**DEPT. OF ELECTRICAL & ELECTRONICS ENGINEERING**
**SRM INSTITUTE OF SCIENCE AND TECHNOLOGY, Kattankulathur – 603203.**

| | |
|---|---|
| Title of Experiment | :7. **Characteristics of semiconductor devices (a) PN junction diode, (b) Zener diode, (c)BJT** |
| Name of the candidate | : ARNAV JAIN |
| Register Number | : RA2011026010158 |
| Date of Experiment | : |
| Date of submission | **:** 20/11/2020 |

| Sl. No. | Marks Split up | Maximum marks (50) | Marks obtained |
|---|---|---|---|
| 1 | Pre Lab questions | 5 | |
| 2 | Preparation of observation | 15 | |
| 3 | Execution of experiment | 15 | |
| 4 | Calculation / Evaluation of Result | 10 | |
| 5 | Post Lab questions | 5 | |
| **Total** | | **50** | |

**Staff Signature**

## PRE LAB QUESTIONS

### 1.What are intrinsic and extrinsic semiconductors?

The pure form of semiconductors in which there is no impurities are known as **intrinsic semiconductors.**
The semiconductor in which intentionally impurities is added for making it conductive is known as the **extrinsic semiconductor**.

### 2.Give examples for Trivalent and Pentavalent impurity.

**Trivalent: -**Boron, Gallium, Indium, Aluminium
**Pentavalent: -** Phosphorus, Arsenic, Antimony

### 3.What is the need for Zener diode?

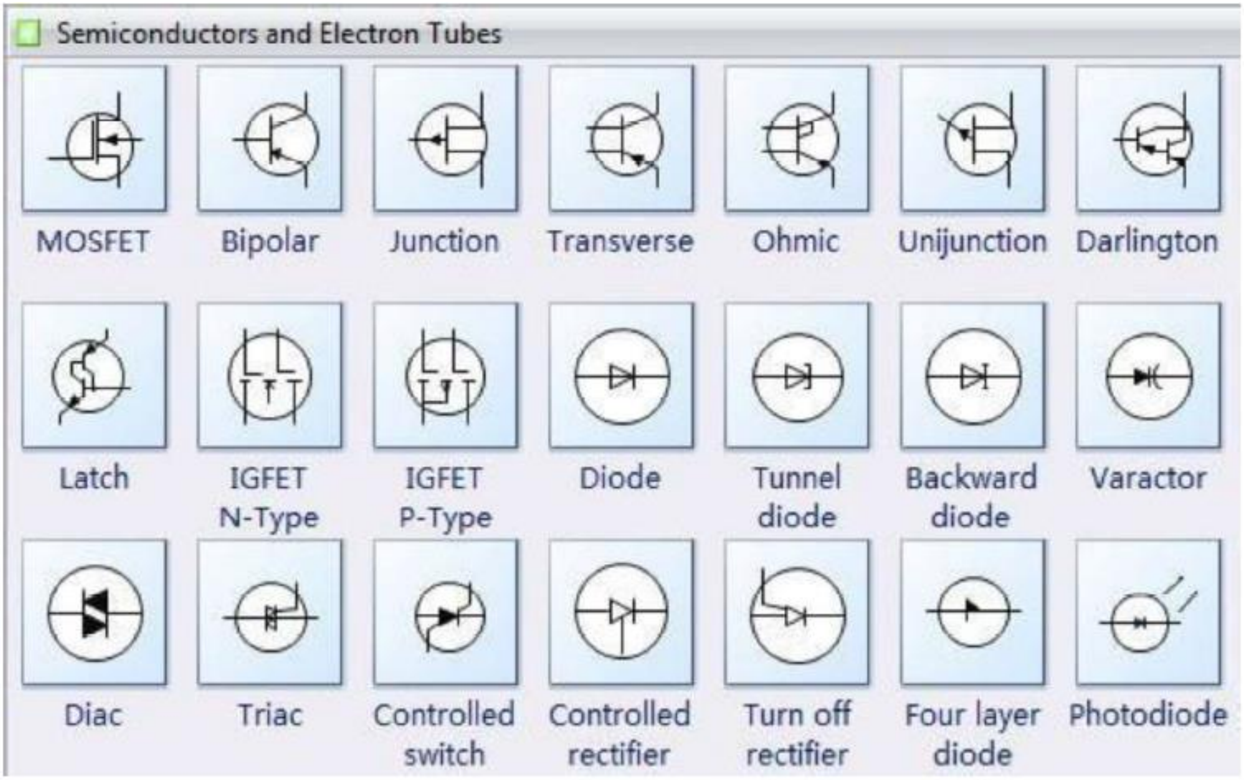
Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits. When connected in parallel with a variable voltage source so that it is reverse biased, a Zener diode conducts when the voltage reaches the diode's reverse breakdown voltage.

### 4.What is voltage regulation and mention its significance?

**Definition:**
Voltage regulation is the measure of how well a power transformer can maintain constant secondary voltage given a constant primary voltage and wide variance in load current.

**Significance:**
The load connected to the power system or a transformer will not be steady all the time. Change in load causes changes in current and hence the voltage drop in the transformer winding as well. It is necessary to maintain the supply voltage of the equipment supplied by the transformer. Because the supply voltage directly affects the performance of the equipment. Hence, the voltage regulation of the transformer is significant.

### 5.Give the different types of semiconductor devices with symbols


Semiconductors and Electron Tubes
MOSFET
Bipolar
Junction
Transverse
Ohmic
Unijunction
Darlington
Latch
IGFET N-Type
IGFET P-Type
Diode
Tunnel diode
Backward diode
Varactor
Diac
Triac
Controlled switch
Controlled rectifier
Turn off rectifier
Four layer diode
Photodiode

| Experiment No. 7 a)<br><br>Date : | CHARACTERISTICS OF PN JUNCTION DIODE |
|---|---|

**Aim**

To study the characteristics of PN Junction diode under forward and reverse bias conditions.

