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UNIT

1 Diodes and Applications

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	and Impact of Electronics in Industry and Society	
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Previous Year Question
(2024 Pattern)

1. Evolution of Electronics & Impact

- Q. Explain the Impact of Electronics on industry and society. (Nov 2024)
- Q. Explain Impact of Electronics on Industry and Society. (April 2025)

2. Introduction to Active & Passive Components

2.1 / 2.2 Active & Passive Components

- Q. Compare Active and Passive Components. (Nov 2024)
- Q. Write a short note on Active and Passive Components. (April 2025)

3. P—N Junction Diode

3.4 V—I Characteristics of PN Junction Diode

- Q. Draw and explain V-I characteristics of P-N Junction Diode. (Nov 2024)
- Q. Draw and Explain V-I Characteristics of PN junction Diode. (April 2025)

3.6 Half-Wave Rectifier

- Q. Draw circuit diagram and explain operation of Half-Wave Rectifier with neat waveforms. (Nov 2024)
- Q. Draw & Explain circuit diagram of Half Wave Rectifier with waveforms. (April 2025)

3.8 Bridge Rectifier

- Q. Draw circuit diagram and explain operation of Bridge Rectifier with neat waveforms. (Nov 2024)

3.5 Diode as a Switch

- Q. Draw and explain Diode as a Switch. (April 2025)

4. Special Purpose Diodes

4.1 Light Emitting Diode (LED)

- Q. Explain construction & operation of Light Emitting Diode (LED). (April 2025)

4.2 Photo Diode

- Q. Compare LED and Photodiode. (Nov 2024)

◀ Introduction ▶

◆ Evolution of Electronics ◆

1. Early Beginnings:
- The discovery of the electron by J.J. Thomson in 1897 laid the foundation for electronics.
- Vacuum tubes were the first electronic components, used in early radios and computers.

2. Transistor Era :
- The invention of the transistor in 1947 replaced vacuum tubes, making devices smaller and more efficient.

3. Integrated Circuits (ICs) :
- ICs, developed in the 1960s, combined multiple components on a single chip, revolutionizing electronics.

4. Modern Era:
- Today, electronics is driven by nanotechnology, IoT, AI, and quantum computing, making devices smarter and more energy-efficient.

◆ Current Trends in Electronic ◆

1. Internet of Things (IoT) :
- Connecting devices to the internet for smarter functionality (e.g., smart homes, wearables).

2. Artificial Intelligence (AI) :
- Integrating AI into devices for automation and decision-making (e.g., voice assistants, self-driving cars).

3. 5G Technology:
- Faster internet speeds enabling real-time communication and IoT applications.

4. Wearable Electronics:

- Devices like smartwatches and fitness trackers for health and fitness monitoring.

5. Green Electronics:

- Focus on eco-friendly and energy-efficient electronic devices.

◆ Impact of Electronics in Industry ◆

Q. Explain the impact of electronics on industry and society.

(Jan 2025 , Oct 2023 , Marks 5)

Ans:-

Electronics has changed the way we work, communicate, and live. It has made industries more efficient and improved our daily lives in many ways.

1. Impact on Industry

a) Faster and Better Production

- Machines and robots help in making products faster and with more accuracy.
- Factories use automation to reduce human effort and increase output.

b) Better Communication and Data Sharing

- Companies use computers, the internet, and mobile devices to communicate quickly.
- Online meetings and cloud storage help businesses work from anywhere.

c) Lower Costs and More Profits

- Automated machines reduce errors and waste, saving money.
- Smart systems help in saving electricity and managing resources better.

◂ P—N Junction Diode ▸

Construction of P—N Junction Diode

- A P—N junction diode is a semiconductor device formed by joining a P-type semiconductor and an N-type semiconductor.
- It allows current to flow in one direction and blocks it in the opposite direction, making it useful for rectification (conversion of AC to DC) .

1. Materials Used:

P-type Semiconductor :

- Made by doping a pure semiconductor (e.g, silicon or germanium) with trivalent impurities like boron or gallium.
- Contains holes as majority charge carriers and a small number of free electrons.

N-type Semiconductor :

- Made by doping a pure semiconductor with pentavalent impurities like phosphorus or arsenic.
- Contains electrons as majority charge carriers and a small number of holes.

2. Formation of P—N Junction:

- The P—N junction is formed by joining the P-type and N-type semiconductors.

During the joining process :

- Electrons from the N-type region diffuse into the P-type region.
- Holes from the P-type region diffuse into the N-type region.
- This diffusion creates a depletion region at the junction.

3. Depletion Region :

- The depletion region is a neutral zone where no free charge carriers (electrons or holes) are present.

