

## 2.3 COMMON EMITTER CONFIGURATION

A transistor is a three terminal device. The terminals are emitter, base, collector. In common emitter configuration, input voltage is applied between base and emitter terminals and output is taken across the collector and emitter terminals. Therefore, the emitter terminal is common to both input and output.

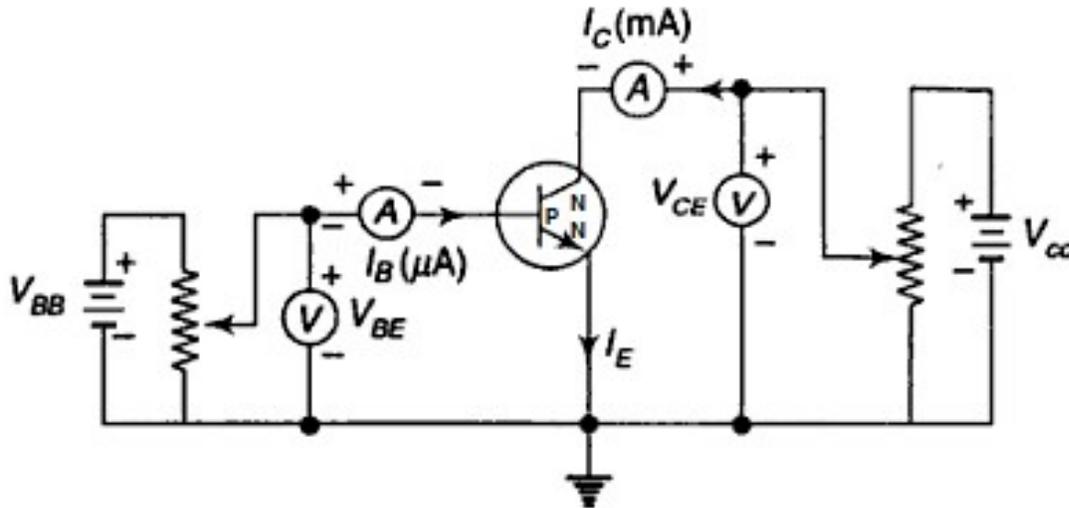


Fig:2.3.1 Common Emitter Configuration of NPN Transistor

### Input characteristics

The input characteristics describe the relationship between input current or base current ( $I_B$ ) and input voltage or base-emitter voltage ( $V_{BE}$ ).

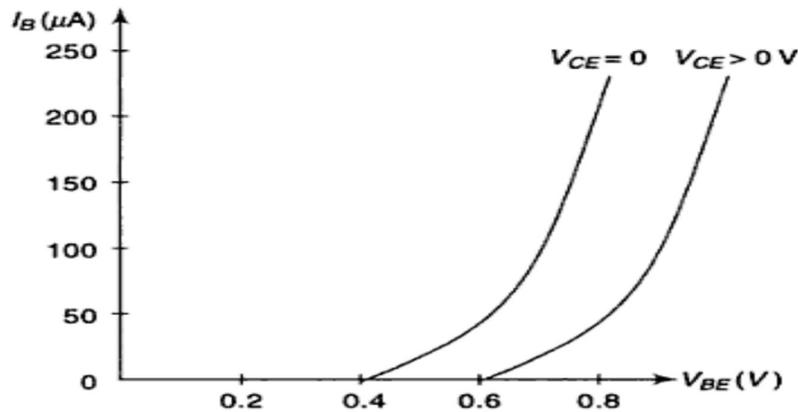
First, draw a vertical line and a horizontal line. The vertical line represents y-axis and horizontal line represents x-axis. The input current or base current ( $I_B$ ) is taken along y-axis (vertical line) and the input voltage ( $V_{BE}$ ) is taken along x-axis (horizontal line).

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.

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 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.

A curve is then drawn between input current  $I_B$  and input voltage  $V_{BE}$  at constant output voltage  $V_{CE}$  (10 volts). This process is repeated for higher fixed values of output voltage ( $V_{CE}$ ). When output voltage ( $V_{CE}$ ) is at zero volts and emitter-base junction is forward biased by input voltage ( $V_{BE}$ ), the emitter-base junction acts like a normal p-n junction diode. So the input characteristics of the CE configuration is same as the characteristics of a normal pn junction diode.



**Fig:2.3.2 Input characteristics of Common Emitter Configuration**

The cut in voltage of a silicon transistor is 0.7 volts and germanium transistor is 0.3 volts. In our case, it is a silicon transistor. So from the above graph, after 0.7 volts, a small increase in input voltage ( $V_{BE}$ ) will rapidly increases the input current ( $I_B$ ).

In common emitter (CE) configuration, the input current ( $I_B$ ) is very small as compared to the input current ( $I_E$ ) in common base (CB) configuration. The input current in CE configuration is measured in microamperes ( $\mu A$ ) whereas the input current in CB configuration is measured in milliamperes (mA).

