UNIT- 5th :- Physical Electronics (sheet-2)

✓ Resistor types

a) Fixed Resistors

Carbon film resistors:

The size of the resistor decides its power rating (i.e., the maximum power it can dissipate without burning).

Power rating from the top of the graph:
1/8 W
1/4 W
1/2 W

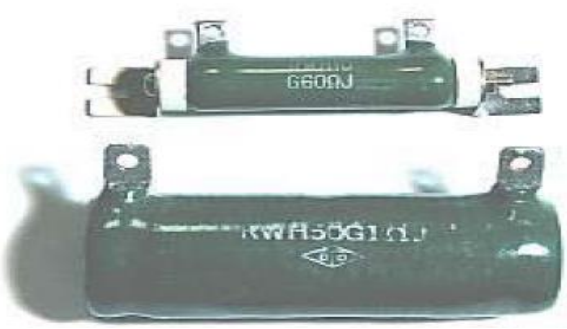
- **These are most common type of low wattage resistor.**
- **They are made of graphite or finely ground carbon mixed with a powdered insulating material , called filler material**

Metal film resistors: Used when a higher tolerance (more accurate value) is needed.

Power rating from the top of the graph:
1/8 W (tolerance ±1%)
1/4 W (tolerance ±1%)
1 W (tolerance ±5%)
2 W (tolerance ±5%)

- **Metal film resistor are also known as thin film resistor .**
- **They are constructed by depositing a thin metal coating on an insulating substrate such as glass or ceramic.**
- **Metal film resistor can range in values upto 10,000 M Ω .**
- **They have high accuracy , Low temperature coefficient , very low noise and excellent tolerance and hence they are suitable for numerous high grade application.**

Wirewound resistors:



- **Wire wound resistor are manufactured by winding a resistor wire around an insulating hollow cylinder core.**
- **In Wire wound resistor, usually wires of material such as constantan (60% Cu & 40%Ni) and Manganin are used. These materials have high resistivity and low temperature coefficients.**
- **The length and resistivity of the resistance wire determines the resistance value.**

b) <u>Variable Resistor</u>

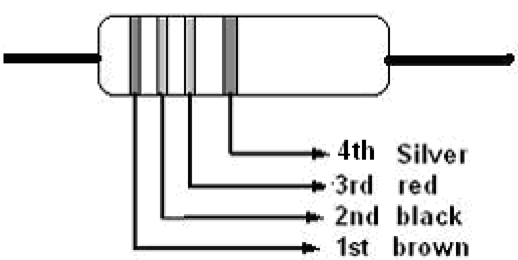
- **These are resistor whose resistance can change between zero and a certain maximum value.**
- **They are used in electronic circuits to adjust the values of voltages and currents.**
- **<u>Examples :-</u> They are used as volume control in Radio and Brightness control in Television.**
- **Variable Resistor can be Wire wound or Resistor type.**

<u>Colour Code for Resistors</u>

Band colour & its value	Band colour & its tolerance
Black = 0	Gold = + - 5%
Brown = 1	Silver = + - 10 %
Red = 2	No colour means 20 %
Orange = 3	
Yellow = 4	
Green = 5	
Blue = 6	
Violet = 7	
Grey = 8	
White = 9	

Trick :- <u>**B B ROY**</u> of <u>**G**reat</u> <u>**B**ritain</u> has <u>**V**ery</u> <u>**G**ood</u> <u>**W**ife</u> wearing <u>**G**old **S**ilver **N**ecklesh</u>

<u>Q.</u>:- Find the equivalent resistor value of shown resistor?



<u>Answer :-</u> here brown = 1, black = 0, red = 2 and silver = 10 % tolerance.

Hence its value is $10 \times 10^{2}\ \Omega = 1\ k\Omega$.

Special purpose resistors :-

- **Light dependent resistors (LDR) is a resistor whose resistance depends upon the amount of light falling on it.**
- **Thermistor is a resistor whose value depends on its temperature**

✓ Inductor Types

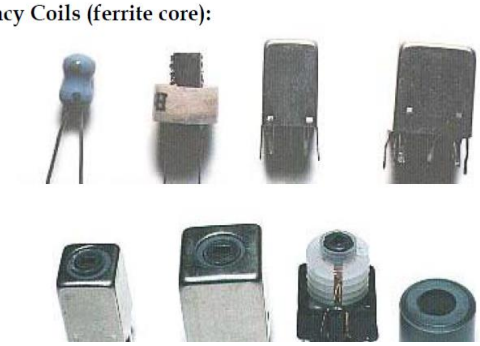
- **Inductor is a component made by a coil of wire which is wound on a core. It is used to vary the impedance of a circuit or used for frequency tuning. The value of an inductor depends upon the total number of turns (N), area of cross-section of the core (A) and length of the core (l).The formula is $L = \mu_o \mu_r N^2 A / l$. Its unit is in Henry**

a) Fixed Inductor

i) Air core inductors also include the radio frequency inductors.

ii) The ferromagnetic core inductors include laminated core, ferrite-core and toroidal core inductors.