**Apparatus Required**

| S.No. | Name | Range | Qty |
|---|---|---|---|
| 1 | R.P.S | (0-30)V | 1 |
| 2 | Ammeter | (0–30)mA | 1 |
| | | (0-500)µA | 1 |
| 3 | Voltmeter | (0–1)V | 1 |
| | | (0-10)V | 1 |

**Components Required**

| S.No. | Name | Range | Qty |
|---|---|---|---|
| 1 | Diode | IN4001 | 1 |
| 2 | Resistor | 1kΩ | 1 |
| 3 | Bread Board | - | 1 |
| 4 | connecting Wires | - | Req |

**Theory**

A PN junction diode is a two terminal semiconducting device. It conducts only in one direction (only on forward biasing).

**Forward Bias**

On forward biasing, initially no current flows due to barrier potential. As the applied potential exceeds the barrier potential the charge carriers gain sufficient energy to cross the potential barrier and hence enter the other region. The holes, which are majority carriers in the P-region, become minority carriers on entering the N-regions, and electrons which are the majority carriers in the N-region, become minority carriers on entering the P-region. This injection of minority carriers results in the current flow, opposite to the direction of electron movement.

**Reverse Bias**

On reverse biasing, the majority charge carriers are attracted towards the terminals due to the applied potential resulting in the widening of the depletion region. Since the charge carriers are pushed towards the terminals no current flows in the device due to majority charge carriers. There will be some current in the device due to the thermally generated minority carriers. The generation of such carriers is independent of the applied potential and hence the current is constant for all increasing reverse potential. This current is referred to as Reverse Saturation Current ($I_O$) and it increases with temperature. When the applied reverse voltage is increased beyond the certain limit, it results in breakdown. During breakdown, the diode current increases tremendously.

**Procedure**

**Forward Bias**

1. Connect the circuit as per the diagram.
2. Vary the applied voltage V in steps of 0.1V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I

**Observations**

1. Find the d.c (static) resistance = V/I.
2. Find the a.c (dynamic) resistance $r = \delta V / \delta I$ **($r = \Delta V/\Delta I$) =** $\frac{V_2 - V_1}{I_2 - I_1}$.
3. Find the forward voltage drop [Hint: it is equal to 0.7 for Si and 0.3 for Ge]

**Reverse Bias**

1. Connect the circuit as per the diagram.
2. Vary the applied voltage V in steps of 1.0V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I
5. Find the dynamic resistance **$r = \delta V / \delta I$.**

**Formula for Reverse Saturation Current ($I_O$):**

$$I_o = \partial I/[\exp(\partial V/\eta V_T)]-1$$

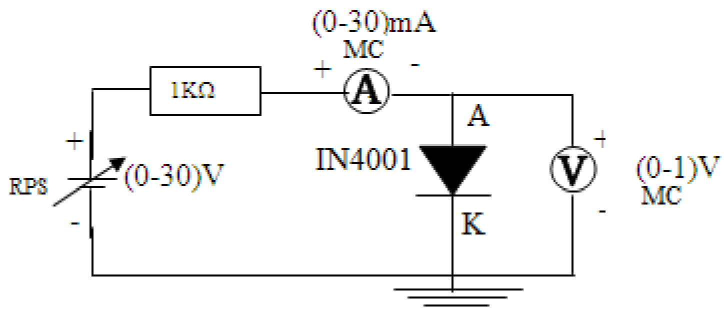
Where $V_T$ is the voltage equivalent of Temperature = kT/q

-k is Boltzmann's constant, q is the charge of the electron and T is the temperature in degrees Kelvin.

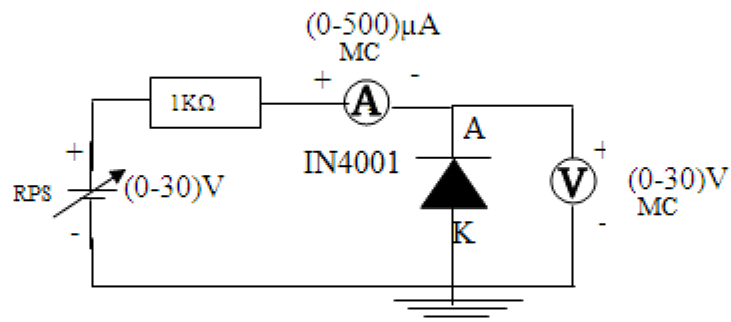
$\eta$ =1 for Silicon and 2 for Germanium

**Circuit Diagram**

**Forward Bias**




**Reverse Bias**




**Specification for 1N4001: Silicon Diode**

Peak Inverse Voltage: 50V

$I_{dc}$ = 1A.

