# Dr.D.Y. Patil Technical Campus

(Engineering and MCA)
First Year Engineering (2024 Pattern)

## Name of Subject-Basic Electronics Engineering
## Subject Code-(ESC-101-ETC)
## NEP 2020 Compliant Curriculum Structure

| Course Code | Course Type | Course Name | Teaching Scheme (Hrs./week) | | | Examination Scheme and Marks | | | | | Credits | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory | Tutorial | Practical | CCE* | End-Sem | Term work | Practical | Oral | Theory | Tutorial | Practical | Total |
| **Semester I** | | | | | | | | | | | | | | |
| BSC-101-BES | Basic Science Course | Engineering Mathematics- I | 3 | 1 | - | 30 | 70 | 25 | - | - | 3 | 1 | - | 4 |
| BSC-102-BES/ BSC-103-BES | Basic Science Course | Engineering Physics / Engineering Chemistry | 3 | - | 2 | 30 | 70 | 25 | - | - | 3 | - | 1 | 4 |
| ESC-101-ETC / ESC-102-ELE | Engineering Science Course | Basic Electronics Engineering / Basic Electrical Engineering | 2 | - | 2 | 30 | 70 | 25 | - | - | 2 | - | 1 | 3 |
| ESC-103-MEC/ ESC-104-CVL | Engineering Science Course | Engineering Graphics / Engineering Mechanics | 2 | - | 2 | 30 | 70 | 25 | - | - | 2 | - | 1 | 3 |
| ESC-105-COM | Engineering Science Course | Fundamentals of Programming Languages | 2 | - | 2 | 30 | 70 | 25 | - | - | 2 | - | 1 | 3 |
| VSE-101/ VSE-102 | Vocational and Skill Enhancement Course | Manufacturing Practice Workshop/ Design Thinking and Idea Lab | - | - | 2 | - | - | 25 | - | - | - | - | 1 | 1 |
| AEC-101 | Ability Enhancement Course | Professional Communication Skills | - | 2 | - | - | - | 25 | - | - | - | 2 | - | 2 |
| CCC-101 | Co-Curricular Courses | Co-Curricular Course-I | - | - | 4 | - | - | 25 | - | - | - | - | 2 | 2 |
| **Total** | | | **12** | **03** | **14** | **150** | **350** | **200** | **-** | **-** | **12** | **03** | **07** | **22** |

# UNITE NO-1. Diodes and Applications

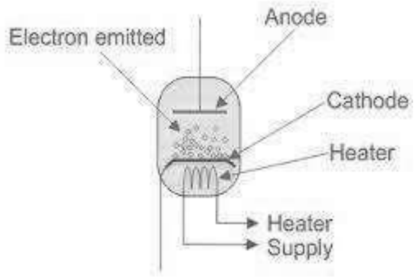
**SYLLABUS**- Evolution of Electronics, Current trends in Electronics, Impact of Electronics in industry and society. Introduction to active and passive components. P-N Junction Diode: P-N Junction diode construction and its working in forward and reverse bias conditions, V-I characteristics of P-N junction Diode, Diode as a switch, Half wave rectifier, Full wave and Bridge rectifier. Special purpose diodes: Light Emitting Diode (LED) and photo diode along with V- I characteristics and their applications.

1. Evolution of Electronics-

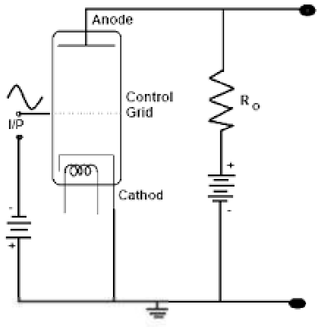
Evolution of electronic components and devices:

Invention of vacuum diode by J.A. Fleming, in 1897

Vacuum Tubes



Diode



Triode

Lee De Forest implemented vacuum triode as amplifying device.

Tetrode & pentode: multi grid devices popular till 1940

BJT invented in 1948 uses germinium, silicon semiconductors

JFETs and MOSFETs during 1951 to 1958

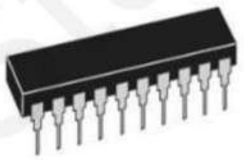
Integrated circuits (ICs) Evolution:

ICs are multiple devices circuit on single chip as Integrated circuit.

