SEMICONDUCTOR DEVICES
1. JUNCTION DIODES

POINTS TO REMEMBER

1. Solids are classified into conductors, insulators and semiconductors basing on band theory of solids.
2. The range of energies possessed by an electron in a solid is known as energy band.
3. The range of energies (band) possessed by a valence electron is known as valance band. It may be either partly filled or completely filled.
4. In certain substances the valence electrons are loosely bound to the nucleus even at ordinary temperatures, some of the valence electrons may get detached to become a free electron. These free electrons are responsible for the conduction of current in a conductor. These electrons are called conduction electrons.
5. The range of energies (band) possessed by the conduction electrons is called conduction band.
6. The separation between the conduction and valence band is called forbidden energy gap.
7. The width of the energy gap is a measure of bondage of valence electrons to the atom.
8. Depending on the number of electrons in the valence band and conduction band and the width of the energy gap, solids are classified as conductors, insulators and semiconductors.
9. In conductors valence band and conduction band overlap each other and the energy gap is zero.
10. In semiconductors Valence band is almost filled and the conduction band is almost empty. The energy gap is very small and it is about 1eV.
11. Energy gap for silicon = 1.12eV
    i. Germanium = 0.72eV.
12. At low temperatures, the semi - conductors behave like an insulator.
13. The temperature coefficient of resistance of a semiconductor is negative.
14. **Fermi Energy Level is t**he highest energy level which an electron can occupy at zero Kelvin.
15. Semiconductors are classified into 2 types.
16. **Intrinsic semiconductor:** The number of electrons in the conduction band and the number of holes in valence band are equal. Charge carries are both electrons and holes.
17. **Extrinsic Semiconductor:** The conductivity of a pure semiconductor can be increased by adding impurities. Adding impurity to a pure semiconductor is called doping. Such a semiconductor is called doped or extrinsic semiconductor.
18. **N-type Extrinsic semiconductor**: Pentavalent substances like arsenic, phosphorus, antimony, bismuth are doped into a pure semiconductor. Majority charge carries are electrons and minority charge carries are holes. Fermi energy level is nearer to the conduction band.
19. **P-type Extrinsic Semiconductor**: Trivalent substances like boron, aluminium, gallium, indium etc are doped in a pure semiconductor. Majority charge carries are holes and minority charge carries are electrons and hence it is called p-type semiconductor. Fermi energy level is nearer to the valence band.

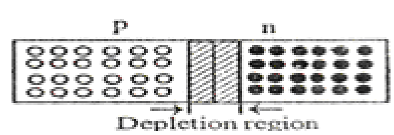
20. P-type and N-type semiconductors are neutral because electrically neutral impurity is added to electrically neutral Si or Ge.
21. **P-n junction:** When a semi conducting material such as silicon or germanium is doped with impurity in such a way that one side n-type and the other side p-type, and then p-n junction is formed.
22. **P-n junction diode:** Due to diffusion, positive ions are left over in n-region and negative ions are left over in p-region, near the junction. Due to these immobile ions on either side of the junction an internal electric field is formed at the junction which is directed from n to p. At p-n junction a neutral region where there are no charge carriers is formed and it is called depletion layer. The potential difference across the barrier o prevents diffusion of charge carriers through the junction and it is called potential barrier or contact potential. The potential barrier for silicon is 0.7 volts and for germanium is 0.3 volts.
23. **Forward Bias:** In forward bias p-region is connected to positive terminal (higher potential) of a battery and n-region is connected to negative terminal (lower potential) of a battery. The voltage of at which the current starts is called knee voltage.
24. **Reverse Bias:** In reverse bias p-region is connected to negative terminal (low potential) of a battery and n-region is connected to a positive terminal (high potential) of the battery. A small current of order of few micro amperes flow through the junction due to the drift of minority charge carriers which is called leakage current
25. In a half wave rectifier a single diode is used. Rectifier efficiency $\eta = \frac{P_{dc}}{P_{ac}} = \frac{0.406\, R_L}{R_L + r_f}$
26. In a full wave rectifier by Center Tapping method two diodes are used.
    Rectifier efficiency $\eta = \frac{P_{dc}}{P_{ac}} = \frac{0.812 R_L}{r_f + R_L}$ where r_f - diode resistance and R_L - load resistance.
27. **Zener diode**: It is the reverse biased p-n junction diode which can be used as a voltage regulator.
28. In forward bias, zener diode act like an ordinary p-n junction diode.

<u>LONG ANSWER QUESTIONS</u>

1. What is junction diode? Explain the formation of depletion layer at the junction. Explain the variation of depletion layer in forward and reverse biased condition.

A. **<u>p – n junction diode:</u>**

When a semi conducting material such as silicon or germanium is doped with impurity in such a way that one side n-type and the other side p-type impurities then p-n junction is formed. p-side of semi conductor contains excess holes and n-side of semi conductor contains excess of electrons.



