# Experiment #1- Part#1

## Characteristics of Bipolar Junction

## Object

The purpose of this experiment is to determine and graph the input and output characteristics of a bipolar junction transistor (BJT) in the common emitter configuration, and to measure its h-parameters at a given DC bias point.

## Required Parts and Equipment's

1. Electronic Test Board. (M90)
2. Dual DC Power Supply.
3. Digital Multi-meters.
4. NPN Transistors (BC337).
5. Resistors 33kΩ,120Ω
6. Leads and Wires.

## Theory

A bipolar junction transistor (BJT) is a three-terminal device capable of amplifying a small AC signal. The three terminals are called the base, emitter, the collector. BJTs consist of a very thin base material sandwiched between two of the opposite type materials. Bipolar transistors are available in two forms, either NPN or PNP. The middle letter indicates the type of material used for the base, while the outer letters indicate the emitter and collector terminals. The emitter is heavily doped, the base is lightly doped, and the collector is intermediately doped. Fig.1 shows BJT transistor construction and symbols.

As shown in Fig.1, two P-N junctions are formed when a transistor is made, the junction between the base and emitter, and the junction between the base and collector. These two junctions form two diodes, the emitter-base diode and the collector-base diode.

There are three configurations in connecting the BJT depending on which of the three terminals is used as the common terminal. These configurations are the common emitter (CE), the common base (CB), and the common collector (CC).

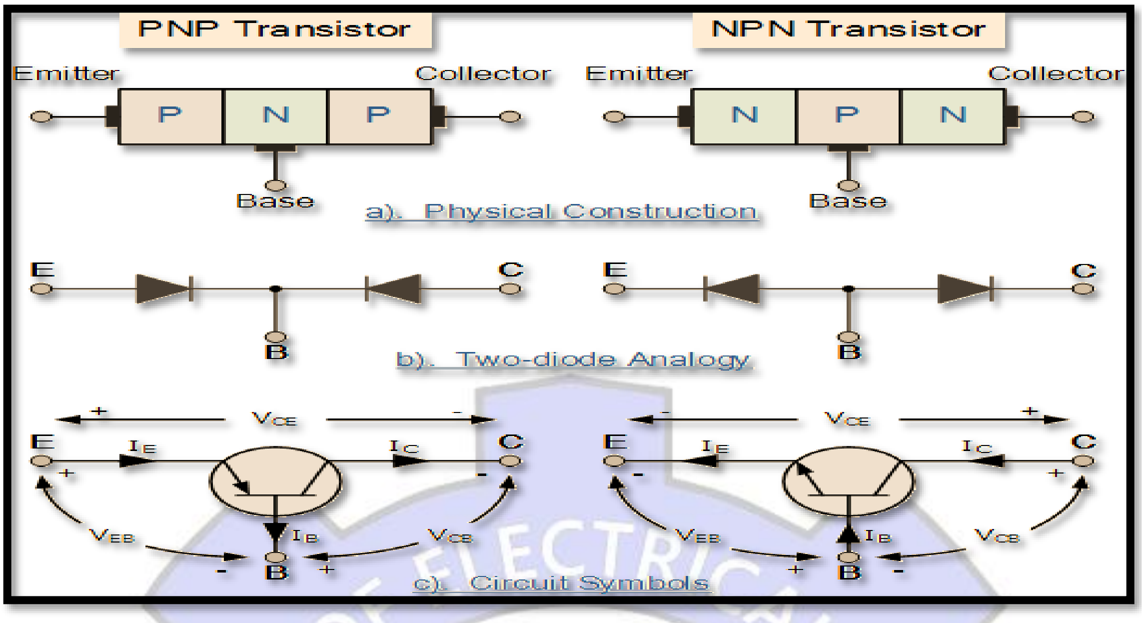


Figure 1: Types of BJT Transistors

Common emitter configuration is most effective because of its high current gain, high voltage gain and power gain. In common emitter configuration, emitter terminal is made common to both input and output circuits as shown in Fig.2. Input junction (Emitter-Base Junction) is forward biased and output junction (Collector-Base Junction) is reverse biased so that the input junction is having low resistance (since it is forward biased) and the output junction is having high resistance (since it is reverse biased).

