

SEMICONDUCTOR DEVICES

Complete Question Bank with Answers

UNIT-I: Semiconductor Fundamentals & PN Junction Diodes

One-Mark Questions With Answers

1. What is a semiconductor?

Answer: A semiconductor is a material whose electrical conductivity lies between that of a conductor and an insulator. Examples: Silicon (Si) and Germanium (Ge).

2. What is meant by an energy band?

Answer: An energy band is a range of energy levels that electrons can occupy in a solid.

3. Name the three important energy bands in a solid.

Answer: Valence band, conduction band and forbidden energy gap.

4. What is forbidden energy gap?

Answer: The energy interval between the valence band and conduction band in which electrons cannot normally exist is called the forbidden energy gap (E_g).

5. What is an intrinsic semiconductor?

Answer: A pure semiconductor without intentional impurity doping is called an intrinsic semiconductor.

6. What is an extrinsic semiconductor?

Answer: A semiconductor whose conductivity is increased by adding controlled impurities is called an extrinsic semiconductor.

7. What is doping?

Answer: Doping is the process of adding a small, controlled amount of impurity to a pure semiconductor to increase its conductivity.

8. What are the two types of extrinsic semiconductors?

Answer: n-type and p-type semiconductors.

9. What is an n-type semiconductor?

Answer: A semiconductor doped with a pentavalent impurity is called an n-type semiconductor.

10. Give three examples of pentavalent impurities.

Answer: Pentavalent impurities are atoms with five valence electrons. Phosphorus (P), Arsenic (As) and Antimony (Sb) are examples of pentavalent impurities.

11. What is a p-type semiconductor?

Answer: A semiconductor doped with a trivalent impurity is called a p-type semiconductor.

12. Give three examples of trivalent impurities.

Answer: Trivalent impurities are atoms with three valence electrons. Boron, Aluminum, Gallium, and Indium are examples of trivalent impurities.

13. What is the majority carrier in an n-type semiconductor?

Answer: Electrons are the majority charge carriers in n-type semiconductor

14. What is the majority carrier in a p-type semiconductor?

Answer: Holes are the majority charge carriers in p-type semiconductor

15. What are minority carriers?

Answer: The charge carriers present in smaller concentration are called minority carriers.

16. What are the charge carriers in a semiconductor?

Answer: Electrons and holes.

17. How does temperature affect semiconductor conductivity?

Answer: As temperature increases, the conductivity of a semiconductor increases.

18. What is a PN junction?

Answer: A PN junction is formed when p-type and n-type semiconductor regions are joined together.

19. What is the depletion region?

Answer: The region around a PN junction depleted of mobile charge carriers is called the depletion region.

20. What is barrier potential?

Answer: The potential difference developed across the depletion region that opposes further diffusion of carriers is called barrier potential.

21. What is forward biasing?

Answer: Connecting the P-side to positive and N-side to negative terminal of a supply is called forward biasing.

22. What is reverse biasing?

Answer: Connecting the P-side to negative and N-side to positive terminal of a supply is called reverse biasing.

23. What happens to the depletion width during forward bias?

Answer: The depletion width decreases.

24. What happens to the depletion width during reverse bias?

Answer: The depletion width increases.

25. What is knee voltage?

Answer: The minimum forward voltage at which appreciable current starts flowing through a diode is called knee voltage.

26. What is a Zener diode?

Answer: A Zener diode is a heavily doped PN junction diode designed to operate in the reverse breakdown region.

27. What is the main application of a Zener diode?

Answer: Voltage regulation.

28. What is an LED?

Answer: LED stands for Light Emitting Diode. It emits light when forward biased.

29. What is a photodiode?

Answer: A photodiode is a semiconductor diode that converts incident light energy into electrical current.

30. What is an LDR?

Answer: LDR stands for Light Dependent Resistor. Its resistance changes with the intensity of incident light.

31. What happens to LDR resistance when light intensity increases?

Answer: Its resistance decreases.

32. What is reverse saturation current?

Answer: The small reverse current due mainly to minority carriers in a reverse-biased diode is called reverse saturation current.

33. What is breakdown voltage?

Answer: The reverse voltage at which the reverse current increases sharply is called breakdown voltage.

Three-Mark Questions with Answers**1. Explain the energy band theory of solids.**

Answer: According to energy band theory, electrons in a solid occupy allowed ranges of energy called energy bands.

1. Valence band: Contains valence electrons.
2. Conduction band: Electrons in this band can participate in electrical conduction.
3. Forbidden energy gap: Energy gap between the valence and conduction bands.

Classification: Conductor—valence and conduction bands overlap; Semiconductor—small energy gap exists; Insulator—large energy gap exists.

2. Differentiate conductors, semiconductors and insulators.

Answer:

Property	Conductors	Semiconductors	Insulators
Conductivity	Very high	Moderate	Very low
Resistance	Very low	Medium	Very high
Charge carriers	Large number of free electrons	Electrons and holes	Almost no free charge carriers
Effect of temperature	Resistance increases	Resistance decreases	Resistance generally decreases slightly
Examples	Copper, Aluminium	Silicon, Germanium	Rubber, Glass

4. Explain the doping process.

Answer: Definition: Doping is the process of adding a small amount of impurity atoms to a pure semiconductor to increase its electrical conductivity.

1. Pentavalent impurities such as phosphorus or arsenic are added to silicon to form an N-type semiconductor, where electrons are the majority carriers.
2. Trivalent impurities such as boron or aluminium are added to silicon to form a P-type semiconductor, where holes are the majority carriers.
3. Thus, doping controls the number of charge carriers and improves the conductivity of the semiconductor.

5. Differentiate between n-type and p-type semiconductors.

N-Type Semiconductor	P-Type Semiconductor
1. It is formed by adding a pentavalent impurity to pure semiconductor.	It is formed by adding a trivalent impurity to pure semiconductor.
2. Examples of impurities are phosphorus, arsenic, and antimony.	Examples of impurities are boron, aluminium, and gallium.
3. The majority charge carriers are electrons.	The majority charge carriers are holes.
4. The minority charge carriers are holes.	The minority charge carriers are electrons.
5. It has electrons as the main carriers of current.	It has holes as the main carriers of current.
6. The impurity is called a donor impurity because it donates an electron.	The impurity is called an acceptor impurity because it accepts an electron.

6. Explain the effect of temperature on a semiconductor.

Answer: Effect of Temperature on a Semiconductor

1. When the temperature of a semiconductor increases, more electrons gain energy and break free from covalent bonds.
2. This produces more electron-hole pairs, increasing the number of charge carriers.
3. Therefore, the conductivity of a semiconductor increases with temperature.
4. As conductivity increases, the resistance of the semiconductor decreases.

Hence, a semiconductor has a negative temperature coefficient of resistance (NTC), meaning its resistance decreases when temperature increases.

7. Explain the formation of a PN junction.

Answer:

1. A PN junction is formed by joining a P-type semiconductor with an N-type semiconductor in a single crystal.
2. At the junction, electrons from the N-side diffuse into the P-side and recombine with holes, creating a region without free charge carriers called the depletion region.
3. This depletion region creates a potential barrier that opposes further movement of charge carriers, forming the PN junction.

8. Explain depletion region and barrier potential.

Answer:

1. Depletion Region: It is the region near a PN junction where free electrons and holes are absent due to recombination of electrons and holes. It contains fixed positive and negative ions.
2. Barrier Potential: The electric field produced by these fixed ions creates a potential difference called barrier potential, which opposes the further movement of majority charge carriers across the junction.

