UNIT 3

Bipolar Junction Transistor

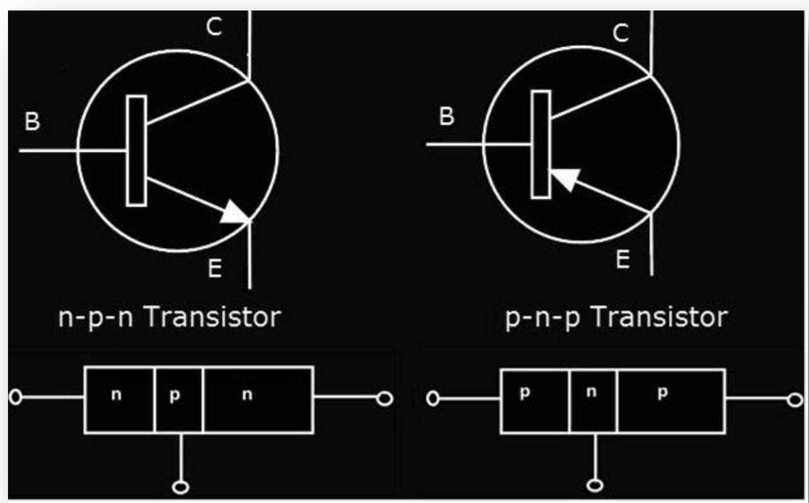
What is Bipolar Junction Transistor (BJT)

- Bipolar Junction means:

  - 2 PN Junctions: Current goes through 2 types of Seminconductor material P & N

  - Uses both "Electrons" & "Holes" as Charge Carriers (Bipolar: 2 polarities), :although holes mobility is much less than that of electrons

