ZENER DIODE

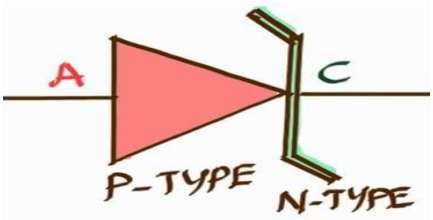
❖ Introduction:

- ❖ American physicist Clarence Melvin Zener invented the zener diode.
- ❖ The term "zener diode" is used independently of the breakdown mechanism.

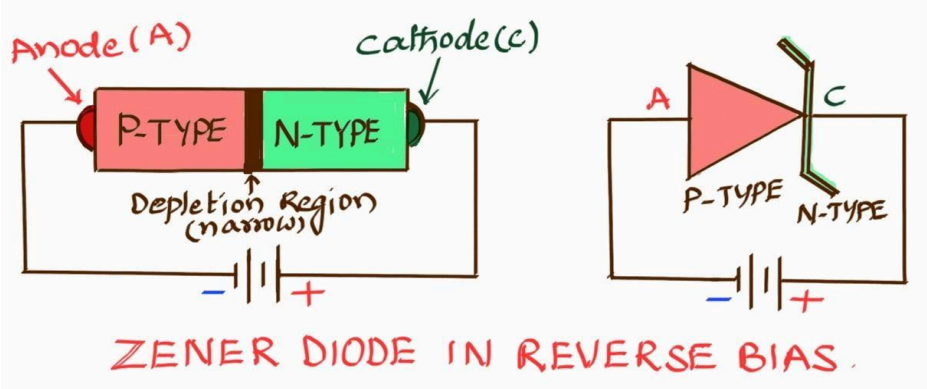
❖ Definition of Zener Diode:

- ❖ The diode which is heavily doped and has adequate power-dissipation capabilities to operate in the breakdown region is called a zener diode.

❖ Symbol of Zener Diode:



❖ Zener Diode Circuit:



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❖ Working of Zener Diode:

- ❖ The basic principle behind the working of a zener diode is based on the cause of breakdown when it reaches a zener voltage under the reverse biased condition.
- ❖ For a zener diode, there are two types of breakdown:

1.Zener breakdown (caused by Zener effect).

2.Avalanche breakdown (caused by Avalanche effect).

❖ 1. Zener Breakdown:

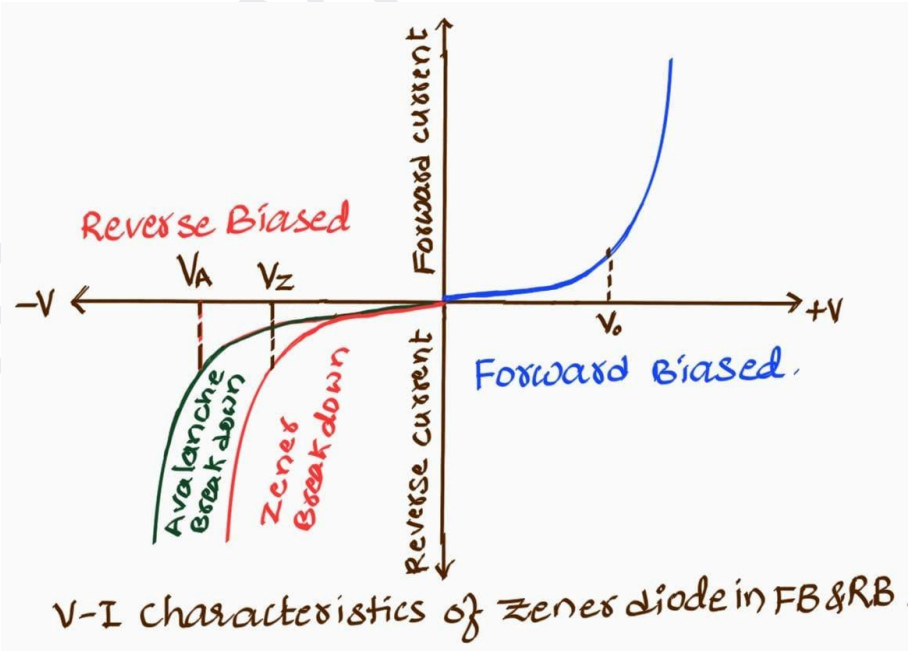
- ❖ When the reverse bias voltage applied to a zener diode approaches its zener voltage, the electric field within the region becomes strong enough to attract and remove electrons from their valence band (VB).
- ❖ These valence electrons, energized by the intense electric field, break free from their parent atoms.This phenomenon takes place in the zener breakdown region, where even a slight increase in voltage leads to a rapid surge in electric current.

❖ 2. Avalanche Breakdown:

- ❖ Avalanche breakdown occurs in both normal and zener diodes when subjected to high reverse voltage.
- ❖ When a significant reverse voltage is applied to the PN Junction, the free electrons gain enough energy to accelerate at high velocities.These high velocity electrons collide with other atoms, causing the ejection of additional electrons.
- ❖ This continuous collision process generates a large number of free electrons, resulting in a rapid increase in electric current through the diode.
- ❖ A zener diode is specifically designed to withstand avalanche breakdown and can handle the sudden current spike.
- ❖ Avalanche breakdown typically occurs in zener diodes with a zener voltage (Vz) >6V.

❖ V-I Characteristics of Zener Diode:

- ❖ The V-I characteristics of a zener diode can be divided into 2 parts as follows:



❖ **(i) Forward Characteristics of zener diode:**

❖ From the graph of I-quadrant, we observe that a zener diode acts very much similar to an ordinary diode under forward bias condition. So the zener diode is not used in FB (forward bias) condition.

❖ **(ii) Reverse Characteristics of zener diode:**

❖ In the graph, the III-Quadrant represents the Reverse characteristics of a zener diode, that are very much different from that of an ordinary diode.

❖ As the reverse voltage (-v) increases, the small reverse saturation current flows across the diode due to thermally generated minority carriers.

❖ As the reverse voltage increases, at a certain value of reverse voltage, the reverse current increases abruptly, which indicates that breakdown has occurred suddenly.

❖ Such breakdown in zener diodes is called zener breakdown and the voltage at which breakdown occurs is called zener voltage (Vz).

❖ After the breakdown, the zener diode operates with constant voltage.If a reverse current above the breakdown value is allowed, the diode is permanently damaged.

❖ Zener diodes are designed in a zener voltage range of 2V to 200V.

❖ APPLICATIONS OF ZENER DIODE:

❖ The following are the applications of zener diode:

❖ **(i) Zener diode as a voltage regulator:**

❖ ZD is used as a shunt voltage regulator for regulating voltage across small loads.

❖ The breakdown voltage of a zener diode will be constant for a wide range of current.

❖ **(ii) Zener diode in over-voltage [or meter] protection:**

❖ When the input voltage is higher than the zener breakdown voltage, the voltage across the resistor drops, resulting in a short-circuit.This can be avoided by using zener diode.

❖ **(iii) Zener diode in clipping circuits:**

❖ Zener diode is used for modifying an AC waveform clipping circuit by limiting parts of either one or both the half cycles of an AC waveform.

❖ **(iv) Clamping circuits:**

❖ The Zener diode which is used in clamping circuits plays a vital role in shifting the original signal to some level on the amplitude. Based on requirement, we will use the respective clamping.