High Frequency Coils (ferrite core):



The Toroidal Coil:

b) The variable inductor :- In certain application such as tuned circuit, it is required to vary the inductance from a minimum value to a maximum value for this purpose variable inductor are used.

✓ Capacitor Types

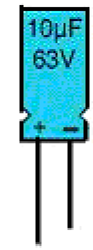
- **Capacitors are capable of storing charges. They are used for coupling ac signals from one circuit to another and for frequency selection etc. A capacitor consists of 2 metallic plates separated by a dielectric. The capacitance is defined as : $C = \epsilon_o \epsilon_r A / d$, where A is the area of plates, d is plates separation, ϵ_o is permittivity of free space and ϵ_r is relative permittivity. An important parameter for capacitors is its voltage handling capacity beyond which the capacitor dielectric breaks down.**
- **The value of a capacitor depends upon the dielectric constant ($K = \epsilon_o \epsilon_r$.) of the material**
- **There are three main classes of capacitors:**

  i) Non electrolytic or normal capacitors and (ii) electrolytic capacitors and (iii) variable capacitors

Electrolytic Capacitors (Electrochemical type capacitors): Used for all values above 0.1μF. Electrolytics have lower accuracy and temperature stability than most other types and are almost always polarised. It's usually best to only use an electrolytic when no other type can be used, or for all values over 100μF.

Examples :-Tantalum & Aluminium Capacitor

From the left to right:
1μF (50V)
47μF (16V)
100μF (25V)
220μF (25V)
1000μF (50V)

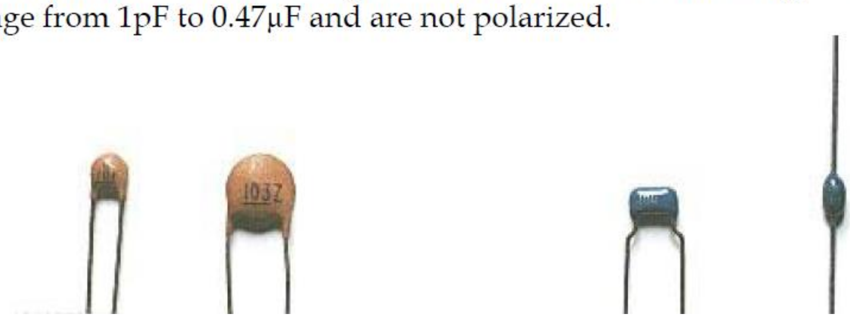


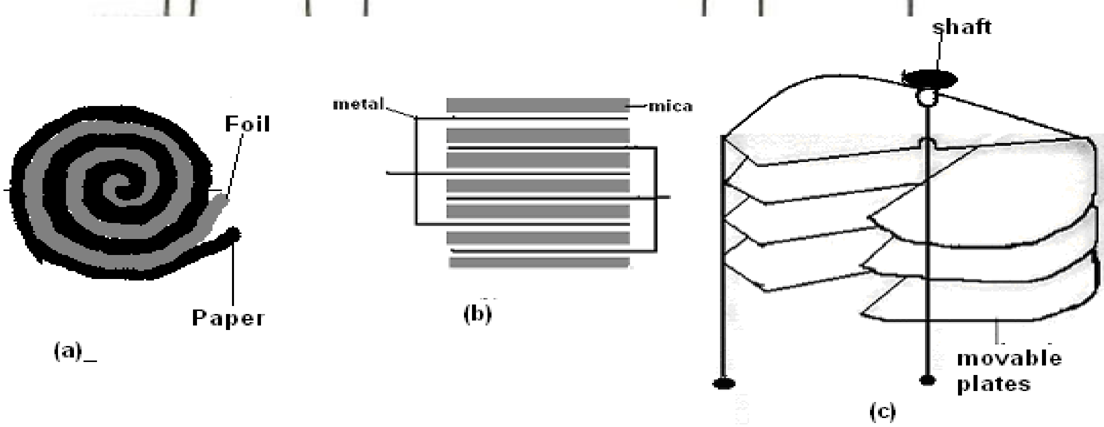
Radial

Non electrolytic or non-polarized Capacitors:-

- **Capacitor of < 1μF value**
- **Examples :- Ceramic , Mica , paper & Plastic Film Capacitor**

Ceramic Capacitors: Limited to quite small values, but have high voltage ratings. They range from 1pF to 0.47μF and are not polarized.