- Two types of BJT are :- NPN & PNP
  – B: Base, C: Collector, E: Emitter

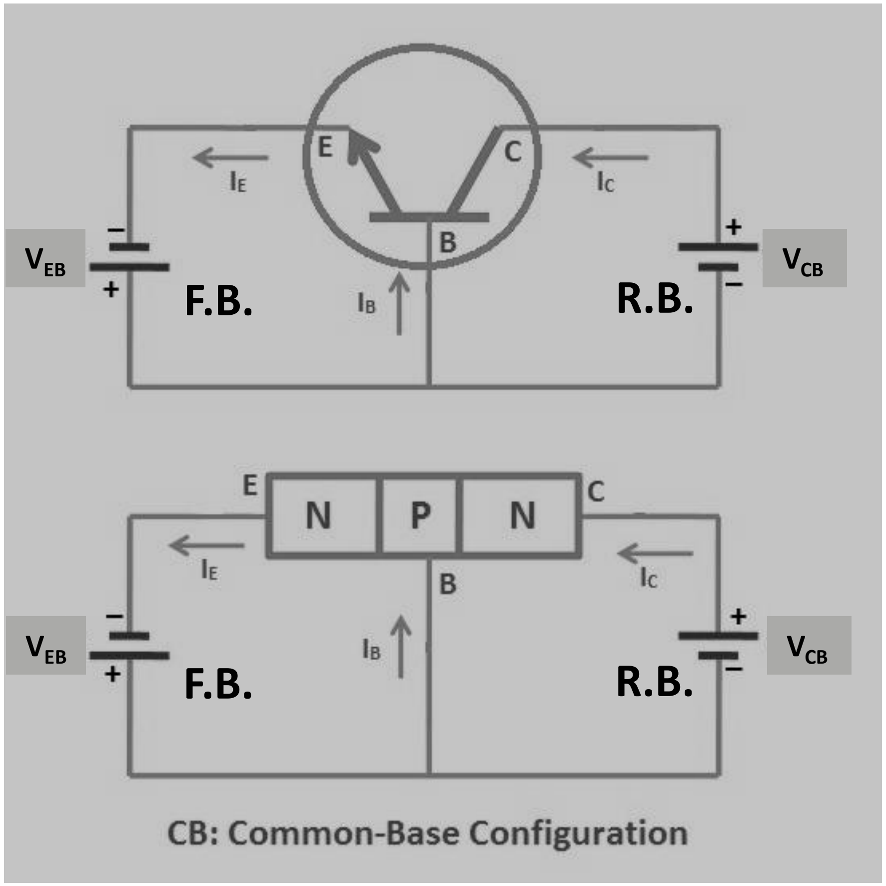


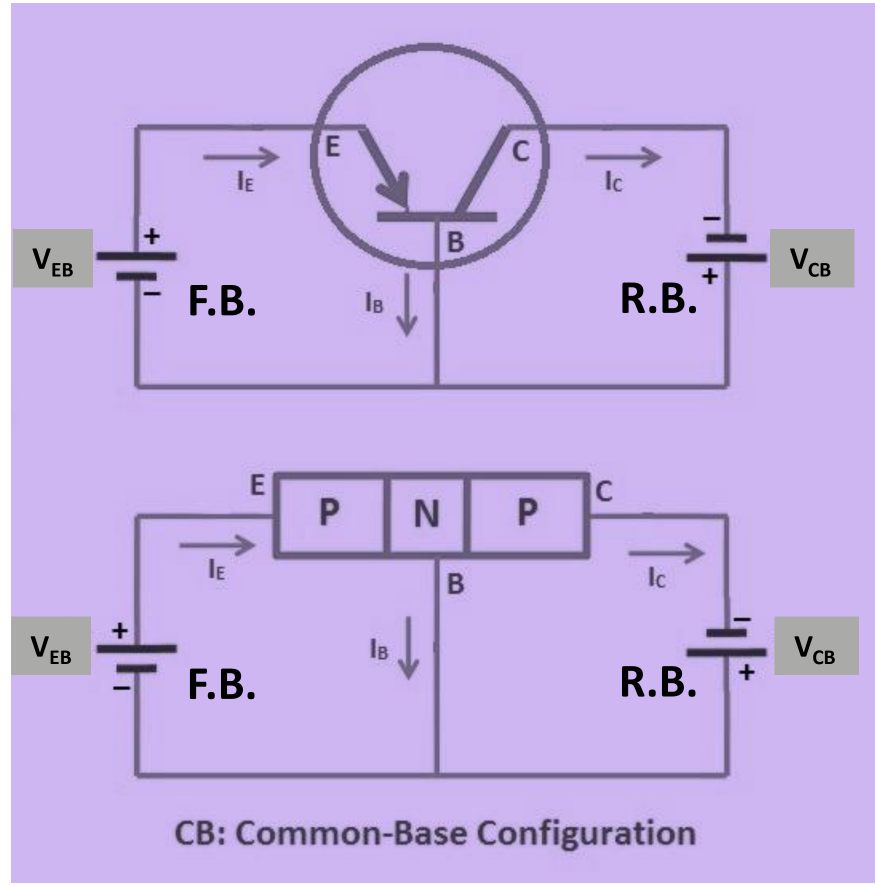
Types of BJT Configurations

- 3 – Types: CB, CE, CC
  - CB: Common-Base
  - CE: Common-Emitter
  - CC: Common-Collector