- At room temperature, the barrier potential is approximately 0.7 V for silicon and 0.3 V for germanium.

9. Explain forward biasing of a PN junction diode.

Answer: Forward Biasing of a PN Junction Diode

- In forward bias, the P-side is connected to the positive terminal of the battery and the N-side is connected to the negative terminal.
- The applied voltage reduces the depletion region and barrier potential, allowing majority charge carriers to cross the junction.
- When the applied voltage exceeds the cut-in voltage (about 0.7 V for silicon and 0.3 V for germanium), a significant forward current flows through the diode.

10. Explain reverse biasing of a PN junction diode.

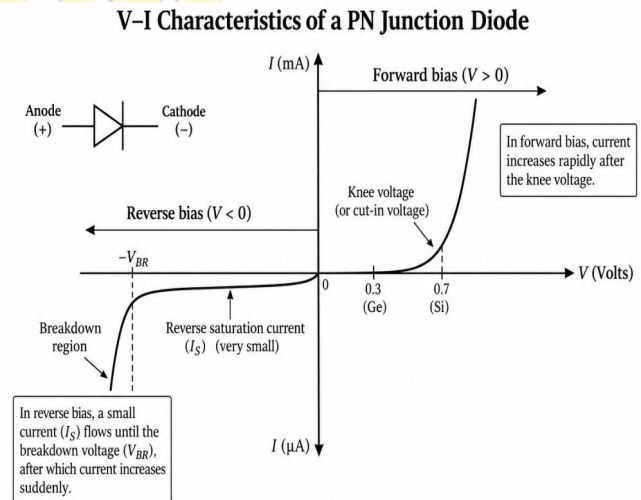
Answer:

- In reverse bias, the P-side is connected to the negative terminal of the battery and the N-side is connected to the positive terminal.
- The applied voltage increases the depletion region and barrier potential, preventing the flow of majority charge carriers across the junction.
- Only a very small reverse saturation current due to minority charge carriers flows through the diode until breakdown occurs at a sufficiently high reverse voltage.

11. Explain the V-I characteristics of a PN junction diode.

Answer: V-I Characteristics of a PN Junction Diode

- The V-I characteristic shows the relationship between the voltage applied across the diode and the current flowing through it.
- In forward bias, the current is very small until the cut-in (knee) voltage is reached. After this voltage, the current increases rapidly. The cut-in voltage is about 0.7 V for silicon and 0.3 V for germanium.
- In reverse bias, only a small reverse saturation current flows. When the reverse voltage reaches the breakdown voltage, the reverse current increases sharply.



12. Explain the working of a Zener diode.

Answer:

- A Zener diode is specially designed to operate in the reverse-bias region and is normally connected in reverse bias.
- When the reverse voltage reaches the Zener breakdown voltage, the diode conducts a large reverse current while maintaining an almost constant voltage across it.
- Therefore, a Zener diode is mainly used for voltage regulation, such as maintaining a constant DC output voltage even when the input voltage or load changes.

13. Explain the working of an LED.

Answer:

1. An LED (Light Emitting Diode) is a semiconductor device that emits light when it is forward biased.
2. When forward biased, electrons and holes recombine at the PN junction and release energy in the form of light.
3. The colour of the emitted light depends on the semiconductor material used. LEDs are widely used in indicators, displays, and lighting systems.

14. Explain the working of a photodiode.

1. A photodiode is a PN junction diode operated mainly in reverse bias.
2. When light falls on the junction, photons generate electron-hole pairs.
3. The electric field in the depletion region separates these charge carriers.
4. This produces a reverse photocurrent, whose magnitude depends on the intensity of incident light.
5. Thus, a photodiode converts light energy into electrical current and is used in light sensors, optical communication, and automatic control systems.

15. Explain the working of an LDR.

Answer:

1. LDR (Light Dependent Resistor) is a light-sensitive device whose resistance changes according to the intensity of light falling on it.
2. When light intensity increases, more charge carriers are generated in the material, so its resistance decreases and current increases.
3. When light intensity decreases, its resistance increases and current decreases. Hence, LDRs are used in automatic street lights, light sensors, and alarm systems.

Five-Mark Questions with Answers

1. Explain energy band theory and classification of solids.

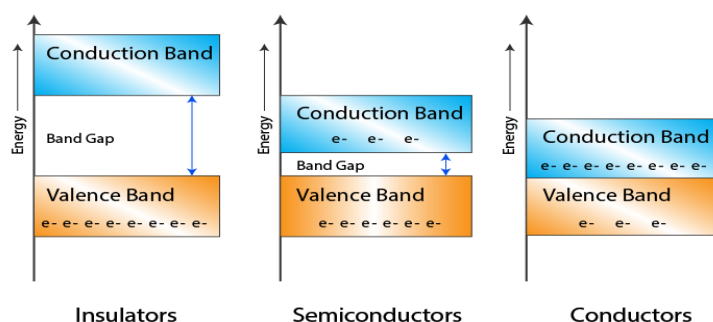
Answer: In an isolated atom, electrons occupy discrete energy levels. In a solid, these levels split into closely spaced levels forming energy bands. The important bands are valence band, conduction band and forbidden energy gap.

Conductors: valence and conduction bands overlap or the conduction band is partially filled, so electrons move easily.

Semiconductors: a small forbidden energy gap exists; electrons can enter the conduction band when sufficient energy is supplied.

Insulators: a large forbidden energy gap makes electron movement difficult.

Electrical conductivity therefore depends mainly on band structure and energy gap.



2. Explain intrinsic and extrinsic semiconductors with n-type and p-type formation.

Answer:

Intrinsic Semiconductor: Intrinsic semiconductor is a pure semiconductor without any impurity added to it. Examples of intrinsic semiconductors are pure Silicon (Si) and Germanium (Ge). In an intrinsic semiconductor, the number of electrons and holes is equal.

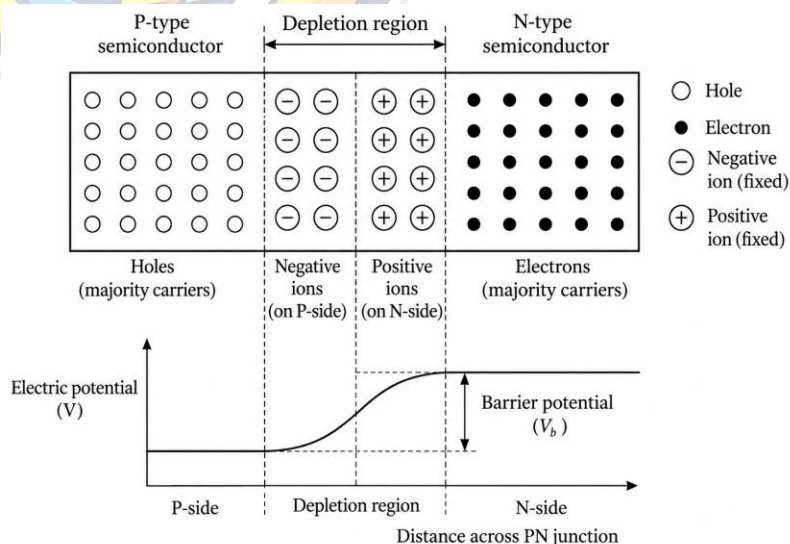
Extrinsic semiconductor: Extrinsic semiconductor is formed by adding a small amount of impurity to a pure semiconductor. The process of adding impurities to a pure semiconductor is called doping.