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- It consists of immobile ions (positive ions on the N-side and negative ions on the P-side).
- The depletion region acts as a barrier to further diffusion of charge carriers.

4. Barrier Potential :

- Due to the immobile ions in the depletion region, an electric field is created.
- This electric field creates a barrier potential (typically 0.7V for silicon and 0.3V for germanium).
- The barrier potential prevents further diffusion of charge carriers across the junction.

5. Symbol of P–N Junction Diode :

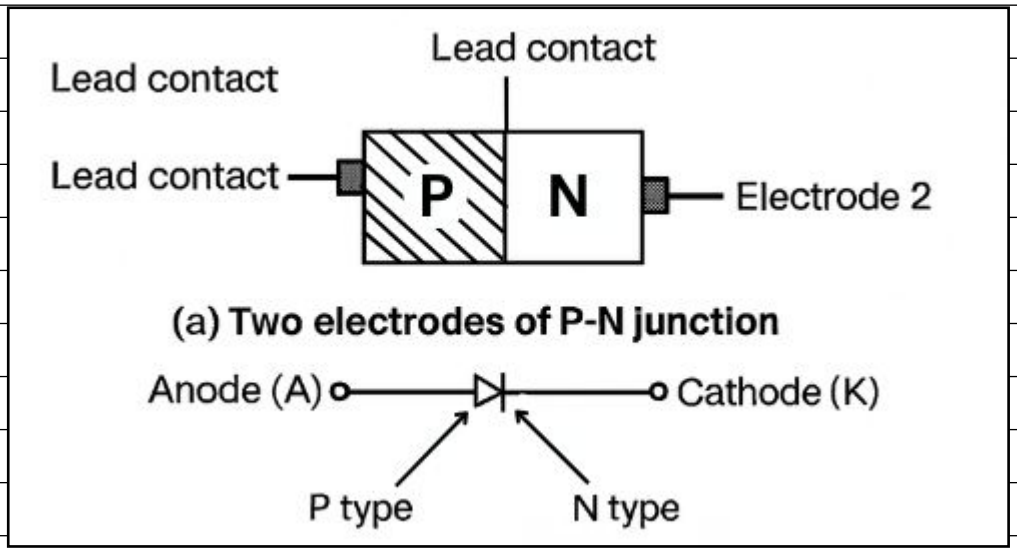
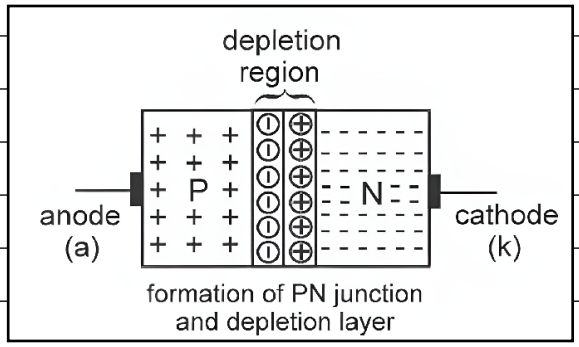


Diagram: P–N Junction Diode Construction :



◆ Full-Wave Rectifier ◆

- A full-wave rectifier is an electronic circuit that efficiently converts alternating current (AC) into direct current (DC) by utilizing both the positive and negative halves of the input AC waveform.
- Unlike a half-wave rectifier, which only processes one half of the input cycle, a full-wave rectifier ensures a smoother and more continuous DC output, making it highly suitable for power supply applications requiring stable voltage and current.

1. Types of Full-Wave Rectifiers

- Full-wave rectifiers are primarily classified into two types :

(A) Center-Tapped Full-Wave Rectifier

- This design employs a center-tapped transformer along with two diodes to achieve full-wave rectification.
- The transformer's secondary winding is split into two equal halves, allowing the circuit to process both halves of the AC input cycle.

(B) Bridge Rectifier

- The bridge rectifier is a more advanced and widely used configuration that utilizes four diodes arranged in a bridge network.
- Unlike the center-tapped rectifier, it does not require a center-tapped transformer, making it more versatile and cost-effective for various applications

(A) Center-Tapped Full-Wave Rectifier

Q. Compare half-wave and full-wave rectifiers.

(Oct 2023 , Marks 5)

Q. For a center-tapped full-wave rectifier, derive expressions for:
(i) DC load current, (ii) Ripple factor (iii) V_{DC} (iv) P_{DC}.