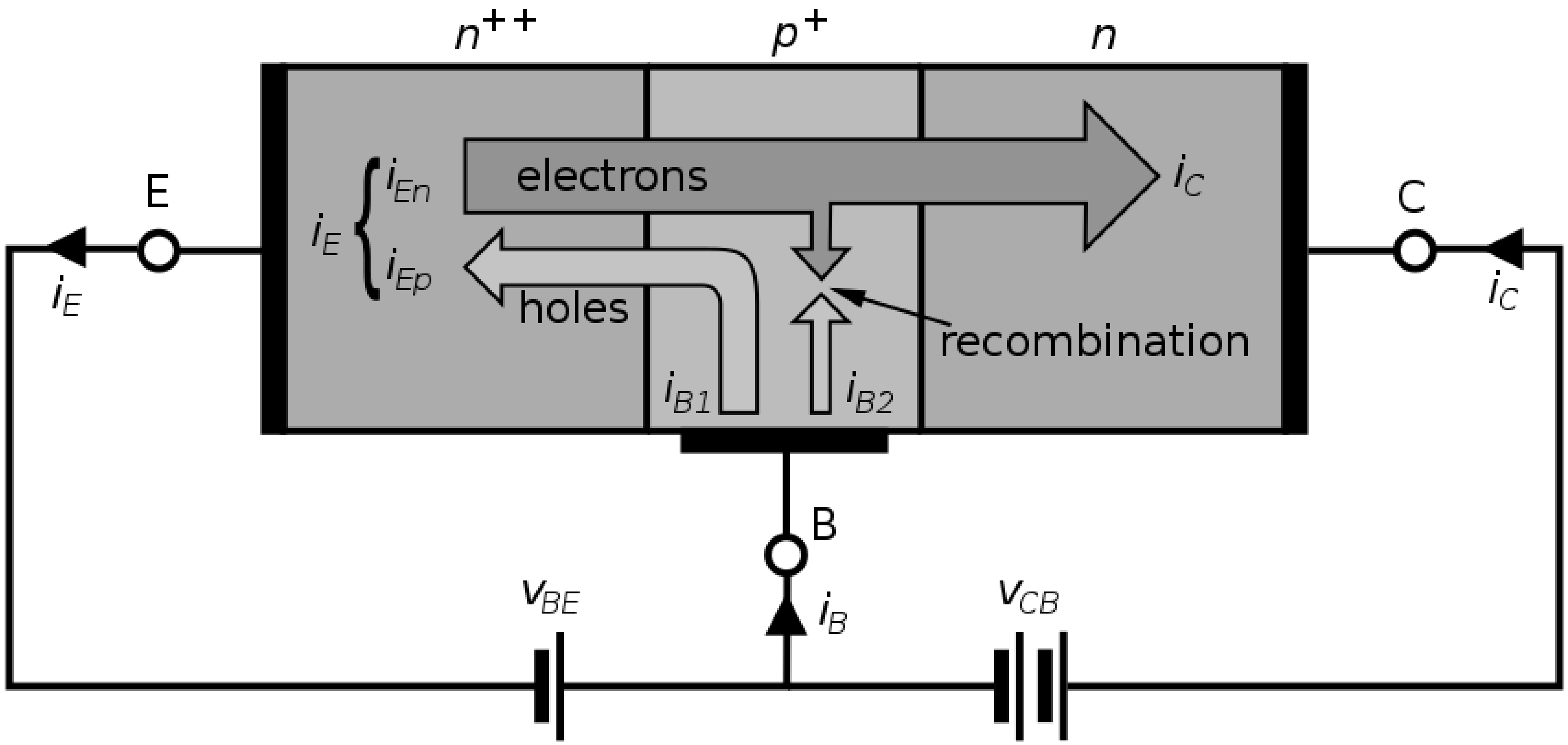
- Common Term (Base/Emitter/Collector) implies that, *the Term (Base/Emitter/Collector) is common to both Input and Output Circuits/Sections of the above 3 BJT Configurations.*

Common-Base (CB) Configuration





- NPN and PNP – CB Configurations have different voltage arrangements, such that
  - Input Section is always Forward Biased (F.B.) &
  - Output Section is always Reverse Biased (R.B.)