Analog ICs – Earlier Bipolar BJT Chips, Then BiFETS, MOSFETs Chips Evolved, IC Blocks have OPAMPS, ADC, DAC etc

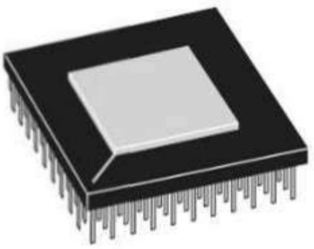
Typical IC Packaging evolution:

**HDIP**
Plastic through-hole package with higher heat dissipation rate



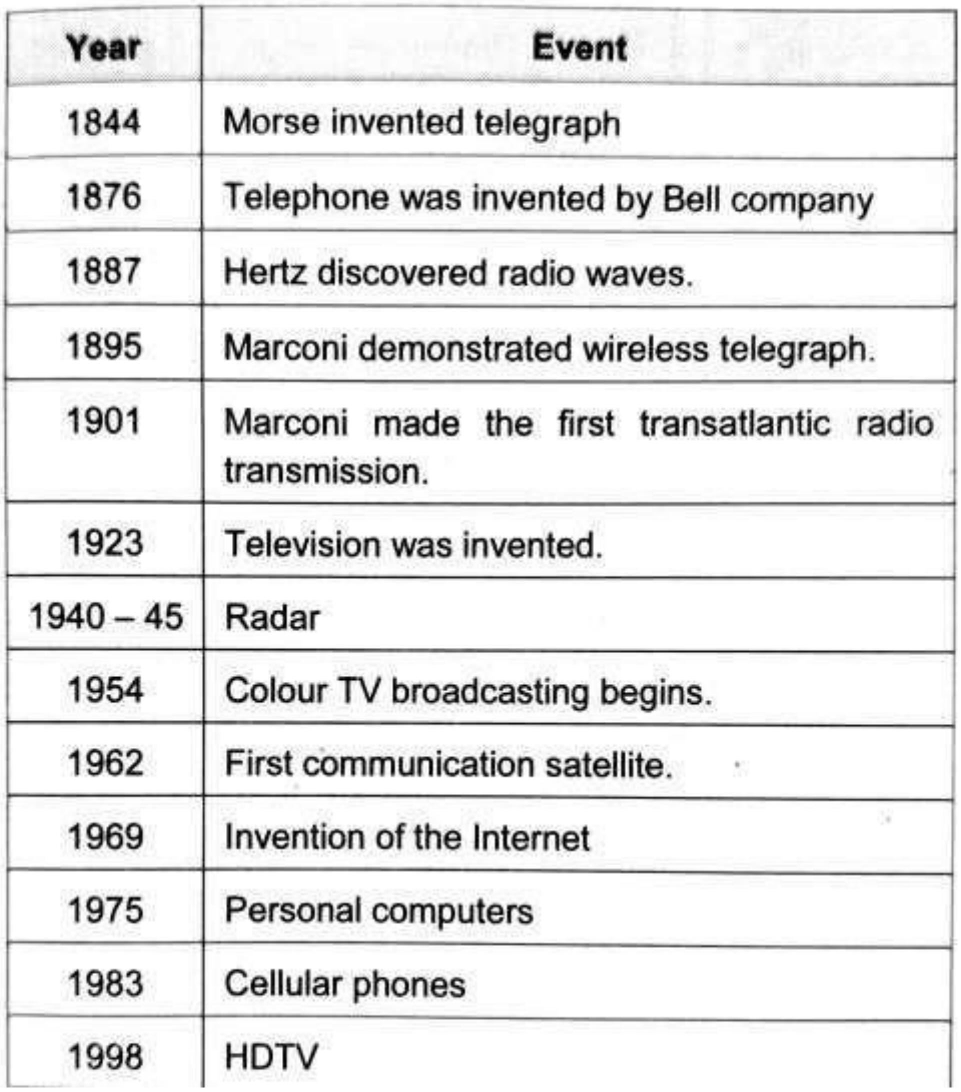
**SDIP**
Plastic through-hole package

**CPGA**
Ceramic through-hole package



**HSOP**
Plastic dual-construction surface mount package with higher heat dissipation rate

Evolution of communication systems:



| Year | Event |
|---|---|
| 1844 | Morse invented telegraph |
| 1876 | Telephone was invented by Bell company |
| 1887 | Hertz discovered radio waves. |
| 1895 | Marconi demonstrated wireless telegraph. |
| 1901 | Marconi made the first transatlantic radio transmission. |
| 1923 | Television was invented. |
| 1940 – 45 | Radar |
| 1954 | Colour TV broadcasting begins. |
| 1962 | First communication satellite. |
| 1969 | Invention of the Internet |
| 1975 | Personal computers |
| 1983 | Cellular phones |
| 1998 | HDTV |

2.Impact on Industry-

- Speed of development increased
- Quality Improved
- Scale of production increased
- Mass production improved supply
- Reducing cost
- Production Automation

Impact on Society

- Ease of operation
- Reduction in labour
- Time saving
- Luxury and ease of living improved

