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Coimbatore-35
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB101 – CIRCUIT ANALYSIS AND DEVICES

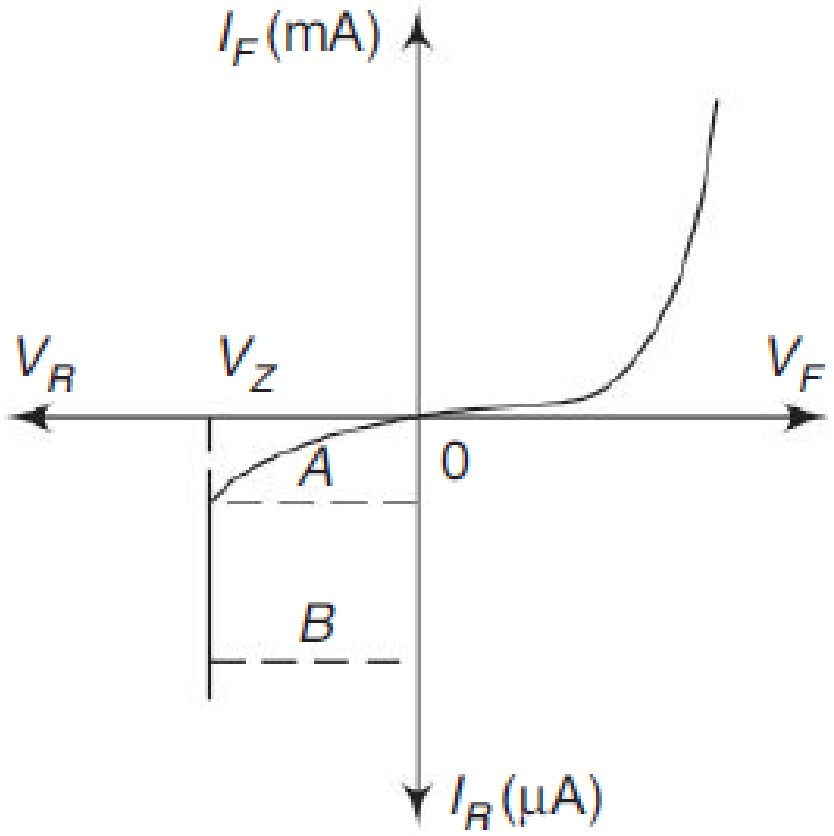
I YEAR/ II SEMESTER

UNIT 4 – SEMICONDUCTOR DIODES AND THEIR APPLICATIONS

TOPIC - Zener and Avalanche Breakdown

Introduction

- When the reverse voltage reaches breakdown voltage in a normal PN junction diode, the current through the junction and the power dissipated at the junction will be high.
- Such an operation is destructive and the diode gets damaged.
- Whereas diodes can be designed with adequate power dissipation capabilities to operate in the breakdown region.
- One such diode is known as the Zener diode.
- The Zener diode is *heavily doped* than the ordinary diode.



V–I characteristics of a Zener diode

- From the V–I characteristics of the Zener diode, shown in Figure, it is found that the operation of the Zener diode is same as that of an ordinary PN diode under forward-biased condition.
- Whereas under reverse-baised condition, breakdown of the junction occurs.
- The breakdown voltage depends upon the amount of doping.
- If the diode is heavily doped, the depletion layer will be thin and, consequently, breakdown occurs at lower reverse voltage and further, the breakdown voltage is sharp.

- Whereas a lightly doped diode has a higher breakdown voltage. Thus, breakdown voltage can be selected with the amount of doping.
- The sharp increasing currents under breakdown conditions are due to the following two mechanisms.

Avalanche breakdown

Zener breakdown

Avalanche breakdown

- As the applied reverse bias increases, the field across the junction increases correspondingly.
- Thermally generated carriers, while traversing the junction, acquire a large amount of kinetic energy from this field.
- As a result, the velocity of these carriers increases. These electrons disrupt covalent bond by colliding with immobile ions and create new electron-hole pairs.
- These new carriers again acquire sufficient energy from the field and collide with other immobile ions thereby generating further electron-hole pairs.
- This process is cumulative in nature and results in generation of avalanche of charge carriers within a short time.