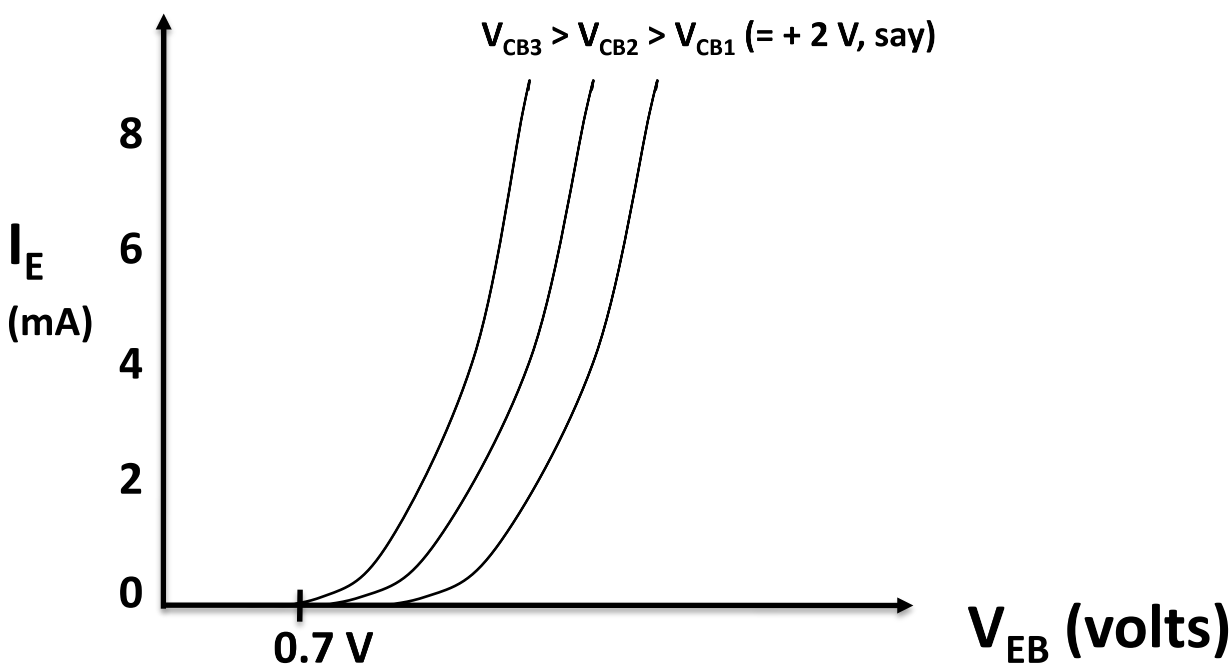
Source: https://en.wikipedia.org/wiki/Bipolar_junction_transistor

Current-Voltage (I-V) Characteristics of npn – CB configuration

- **Input (or Emitter) Static Characteristics:**

- Input Current (I_E) vs Input Voltage (V_{EB})