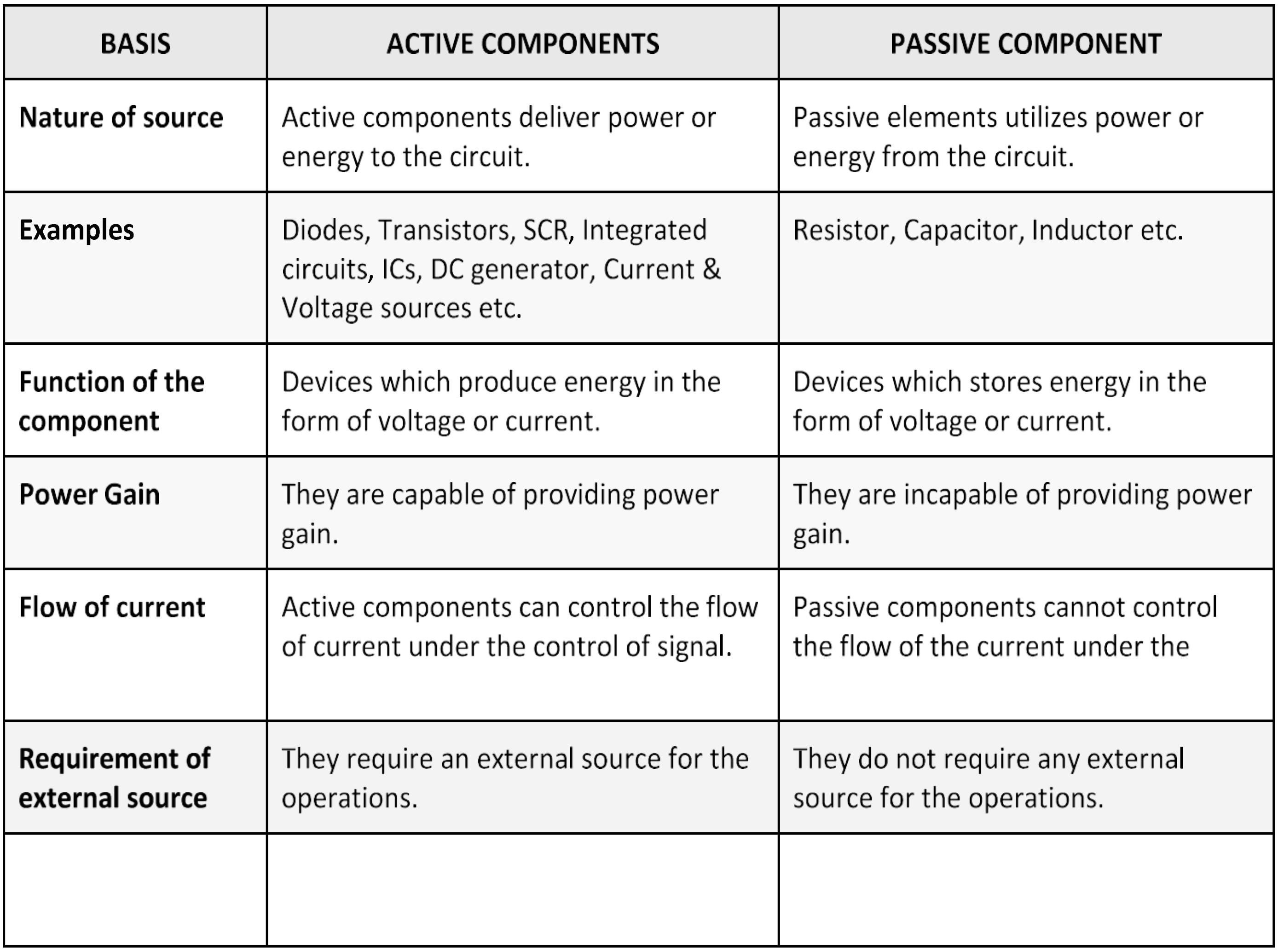
Application of Electronics in various Aera-

- Defence application and Radar satellite
- Industrial applications
- Robotics and artificial intelligence. ...
- Medical applications.
- Defence and Aerospace.
- Automobiles.
- Functions of Electronics.
- Communication social media and entrainment.

3. Types of Electronics Components-

Active & Passive Components:

Comparison of active and Passive conponents:



| BASIS | ACTIVE COMPONENTS | PASSIVE COMPONENT |
|---|---|---|
| **Nature of source** | Active components deliver power or energy to the circuit. | Passive elements utilizes power or energy from the circuit. |
| **Examples** | Diodes, Transistors, SCR, Integrated circuits, ICs, DC generator, Current & Voltage sources etc. | Resistor, Capacitor, Inductor etc. |
| **Function of the component** | Devices which produce energy in the form of voltage or current. | Devices which stores energy in the form of voltage or current. |
| **Power Gain** | They are capable of providing power gain. | They are incapable of providing power gain. |
| **Flow of current** | Active components can control the flow of current under the control of signal. | Passive components cannot control the flow of the current under the |
| **Requirement of external source** | They require an external source for the operations. | They do not require any external source for the operations. |
|  |  |  |

