Aim ↬

i. **Study of Forward Characteristics of Silicon diode.**
ii. **Study of Reverse Characteristics of Germanium Diode.**

Equipment Required ↬

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

Theory ↬

A P-N junction diode is created by combining P-type and N-type semiconductor materials, forming a depletion region that acts as a barrier to charge carriers. This design enables the diode to conduct current in one direction (forward bias) while blocking it in the other (reverse bias). In forward bias, when a positive voltage is applied to the P-type side and a negative voltage to the N-type side, the external voltage reduces the barrier formed by the depletion region. Once this voltage exceeds the barrier potential—approximately 0.7V for silicon and 0.3V for germanium—the diode starts conducting. In reverse bias, the depletion region widens, preventing significant current flow except for a small leakage current, which persists until a high reverse voltage causes breakdown.

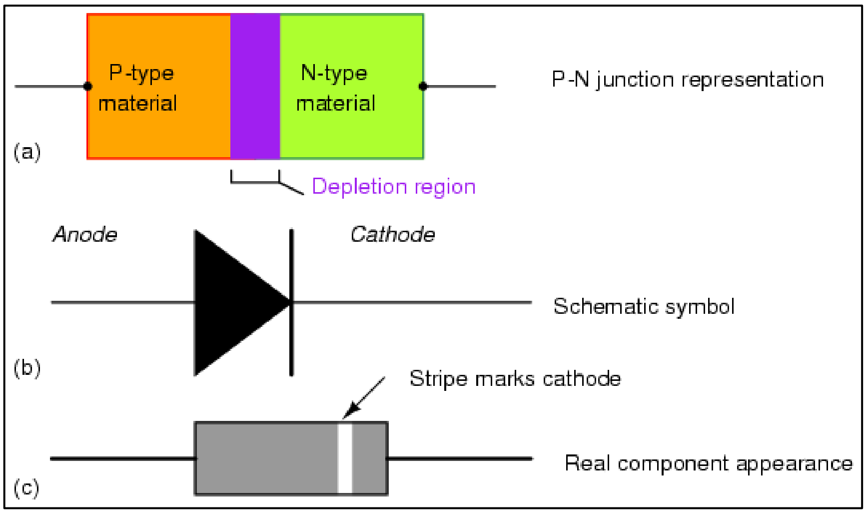

Fig. i) Diode Representations

In forward bias, the diode initially resists current flow due to the depletion region. As the applied voltage rises above the threshold, the diode enters conduction, where current increases rapidly. For a typical silicon diode, exceeding 0.7V leads to a sharp current rise, often reaching levels like 50mA. This behavior can be described by the Shockley diode equation:

$$I = I_S(e^{\frac{qV}{kT}} - 1)$$

where I_S is the reverse saturation current. The forward characteristic curve illustrates a steep increase in current after overcoming the barrier potential, essential for applications needing unidirectional current flow, such as rectifiers.

In reverse bias, the depletion region serves as an insulator, allowing only a minimal leakage current due to minority carriers. This current remains relatively constant until the breakdown voltage is reached, leading to a rapid increase in current as the electric field frees electrons. In standard diodes, this breakdown is undesirable, but in Zener diodes, it is exploited for voltage regulation.

$$I_{reverse} \approx I_S$$

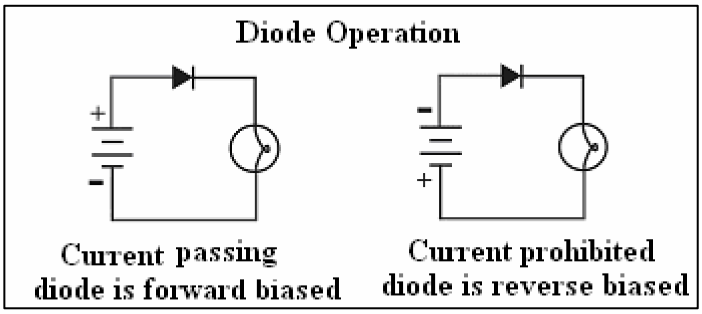

Fig. ii) Bias Circuits

The expected V-I characteristics of a P-N junction diode will show negligible current in forward bias until the threshold voltage is surpassed, after which the current increases sharply. In reverse bias, the current remains low until the breakdown. These results emphasize the diode's capability to conduct in one direction while blocking current in the opposite direction, making it vital for rectification and voltage protection in various electronic circuits.