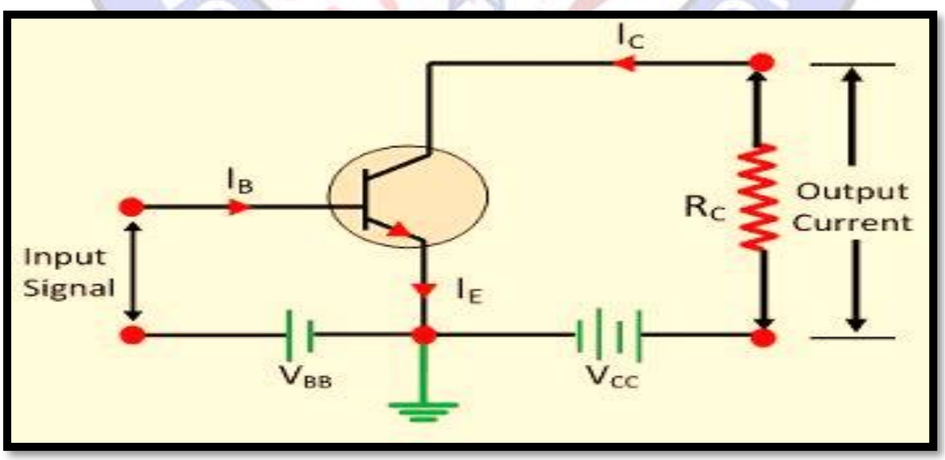


Figure 2: Common Emitter Transistor Configuration

Bipolar transistors are primarily current amplifiers. In the CE configuration, a small base current is amplified to a larger current in the collector circuit. The ratio of the DC collector current $I_C$ to the DC base current $I_B$ is called the DC beta ($\beta_{dc}$) of the transistor. Thus:

$$\beta_{dc} = \frac{I_C}{I_B}$$

Typical values of $\beta_{dc}$ range from 20 to 250 or higher. $\beta_{dc}$ is usually designated as $h_{FE}$ in transistor datasheets. Hence:

$$h_{FE}=\beta_{dc}$$

Another useful parameter in bipolar transistors is the DC alpha ($\alpha_{dc}$). It is defined as the ratio of the DC collector current $I_C$ to the DC emitter current $I_E$. Thus:

$$\alpha_{dc} = \frac{I_C}{I_E}$$

Typically, values of αdc range from 0.95 to 0.99, but αdc is always less than 1.

- **Common Emitter Input and Output Characteristics**

Two sets of characteristics are necessary to describe fully the behavior of the common emitter configuration: the input (or base) characteristics, and the output (or collector) characteristics. Input characteristics of a transistor are curves showing the variation of input (base) current IB as a function of input (base-emitter) voltage $V_{BE}$, when the output (collector-emitter) voltage VCE is kept constant. Fig.3 depicts the input characteristics for a typical transistor.