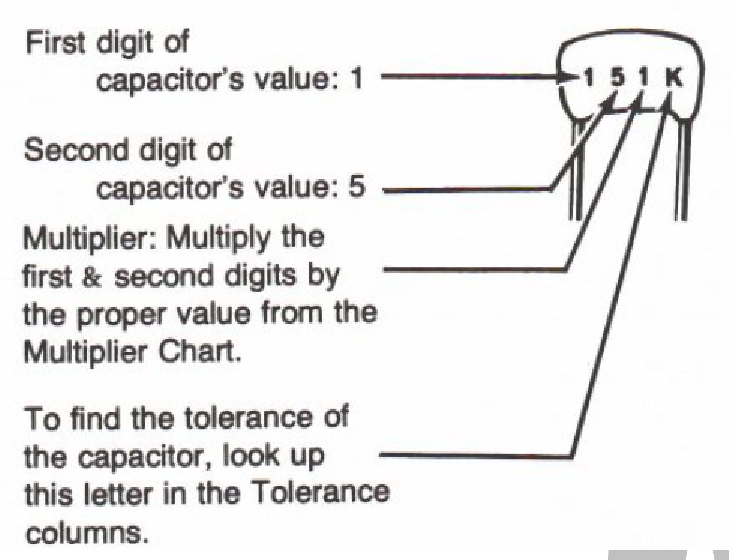




(a) A crossectional view of paper capacitor, (b) Mica capacitor, (c)variable air Cap.

Capacitor Colour Code :-

Reading Ceramic Capacitor values:

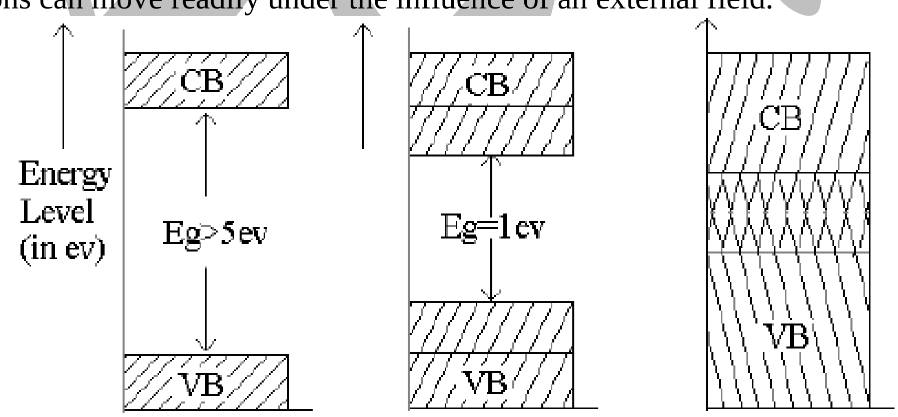


For the number:	Multiply by:	LETTER	TOLERANCE 10pF or LESS	TOLERANCE OVER 10pF
0	1	B	+/- 0.1pF	
1	10	C	+/-0.25pF	
2	100	D	+/- 0.5pF	
3	1000	F	+/- 1.0pF	+/- 1%
4	10,000	G	+/- 2.0pF	+/- 2%
5	100,000	H		+/- 3%
		J		+/- 5%
8	0.01	K		+/- 10%
9	0.1	M		+/- 20%

Example:- 102 means 10 X 10^2 pF = 1nF and 472J means 4700pF = 4.7nF (J means 5% tolerance).

✓ Types of Material

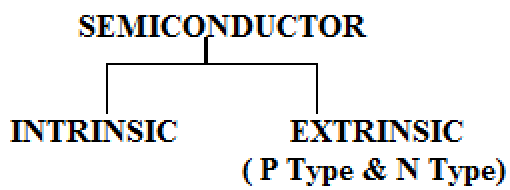
- Materials are of three type Conductor , insulator and semiconductor
- Conducting materials (such as silver, copper, aluminium etc.) are good conductors of electricity and are characterised by a large electrical conductivity and small electrical resistivity.
- Within any given material there are two distinct energy bands in which electrons may exist.
- These two energy bands are valence band and conduction band and are separated by an energy gap in which no electrons normally exist. This energy gap is termed the Forbidden gap E_G.
- The energy band of interest is the highest energy band or valence band. If a sufficient amount of energy is given to an electron in the valence band the electrons is freed of the atomic structure, such an electron is said to possess enough energy to be in conduction band , where it can take part in electric current flow. Free electrons can move readily under the influence of an external field.



