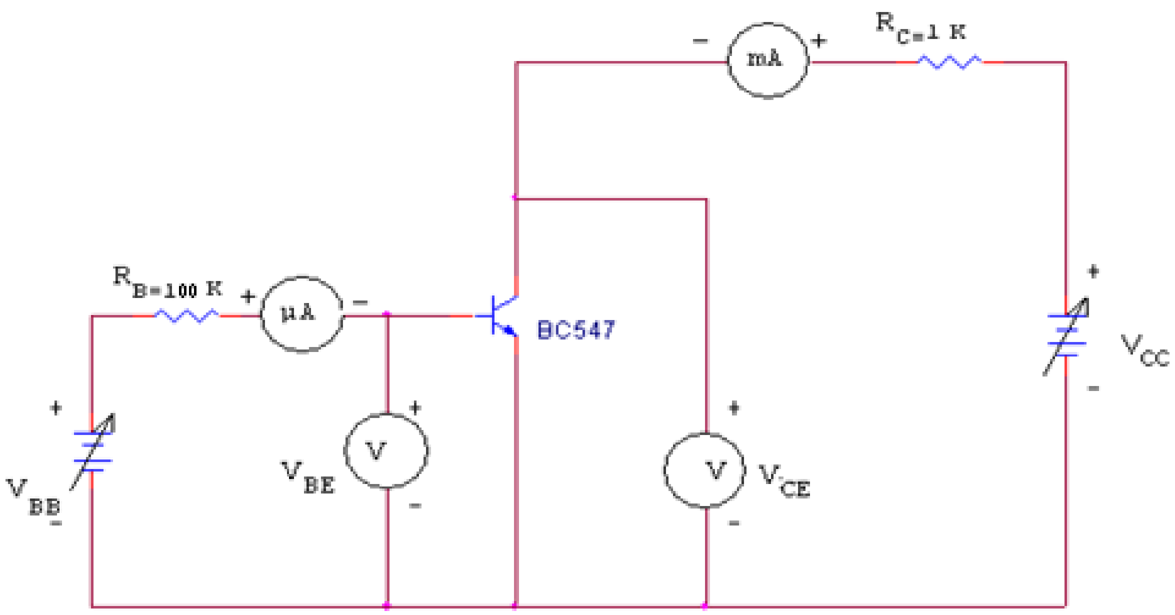
# EXPERIMENT 11: NPN BJT COMMON EMITTER CHARACTERISTICS

**AIM:** To study input and output characteristics of a NPN Bipolar Junction Transistor (BJT) in Common-emitter configuration.

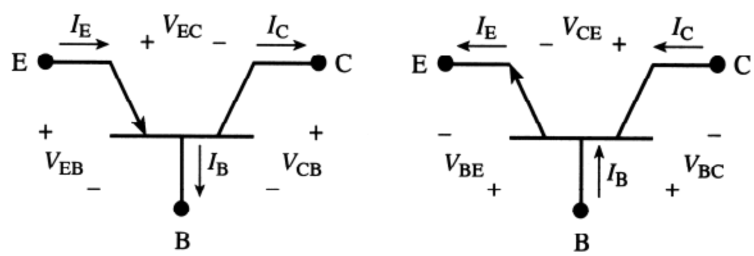
**APPARATUS:** BJT (BC-547B), Bread board, resistor (1KΩ, 100KΩ), connecting wires, Ammeters (0- 10mA, 0- 100μ A), DC power supply (0- 30V) and multimeter.

**CIRCUIT DIAGRAM:**



## THEORY:

The transistor is a two junction, three terminal semiconductor device which has three regions namely the emitter region, the base region, and the collector region. There are two types of transistors. An npn transistor has an n type emitter, a p type base and an n type collector while a pnp transistor has a p type emitter, an n type base and a p type collector. The emitter is heavily doped, base region is thin and lightly doped and collector is moderately doped and is the largest. The current conduction in transistors takes place due to both charge carriers- that is electrons and holes and hence they are named Bipolar Junction Transistors (BJT).