| Active | Passive |
|---|---|
| ▪ Diodes (All) | ▪ Antennas |
| ▪ Light-Emitting Diode (LED) | ▪ Assembly Modules |
| ▪ Rectifier Diode | ▪ Capacitors (All Types) |
| ▪ Schottky Diode | ▪ Detectors |
| ▪ Solar PV Cell, PV Panel | ▪ Inductors / Coil |
| ▪ Unipolar / Bipolar Diode | ▪ Memristor / Network |
| ▪ Varicap | ▪ Resistors (All Types) |
| ▪ Varactor | ▪ Sensors |
| ▪ Zener Diode | ▪ Transducers |
| ▪ Composit Transistors | ▪ Cables |
| ▪ Compound Transistor | ▪ Circuit Protection Devices |
| ▪ Darlington Transistor | ▪ Crystals |
| ▪ Field-Effect Transistor (FET) | ▪ Mechanical Devices such as a Fan, Lamp |
| ▪ JFET (Junction Field-Effect Transistor) | ▪ PCB |
| ▪ MOSFET (Metal Oxide Semiconductor FET) | ▪ Piezoelectric devices |
| ▪ Photo Transistor | ▪ Resonators |
| ▪ Transistors (All) | ▪ Switches |
| ▪ Thyristors | ▪ Terminals and Connectors |

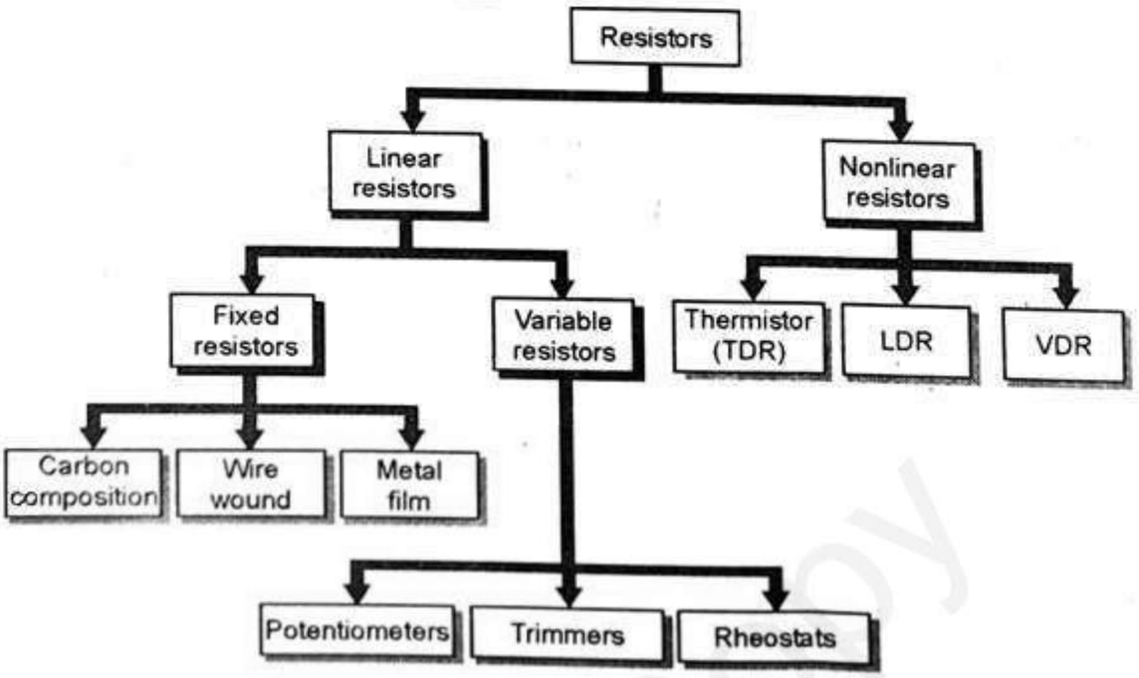
Resistor :

Component that opposes the flow of current called resistance /Resistor.

