2.4 COMMON BASE CONFIGURATION

In common base configuration, emitter is the input terminal, collector is the output terminal and base terminal is connected as a common terminal for both input and output. That means the emitter terminal and common base terminal are known as input terminals whereas the collector terminal and common base terminal are known as output terminals.

In common base configuration, the base terminal is grounded so the common base configuration is also known as grounded base configuration. Sometimes common base configuration is referred to as common base amplifier, CB amplifier, or CB configuration.

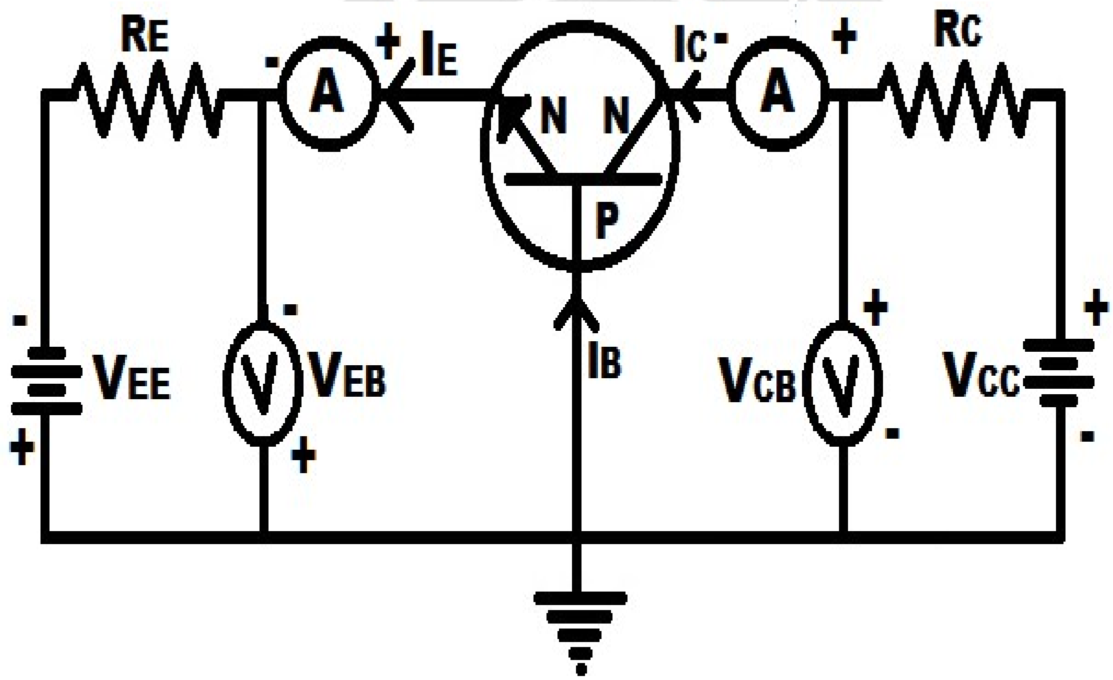

Fig:2.4.1 Common Base Configuration of NPN Transistor

The input signal is applied between the emitter and base terminals while the corresponding output signal is taken across the collector and base terminals. Thus the base terminal of a transistor is common for both input and output terminals and hence it is named as common base configuration.

The supply voltage between base and emitter is denoted by VBE while the supply voltage between collector and base is denoted by VCB.

In every configuration, the base-emitter junction JE is always forward biased and collector-base junction JC is always reverse biased. Therefore, in common base configuration, the base-emitter junction JE is forward biased and collector-base junction JC is reverse biased.

Input characteristics

The input characteristics describe the relationship between input current (IE) and the input voltage (VBE).

First, draw a vertical line and horizontal line. The vertical line represents y-axis and horizontal line represents x-axis. The input current or emitter current (IE) is taken along the y-axis (vertical line) and the input voltage (VBE) is taken along the x-axis (horizontal line).

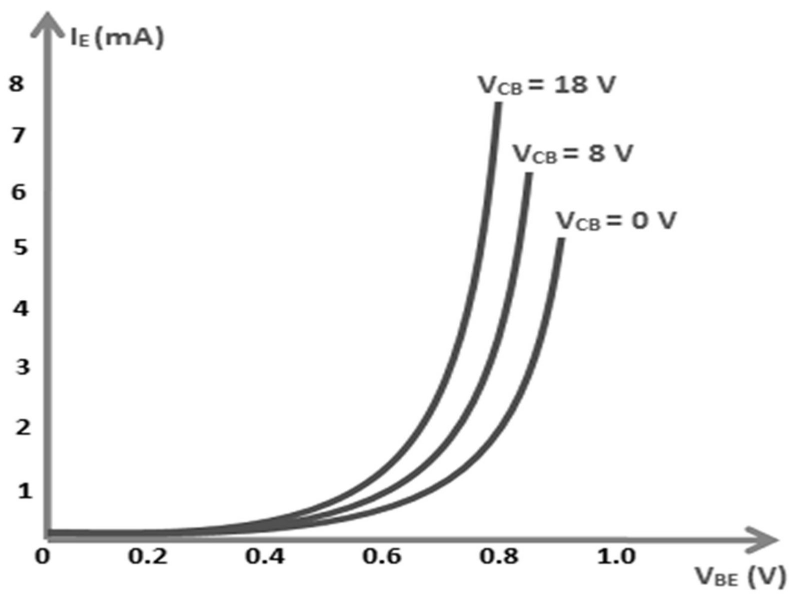

Fig:2.4.2 Input characteristics of Common Base Configuration

To determine the input characteristics, the output voltage VCB (collector-base voltage) is kept constant at zero volts and the input voltage VBE is increased from zero volts to different voltage levels. For each voltage level of the input voltage (VBE), the input current (IE) is recorded on a paper or in any other form.

