To Draw the Characteristic Curve Of a Zener Diode & to Determine Its Reverse Breakdown Voltage

Aim

To draw the characteristic curve of a Zener diode and to determine its reverse breakdown voltage.

Apparatus

A Zener diode (with small reverse breakdown voltage of about 6 volts), [i.e., V_z = 6 V], a ten volt battery, a high resistance rheostat, two 0-10 V voltmeter, one 0-100 mA ammeter, one 20 Ω. resistance, one way key, connecting wires.

Theory

Zener Diode. It is a semiconductor diode, in which the n-type and the p-type sections are heavily doped, i.e., they have more percentage of impurity atoms. This heavy doping results in a low value of reverse breakdown voltage (BV_R). This value can be controlled during manufacture.

The reverse breakdown voltage of a Zener diode, is called Zener voltage (V_z). The reverse current that results after the breakdown, is called Zener current (I_z).

Circuit Parameters

In the circuit given before.

V_I = Input (reverse bias) voltage

V_0 = Output voltage (R_L/I_L)

R_I = Input resistance

R_L = Load resistance

I_I = Input current (reverse current)

I_Z = Zener diode current

I_L = Load current

Relations

$$I_L = I_I - I_Z \quad \text{...(1)}$$

$$V_0 = V_I - R_I I_I \quad \text{...(2)}$$

Initially as V_1 is increased, I_1 increases a little, then V_0 increases.

At breakdown, increase of V_I increases I_I by large amount, so that $V_0 = V_I - R_I I_I$ becomes constant. This constant value of V_0 which is the reverse breakdown voltage, is called Zener voltage.

Formula used

$$V_0 = V_I - R_I I_I$$

Constant value of V_0 gives reverse breakdown voltage.

Diagram

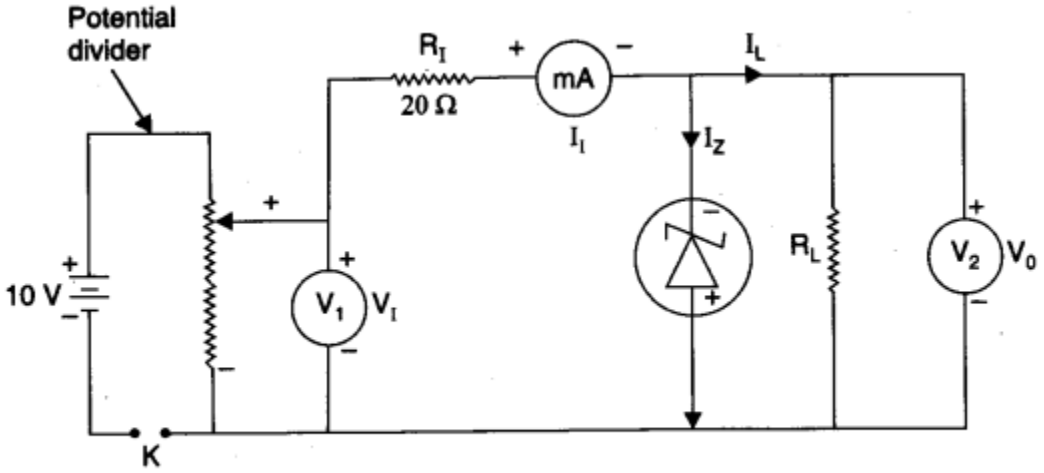

Fig. Zener diode characteristics.

Procedure

1. Arrange apparatus as shown in circuit diagram.
2. Make all connections neat, clean and tight.
3. Note least count and zero error of voltmeters and milli-ammeter. (micro-ammeter)
4. Bring moving contact of potential divider (rheostat) near negative end and insert the key K. Voltmeters and milli-ammeter will give zero reading.
5. Move the contact a little towards positive end to apply some reverse bias voltage (V_I). Milli-ammeter reading remains zero. Voltmeters give equal readings. [i.e.,$V_0 = V_I$ .. $I_I = 0$ (eqn. 2)]
6. As V_I is further increased, I_I starts flowing. Then V_0 becomes less than V_INote the values of V_p I_I and V_0.
7. Go on increasing V_I in small steps of 0.5 V. Note corresponding values of I_I and V_0 which will be found to have increased.
8. As V_I is made more and more, I_I and V_0 are found to increase. Values are noted.
9. At one stage, as V_I is increased further, I_I increases by large amount and V_0 does not increase. This is reverse breakdown situation.
10. As V_I is increased further, only I_I is found to increase, V_0 becomes constant. Note values of V_I, I_I and V_0.
11. Increase V_1 to a value of 10 V, noting corresponding values.
12. Record your observations as given ahead.

Observations

Least count of voltmeter (V_1) = ... V
Zero error of voltmeter (V_1) = ... V
Least count of voltmeter (V_2) = ... V
Zero error of voltmeter (V_2) = ... V
Least count of milli-ammeter = ... mA
Zero error of milli-ammeter = ... mA.

Table for V_I, I_I and V_0

Serial No. of Obs. (1)	*Input voltage (V_I) (V) (2)*	*Input current (I_I) (μA) (3)*	*Output voltage V_0 (V) (4)*
1.	.....	.....	
2.	.....	.....	
⋮			
⋮			
⋮			
20.	.....	.....	
21.	.....	.....	