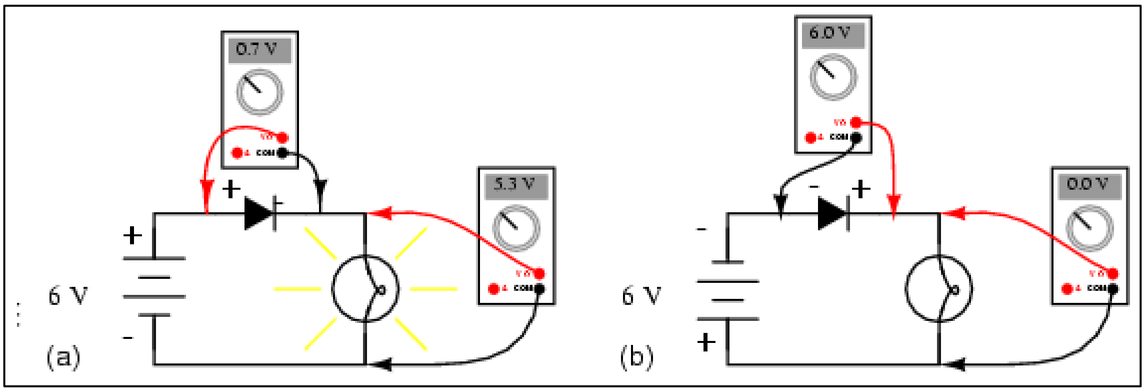

Fig. iii) Diode Circuit voltage measurements

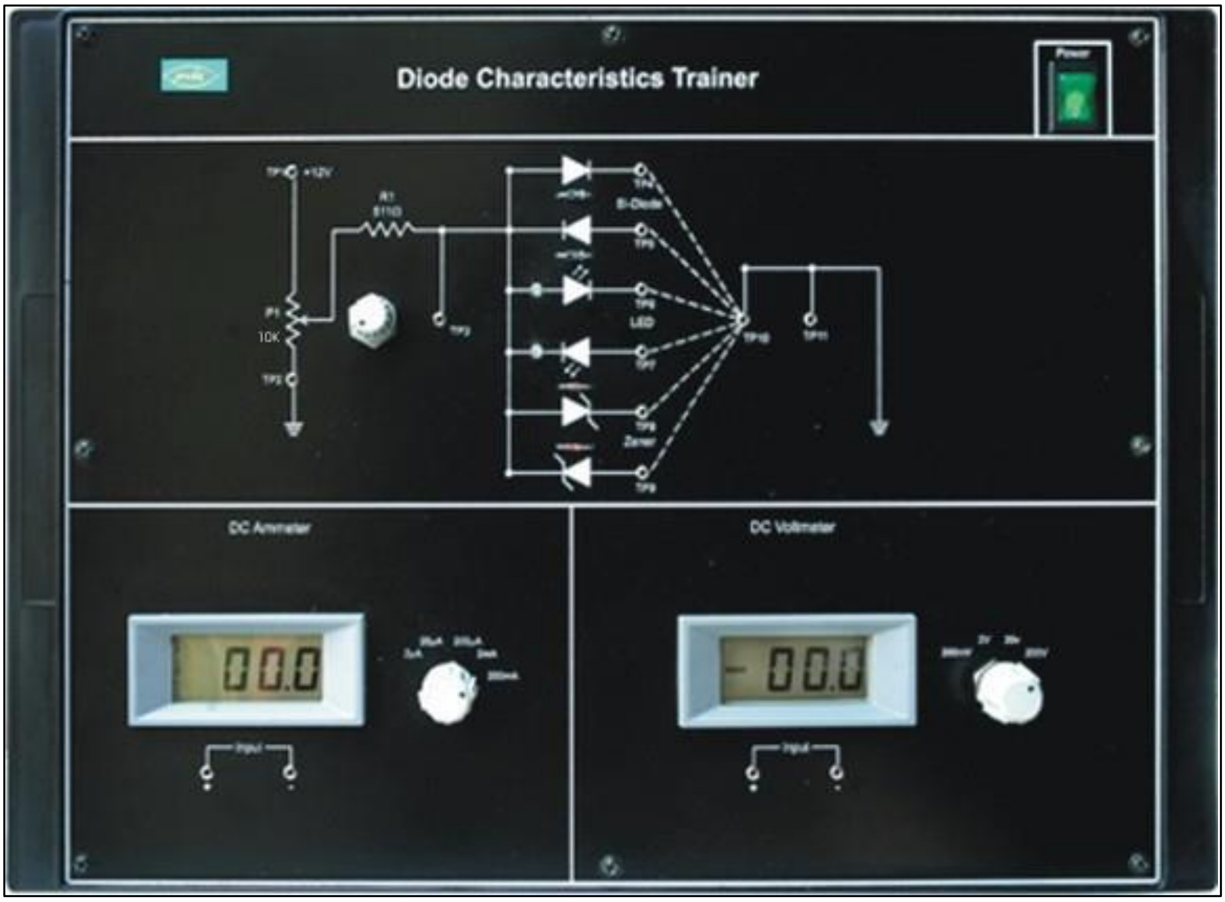

Fig. iv) Diode Characteristics Trainer Kit

Procedure ↬

To plot Forward Characteristics proceed as follows

1. Before switching ‘On’ the supply rotate potentiometer P1 fully in CCW [counterclockwise direction].
2. Connect the Ammeter between TP4 and TP10 to measure the diode current ID (mA) & set the Ammeter at the 2mA / 200mA range (as per instructor instructions).
3. Connect Voltmeter across TP3 and TP11, to measure diode voltage V_D & 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_D from 0 to 1V (0.83V) in steps and measure the corresponding values of diode current ID in mA.
6. Plot a curve between diode voltage V_D and diode current I_D. This curve is the required forward characteristic of the Si 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 [counter clockwise direction].
2. Connect the Ammeter between TP5 and TP10 to measure the diode current I_D (μA) & set the Ammeter at the 200μA range (as per instructor instructions).