For Insulator For Semiconductor For Conductor

✓ Semiconductor

- The group of materials which are neither good conductors nor good insulators are called semiconductors.
- At room temperature such materials have conductivities considerably lower than those of conductors and much higher than those of insulators such materials are called semiconductors.
- The resistivity of various semiconductor materials lies in a very wide range from 10^{-4} to about 0.5 W-m.
- The resistance of semiconductors decreases with the increase in temperature i.e. temperature coefficient of semiconductors is negative.



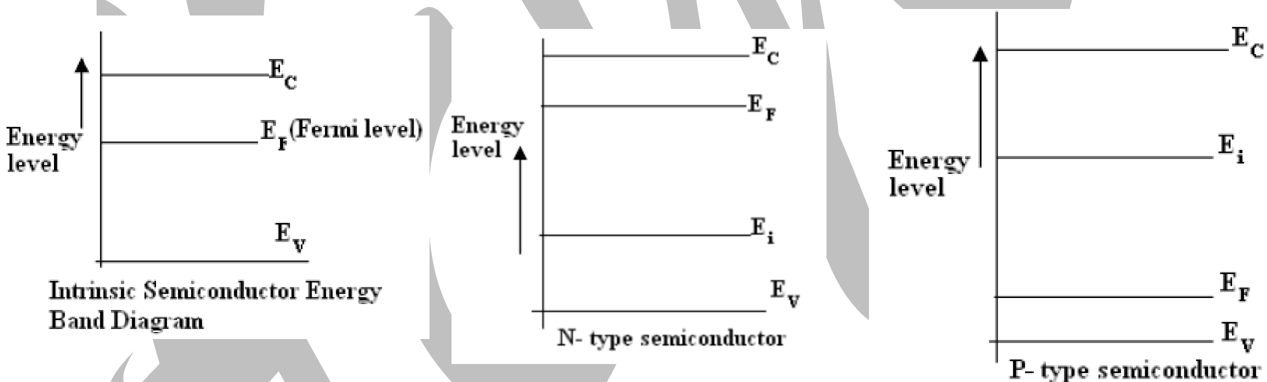
• Intrinsic semiconductor

- An intrinsic semiconductor is one which is made of the semiconductor material in its extremely pure form.
- At absolute zero temperature, all the electrons of intrinsic semiconductors are tightly held by their atoms. The inner orbit electrons are bound to nucleus whereas, the valence electrons are bound by the forces of covalent bonds. Thus, at absolute zero temperature no free electron is available in the intrinsic semiconductor so it behaves like a perfect insulator. When the material is heated, electrons break away from their atoms and move from the valence band to conduction band. Thus produces holes in the valence band and free electrons in the conduction band. Conduction can then occur by electron movement and hole transfer. With the increase in temperature, the rate of generation of electron hole pairs is increased. This in turn increases the rate of recombination. Thus with the increase in temperature, the concentration of charge carriers increases. As more charge carriers are made available, the conductivity of a pure semiconductor increases with the increase in temperature.

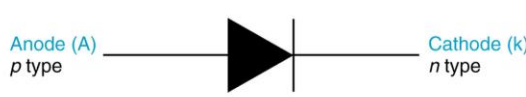
• Extrinsic Semiconductor

	Intrinsic semiconductor	Donor atoms	Acceptor atoms
Group IV semiconductors	Silicon, Germanium	Phosphorus, Arsenic	Boron, Aluminium
Group III-V semiconductors	Aluminum phosphide, Aluminum arsenide, Gallium arsenide, Gallium nitride	Selenium, Tellurium, Silicon,Germanium	Beryllium, Zinc, Cadmium, Silicon,Germanium

