Aim ↬ Study of characteristics of Zener diode in Forward bias & Reverse bias.

Equipment Required ↬

Diode characteristics trainer kit, patch cords, power supply, etc.

Theory ↬

The Zener diode is a reverse-biased heavily-doped silicon or germanium P-N junction diode operating in the breakdown region, where current is limited by external resistance and power dissipation. Silicon is preferred due to its higher temperature and current capability. Zener breakdown occurs when a strong electric field in the depletion region breaks covalent bonds, producing a large number of electrons and holes that constitute the reverse saturation current, known as Zener current (I_Z).

The V-I characteristics indicate that the forward characteristic resembles that of a regular forward-biased diode. Key points include V_Z (Zener breakdown voltage), I_{Zmin} (minimum current for breakdown), and I_{Zmax} (maximum Zener current limited by power dissipation). The dynamic impedance Z is calculated as $Z_Z=\Delta V_Z/\Delta I_Z$. Zener diodes range from 2.4V to 200V in breakdown voltage, which is temperature-dependent, and their power dissipation is the product of V_Z and I_Z, with maximum ratings from 150mW to 50W.

For proper operation, a Zener diode must be reverse-biased, have a voltage across it greater than V_Z, and operate in a circuit where the current is less than I_{Zmax}. Avalanche diodes conduct in reverse when the reverse bias voltage exceeds the breakdown voltage. They break down via the avalanche effect, which creates a large current. The distinction between Zener and avalanche diodes lies in their temperature coefficients.

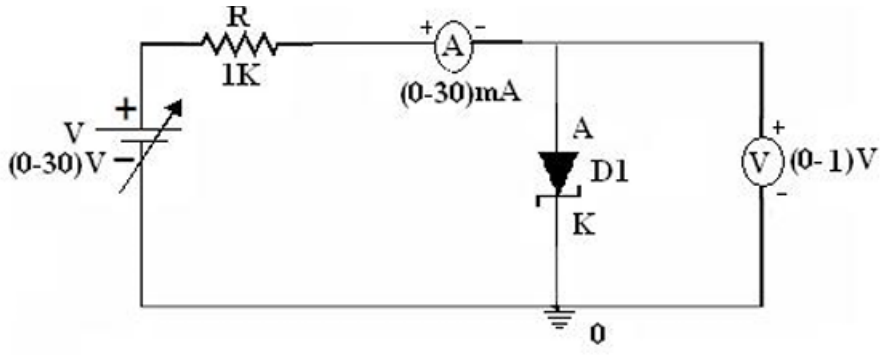

Fig. i) Forward Bias

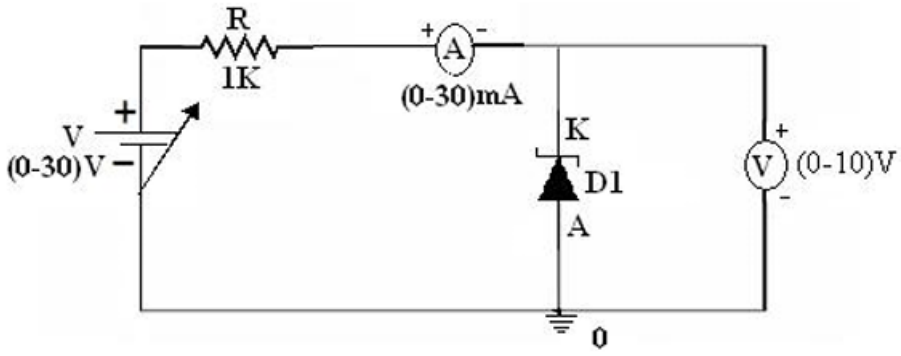

Fig. ii) Reverse Bias

In addition to voltage regulation, Zener diodes are used in temperature sensing and computing analog logarithms. They allow current to flow more easily in one direction, as represented in circuit diagrams. A diode permits current flow when forward-biased and blocks it when reverse-biased, akin to a hydraulic check valve that opens to allow flow in one direction while closing to block the opposite flow. Understanding Zener diodes' characteristics and operation is essential for effective circuit design and application.

