Expt.No.6: Transistor characteristics

Aim:

1. Obtain the IV characteristics of a given transistor in its CE configuration.

Apparatus:

Transistor, Micro ammeter, Millimeter, Voltmeter, & connecting wires, etc**.**

Theory:

The transistor was invented by John Bardeen and Walter Brattain in the year 1948 and was improved by William Shockley in 1951. The three of them received the Nobel Prize for Physics in 1956 for the invention of transistor. Transistors form the basis of almost all modern electronic devices. A transistor consists of two P-N junctions formed by sand witching either a P-type or N-type semiconductor material between a pair of opposite type of semiconductor materials. Hence two types of transistors (i) PNP and (ii) NPN transistors are possible [figure 3.1(a) & figure 3.1(b)]. Their symbols are also shown in the figure.

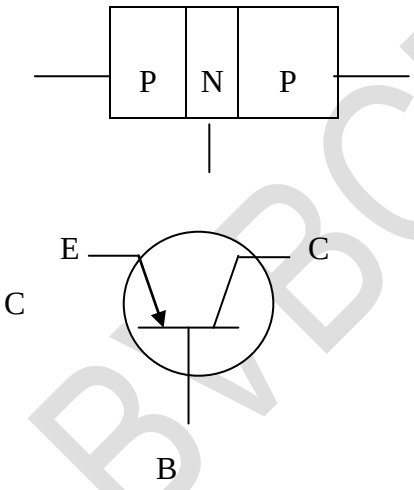


Figure3. 1(a)

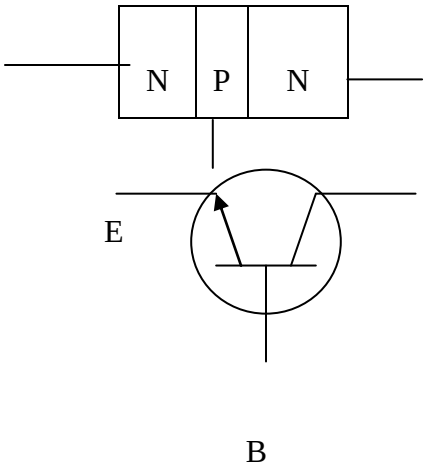


Figure 3.1(b)

E – Emitter B – Base C – Collector

Terminals of Transistor: A transistor may be regarded as made up of two P-N junctions connected back to back. The middle section of the transistor is known as

'Base'. The section on one side of the base which supplies the free charges is known as **'Emitter'** and the section on the other side which collects these charges is known as **'Collector'**. The junction between the emitter and base is known as **emitter-base junction** or simply emitter junction. The junction between collector and base is known as **collector-base junction** or simply collector junction. In schematic symbols of transistor an arrow is shown for emitter to indicate the direction of the conventional current.

Transistor action: For normal operation of the transistor the emitter junction must be forward biased and the collector junction must be reverse biased [Figure 3. 2(a) and(b)]. The forward biased emitter junction offers very low resistance to the current flow and the reverse biased collector junction offers high resistance to the flow of current. A weak signal is introduced at the low resistance emitter side and the output is taken from the high resistance collector side. A transistor, therefore, transfers signal from low resistance side to high resistance side. Hence the name transistor is derived from the two words **TRANSfer resISTOR.**

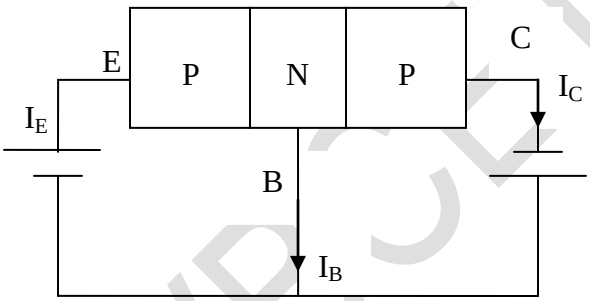


Figure 3. 2(a)

