General Topic :-

In this fast developing Society, Electronics has Come to Stay as the most important branch of Engineering. Electronic devices are being used in almost all the Industries for all Quality Control and automation.

On the opinion of Electronics, during the Recent years they have demonstrated that this versatile tool Can be of great importance in Increasing Production, Efficiency and Control.

The purpose of this chapter is to provide the elementary knowledge.

Electronics :-

The Branch of Engineering which deals with Current Conduction through a vaccum (or) gas (or) Semi Conductor is known as the Electronics.

So this Electronics Essentialy deals with the Electronic devices and their utilization.

An Electronic device is that in which Current flows through a Vaccum (or) gas (or) Semiconductor.

Such devices have valuable Properties which Enable them to Function and behave as the friend of man today.

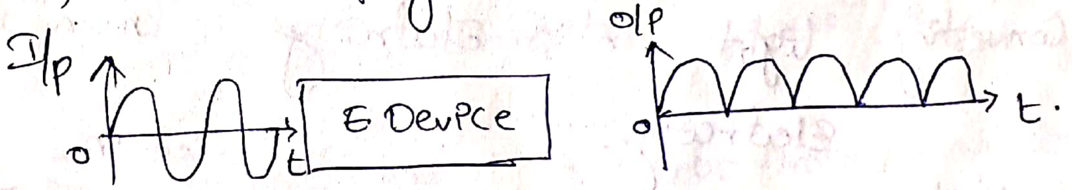
Importance. The Electronics has gained much importance due its Numerical applications in Industry.

The Electronic devices are Capable of performing the following Functions.

1. Rectification.
2. Amplification.
3. Control
4. Generation
5. Conversion of light into Electricity
6. Conversion of Electricity into light.

Rectification :- The process of converting a.c Energy into d.c Energy is called rectification. Electronic devices can convert a.c power into d.c power, with very high Efficiancy.

This d.c Supply can be used for charging storage batteries, field supply of d.c generators....



Amplification :- The process of raising the strength of a weak signal is called amplification. Job of amplification Electronic device can accomplish and acts as an amplifier.

The Amplifiers are used in a wide variety of ways. For Example, an amplifier is used in radio-set where the weak signal is amplified so that it can be heard loudly.

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Control :- Electronic devices find wide applications in automatic control.
For Example, speed of a motor, voltage across a refriegerator etc.., can be automatically controlled with the help of such devices.

Generation :- Electronic devices can convert d.c power into a a.c power of any frequency. when performing this function, they are known as the oscillators. The oscillators are used in wide variety of ways.
For Example, electronic high frequency heating is used for annealing and hardening.

Conversion of light into Electricity :- Electronic devices can convert light into electricity. The process of converting light into electricity is known as the photo-electricity.
Photo-electric devices are ~~known as the~~ used in Burglar Alarms, Sound Recording on motion pictures etc..,

Conversion of light into Electricity :- Electronic devices can convert (i.e) Electricity into light. This valuable property is used in the Radar and Televisions.

Atomic Structure :-

According to the modern theory, matter is Electrical nature. All the materials are composed of very small particles called atoms. The atoms are consists of a central nucleas of positive charge around which small negatively charged particles, called electrons revolve in different paths (or) orbits.

Nucleus :-

1. It is the central part of atom.
2. Contains protons and Neutrons.
3. A proton is a positively charged particle, while the Neutron has the same mass as the proton, but has no charge.
4. Therefore, the nucleus of an atom is positively charged.
5. The sum of protons and neutrons constitutes the entire weight of an atom and is called atomic weight.
6. Electrons have negligible weight. Let us take mass of Electrons is 9.1×10^{-31} kg

   So Atomic weight = No. of protons + No. of neutrons.
7. The charge on an electron is equal to but opposite to that on a proton.
8. The number of Electrons is equal to the number of protons in an atom under ordinary conditions.
9. The Number of Electrons (or) protons in an atom is called the atomic Number.

   atomic Number = No. of protons (or) Electrons in an atom.

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10. The Number of Electrons in any orbit is given by $2n^2$ where n is the number of orbit.

First orbit contains $2 \times 1^2 = 2$ Electrons.

Second orbit contains $2 \times 2^2 = 8$ Electrons

Third orbit contains $2 \times 3^2 = 18$ Electrons.

Structure of Elements :-

The difference B/w various types of Elements is due to different Number and arrangement of these particles with in their atoms.

For Example, the structure of Copper atom is different from that of Carbon atom and hence the Two Elements have different properties.

Electron

Electronics deals with tiny particles called electrons.

Electron is a negatively charged particle having negligible Mass.

Charge of on an Electron $e = 1.602 \times 10^{-19}$ Coulomb.

Mass of an electron, $m = 9.0 \times 10^{-31}$ kg

Radius of an electron, $r = 1.9 \times 10^{-15}$ metere

Note:-

1. mass of Electron is very small, due to this the property of an Electron that it is very mobile and is greatly influenced Electronic (or) magnetic fields.

Energy of an Electron:-

1. An electron moving round the nucleus posses two types of Energies 1. Kinetic Energy 2. potential Energy.
2. Kinetic Energy is due to its motion
3. Potential Energy is due to charge on the nucleus.
4. The total Energy is Sum of Two Energies.
5. The Energy of an Electron increses as its distance from the nucleus increases.
6. Electron in the Second orbit posses more Energy than the electron in the first orbit.

   Electron in the third orbit has higher than the Energy in the Second orbit.

The Electrons in the outermost orbit of an atom are called as the valence electrons.

The valance Electrons determine the physical and chemical properties of a material.

These electrons determine whether or not the material is chemically active ; metal (or) non-metal or, gas (or) solid.

These Electrons also determine the Electrical properties of a Material.

On the basis of Electrical Conductivity materials are classified into Conductors, Insulators and semiconductors.

One can determine the Electrical conductivity (or) behaviour of a material from the number of valance Electrons as under:

① when the number of valance electrons of an atom is less than "4", (i.e., half of the maximum eight Electrons) the material is usually a metal (or) Conductor.

Examples are: Sodium (11), Magnesium (12), and aluminium (13) which have 1, 2 and 3 valence electrons respectively.

② when the number of valance Electrons of an atom is more than "4" (i.e., > half of the maximum eight Electrons) the material is usually a non-metal (or) an Insulator.

Examples are nitrogen, Sulphar, and neon which have 5, 6 and 8 valance Electrons.

③ when the number of valance Electrons of an atom is "4" (i.e., Exactly one of maximum 8 Electrons), the material has both metal and non-metal properties and is usually a Semi Conductor.

Eg:- Carbon, Silicon and germanium.

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(*) The valance electrons of different materials posses different energies. The greater energy of valance electron is lesser to bond the nucleus. These loosely attached valance electrons move at random with in the material and are called free electrons.

The valance electrons which are very loosely attached to the nucleus are known as the free electrons.

The free electrons can be easily removed (or) detached by applying a small amount of external energy. As a matter of fact that is, these are free electricalons which ~~remove~~ determine the electrical conductivity of a material.

On this basis, conductors, insulators and semiconductors can be defined as under:

1. A conductor is a substance which has large number of electrons. When the potential difference is applied across the conductor, the free electrons move towards the positive terminal of supply, constituting the electric current.

2. An insulator is a substance which has practically no free electrons at ordinary temperature. Therefore, an insulator does not conduct current under the influence of potential difference.

3. A semiconductor is a substance which has very few electrons at room temperature. Consequently, under the influence of a potential difference, a semiconductor practically conducts and constitutes a current.

Semi Conductor

A Semiconductor is a substance which has resistivity in b/w (10⁴ to 0.5 Ωm) conductors and Insulators.

Eg:- germinum, silicon, selenium, carbon etc..)

Semiconductors have a number of peculiar properties which distinguish them from conductors, Insulators, and resistance materials.

Properties of Semiconductors:-

1. The Resistivity of a semiconductor is less than the Insulator but more than a conductor.

2. Semi conductors have negative temperature coefficient of resistance i.e., the Resistance of semi conductor decreases with increases in temperature.

For ex:- Ge is Actually an insulator at low temperature but it becomes a good conductor at high temperature.

3. When a suitable metalic impurity (e.g. arsenic, galium) is added to a semiconductor, its current conducting properties changes appreciably. This property is the most Important.

Bonds in a Semiconductor:-

In semiconductors, bonds are formed by sharing the valence electrons. Such bonds are called the co-valent bonds.

In this formation of co-valent Bond, each atom contributes equal number of valence electrons and the contributed electrons are shared by atoms engaged in the formation of bond.

The following points may be noted regarding the co-valent bond:

(i) Co-valent Bonds are formed by sharing of valence electrons.

(ii) In the formation of co-valent Bond, each valance electron of of atom forms direct bond with valance electron of on adjacent atom.

"For this Reason, valance electrons in a semiconductors are not free."

Commonly used semiconductors are two :-

1. There are many semiconductors available, but very few of them have practical application in electronics. The two most frequently used materials are germanium and silicon.

Reason is the energy required to break their covalent bonds is very small. being 0.7 ev for germanium and 1.ev for silicon.

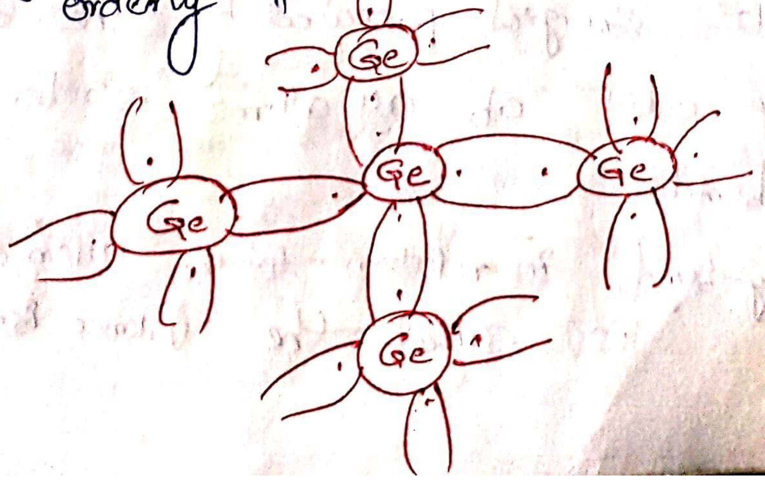
Germanium (Ge) :-

The atomic Number of germanium is 32. Therefore it has 32 protons and 32 electrons.

2 electrons are in the first orbit, eight electrons are in the 3rd orbit and 18 electrons in the outer (or) valance orbit.

It clear that Ge has four valance electrons., It is a Tetra valent atom

Below figure shows how the covalent Bonds are arranged in an orderly pattern.