Maximum forward voltage drop at 1 Amp is 1.1 volts

Maximum reverse current at 50 volts is 5μA

**Tabular Column**

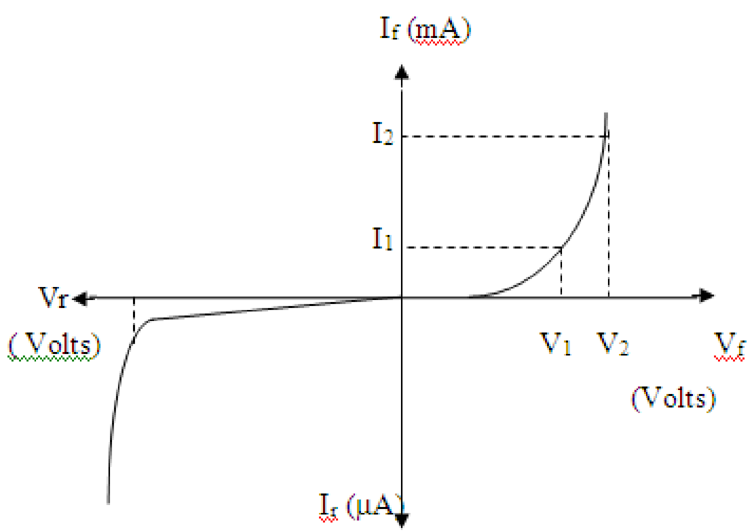
**Forward Bias**

| S.No. | Voltage (In Volts) | Current (In mA) |
|---|---|---|
| 1 | 0.609 | 0.39 |
| 2 | 0.641 | 1.36 |
| 3 | 0.670 | 4.33 |
| 4 | 0.689 | 9.31 |
| 5 | 0.700 | 14.30 |
| 6 | 0.707 | 19.29 |
| 7 | 0.716 | 24.29 |
| 8 | 0.718 | 29.28 |

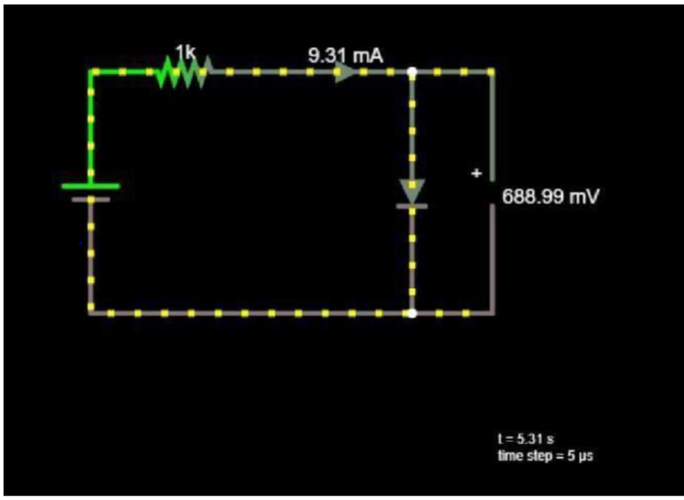
**Reverse Bias**

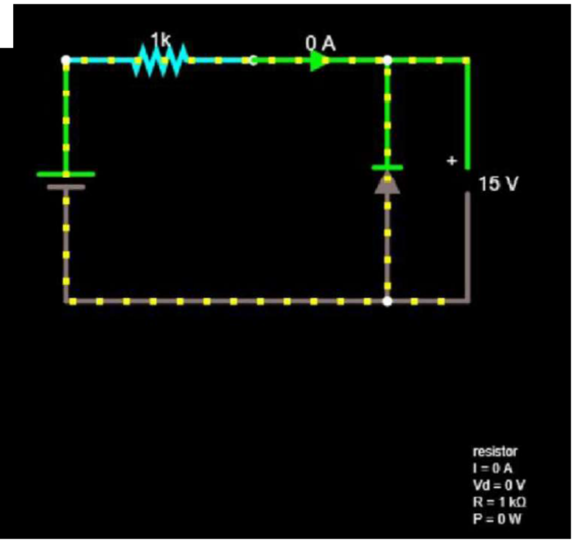
| S.No. | Voltage (In Volts) | Current (In μA) |
|---|---|---|
| 1 | 1 | 0 |
| 2 | 2 | 0 |
| 3 | 5 | 0 |
| 4 | 10 | 0 |
| 5 | 15 | 0 |
| 6 | 20 | 0 |
| 7 | 25 | 0 |
| 8 | 30 | 0 |

