# ELECTRONICS DEVICES AND CIRCUITS

## SECTION - B

## Semiconductors, Construction & Characteristics of Devices

OBJECTIVE

# BREAKDOWN IN DIODES

- When an ordinary **P-N junction diode** is reverse biased, normally only very small reverse saturation current flows.
- This current is due to movement of minority carriers. It is almost independent of the voltage applied.
- However, if the reverse bias is increased, a point is reached when the junction breaks down and the reverse current increases abruptly.

- Reverse current could be large enough to destroy the junction.

- If the reverse current is limited by means of a suitable series resistor, the power dissipation at the junction will not be excessive, and the device may be operated continuously in its breakdown region to its normal (reverse saturation) level.

- Breakdown voltage is very stable over a wide range of reverse currents. This quality gives the *breakdown* ***diode*** many useful applications as a *voltage reference source.*


FORWARD CURRENT, I IN mA
12
10
8
6
4
2
REVERSE BIAS IN VOLTS
-8 -7 -6 -5 -4 -3 -2 -1
-V
+V
0.2 0.4 0.6 0.8
FORWARD BIAS IN VOLTS
-0.5
-1
-1.5
-2
-2.5
KNEE
AVALANCHE BREAK DOWN
ZENER BREAK DOWN
$I_0$ IN μA

- The critical value of the voltage, at which the breakdown of a P-N junction diode occurs is called the ***breakdown voltage***.

- The breakdown voltage depends on the width of the depletion region, which, in turn, depends on the doping level. The junction offers almost zero resistance at the breakdown point

# Zener breakdown and Avalanche breakdown:

- There are two mechanisms by which breakdown can occur at a reverse biased P-N junction :
- ***Avalanche breakdown,*** **and**
- ***Zener breakdown.***

- The minority carriers, under reverse biased conditions, flowing through the junction acquire a kinetic energy which increases with the increase in reverse voltage.

- At a sufficiently high reverse voltage (say 5 V or more), the kinetic energy of minority carriers becomes so large that they knock out electrons from the covalent bonds of the semi-conductor material.

- As a result of collision, the liberated electrons in turn liberate more electrons and the current becomes very large leading to the breakdown of the crystal structure itself. This phenomenon is called the **avalanche breakdown.**

- **Under a very high reverse voltage**, the depletion region expands and the potential barrier increases leading to a very high electric field across the junction.

- Because of that, the **electric field** will break some of the covalent bonds of the semiconductor atoms leading to a large number of free minority carriers, which suddenly increase the reverse current. This is called the **Zener effect**.

- The breakdown occurs at a particular and constant value of reverse voltage called the breakdown voltage, it is found that Zener breakdown occurs at electric field intensity of about 3 x 10^7 V/m.

- Either of the two (**Zener breakdown or avalanche breakdown**) may occur independently, or both of these may occur simultaneously.

- Diode junctions that breakdown below 5 V are caused by Zener effect. Junctions that experience breakdown above 5 V are caused by ava-lanche effect..