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| **Course Name:** | **Basic Electronic Circuits** | **Semester:** | **III** |
| **Date of Performance:** | **10/08/2020** | **Batch No:** | **B1** |
| **Faculty Name:** | **B** | **Roll No:** | **1912052** |
| **Faculty Sign & Date:** |  | **Grade/Marks:** | **/25** |

**Experiment No: 1**

**Title: Study of V-I characteristics of PN junction diode and zener diode**

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| **Aim and Objective of the Experiment:** Study of V-I characteristics of PN junction diode and zener diode |
| * To analyze the Diode Characteristics * Observe the cut-in voltage for p-n Junction diode * Observe breakdown voltage in case of Zener diode |

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| **COs to be achieved:** |
| **CO1:** **Analyze and design Diode circuits.** . |

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| **Theory:** |
| Semiconductors, like Silicon or Germanium, are elements having resistivity that in intermediate between a conductor and an insulator. They inherently have four electrons in the valence band, which helps them to form covalent bonds with four neighboring silicon atoms. Hence, at absolute zero, the material behaves like an insulator. At room temperature, few of these electrons absorb enough energy to break away from the nucleus and serve as conduction electrons. The conduction properties can also be easily changed by changing the doping (adding different elements to) the semiconductor. Addition of a pentavalent impurity such as Phosphorus, N – type dopant, gives an additional electron after the four silicon bonds are satisfied. Similarly, a trivalent impurity such as Boron, P‐ type dopant, creates an absence of electron, a hole. The entire semiconductor material is a single crystal, with one-region dopes to be P‐type, with excess holes, and the adjacent region to be N‐ type, with excess electrons. This creates a metallurgical junction between the p and n regions. The contact to the p region is called the anode and that of the n region is called cathode.  **Forward Biased P‐N junction:** Application of a positive voltage to the p region and negative voltage to the n region creates an additional electric field in the space charge region. However, this time the field opposes the space – charge E‐field. This disturbs the balance between diffusion and E‐ field force. Hence, majority carriers from the p region diffuse over to the n side and electrons from n side move over to the p side of the junction. This process continues as long as the voltage is applied. Thus, in the forward bias mode, the diode carries a large current.  **Reverse Biased P‐N junction:** A voltage source with its positive terminal connected to the n region and negative terminal connected to the p region reverse biases the P‐N junction. This increased electric filed holds back the holes in the p region and electrons in the n region and hence, there is no current flow. The electric field and the width of the space‐charge region increases. There is also a decrease in junction capacitance associated due to increase in the width. Thus, the reverse bias region is characterized by negligible current (due to minority carriers) even on the application of a very high voltage across the terminals, the limit being decided by reverse breakdown voltage of the diode.  **Zener Diode:** Zener diode is a P-N junction diode specially designed to operate in the reverse biased mode. It is acting as normal diode while forward biasing. It has a particular voltage known as break down voltage, at which the diode breakdowns while reverse biased. In the case of normal diodes, the diode damages at the break down voltage. However, zener diode is specially designed to operate in the reverse breakdown region. |

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| **Circuit Diagram/ Block Diagram:** |
| 1. **Pn Junction Diode**   **Forward biased Reverse biased** |
| 1. **Zener Diode**   **Forward biased Reverse biased** |

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| **Stepwise-Procedure:** |
| 1. Open a new Schematic. 2. Draw the Circuit As Shown. 3. Plot the Graphs. 4. Note down Values, And Update The Observation Table. 5. Note down Knee (Cut-In) Voltage For Both The Diodes. 6. Note down Breakdown Voltage For Zener Diode. 7. Calculate on-resistance of the diode from characteristics. |