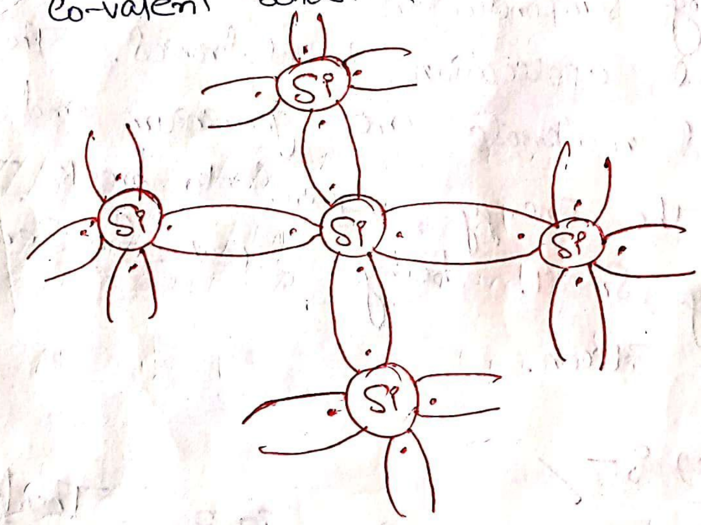


Silicon :- The atomic Number of Silicon is 14. Therefore It has 14 protons and 14 electrons.

Two Electrons in the first orbit, eight Electrons in the second orbit and four Electrons in the 3rd orbit.

It is clear that silicon atom has four valance electrons. And It is a Tetravalent element.

Below figure shows how various silicon atoms are held through Co-valent Bonds.



Energy Band Description :-

1. A Semi Conductor is a Substance whose resistivity is lies in b/w the Conductors and Insulators.
2. The Resistivity is of the order of 10^{4} to 0.5 ohm-m
3. The Semiconductor is defined much more Comprehensively on the basis of Energy bands.
4. The Range of energies possessed by the Electrons of any orbit of all atoms is referred to as the Energy band.
5. The Energy band in relation to the valence Electron is called the valance Band.

Effect of Temperature on Semiconductors:-

The Electrical Conductivity of a semiconductor changes appreciably with Temperature variations.

At absolute zero:- Normal Description:-

At absolute zero Temperature, all the Electrons are tightly held by the semiconductor atoms. The Inner orbit Electrons are bound whereas the valance Electrons are engaged in co-valent bonding. At this Temperature, the co-valent bonds are very strong and there are no free Electrons. Therefore, the semiconductor crystal behaves as a perfect Insulator.

In terms of Energy band Description:-

The valance band is filled and there is a large Energy gap b/w valance Band and Conduction Band. Therefore, no valance Electron can reach the Conduction Band to Become free electron. It is due to the non-availability of free Electrons that a semi-conductor behaves as an insulator.

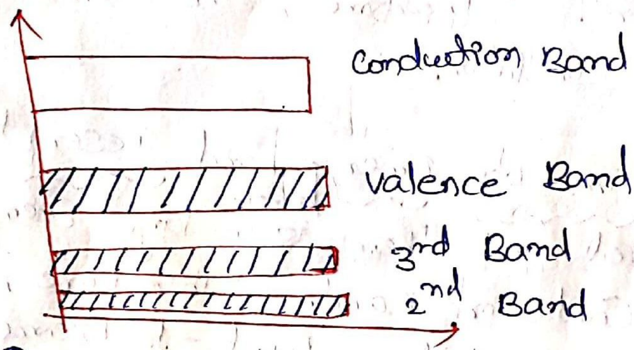
Above absolute zero Temperature:- Normal Description:-

When the Temperature is raised, some of the co-valent Bonds in the semiconductor break due to the Thermal Energy supplied. The Breaking of Bonds set those free electrons which are engaged in formation of these Bonds. The Result is that a few free electrons Exist in semiconductor. These free Electrons can constitute a tiny Electric Current if potential difference is applied across the semiconductor crystal.

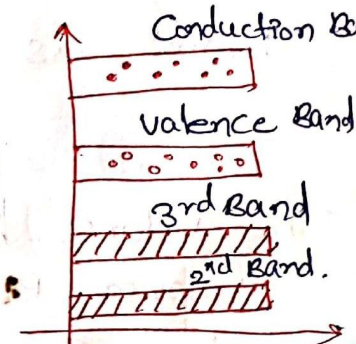
And also this shows that resistance of semiconductor decreases with a rise in Temperature. That means it has a negative Temperature coefficient Resistance.

Interms of Energy band level Description.

As the Temparature is raised, Some of the valance Electrons, acquire sufficient Energy to Enter into the conduction Band and thus become free electrons. Under the influence of electric field, these free Electrons will constitute electric current. It may be noted that Each time a valance electron enters into a Conduction band, a hole is created in the Valence band.



ⓐ At absolute zero Temparature

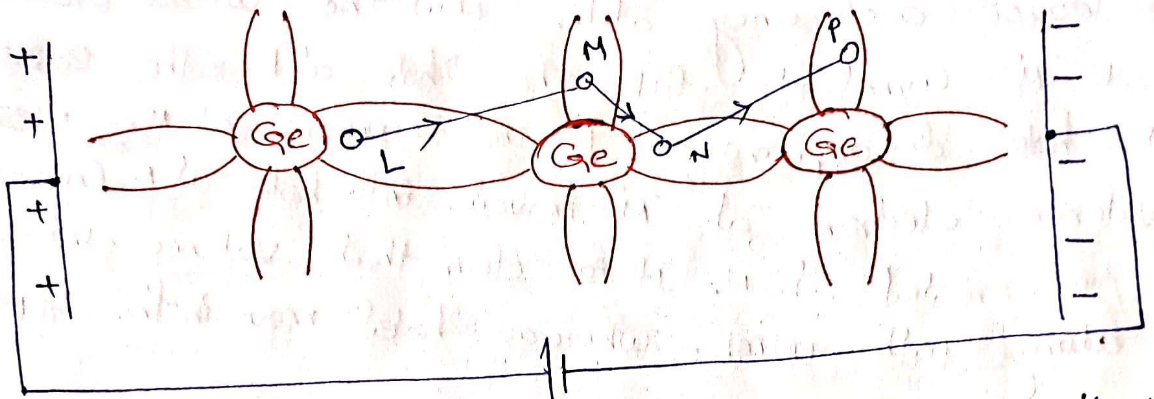


ⓑ At above absolute zero Temp.

Hole Current :-

At Room Temparature, Some of Covalent Bonds in pure Semiconductor break, setting up free electrons. Under the Influence of electric field, these free Electrons Constitute Electric Current. At the Same time another Current - the hole Current also flows in the semiconductor. When a Covalent bond is broken due to Thermal Energy, the Removal of one Electron leaves a vacancy. i.e., missing electron in the Covalent Bond. This missing Electron is called a hole which acts as a positive Charge.

For one electron set free, one hole is created. Therefore



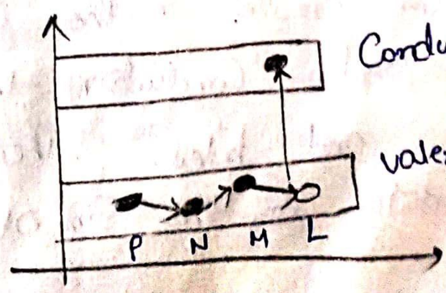
The hole shows a missing electron. Suppose the valence electron at 'L' has become free due to Thermal Energy. This creates a hole in the Covalent Bond at L.

The hole is strong centre of attraction for the electron. A valence electron from near by Co-valent Bond comes to fill in the hole at L. This results in the creation of hole at M. Another valence electron in turn may leave the its bond to fill the hole at M, thus creates a hole at N. Thus hole is having positive charge has moved from L to N. i.e., towards a negative supply. This constitutes a hole current.

"It may be noted that hole current is due to the movement of valence electrons from one covalent Bond to another bond."

Energy Band description:-

The hole current can be beautifully explained in terms of energy bands. Suppose due to Thermal Energy an electron leaves the valence band to enter into the Conduction band.



This leaves a vacancy at L. Now the valence electron at 'M' comes to fill the hole at L. The Result is that hole disappears at 'L' and appears at M. Next, the valence electron at 'N' moves into hole at M. Consequently hole is created at N. It is clear that valence electrons move along path PNML. whereas holes move in the opposite direction path LMNP.

Semiconductors

- Intrinsic Semicond (Extreemely pure form)
- Extrinsic Semiconductors.
  - N-Type Semiconductors
  - P-type Semiconductors

Intrinsic Semiconductors :-

- A Semi Conductor is an extremely pure form is called the Intrinsic Semiconductor.

When electric field is applied across the Intrinsic Semiconductor, the current conduction takes place by two processes, namely, by free electrons and holes.

The free electrons are produced due to the breaking up of valence ~~electrons~~ covalent bonds by thermal energy. At the same time holes are created in the covalent bonds. Under the influence of electric field, conduction through semiconductor is by ~~through~~ electrons and holes. Therefore the total current inside the semi conductor is the sum of currents due to free electrons & holes.

Extrinsic Semiconductor:-

The Intrinsic Semiconductor has little current conduction capability at Room Temperature. To be useful in Electronic devices, the pure Semiconductor must be altered so as to significantly increase its conducting properties. This is achieved by adding a small amount of suitable impurity to a semiconductor. The process of adding impurities to a semiconductor is called as doping.

The amount and Type of such Impurities have to be closely controlled by during the preparation of semiconductor. Generally, for 10^8 atoms of semiconductor, one impurity atom is added.

The purpose of Impurity atom is to increase either the number of free electrons (or) holes in the semiconductor crystal.

1. If a pentavalent atom is impurity is added to the semi conductor, a large number of free electrons are produced in the semiconductor.

2. If a trivalent atom is impurity is added to the semi conductor, creates a large number of holes in the semiconductor crystal.

Depending upon the type of impurity added, extrinsic semi-conductors are classified into

① n-type semiconductor.

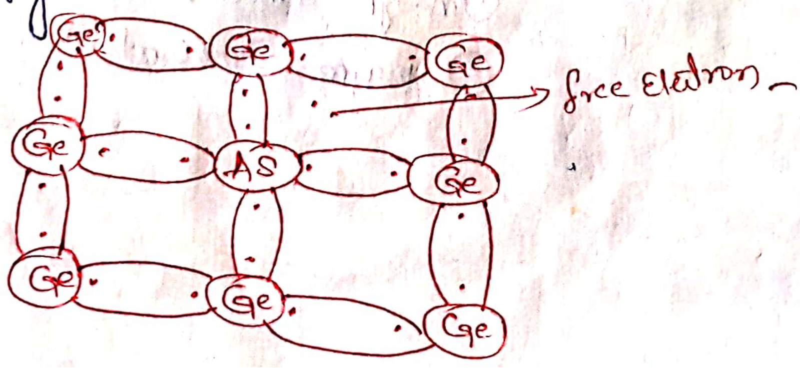
② p-type semiconductor.

N-Type Semiconductors:-

when a small amount of Impurity provides a large number
of a free electrons in the semiconductor crystals. Typical
Examples of pentavalent impurities are arsenic (At. no: 33)
and Antimony (At. No: 51). Such Impurities which provides
produce n-type semiconductor are known as the donar
Impurities, because they donate (or) provide free electrons
to the semiconductor crystal.