- N type:** Adding a pentavalent impurity like Phosphorus or Arsenic forms an N-type semiconductor. In N-type semiconductor, electrons are the majority carriers and holes are minority carriers.
 - P type:** Adding a trivalent impurity like Boron or Aluminium forms a P-type semiconductor. In P-type semiconductor, holes are the majority carriers and electrons are minority carriers.
- Thus, N-type and P-type semiconductors are widely used in diodes, transistors and other electronic devices.

3. Explain formation of PN junction, depletion region and barrier potential.

Answer: Depletion region: A PN junction is formed by joining a P-type semiconductor with an N-type semiconductor. The P-side has holes as majority carriers, while the N-side has electrons as majority carriers. When they are joined, electrons diffuse from the N-side to the P-side and holes diffuse from P-side to N-side. Near the junction, electrons and holes recombine with each other. This leaves behind immobile positive and negative ions near the junction. The region containing these immobile ions is called the **depletion region**.

Barrier potential: The depletion region has very few free charge carriers and therefore offers high resistance. The ions in the depletion region create an electric field across the junction. This electric field produces a potential difference called the **barrier potential**. The barrier potential opposes further diffusion of charge carriers; it is approximately 0.7 V for silicon and 0.3 V for germanium.



4. Explain forward and reverse biasing of a PN junction diode.

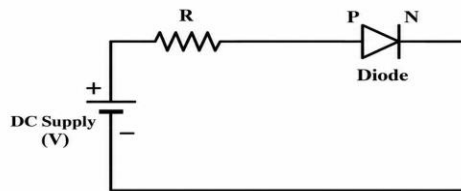
Answer: Biasing means applying an external voltage to a PN junction diode.

- Forward Bias:** In forward bias, the P-side is connected to the positive terminal and N-side to the negative terminal of the battery.
- Forward bias reduces the depletion region and barrier potential.

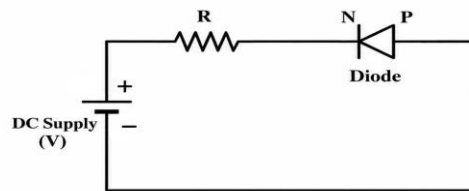
- c) When the applied voltage exceeds the cut-in voltage (Knee voltage), the diode conducts significant current.
- d) The cut-in voltage is approximately 0.7 V for silicon and 0.3 V for germanium.
- a) **Reverse Bias:** In reverse bias, the P-side is connected to the negative terminal and N-side to the positive terminal of the battery.
- b) Reverse bias increases the width of the depletion region and barrier potential.
- c) Only a very small reverse saturation current flows due to minority carriers.
- d) If the reverse voltage exceeds the breakdown voltage, a large reverse current flows.

Thus, a PN junction diode conducts mainly in forward bias and blocks current in reverse bias.

Forward Biasing of a PN Junction Diode



Reverse Biasing of a PN Junction Diode



5. Draw and explain the V-I characteristics of a PN junction diode.

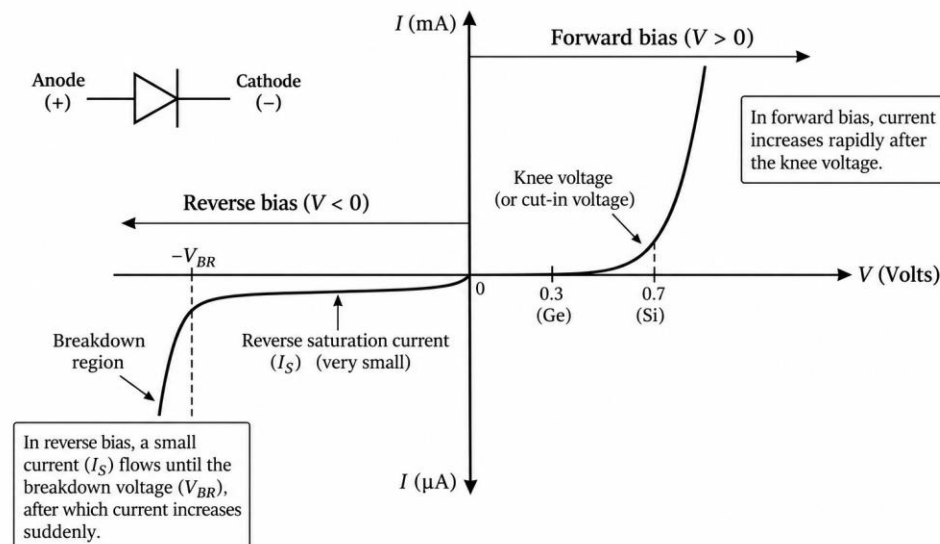
Answer: The V-I characteristic shows the relationship between the voltage applied across a diode and the current flowing through it. It has two regions: forward-bias region and reverse-bias region.

In forward bias, the current is very small until the cut-in (knee) voltage is reached. After the cut-in voltage, a small increase in voltage causes a large increase in current. The cut-in voltage is about 0.7 V for silicon and 0.3 V for germanium.

In reverse bias, only a small current called reverse saturation current flows. This reverse current remains almost constant as the reverse voltage increases. At a particular reverse voltage called breakdown voltage, the reverse current increases suddenly.

The graph below shows the typical V-I characteristic of a PN junction diode.

V-I Characteristics of a PN Junction Diode

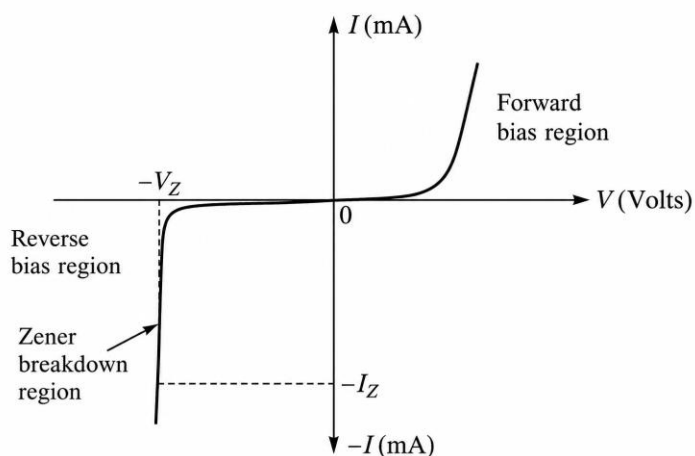


6. Draw and explain the V-I characteristics of a Zener diode.

Answer: The V-I characteristic shows the relationship between voltage across a Zener diode and the current flowing through it.

- In forward bias, the Zener diode behaves like an ordinary PN junction diode. Forward current increases rapidly after the cut-in voltage (about 0.7 V for silicon).
- In reverse bias, only a small reverse current flows initially. When the reverse voltage reaches the Zener voltage (V_Z), breakdown occurs. After breakdown, the reverse current increases sharply with only a small change in voltage. The voltage across the Zener diode remains almost constant in the breakdown region.

This constant-voltage property makes the Zener diode useful as a voltage regulator. The typical V-I characteristic of a Zener diode is shown below.