- **N Type :-** When a small amount of pentavalent impurity such as arsenic, antimony or phosphorous isadded to a pure semiconductor crystal during crystal growth the resulting crystal is called the N-type extrinsic semiconductor.
  - Extrinsic semiconductors with a larger electron concentration than hole concentration are known as n-type semiconductors.
  - The phrase 'n-type' comes from the negative charge of the electron.
  - In n-type semiconductors, electrons are the majority carriers and holes are the minority carriers.
  - N-type semiconductors are created by doping an intrinsic semiconductor with donor impurities (or doping a p-type semiconductor as done in the making of CMOS chips). A common dopant for n-type semiconductors is Phosphorous. In an n-type semiconductor, the Fermi energy level is greater than that of the intrinsic semiconductor and lies closer to the conduction band than the valence band.
- **P Type :-** When a small amount of trivalent impurity such as boron, gallium, indium or aluminium is added to a pure semiconductor crystal during the crystal growth, the resulting crystal iscalled the P-type extrinsic semiconductor.
  - As opposed to n-type semiconductors, p-type semiconductors have a larger hole concentration than electron concentration.
  - The phrase 'p-type' refers to the positive charge of the hole.
  - In p-type semiconductors, holes are the majority carriers and electrons are the minority carriers.
  - P-type semiconductors are created by doping an intrinsic semiconductor with acceptor impurities (or doping a n-type semiconductor). A common P-type dopant is Boron.
  - P-type semiconductors have Fermi energy levels below the intrinsic Fermi energy level. The Fermi energy level lies closer to the valence band than the conduction band in a p-type semiconductor.



✓ **PN Junction Diode**



- A PN Junction diode is a 2-terminal semiconductor electronic On/Off switch that allows current flow in only one direction.
- The terminals are called the Anode (A) and the Cathode (K). The state of the diode switch (open or closed) is determined by the polarity of the voltage across it.

Semiconductor device have three modes of operation:

1) Thermal Equilibrium

At thermal equilibrium there are no external inputs such as light or applied voltage. The currents balance each other out so there is no *net* current within the device.

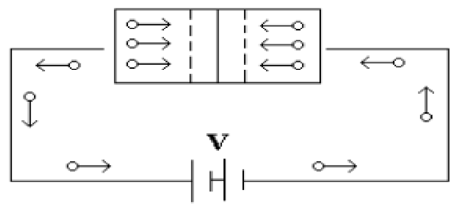
2) Steady State

Under steady state there are external inputs such as light or applied voltage, but the conditions do not change with time. Devices typically operate in steady state and are either in forward or reverse bias.

3) Transient

If the applied voltage changes rapidly, there will be a short delay before the solar cell responds. As solar cells are not used for high speed operation there are few extra transient effects that need to be taken into account.

- **Forward Biasing :-**



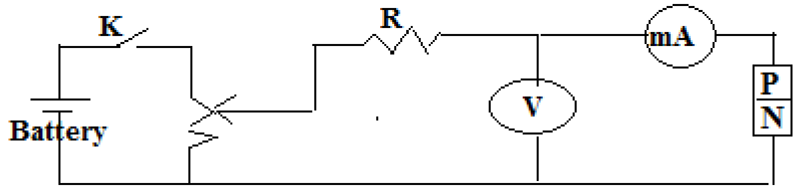
Forward Biasing

  - Forward bias refers to the application of voltage across the such that the electric field at the junction is reduced.
  - By applying a positive voltage to the *p*-type material and a negative voltage to the *n*-type material, an electric field with opposite direction to that in the depletion region is applied across the device.
  - The negative potential on the P-side prevents the migration of any more electrons from the N-type material to the P-type material.
  - Similarly the positive potential on the N-side prevents any further migration of holes across the boundary.
  - Thus the initial diffusion of charge carriers creates a Barrier Potential at the junction.The region around the junction is completely ionised. As a result, there are no free electrons on the N-side nor there are holes on the P-side. Since the region around the junction is depleted of mobile charges it is called the Depletion Region. The thickness of the depletion region (or layer) is of the order of 1 micron.
  - Barrier voltage depends on doping density, electronic charge and temperature, the first two factors are fixed thus making barrier potential dependent on temperature.

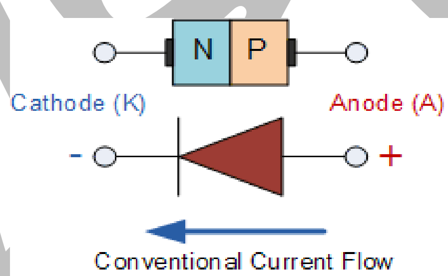
- **Reverse Biasing :-**
  - When P terminal of diode is connected to negative terminal of battery and N terminal of diode is connected to positive terminal of battery, the biasing is termed as Reverse Biasing.
  - In reverse bias a voltage is applied across the device such that the electric field at the junction increases. The higher electric field in the depletion region decreases the probability that carriers can diffuse from one side of the junction to the other, hence the diffusion current decreases. As in forward bias, the drift current is limited by the number of minority carriers on either side of the p-n junction and is relatively unchanged by the increased electric field. A small increase in the drift current is experienced due to the small increase in the width of the depletion region, but this is essentially a second-order effect in silicon solar cells. In many thin film solar cells where the depletion region is around half the thickness of the solar cell the change in depletion region width with voltage has a large impact on cell operation.