-@ Constant value of Collector-Base Voltage (V_{CB}) for each curve



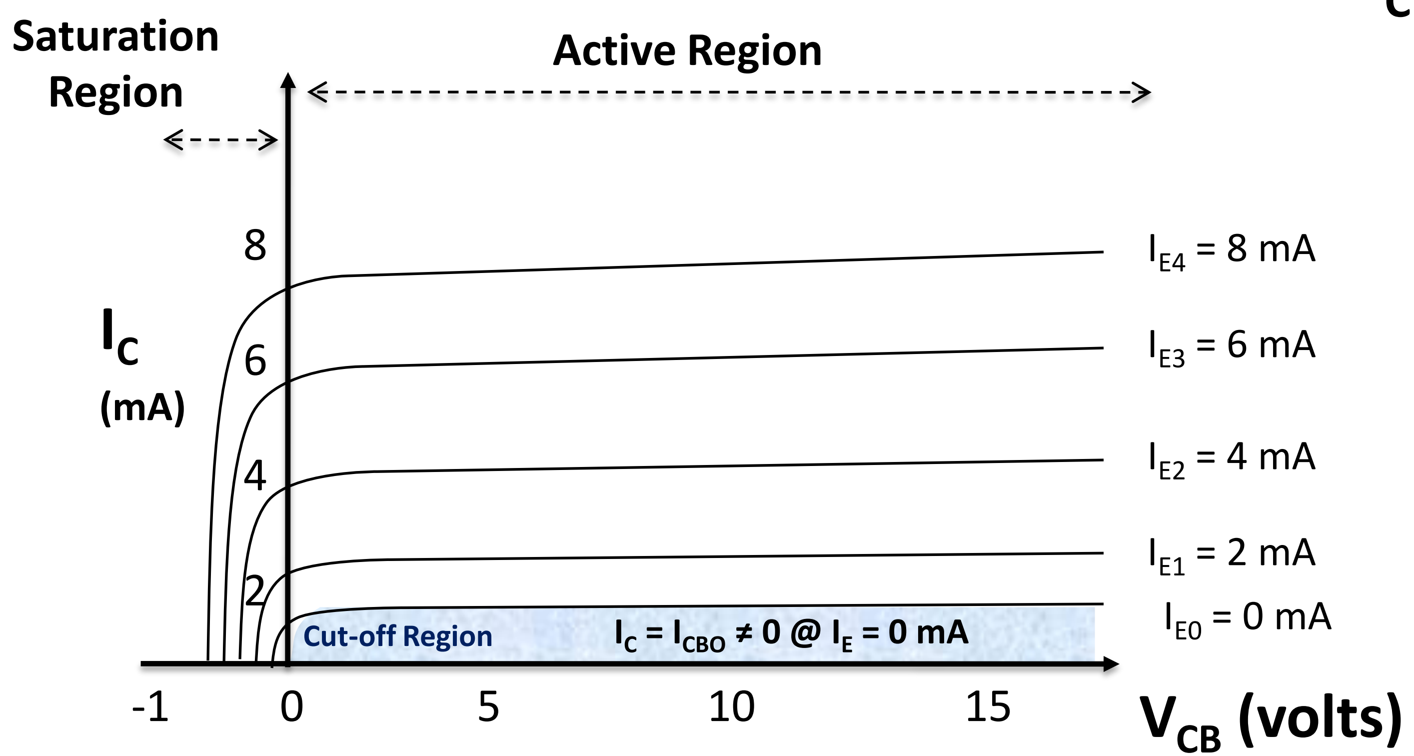
Current-Voltage (I-V) Characteristics of npn – CB configuration

- **Output (or Collector) Static Characteristics:**

- Output Current (I_C) vs Output Voltage (V_{CB})

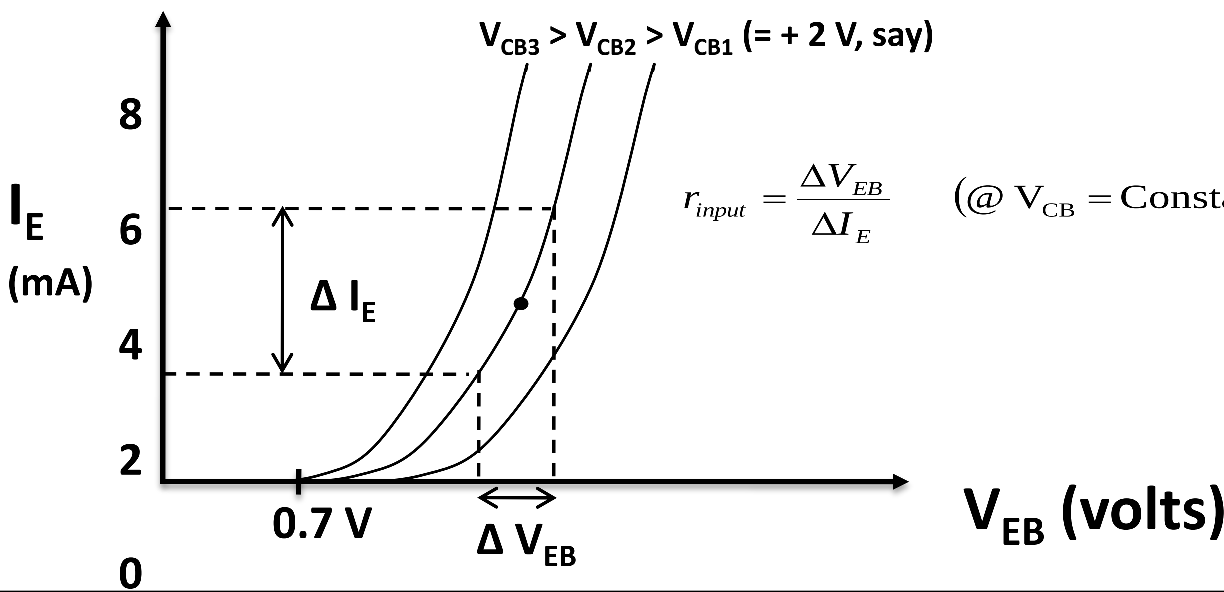
-@ Constant value of Emitter Current (I_E) for each curve