Explanation for the formation of n-Type semiconductor :-

Let us consider a pure germanium crystal. "Ge" has four valence
Electrons. when a small amount of pentavalent impurities
like Arsenic is added to a crystal, a Large number of free
Electrons become available in the crystal.
The Reason is Arsenic is a pentavalent i.e., its atom has five
valance electrons. An Arsenic atom fits in the Ge crystal in such a
way that its four valence electrons form ~~crystal~~ covalent
Bonds and is thus fifth valance Electron of arsenic atom
finds no place in co-valent Bonds and thus free.
Therefore Each arsenic Atom is added, one Electron will
be available in the germanium crystal. Though Each
Arsenic atom provides one free Electron, yet an Extremely
small amount of Arsenic Impurity provides enough
atoms to supply millions of free electrons.



Energy band description of n-Type Semiconductor:—

The Addition of a pentavalent Impurity has produced a number of Conduction Band Electrons. i.e., free electrons. The four valance Electrons of pentavalent atom form covalent Bonds with four neighbouring Ge atoms. The fifth left over valance electron of pentavalent atom cannot be accomodated in the valance bond and travels to the conduction Band.

The following points may be noted carefully:

1. Many new free electrons are produced by the addition of pentavalent Impurity.
2. Thermal Energy of room temperature still generates a few hole-electron pairs. However, the Number of free electrons provided by pentavalent Impurities far exceeds the number of free electrons.

P-Type Semiconductor:—

When a Small amount of Trivalent impurity is added to a pure semiconductor, it is called P-Type Semiconductor.

The Addition of Trivalent Impurities provides a large number of "holes" in a Semiconductor. Typical Examples of Trivalent Impurit are galium (GA) (atomic No: 31) and Indium (At. No: 49) Such Impurities which produce p-type Semiconductor are known as the "Aceeptor Impurities" because the holes created can accept the electron.

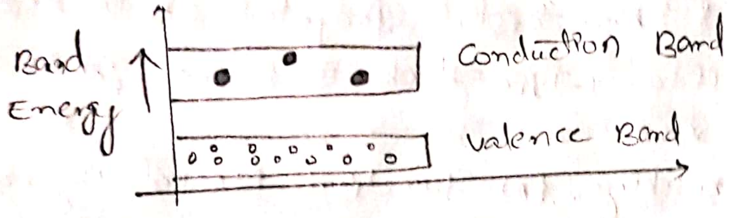
Explanation for the formation of P-Type Semicond

when a Small amount of Trivalent Impurity like a gallium is added to germanium crystal, there exist a large number of holes in the crystal.
The Reason is Gallium is Trivalent i.e., it has 3valence Electrons. Each atom of gallium fits into germanium crystal. But now only three covalent Bonds are formed. It is because three valence Electrons of gallium atom can form only 3 Single covalent bonds with 3 germanium atoms. In the fourth covalent Bond, only germanium atom contributes one valence Electron while gallium has no valence electron to contribute as all its 3 valence electrons are already engaged in the covalent Bonds with neighbouring germanium ~~bonds,~~ atoms. In otherwords, fourth bond is incomplete; being short of one electron. The missing electron is called a hole.
∴ "Therefore, for each gallium atom is added, one hole is created. A Small amount of gallium provides millions of holes."//

Energy band description of the P-Type Semicond

The ~~Addition~~ of Trivalent Impurity is added ~~to~~ it produce a Large number of holes. However, there are a few Conduction Band Electrons due to thermal Energy associated with Room Temperature. But the holes far out Number the Conduction band electrons.
It is due to the predominance of holes over free $\bar{e}$s, that it is called P-Type Semiconductor.

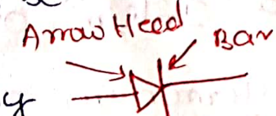
Energy band diagram :- (P-Type Semiconductor)



-: Semiconductor Diode :-
(Or)
PN-Junction Diode :-

Introduction :-

1. A PN Junction is known as a semiconductor (or) crystal diode. The outstanding property of a crystal diode to conduct current in one direction only permits it to be used as a rectifier.

2. A crystal diode is usually represented by 

The Arrow in the symbol indicates a direction of easier conventional current flow. A crystal diode has two terminals. when it is connected in a circuit, one thing to decide is whether the diode is forward biased (or) Reverse Biased.

3. If the external circuit is trying to push the conventional current in the direction of arrow, the diode is forward biased. On the other hand, if the conventional current is trying to flow opposite the arrowhead, the Arrow head is Reverse Biased.

PN-Junction :-

when a P-Type semiconductor is suitably joined to n-Type semiconductor, the contact surface is called pn Junction. Most of the semiconductor devices contain one or more PN Junctions. The PN-Junction is of a great importance because it is in effect the control element for semiconductor devices.

Formation of PN Junction :-

In actual practice, that characteristic properties of PN Junction will not be apparent if a P-Type block is just brought in contact with n-Type block.

* One common method of making PN Junction is called alloying. In this method, a small Block of Indium (Trivalent Impurity) is added to (or) placed on the n-Type germanium slab.
* The system is then heated to a Temparature of 500°c. The Indium and some of the germanium melt to form a small puddle of molten germanium - Indium mixture. The Temparature is then lowered and puddle begins to solidify. under proper conditions, the atoms of Indium impurity will be suitably adjusted in the germanium slab to form a single crystal. The addition of a Indium overcomes the excess of Electrons in the n-Type germanium to such an extent that it creates a P-Type Region. As the process goes on, the Remaining mixture will becomes Increasingly rich in ~~Condition.~~ Indium.

Properties of PN Junction :-

PN Junction Diode has two types of materials one is P-Type and another one is N-Type. P Type semiconductor having negative acceptor ions and positively charged holes. The Right side material is N-type semiconductor having positive donor ions and free Electrons.

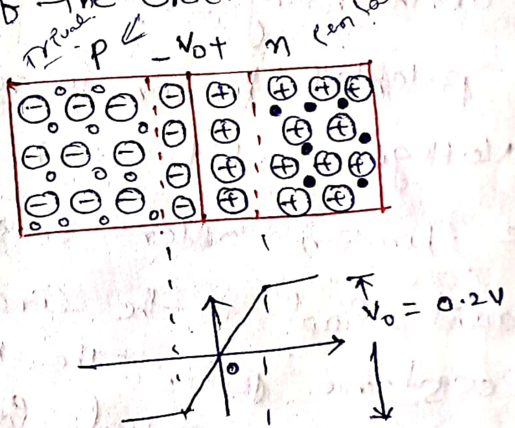
Now, suppose the two pieces are suitably treated form P-N Junction. n-type material has a high concentration of free electrons while P-Type material has a high concentration of holes. Therefore, at the junction, there is a Tendency for the free Es to diffuse over to the P-side holes to n-side.

This process is called the diffusion. As the free Electrons move across the junction from n-Type to P-Type, positive donor Ions are uncovered i.e., They are robed of free elect-

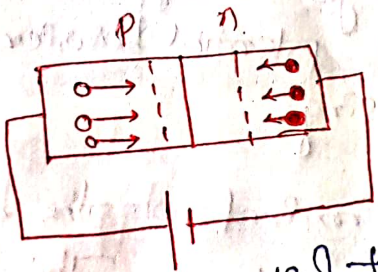
Hence a positive charge is built on the n-side of the junction. At the same time, the free electrons cross the junction and uncover the negative acceptor ions by filling in the holes. Therefore a net negative charge is established on the p-side of the junction. When the sufficient number of donor and acceptor ions is uncovered, further diffusion is prevented.

It is because now positive charge n-side repels holes to cross from p-type to n-type and negative charge on p-side repels free electrons to enter from n-type to p-type. Thus a barrier setup against further movement of charge carriers i.e., holes and electrons. This is called potential barrier (or) junction barrier V_0.

The potential barrier is of the order of 0.1 to 0.3 volts.



Forward Biasing:-



When external voltage is applied to junction is in such a direction that it cancels the potential barrier, thus permitting the current flow in it is called the forward biasing.

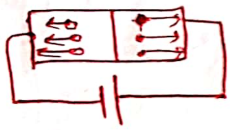
To apply forward bias, connect positive terminal of the battery to the p-type and negative terminal to n-type.

The applied Forward potential establishes an Electric field which acts against the field due to potential barrier. Therefore resultant field is weakened and the barrier height is Reduced at the junction. As the potential barrier voltage is very small (0.1 to 0.3 V), therefore a small voltage is sufficient to completely eliminate the barrier.

Once the barrier voltage is eliminated by forward voltage, junction Resistance becomes almost zero and a low Resistance path is established for the Entire circuit. Therefore current flows in the circuit. This is called forward current.

with Forward bias to pn Junction, the following points are worth noting:-

1. The potential barrier is reduced and at some forward voltage (0.1 to 0.3 V) it is eliminated together.
2. The junction offer resistance to current flow.
3. Current flows in the circuit due to establishment of low Resistance path. The magnitude of current depends upon the applied forward voltage.



Reverse biasing:-

when a External voltage is applied to the junction is in such a direction that potential barrier is increased, it is called reverse biasing.

we connect negative Terminal of the battery to p-type and positive terminal to n-type. The applied Reverse voltage establishes an Electric field which acts in same direction as the field due to potential barrier.

The applied Reverse voltage establishes an electric field. Therefore, the resultant field at the junction is strengthened and the barrier height is increased.

The Increased barrier potential prevents the flow of charge carriers across the junction. Thus a high resistance path is established for the entire circuit and hence the current does not flow. With Reverse bias to pn junction, the following points are worth noting:—

1. The potential barrier is increased
2. The junction offers very high Resistance (called R_r) to current flow.
3. No current flows in the circuit due to establishment of high resistance path.

Current Flow in a Forward Biased pn Junction :—

Under the influence of forward voltage, the free electrons in n-Type move towards the junction, leaving behind positively charged atoms. However, more electrons arrive from negative battery Terminal and enter the n-region to takeup their places.
As the free electrons reach the junction, they become valance electrons. As valance electrons, they move through the holes in the p-region. The valance electrons move towards left in the p-region which is equivalent to the holes moving to right. When the valence electrons reach left end of crystal, they flow into a positive Terminal of the battery.

The machanism of current flow in a forward Biased pn junction can be summed as under:—

① The free electrons from the negative Terminal of continue to pour into n-region while the ~~free~~ free electrons in the n-region move towards the junction.

② The electrons Travel through the n-region as free-electrons. i.e., current in n-region is by free-electrons.

③. When these Electrons reach Junction, they combine with the holes and become valance Electrons.

④. The Electrons Travel through P-region as valence Electron i.e., current in the P-region by holes.

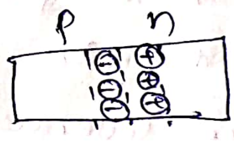
⑤. When these valance Electrons reach left end of crystal, they flow into the positive terminal of battery.