7. Explain LED construction, working and applications.

Construction:

- LED (Light Emitting Diode) is a semiconductor device that emits light when it is forward biased.
- It is made using semiconductor materials such as Gallium Arsenide (GaAs) or Gallium Phosphide (GaP).
- An LED consists of a P-type layer, N-type layer and PN junction enclosed in a transparent protective case.
- The PN junction is mounted in a reflector cup to direct the emitted light outward.

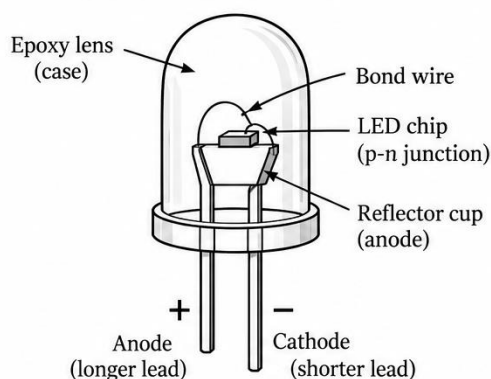
Working:

- When the LED is forward biased, electrons from the N-side and holes from the P-side move towards the junction.
- Electrons and holes recombine at the junction and release energy in the form of light.
- The colour of light depends on the semiconductor material and energy band gap.
- LEDs consume less power, have a long life and produce less heat compared with conventional lamps.

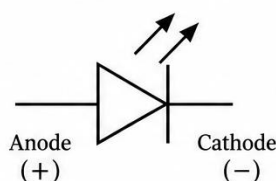
Applications:

LEDs are used in indicators, displays, traffic signals and digital clocks. They are also widely used in TVs, remote controls, lighting systems and optical communication.

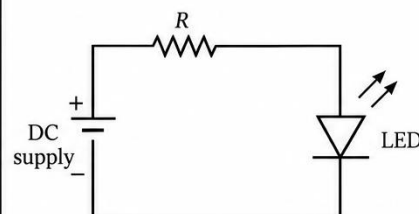
Construction of LED



LED Symbol

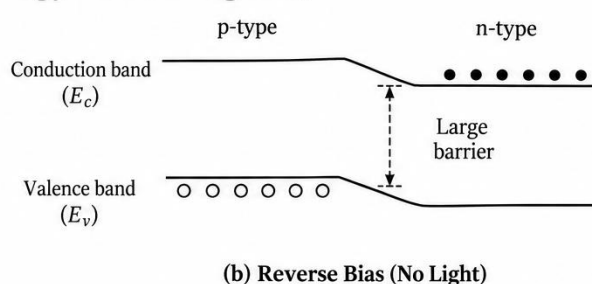
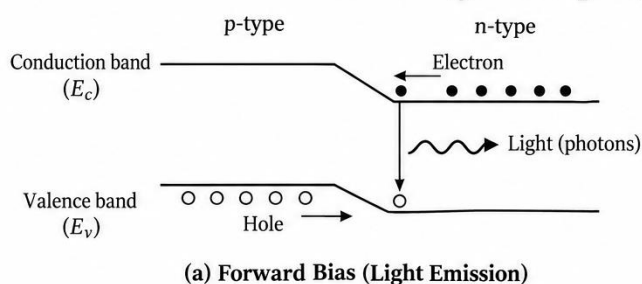


Working of LED (Forward Bias)



When forward biased, electrons and holes recombine at the p-n junction and release energy in the form of light (photons).

Working Principle (Energy Band Diagram)



LED emits light only when it is forward biased.

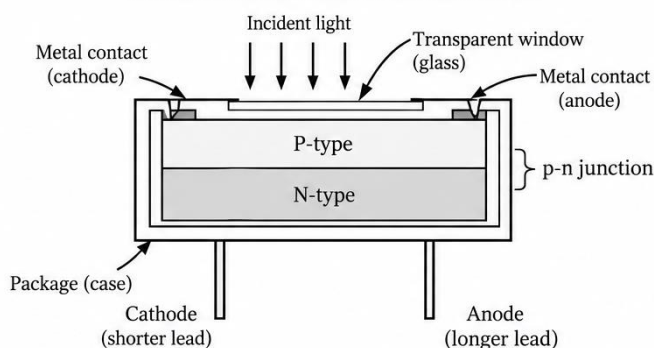
8. Explain photodiode construction, working and applications.

A. Construction: A photodiode is a semiconductor device that converts light energy into electrical current. It is generally made using silicon or germanium and has a PN junction. The PN junction is provided with a transparent window so that light can fall directly on the junction.

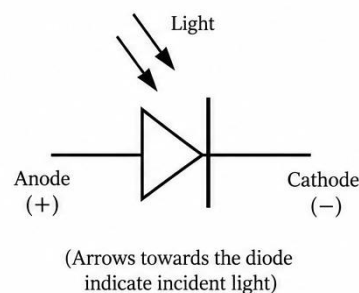
Working: A photodiode is normally operated in reverse bias. When light falls on the depletion region, it produces electron-hole pairs. The electric field in the depletion region separates these electrons and holes. This movement of charge carriers produces a reverse current called photocurrent. The photocurrent increases with an increase in the intensity of incident light.

Applications: Photodiodes are used in light sensors, automatic lighting systems and optical communication. They are also used in smoke detectors, barcode scanners and remote-control systems.