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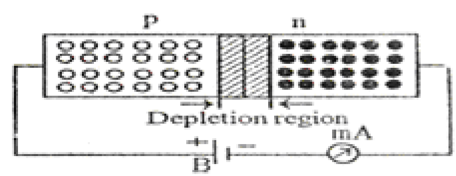
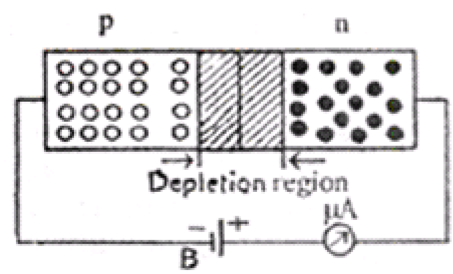
Near the junction, the free electrons from n-region migrate towards p-region and the holes in p-region migrate towards n-region. This process is known as diffusion. Due to diffusion, positive ions are left over in n-region and negative ions are left over in p-region, near the junction. These ions are immobile. Due to the immobile ions on either side of the junction an internal electric field is formed at the junction which is directed from n to p. At p-n junction a neutral region where there are no charge carriers is formed and it is called depletion layer. The thickness of the depletion layer is of the order of 10^{-6} m. The potential difference across the barrier prevents diffusion of charge carriers through the junction and it is called potential barrier or contact potential. The potential barrier for silicon is 0.7 volts and for germanium is 0.3 volts. The potential barrier depends on the nature of semiconductor, doping concentration and temperature of the junction.

Depletion layer – Potential barrier: In p-n junction electrons from n-side diffuse across the junction into p-side and combine with holes there. Similarly, holes from p-side diffuse across the junction into n side and combine with electrons there. The atoms in n-side loosing electrons become positive ions and repel the further holes moving towards n-side. The atoms in p-side loosing holes become negative ions and repel the further electrons moving towards p-side. Due to this, a region formed at the junction where the holes and electrons cannot movie. This region is called depletion layer.

Forward Bias: Inap-njunctiondiode, p-region is connected to positive terminal (higher potential) of a battery and n-region is connected to negative terminal (lower potential) of a battery .Then it is said to be



forward biased. The width of depletion layer and barrier potential decrease. The resistance of an ideal diode in forward biased condition is zero .In forward biased condition, the flow of current is mainly due to the diffusion of charge carriers. The direction of current is from p to n .The voltage of at which the current starts is called knee voltage. The current will be of order of few mill amperes

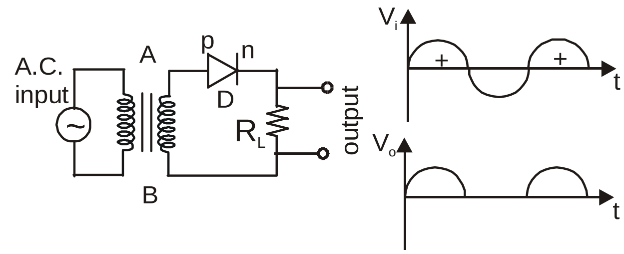


ReverseBias: In a p-n junction diode, p-region is connected to negative terminal (low potential) of a battery and n-region is connected to a positive terminal (high potential) of the battery then it is said to be reverse biased. The resistance of the p-n junction diode in reverse bias is about 10kΩ.The width of the depletion layer and barrier potential increase. The resistance of an ideal diode in reverse bias condition is infinity. In reverse biased condition, a small current of order of few micro amperes flow through the junction due to the drift of minority charge carriers .This is called leakage current .The direction of current in it is from n to p. During reverse bias,

2. What is rectifier? Explain the working of half wave and full wave rectifiers using diagrams.

A. Conversion of A.C. voltage into D.C. voltage is called rectification. A p-n junction diode is used as a rectifier.

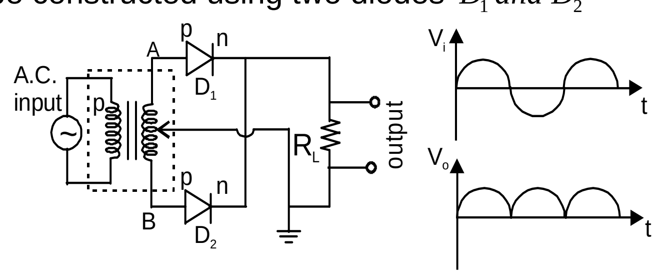
Half wave rectifier : In a half wave rectifier a single diode is used. The AC from the secondary of the transformer AB is applied to the diode and a load resistance R_L in series. The potential across AB change to every half cycle. During the positive half cycle, the diode is forward biased and current flows though the diode and the load resistance. During the negative half cycle, the diode is reversing biased and current does not flow through the diode and load resistance. Thus current flows during the positive half cycle and is blocked during the negative half cycle. The output across the load resistance contains rectified voltage which is a variable DC.



