UNIT-IV

Fundamentals of semiconductor devices and digital circuits

Lecture 27

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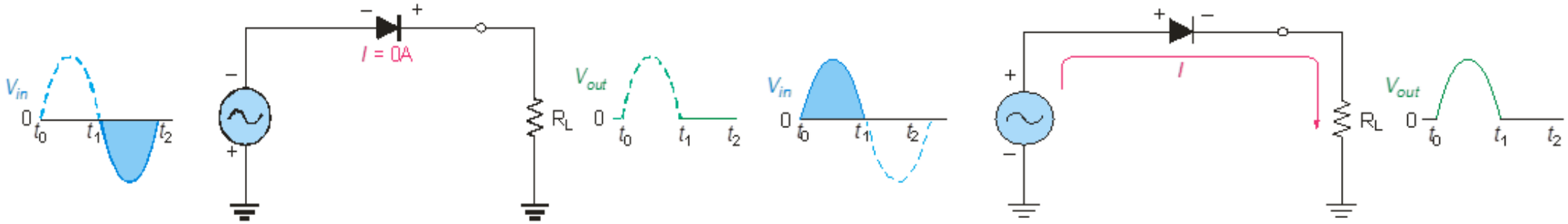
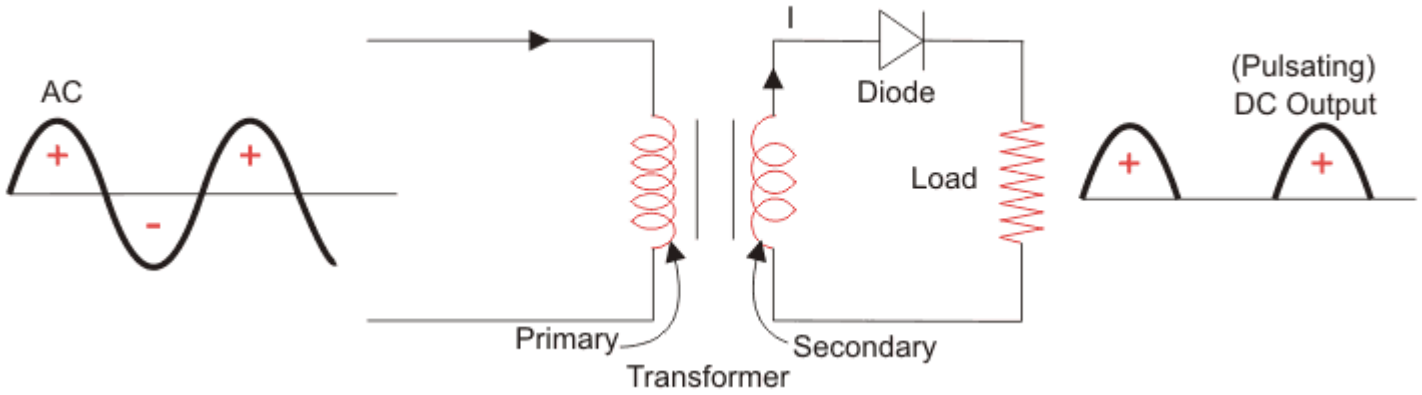
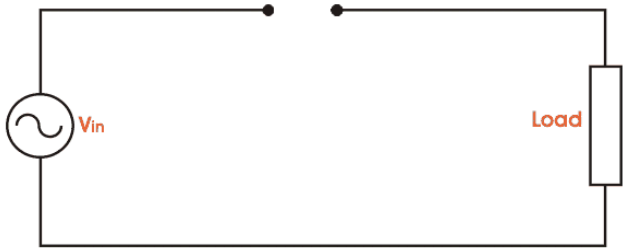
Half wave Rectifiers

- As diodes conduct current in one direction and block in other.
- When connected with ac voltage, diode only allows half cycle passing through it and hence convert ac into dc.
- As the half of the wave get rectified, the process called half wave rectification.
  - A diode is connected to an ac source and a load resistor forming a half wave rectifier.
  - Positive half cycle causes current through diode, that causes voltage drop across resistor.