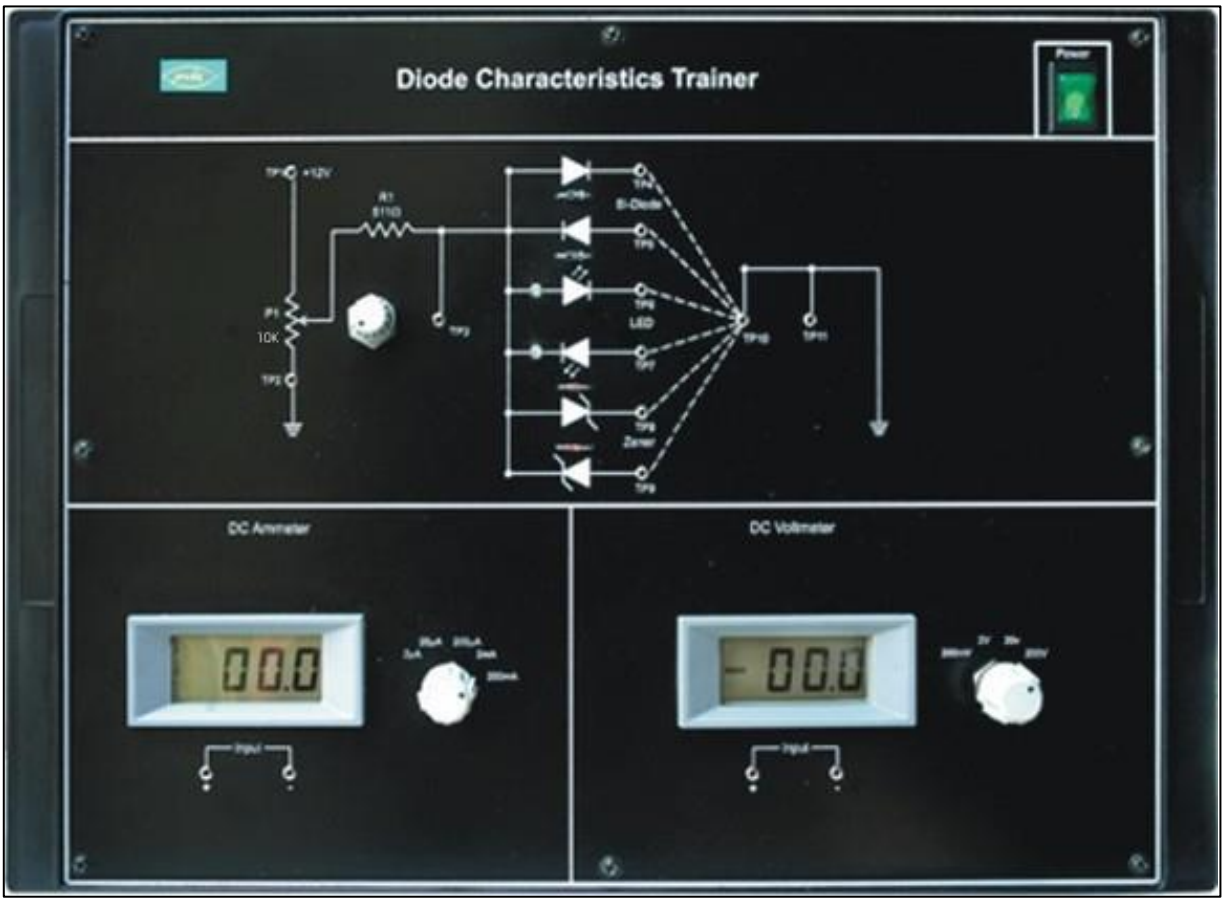

Fig. iii) Diode Characteristics Trainer Kit

Procedure ↬

To plot Forward Characteristics proceed as follows

1. Rotate potentiometer P1 fully in CCW [counterclockwise direction].
2. Connect Ammeter between TP8 and TP10, to measure diode current I_Z (mA) & set Ammeter at 2mA / 200mA range.
3. Connect Voltmeter across TP3 and TP11, to measure diode voltage V_Z & set Voltmeter at 20V range.
4. Switch 'On' the power supply.
5. Vary the potentiometer P1 so as to increase the value of Zener voltage V_z from zero to 1V in steps and measure the corresponding values of Zener current I_z in mA.
6. Plot a curve between diode voltage V_z and diode current I_z. This curve is the required Forward Characteristic of the Zener diode.
7. Switch 'Off' the supply.