Efficiency of half- wave rectifier = $\frac{DC\ \ poweroupt}{AC\ \ powerinput} = \frac{0.406 R_L}{R_L + r_f}$

Where $r_f =$ forward resistance of diode. R_L - Load resistance

Full – Wave rectifier: It can be constructed using two diodes D_1 *and* D_2 which are connected in parallel. The secondary of the transformer AB is centre tapped. The two ends A and B are connected to both the p-sides of the diodes and both the n-sides are joined.

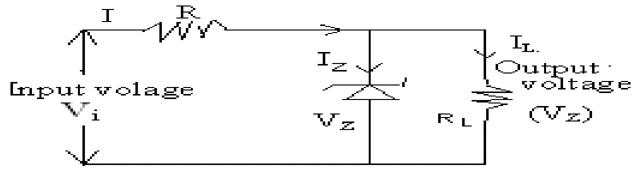


Across the common point of n-sides and the central tap C, a load resistance two ends A and B are connected to both the p-ends of the diodes and both the n-ends are joined. Across the common point of n-ends and the central tap C, a load resistance in connected. Due to the central tapping when A is in positive cycle, B will be in negative cycle. When A is in positive half cycle. Diode D_1 is formed biased and D_2 is reverse biased. Thereby current flows through D_1 when A is in negative half cycle. Diode D_2 is forward biased and D_1 is reverse biased. Hence current flow through D_2 During one full cycle both the diodes conduct electricity one after another, due to which current flows through the load resistance R_L during the full cycle. Thus a full wave is rectified

Efficiency of the full-wave rectifier = $\frac{DC\ power\ output}{AC\ power\ input} = \frac{0.812 R_L}{r_f + R_L}$

3. What is a Zener diode? Explain how it is used as voltage regulator?

A. **Zener diode :** It is a heavily doped p-n junction diode which is operated in the breakdown region in reverse bias mode.Zener diode has a sharp breakdown voltage



in the reverse bias because of heavy doping. This voltage is called Zener Voltage (V_Z). Because of heavy doping width of the depletion layer decreases.In forward bias, zener diode act like an ordinary p-n junction diode.Zener diode is used as a voltage regulator. If the input voltage increases, more current passes thorugh the zener and more potential is dropped across R. The potential V across the zener remains same.When R_L is less more current passes through it, and p.d across R is less, And the p.d across zener remains constant. Thus the output voltage is regulated.

Output voltage (V_O) = Zener voltage (V_Z)

Current through load resistance $(I_L) = \frac{V_Z}{R_L}$

Voltage across series resistance (V)=input voltage – zener voltage.

Current through zener diode (I_Z) = $I - I_L$.

SHORT ANSWER QUESTIONS

1. What are n- type and p- type semi-conductors? How is semi conductor junction formed? (March 2011)

A. The conductivity of a pure semiconductor can be increased by adding impurities. Adding impurity to a pure semiconductor is called doping.Such a semiconductor is called doped or extrinsic semiconductor.

Extrinsic semiconductors are classified into 2 types, namely .N type and P – type

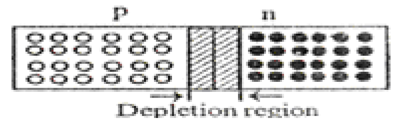
N-type Extrinsic semiconductor

Pentavalent substances like arsenic, phosphorus, antimony, bismuth are doped into a pure semiconductor.Every arsenic atom supplies a free electron and hence it is called donor impurity. Majority charge carries are electrons and minority charge carries are holes. Hence it is called N-type semiconductor.Since the no of electrons are more than the no of holes, Fermi energy level is nearer to the conduction band.

P-type Extrinsic Semiconductor

Trivalent substances like boron, aluminium, gallium, indium etc are doped in a pure semiconductor. The three valence electrons of boron form three covalent bonds with silicon atoms.There is a gap for the fourth bonding which creates a positive hole.Every boron atoms gives rise to a positive hole and hence boron is called acceptor impurity.Majority charge carries are holes and minority charge carries are electrons and hence it is called p-type semiconductor.Since the number of holes in the valence band is more, the Fermi energy level is nearer to the valence band.

p – n junction :



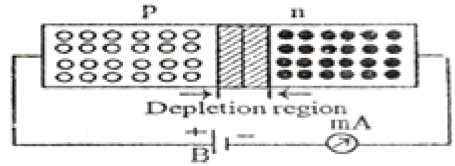
When a semi conducting material such as silicon or germanium is doped with impurity in such a way that one side n-type and the other side p-type impurities then p-n junction is formed. p-side of semi conductor contains excess holes and n-side of semi conductor contains excess of electrons.