**Symbol-**

**Unit:** Ohms, (Ω,

### 3.1 Classification of Resistors:



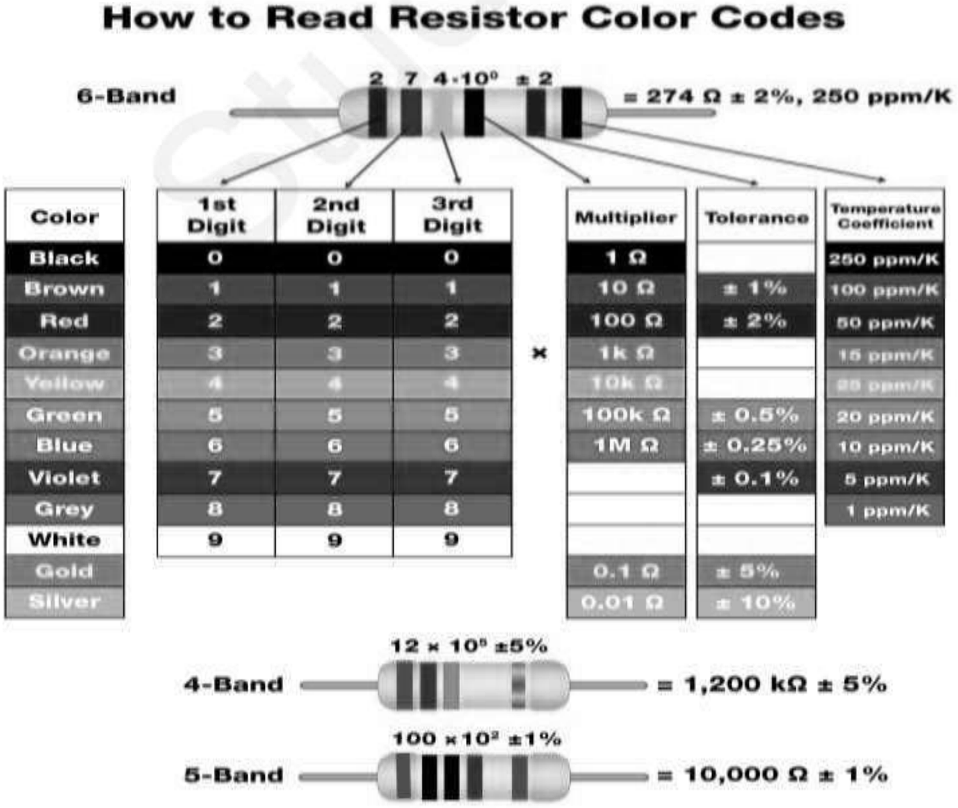
General Specifications of Resistors:

Maximum voltage & current rating: $I_{max}, V_{max}$

Maximum Power rating: $P = I^2R, \frac{V^2}{R}, \quad V \times I \text{ in watts,}$

$$\textit{Available in Ratings of } \frac{1}{4}W, \frac{1}{2}W, 1W, 2W, 5\,W, 10\,W \textit{ etc}$$

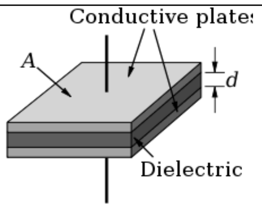
Resistance Value, Tolerance & Temperature Coeff.

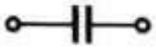


**How to Read Resistor Color Codes**

| Color | 1st Digit | 2nd Digit | 3rd Digit | Multiplier | Tolerance | Temperature Coefficient |
|---|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | 1 Ω | | 250 ppm/K |
| Brown | 1 | 1 | 1 | 10 Ω | ± 1% | 100 ppm/K |
| Red | 2 | 2 | 2 | 100 Ω | ± 2% | 50 ppm/K |
| Orange | 3 | 3 | 3 | 1k Ω | | 15 ppm/K |
| Yellow | 4 | 4 | 4 | 10k Ω | | 25 ppm/K |
| Green | 5 | 5 | 5 | 100k Ω | ± 0.5% | 20 ppm/K |
| Blue | 6 | 6 | 6 | 1M Ω | ± 0.25% | 10 ppm/K |
| Violet | 7 | 7 | 7 | | ± 0.1% | 5 ppm/K |
| Grey | 8 | 8 | 8 | | | 1 ppm/K |
| White | 9 | 9 | 9 | | | |
| Gold | | | | 0.1 Ω | ± 5% | |
| Silver | | | | 0.01 Ω | ± 10% | |

### 3.2 Capacitor-

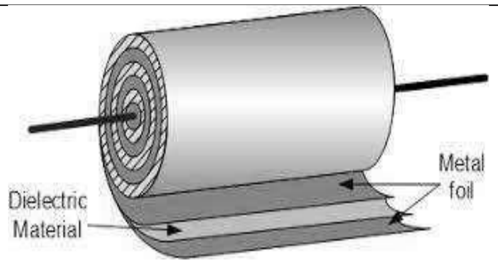




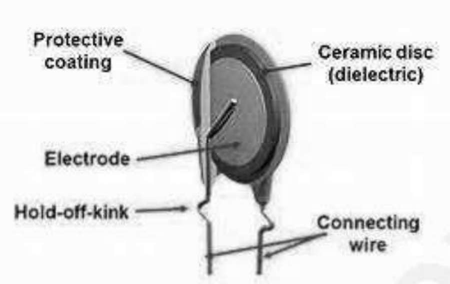
Symbol

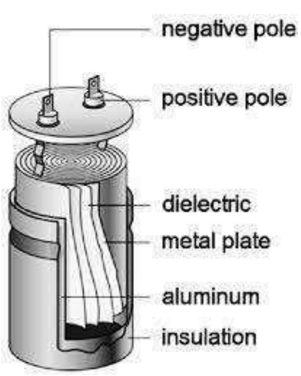
Capacitance $C = \frac{\epsilon A}{d}\ \mu F$

$: pf, nf, \mu f, mf, F$



Cylendrical





Construction
Electrolitic Capacitor

Classification of Capacitors:

Fixed value capacitor

Variable capacitor

Types of Capacitors

Ceramic Capacitors.

