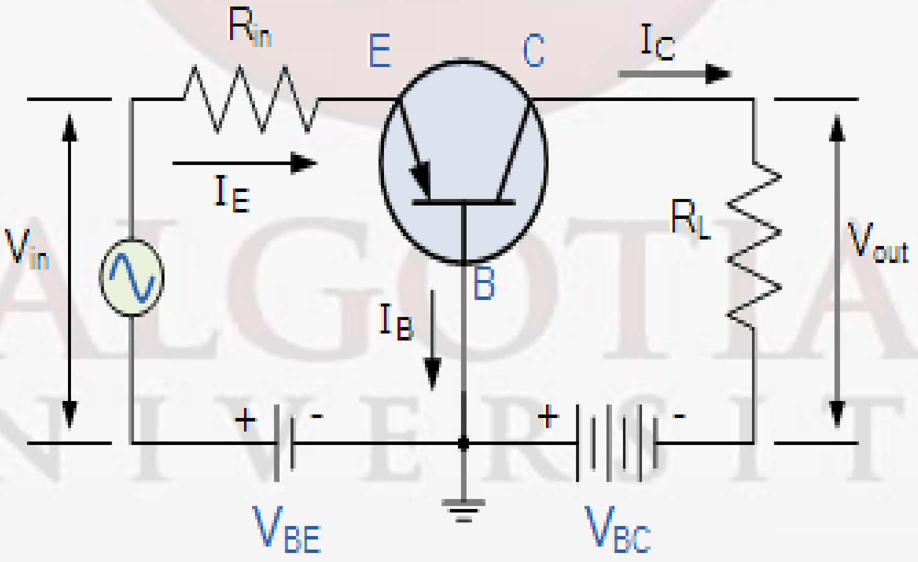
Bipolar Transistor Configurations

- ❖ As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output.
- ❖ Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor vary with each circuit arrangement.

- **Common Base Configuration** – has Voltage Gain but no Current Gain.
- **Common Emitter Configuration** – has both Current and Voltage Gain.
- **Common Collector Configuration**–has Current Gain but no Voltage Gain.

The Common Base (CB) Configuration

- As its name suggests the BASE connection is common to both the input signal AND the output signal.
- The input signal is applied between the transistors base and the emitter terminals, while the corresponding output signal is taken from between the base and the collector terminals as shown



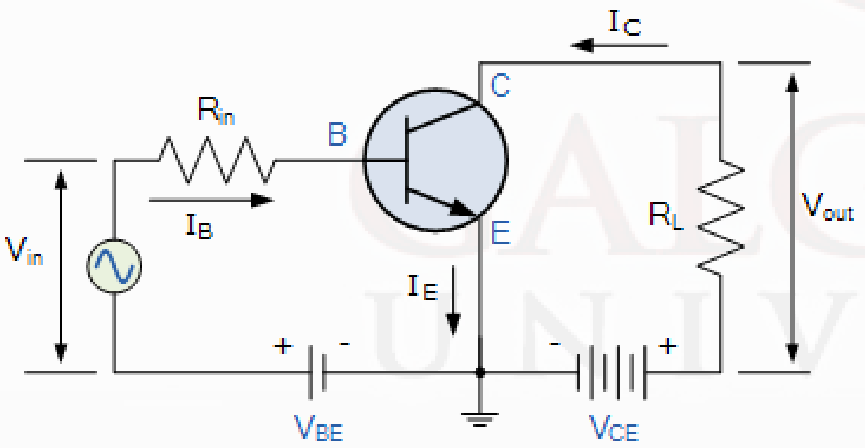
Common Base Voltage Gain

$$A_V = \frac{Vout}{Vin} = \frac{I_C \times R_L}{I_E \times R_{IN}}$$

Where: Ic/Ie is the currentgain,alpha(α) and RL/Rin is the resistance gain

The Common Emitter (CE) Configuration

- In the **Common Emitter** or grounded emitter configuration, the input signal is applied between the base and the emitter, while the output is taken from between the collector and the emitter as shown



The common emitter amplifier configuration produces the highest current and power gain of all the three bipolar transistor configurations. This is mainly because the input impedance is LOW

- the current gain of the common emitter transistor configuration is quite large as it is the ratio of Ic/Ib. A transistors current gain is given the Greek symbol of **Beta, (β).**

- By combining the expressions for both **Alpha, α and Beta, β** the mathematical relationship between these parameters and therefore the current gain of the transistor can be given as:

$$\text{Alpha}, (\alpha) = \frac{I_C}{I_E} \quad \text{and} \quad \text{Beta}, (\beta) = \frac{I_C}{I_B}$$