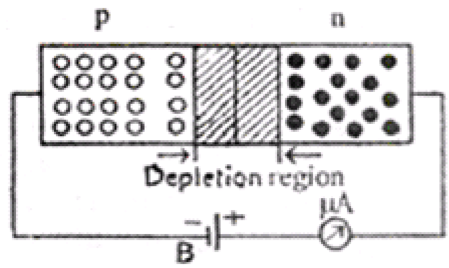
`` Near the junction, the free electrons from n-region migrate towards p-region and the holes in p-region migrate towards n-region. This process is known as diffusion. Due to diffusion, positive ions are left over in n-region and negative ions are left over in p-region, near the junction. These ions are immobile. Due to the immobile ions on either side of the junction an internal electric field is formed at the junction which is directed from n to p. At p-n junction a neutral region where there are no charge carriers is formed and it is called depletion layer. The thickness of the depletion layer is of the order of 10^{-6} m. The potential difference across the barrier prevents diffusion of charge carriers through the junction and it is called potential barrier or contact potential. The potential barrier for silicon is 0.7 volts and for germanium is 0.3 volts. The potential barrier depends on the nature of semiconductor, doping concentration and temperature of the junction.

2. Discuss the behavior of a p-n junction. How a potential barrier develops at the junction?

A. **Depletion layer – Potential barrier:** When a semi conducting material such as silicon or germanium is doped with impurity in such a way that one side n-type and the other side p-type impurities then p-n junction is formed. p-side of semi conductor contains excess holes and n-side of semi conductor contains excess of electrons In p-n junction electrons from n-side diffuse across the junction into p-side and combine with holes there. Similarly, holes from p-side diffuse across the junction into n side and combine with electrons there. The atoms in n-side loosing electrons become positive ions and repel the further holes moving towards n-side. The atoms in p-side loosing holes become negative ions and repel the further electrons moving towards p-side. Due to this, a region formed at the junction where the holes and electrons cannot movie. This region is called depletion layer.

Forward Bias: In a p-n junction diode, p-region is connected to positive terminal (higher potential) of a battery and n-region is connected to negative terminal (lower potential) of a battery .Then it is said to be forward biased. The width of depletion layer and barrier potential decrease. The resistance of an ideal diode in forward biased condition is zero .In forward biased condition, the flow of current is mainly due to the diffusion of charge carriers. The direction of current is from p to n .The voltage of at which the current starts is called knee voltage. The current will be of order of few mill amperes

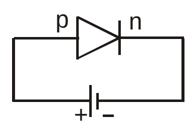




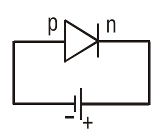
ReverseBias: In a p-n junction diode, p-region is connected to negative terminal (low potential) of a battery and n-region is connected to a positive terminal (high potential) of the battery then it is said to be reverse biased. The resistance of the p-n junction diode in reverse bias is about 10kΩ.The width of the depletion layer and barrier potential increase. The resistance of an ideal diode in reverse bias condition is infinity. In reverse biased condition, a small current of order of few micro amperes flow through the junction due to the drift of minority charge carriers .This is called leakage current .The direction of current in it is from n to p. During reverse bias,

3. Draw and explain the current voltage characteristic curves of junction diode in forward and reverse bias.

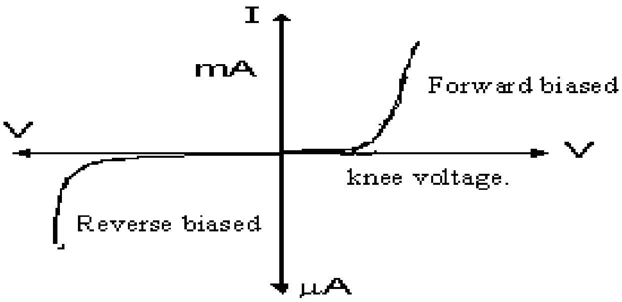
A. **Forward Bias :**In a p-n junction diode, p-region is connected to positive terminal (higher potential) of a battery and n-region is connected to negative terminal (lower potential) of a battery .Then it is said to be forward biased. The width of depletion layer and barrier potential decrease.The resistance of an ideal diode in forward biased condition is zero.In forward biased condition, the flow of current is mainly due to the diffusion of charge carriers.The direction of current is from p to n.The voltage of at which the current starts is called knee voltage.The current will be of order of few mill amperes



Reverse Bias : In a p-n junction diode, p-region is connected to negative terminal (low potential) of a battery and n-region is connected to a positive terminal (high potential) of the battery then it is said to be reverse biased.The resistance of the p-n junction diode in reverse bias is about 10kΩ.The width of the depletion layer and barrier potential increase.The resistance of an ideal diode in reverse bias condition is infinity.In reverse biased condition, a small current of order of few micro amperes flow through the junction due to the drift of minority charge carriers .This is called leakage currentThe direction of current in it is from n to p.During reverse bias , if the reverse voltage is high, the covalent bonds get ruptured and the number of electrons suddenly increases. This voltage is called breakdown voltage.