Calculations

Plot a graph between input voltage V_I (column 2) and input current (column 3), taking V_I along X-axis and I_I along Y-axis.

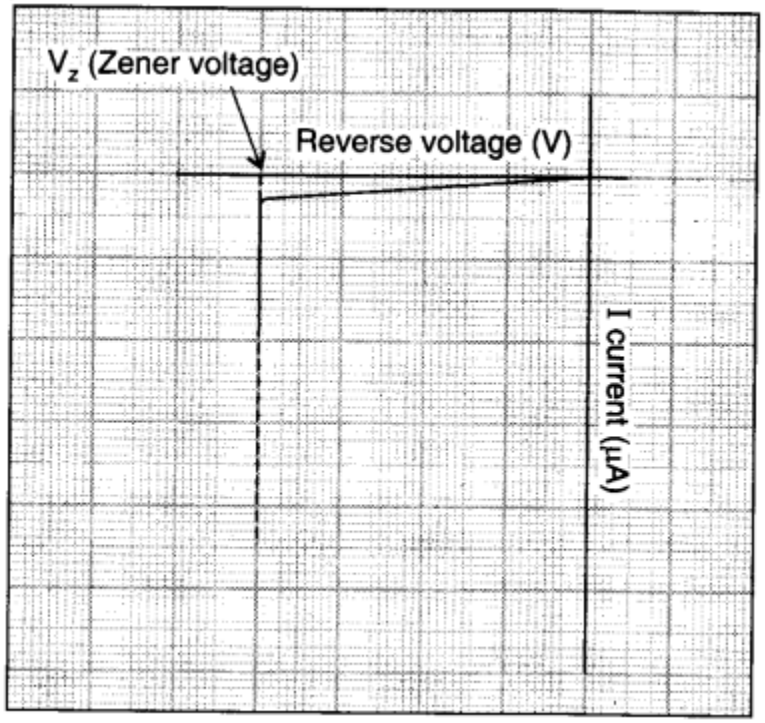

Fig. Characteristic curve of a zener diode.

Result

The reverse' breakdown voltage of given Zener diode is

Precautions

1. All connection should be neat, clean and tight.
2. Key should be used in circuit and opened when the circuit is not being used.

Viva Voce

Question. 1. What is reverse current?
Answer. The current due to reverse bias voltage, is called reverse current.

Question. 2. What constitutes the reverse current?
Answer. The reverse current is due to minority carriers.

Question.3. What are minority carriers?
Answer. Free electrons in p-type semiconductor and holes in re-type semiconductor, are called minority carriers. They are present due to breaking of covalent bonds.

Question.4. What is reverse breakdown?
Answer. At certain stage of increased reverse bias voltage, the reverse current increases suddenly. This situation is called reverse breakdown. This phenomenon is called Zener effect.

Question.5. What causes reverse breakdown?
Answer. The rupture of all covalent bonds causes reverse breakdown.

Question. 6. Is the reverse breakdown recoverable?
Answer. Yes. The decrease of reverse bias voltage restores the condition. The broken bonds are reassembled.

Question.7. What is reverse breakdown voltage?
Answer. The reverse bias voltage which causes breakdown, is called reverse breakdown voltage. It is represented by the symbol BV_R.

Question. 8. On which factor does the reverse breakdown voltage depend?
Answer. It depends upon the level of doping of re-type and p-type section of the diode. General purpose diodes have each section lightly doped. They have high value of reverse breakdown voltage.
Zener diodes have each section heavily doped. They have low value of reverse breakdown voltage.

Question.9. What is Zener voltage?
Answer. The reverse breakdown voltage of Zener diodes, is called Zener voltage. It is represented by the symbol V_z.

Question. 10. How does Zener voltage differ for Germanium and Silicon?
Answer. For same order of doping, it is less for Germanium and more for silicon.

Question.11.What is Zener current?
Answer. The reverse current after breakdown, is called Zener current. It is represented by the symbol I_z.

Question.12.How does a Zener diode work as a voltage regulator?
Answer. At breakdown and after, output voltage (V_0) becomes constant at value of Zener voltage (V_z) even when input voltage (V_i) increases.
Thus, the Zener diode will give same output voltage for all input voltage of higher values. It becomes a voltage stabilizer for voltage equal in value of Zener voltage (V_z). The current drawn does not affect the zener voltage.

Question.13.What is the Knee voltage?
Answer. The forward voltage beyond which the current starts to increase rapidly with voltage is called the cut-in or Knee voltage of the diode.

Question.14.What happens to the potential barrier and depletion layer when a reverse bias is applied to a p-n junction diode?
Answer. Both increases.

Question.15.What is fermi level?
Answer. It is the highest energy level in the conduction band occupied by the electrons at the absolute zero of temperature.

Question.16.What is Zener breakdown?
Answer. Due to small junction width, the junction field is high. Due to this internal high field, there is large production of electron-hole pairs. The corresponding breakdown is called breakdown.

Question.17.What is Zener diode?
Answer. It is specially designed p-n diode whose both sides are heavely doped and work only in the reverse breakdown region.

Question.18.Give one application of a diode.
Answer. Rectifier.

Question.19.What is ideal diode?
Answer. It is a diode which offers zero resistance in forward biasing and infinite resistance in reverse biasing.

Question.20.How the energy gap changes with (i) doping (ii) temperature?
Answer. Decrease with increase in doping and temperature.