(a) *pnp* (b) *npn*

BJTs are extensively used in all types of electronic circuits. The aim of this part of the experiment is to familiarize you with the basic modes of operation and features of a BJT. The BJT that you will be using in this experiment is BC 547 (the pin diagram is shown in Fig.1), which has a typical current rating of 100 mA (maximum).
Two of the most important applications for the transistor are (1) as an amplifier in analog electronic systems, and (2) as a switch in digital systems.

Basic Concepts The operation of the BJT is based on the principles of the pn junction. In the npn BJT, electrons are injected from the forward-biased emitter into the thin base region where, as minority carriers, they diffuse toward the reverse-biased collector. Some of these electrons recombine with holes in the base region, thus producing a small base current, $I_B$. The remaining electrons reach the collector where they provide the main source of carriers for the collector current, $I_C$. Thus, if there are no electrons injected from the emitter, there will be (almost) no collector current and, therefore, the emitter current controls the collector current. Combining currents, the total emitter current is given as $I_E = I_B + I_C$. For normal pnp operation, the polarity of both voltage sources must be reversed.

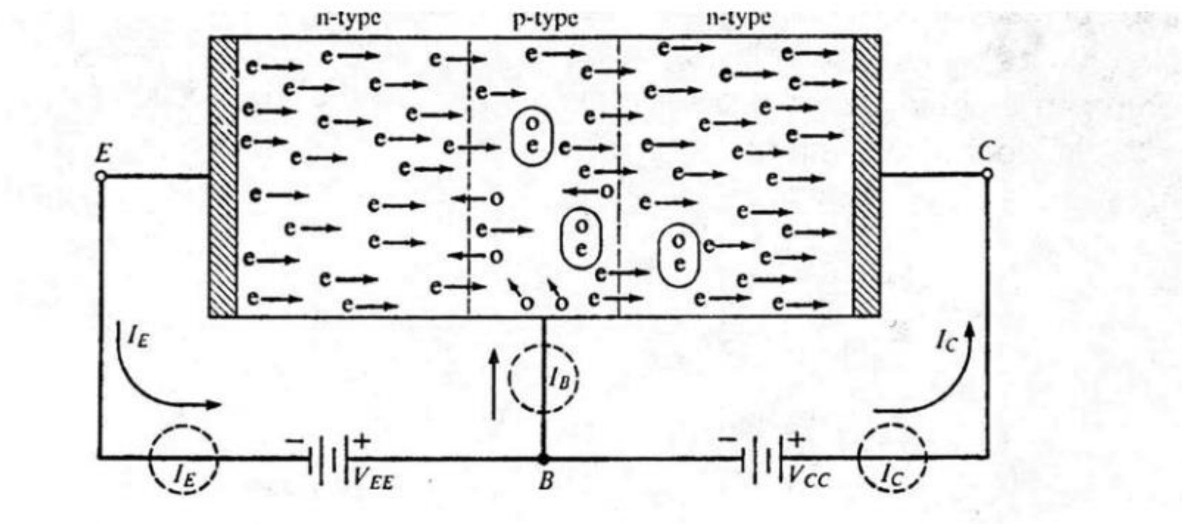
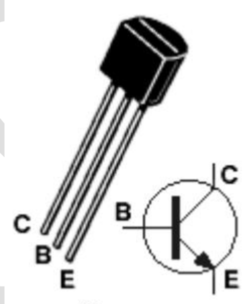



Figure : Representation of npn transistor in operation with forward biased emitter-base junction and reverse biased collector-base junction (e = electrons, 0 = holes, and oe = recombination of holes and electrons).

**(Don't draw)- only for reference**

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BJTs are used to amplify current, using a small base current to control a large current between the collector and the emitter. This amplification is so important that one of the most noted parameters of gain, β (or $h_{FE}$), which is the ratio of collector current to base current.