To plot Reverse Characteristics proceed as follows

1. Before switching 'On' the supply rotate potentiometer P1 fully in CCW [counterclockwise direction].
2. Connect the Ammeter between TP5 and TP10 to measure the diode current I_Z (µA) & set the Ammeter at the 200µA range.
3. Connect Voltmeter across TP3 and TP11, to measure diode voltage V_Z & set Voltmeter at 20V range.
4. Switch 'On' the power supply.
5. Vary the potentiometer P1 so as to increase the value of diode voltage V_Z from 0 to maximum in steps and measure the corresponding values of diode current I_Z in A.
6. Plot a curve between diode voltage V_D and diode current I_D. This curve is the required reverse characteristic of the Ge diode.
7. Switch 'Off' the supply.

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	0.516	484
10	1.1	0.521	579
11	1.2	0.525	675
12	1.3	0.528	772
13	1.4	0.531	869
14	1.5	0.534	966
15	1.6	0.536	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 ↬

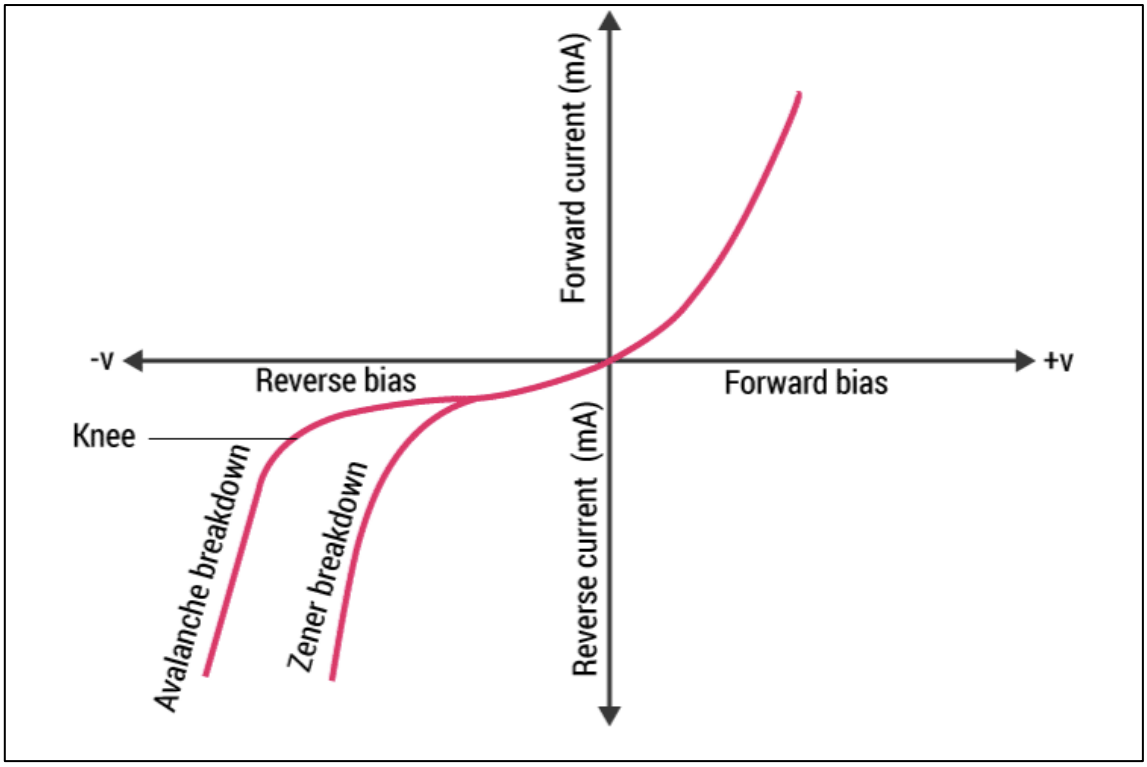

Fig. iv) I-V characteristics of PN Junction Diode

Result ↬

The experiment successfully illustrated the forward and reverse characteristics of the Zener diode. In forward bias, the current increased rapidly after surpassing the threshold voltage. In reverse bias, the diode exhibited a stable voltage drop at the Zener breakdown voltage.

Conclusion ↬

The forward and reverse characteristics of the Zener diode were confirmed, demonstrating its critical role in voltage regulation. The experiment matched theoretical expectations, highlighting the Zener diode's effectiveness in stabilizing voltage in electronic circuits.

Precautions ↬

- Ensure all connections are secure and components are correctly placed.
- Do not exceed voltage ratings for the Zener diode.
- Verify polarity before powering on.
- Double-check the circuit setup for safety and accuracy.