Construction of Photodiode



Symbol of Photodiode

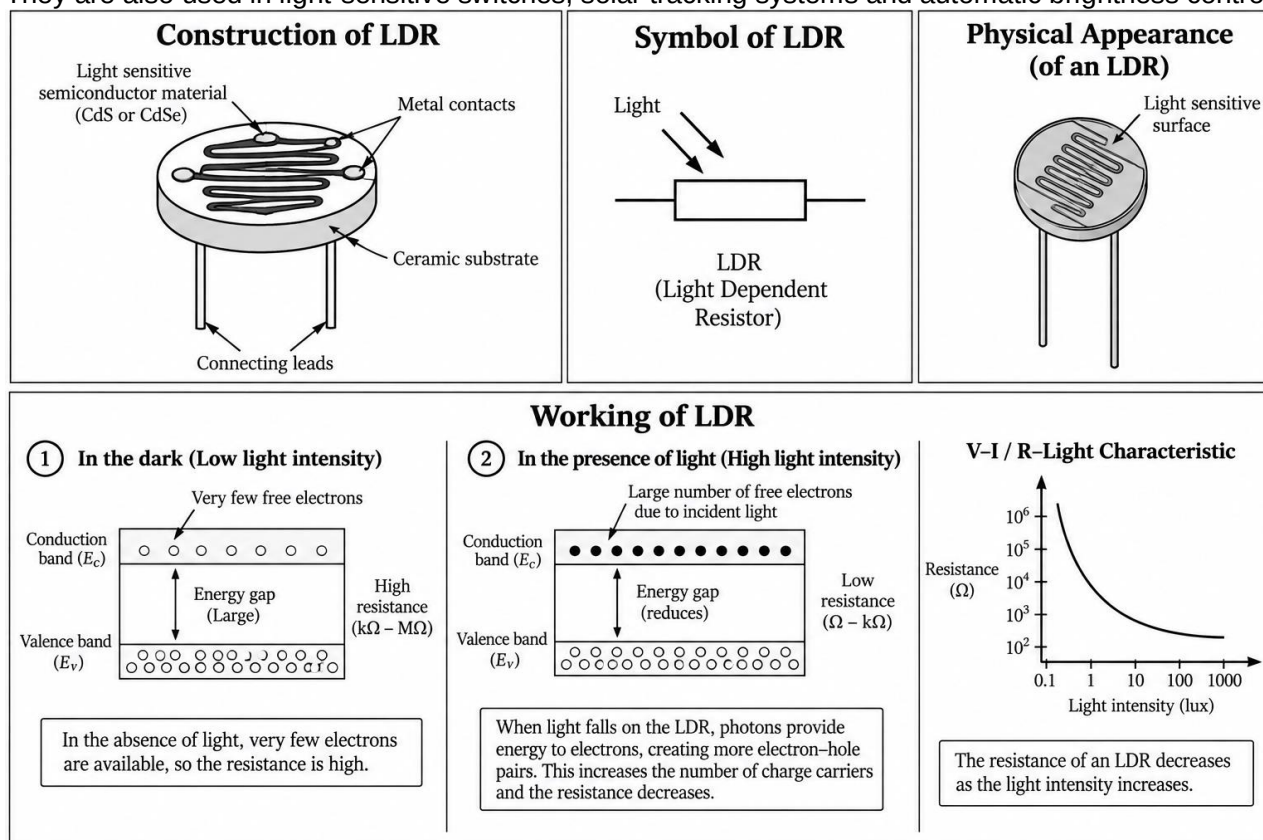


9. Explain LDR with its working and applications.

Construction: LDR (Light Dependent Resistor) is a light-sensitive resistor whose resistance changes with light intensity. It is made using a photosensitive material such as cadmium sulphide (CdS). The photosensitive material is placed in a zig-zag pattern between two metal contacts. The arrangement is mounted on an insulating base and covered with a transparent protective material.

Working: In darkness, the LDR has very high resistance and allows very little current to flow. When light falls on the LDR, more charge carriers are generated in the material. Therefore, its resistance decreases and the current through it increases. Thus, the resistance of an LDR varies inversely with the intensity of light.

Applications: LDRs are used in automatic street lights, camera light meters and burglar alarm systems. They are also used in light-sensitive switches, solar tracking systems and automatic brightness control.



UNIT-II: Rectifiers & Power Supplies

One-Mark Questions with Answers

1. What is rectification?

Answer: Rectification is the process of converting AC into pulsating DC.

2. What is a rectifier?

Answer: A rectifier is an electronic circuit that converts AC voltage into unidirectional or pulsating DC voltage.

3. Name the types of rectifiers.

Answer: Half-wave rectifier, full-wave rectifier and bridge rectifier.

4. How many diodes are used in a half-wave rectifier?

Answer: One diode.

5. How many diodes are used in a centre-tapped full-wave rectifier?

Answer: Two diodes.

6. How many diodes are used in a bridge rectifier?

Answer: Four diodes.

7. What is ripple?

Answer: The unwanted AC component present in the rectifier output is called ripple.

8. Define ripple factor.

Answer: Ripple factor is the ratio of the RMS value of the AC component to the DC component of rectifier output: $r = V_{ac(rms)}/V_{dc}$.

9. What is rectifier efficiency?

Answer: Rectifier efficiency is the ratio of DC output power to AC input power: $\eta = (P_{DC}/P_{AC}) \times 100$.

10. What is a filter?

Answer: A filter is a circuit used to reduce the AC ripple component from rectifier output.

11. Why are filters used in power supplies?

Answer: Filters are used to obtain a smoother DC voltage by reducing ripple.

12. Name different types of filters.

Answer: Capacitor filter, inductor filter, LC filter and π (pi) filter.

13. What is a capacitor filter?

Answer: A capacitor connected across the rectifier load to reduce output ripple is called a capacitor filter.

14. What is an LC filter?

Answer: An LC filter uses an inductor and capacitor to reduce ripple in rectifier output.

15. What is voltage regulation?

Answer: Voltage regulation is the ability of a power supply to maintain nearly constant output voltage despite changes in load or input voltage.

16. What is the main purpose of a regulated power supply?

Answer: To provide a constant DC output voltage to the load.

B. THREE-MARK QUESTIONS WITH ANSWERS

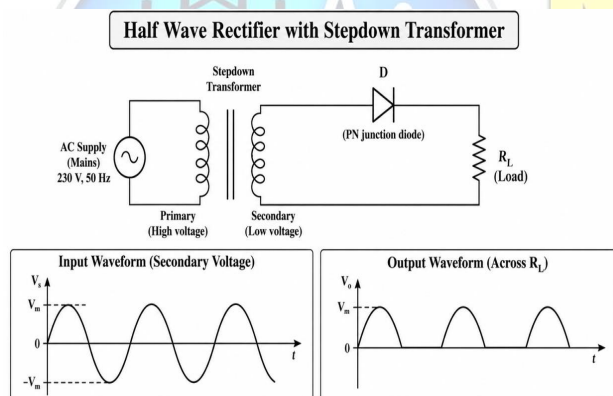
1. Explain the need for rectification.

Answer:

1. Rectification is the process of converting AC voltage into DC voltage using semiconductor devices such as diodes.
2. Most electronic circuits and devices require a constant DC supply for their proper operation, while the electrical supply available from the mains is AC.
3. Therefore, rectification is necessary in power supplies, battery chargers, electronic circuits, and DC-operated devices to obtain the required DC voltage from an AC source.

2. Explain the working of a half-wave rectifier.

Answer:



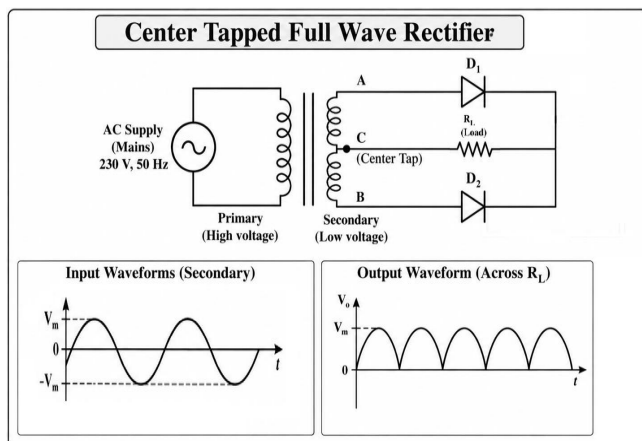
1. A half-wave rectifier uses a single diode to convert AC voltage into pulsating DC voltage. During the positive half-cycle, the diode is forward biased and current flows through the load.

2. During the negative half-cycle, the diode is reverse biased and blocks current, so no current flows through the load.

3. Thus, the rectifier allows only one half-cycle of the AC input to pass through the load, producing a pulsating DC output..

3. Explain the working of a full-wave rectifier.

Answer:



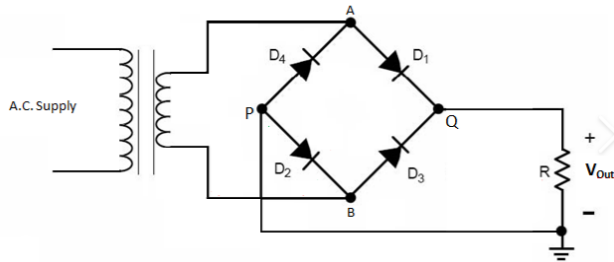
1. A full-wave rectifier converts both half-cycles of an AC input into pulsating DC. It generally uses two diodes with a centre-tapped transformer.