3. Connect Voltmeter across TP3 and TP11, to measure diode voltage V_D & 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_D from 0 to maximum in steps and measure the corresponding values of diode current I_D 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 V_D(V)	Output Current I_D(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 V_D(V)	Output Current I_D (A)
1	0	0	0
2	0.2	0.2	0
3	0.5	0.5	0
4	0.7	0.7	0
5	1	1	0
6	1.5	1.5	0
7	2	2	0
8	3	3	0
9	4	4	0
10	5	5	0

Graphs ↬

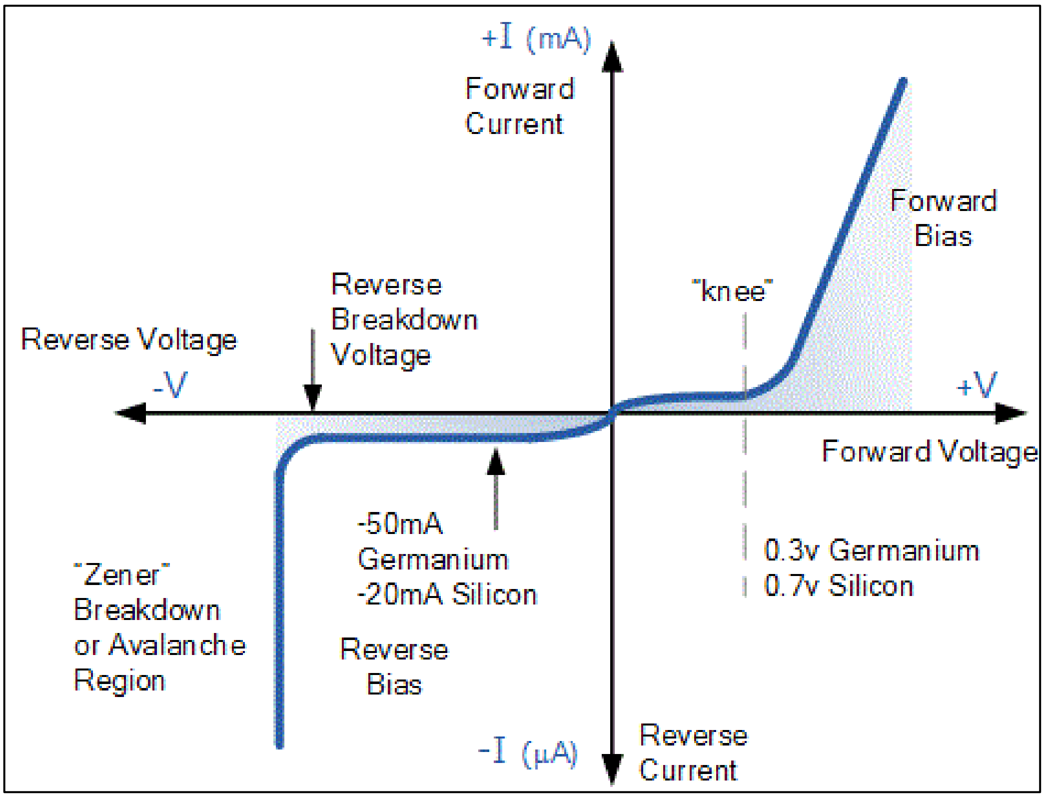

Fig. v) I-V characteristics of PN Junction Diode

Result ↬

The experiment successfully illustrated the forward and reverse characteristics of silicon and germanium diodes. The silicon diode showed a marked increase in current after reaching 0.7V in forward bias, while the germanium diode displayed minimal leakage current in reverse bias until breakdown.

Conclusion ↬

The forward and reverse characteristics of P-N junction diodes were confirmed, matching theoretical predictions. The experiment highlighted their significance in applications like rectification and voltage regulation.

Precautions ↬

- Check all connections and ensure components are secure.
- Do not exceed voltage ratings, especially for diodes.
- Verify polarity before powering on.
- Double-check the setup for safety and accuracy.