**Model Graph**

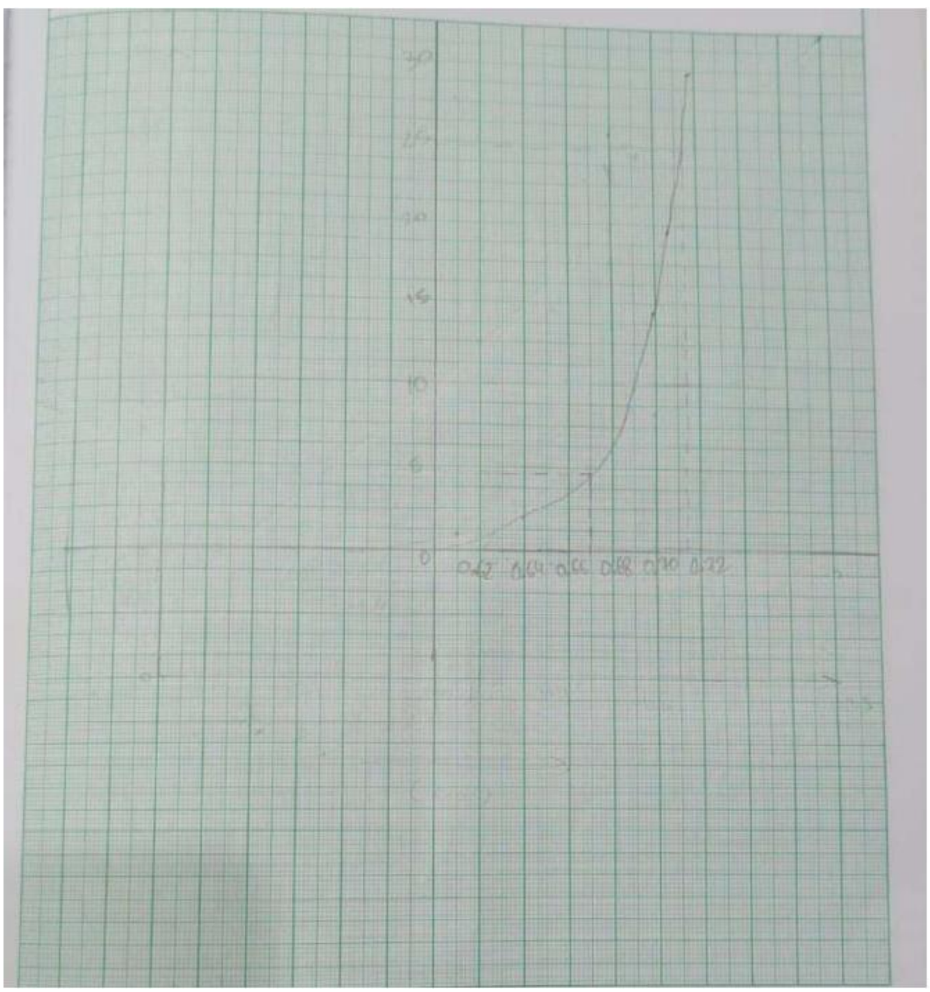



**FROWARD BIAS** **REVERSE BIAS**




**GRAPH:**



**RESULT:**

The characteristics of the PN diode under forward and reverse bias conditions is successfully done.

| | |
|---|---|
| **Experiment No.  7b)**<br>**Date :** | **CHARACTERISTICS OF ZENER DIODE** |

**Aim**

To find the forward and reverse bias characteristics of a given Zener diode.

**Apparatus Required**

| S.No. | Name | Range | Qty |
|---|---|---|---|
| 1 | R.P.S | (0-30)V | 1s |
| 2 | Ammeter | (0–30)mA | 2 |
| 3 | Voltmeter | (0–10)V | 1 |
| | | (0–1)V | 1 |

**Components Required**

| S.No. | Name | Range | Qty |
|---|---|---|---|
| 1 | Zener diode | FZ5.1 | 1 |
| 2 | Resistor | 1KΩ | 1 |
| 3 | Bread Board | - | 1 |
| 4 | Wires | - | Req |

**Theory**

A properly doped crystal diode, which has a sharp breakdown voltage, is known as Zener diode.

**Forward Bias**

On forward biasing, initially no current flows due to barrier potential. As the applied potential increases, it exceeds the barrier potential at one value and the charge carriers gain sufficient energy to cross the potential barrier and enter the other region. the holes ,which are majority carriers in p-region, become minority carriers on entering the N-regions and electrons, which are the majority carriers in the N-regions become minority carriers on entering the P-region. This injection of minority carriers results current, opposite to the direction of electron movement.

**Reverse Bias**

When the reverse bias is applied, due to majority carriers small amount of current (ie) reverse saturation current flows across the junction. As the reverse bias is increased to breakdown voltage, sudden rise in current takes place due to Zener effect.

**Zener Effect**

Normally, PN junction of Zener Diode is heavily doped. Due to heavy doping the depletion layer will be narrow. When the reverse bias is increased the potential across the depletion layer is more. This exerts a force on the electrons in the outermost shell. Because of this force the electrons are pulled away from the parent nuclei and become free electrons. This ionization, which occurs due to electrostatic force of attraction, is known as Zener effect. It results in large number of free carriers, which in turn increases the reverse saturation current

**Procedure**

**Forward Bias**

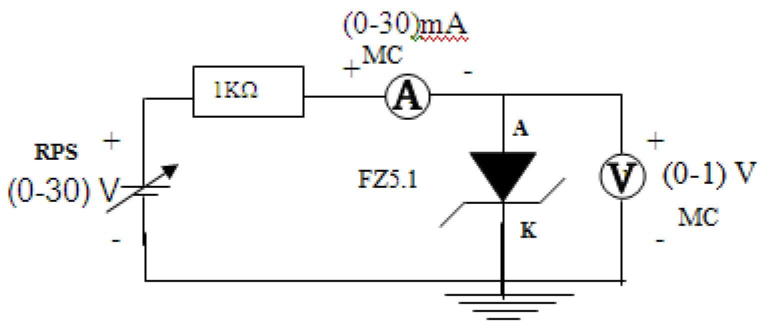
1. Connect the circuit as per the circuit diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding ammeter readings.
4. Plot the graph :V (vs) I.
5. Find the dynamic resistance **r = δV / δI.**

**Reverse Bias**

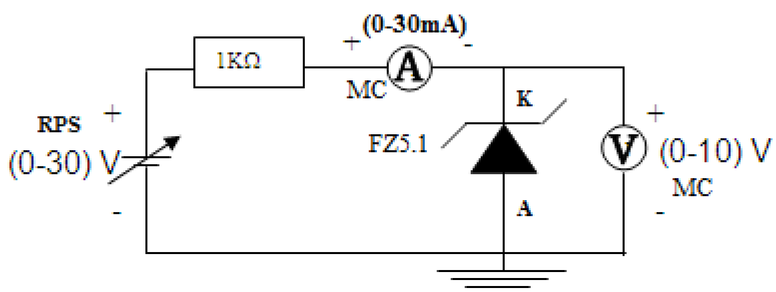
1. Connect the circuit as per the diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I
5. Find the dynamic resistance **r = δV / δI.**
6. Find the reverse voltage Vr at $I_z$=20 mA.