V&I characteristics of a PN Junction :-

Volt-ampere (or) V-I characteristic of a PN junction is the curve between the voltage across the junction and current flows through it.

Usually voltage is taken across x-axis and current is taken across the y-axis.

Normally the characteristics can be studied in a 3 Regions. namely zero external voltage, Forward Bias voltage, Reverse Bias voltage.



(i) Zero External Voltage :-

When the External voltage is zero, the potential barrier across junction does not permit to current flow. Hence the current in the circuit is zero.

(ii) Forward Voltage :-

With Forward Bias to PN Junction i.e., P-type is connected to the positive Terminal of Battery and ne-type is connected to negative Terminal of Battery, the potential Barrier is reduced.

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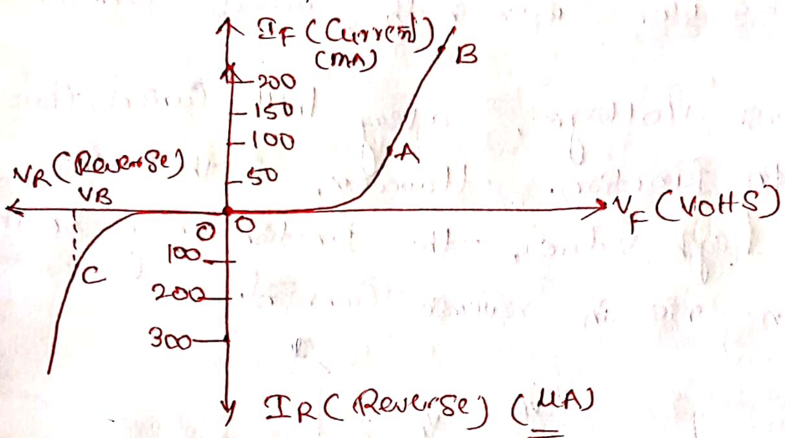
At some point the potential ~~point is~~ barrier is eliminated. From now onwards current starts flowing in the circuit and the current increases with the forward voltage.



A rising curve "OB" is obtained with the help of forward bias. From the forward characteristic curve, it is seen that at first, the current increases very slowly and the curve is non-linear. It is because the external voltage is used up overcoming the potential barrier. However once the ~~potential barrier~~ external voltage exceeds the potential barrier voltage, the PN junction behaves like an ordinary current carrying conductor. Therefore the current rises very sharply from A to B.

(b) Reverse Bias :-

For the PN junction with reverse bias, P-type is connected to negative terminal of battery, N-type is connected to positive terminal of the battery, potential barrier is increased. Therefore junction resistance is becomes high and no current flows in the circuit. In practice very small amount of reverse saturation current flows into the circuit. We generally use we reverse saturation current for a maximum level of current.

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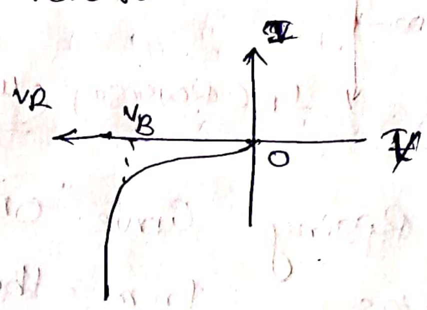
(2) Breakdown Voltage :-

It is the Reverse Voltage at which pn Junction Breaks down the Sudden Rise in the Reverse Current.

Under normal reverse voltage, a very little current flows through the pn junction. However, if the Reverse voltage attains a high value, the junction may break down with sudden rise in reverse current.



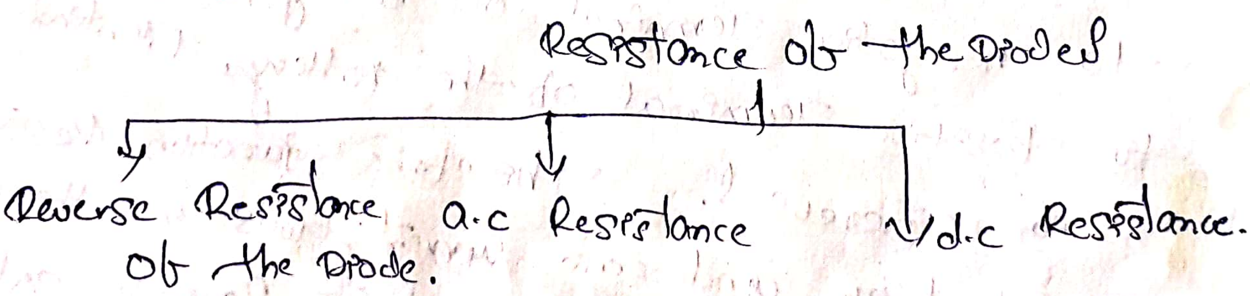
Knee Voltage :-

It is the Forward Voltage at which the current through the junction starts to increases rapidly.

When a diode is forward Biased, it conducts current very slowly until we overcome the potential barrier. For silicon pn junction, the potential barrier is 0.7V. whereas it is 0.3V for germanium junction.

Once the applied Forward Voltage exceeds the knee voltage, the current starts increasing rapidly.

Resistance of the Diode :-



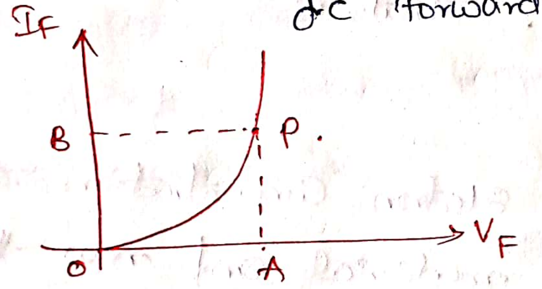
ⓐ Forward Resistance:-

The Resistance offered by the diode to the forward bias is known as the forward resistance. The Resistance as for the is not the same for flow of direct current as for changing current.

ⓘ d.c Forward Resistance:-

This is the Resistance offered by diode to the direct current. It is measured by the ratio of d.c voltage across the diode to resulting d.c current through it.

d.c Forward Resistance, $R_f = \frac{OA}{OB}$



(ii) a.c Forward Resistance:-

It is the opposition offered the resistance in forward bias. It is measured by ratio of change in the voltage across the diode to resulting a.c current through it.

∴ A.C forward Resistance, $= \frac{\text{Change in Voltage across}}{\text{Corresponding change}}$

Mass Action Law:-

When pentavalent impurities are added to an intrinsic semiconductor material, the semiconductor is to be referred as the n-type material, electron concentration is much larger than the hole concentration.

That is $n >> p$

and similarly in a p-type semiconductor material, when trivalent impurity is added to the intrinsic semiconductor, the hole concentration is much larger than the electron concentration. That is

$$p >> n$$

Then clearly the hole and electron concentration are altered in extrinsic material and now they are governed by "Mass Action Law" which states that

$$\boxed{n \cdot p = n_i^2}$$

The product of electron concentration and hole concentration in any type of semiconductor is equal to the square of the intrinsic concentration of the material.

Note:-

The intrinsic concentration depends on the temperature, and as the temperature increases, intrinsic concentration of the material increases.

Currents in the Semiconductor material:-

1. Drift Current

2. Diffusion Current

The flow of charge i.e., Current, through the Semiconductor material are two types. namely Drift and Diffusion Current.

Note:- The net Current flow through a PN Junction diode also has two Currents (i) Drift Current (ii) Diffusion Current.

Drift Current:-

when an electric field is applied across the semiconductor material, the charge carriers attains the some certain drift velocity V_d.

$\boxed{\frac{V_d}{E} = \mu_e}$

which is equal to the product of mobility of the charge carriers and applied electric field E. The holes move towards the -ve Terminal of the battery and Electrons move towards the +ve Terminal. This Combined Effect of movement of the charge carriers constitutes a Current known as the drift Current.

Thus the drift Current is defined the flow of Electrons (or) holes (charge carries) under the Influence of Electric field.

Drift Current Density:-

The Drift Current Density due to the charge carriers such as free Electrons and holes are passing through a square centimeter and direction is perpendicular to the Current flow.

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The Equation for the drift Current Density 'J' due to the Electrons and holes is given by the

$J_n = n \mu_n E \ (A/m^2)$ — due to Electrons

$J_p = p \mu_p E \ (A/m^2)$ — due to holes.

Here: μ_n = mobility of Electrons

μ_p = mobility of holes

n = Concentration of Electrons

p = Concentration of holes

E = Applied External Electric field.

Diffusion Current:-

It is possible for an Electric Current to flow in Semi-Conductor material ~~with~~ Even in the absence of the External Electric field, Provided a concentration gradient exist in a material.

A Concentration gradient Exist if the number of holes (or) Electrons are greater in one region of Semi Conductor as Compared with the other region.

In a Semiconductor material, the Charge Carriers have the Tendency to move from one place to another place. Thus movement of Charge Carriers takes place resulting in a Current called diffusion Current.

The diffusion Current depends upon the material Semi Conductor type, type of charge Carriers, and concentration gradient.

Hear $I_p = -qA D_p \frac{dp}{dx}$ → Current due to holes

$I_n = qA D_n \frac{dn}{dx}$ → Current due to electrons

D_n, D_p = Diffusion constants of p-Type and N-Type.

q = Charge Associated with carrier.

Hall Effect:-

If a material (or) Semiconductor is carrying a Current 'I' is placed in a magnetic field 'B', an Electric field is Induced 'E' in the direction perpendicular to Both the I & B. This phenomenon is known as the Hall Effect.

It is used to determine whether the Semiconductor is n-Type Semiconductor (or) p-Type Semiconductor.

→ Now let us consider. Current is in the +x direction and 'B' is +ve 'z' direction. So a Force will be Exerted in the -ve 'y' direction. If the Semiconductor is n-type, so that Current is carried by Electrons, the Electrons will be forced down wards towards the side 1.

So side '1' becomes the -vely charged with respect to the side '2'. Then particular Semiconductor is said to be the n-type Semiconductor, otherwise it is said to be a p-Type Semi Conductor.

And hear we can say that side -1 becomes -vely charged with respect to the side 2. Hence a potential V_H appears b/w the surface 1 & 2. called a Hall voltage

In the equilibrium condition, the force due to Electric field intensity 'E' is just balanced by the magnetic field intensity 'H'.

$$\cancel{eE} = \cancel{Bev} \quad \text{——} (1)$$

$$\Rightarrow \boxed{E = Bv} \quad \text{——} (2)$$

And, The Electric field $\boxed{E = \frac{V_H}{d}}$ —— (3).

from this $V_H = Ed$

But $J = \rho v$ —— (4)

& $J = \frac{I}{wd}$ —— (5).

$$\Rightarrow V_H = E \cdot d$$

$$V_H = B \cdot v \cdot d$$

$$= B \cdot \frac{J}{\rho} \cdot d$$

$$\boxed{V_H = B \cdot \frac{I}{w\cancel{d} \cdot \rho} \cdot \cancel{d}} \quad \text{——} (1)$$

Hall voltage is $\Rightarrow$ $\boxed{V_H = \frac{B \cdot I}{w \rho}}$ —— (7)

$\rho = n \times e$ ⟶ for n-type semiconductor.