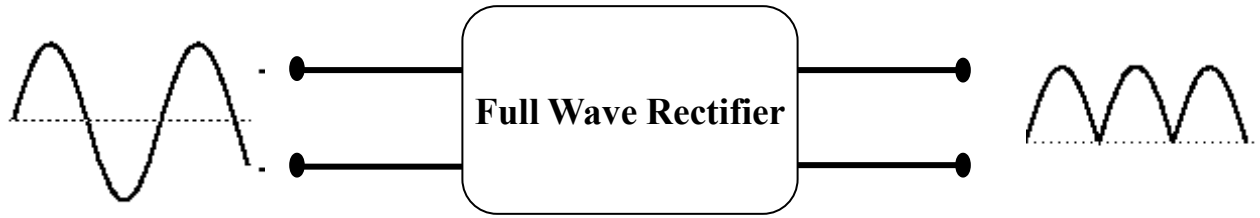
Explanation Slide





Full wave Rectifiers

- A full wave rectifier converts both halves of each cycle of an alternating wave (AC signal) into pulsating DC signal.

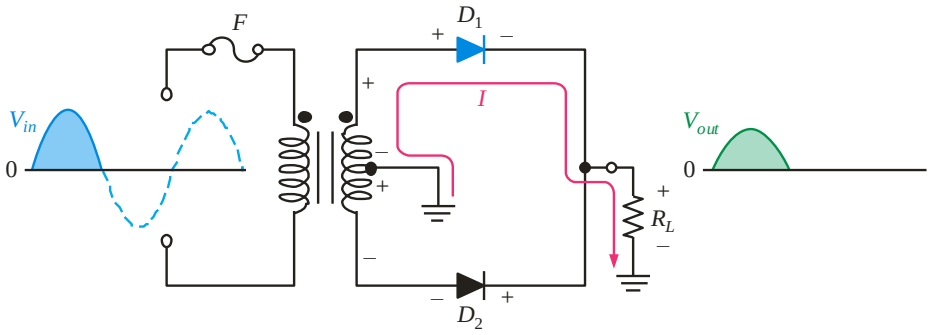


- We can further classify full wave rectifiers into:

1. **Centre-tapped Full Wave Rectifier**
2. **Full Wave Bridge Rectifier**

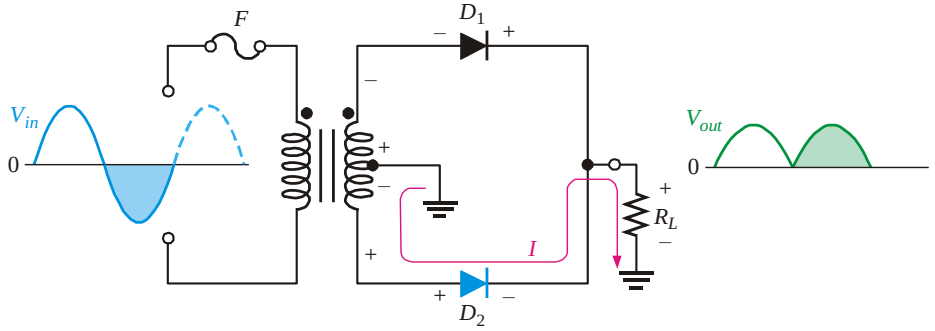
The Center-Tapped Full wave rectifiers

- A center-tapped transformer is used with two diodes that conduct on alternating half-cycles.



During the positive half-cycle, the upper diode is forward-biased and the lower diode is reverse-biased.

During the negative half-cycle, the lower diode is forward-biased and the upper diode is reverse-biased.