When the BJT is used with the base and emitter terminals as the input and the collector and emitter terminals as the output, the current gain as well as the voltage gain is large. It is for this reason that this common-emitter (CE) configuration is the most useful connection for the BJT in electronic systems

## Operation regions and characteristics curves:

Depending upon the biasing of the two junctions, emitter-base (EB) junction and collector-base(CB) the transistor is said to be in one of the four modes of operation. as described below:

| Operating region | B-E Junction | B-C Junction | Features | | | |
|---|---|---|---|---|---|---|
| **Cut-off** | Reverse | Reverse | $I_B \approx I_C \approx I_E \approx 0$ | Off state – no current ($V_{BE}<0.7V$) | | |
| **Saturation** | Forward | Forward | Conducting structure | $V_{BE}=0.7V$ | $V_{CE} \approx 0.2V$ | |
| **Active** | Forward | Reverse | Amplifier Gain: 100-1000 | ($I_C=\beta I_B$) | $V_{BE}=0.7V$ | $V_{CE}>0.2V$ |
| **Reverse-active** | Reverse | Forward | Limited use Gain< 1 | ($I_B>I_C$) | | |

**NOTE : $V_{BE}$ will vary from 0.6 to 0.7 V**

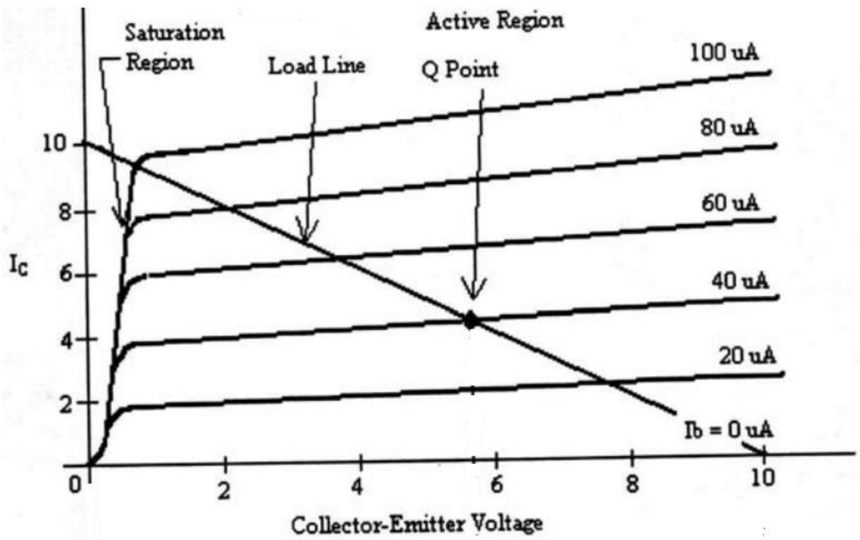
The most important characteristics of transistor in any configuration are input and output characteristics.

**A. Input Characteristics: -**

It is the curve between input current $I_B$ and input voltage $V_{BE}$ constant collector emitter voltage $V_{CE}$. The input characteristic resembles a forward biased diode curve. After cut in voltage the $I_B$ increases rapidly with small increase in $V_{BE}$. It means that dynamic input resistance is small in CE configuration. It is the ratio of change in $V_{BE}$ to the resulting change in base current at constant collector emitter voltage. It is given by $\Delta V_{BE} / \Delta I_B$

**B. Output Characteristics:-**

This characteristic shows relation between collector current $I_C$ and collector voltage for various values of base current. The change in collector emitter voltage causes small change in the collector current for the constant base current, which defines the dynamic resistance and is given as $\Delta V_{CE} / \Delta I_C$ at constant $I_B$. The output characteristic of common emitter configuration consists of three regions: Active, Saturation and Cut-off.




**Active region:** In this region base-emitter junction is forward biased and base-collector junction is reversed biased. The curves are approximately horizontal in this region.

**Saturation region:** In this region both the junctions are forward biased.

**Cut-off:** In this region, both the junctions are reverse biased. When the base current is made equal to zero, the collector current is reverse leakage current $I_{CEO}$. The region below $I_B = 0$ is the called the cut-off region.