$\rho = p \times e$ ⟶ for p-type semiconductor.

$$\Rightarrow \boxed{V_H = \frac{B \cdot I}{w \cdot n e}} \qquad \boxed{V_H = \frac{B \cdot I}{w \cdot p e}}$$

from equation (7):

$$\rho = \frac{B \cdot I}{w V_H}.$$

From this, ~~R~~ Hall coefficient is given by the

$$\Rightarrow R_H = \frac{1}{\rho} = \frac{w V_H}{BI} \quad m^3/\text{coulomb}.$$

// If the conductivity is due to majority charge carriers, in n-type semiconductors.

Conductivity, $\sigma = ne\mu$

$$\Rightarrow ne = \rho$$

$$\Rightarrow \sigma = \rho\mu$$

But $\frac{1}{\rho} = R_H$

$$\Rightarrow \sigma = \frac{\mu}{R_H} \Rightarrow \boxed{\mu = \sigma . R_H}$$

$$\boxed{\therefore \mu = \sigma . \frac{w V_H}{B I}}$$

$$\Rightarrow \frac{\mu}{\sigma} = \frac{w V_H}{BI}$$

$$\boxed{R_H = \frac{w V_H}{BI}}$$

From this mobility of carriers can be determined experimentally by using the Hall effect.

Mobility: Average of drift velocity per unit Electric field is called the mobility.

μ_n, μ_p, mobility of Electrons, Holes.

$R = \frac{dV}{dI}$

$\frac{dV}{dI} = ?$ $\quad \frac{dI}{dV} = \frac{d}{dV} I_0 \left[e^{\frac{KV_D}{T_K}} - 1\right]$

$= I_0 \cdot \frac{K}{T_K} \cdot \left[e^{\frac{KV_D}{T_K}} - 1\right]$

$R = \frac{1 \cdot T_K}{I_0 \cdot K \left[e^{\frac{KV_D}{T_K}}\right] + I_0}$

$= \frac{T_K}{(I_0 + I) K} = \frac{T_K}{(I + I_0)\left(\frac{11,600}{n}\right)}$

$V_T = \frac{T}{11,600}$

$K = \frac{11,600}{n}$

$$\boxed{R = \frac{n \cdot V_T}{I + I_0}}$$

piece-wise linear approximation

pieace -wise linear

piece-wise -linear approximation

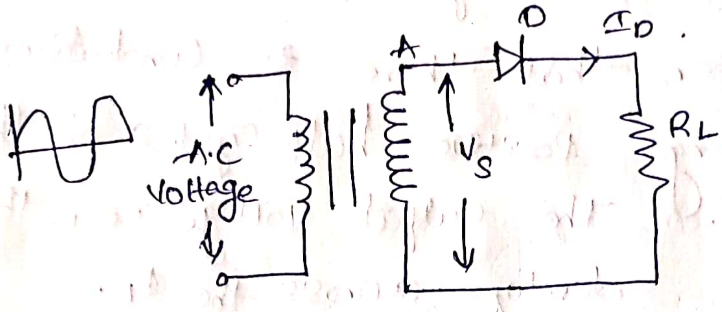
$I = I_0 \left[e^{\frac{KV_D}{T_K}} - 1\right]$ — (1)

$T_K =$ $\quad K = \frac{11,600}{n}$

$\rightarrow I = I_0 \left[e^{\frac{V_D}{n V_T}} - 1\right]$ — (2) $\quad n = 1;$ $\quad V_T = \frac{T}{11,600}$

Half wave Rectifier :-

The Circuit setup is shown in figure:



Here
V_S = Secondary voltage
D = Diode
R_L = Load Resistance.

Connections :-

1. Circuit is divided into Two parts
   1. Transformer Part.
   2. Rectification Part.
2. Rectification part consists of Diode 'D' and load Resistor 'R_L' Both are connected in series.
3. A.C Voltage is Transformed and Secondary voltage is applied Input Terminals of Diode and load R_L
4.

Observations :-

1. During the +ve half cycle of Input Signal, End 'A' is +ve and is applied Input Terminals of Diode 'D' and load Resistor 'R_L'.
2. The Diode 'D' is forward Biased and hence it conducts. A current flows through Load R_L.
3. During the -ve half cycle of the emf V_S, End A becomes negative, and the diode D gets Reverse B[iased]
4. It doesnot conduct, and hence there is no output current through the R_L.

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5. The diode conducts again during the subsequent positive half cycle and there is a flow of current through R_L.

6. Thus it is seen that there is conduction only during positive half cycles of the applied E.m.f. The output voltage i.e., the voltage which develop across the R_L.

7. From this, it is clear that all the negative half cycles of the input voltage are suppressed.

Note:-

The Rectified output i.e., current I_L is unidirectional, but it is not pure d.c., nor is continuous. It is termed as pulsating D.C.

Rectification Efficiency :-

The Rectification Efficiency of a Rectifier is defined as the Ratio of d.c output power to a.c input power.

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

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

(a) as $i = i_m \sin\theta$

$$i_{av} = \frac{1}{2\pi}\int_0^{\pi} i . d\theta$$

$$= \frac{1}{2\pi}\int_0^{\pi} (i_m \sin\theta \, d\theta) \cancel{d\theta}$$

$$= \frac{1}{2\pi} . i_m \left[-\cos\theta\right]_0^{\pi}$$

$$= \frac{i_m}{2\pi}\left[-\cos\pi + \cos 0\right] = \frac{2 . i_m}{2\pi}$$

$$\boxed{\therefore \; i_{av} = \frac{i_m}{\pi}}$$

(b). Rms value $I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} i^2 d\theta}$

$$= \sqrt{\frac{1}{2\pi}\int_0^{\pi} (i_m \sin\theta)^2 d\theta}$$

$$= \sqrt{\frac{1}{2\pi} . i_m^2 . \int_0^{\pi} \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{i_m^2}{2\pi} . \int_0^{\pi} \left(\frac{1-\cos 2\theta}{2}\right) d\theta}$$

$$= \sqrt{\frac{i_m^2}{2\pi} \int_0^{\pi} \left(\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right)}$$

$$= \sqrt{\frac{i_m^2}{2\pi}\left[\frac{\pi}{2} - 0 - 0\, 0\right]}$$

$$= \sqrt{\frac{i_m^2}{4}} = \frac{i_m}{2}.$$

$$\boxed{\therefore \; I_{rms} = \frac{I_m}{2}.}$$

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(c) the secondary induced emf can be expressed as the

$$V_S = V_m \sin\theta$$

Hear

V_m = Peak value.

$I_{rms} = \frac{I_m}{2}$ lly $V_{rms} = \frac{V_m}{2}$

$I_m = ?$

$$-V_m + I_m R_f + I_m R_L + I_m R_S = 0.$$

$$V_m = I_m (R_f + R_L + R_S)$$

$$\Rightarrow I_m = \frac{V_m}{R_F + R_L + R_S} \quad \underline{4}$$

$$\therefore \boxed{I_{rms} = \frac{V_m}{2(R_L + R_F + R_S)} \text{ amp.}}$$

$I_{rms} = \frac{I_m}{2}$; $I_{dc} = \frac{I_m}{\pi}$

→ R.m.s or Effective value of Transformer Secondary Current.

It is denoted by I_{rms}.

$V_{rms} = \frac{V_m}{2}$ But not $V_{dc} = ?$

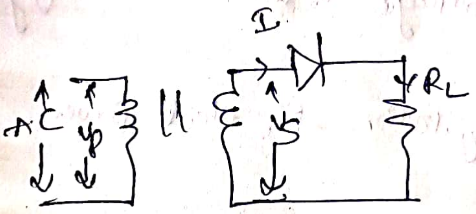
Because V_{rms} is Purely depends upon the Peak value.

But V_{dc} is average value.

For Ideal Power Supply $V_{dc} = \frac{V_m}{\pi}$

But for Real Time = ?

$V_{dc} = I_{dc} \times R_L$.



$\rightarrow I_{dc} = \frac{I_m}{\pi}$ Now $I_m = ?$

$\rightarrow -V_s + I_m R_p + I_m R_L + I_m R_s = 0$.

$I_m = \frac{V_s}{R_p + R_s + R_L}$

$\therefore V_{dc} = \frac{V_m}{\pi} - V_{dc}\, I_{dc}(R_p + R_s)$.

$I_{dc} = \frac{(V_s)}{(\pi)\,(R_p + R_s + R_L)}$

$= \frac{V_m}{\pi(R_p + R_s + R_L)}$

$$\boxed{\therefore V_{dc} = \frac{V_m}{\pi} - I_{dc}(R_p + R_s)}$$

$V_{dc} = \frac{V_m}{\pi(R_p + R_s + R_L)} \times R_L$.

$\Rightarrow V_{dc} = \frac{V_m(R_L + R_p + R_s - R_p - R_s)}{\pi(R_p + R_s + R_L)}$

$= \frac{V_m}{\pi} - \frac{V_m(R_p + R_s)}{\pi(R_p + R_s + R_L)}$

The above expression indicates that V_{DC} is $\frac{V_m}{\pi}$ at no load current is zero (or) No load.

And the value is decreases with increase in the I_{DC}.

Notes:

~~If we plot the graph~~

If we graph is plotted b/w the V_{DC} & I_{DC} the slope of the curve gives $(R_f + R_s)$.

Here R_f = Forward Resistance.

R_s = Secondary Resistance.

% Regulation:

Regulation indicates the how d.c voltage is varies accordingly d.c current.

In general, the percentage of regulation for ideal power supply is zero.

$$\% \text{ Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%.$$

$$V_{NL} = \frac{V_m}{\pi}; \quad V_{FL} = V_{dc} = \frac{V_m}{\pi} - I_{dc} R_f$$

$$\Rightarrow \% \text{ Reg} = \frac{\frac{V_m}{\pi} - \left(\frac{V_m}{\pi} - I_{dc} R_f\right)}{\left(\frac{V_m}{\pi} - I_{dc} R_f\right)}$$

$$= \frac{I_{dc} R_f}{\frac{V_m}{\pi} - I_{dc} R_f} \times 100\%.$$

$$= \frac{1}{\frac{V_m}{\pi \cdot I_{dc} \cdot R_f} - 1} \times 100\%.$$

$$\% \text{ Regulation} = \frac{1}{\frac{V_m}{\pi} \cdot \frac{\pi \cdot (R_L + R_f + R_s)}{V_m (R_f + R_s)}} - 1$$

$$\boxed{\% \text{ Regulation} = \frac{R_f + R_s}{R_L} \times 100\%}$$

for Example:-

For a given Circuit, the Rectifier Specifications are 15V and 100mA.

i.e., $V_m = 15V$; $V_{NL} = 15$ volts ; $R_f + R_s = 20\Omega$

$I_{dc} = 100mA \rightarrow$ ~~no~~ load Current Current

$$\% \text{ Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100.$$

$$= \frac{15 - V_{FL}}{V_{FL}} \times 100$$

$$V_{FL} = \frac{V_m}{\pi} - I_{dc}(R_f)$$

$$= 15 - \frac{V_m}{\pi(R_f + R_s + R_L)} \cdot R_f$$

$$= 15 - (100m)(20)$$

$$= 15 - 2 = 13 \text{ Volts.}$$

$$\% \text{ Regulation} = \frac{15 - 13}{13} \times 100\%.$$

$$= \frac{2}{13} \times 100\% = 15.38\%$$

Ripple factor:- Ripple factor (γ) may be defined as the ratio of the root mean square value of (ripple) voltage to the absolute value of the DC component output voltage.