2. During the positive half-cycle, one diode conducts and current flows through the load in one direction. During the negative half-cycle, the other diode conducts and current again flows through the load in the same direction.

3. Thus, both half-cycles of the AC input are used, producing a higher and smoother DC output than a half-wave rectifier.

4. Explain the working of a bridge rectifier.

Answer:



1. A bridge rectifier uses four diodes connected in a bridge arrangement to convert AC voltage into pulsating DC voltage.

2. During the positive half-cycle, two diodes conduct and current flows through the load in one direction. During the negative half-cycle, the other two diodes conduct, but the current through the load remains in the same direction.

3. Thus, a bridge rectifier uses both half-cycles of the AC input and produces a full-wave pulsating DC output without requiring a centre-tapped transformer.

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

Answer:

Parameter	Half-Wave Rectifier	Full-Wave Rectifier
Number of diodes	Uses 1 diode	Uses 2 diodes (centre-tapped) or 4 diodes (bridge)
AC cycles used	Uses only one half-cycle	Uses both half-cycles
Efficiency	Low, about 40.6%	High, about 81.2%
Ripple	High ripple	Low ripple
Output	Low pulsating DC	Higher and smoother pulsating DC

A full-wave rectifier is more efficient and produces a smoother DC output than a half-wave rectifier.

6. Define ripple factor and explain its significance.

Answer: Definition: Ripple factor is the ratio of the RMS value of the AC component present in the rectifier output to the DC component of the output.

$$\text{Ripple factor} = V_{AC(rms)} / V_{DC}$$

Significance:

1. It indicates the amount of AC ripple present in the rectified output.
2. A lower ripple factor means smoother DC output and better rectification.
3. Filters such as capacitor, LC and π filters are used to reduce the ripple factor.

7. Explain rectifier efficiency.

Answer: Definition: Rectifier efficiency is the ratio of DC output power delivered to the load to the AC input power supplied to the rectifier.

$$\eta = \frac{\text{DC Output Power}}{\text{AC Input power}} \times 100$$

Significance:

1. It indicates how effectively a rectifier converts AC power into DC power.
2. Higher efficiency means less power is wasted in the rectifier.
3. The maximum theoretical efficiency is 40.6% for a half-wave rectifier and 81.2% for a full-wave rectifier.

8. Explain the need for filters in power supplies.

Answer: Need for Filters in Power Supplies

1. A rectifier converts AC into pulsating DC, which contains unwanted AC components called ripples.
2. A filter circuit is used after the rectifier to remove or reduce these ripples and make the output voltage smoother.
3. Therefore, filters are necessary to provide a smooth and stable DC voltage for the proper operation of electronic circuits and devices.

9. List the different types of filters used in power supplies.

Answer: The different types of filters used in power supplies are:

1. **Capacitor (C) Filter** – Uses a capacitor connected across the load to reduce ripple.
2. **Inductor (L) Filter** – Uses an inductor connected in series with the load to oppose AC ripple.
3. **LC and π (Pi) Filters** – Use combinations of inductors and capacitors for better ripple reduction.

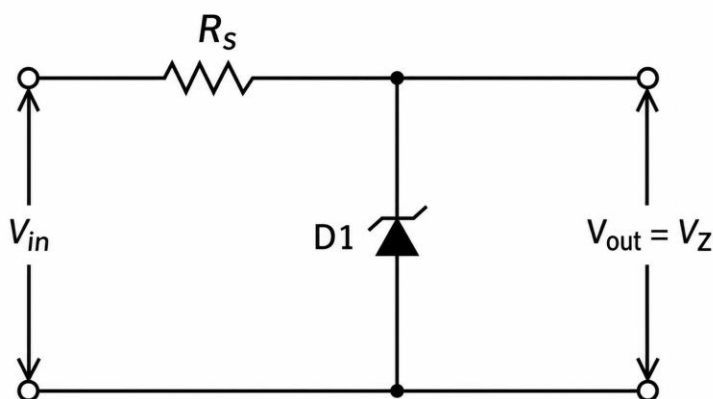
10. Define voltage regulation.

Answer: Voltage regulation is the ability of a power supply to maintain a constant output voltage when the load changes. It indicates how much the output voltage varies between no-load and full-load conditions. Good voltage regulation means the output voltage changes very little with load variations. It is usually expressed as a percentage.

Voltage Regulation (%) = $[(V_{NL} - V_{FL}) / V_{FL}] \times 100$, where V_{NL} is no-load voltage and V_{FL} is full-load voltage.

11. Explain Zener diode as a voltage regulator.

Answer:



1. A Zener diode is connected in reverse bias across the load, with a series resistor used to limit the current.

2. When the input voltage changes, the Zener diode adjusts its current while maintaining an almost constant voltage across the load, approximately equal to the Zener voltage V_Z .

3. Thus, the Zener diode provides a stable DC output voltage and is used for

voltage regulation in electronic power supplies.

C. FIVE-MARK QUESTIONS WITH ANSWERS

1. Draw and explain the working of a half-wave rectifier.

Answer: The step-down transformer reduces the 230 V AC supply to a suitable low AC voltage. The secondary voltage of the transformer is applied to the PN junction diode D.

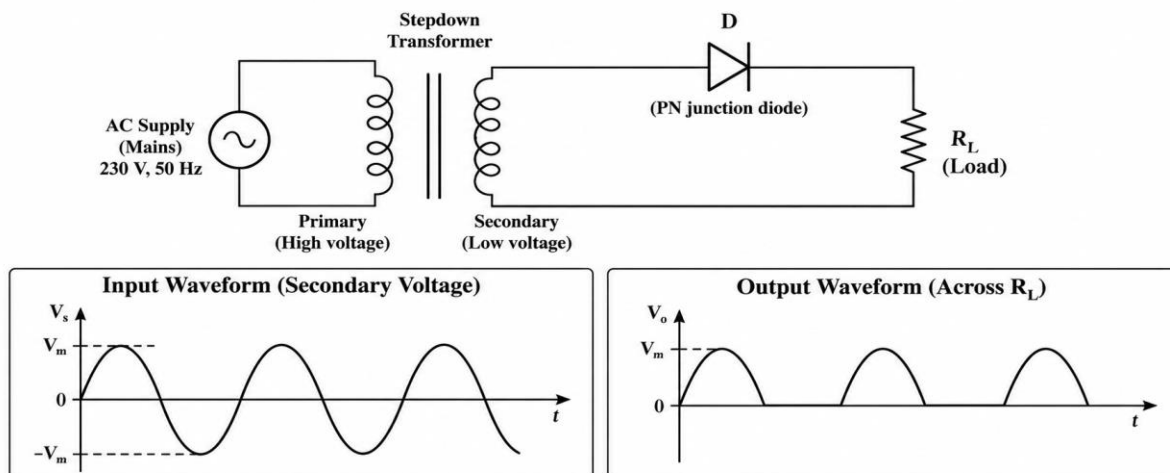
During the positive half-cycle, the upper end of the secondary becomes positive. The diode is forward biased and conducts current. Current flows through $D \rightarrow \text{load resistor } R_L \rightarrow \text{transformer secondary}$. A positive voltage is therefore obtained across the load during this half-cycle.

During the negative half-cycle, the diode becomes reverse biased. The diode blocks current, so no voltage appears across the load.

Thus, only one half of the AC waveform is passed through the load, producing pulsating DC. The output (ripple) frequency is the same as the input frequency, i.e., 50 Hz for a 50 Hz AC supply.