## OBSERVATION:

### INPUT CHARACTERISTICS

| $V_{BB}$ | $V_{CE}$=2V | | $V_{CE}$=3V(Choose value which u took in lab) | |
|---|---|---|---|---|
| | $V_{BE}$ (V) | $I_B$ (μA) | $V_{BE}$ (V) | $I_B$ (μA) |
| 0.1 | | | | |
| 0.2 | | | | |
| . | | | | |
| 1 | | | | |
| 1.5 | | | | |
| . | | | | |
| 5 | | | | |

**OUTPUT CHARACTERISTICS**

| $V_{CC}$ | $I_B$ =10(μA) | | $I_B$ =20(μA)(Choose value which u took in lab) | |
|---|---|---|---|---|
| | $V_{CE}$ (V) | Ic (mA) | $V_{CE}$ (V) | Ic(mA) |
| 0 | | | | |
| 0.2 | | | | |
| . | | | | |
| . | | | | |
| 1 | | | | |
| 1.5 | | | | |
| . | | | | |
| . | | | | |
| 5 | | | | |
| 6 | | | | |
| . | | | | |
| 20 | | | | |

**PROCEDURE:**

**A. Input Characteristics**

1) Make the circuit connection as shown in the circuit diagram.
2) Set the voltage $V_{CE}$ = 2 V and vary $I_B$ with the help of $V_{BB}$ and measure $V_{BE}$.
3) Set the voltage $V_{CE}$ = 3 V and vary $I_B$ with the help of $V_{BB}$ and measure $V_{BE}$.
4) Plot graph of $I_B$ v/s $V_{BE}$.
5) Evaluate dynamic input resistance which is the ratio of change in $V_{BE}$ to the resulting change in base current at constant collector emitter voltage. It is given by $\Delta V_{BE} / \Delta I_B$
6) The reciprocal of the slope of the linear part of the characteristic gives the dynamic input resistance of the transistor.

**B. Output Characteristics**

1) Keep $I_B$ constant say 10 μA, vary $V_{CE}$ and note down the collector current $I_C$.
2) Now keep $I_B$ = 20 μA, vary $V_{CE}$ and note down the collector current $I_C$.
3) Plot graph of $I_B$ v/s $V_{CE}$.
4) The change in collector emitter voltage causes small change in the collector current for the constant base current, which defines the dynamic output resistance and is given as $\Delta V_{CE} / \Delta I_C$ at constant $I_B$ or the output conductance is given $\Delta I_C/\Delta V_{CE}$ with the $I_B$ at a constant current.
5) Find output conductance from the slope of the linear portion of the characteristic curves and also find small-signal current gain which is calculated by $\beta = \Delta I_C/\Delta I_B$ with the $V_{CE}$ at a constant voltage.

**CALCULATION:**

1. **Small-Signal Current Gain:** $\beta = \Delta I_C / \Delta I_B$ with the $V_{CE}$ at a constant voltage.
2. **Dynamic input resistance:** It is given by $\Delta V_{BE} / \Delta I_B$ at constant $V_{CE}$
3. **Dynamic output resistance:** It is given as $\Delta V_{CE} / \Delta I_C$ at constant $I_B$

**RESULTS:**

1. **Small-Signal Current Gain:___________**
2. **Dynamic input resistance: ____________**
3. **Dynamic output resistance: ____________**

**CONCLUSION:**

**POST LAB QUESTIONS:**

1. What is the function of base region of a transistor? Why this region is made thin and lightly doped?

2. What is the voltage across the collector to emitter terminal when the transistor is in (i) saturation (ii) cut-off (iii) active region?

3. Describe, based on your observations, the I-V curves of npn transistor. At approximately what collector-emitter voltage ($V_{CE}$) does the transition from saturation to active region occur?

4. Describe the necessary conditions operation in the active region in terms of $V_{BE}$ and $V_{CE}$.

5. Explain early effect?