I-V characteristics :



4. Describe how a semi conductor diode is used as half wave rectifier?

(June 2010, March 2010)

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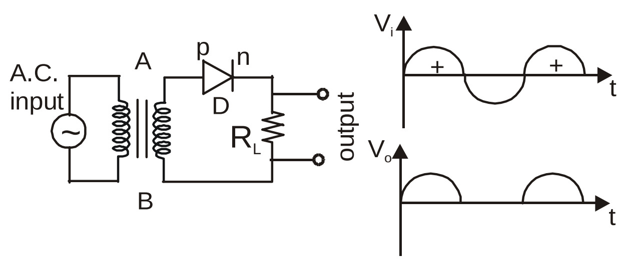
A. Conversion of A.C. voltage into D.C. voltage is called rectification. A p-n junction diode is used as a rectifier.

Half wave rectifier : In a half wave rectifier a single diode is used.The AC from the secondary of the transformer AB is applied to the diode and a load resistance R_L in series. The potential across AB change to every half cycle. During the positive half cycle, the diode is forward biased and current flows though the diode and the load resistance. During the negative half cycle, the diode is reversing biased and current does not flow through the diode and load resistance. Thus current flows during the positive half cycle and is blocked during the negative half cycle. The output across the load resistance contains rectified voltage which is a variable DC.



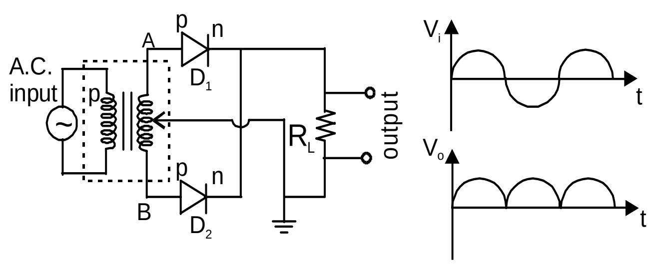
Efficiency of half- wave rectifier = $\frac{DC\ \ poweroupt}{AC\ \ powerinput} = \frac{0.406 R_L}{R_L + r_f}$

Where $r_f =$ forward resistance of diode. R_L - Load resistance

5. What is rectification? Explain the working of a full wave rectifier?

(March 2009, May2010))

A. **Full – Wave rectifier:** It can be constructed using two diodes $D_1\ and\ D_2$ which are connected in parallel. The secondary of the transformer AB is centre tapped . The two ends A and B are connected to both the p-sides of the diodes and both the n-sides



are joined. Across the common point of n-sides and the central tap C, a load resistance two ends A and B are connected to both the p-ends of the diodes and both the n-ends are joined. Across the common point of n-ends and the central tap C, a load resistance in connected. Due to the central tapping when A is in positive cycle, B will be in negative cycle. When A is in positive half cycle. Diode D_1 is formed biased and D_2 is reverse biased. Thereby current flows through D_1 when A is in negative half cycle. Diode D_2 is forward biased and D_1 is reverse biased. Hence current flow through D_2 During one full cycle both the diodes conduct electricity one after another, due to which current flows through the load resistance R_L during the full cycle. Thus a full wave is rectified

Efficiency of the full-wave rectifier = $\frac{DC\ power\ output}{AC\ power\ input} = \frac{0.812 R_L}{r_f + R_L}$

Where $r_f =$ forward resistance of diode. R_L - Load resistance

6. Distinguish between the half- wave and full – wave rectifiers.

A.

Half wave rectifier	Full – wave rectifier
1. Every positive half cycle of A.C is rectified converts to D.C	1. Both positive and negative half cycles of A.C. are rectified.
2. One diode rectifies one half- cycle only	2. The two diodes rectify the two half cycles separately.
3. Efficiency is low (40.6%)	3. Efficiency is high (81.2%)

7. Distinguish between Zener breakdown and avalanche breakdown.

A. **Zener Breakdown:** If a diode is heavily doped ,the depletion region width becomes very small and an applied voltage of 6V or less causes an electric field of 10^7 V/m at junction. This causes Zener breakdown in heavily doped diode at low reverse bias voltage.

Avalanche Breakdown: The thermally generated electrons and holes acquire sufficient energy from applied potential to produce new carriers by removing valence electrons from their bonds. These new carriers in turn produced additional carriers again through the process of disrupting bonds. This process is referred as avalanche multiplication. It results in large current. This occurs in lightly doped diodes at high reverse bias voltage.