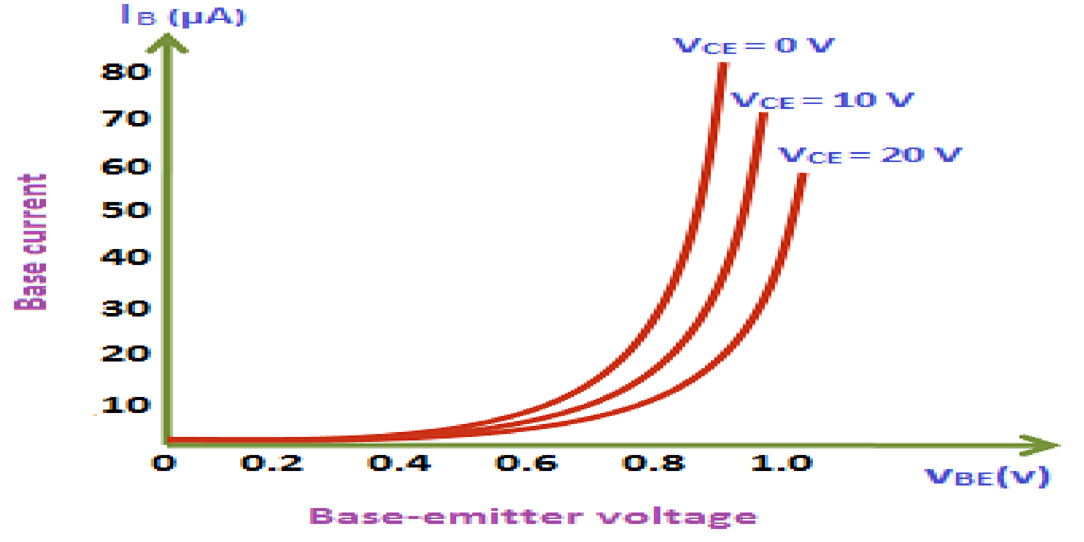
- .

$$\therefore I_C = \alpha . I_E = \beta . I_B$$

$$\text{as: } \alpha = \frac{\beta}{\beta + 1} \quad \beta = \frac{\alpha}{1 - \alpha} \quad I_E = I_C + I_B$$

Input characteristics

- The input characteristics describe the relationship between input current or **base current (I_B)** and input voltage or **base-emitter voltage (V_{BE}).**
- To determine the input characteristics, the output voltage V_{CE} is kept constant at zero volts and the input voltage V_{BE} is increased from zero volts to different voltage levels. For each voltage level of input voltage (V_{BE}), the corresponding input current (I_B) is recorded.



I/P characteristics CE configuration

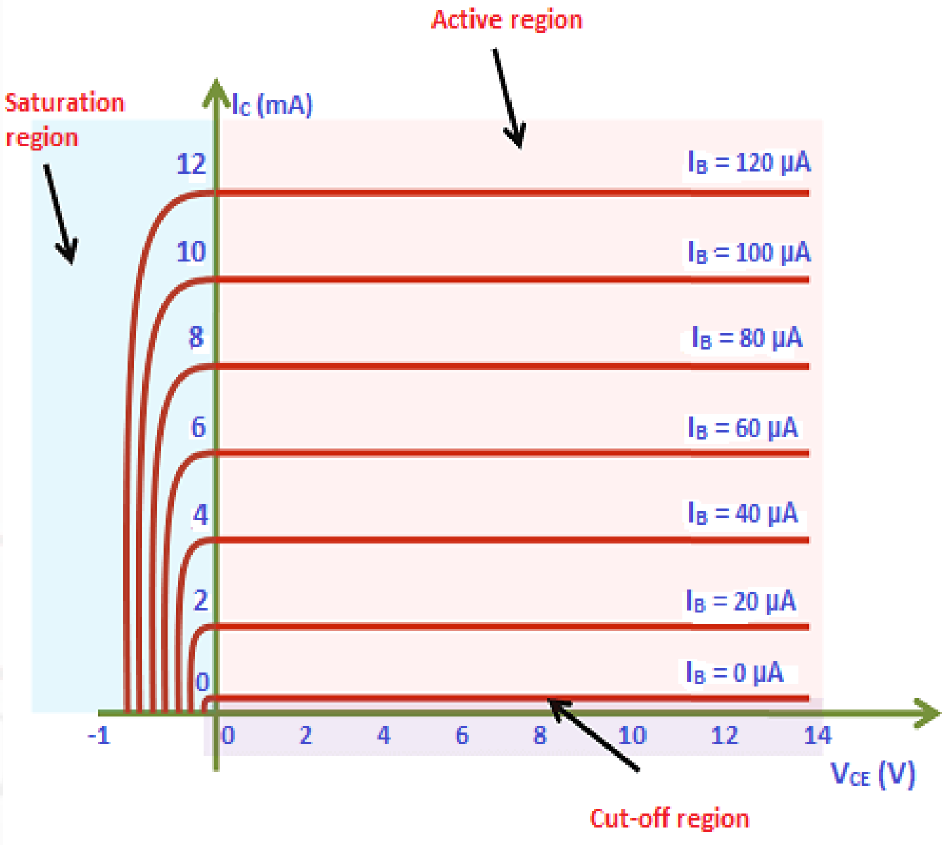
- A curve is then drawn between input current I_B and input voltage V_{BE} at constant output voltage V_{CE} (0 volts).