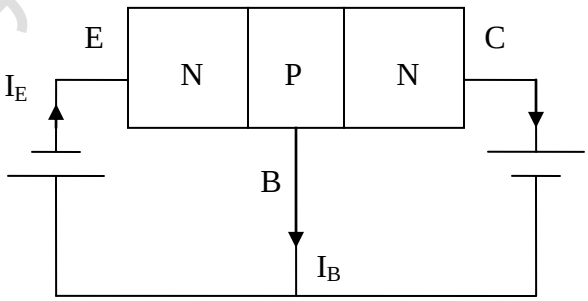


Figure 3. 2(b)

The current flow in the emitter base junction has to primarily carry out by the majority carriers in the emitter region. The flow of majority carriers from the base to the emitter does not contribute to the collector current. Hence **in a transistor the emitter region is heavily doped, the base is lightly doped.** The collector is doped to a level greater than that of the base and less than that of the emitter. For efficient working of a transistor, collector current must be a large fraction of the emitter current. This is possible only if emitter current is entirely due to the flow of the majority carriers from the emitter and the

loss of majority carriers from emitter in base is kept a minimum. This is possible only if the emitter is heavily doped and the base is made very thin.

The area of the collector junction is generally made considerably larger than that of the emitter junction. This is necessary because the majority carriers from the emitter diffuse through the base in forward direction and as well as sideways. A large area of the collector junction prevents excess recombination of holes and electrons in the base region.

Transistor configurations: The transistor is a three terminal device. A transistor is normally used as an amplifier. For an amplifier there should be two terminals for input and two terminals for output. Since the transistor has only three terminals, one of the terminals is used as a common terminal to both the input and the output. Accordingly, a transistor can be connected in the following three different configurations:

(1) Common -- Base (CB) configuration
(2) Common – Emitter (CE) configuration.
(3) Common – Collector (CC) configuration.

Regardless of the type of connection, the emitter-base junction is always forward biased and collector-base junction is reverse biased, when used as an amplifier. Each of these circuit connections has specific advantages and disadvantages. The common-emitter configuration has a specific feature that its high gain which is due to the fact that the changes in base current affect the collector current more than changes in emitter current for common-base circuit.

A bipolar transistor is usually regarded as a current amplifier, and its characteristics are usually described in term of current. In each configuration, the transistor has two characteristics, viz. (i) Input characteristics, and (ii) Output characteristics.

Current Gain: Since the input controls the output current the gain in the transistor is characterized by current gain or current amplification factor.

In general current amplification is defined as the ratio of the output current to the input current.

The Beta factor (β) : It is the property of the common-emitter circuits. It is the ratio of collector current (I_C) to the base current (I_B) at constant collector to emitter potential (V_{CE}).

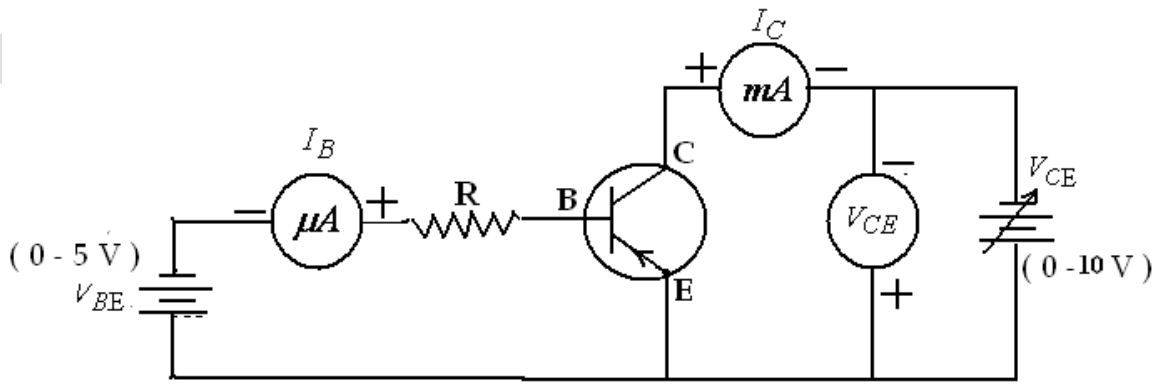
$$\beta_{dc} = \left(\frac{I_C}{I_B}\right)_{V_{CE}} \quad ----(2)$$

In Junction transistors, β reaches the value of 40 and even 100 in some units. The reason for this is that I_B is very small as compared to I_C.