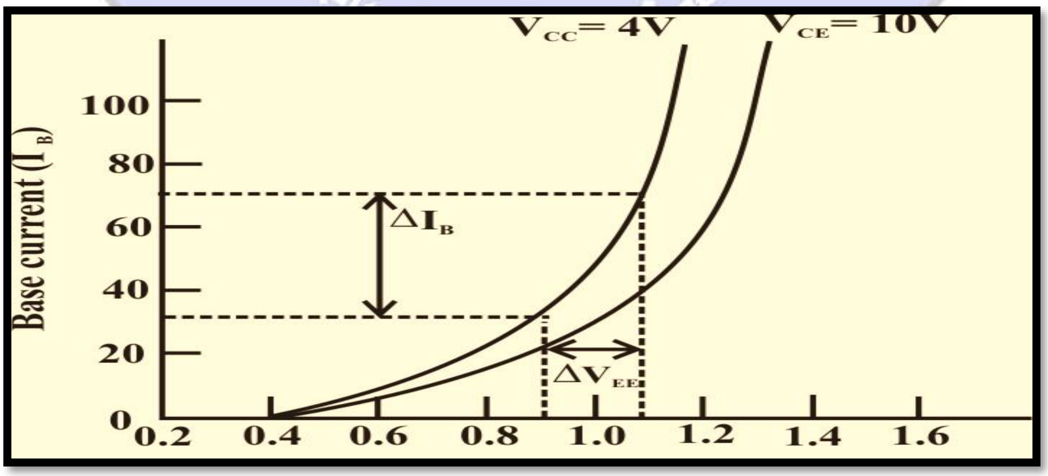


Figure 3: Typical Input Characteristics of a Silicon NPN Transistor in the Common Emitter Configuration

As shown from Fig.3, the input characteristics are similar to that of a forward-biased diode since the emitter-base junction is forward-biased. Note also the slight shift in the curves when increasing $V_{CE}$.

Output characteristics of a transistor are curves showing the variation of the output current $I_C$ as a function of output voltage $V_{CE}$, when the input current $I_B$ is kept constant. Fig.4 depicts the output characteristics for a typical transistor.

