**Aim ↬ To find the VI characteristics of the Zener Diode and the working of the Zener Diode as a Voltage regulator.**

## Equipment Required ↬

Zener diode, Resistance, Power supply, Ammeter, Voltmeter, Breadboard, and connecting wires.

## Theory ↬

A Zener diode is a special type of diode designed to operate in the reverse breakdown region. Unlike regular diodes, which are damaged by excessive reverse voltage, Zener diodes are specifically doped to have a precise and stable breakdown voltage. This allows them to conduct in reverse when the voltage exceeds a certain value, known as the Zener breakdown voltage. The VI characteristics of a Zener diode show a sharp increase in reverse current once this breakdown voltage is reached while maintaining a relatively constant voltage across the diode. This unique property makes Zener diodes ideal for use as voltage regulators.

In forward bias, a Zener diode behaves like a regular diode, with a small forward voltage drop and a significant increase in current as the forward voltage increases. In reverse bias, the Zener diode remains non-conductive until the reverse voltage reaches the Zener breakdown voltage. Beyond this point, the diode allows current to flow in the reverse direction, but the voltage across the diode remains nearly constant, regardless of the increase in current. This constant voltage characteristic is leveraged in voltage regulation applications.

Zener breakdown happens at low voltages (below 5-6V) and involves electrons tunneling through a narrow gap, giving a precise breakdown voltage. Avalanche breakdown occurs at higher voltages (above 6V) due to collisions creating more charge carriers, leading to a gradual rise in current

As a voltage regulator, a Zener diode can stabilize the voltage across a load. When connected in parallel with a load, the Zener diode maintains the voltage at its breakdown value, even if the input voltage or load current varies. This is particularly useful in protecting sensitive electronic components from voltage fluctuations. By ensuring a stable output voltage, Zener diodes help maintain the reliable and consistent operation of electronic circuits, making them essential in power supply design.