For an ideal rectifier: $V_{DC} = V_m/\pi$; ripple frequency $f_r = f$; maximum theoretical efficiency $\eta = 40.6\%$.

Half Wave Rectifier with Stepdown Transformer



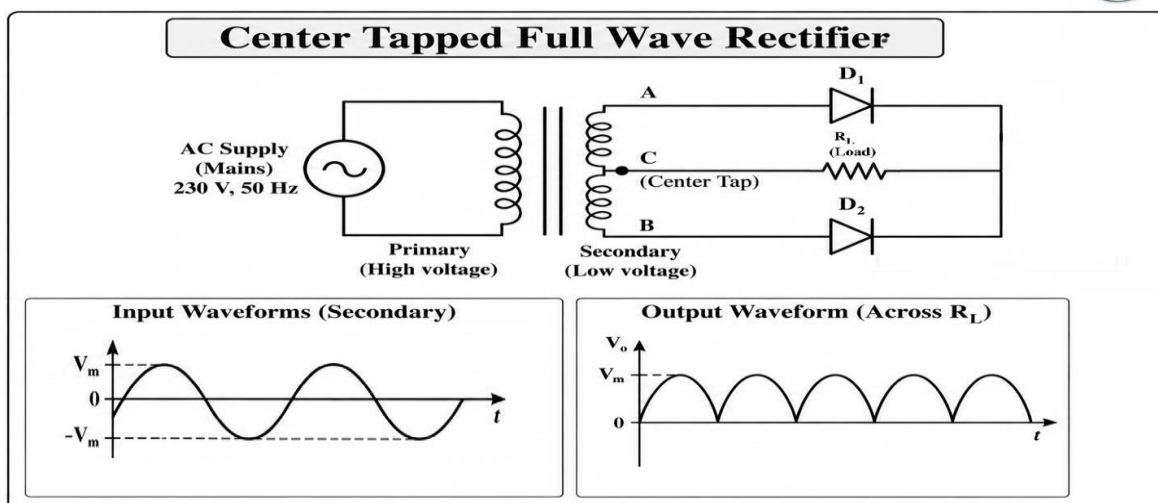
2. Draw and explain the working of a full-wave rectifier.

Answer: The circuit uses a center-tapped transformer and two diodes, D_1 and D_2 . The transformer steps down the 230 V AC supply and provides two equal secondary voltages with respect to the center tap C.

During the positive half-cycle, end A becomes positive with respect to C. Therefore, D_1 conducts while D_2 remains reverse biased. Current flows through $D_1 \rightarrow R_L \rightarrow \text{center tap C}$, producing a positive output across the load.

During the negative half-cycle, end B becomes positive with respect to C. Therefore, D_2 conducts while D_1 remains reverse biased. Current again flows through R_L in the same direction, producing a positive output.

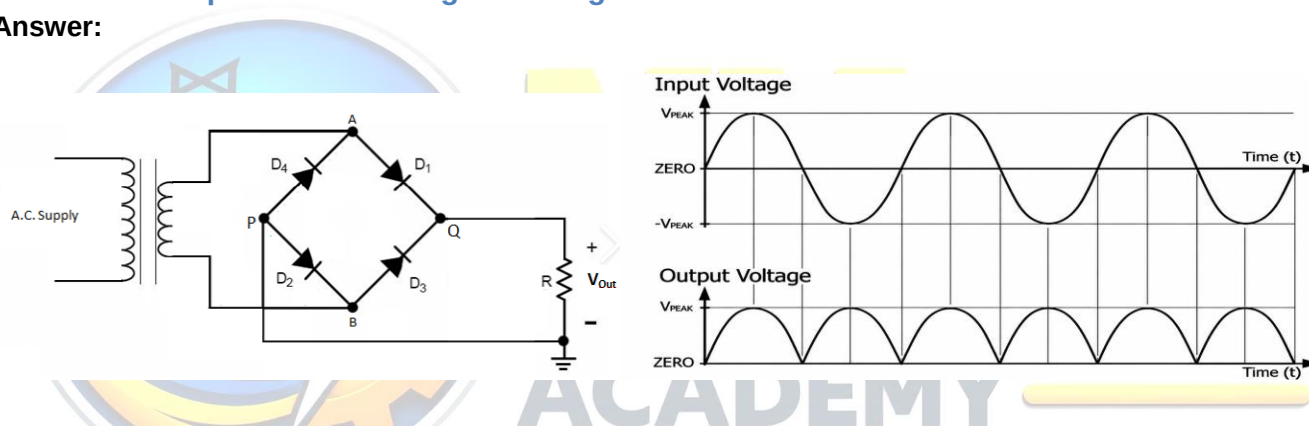
Thus, both halves of the AC input are converted into pulsating DC. The output frequency is twice the input frequency; for a 50 Hz supply, the ripple frequency is 100 Hz.



For an ideal full-wave rectifier: $V_{DC} = 2V_m/\pi$; ripple frequency $f_r = 2f$; maximum efficiency $\eta = 81.2\%$.

3. Draw and explain the working of a bridge rectifier.

Answer:



A bridge rectifier uses four diodes D_1 , D_2 , D_3 , D_4 connected in a bridge arrangement. The AC supply is applied to the bridge through the transformer secondary.

During the positive half-cycle, diodes D_1 and D_2 are forward biased and conduct. Diodes D_3 and D_4 are reverse biased and do not conduct. Current flows through $D_1 \rightarrow$ load R_L and $R_L \rightarrow D_2$, producing a positive output.

During the negative half-cycle, diodes D_3 and D_4 are forward biased and conduct. Diodes D_1 and D_2 are reverse biased during this half-cycle. Current flows through $D_3 \rightarrow$ load R_L and $R_L \rightarrow D_4$, again in the same direction through the load.

Thus, both half-cycles of AC are converted into pulsating DC. The output frequency is twice the input frequency, so for a 50 Hz supply, the ripple frequency is 100 Hz.

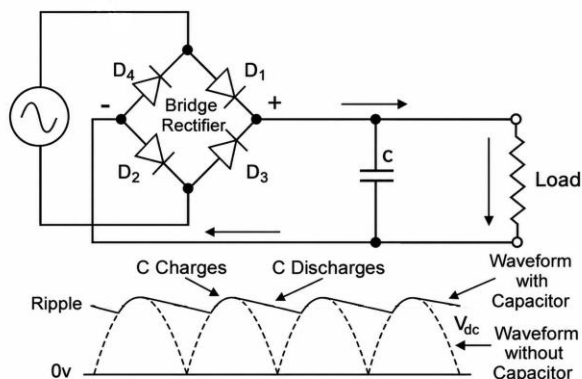
4. Compare half-wave, full-wave and bridge rectifiers.

Answer:

Parameter	Half-Wave Rectifier	Full-Wave Rectifier (Centre-Tapped)	Bridge Rectifier
Number of diodes	1	2	4
AC cycles used	Only one half-cycle	Both half-cycles	Both half-cycles
Transformer	Ordinary transformer	Centre-tapped transformer required	Ordinary transformer can be used
Ripple frequency	Same as supply frequency, f	Twice the supply frequency, $2f$	Twice the supply frequency, $2f$
Rectifier Efficiency	Low (about 40.6%)	High (about 81.2%)	High (about 81.2%)
Ripple factor	High	Low	Low
DC output	Low	Higher	Higher
PIV per diode	V_m	$2V_m$	V_m
Main advantage	Simple and low cost	Better efficiency	No centre-tapped transformer required
Main disadvantage	High ripple and low efficiency	Requires centre-tapped transformer	Uses four diodes

5. Explain the capacitor filter with circuit and waveform.

Answer:



Diode Bridge Rectifier

The capacitor filter is connected parallel to the load at the output of the rectifier. The bridge rectifier converts the AC input into a pulsating DC voltage.