(May 2020 , Marks 4)

Q. A full-wave rectifier using two diodes has a maximum voltage of 18 V across the secondary winding. Calculate the peak inverse voltage for the diodes. (Dec 2022 , Marks 5)

Q. In a center-tapped full-wave rectifier, the RMS half-secondary voltage is 9 V. Assuming ideal diodes and R_L=1kΩ , find:
1. Peak current , 2. DC load voltage, 3. RMS current, 4. Ripple factor
5. Efficiency (May 2022 , Marks 8)

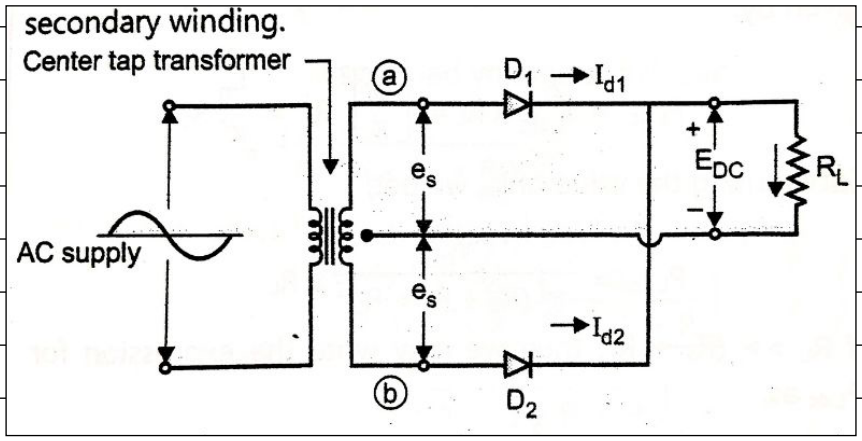
Q. Compare full-wave rectifiers using:
(i) Center-tapped transformer,
(ii) Bridge circuit. (Dec 2019 , Marks 5)

Ans:

Working Principle :

1. Transformer Action

- The AC input is applied to a center-tapped transformer, which splits the secondary voltage into two equal and opposite phases (e_s at terminal A and - e_s at terminal B).
- The center-tap acts as a reference ground.



- It shows the center-tapped transformer with two diodes (D_1 and D_2).

2. Positive Half-Cycle (D_1 Conducts)

- When terminal A is positive ($+e_s$) and terminal B is negative ($-e_s$):

Diode D_1 is forward-biased → It conducts current.

Diode D_2 is reverse-biased → It blocks current.

Current Flow Path:

- A → D_1 → Load Resistor (R_L) → Center Tap (Ground).

3. Negative Half-Cycle (D_2 Conducts)

- When terminal B is positive ($+e_s$) and terminal A is negative ($-e_s$):

Diode D_2 is forward-biased → It conducts current.

Diode D_1 is reverse-biased → It blocks current.

Current Flow Path:

B → D_2 → Load Resistor (R_L) → Center Tap (Ground).

4. Output Waveform

- A pulsating DC voltage appears across the load resistor, utilizing both half-cycles of the AC input.
- Frequency of ripple = 2 × input frequency (since both halves of AC are used).

- Formulas for Center-Tapped Full-Wave Rectifier :

1. Peak Inverse Voltage (PIV)

Definition: The maximum voltage a diode must withstand in reverse bias.

Formula:

$$PIV = 2V_m$$

Where V_m = Peak input AC voltage.

2. DC Output Voltage (Average Output Voltage)

Definition: The average value of the rectified output voltage.

Formula :

$$V_{DC} = \frac{2V_m}{\pi}$$

Where V_m = Peak AC voltage.

3. RMS Output Voltage

Definition: The effective voltage of the rectified DC output.

Formula:

$$V_{RMS} = \frac{V_m}{\sqrt{2}}$$

Where V_m = Peak AC voltage.

4. Ripple Frequency

Definition: The frequency of the pulsating DC output.

Formula:

$$f_{\text{ripple}} = 2 \times f_{\text{AC}}$$

5. Ripple Factor

Definition: It measures the amount of AC content in the rectified output.

$$\gamma = \frac{\sqrt{V_{\text{RMS}}^2 - V_{\text{DC}}^2}}{V_{\text{DC}}}$$

For a full-wave rectifier, $\gamma = 0.482$ (i.e. 48.2%).

Important Solved Examples

Example 1

A voltage $v = 300\cos 100t$ is applied to a half-wave rectifier with $R_L = 5\,k\Omega$ The rectifier may be represented by an ideal diode in series with a resistance of $R_F = 1\,k\Omega$

Calculate :

(1) Peak load current I_m
(2) D.C. power $P_{L(dc)}$
(3) A.C. input power P_{ac}
(4) Rectifier efficiency η
(5) Ripple factor γ

Solution :