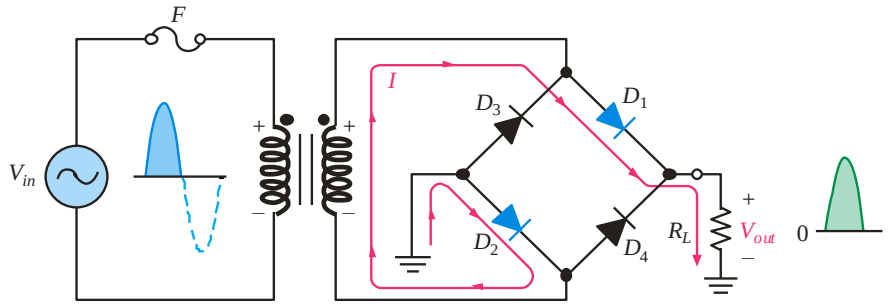


Explanation Slide

- PIV
- Ripple factor
- Form factor
- Efficiency

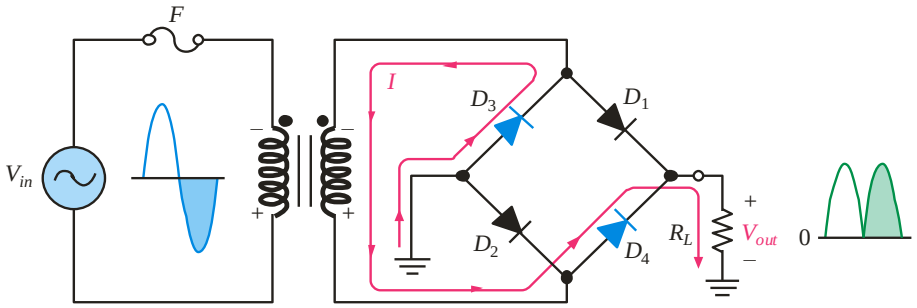
The Bridge Full-wave rectifiers

❖The Bridge Full-Wave rectifier uses four diodes connected across the entire secondary as shown.

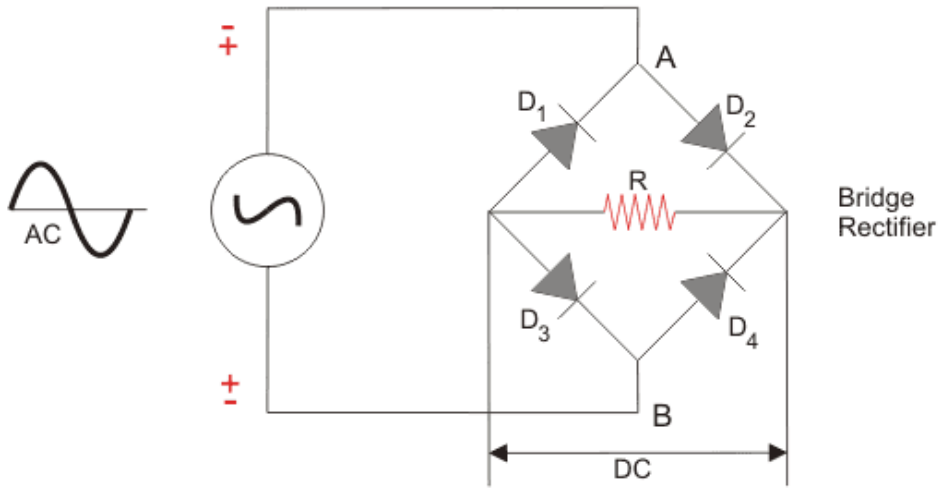


Conduction path for the positive half-cycle.

Conduction path for the negative half-cycle.



Explanation Slide



Parameters

- Ripple Factor $= \sqrt{\left(I_{RMS}^2 / I_{av}^2 - 1 \right)}$ or $\sqrt{\left(V_{RMS}^2 / V_{av}^2 - 1 \right)}$
- Form Factor

QUICK QUIZ (POLL)

If input frequency is 50Hz for a full wave rectifier, the ripple frequency of it would be _____

a) 100Hz

b) 50Hz

c) 25Hz

d) 500Hz

QUICK QUIZ (POLL)

If input frequency is 50Hz then ripple frequency of half wave rectifier will be equal to _____

a) 100Hz

b) 50Hz

c) 25Hz

d) 500Hz

QUICK QUIZ (POLL)

DC average current of a half wave rectifier output is _____

(Where Im is the maximum peak current of input)

