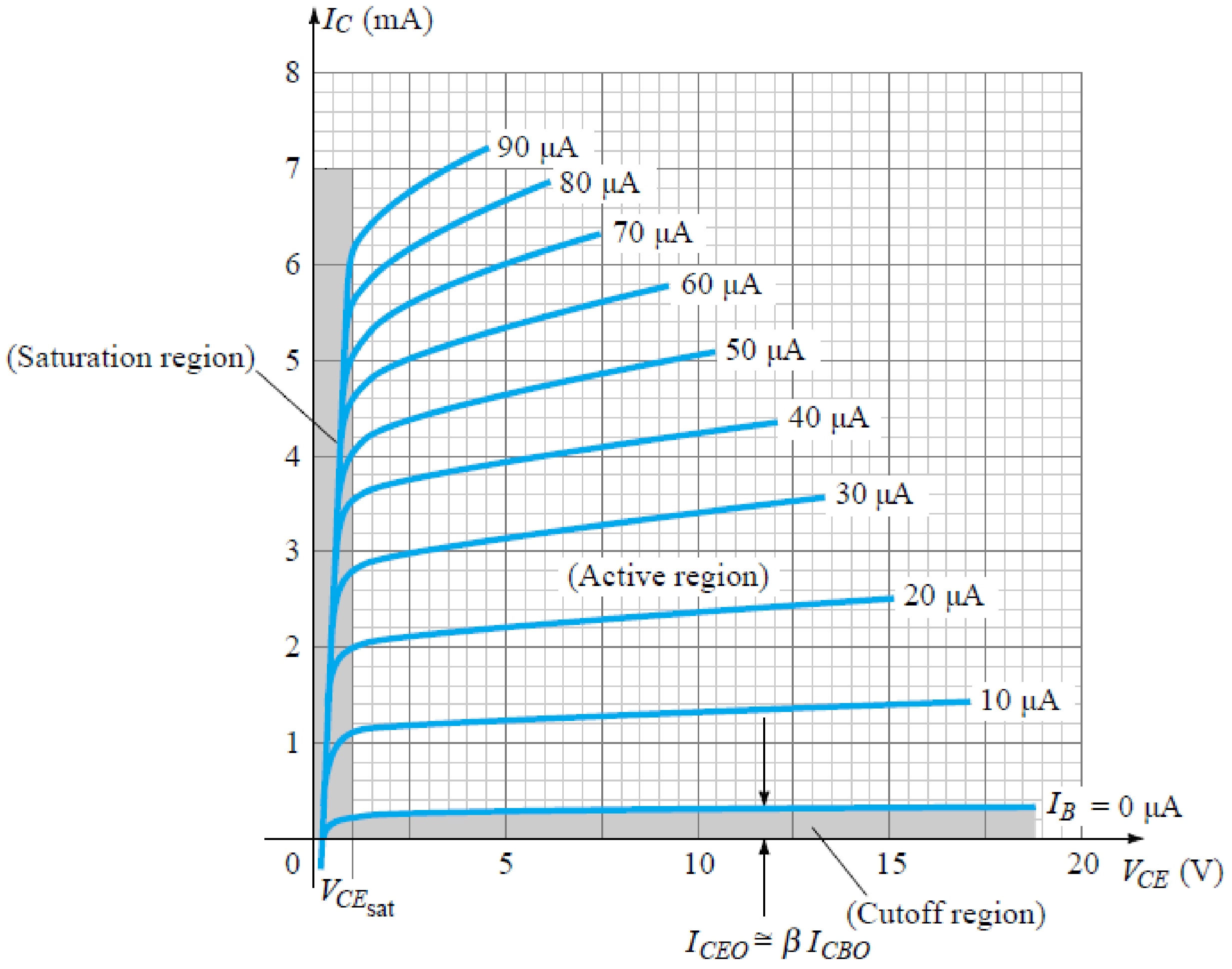
Common emitter configuration



- V_{BE} Vs I_B
- Small current flows until V_{BE} exceeds 0.6 V, shows the Si diode forward char.

Common Emitter: Output Characteristics

- V_{CE} Vs I_C
- There modes of operation are shown
- I_B = 0 cut-off
- $V_{CE} < V_{CEsat}$ saturation



BJT: Parameters

- Input resistance:

$$\text{Static (or d.c.) input resistance} = \frac{V_{BE}}{I_B}$$

$$\text{Dynamic (or a.c.) input resistance} = \frac{\Delta V_{BE}}{\Delta I_B}$$

- Output resistance:

$$\text{Static (or d.c.) output resistance} = \frac{V_{CE}}{I_C}$$

$$\text{Dynamic (or a.c.) output resistance} = \frac{\Delta V_{CE}}{\Delta I_C}$$

- Current Gain:

$$\text{Static (or d.c.) current gain} = \frac{I_C}{I_B}$$

$$\text{Dynamic (or a.c.) current gain} = \frac{\Delta I_C}{\Delta I_B}$$

For a transistor circuit, the base terminal is grounded, and Collector is connected to a supply voltage of 10 V via R_C = 5 K ohms and emitter is connected to a supply voltage of

-10 V via R_E = 10 K ohms, the voltage at the emitter was measured and found to be -0.7 V. if β = 50, find I_E, I_B, I_C, and V_C.

- I_E = 0.93 mA
- I_B = 18.2 μA
- I_C = 0.91 mA
- V_C = 5.45 V