Given :

$$V_m = 300\ V, \quad R_F = 1\,k\Omega, \quad R_L = 5\,k\Omega, \quad R_s = 0$$

(1) Peak load current (I_m)

$$I_m = \frac{V_m}{R_s + R_F + R_L}$$

$$I_m = \frac{300}{0 + 1k + 5k}$$

$$I_m = 0.05A = 50\,mA$$

(2) D.C. power $P_{L(dc)}$

$$P_{L(dc)} = \frac{2}{\pi} I_m \times R_L \times \frac{I_m}{\pi}$$

$$= \frac{2}{\pi}\left(\frac{I_m}{\pi}\right)^2 \times R_L$$

$$= \frac{2}{\pi}\left(\frac{0.05}{\pi}\right)^2 \times 5 \times 10^3$$

$$= 1.2655W$$

(3) A.C. input power P_{ac}

$$P_{ac} = I_{rms}^2(R_s + R_F + R_L)$$

$$= \left(\frac{I_m}{2}\right)^2 \times (6 \times 10^3)$$

$$= (0.05/2)^2 \times 6 \times 10^3$$

$$= 3.75W$$

(4) Rectifier efficiency (η)

$$\eta = \frac{P_{dc}}{P_{ac}} \times 100$$

$$\eta = \frac{1.2665}{3.75} \times 100$$

$$= 33.77\%$$

(5) Ripple factor (γ)

First we find:

$$I_{L(rms)} = \frac{I_m}{2} = 25\,mA$$

and

$$I_{L(dc)} = \frac{I_m}{\pi} = 15.91\,mA$$

Now,

$$\gamma = \left[\frac{I_{rms}^2 - I_{dc}^2}{I_{dc}^2}\right]^{1/2} \times 100$$

$$\gamma = \left[\frac{25^2 - (15.91)^2}{(15.91)^2}\right]^{1/2} \times 100$$

$$\gamma = 121.13\%$$

Example 2

A half-wave rectifier with $R_L = 1\,k\Omega$ is given an input of $10\,V$ peak from a step-down transformer. Calculate the D.C. voltage and load current for an ideal diode and a silicon diode.

[Dec 2019]

Given :

$$R_L = 1\,k\Omega, \quad V_m = 10\,V, \quad R_s = 0\,\Omega$$

(a) Calculations Assuming Ideal Diode

For an ideal diode, diode drop

$$V_F = 0$$

(i) D.C. voltage

$$V_{L(dc)} = \frac{V_m}{\pi} = \frac{10}{\pi}$$

$$V_{L(dc)} = 3.18 \text{ volts}$$

(ii) Load current

$$I_{L(dc)} = \frac{I_m}{\pi} = \frac{V_m}{\pi(R_s + R_F + R_L)}$$

But for ideal diode,

$$R_F = 0$$

$$I_{L(dc)} = \frac{V_m}{\pi R_L} = \frac{3.18}{1k\Omega}$$

$$I_{L(dc)} = 3.18\,mA$$

(b) Calculations with Silicon Diode

For a silicon diode:

$$V_F = 0.7V$$

(i) D.C. output voltage

$$V_{L(dc)} = \frac{(V_m - 0.7)}{\pi}$$

$$V_{L(dc)} = \frac{9.3}{\pi}$$

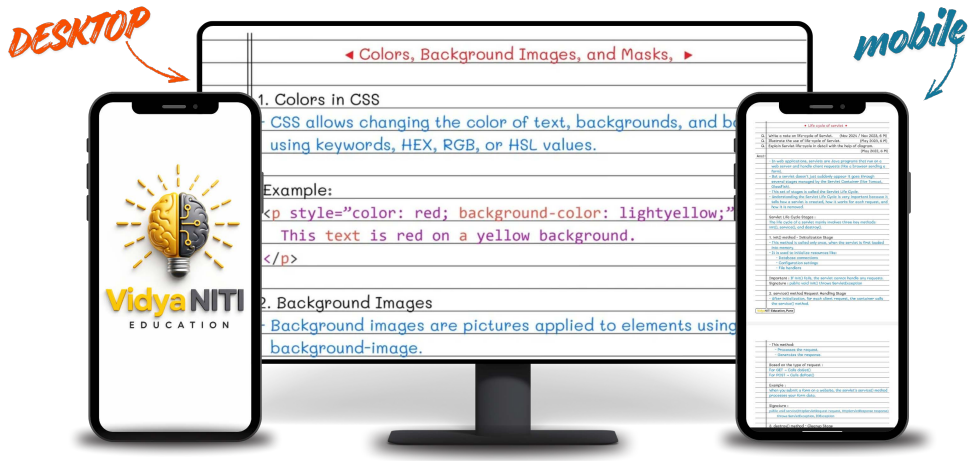
$$V_{L(dc)} = 2.96\,V$$

(ii) Load current

$$I_{L(dc)} = \frac{V_{L(dc)}}{R_L}$$

$$I_{L(dc)} = \frac{2.96}{1k\Omega}$$

$$I_{L(dc)} = 2.96\,mA$$



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