A curve is then drawn between input current IE and input voltage VBE at constant output voltage VCB (0 volts).

The output voltage (VCB) is increased from zero volts to a certain voltage level (8 volts) and kept constant at 8 volts. While increasing the output voltage (VCB), the input voltage (VBE) is kept constant at zero volts. After kept the output voltage (VCB) constant at 8 volts, the input voltage VBE is increased from zero volts to different voltage levels. For each voltage level of the input voltage (VBE), the input current (IE) is recorded on a paper or in any other form.

A curve is then drawn between input current IE and input voltage VBE at constant output voltage VCB (8 volts).

This is repeated for higher fixed values of the output voltage (VCB).

When output voltage (VCB) is at zero volts and emitter-base junction JE is forward biased by the input voltage (VBE), the emitter-base junction acts like a normal p-n junction diode. So the input characteristics are same as the forward characteristics of a normal pn junction diode.

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, can see that after 0.7 volts, a small increase in input voltage (VBE) will rapidly increase the input current (IE).

When the output voltage (VCB) is increased from zero volts to a certain voltage level (8 volts), the emitter current flow will be increased which in turn reduces the depletion region width at emitter-base junction. As a result, the cut in voltage will be reduced. Therefore, the curves shifted towards the left side for higher values of output voltage VCB.

Output characteristics

The output characteristics describe the relationship between output current (IC) and the output voltage (VCB).

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 (IC) is taken along the y-axis (vertical line) and the output voltage (VCB) is taken along the x-axis (horizontal line).

To determine the output characteristics, the input current or emitter current IE is kept constant at zero mA and the output voltage VCB is increased from zero volts to different voltage levels. For each voltage level of the output voltage VCB, the output current (IC) is recorded.

A curve is then drawn between output current IC and output voltage VCB at constant input current IE (0 mA).

When the emitter current or input current IE is equal to 0 mA, the transistor operates in the cut-off region.

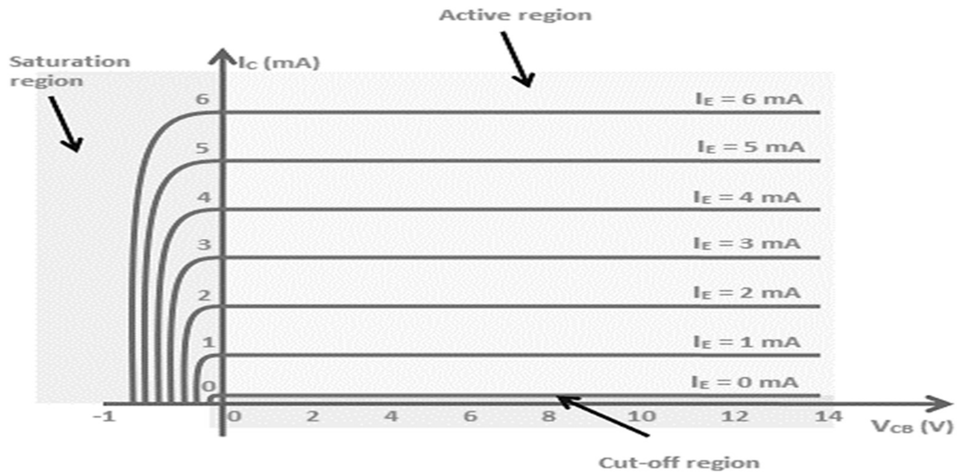

Fig:2.4.3 Output characteristics of Common Base Configuration

Next, the input current (IE) is increased from 0 mA to 1 mA by adjusting the input voltage VBE and the input current IE is kept constant at 1 mA. While increasing the input current IE, the output voltage VCB is kept constant.

After kept the input current (IE) constant at 1 mA, the output voltage (VCB) is increased from zero volts to different voltage levels. For each voltage level of the output voltage (VCB), the output current (IC) is recorded.

A curve is then drawn between output current IC and output voltage VCB at constant input current IE (1 mA). This region is known as the active region of a transistor.

This is repeated for higher fixed values of input current IE (I.e. 2 mA, 3 mA, 4 mA and so on).

From the above characteristics, can see that for a constant input current IE, when the output voltage VCB is increased, the output current IC remains constant.

At saturation region, both emitter-base junction JE and collector-base junction JCare forward biased. From the above graph, can see that a sudden increase in the collector current when the output voltage VCB makes the collector-base junction JC forward biased.

Early effect

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

If the output voltage VCB applied to the collector-base junction JC 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. This dependency of base width on the output voltage (VCB) is known as an early effect.

If the output voltage VCB applied to the collector-base junction JC is highly increased, the base width may be reduced to zero and causes a voltage breakdown in the transistor. This phenomenon is known as punch through.

Transistor parameters

Dynamic input resistance (ri)

Dynamic input resistance is defined as the ratio of change in input voltage or emitter voltage (VBE) to the corresponding change in input current or emitter current (IE), with the output voltage or collector voltage (VCB) kept at constant.

$$r_i = \frac{\Delta V_{BE}}{\Delta I_E}, \qquad V_{CB} = \text{constant}$$

The input resistance of common base amplifier is very low.

Dynamic output resistance (ro)

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

$$r_o = \frac{\Delta V_{CB}}{\Delta I_C}, \qquad I_E = \text{constant}$$

The output resistance of common base amplifier is very high.

Current gain (α)

The current gain of a transistor in CB configuration is defined as the ratio of output current or collector current (IC) to the input current or emitter current (IE).

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

The current gain of a transistor in CB configuration is less than unity. The typical current gain of a common base amplifier is 0.98.