- This mechanism of carrier generation is known as **avalanche multiplication**.
- This process results in flow of large amount of current at the same value of reverse bias.

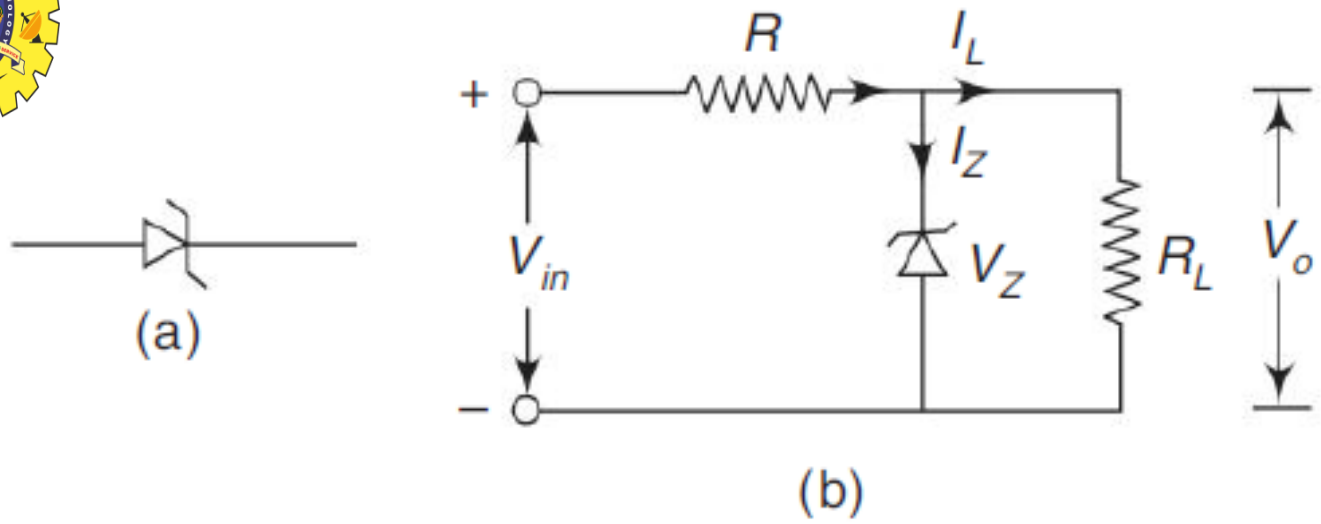
Zener Breakdown

- When the P- and N-regions are heavily doped, direct rupture of covalent bonds takes place because of the strong electric fields, at the junction of the PN diode.
- The new electron-hole pairs so created increase the reverse current in a reverse-biased PN diode.
- The increase in current takes place at a constant value of reverse bias typically *below 6 V for heavily doped diodes*.
- As a result of heavy doping of P- and N-regions, the depletion-region width becomes very small and for an applied voltage of 6 V or less, the field across the depletion region becomes very high, of the order of 10^7 V/m, making conditions suitable for Zener breakdown.

- For lightly doped diodes, Zener breakdown voltage becomes high and breakdown is then predominantly by avalanche multiplication.
- Though Zener breakdown occurs for lower breakdown voltage and avalanche breakdown occurs for *higher breakdown voltage*, such diodes are normally called Zener diodes.

Zener Diode Applications

- From the Zener characteristics, under the reverse-bias condition, the voltage across the diode remains almost constant although the current through the diode increases as shown in region AB.
- Thus, the voltage across the Zener diode serves as a reference voltage.
- Hence, the *diode can be used as a voltage regulator*.
- In Figure, it is required to provide constant voltage across load resistance RL, whereas the input voltage may be varying over a range.



Zener diode: (a) Circuit symbol (b) As a voltage regulator

- As shown, Zener diode is reverse biased and as long as the *input voltage does not fall below Vz* (Zener breakdown voltage), the voltage across the diode will be constant and hence the load voltage will also be constant.


THANK YOU