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| **Observation Table:** |
| Si diode : Forward bias   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Sr. no | Supply Voltage (V) | VD (v) | VR (v) | IR(A) | | 1 | 0.1 | 99.482223mV | 29.535138µV | 30.441656nA | | 2 | 0.2 | 198.80222mV | 364.65602µV | 203.15009nA | | 3 | 0.3 | 296.71872mV | 2.1752739mV | 2.3330649µA | | 4 | 0.4 | 385.31824mV | 16.03683mV | 12.739176µA | | 5 | 0.5 | 447.63943mV | 51.80038mV | 53.288667µA | | 6 | 0.6 | 484.78539mV | 119.12578mV | 112.63553µA | | 7 | 0.7 | 508.41934mV | 190.6482mV | 193.37743µA | | 8 | 0.8 | 526.78828mV | 278.49581mV | 281.78816µA | | 9 | 2 | 599.88042mV | 1.4171239V | 1.3922365mA | | 10 | 4 | 640.88152mV | 3.3597805V | 3.3320542mA | | 11 | 6 | 663.04566mV | 5.3785261V | 5.3252965mA | | 12 | 8 | 678.5282mV | 7.3577586V | 7.3136953mA | | 13 | 10 | 690.49273mV | 9.3171739V | 9.2938998mA | | 14 | 12 | 700.48033mV | 11.301853V | 11.299531mA | | 15 | 14 | 709.07458mV | 13.299563V | 13.294934mA |   Si diode: Reverse biased   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Sr. no | Supply Voltage (V) | VD (v) | VR (v) | IR(A) | | 1 | 0.1 | 107.1406mV | 2.2603803µV | 1.9490807nA | | 2 | 0.2 | 214.28322mV | 2.4935698µV | 2.4920127nA | | 3 | 0.3 | 303.56892mV | 2.5170508µV | 2.5173378nA | | 4 | 0.4 | 410.71177mV | 2.5200762µV | 2.5201038nA | | 5 | 0.5 | 499.99748mV | 2.5204592µV | 2.5204649nA | | 6 | 0.6 | 607.14036mV | 2.5206029µV | 2.5206042nA | | 7 | 2 | 1.9999975V | 2.5220178µV | 2.5219988nA | | 8 | 4 | 4.0357117V | 2.5239999µV | 2.5240324nA | | 9 | 6 | 6.0178546V | 2.5259999µV | 2.5259966nA | | 10 | 8 | 8.0178547V | 2.5280001µV | 2.5280128nA | | 11 | 10 | 9.9999975V | 2.5300001µV | 2.530081nA | | 12 | 12 | 11.999997V | 2.5320001µV | 2.5320104nA | | 13 | 14 | 14.017855V | 2.534µV | 2.5340092nA |   Zener diode : Forward bias   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Sr. no | Supply Voltage (V) | VD (v) | VR (v) | IR(mA) | | 1 | 0.1 | 100.03834mV | 37.354694µV | 91.142641nA | | 2 | 0.2 | 198.40486mV | 1.7075394mV | 3.4465813µA | | 3 | 0.3 | 271.36563mV | 29.123943mV | 29.667997µA | | 4 | 0.4 | 302.90531mV | 99.952611mV | 97.559898µA | | 5 | 0.5 | 319.43414mV | 189.86812mV | 177.19932µA | | 6 | 0.6 | 329.474mV | 275.19422mV | 276.95901µA | | 7 | 0.7 | 337.24536mV | 362.92977mV | 368.45713µA | | 8 | 0.8 | 343.17457mV | 452.417mV | 465.65174µA | | 9 | 1 | 352.24068mV | 652.18768mV | 646.99597µA | | 10 | 2 | 376.47974mV | 1.6250426V | 1.6178603mA | | 11 | 3 | 389.21959mV | 2.6130243V | 2.612399mA | | 12 | 4 | 398.07849mV | 3.612519V | 3.598667mA | | 13 | 5 | 404.85096mV | 4.595149V | 4.5951493mA |   Zener diode: Reverse biased   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Sr. no | Supply Voltage (V) | VD (v) | VR (v) | IR(A) | | 1 | 0.1 | 99.999218mV | 714.30076nV | 784.27943pA | | 2 | 0.2 | 199.9992mV | 799.87222nV | 799.77184pA | | 3 | 0.3 | 299.99921mV | 800.30095nV | 800.2982pA | | 4 | 0.4 | 399.99921mV | 800.37427nV | 800.39885pA | | 5 | 0.5 | 499.9992mV | 800.61549nV | 800.50469pA | | 6 | 0.6 | 599.99922mV | 800.7979nV | 800.59857pA | | 7 | 2 | 1.9999992V | 802.00607nV | 801.99533pA | | 8 | 4 | 3.9999992V | 4.0235562V | 804.01407pA | | 9 | 6 | 5.9999992V | 806.06511nV | 806.01pA | | 10 | 8 | 7.9565943V | 49.203108mV | 50.780158µA | | 11 | 10 | 8.244543V | 1.7627388V | 1.755457mA | | 12 | 12 | 8.303299V | 3.6989333V | 3.6921062mA | | 13 | 14 | 8.3373723V | 5.6596311V | 5.6649428mA |   Knee voltage for both the diodes =  For SI Diode : 0.47V  For Zener Diode : 0.253V  Breakdown Voltage for Zener = 8.1523V |

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| **Calculation:** |
| 1. Diode resistance for both Si diode and Zener:  rd = = =  For SI Diode : 4.6203 ohms  For Zener Diode : 2.7581 ohms |

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| **Waveform** |
| 1. **Forward Characteristics of Si Diode**          1. **Reverse Characteristics of Si Diode**          1. **Forward Characteristics of Zener Diode**          1. **Reverse Characteristics of Zener Diode** |

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| **Post Lab Subjective/Objective type Questions: (hand written)** |
| 1. What is meant by drift current ?   Drift current is the [electric current](https://en.wikipedia.org/wiki/Electric_current) caused by particles getting pulled by an electric field.   1. What type of extrinsic semiconductor is formed when   (i) Germanium is doped with indium?  P type  (ii) Silicon is doped with bismuth?  P type  3. With the help of a suitable diagram, explain the formation of the depletion region in a p-n junction.  How does its width change when junction is  (a)forward bias  (b)reverse bias      At the junction there is diffusion of charge carriers due to thermal agitation; so that some of electrons of n-region diffuse to p-region while some of holes of p-region diffuse into n-region. Some charge carriers combine with opposite charges to neutralise each other. Thus near the junction there is an excess of positively charged ions in n-region and an excess of negatively charged ions in p-region. This sets up a potential difference and hence an internal electric field Ei across the junctions. The field Ei is directed from n-region to p-region. This field stops the further diffusion of charge carriers. Thus the layers (= 10-4 cm 10-6cm) on either side of the junction becomes free from mobile charge carriers and hence is called the depletion layer. The symbol of p-n junction diode is shown in Fig.    **Effect of Forward and Reverse Bias**:   1. Under forward biasing the applied potential difference causes a field which acts opposite to the potential barrier. This results in reducing the potential barrier, and hence the width of the depletion layer decreases.      1. Under reverse biasing the applied potential difference causes a field which is in the same direction as the field due to internal potential barrier. This results in an increase in barrier voltage and hence the width of the depletion layer increases. |
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| **Conclusion: (to be written in own words)** |
| Hence, we simulated and verified the characteristic graphs for both Silicon and Zener diodes.  Their forward, and reverse characteristics were studied, breakdown and knee voltages were computed by waveform plots. |

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| **Signature of faculty in-charge with Date:** |