a) $\frac{2I_m}{\pi}$

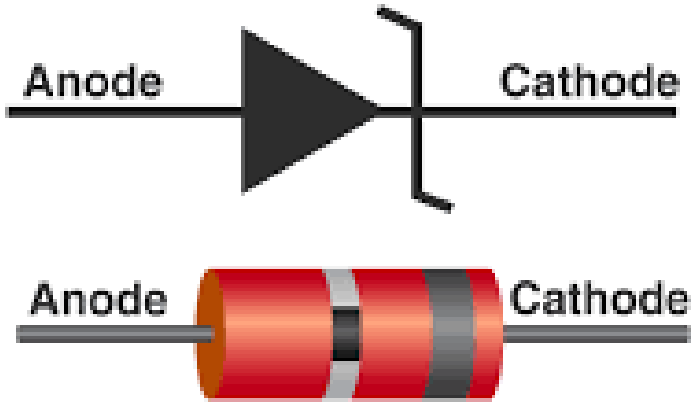
b) $\frac{I_m}{\pi}$

c) $\frac{1.414I_m}{\pi}$

d) $\frac{1.414I_m}{2\pi}$

Zener Diodes

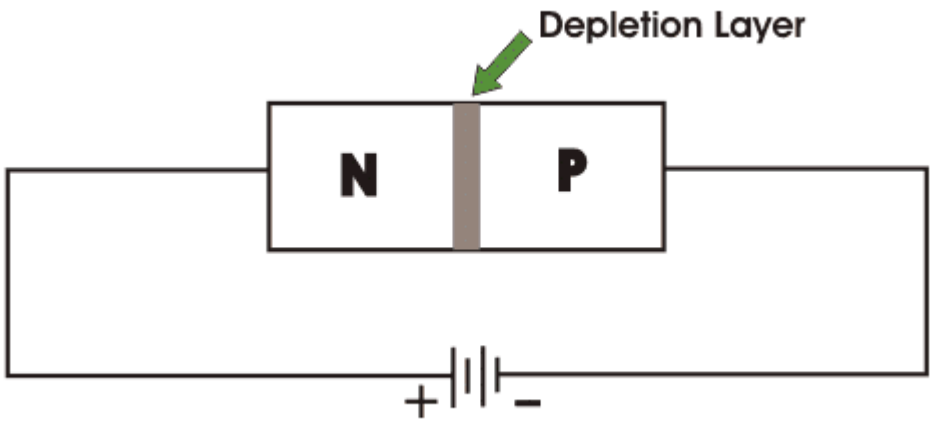
- Zener diode is basically like an ordinary PN junction diode but normally operated in reverse biased condition.
- But ordinary PN junction diode connected in reverse biased condition is not used as Zener diode practically.
- A Zener diode is a specially designed, highly doped PN junction diode.
- Ideally, the reverse breakdown has a constant breakdown voltage. This makes it useful as a **voltage reference, which is its primary application.**



(Zener diode)

Working Principle of Zener Diode

- When a PN junction diode is reverse biased, the depletion layer becomes wider. If this reverse biased voltage across the diode is increased continually, the depletion layer becomes more and more wider. At the same time, there will be a constant reverse saturation current due to minority carriers.



Working Principle of Zener Diode

- Avalanche Breakdown Phenomenon:

- After certain reverse voltage across the junction, the minority carriers get sufficient kinetic energy due to the strong electric field.
- Free electrons with sufficient kinetic energy collide with stationary ions of the depletion layer and knock out more free electrons.
- These newly created free electrons also get sufficient kinetic energy due to the same electric field, and they create more free electrons by collision cumulatively.
- As a result, very soon, **huge number of free electrons get created** in the depletion layer, and the entire diode will become conductive.
- This type of breakdown of the depletion layer is known as **avalanche breakdown.**