→ It is a measure of fluctuating components present in the d-c signal.

$$\gamma = \frac{\text{RMS value of a.c ripples present in o/p}}{\text{d-c value of the wave form.}}$$

$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} \qquad \gamma = \frac{I'_{rms}}{I_{dc}} = \frac{V'_{rms}}{V_{dc}}$$

$\frac{10}{100} \times 100\%$

10 %.

I'_{rms} = Root mean square value
(or)
Effective value of ripples present in the o/p waveform.
(or)
Instantaneous current value.

$$\Rightarrow \quad I'_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2 \, d\theta}$$

But $i = i_{ac} = I - I_{dc}$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (I - I_{dc})^2 \, d\theta}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (I^2 + I_{dc}^2 - 2I_{dc} \cdot I) \, d\theta.}$$

$$= \sqrt{\frac{1}{2\pi}\left(\int_0^{2\pi} I^2 \, d\theta + \int_0^{2\pi} I_{dc}^2 \, d\theta - 2\int_0^{2\pi} I \cdot I_{dc} \, d\theta\right)}$$

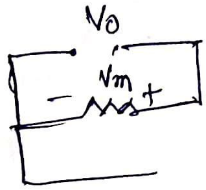
$$= \sqrt{\frac{1}{2\pi}\left(\int_0^{2\pi} I^2 \, d\theta\right) + \frac{I_{dc}^2 (\cancel{2\pi})}{\cancel{2\pi}} - 2I_{dc}^2}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} I^2 \, d\theta - I_{dc}^2}$$

$$I'_{rms} = \sqrt{(I_{rms})^2 - I_{dc}^2}$$

$$\therefore \gamma = \frac{I'_{rms}}{I_{dc}} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

$$\therefore \gamma = \sqrt{\left(\frac{\frac{I_m}{2}}{\frac{I_m}{\pi}}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1}$$



$$= \sqrt{\left(\frac{3.14}{2}\right)^2 - 1} = \underline{1.21 > 1}$$

→ Ratio of Rectification factor:

$$\text{Ratio of Rectification} = \frac{\text{D.C power delivered to the load}}{\text{A.C input power from transformer secondary}}$$

$$= \frac{P_{dc}}{P_{ac}}$$

$$= \frac{I_{dc}^2 \cdot R_L}{I_{ac}^2 (R_L + R_f + R_s)}$$

$$= \frac{\left(\frac{I_m}{\pi}\right)^2 \cdot R_L}{\left(\frac{I_m}{2}\right)^2 (R_L + R_f + R_s)}$$

$$= \frac{4}{\pi^2} \cdot \frac{R_L}{R_f + R_s + R_L}$$

$$= \frac{4}{\pi^2} \quad [\because R_L >> R_f + R_s]$$

$$= 0.406$$

$$\% \eta = 0.406 \times 100\% = \underline{40.6\%}$$

The AC Input power is not converted to D.C.

Only part of it is converted to D.C. and is dissipated in the load.

The balance of power is also dissipated in the load it self as A.C power.

Transformer utilization Factor:-

Transformer utilization factor (TUF) = $\frac{P_{dc}}{P_{ac} \text{ rated of Transfo Secondary}}$

$$TUF = \frac{I_{dc}^2 \cdot R_L}{V_{rms} \times I_{rms}}$$

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

$$= \frac{2\sqrt{2}}{\pi^2}$$

Transformer utilization factor (TUF) $= 0.287$

High disadvantages:-

1. Ripple factor High (1.21)
2. low Ratio of Rectification (0.406)
3. low TUF (0.287)
4. D-C Saturatuation of transformer.

Full wave:-

$$TUF = \frac{\left(\frac{2I_m}{\pi}\right)^2 \cancel{R_L}}{\frac{I_m \cancel{R_L}}{\sqrt{2}}\left(\frac{I_m}{\sqrt{2}}\right)} = \frac{\left(\frac{2I_m}{\pi}\right)^2}{\frac{I_m^2}{2}} = \frac{8}{\pi^2}$$

Iav

Irms

Vav.

Vrms.

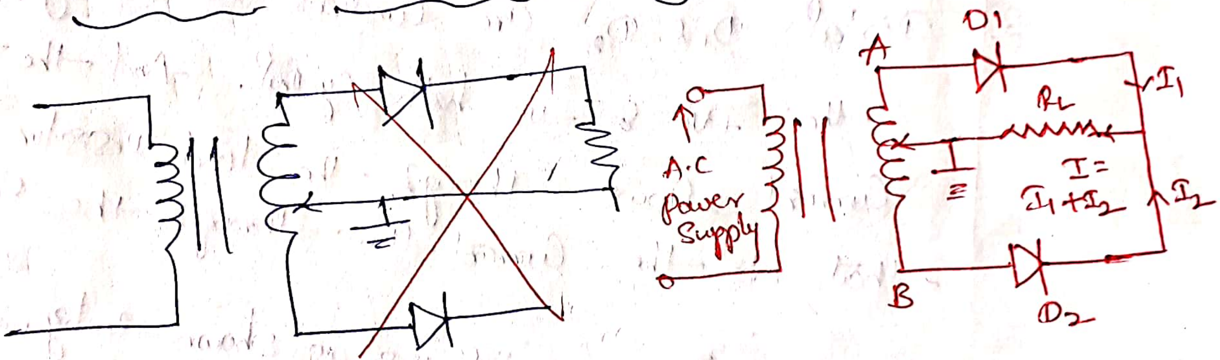
Full wave Rectifier :-

1. Full Rectification can be achieved by using Two (or) 4 diodes.

2. If only 2 diodes are used a centre-Tap Transformer is needed.

2. If 4 diodes are used, they are arranged in a bridge manner. This set-up does not require centre-tap transformer.

(i) Full wave Rectification using Two diodes :-



(a) Circuit Details

1. D_1 & D_2 are incorporated in the secondary circuit of T/F such that, when each diode conducts it comes in series with the load Resistor R_L and one half of Transformer secondary winding.

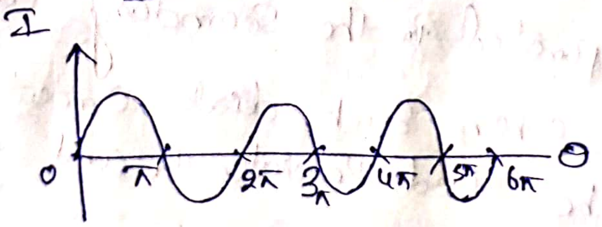
(b) Circuit operation :-

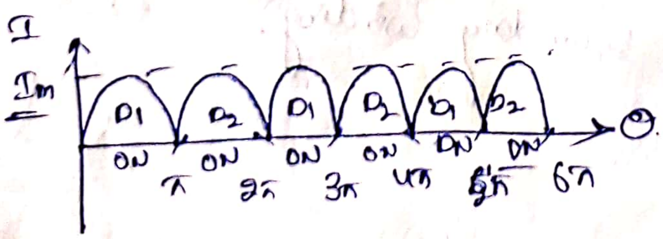
1. During the +ve half of the signal transformer secondary winding is +ve (Terminal -A) and the Diode D_1 Conducts. The Current is flows through the Load Resistor. R_L.

2. During the -ve half cycle the transformer secondary winding another terminal 'B' will be +ve and the Diode D_2 conducts. Then the current is flows through the load Resistor R_L.

3. Diodes D_1 & D_2 are Conducts alternately during the +ve & -ve half cycles. And the total current flows through the load Resistor is twice that of the Current flows through the ~~Resistor~~.

4. Corresponding waveforms as shown in figure.





Parameters :—

$I_L = I_m \sin\theta \quad 0 \le \theta \le \pi$

$= I_m \sin\theta \quad \pi \le \theta \le 2\pi$

(1). $I_{av} = ?$

$$I_{av} = \frac{\text{Area of the Curve}}{\text{Base value of Curve}}$$

$$= \frac{1}{\pi} \int_0^{\pi} I_L \, d\theta$$

$$= \frac{1}{\pi} \int_0^{\pi} I_m \sin\theta \, d\theta$$

$$= \frac{1}{\pi} \cdot I_m \cdot \left[-\cos\theta\right]_0^{\pi} = \frac{I_m}{\pi} \cdot \left[-\cos\pi + \cos 0\right]$$

$$\boxed{I_{av} = \frac{2I_m}{\pi} \text{ amp}}$$

(2). $I_{rms} = ?$ ~~Area of the~~

$$I_{rms} = \frac{\sqrt{i_1^2 + i_2^2 + i_3^2 + \cdots + n}}{\sqrt{n}} = \sqrt{\frac{1}{2\pi} \int_0^{2\pi} i \, d\theta}.$$

Here

$$I_{rms} = \sqrt{\frac{1}{\pi} \int_0^{\pi} i_L^2 \, d\theta}$$

$$= \sqrt{\frac{1}{\pi} \int_0^{\pi} I_m^2 \sin^2\theta \, d\theta} = \sqrt{\cancel{\frac{1}{\pi} \cdot I_m^2 (-\cos\theta)_0^{\pi}}}$$

$$= \sqrt{\cancel{\frac{1}{\pi} I_m (2)}} = \sqrt{\frac{1}{\pi} \int_0^{\pi} I_m^2 \left(\frac{1-\cos 2\theta}{2}\right) d\theta}$$

$$= \sqrt{\frac{I_m^2}{\pi} \int_0^{\pi} \left(\frac{1-\cos 2\theta}{2}\right) d\theta} = \sqrt{\frac{I_m^2}{\pi} \left(\frac{\theta}{2} + \frac{\sin 2\theta}{4}\right)}$$

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

$$\therefore \boxed{I_{rms} = \frac{I_m}{\sqrt{2}} \text{ amp}}$$

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(iii) $V_{rms} = ?$

V_{rms} = It is depends upon the peak value of A C Components

$$\therefore V_{rms} = \frac{V_m}{\sqrt{2}} \text{ Volts}$$

(iv) $V_{av} = V_{dc} = ?$

$$V_{av} = I_{dc} R_L$$

$$= \frac{2I_m}{\pi} \cdot R_L$$

$$= \frac{2}{\pi} \cdot \frac{V_m}{R_f + R_s + R_L} \cdot R_L$$

$$= \frac{2}{\pi} \cdot V_m \cdot \frac{(R_L + R_f + R_s - R_f - R_s)}{R_f + R_s + R_L}$$

$$= \frac{2V_m}{\pi} \cdot \left(1 - \frac{R_f + R_s}{R_L + R_f + R_s}\right)$$

$$= \frac{2V_m}{\pi} - \frac{2V_m}{\pi} \cdot \frac{R_f + R_s}{R_L + R_f + R_s}$$

$$\boxed{\therefore V_{av} = \frac{2V_m}{\pi} - I_{dc}(R_f + R_s)}$$

1. This Expression indicates that V_{dc} is $\frac{V_m}{\pi}$ at no load con when the load current is zero.
2. It Indicates V_{DC} decreases with Increase in I_{DC} Linearly since R_f is more (or) less constant for a given Diode.