In common emitter (CE) configuration, the input current ( $I_B$ ) is produced in the base region which is lightly doped and has small width. So the base region produces only a small input current ( $I_B$ ). On the other hand, in common base (CB) configuration, the input current ( $I_E$ ) is produced in the emitter region which is heavily doped and has large width. So the emitter region produces a large input current ( $I_E$ ). Therefore, the input current ( $I_B$ ) produced in the common emitter (CE) configuration is small as compared to the common base (CB) configuration.

Due to forward bias, the emitter-base junction acts as a forward biased diode and due to reverse bias, the collector-base junction acts as a reverse biased diode. Therefore, the width of the depletion region at the emitter-base junction is very small whereas the width of the depletion region at the collector-base junction is very large.

If the output voltage  $V_{CE}$  applied to the collector-base junction is further increased, the depletion region width further increases. The base region is lightly doped as compared to the collector region. So the depletion region penetrates more into the base region and less into the collector region. As a result, the width of the base region decreases which in turn reduces the input current ( $I_B$ ) produced in the base region.

From the above characteristics, for higher fixed values of output voltage  $V_{CE}$ , the curve shifts to the right side. This is because for higher fixed values of output voltage, the cut in voltage is increased above 0.7 volts. Therefore, to overcome this cut in voltage, more input voltage  $V_{BE}$  is needed than previous case.

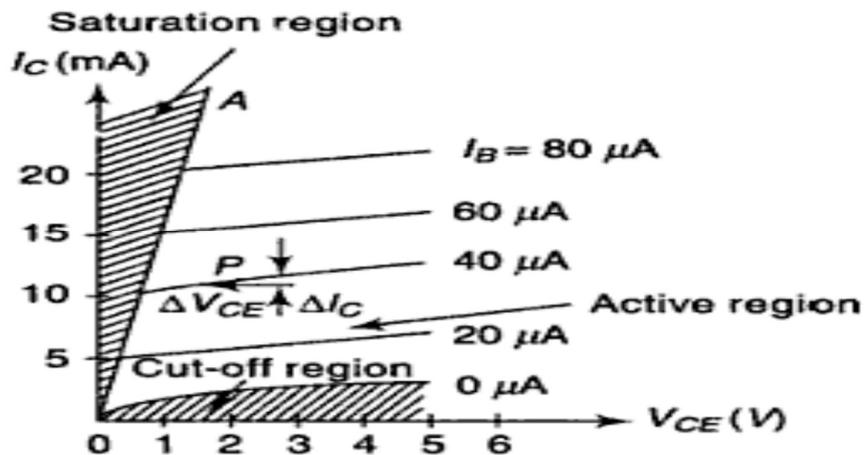
### **Output characteristics**

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

First, draw a vertical line and a horizontal line. The vertical line represents y-axis and horizontal line represents x-axis. The output current or collector current ( $I_C$ ) is taken along y-axis (vertical line) and the output voltage ( $V_{CE}$ ) is taken along x-axis (horizontal line).

To determine the output characteristics, the input current or base current  $I_B$  is kept constant at  $0 \mu A$  and the output voltage  $V_{CE}$  is increased from zero volts to different voltage levels. For each level of output voltage, 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  $I_B$  ( $0 \mu A$ ).



**Fig:2.3.3 Output characteristics of Common Emitter Configuration**

When the base current or input current  $I_B = 0 \mu A$ , 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  $0 \mu A$  to  $20 \mu A$  by adjusting the input voltage ( $V_{BE}$ ). The input current ( $I_B$ ) is kept constant at  $20 \mu A$ .

While increasing the input current ( $I_B$ ), the output voltage ( $V_{CE}$ ) is kept constant at 0 volts.

After kept the input current ( $I_B$ ) constant at  $20 \mu A$ , 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  $I_B$  ( $20 \mu A$ ). This region is known as the active region of a transistor. In this region, emitter-base junction is forward biased and the collector-base junction is reverse biased.

This steps are repeated for higher fixed values of input current  $I_B$  (I.e.  $40 \mu A$ ,  $60 \mu A$ ,  $80 \mu A$  and so on).

### Transistor parameters

#### Dynamic input resistance ( $r_i$ )

Dynamic input resistance is defined as the ratio of change in input voltage or base voltage ( $V_{BE}$ ) to the corresponding change in input current or base current ( $I_B$ ), with the output voltage or collector voltage ( $V_{CE}$ ) kept at constant.

$$r_i = \frac{\Delta V_{BE}}{\Delta I_B}, \quad V_{CE} = \text{constant}$$

In CE configuration, the input resistance is very low.

**Dynamic output resistance ( $r_o$ )**

Dynamic output resistance is defined as the ratio of change in output voltage or collector voltage (VCE) to the corresponding change in output current or collector current (IC), with the input current or base current (IB) kept at constant.

$$r_o = \frac{\Delta V_{CE}}{\Delta I_C}, \quad I_B = \text{constant}$$

In CE configuration, the output resistance is high.

**Current gain ( $\alpha$ )**

The current gain of a transistor in CE configuration is defined as the ratio of output current or collector current (IC) to the input current or base current (IB).

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

The current gain of a transistor in CE configuration is high. Therefore, the transistor in CE configuration is used for amplifying the current.