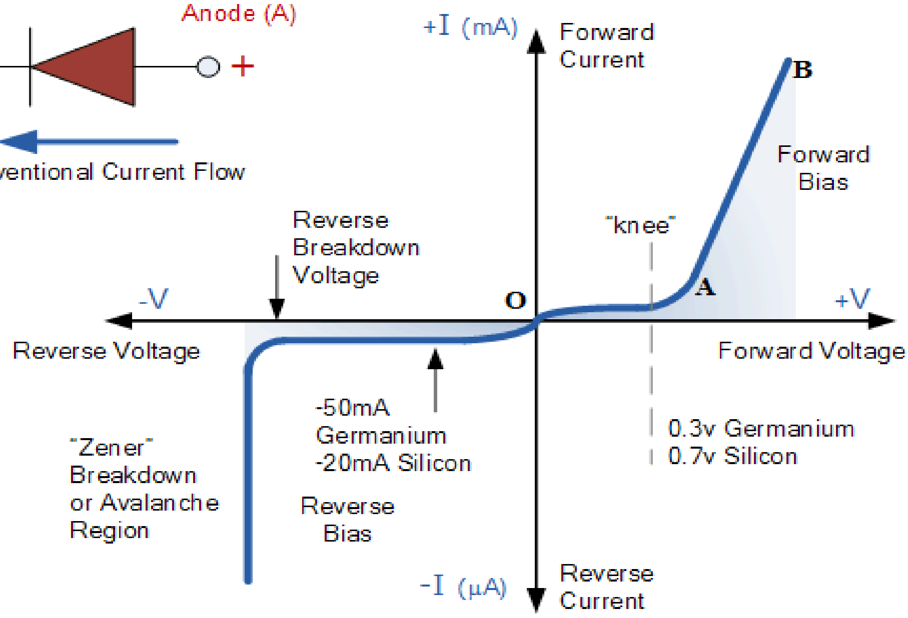
✓ V-I characteristic of PN Junction Diode

There are two operating regions and three possible "biasing" conditions for the standard **Junction Diode** and these are:



1) Zero Bias - No external voltage potential is applied to the PN-junction as circuit is open at K. Potential Barrier at the junction does not permit current flow. Therefore circuit current is zero as indicated by point A in V-I characteristic diagram.
2) Forward Bias - The positive (+ve) terminal of voltage potential is connected to the P-type material and negative (-ve) terminal is connected to the N-type material across the diode which has the effect of **Decreasing** the PN- junction width. At some forward voltage (0.7 V for Si & 0.3V for Ge),the potential barrier is altogether eliminated and current starts flowing in the circuit. From now onwards, the current increases with increase in forward voltage. Thus the rising curve OB is obtained with forward bias as indicated in V I characteristic. From the forward characteristic it is obvious that the first current flows very slowly at region OA and curve is nonlinear as external voltage is used up in overcoming the potential barrier. However once the external voltage Exceed the potential barrier voltage ,the PN junction behaves like an ordinary conductor and hence current rises very sharply with increase in external voltage as indicated in AB on the curve, the curve is almost linear.
3) Reverse Bias – The negative (-ve) terminal of voltage potential is connected to the P-type material and positive (+ve) terminal of voltage potential is connected to the N-type material across the diode which has the effect of **Increasing** the PN-junction width. The junction resistance is very high and practically no current flow through the circuit. However, in practice very small current of micro ampere range flow due to minority charge carrier as shown in curve. It is known as reverse saturation current (i_s). If reverse current is increased continuously, the kinetic energy of electron the minority charge carriers may become high enough to knock out electrons from the semiconductor atoms. At this stage breakdown of junction occurs, characterised by sudden rise of reverse current and sudden fall of the resistance of barrier region. This may destroy the junction permanently.