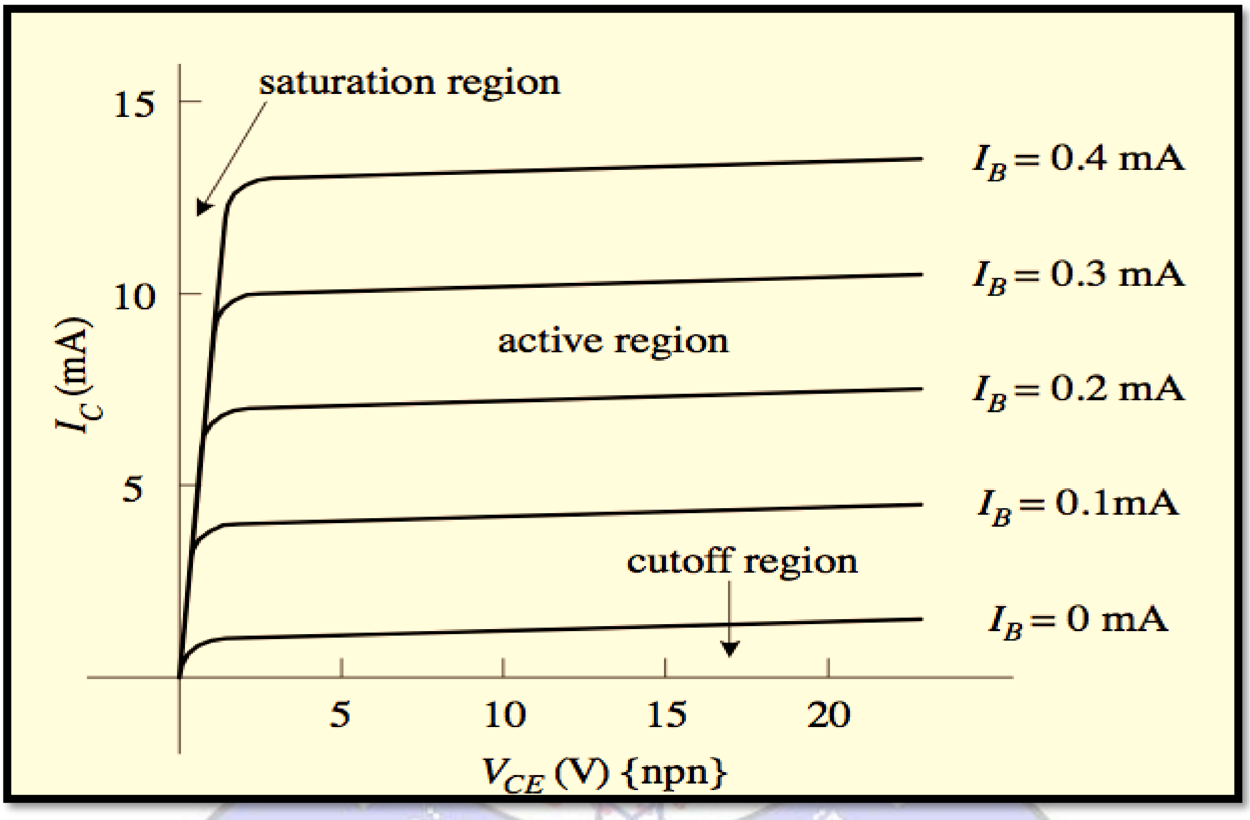


Figure 4: Typical Output Characteristics of a Silicon NPN Transistor in the Common Emitter Configuration

As shown from Fig.4, for very small values of $V_{CE}$ the collector-base junction is forward biased and the transistor is in the saturation region. In this portion of the curves, $I_C$ is increased linearly with $V_{CE}$. As $V_{CE}$ increases, the collector-base junction becomes reverse-biased and the transistor goes into the active region. In this portion of the curves, $I_C$ remains essentially constant (for a given value of $I_B$) as $V_{CE}$ continues to increase. Actually, $I_C$ increases very slightly as $V_{CE}$ increases due to widening of the collector-base depletion region. For this portion of the characteristic curves, the value of $I_C$ is only determined by the expression:

$$I_C = \beta_{dc} I_B$$

Fig.5 shows a common emitter circuit that can be used to generate the input and output characteristic curves. The purpose of RB in this circuit is to limit the base current to a safe level.

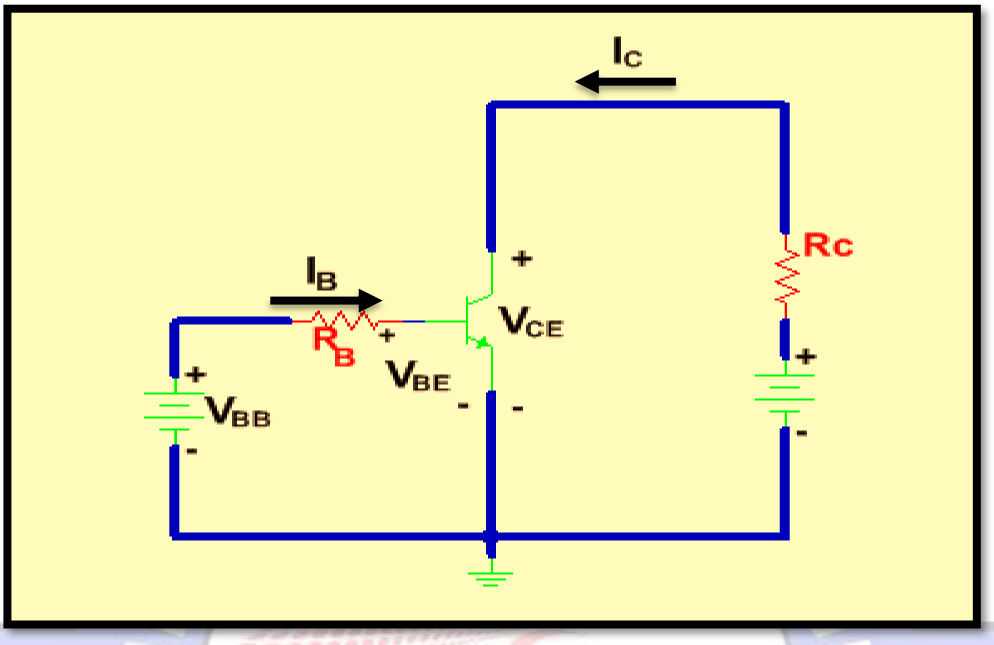


Figure 5: Test Circuit used to generate the Common Emitter Input and Output Characteristics