Film Capacitors.

Power Film Capacitors.

Electrolytic Capacitors.

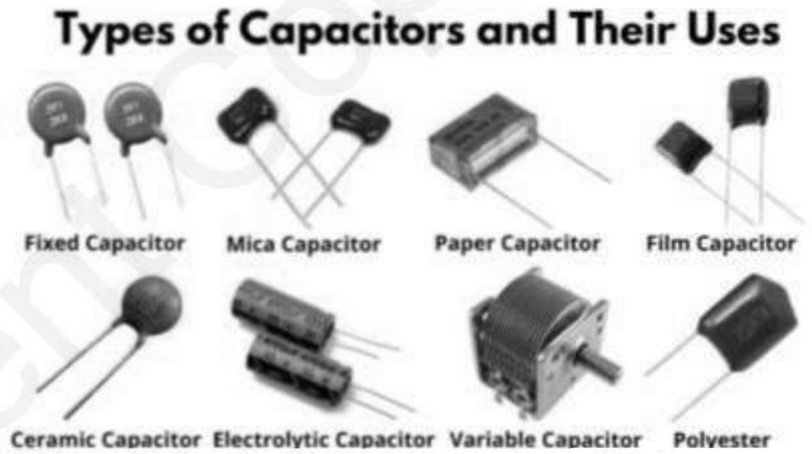
Ceramic capacitors.

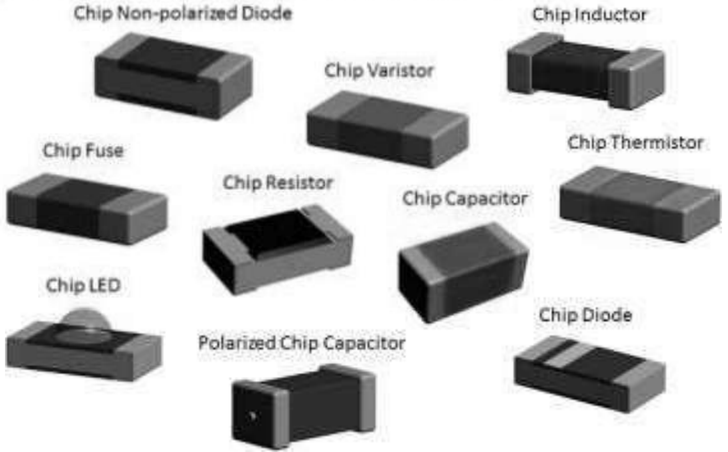
Film capacitors.

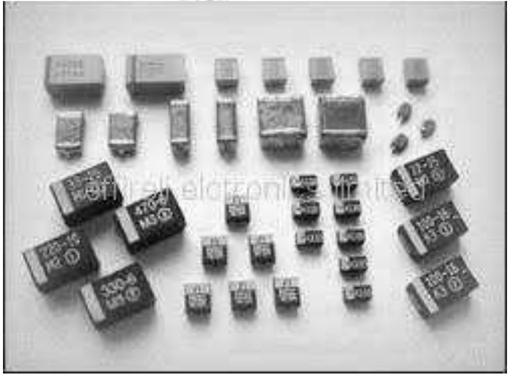
Paper capacitors.

Electrolytic capacitors.