✓ Rectifier

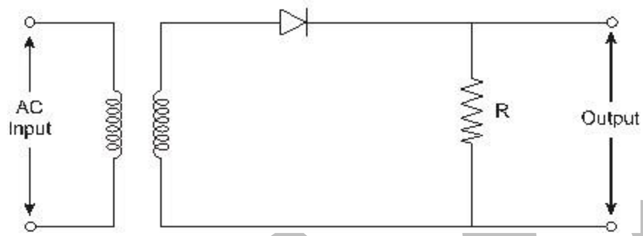
- The circuit which converts AC into DC is called Rectifier Circuit.

There are basically two types of Rectifier Circuit:

1) Half wave Rectifier
2) Full wave Rectifier
   (a) Centre Tap Full Wave Rectifier
   (b) Bridge Full Wave Rectifier

Half wave Rectifier

- This is the simplest Rectifier Circuit. The circuit has only one diode.

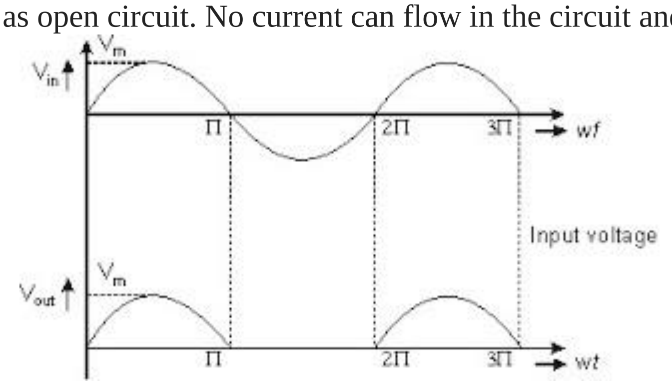


IN POSITIVE CYCLE OF THE INPUT AC VOLTAGE:

When the input voltage is positive the anode of diode is +ve and the cathode of diode is –ve. This results in forward biasing of the diode. When the diode is forward bias it behaves as a short circuit as a result we get the input voltage at the output of the circuit

IN NEGATIVE CYCLE OF THE INPUT VOLTAGE

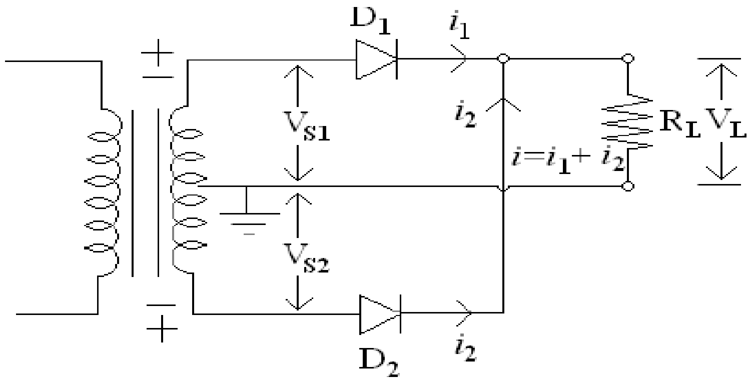
When the inputs reverse its cycle the anode of the diode become –ve. This reverse biases the diode. As a result the diode behaves as open circuit. No current can flow in the circuit and the output voltage is zero.

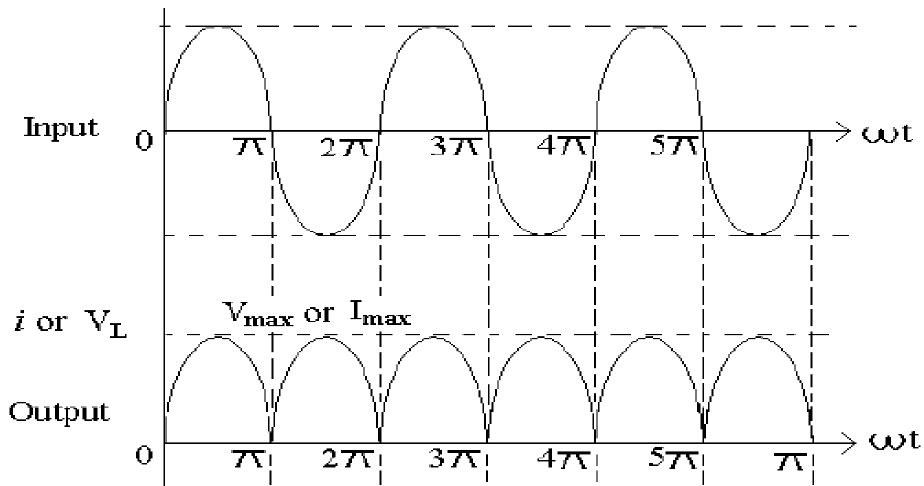


Center tap Full wave Rectifier

- In centre tap rectifier, the ac input is applied through a transformer, the anodes of the two diodes D_1 and D_2 are connected to the opposite ends of the centre tapped secondary winding and two cathodes are connected to each other and are connected through the load resistance R_L and back to the centre of the transformer as shown.
- When the top of the transformer secondary winding is positive, the anode of diode D1 is positive with respect to cathode and anode of diode D_2 is negative with respect to cathode. Thus only diode D_1 conducts, being forward biased and current flows from cathode to anode of diode D_1, through load resistance R_L.