$$I_E = I_C + I_B \approx I_C$$



Input (or Emitter) Static Characteristics

- Represents simply the Forward Characteristics of Emitter-Base Diode (@ various Collector Voltages)
- Threshold Voltage below which I_E is Very Small
  - 0.6-0.7 V (Si) and 0.1 V (Ge) materials
- Input Curves will shift towards left as $\mathbf{V_{CB}}$ Increases.



$$r_{input} = \frac{\Delta V_{EB}}{\Delta I_E} \qquad (@\ \mathrm{V_{CB}} = \mathrm{Constant})$$

- **Dynamic Input Resistance (r_i) can be calculated from I/P characteristics**
- **It varies with the point of measurement**
- **Typical values of r_i are ≈ 20 – 100 Ω**
- **So, Input Resistance of CB config. is Very Low**

Output (or Collector) Static Characteristics

- **Divided into 3 Regions: - Active Region, - Saturation Region, - Cutoff Region**

	Active Region	**Saturation Region**	**Cutoff Region**
Emitter-Base	***Forward Biased***	Forward Biased	Reverse Biased
Collector-Base	***Reverse Biased***	Forward Biased	Reverse Biased

Active Region:

-I_C is essentially independent of V_{CB}
- I_C depends only upon I_E
- Curves are nearly flat in Active region

- **For $I_E = 0$, $I_C = I_{CBO}$ (or I_{CO}) ≠ 0 [called "Reverse Saturation/Leakage Current]**
- **"Reverse Saturation/Leakage Current (I_{CO}) - μA for Ge, nA for Si**

$$I_C = I_E - I_B \quad \& \quad I_C = \alpha_{dc} I_E + I_{CO}$$

Output (or Collector) Static Characteristics

$$\alpha_{dc} = \frac{I_C - I_{CO}}{I_E} \approx \frac{I_C}{I_E} \quad \text{as } I_{CO} << I_C$$

α_{dc} is called "Large Signal Current Gain" or simply "dc alpha"

= Fraction of total emitter current (i.e. electrons) that have traveled from emitter across base to the collector region.