## Circuit Diagram ↬

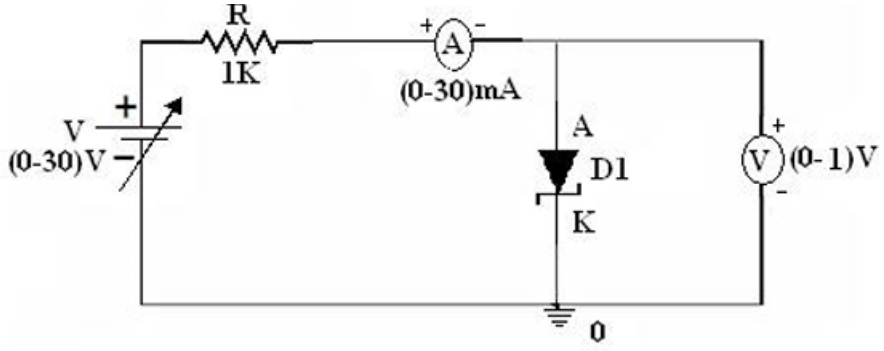


Fig 1. Forward Bias

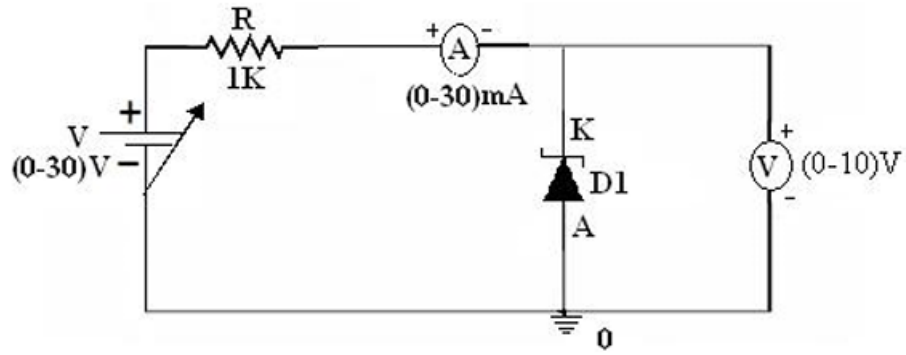


Fig 2. Reverse Bias

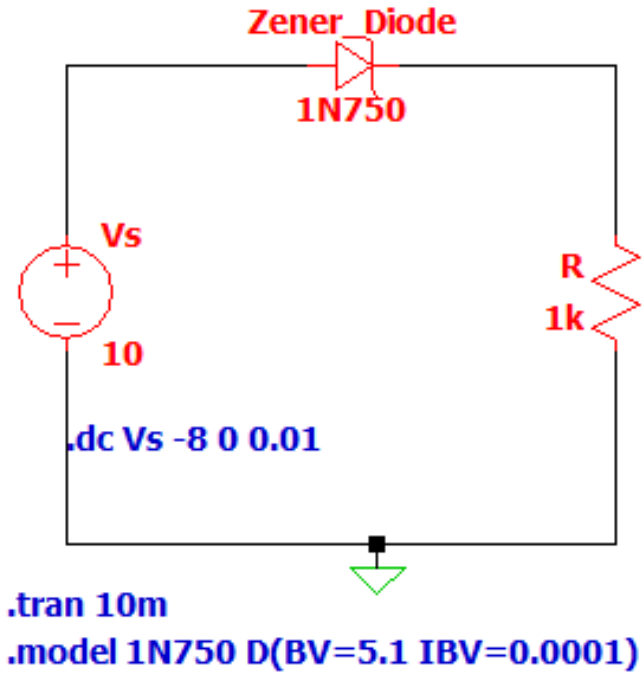


Fig 3. Circuit in LTSpice

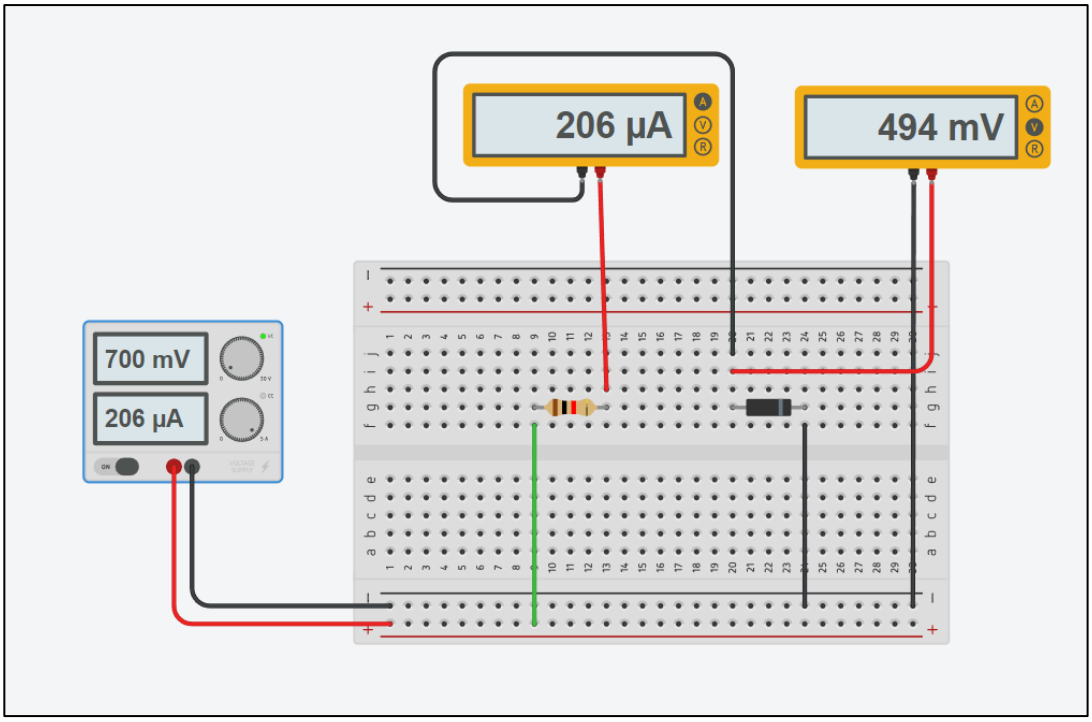


Fig 4. Circuit in TinkerCad

## Observation Table ↬

➢ Forward Bias ↪

| S.No. | Supply Voltage Vs(V) | Output Voltage Vz(V) | Output Current Iz(µA) |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 2 | 0.2 | 0.2 | 0 |
| 3 | 0.4 | 0.395 | 0 |
| 4 | 0.5 | 0.455 | 45.2 |
| 5 | 0.6 | 0.480 | 120 |
| 6 | 0.7 | 0.494 | 206 |
| 7 | 0.8 | 0.503 | 0.297 |
| 8 | 0.9 | 0.510 | 390 |
| 9 | 1.0 | 516 | 484 |
| 10 | 1.1 | 521 | 579 |
| 11 | 1.2 | 525 | 675 |
| 12 | 1.3 | 528 | 772 |
| 13 | 1.4 | 531 | 869 |
| 14 | 1.5 | 534 | 966 |
| 15 | 1.6 | 536 | 1060 |