- Next, the output voltage (V_{CE}) is increased from zero volts to certain voltage level (10 volts) and the output voltage (V_{CE}) is kept constant at 10 volts. While increasing the output voltage (V_{CE}), the input voltage (V_{BE}) is kept constant at zero volts. After we kept the output voltage (V_{CE}) constant at 10 volts, the input voltage V_{BE} is increased from zero volts to different voltage levels. For each voltage level of input voltage (V_{BE}), the corresponding input current (I_B) is recorded.

- This process is repeated for higher fixed values of output voltage (V_{CE}).

Output characteristics

- The **output characteristics** describe the relationship between output current (I_C) and output voltage (V_{CE})



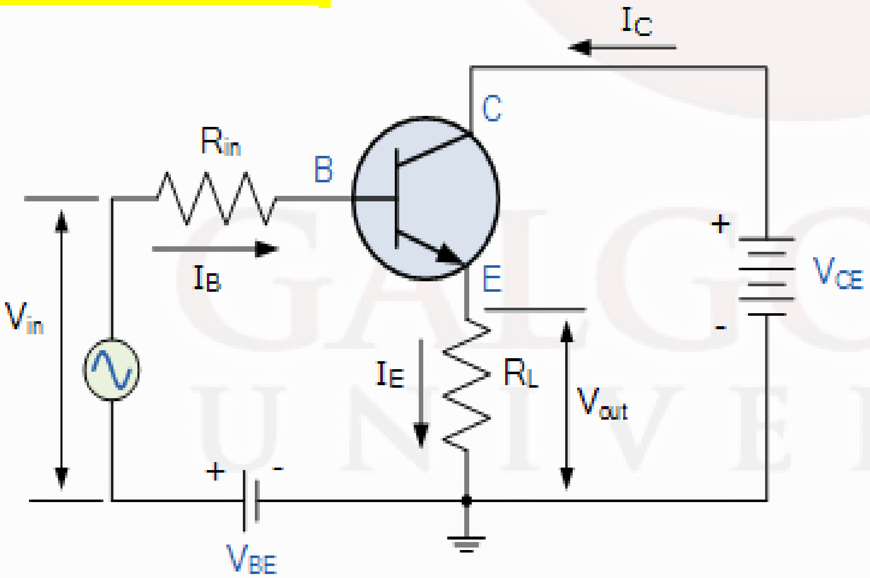
O/P Characteristics CE Configuration

- A curve is then drawn between output current I_C and output voltage V_{CE} at constant input current I_B (0 μA).
- When the base current or input current I_B = 0 μA, the transistor operates in the cut-off region. In this region, both junctions are reverse biased.
- Next, the input current (I_B) is increased from 0 μA to 20 μA by adjusting the input voltage (V_{BE}). The input current (I_B) is kept constant at 20 μA
- After we kept the input current (I_B) constant at 20 μA, the output voltage (V_{CE}) is increased from zero volts to different voltage levels. For each voltage level of output voltage (V_{CE}), the corresponding output current (I_C) is recorded.
- A curve is then drawn between output current I_C and output voltage V_{CE} at constant input current I_B (20 μA). This region is known as the active region of a transistor.

The Common Collector (CC) Configuration

- In the **Common Collector** or grounded collector configuration, the collector is connected to ground through the supply, thus the collector terminal is common to both the input and the output

- This type of configuration is commonly known as a **Voltage Follower or Emitter Follower circuit**



The Common Collector Current Gain

$$I_E = I_C + I_B$$

$$A_i = \frac{I_E}{I_B} = \frac{I_C + I_B}{I_B}$$

$$A_i = \frac{I_C}{I_B} + 1 \qquad A_i = \beta + 1$$

Relationship between DC Currents and Gains

$$I_E = I_B + I_C \qquad \alpha = \frac{I_C}{I_E} = \frac{\beta}{1+\beta}$$

$$I_C = I_E - I_B$$

$$I_B = I_E - I_C \qquad \beta = \frac{I_C}{I_B} = \frac{\alpha}{1-\alpha}$$

$$I_B = \frac{I_C}{\beta} = \frac{I_E}{1+\beta} = I_E(1-\alpha) \qquad I_C = \beta.I_B = \alpha.I_E \qquad I_E = \frac{I_C}{\alpha} = I_B(1+\beta)$$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