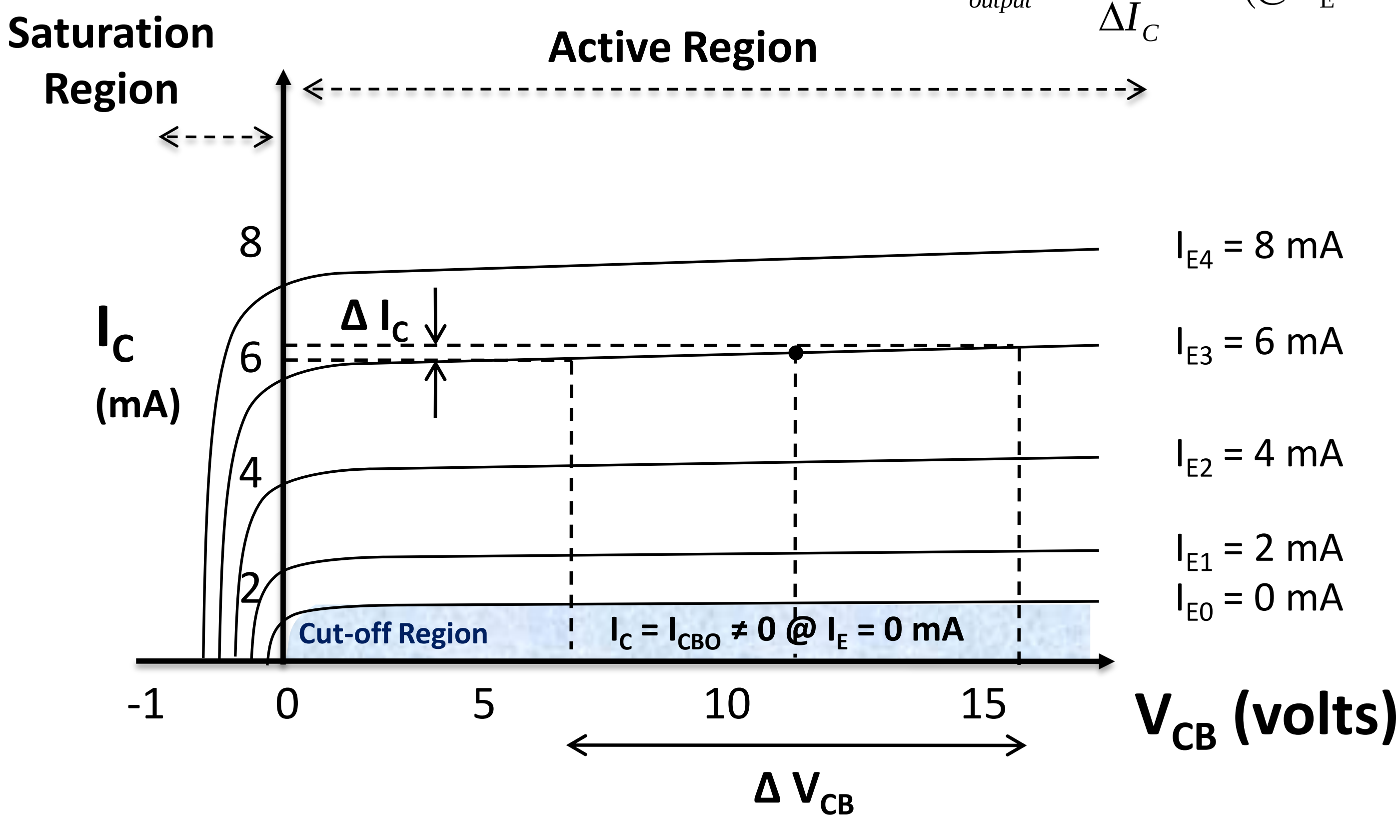
- Typical value of **$\alpha_{dc} \approx 0.98$ (usually range between 0.90 – 0.995)**
- It is not a constant but varies with I_E, V_{CB} & Temperature.

$$\alpha \text{ (or } h_{fb}) = \frac{\Delta I_C}{\Delta I_E} \quad (@ \text{ constant } V_{CB})$$

α is called "Small Signal Short circuit Current Transfer Ratio or Gain" or simply "ac alpha"

Output (or Collector) Static Characteristics

$$r_{output} = \frac{\Delta V_{CB}}{\Delta I_C} \quad (@\ I_E = \text{Constant})$$



- **Dynamic Output Resistance (r_o) can be calculated from O/P characteristics**
- **It does not varies much as curves are almost flat (slope doesn't change much)**
- **Typical values of r_o are ≈ 1M Ω**
- **So, Output Resistance of CB config. is Very Very Large**

Output (or Collector) Static Characteristics

Saturation Region:

- Both E-B and C-B Junctions are Forward –Biased
- As V_{CB} becomes Negative (for npn), the C-B Junction becomes Forward Biased
- Due to C-$B_{Forward\text{-}Bias}$, I_C changes are large for very small change in V_{CB}(Negative values)
- I_C , therefore, sharply decreases (for a given I_E)
- In Saturation Region, I_C doesn't depend much on I_E

Cutoff Region:

- As both E-B and C-B Junctions are Reverse –Biased
- Only Reverse Leakage/Saturation Current I_{CO} (or I_{CBO}) flows in the output circuit