8. Explain hole conduction in intrinsic semiconductors.

A. A semi conductor in its pure form is known as intrinsic semi-conductor..

At a very low temperature (O K) the crystal behaves like an an insulator. Due to thermal energy itself. Some of the electrons escape from the bonds and an empty space is left behind in the valence bond. This vacancy in the valence bond is called a hole. The liberated electrons go to conduction band thus electron-hole pairs are created due to thermal energy. Under applied electric field the holes drift in an opposite direction to electrons with lesser speed and behave like positive charge carriers.

VERY SHORT ANSWER QUESTIONS

1. What Is n-type semi conductor? What are the majority and minority charge carriers in it?

A. Pentavalent substances like arsenic, phosphorus, antimony, bismuth are doped into a pure semiconductor. The majority charge carriers are the electrons and the minority charge carriers are holes in n-types semiconductors.

2. What are intrinsic and extrinsic semiconductors?

A. Pure semiconductors are called the intrinsic semiconductors. Eg : Ge, Si etc.

Doped semiconductors are called the extrinsic semiconductors. Eg : P-type and n – type

3. What are majority and minority charge carriers in p-type semiconductor? (March 2009)

A. In p-type semi conductors, majority carriers are holes and minority carriers are electrons

4. What is p – n junction diode? Define depletion layer. (March 2010)

A. When an intrinsic semi conductor is grown with one side doped with trivalent substance and other side with pentavalent substance, a junction is formed in the crystal called p – n junction diode. A region without any charge carriers is formed at p-n junction due to the recombination of electrons and holes is called depletion layer.

5. How is a battery connected to a junction diode in 1) forward and 2) reverse bias?

A. In a p-n junction diode, p-region is connected to positive terminal (higher potential) of a battery and n-region is connected to negative terminal (lower potential) of a battery .Then it is said to be forward biased.

In a p-n junction diode, p-region is connected to negative terminal (low potential) of a battery and n-region is connected to a positive terminal (high potential) of the battery then it is said to be reverse biased.

6. What is the maximum percentage of rectification in half wave and full wave rectifiers?

A. 1) 40.6% 2) 81.2%

7. What is zener voltage (V_z) and how will a zener diode be connected in circuits generally?

A. A zener diode is a reverse biased heavily doped silicon (or Germanium) p-n junction diode which is operated in the breakdown region. It is connected in the reverse bias

8. Write the expressions for efficiency of a full wave rectifier and a half wave rectifier.

A. For half-wave rectifier. Efficiency $\eta = \dfrac{0.406R_L}{r_f + R_L}$

For full-wave rectifier. Efficiency $\eta = \dfrac{0.812R_L}{r_f + R_L}$

Where $r_f =$ forward resistance of diode $R_L =$ load resistance.

9. What happens to the width of the potential barrier in a p-n diode 1) when it is forward biased and 2) reverse biased?

A. i) In forward bias width of the potential barrier decreases.

ii) In reverse bias condition width of the potential barrier increases

SOLVED PROBLEMS

1. The applied input ac power to a half wave rectifier is 100W. The dc output power obtained is 40W. Find the rectifier efficiency.

A. AC input power = 100W; DC output power = 40 W.

Rectifier efficiency = $\frac{dc\ power\ output}{Input\ ac\ power} = \frac{P_{dc}}{P_{ac}} = \frac{40}{100} = 0.4 = 40\%$

2. A p-n diode is used in a half wave rectifier with a load resistance of 1000 Ω. If the forward resistance (r_f) of diode is 10Ω, calculate the efficiency of this half wave rectifier.

A. $R_L = 1000\Omega$; $r_f = 10\Omega$

Efficiency $\eta = \frac{0.406 R_L}{r_f + R_L} = \frac{0.406 \times 1000}{1010} = 0.4019$ Or η = 40.19%

3. A full wave rectifier uses two diodes with a load resistance of 100Ω. Each diode is having negligible forward resistance. Find the efficiency of this full wave rectifier.

A. $r_f = 0\Omega$; $R_L = 100\Omega$; $\eta = ?$

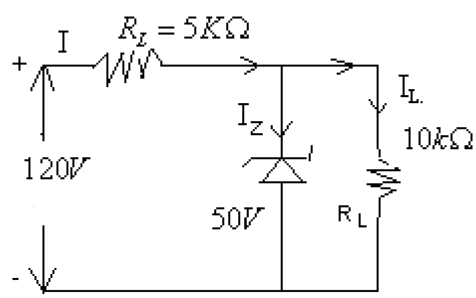
Efficiency $\eta = \frac{0.812 R_L}{r_f + R_L} = \frac{0.812 \times 100}{100} = 81.2\%$

4. For the circuit shown in figure find

1) The output voltage.

2) The voltage drop across series resistance;

3) The current through Zener diode.



A. $R = 5k\Omega = 5 \times 10^3 \Omega$

$V_{in} = 120V$; $R_L = 10k\Omega = 10 \times 10^3 \Omega$, $V_z = 50V$.