**Circuit Diagram**

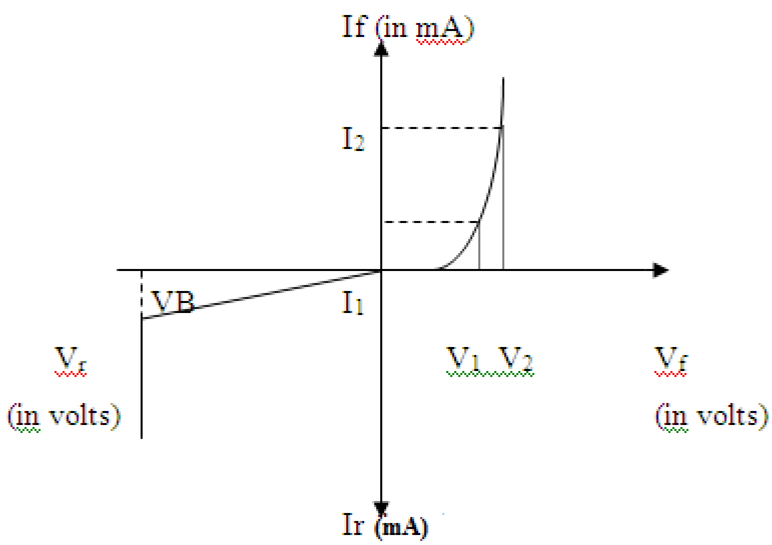
**Forward Bias**




**Reverse Bias**




**Zener Diode**




**Tabular Column**

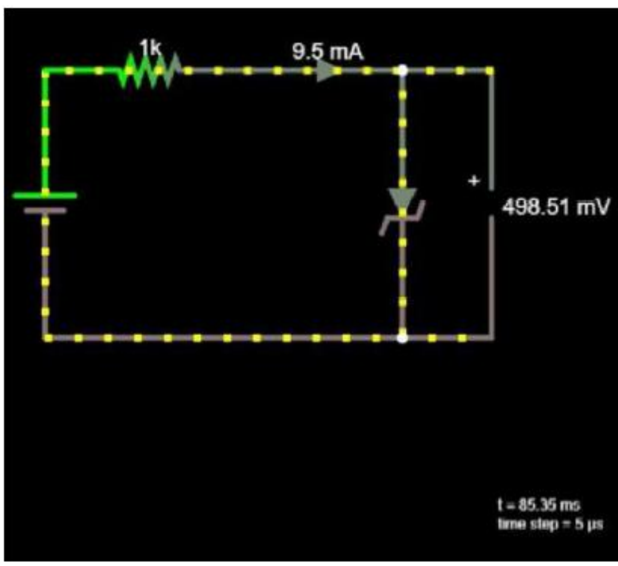
**Forward Bias**

**Reverse Bias**

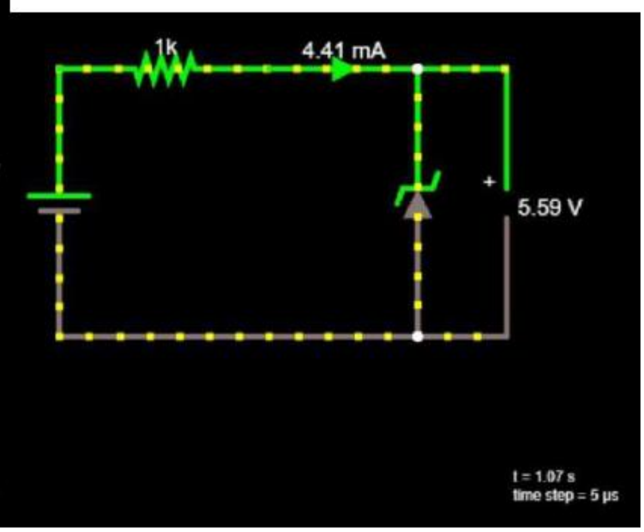
| S.No. | Voltage (In Volts) | Current (In mA) |
|---|---|---|
| 1 | 0.4499 | 4.55 |
| 2 | 0.4985 | 9.5 |
| 3 | 0.5262 | 14.47 |
| 4 | 0.5458 | 19.45 |
| 5 | 0.5608 | 24.44 |
| 6 | 0.5731 | 29.43 |
| 7 | 0.5834 | 34.42 |
| 8 | 0.5924 | 39.41 |
| 9 | 0.6002 | 44.4 |
| 10 | 0.6073 | 49.39 |

| S.No. | Voltage (In Volts) | Current (In mA) |
|---|---|---|
| 1 | 4.99 | 5.52 |
| 2 | 5.59 | 4.41 |
| 3 | 5.64 | 9.36 |
| 4 | 5.67 | 14.33 |
| 5 | 5.69 | 19.31 |
| 6 | 5.70 | 24.3 |
| 7 | 5.72 | 29.28 |
| 8 | 5.73 | 34.27 |
| 9 | 5.74 | 39.26 |
| 10 | 5.74 | 44.26 |