3. For a given circuit of Halfwave Rectifier, if a graph is plotted b/w V_{DC} & I_{DC} the slope of curve gives the value of $R_f + R_s$.

Here R_f = Forward Resistance

R_s = Series Resistance of secondary Transformer.

(v) Form Factor:-

$$\text{Form Factor} = \frac{I_{rms}}{I_{dc}}$$

$$= \frac{\frac{I_m}{\sqrt{2}}}{\frac{2I_m}{\pi}}$$

$$= \frac{\pi}{2\sqrt{2}} \text{ amp}$$

$$\text{Form Factor} = 1.110$$

$$\boxed{I_{rms} = 1.11 \times I_{dc}}$$

(vi) Regulation:-

$$\% \text{ Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

$$= \frac{V_{DC} - V_{FL}}{V_{FL}} \times 100\%$$

$$= \frac{\frac{2V_m}{\pi} - \left(\frac{2V_m}{\pi} - (R_f + R_s) I_{dc}\right)}{\frac{2V_m}{\pi} - I_{dc}(R_f + R_s)} \times 100$$

$$= \frac{1}{\frac{2V_m}{\pi} \cdot \frac{1}{I_{dc}(R_f + R_s)} - 1}$$

$$\boxed{\% \text{ Regulation} = \frac{R_f + R_s}{R_L} \times 100\%}$$

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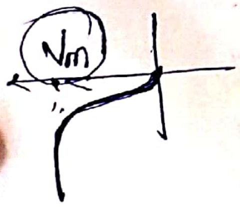
(viii). **Rectification Efficiency :-**

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

$$= \frac{I_{dc}^2 R_L}{I_{ac}^2 (R_L + R_f + R_s)} \times 100\%$$

$$= \frac{\left(\frac{2I_m}{\pi}\right)^2 R_L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 (R_L + R_f + R_s)} \times 100$$

$$= \frac{\frac{4}{\pi^2} R_L}{\frac{1}{2} \cdot (R_L + R_f + R_s)} \times 100$$



$$= \frac{8}{\pi^2} \times \frac{R_L}{R_L + R_f + R_s} \times 100\%$$

$$= \frac{0.810 \, R_L}{R_f + R_L + R_s} \times 100\%$$

For Ideal case:

$R_L >> R_f + R_s$

$$= 0.810 \times 100\%$$

$$= 81.0\%$$

PIV (Peak-Inverse Voltage) :-

PIV of a Rectifier is defined as the maximum Reverse Voltage that a diode can withstand.

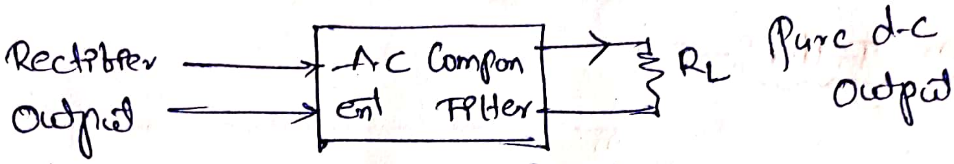
If a Reverse bias voltage exceeds this value, the Reverse Current Increases rapidly and the Junction Breakdown The P.I.V

It is the voltage which makes the Insulator into a Conductor.

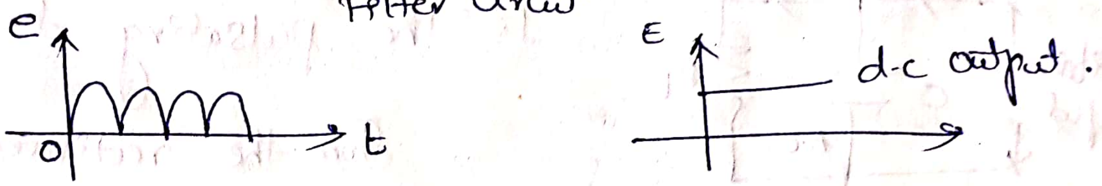
which allows the flow of Current in a unidirectional

Filters:-

A Filter Circuit is a device which removes the a.c component of a ~~filter~~ rectifier output but allows the d.c component to reach the load.

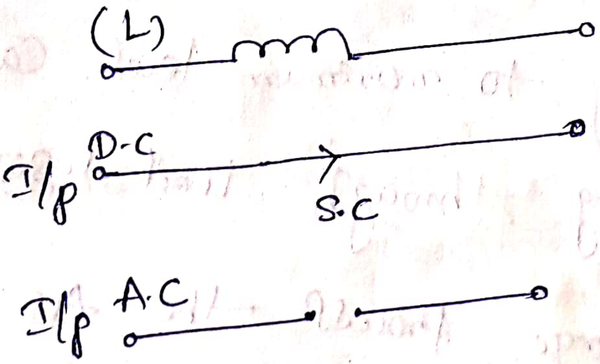


Filter Circuit.

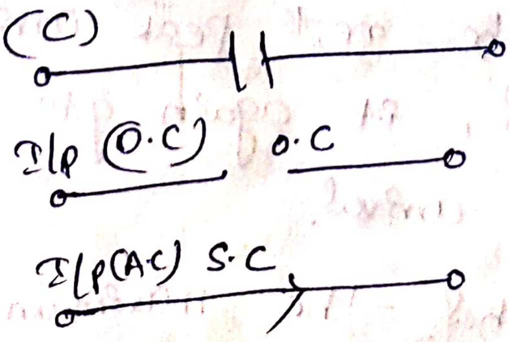


1. A Filter is built up of Energy storage elements like inductors and capacitors.

2. An Inductor acts as a short circuit for d-c current and offers zero opposition to flow it.



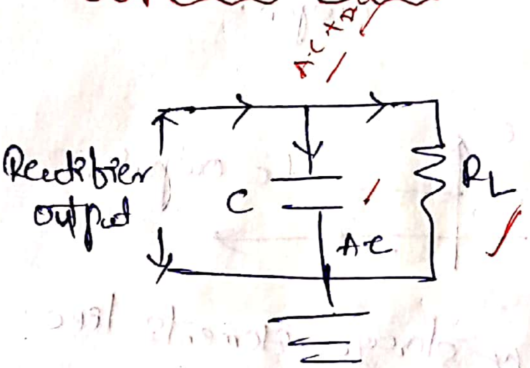
3. A Capacitor is acts like open circuit for d.c, and it allows the A.C component.



- : Types of Filters :- Practical filters fall into 3 categories.

1. Capacitor filter
2. Choke input filter (or L-filter)
3. Capacitor input filter (or π-filter)

Capacitor filter :-



1. The pulsating d.c. is obtained from the rectifier output is applied across the capacitor terminals.

2. During +ve peak of the signal capacitor gets charged to maximum voltage level. (V_m)

3. After reaching to maximum level. Capacitor starts discharging through load resistor R_L.

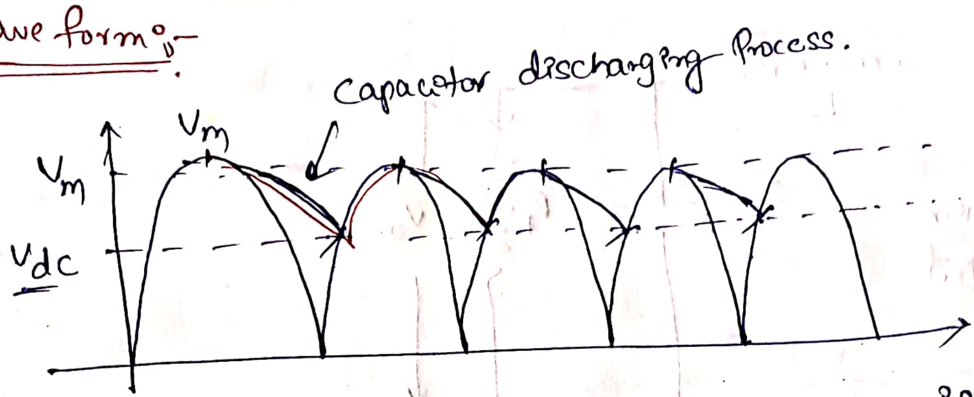
4. During discharge process the AC component of current flow through load resistor, this will appear in the form of heat.

5. As soon as the next peak arrives, the capacitor discharges, it again gets charged when next peak arrives.

6. When it reaches the maximum level, the capacitor again discharges and this

Process is Continuous throughout the full cycle output.

Wave form :-



The Ripple Factor of a Capacitor Filter is given by the

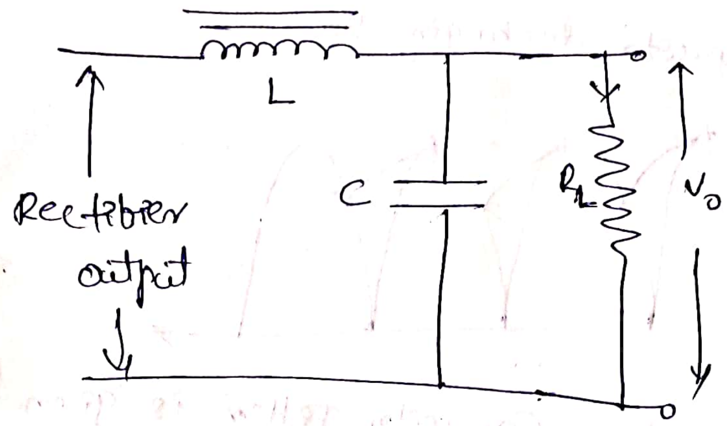
1. $\gamma = \dfrac{1}{2\sqrt{3}\, f C R_L}$ ⟶ Half wave Rectifier

2. $\gamma = \dfrac{1}{4\sqrt{3}\, f C R_L}$ ⟶ Full wave Rectifier

Operation :-

1. Rectifier output is Consists of Both A.C and D.C
2. Capacitor Block d.c Component and allows the A.C Component.
3. This A.C Component flows through the Capacitor and Reached to the ground Terminal.
4. The D.C Component (Left over) will be appear at the Resistor Terminals.