When the rectified voltage rises, the capacitor charges rapidly up to nearly the peak value. When the rectified voltage starts falling, the diodes become reverse biased. The capacitor then discharges slowly through the load and supplies current to it. This discharge maintains the output voltage even when the rectified voltage decreases.

Thus, the capacitor fills the gaps between successive rectified voltage peaks. The variation in the output voltage is called ripple voltage. A larger capacitance provides better filtering and lower ripple. Therefore, the capacitor filter produces a smoother DC output from the rectified voltage.

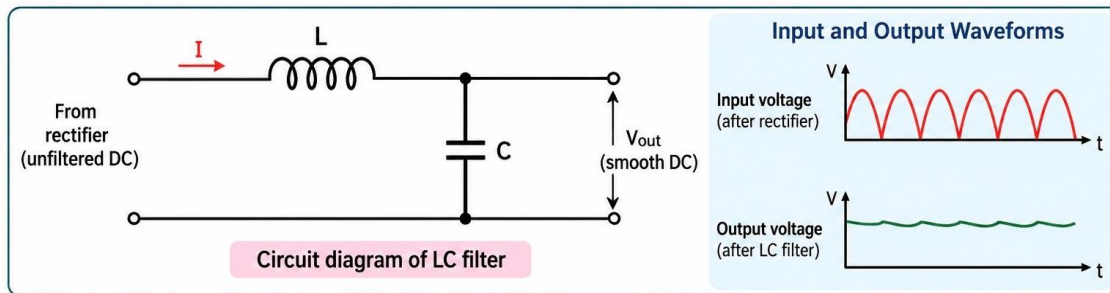
6. Explain LC filter with circuit and working.

Answer: The L-C filter is used to reduce the AC ripples present in the rectified output. It consists of a series inductor (L) and a parallel capacitor (C).

The rectified output is first applied to the inductor L. The inductor offers high opposition to AC ripple currents. It allows the DC component to pass through with very little opposition. The filtered output then

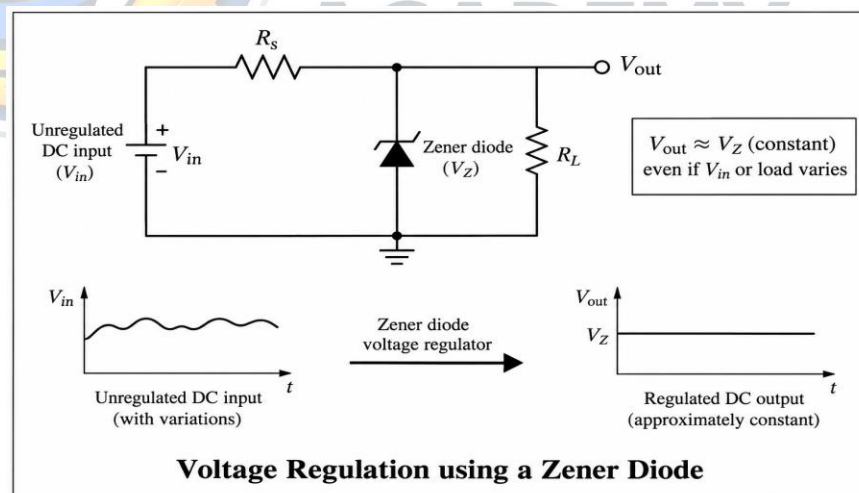
reaches the capacitor C connected across the load. The capacitor provides a low-impedance path for AC ripples.

Thus, the capacitor bypasses the remaining AC ripples to ground. The combination of L and C produces a smooth DC output voltage. Therefore, an L-C filter is mainly used where a low-ripple DC supply is required.



7. Explain voltage regulation using a Zener diode.

Answer: The Zener diode is connected in reverse bias across the load R_L . A series resistor R_S is connected between the input supply and the load. When V_{in} reaches the Zener breakdown voltage, the Zener starts conducting. The Zener maintains an approximately constant voltage V_Z across the load. Therefore, the output voltage is approximately $V_{out} \approx V_Z$. If V_{in} increases, the excess voltage is dropped across R_S . The increase in input voltage mainly causes an increase in Zener current. If the load current changes, the Zener current automatically adjusts to maintain V_{out} . Thus, variations in input voltage and load are largely prevented from appearing at the output. Hence, a Zener diode provides a stable DC voltage and acts as a simple voltage regulator.

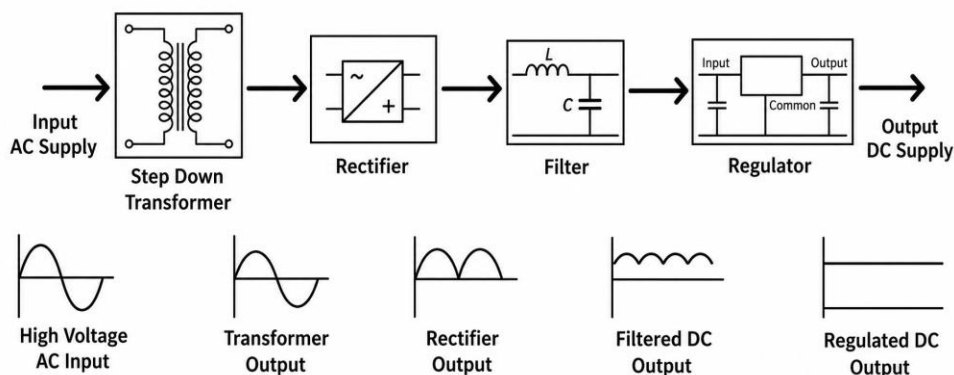


8. Draw and explain the block diagram of a regulated power supply.

Answer:

The AC supply provides high-voltage alternating current as the input.

1. The step-down transformer reduces the high AC voltage to the required lower AC voltage. The transformer also provides electrical isolation between the input and output.



2. The rectifier converts the low-voltage AC into pulsating DC. The rectifier output contains unwanted AC ripples along with DC.

3. The filter uses components such as capacitors and inductors to reduce these ripples. The filter produces a smoother DC voltage.

4. The regulator maintains the output voltage at a constant value despite changes in input voltage or load. The regulator further reduces any remaining variations or ripples in the DC supply.

Thus, the regulated power supply provides a constant and smooth DC voltage to electronic circuits.

9. Explain the applications of regulated power supplies.

Answer: A regulated power supply provides a constant DC voltage to electronic circuits even when the input voltage or load changes.

1. **Electronic equipment:** Used to provide a stable DC supply to devices such as televisions, radios, and audio systems.
2. **Computers and digital circuits:** Provides constant voltage to microprocessors, ICs, and other digital circuits.
3. **Communication systems:** Used in transmitters, receivers, and communication equipment to ensure reliable operation.
4. **Laboratory equipment:** Used in DC power supply units to provide adjustable and stable voltage for testing electronic circuits.
5. **Battery charging and control circuits:** Used in battery chargers, control systems, and instrumentation where a constant voltage is required.