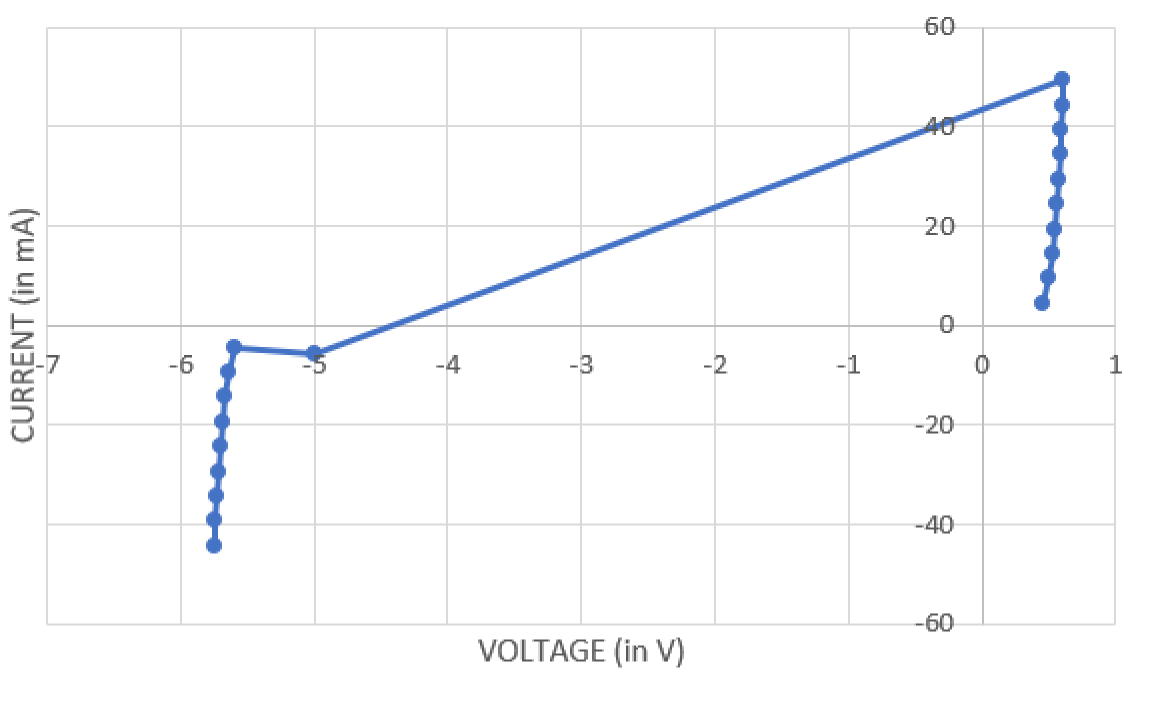
**FORWARD BIAS**




**REVERSE BIAS**



**GRAPH:**




**RESULT:**

The forward and reverse bias character of Zener diode is verified.

| Experiment No. 7c)<br>Date : | CHARACTERISTICS OF BJT (CE CONFIGURATION) |
|---|---|

**Aim**

To plot the transistor (BJT) characteristics of CE configuration.

**Apparatus Required**

| S.No. | Name | Range | Qty |
|---|---|---|---|
| 1 | R.P.S | (0-30)V | 2 |
| 2 | Ammeter | (0–30) mA MC | 1 |
| | | (0–250) µA MC | 1 |
| 3 | Voltmeter | (0–30)V MC | 1 |
| | | (0–1)V MC | 1 |

**Components Required**

| S.No. | Name | Range | Qty |
|---|---|---|---|
| 1 | Transistor | BC 107 | 1 |
| 2 | Resistor | 10 KΩ | 1 |
| | Resistor | 1 KΩ | 1 |
| 3 | Bread Board | | 1 |
| 4 | Wires | | |

**Theory**

A BJT is a three terminal two – junction semiconductor device in which the conduction is due to both the charge carrier. Hence it is a bipolar device. BJT is classified into two types – NPN & PNP. A NPN transistor consists of two N types in between which a layer of P is sandwiched. The transistor consists of three terminal emitter, collector and base. The emitter layer is the source of the charge carriers and it is heavily doped with a moderate cross sectional area. The collector collects the charge carries and hence moderate doping and large cross sectional area. The base region acts a path for the movement of the charge carriers. In order to reduce the recombination of holes and electrons the base region is lightly doped and is of hollow cross sectional area. Normally the transistor operates with the EB junction forward biased.

**Procedure**

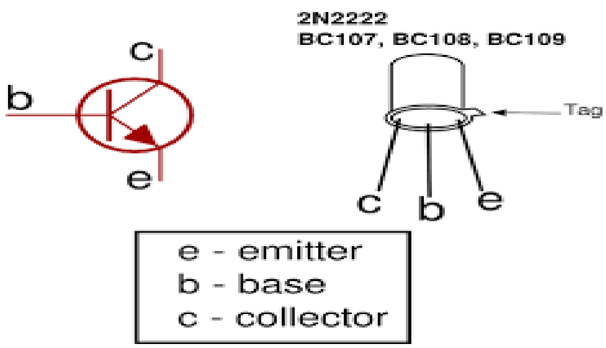
**Input Characteristics**

1. Connect the circuit as per the circuit diagram.
2. Set $V_{CE}$, vary $V_{BE}$ in regular interval of steps and note down the corresponding $I_B$ reading. Repeat the above procedure for different values of $V_{CE}$.
3. Plot the graph: $V_{BE}$ Vs $I_B$ for a constant $V_{CE}$.

**Output Characteristics**

1. Connect the circuit as per the circuit diagram.
2. Set $I_B$, Vary $V_{CE}$ in regular interval of steps and note down the corresponding $I_C$ reading. Repeat the above procedure for different values of $I_B$.
3. Plot the graph: $V_{CE}$ Vs $I_C$ for a constant $I_B$.