Chip Capacitors & SMDs

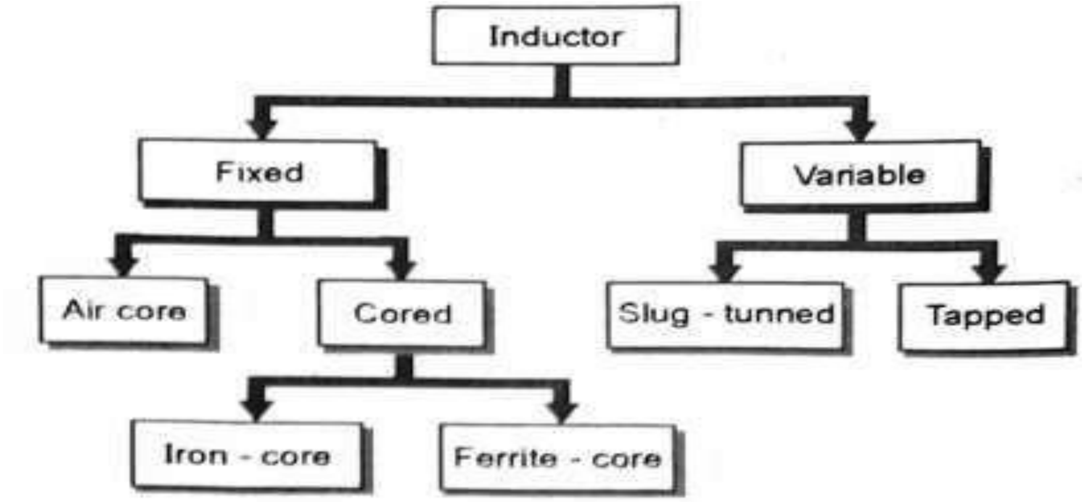






### 3.3 Inductor

**Types of Inductors-1) Fixed Inductor 2) Variable Inductor**



### 3.4 Active Device

**DIODE -**a semiconductor device with two terminals, typically allowing the flow of current in one direction only.

Types of Diode-1) P-N junction diode

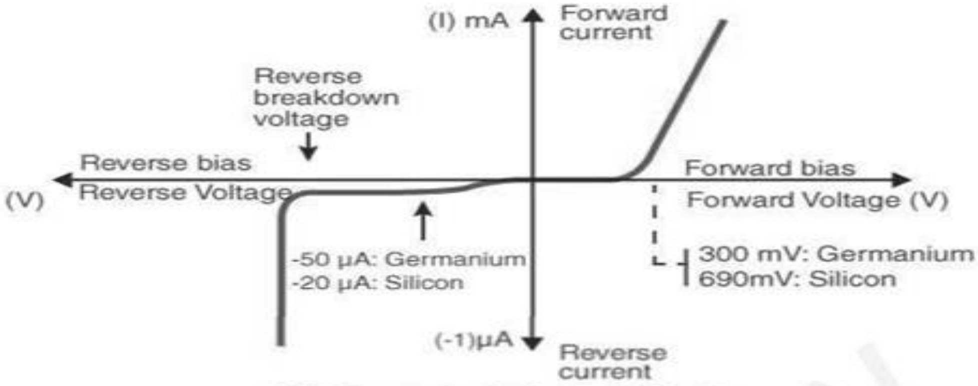
2)Light emitting diode

3)Laser diode

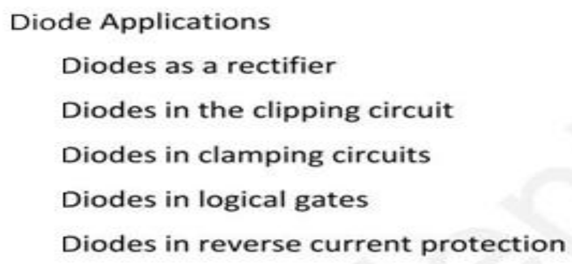
4) Avalanche diode

5)Photo diode

V-I Characterise of P-N junction diode



VI characteristics of Diode



Diode Applications

- Diodes as a rectifier
- Diodes in the clipping circuit
- Diodes in clamping circuits
- Diodes in logical gates
- Diodes in reverse current protection

### 3.4.1 P-N Junction

**Semiconductor-**The material having conductivity in-between conductor and insulator called semiconductor.

Types of semiconductor-I) Intrinsic semiconductor-Pure semiconductor without any impurity called intrinsic semiconductor.e.g.Si,Ge.

II) Extrinsic semiconductor- semiconductor with added some impurity via doping process called extrinsic semiconductor.

Types of Extrinsic semiconductor-i) n-type semiconductor ii) p-type semiconductor

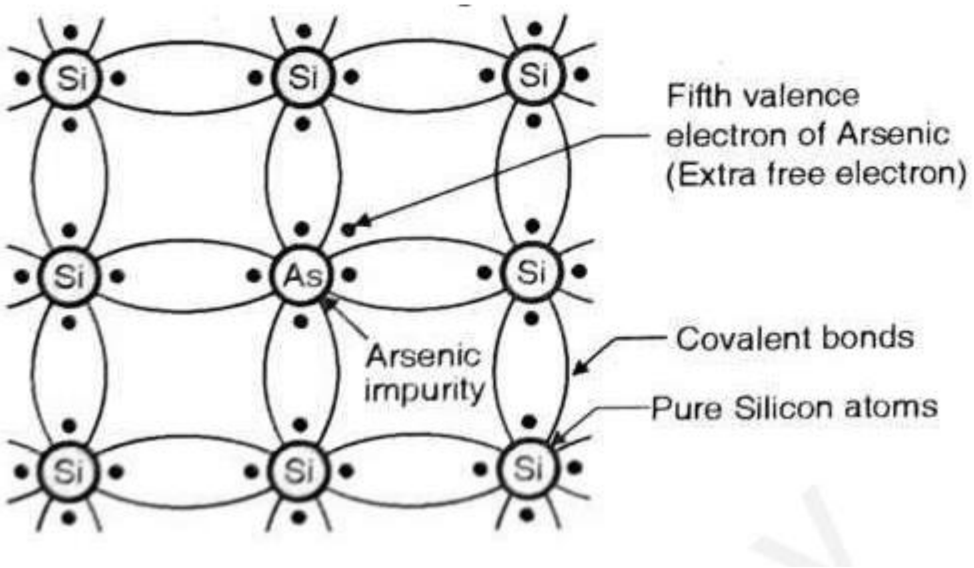
#### i) n- type semiconductor

¬ When a small amount of pentavalent impurity is added to a pure semiconductor, it is called n-type semiconductor.