Experimental Procedure:

1. The given transistor is connected in CE configuration as shown in circuit diagram.
2. First, the base current 'I_B' is fixed for certain value. Then V_{CE} is varied in steps and corresponding collector current I_c is noted down till you get a constant collector current.
3. Step 2 is repeated for different fixed values of I_B.
4. A graph of I_C v/s V_{CE} for various fixed I_B is plotted.
5. Note down Steady Value of I_C for various fixed I_B value in table 2.
6. Another graph is plotted for I_C v/s I_B.
7. Finally the current amplification factor 'β' is calculated from the graph.

Circuit Diagram :



Nature of Graph:

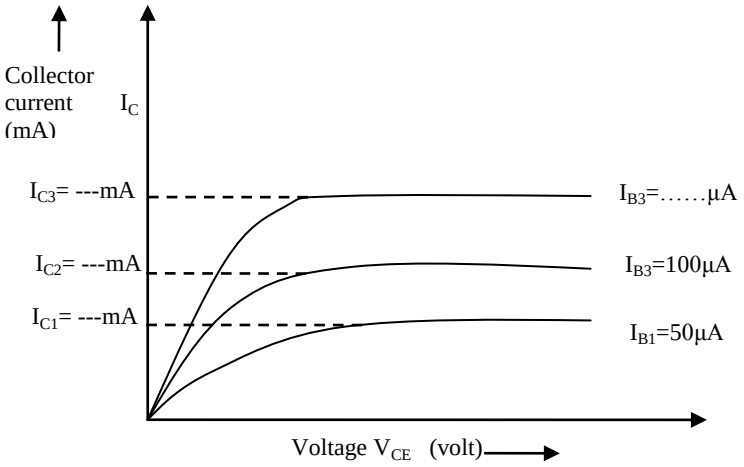


Figure: 1

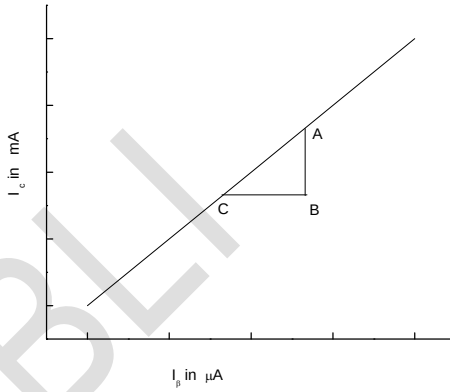


Figure: 2

Tabular column 1: Variation of collector current with base current

Sl. No.	I_B =50 μA		I_B =100μA		I_B =150 μA		I_B =200 μA		I_B =250 μA	
	V_{CE} in Volts	I_C in mA	V_{CE} in Volts	I_C in mA	V_{CE} in Volts	I_C in mA	V_{CE} in Volts	I_C in mA	V_{CE} in Volts	I_C in mA
Error	±	±								

Tabular Column 2: Saturated collector current with base current

Base Current I_B in μA	Collector Current I_C in mA
50	
100	
150	
200	
250	

Result:

1. The current amplification factor $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}} = \ldots\ldots\ldots\ldots\ldots$ from graph

(Figure 2)

Viva Questions:

1. Why it is called a transistor?
2. What are other modes of operation of a transistor?
3. What is the advantage of using a transistor over a triode valve?
4. Under normal use of transistors, how they are biased?
5. What is meant by input characteristics of a transistor?
6. Which configuration gives mare current gain and voltage gain (more than unity)?
7. On what a factor does the characteristic of a transistor depends?
8. What are the advantages of common emitter configuration?
9. What are the applications of transistor?