1) Output voltage, $V_z = 50V$

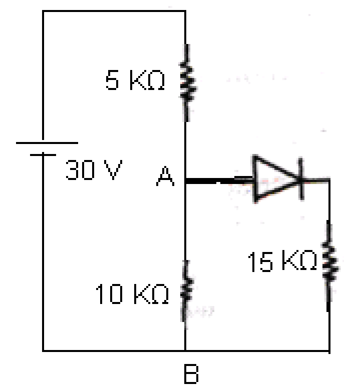
2) Voltage drop across series resistance $R = V_{in} - V_Z = 120 - 50 = 70V$

3) Load current $I_L = \frac{V_Z}{R_L} = \frac{50}{10\times10^3} = 5\times10^3 A$

Current through R = I = $\frac{Voltage\,drop across R}{R} = \frac{70}{5\times10^3} = 14\times10^{-3} A$

$\therefore$ Zener current, $I_Z = I - I_L = 14\times10^{-3} - 5x10^{-3} = 9\times10^{-3} = 9mA$

5 Find maximum voltage across AB in the circuit shown. Assume that the diode is ideal.



A. $10k\Omega$ is in parallel with 15 $k\Omega$ and the effective resistance across AB is $R_{AB} = \frac{10\times15}{10+15} = 6k\Omega$

$6k\Omega$ is in series with $5k\Omega$ to give an effective resistance of 11 $k\Omega$

$R_e = 11k\Omega, V = 30V$

Current dranw from the battery is $I = \frac{V}{R_e} = \frac{30V}{11k\Omega} = 2.72mA$

$V_{AB} = IR_{AB} = 2.72mA\times6k\Omega = 16.32V$

6. Determine the current through a silicon diode of (barrier potential = 0.7V) figure assume that the diode resistance is negligible.

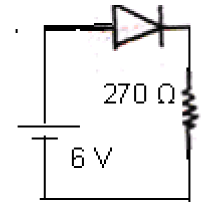
A. Since diode is forward biased, the barrier potential acts opposite to the supply voltage therefore

$$I = \frac{V - V_B}{R} = \frac{(10-0.7)V}{10k\Omega} = \frac{9.3V}{10k\Omega} = 0.93mA$$

7 In the figure $V_B = 0.6V$

a) Calculate the current I in the circuit

b) In figure find the current (I) if the diode is reversed.



A. a) $I = \frac{5.4}{270} = \frac{54\times10^{-2}}{27} = 2\times10^{-2} = 20mA$ n

b) I = 0 since diode is reverse biased (open circuited).

UNSOLVED PROBLEMS:

1. In half wave rectifier, a p – n junction diode with internal resistance 20Ω is used. If the load resistance of 2 $k\Omega$ is used in the circuit, then find the efficiency of this half wave rectifier. (June 2010)

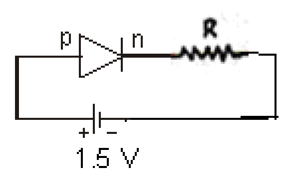
A. $r_f = 20\Omega$; $R_L = 2kW = 2000\,\Omega$

Efficiency $\eta = \frac{0.406\times R_L}{R_L + r_f}\times100 = \frac{0.406\times2000\times100}{2000+20} = 40.2\%$

2. A full wave p-n junction diode rectifier uses a load r4esistance of 1300Ω. The internal resistance of each diode is 9Ω. Find the efficiency of this full wave rectifier? (May 2009)

A. Efficiency $\eta = \frac{0.812\times R_L}{R_L + r}\times100 = \frac{0.812\times1300}{1300+9}\times100 = 80.64\%$

3. Calculate the value of R, if the maximum value of forward current of the diode is 100 mA when diode is



a) Ge (Barrier potential = 0.3 V)

b) Si (Barrier potential = 0.7 V)

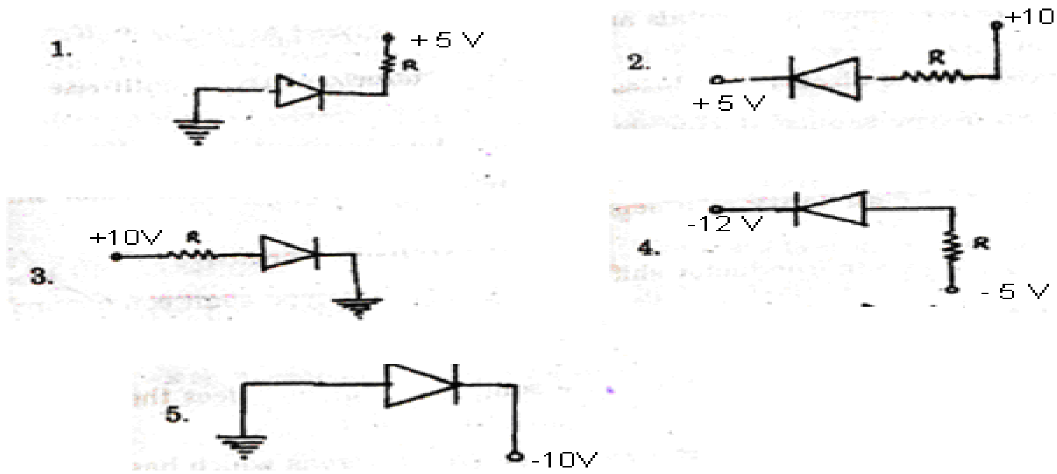
A. a) For Ge , Net emf = 1.5 – 0.3 = 1.2V