- During the second half-cycle of the input voltage polarity is reversed, making the bottom of the secondary winding positive with respect to centre-tap and thus diode D_2 is forward biased and the diode conducts and current flows the load resistance R_L.

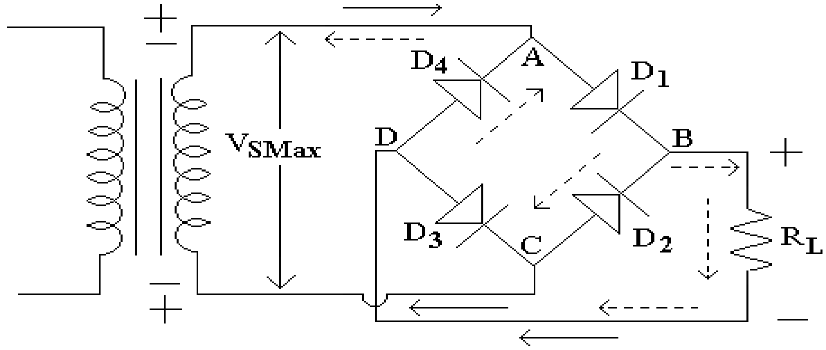


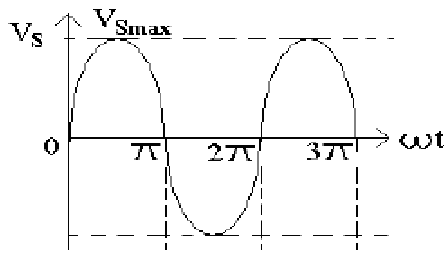


Bridge Full wave Rectifier

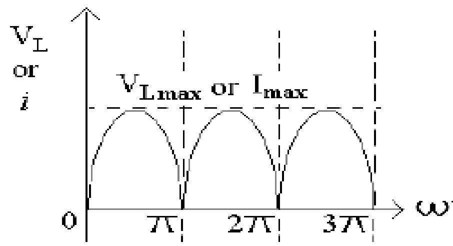
- When the upper end of the transformer secondary winding is positive, diodes D1 and D3 are forward biased and current flows through arm AB, enters the load at positive terminal, leaves the load at negative terminal and returns back flowing through arm DC. During this half of each input cycle, the diodes D_2 and D_4 are reverse biased, and so the current is not allowed to flow in arms AD and BC. The flow of current is indicated by solid arrows in the figure.

- In the second half of the input cycle the lower end of ac supply becomes positive diodes D_2 and D_4 become forward biased and current flows through arm CB, enters the load at the positive terminal, leaves the load at the negative terminal and returns back flowing through arm DA. Flow of current has been shown by dotted arrows in the figure. Thus the direction of flow of current through the load resistance RL remains the same during both half cycles of the input supply voltage





Input



Output

Advantages-

1) Low cost, highly reliable and small sized silicon diodes.
2) No centre tap is required in the transformer secondary so in case of a bridge rectifier the transformer required is simpler.
3)The PIV is one half that of centre-tap rectifier. Hence bridge rectifier is highly suited for high voltage applications.
4)Transformer utilization factor, in case of a bridge rectifier is higher than that of a centre tap transformer.

Disadvantages-
It needs four diodes, two of which conduct in alternate half cycles. Because of this the total voltage drop in diodes becomes double of that in case of centre tap rectifier.

<u>Basic parameters of Rectifier circuit</u>

1) **Ripple Factor –** The ratio of rms value of a.c. component to the dc component in the rectifier output is known as Ripple Factor.
   - For half wave Ripple factor is **1.21** and that for Full wave rectifier is **0.48.**

2) **Efficiency –** The ratio of DC power output to the applied input AC power is known as Rectifier efficiency
   - For half wave Efficiency is **40.6%** and that for Full wave rectifier is **81% .**