Choke-Input Filter:-



1. Capacitor allows the A.C, Blocks the d.c
2. Inductor allows the D.C, Blocks the A.C

→ The Input Choke readily allows the ~~d~~c Component and Blocks the a.c (Alternate) Current

At this stage much of Ripple content is Suppressed, and there is very little of Current flowing through the Inductor.

→ This Current reaches the Capacitor.

→ Capacitor Blocks d.c and this d.c Component straight away appears across the Resistor.

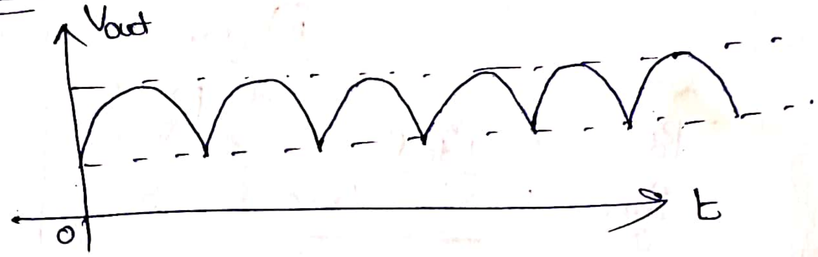
→ And Remaining A.C Component flows through the capacitor and Reaches to the ground Terminal.

→ Ripple Factor, For fullwave Rectification is given by the $\boxed{\gamma = \frac{1.19}{LC}}$ ✓

for fullwave Rectifier L = Inductance in henry
C = Capacitance in farad

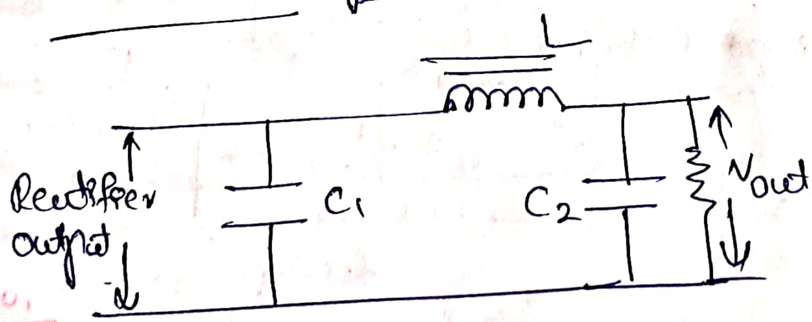
Note:-
The filtering action of choke input filter is more effective than the that of capacitor filter.

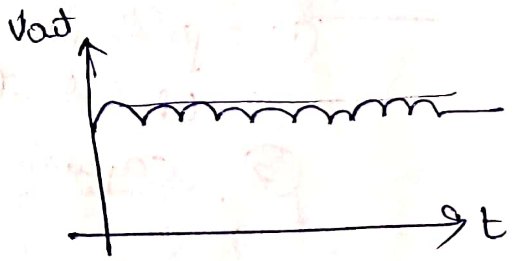
Wave form:-



Capacitor input filter:- (or π-filter):-
— This type of filter makes use of two capacitors and a choke

Circuit diagram:-





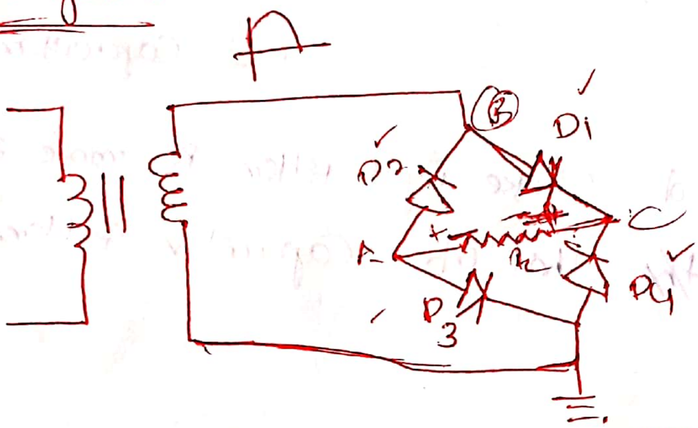
1. Input capacitor C_1 blocks d.c and allows A.c it is reaches to ground. Most of A.c is supressed hear. Next this D.c flows through the ~~capacitor~~ Inductor component.
And it blocks the A.c Resistor R_L
Now complete D.c will be appear at the

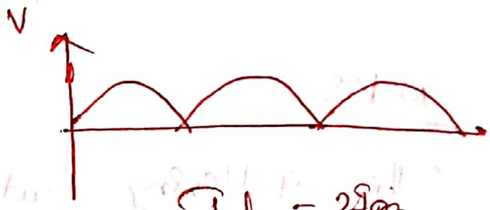
Ripple Factor efficiency is given by the

$$\boxed{\gamma = \frac{5700}{C_1 C_2 L R_L}}$$

Bridge Rectifier

Components.





$$I_{dc} = \frac{2I_m}{\pi}$$

$$I_{dc} = \frac{I_m}{\pi} ; \quad I_{dc} = \frac{2I_m}{\pi}$$

$$I_m = \frac{V_m}{R_F + R_L} = \frac{V_m}{2R_F + R_L}$$

(ii) TUF

d.c power due

$$\frac{P_{dc}}{P_{rms}} = \frac{I_{dc}^2 R_L}{V_{rms} I_{rms}}$$

TUF Half $= \dfrac{\left(\frac{2I_m}{\pi}\right)^2 R_L}{\frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}} \Rightarrow \dfrac{\left(\frac{I_m}{\pi}\right)^2 \cdot R_L}{\frac{I_m R_L}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}}$

comparision.

Filters

(1) capacitor filt

(2) inductor filter. (L-section) $\frac{2}{\pi^2}$ $= 0.2026$

(3). capacitor input filter (π-section filter)

(4) Q

Question paper discussion

Rectified output & ond above, dc Comp,

(1) $\frac{1}{4\sqrt{3} f C R_L}$

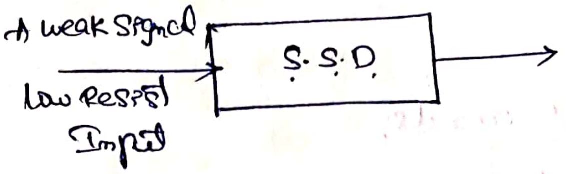
(2) $\frac{1.19}{LC}$

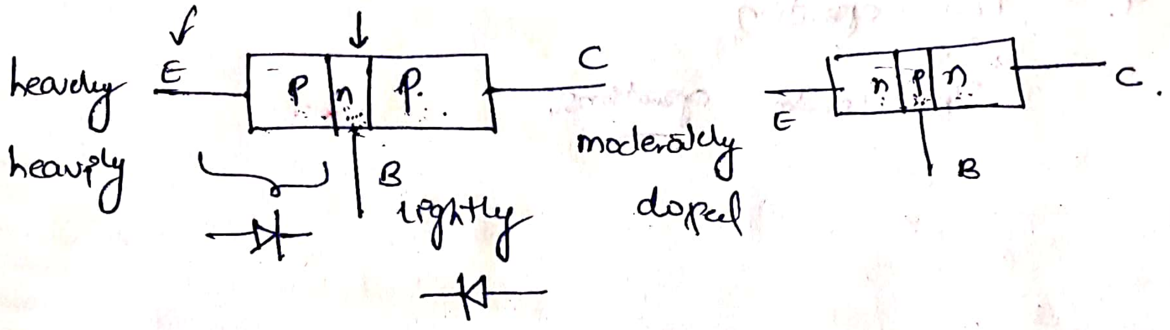
(3) $\frac{5700}{C_1 C_2 L R_L}$

Invented in 1948
by J. Bardeen
&
W.H. Brattain

Introduction to Transistors:-

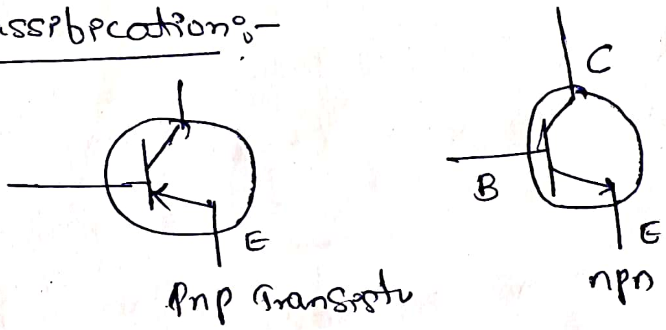
(1)





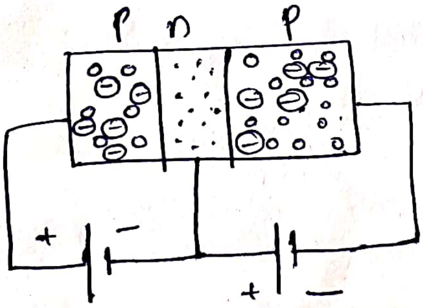
→ Application:-

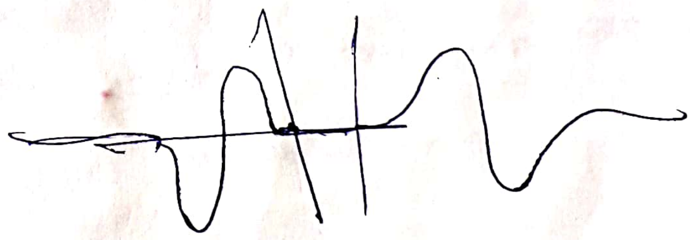
Classification:-

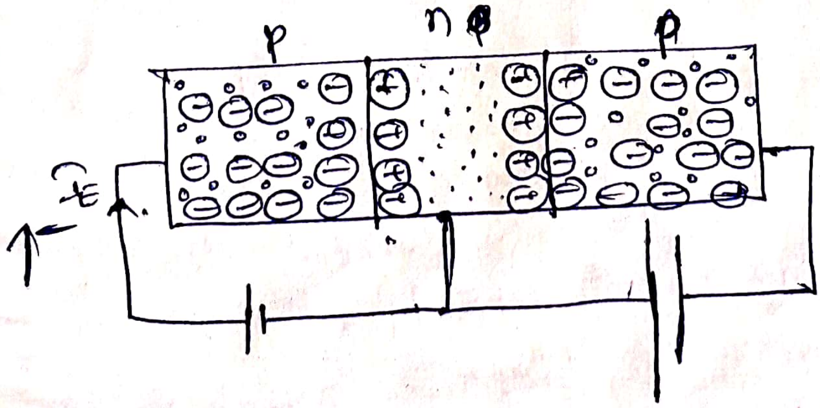


Arrow head — direction of conventional current
or
motion of holes.

NPN & PNP Schematic diagrams:-







$I_E = I_C + I_B$

$I_C = \alpha_{dc} I_E + I_{CBO}$

$\alpha_{dc} = \frac{I_C - I_{CBO}}{I_E}$

α
β
γ
value.

1. Characteristics of CE & CB, CC Configurations

2. Problems,

3. H-parameter models.

4. FET operation

5. I_D, I_S, I_G operations.

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