$\therefore$ Resistance = R = $\frac{Net\,emf}{Current} = \frac{1.2}{100\times10^{-3}} = 12\Omega$

b) For Silicon Net emf = 1.5 – 1.7 = 0.8 V

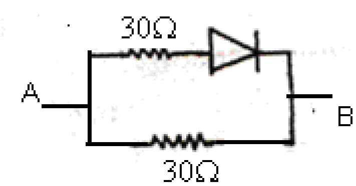
Resistance = $R = \frac{Net\,emf}{Current} = \frac{0.8}{100\times10^{-3}} = 8\Omega$

4 Which of the following diodes are forward biased?



A. Diodes 2,3,4 and 5 are forward biased

5 If $V_A \, and \, V_B$ denote potentials of A and B, then the equivalent resistance between A and B in the circuit shown a) if $V_A > V_B$, b) if $V_A < V_B$



A. a) If $V_A > V_B$, then diode will be forward biased. Hence

$$R = \frac{30 \times 30}{30 + 30} = \frac{900}{60} = 15\Omega$$

b) If $V_A < V_B$, then diode will be reverse biased. Hence R = 30Ω .

Assess yourself

1. If n_p represents the hole concentration or the number of holes per unit volume and n_e represents the (free) electron concentration or the number of (free) electrons per unit volume, what is the relation between them in an intrinsic semiconductor?

A. $n_p = n_e$

2. What is the ratio of $n_p \, to \, n_e$ in a p – type semiconductor?

A. The ratio is greater than one

3. What is the ratio of $n_p \, to \, n_e$ in an n-type semiconductor?

A. The ratio is less than one

4. How does the conductivity of a semiconductor change with rise in temperature?

A. The conductivity of a semiconductor increases with rise in temperature

5. What is the effect of temperature on the resistance of i) metals and ii) semiconductors?

A. As temperature increases the resistance of i) metals increases and ii) a semiconductor decreases.

6. Why does the Fermi energy level in an n-type semiconductor shift towards the conduction band?

A. Excess electrons are available and their energy levels are just below the conduction band.

7. Why does the Fermi energy level in a p – type semiconductor shift towards the valence band?

A. Excess holes are available and their energy levels are just above the valence band.

8. When an electric field is applied on a semiconductor how does the current flow occur?

A. Holes move in the direction of the electric field and the electrons move opposite to the field and thereby the current flow occur.

9. Of the two type of charge carriers – holes and electrons which has greater mobility?

A. Electrons.

10. In which bias Zener diode characteristic is same as that of junction diode?

A. Forward bias.

11. Can we measure the potential barrier of a p-n junction diode by connecting a sensitive voltmeter across its terminals?

A. No. Because the depletion layer does not contain either electrons or holes.

12. To forward bias a diode, its p-type is to be connected to the positive terminal of a cell and n-type to the negative terminal of the cell. Is it necessary?

A. No. If t he p-region is at a higher potential compared to the n-region ,the diode will be in forward bias.

13. To reverse – bias a diode, its p-type is to be connected to the negative terminal of a cell and n-type to the positive terminal of the cell. Is it necessary?

A. No. If t he p-region is at a lower potential compared to the n-region ,the diode will be in reverse bias.

14. Which type of biasing gives a semiconductor diode very high resistance?

A. Reverse bias.

15. In which part of a cycle the diode conducts in half wave rectifier?

A. Positive half cycle.

16. In which biasing zener diode is used as voltage regulator?

A. Reverse bias.

17. Which rectifier produces double frequency at the output?

A. Full wave rectifier.

18. Which type of break down results due to strong electric fields at the junction?

A. Zener break down

19. Which region of junction diode acts as capacitor?

A. Depletion layer.

20. Can a Zener diode be used in the place of a junction diode in rectifier circuit?

A. Yes. A Zener diode be used in the place of a junction diode in rectifier circuit below the Zener break down voltage.

21. Is it correct to say that a diode behaves like a closed switch in the forward biased condition and behaves like an open switch in the reverse – biased condition?

A. Yes.