➢ Reverse Bias ↪

| S.No. | Supply Voltage Vs(V) | Output Voltage Vz(V) | Output Current Iz(μA) |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 2 | 0.5 | 0.5 | 0 |
| 3 | 1 | 1 | 0 |
| 4 | 2 | 2 | 0 |
| 5 | 3 | 3 | 0 |
| 6 | 4 | 4 | 0 |
| 7 | 5 | 5 | 0 |
| 8 | 5.1 | 5.07 | 32.2 |
| 9 | 5.2 | 5.1 | 99.4 |
| 10 | 5.4 | 5.13 | 265 |
| 11 | 5.5 | 5.15 | 353 |
| 12 | 5.7 | 5.17 | 532 |
| 13 | 6 | 5.19 | 807 |
| 14 | 7 | 5.26 | 1740 |

Graphs ↬

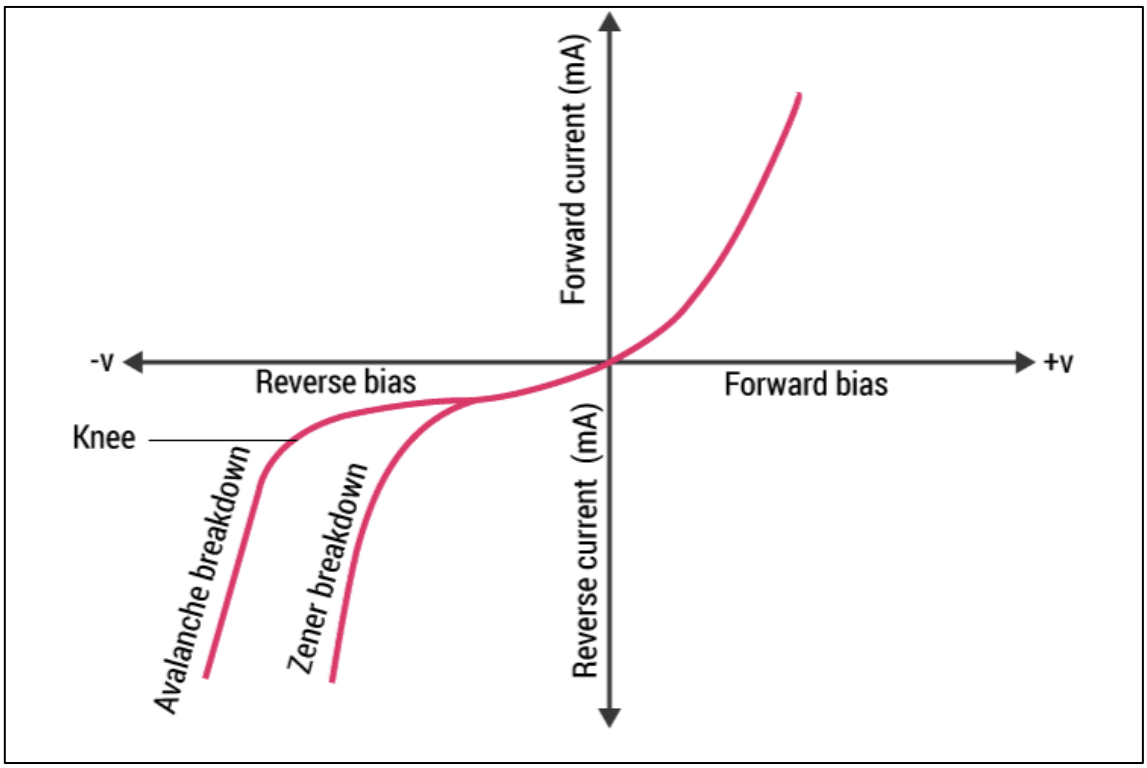


Fig 5. Ideal Characteristic Curve

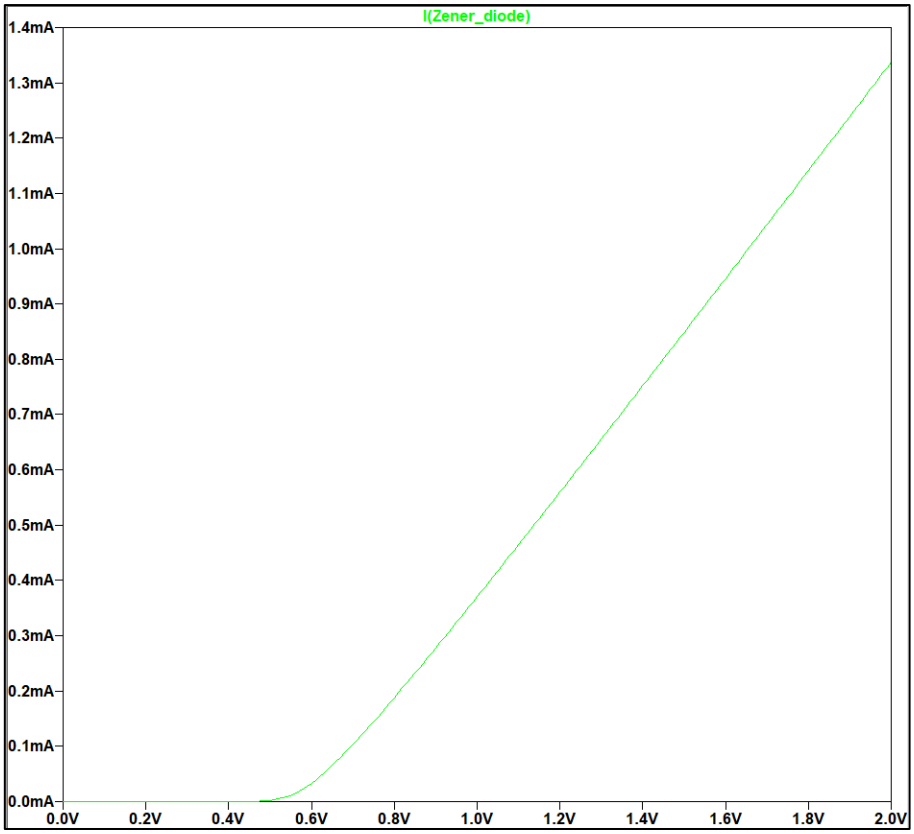


Fig 6. Forward Bias

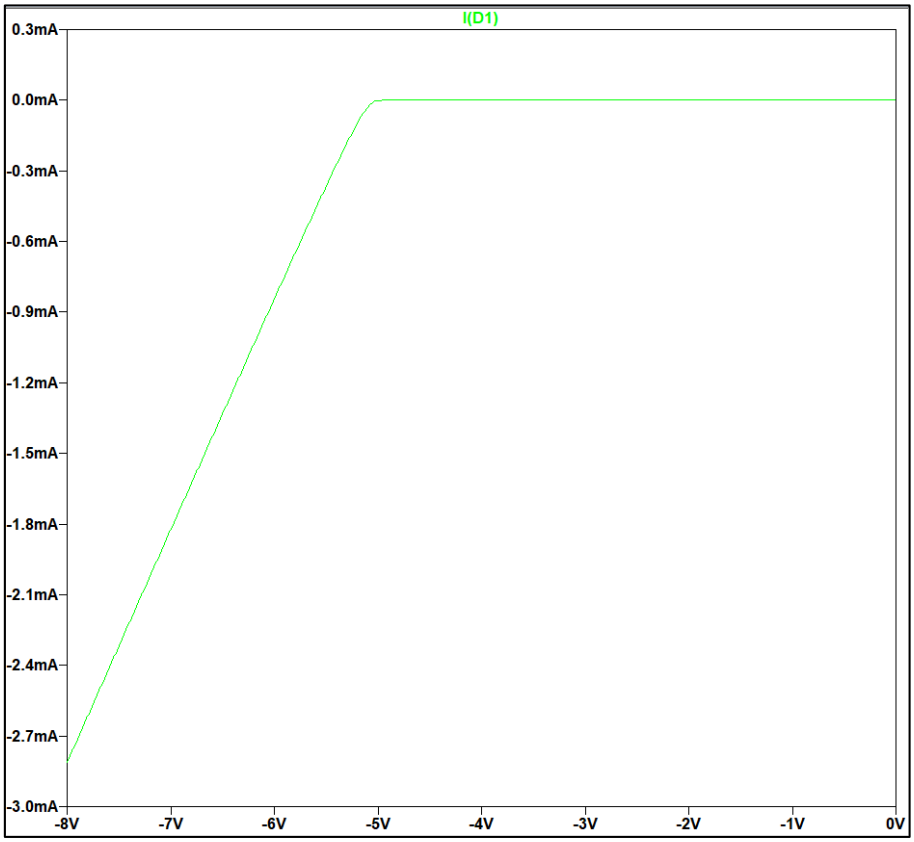


Fig 7. Reverse Bias

## Result ↬

The experiment demonstrated that the Zener diode has a Zener breakdown voltage of approximately 5.1V. In forward bias, the current increased steadily with voltage, which is typical of diode behavior. In reverse bias, the current remained negligible until the breakdown voltage was reached, after which it increased significantly while maintaining a constant voltage of 5.1V. When used as a voltage regulator, the Zener diode successfully maintained a stable output voltage of 5.1V across the load despite variations in the input voltage and load current.

## Conclusion ↬

Successfully performed the experiment and verified the result with the simulation result.

## Precautions ↬

- While doing the experiment, do not exceed the ratings of the diode. This may lead to damage to the diode.
- Connect the voltmeter and Ammeter in the correct polarities as shown in the circuit diagram.
- Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.