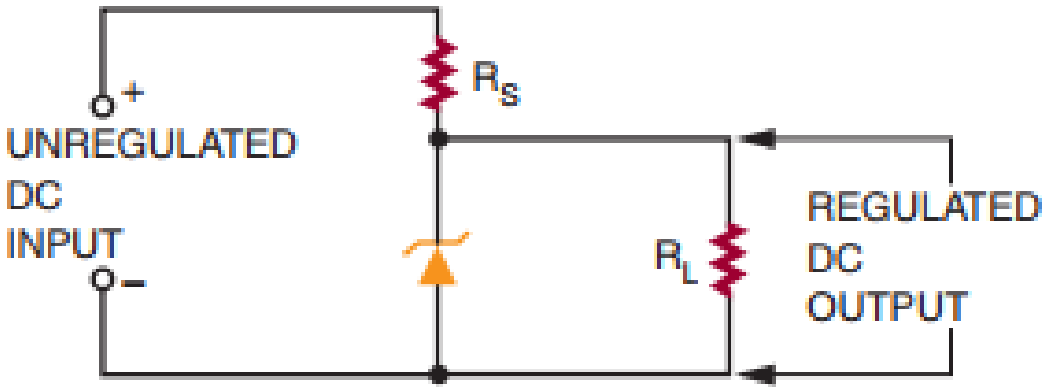
Working Principle of Zener Diode

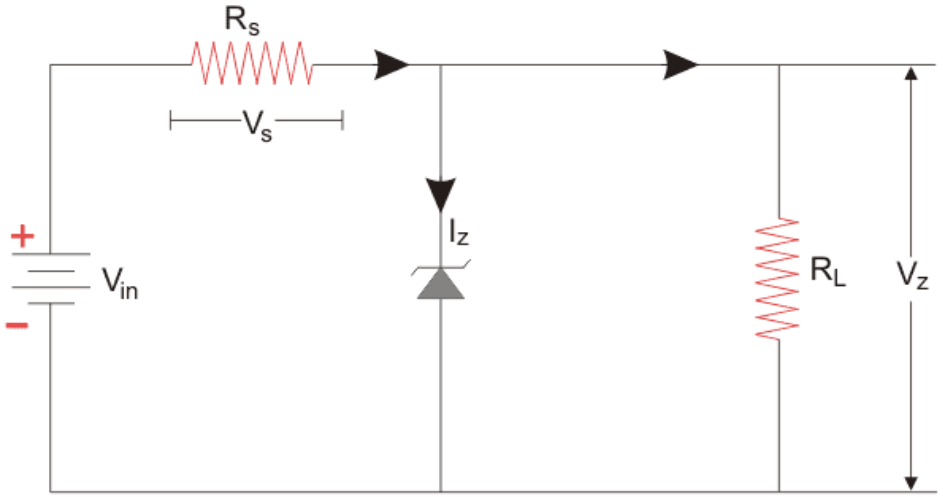
- Zener Breakdown Phenomenon:

- There is another type of breakdown in depletion layer which is sharper compared to avalanche breakdown, and this is called Zener breakdown.
- When a PN junction is diode is highly doped, the concentration of impurity atoms will be high in the crystal.
- This higher concentration of impurity atoms causes the higher concentration of ions in the depletion layer hence for same applied reverse biased voltage, the width of the depletion layer becomes thinner than that in a normally doped diode.
- Due to this thinner depletion layer, voltage gradient or electric field strength across the depletion layer is quite high.
- If the reverse voltage is continued to increase, after a certain applied voltage, the electrons from the covalent bonds within the depletion region come out and make the depletion region conductive. This breakdown is called Zener breakdown.