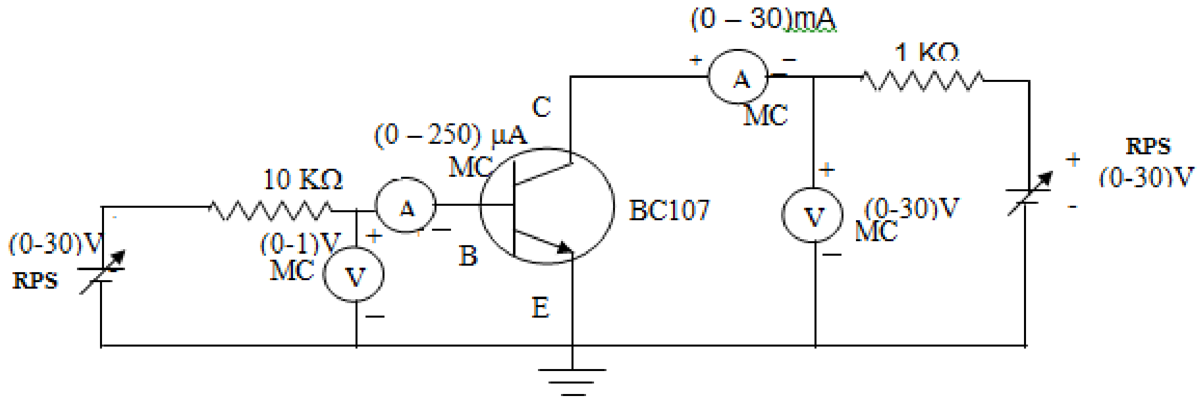
**Pin Diagram**

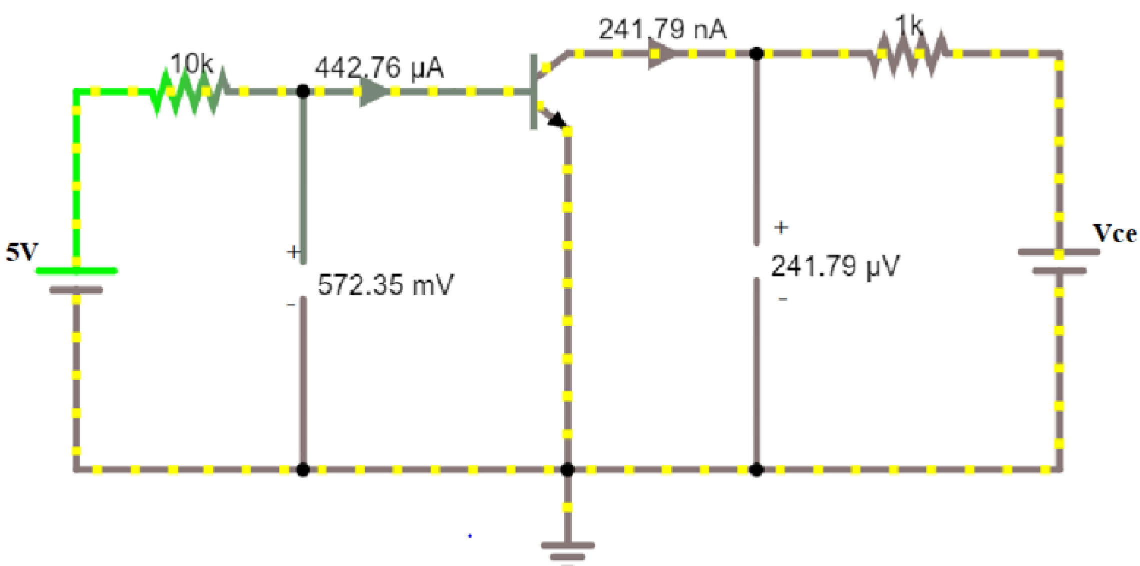




Specification: BC107/50V/0.1A,0.3W,300MH

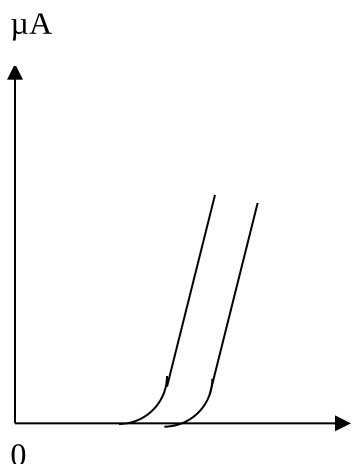
**Circuit Diagram**

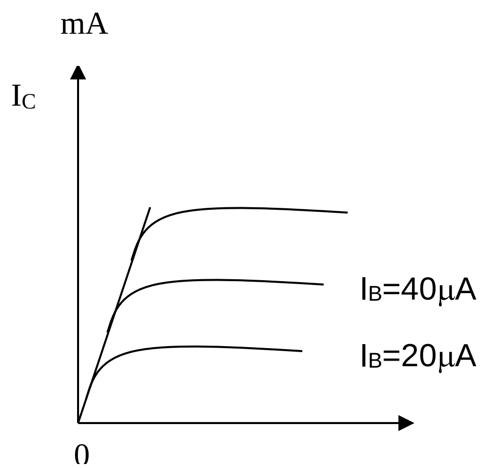


**Model Graph**

**Input Characteristics** **Output Characteristics**




**Tabular Column**

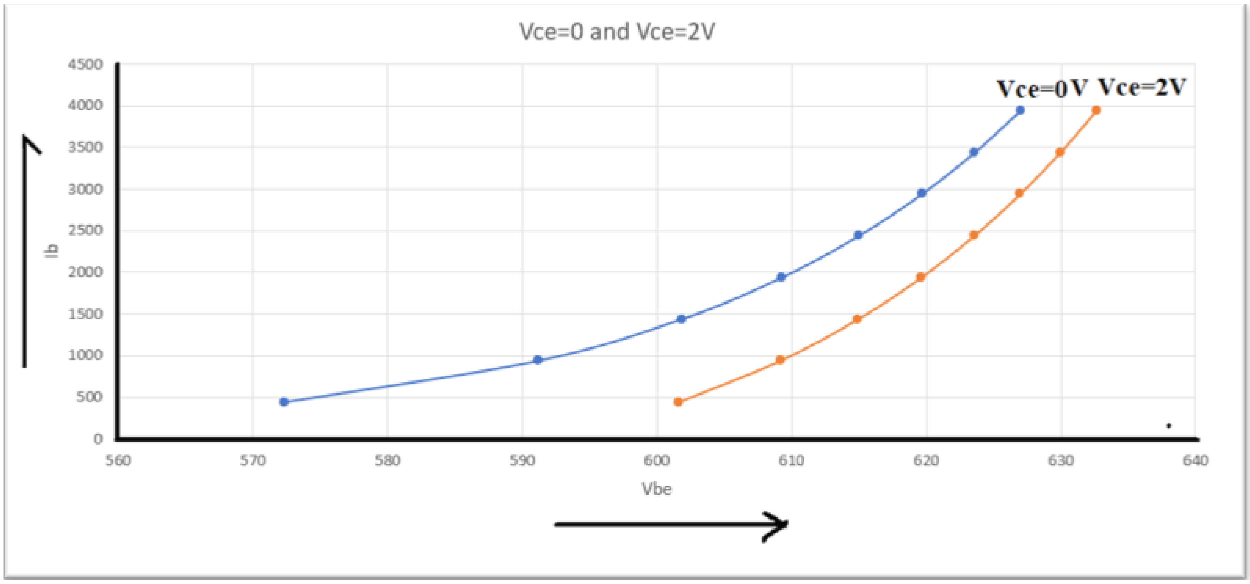
**Input Characteristics**

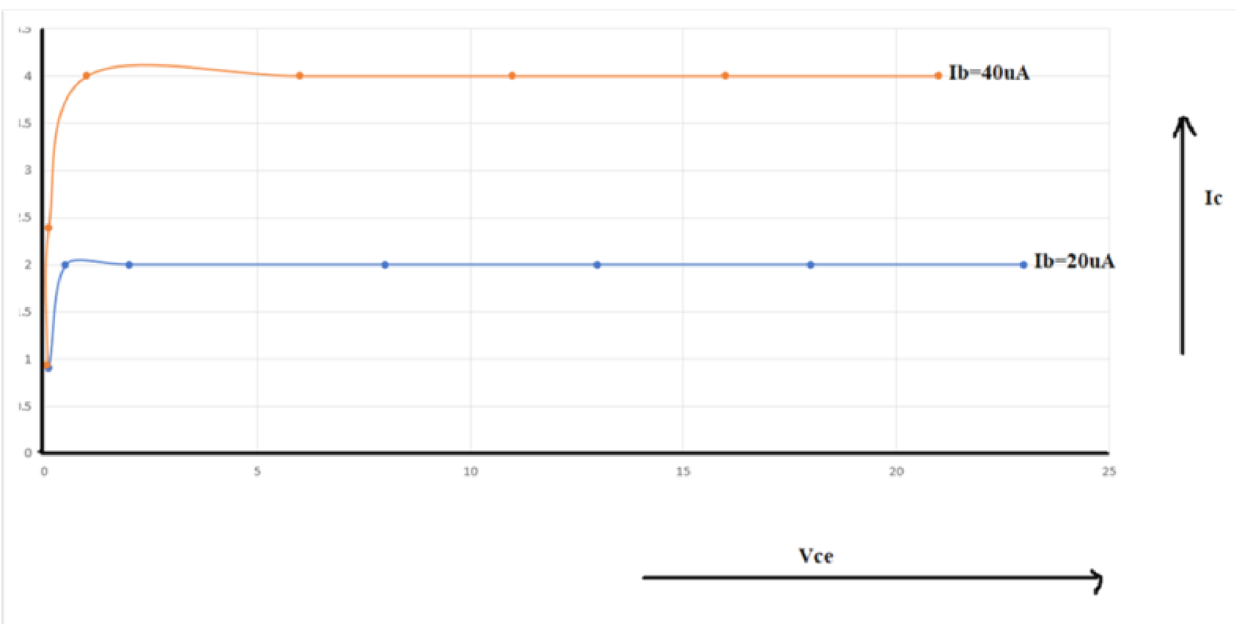
| $V_{CE}$ = 0 V | | $V_{CE}$ = 2V | |
|---|---|---|---|
| $V_{BE}$(V) | $I_B$(μA) | $V_{BE}$(V) | $I_B$(μA) |
| 572.35 | 442.76 | 601.57 | 439.84 |
| 591.20 | 940.88 | 609.16 | 939.08 |
| 601.84 | 1440.00 | 614.94 | 1440.00 |
| 609.28 | 1940.00 | 619.63 | 1940.00 |
| 615.01 | 2440.00 | 623.57 | 2440.00 |
| 619.67 | 2940.00 | 626.97 | 2940.00 |
| 623.60 | 3440.00 | 629.96 | 3440.00 |
| 626.99 | 3940.00 | 623.63 | 3940.00 |

**Output Characteristics**

| $I_B$=20μA | | $I_B$=40μA | |
|---|---|---|---|
| $V_{CE}$ (V) | $I_C$ (mA) | $V_{CE}$ (V) | $I_C$ (mA) |
| 0.094 | 0.905 | 0.070 | 0.929 |
| 0.5 | 2 | 0.108 | 2.39 |
| 2 | 2 | 1 | 4 |
| 8 | 2 | 6 | 4 |
| 13 | 2 | 11 | 4 |
| 18 | 2 | 16 | 4 |
| 23 | 2 | 21 | 4 |

**GRAPH:**




**RESULT:**

The circuit was drawn, the readings were tabulated and the graphs were drawn.

## POST LAB QUESTIONS

**1 What is Punch through voltage?**

An emitter-to-collector breakdown which can occur in a junction transistor with very narrow base region at sufficiently high collector voltage when the space-charge layer extends completely across the base region.

**2 What is early effect?**

The early effect is the variation in the width of the base in a bipolar transistor due to a variation in the applied base-to-collector voltage.

**3 State maximum rating of transistor.**

The rating for maximum collector-emitter voltage VCE can be thought of as the maximum voltage it can withstand while in cut-off mode (no base current). This rating is of particular importance when using a bipolar transistor as a switch. A typical value for a small signal transistor is 60 to 80 V.

**4. What is leakage current and mention its range?**

A leakage current is an electric current in an unwanted conductive path under normal operating conditions. If the conductors are separated by a material with a small conductivity rather than a perfect dielectric, then a small leakage current flow directly between them.

**5. What is base – width modulation?**

The base width modulation is the variation in the width of the base in a bipolar transistor due to a variation in the applied base-to-collector voltage. For example, a greater reverse bias across the collector- base junction increases the collector-base depletion width.