Explanation Slide

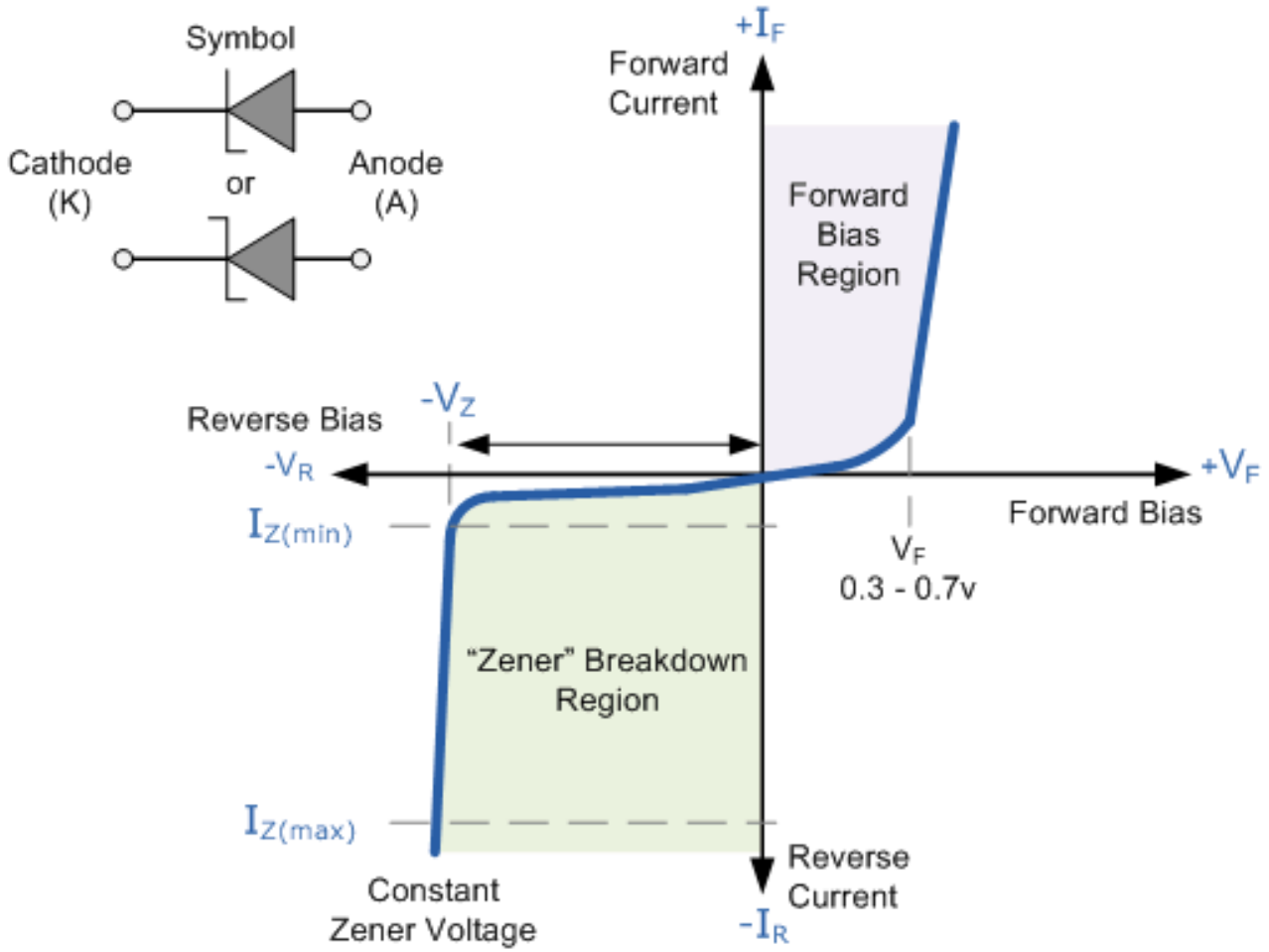
Zener Diode as a Voltage Regulator



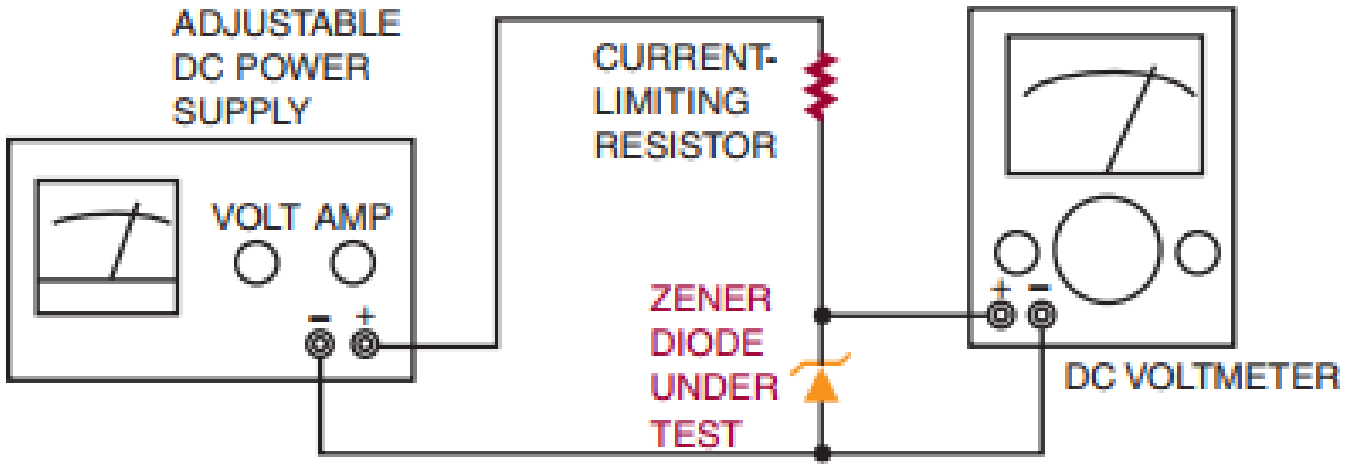


- When we apply a reverse voltage to a Zener diode, a negligible amount of current flows through the circuit. When a voltage higher than Zener breakdown voltage is applied, Zener breakdown occurs.
- Zener breakdown voltage typically can range from 1.2 V to 200 V depending on its application.
- Thus the Zener diode serves two purposes here: Zener diode as a voltage regulator as well as it protects the load from excessive current.

VI Characteristics of Zener Diode



Zener Diode Testing



QUICK QUIZ (POLL)

What is the level of doping in Zener Diode?

a) Lightly Doped

b) Heavily Doped

c) Moderately Doped

d) No doping

QUICK QUIZ (POLL)

The depletion region of the Zener diode is _____

a) Thick

b) Normal

c) Very Thin

d) Very thick

Explanation Slide