¬ The pentavalent impurity is also called donor impurity has five valence electrons.

¬ Examples: Phosphorous, Arsenic, Antimony, Bismuth.

¬ Consider the formation of n type material by adding Arsenic(As) into Silicon(Si).



¬ The As atom has five valence electrons. An As atom fits in the silicon crystal in such a way that its four valence electrons from covalent bonds with four adjacent Si atoms.

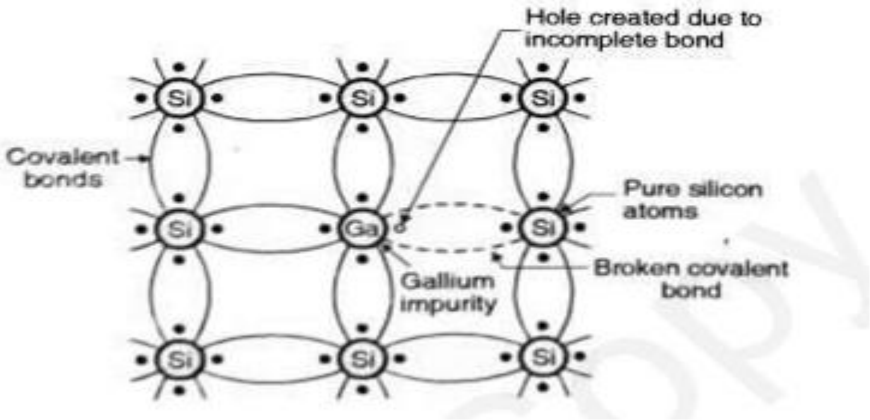
¬ The fifth electron has no chance of forming a covalent bond. It enters the conduction band as a free electron. ¬ One donor impurity atom donates one free electron in n- type material. The free electrons are majority charge carriers.

#### ii) p- type semiconductor

¬ When a small amount of trivalent impurity is added to a pure semiconductor, it is called p-type semiconductor.

¬ The trivalent impurity is also called acceptor impurity has three valence electrons.

¬ Examples: Boron, Aluminium, Gallium, Indium. ¬ Consider the formation of p- type material by adding Gallium(Ga) into Silicon(Si).



¬ The Ga atom has three valence electrons, the fourth covalent bond in the valence shell is incomplete. The resulting vacancy is called a hole.

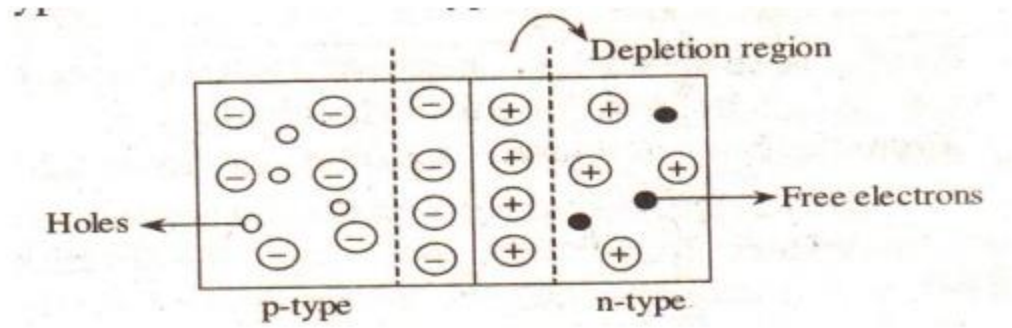
¬ This means that each Ga atom added into Si atom gives one hole.

¬ One acceptor impurity creates one hole in a p- type material. The holes are majority charge carriers.

**Diffusion current:** The flow of charge carriers from a high-density region to low density region constitute diffusion current.

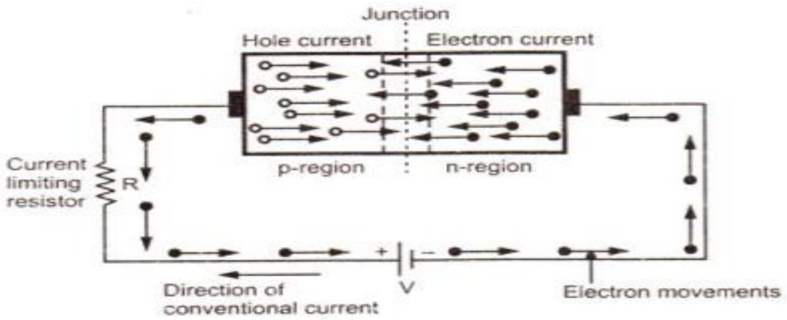
**Drift current:** Whenever voltage is applied to the pn junction, there exist a flow of current because of applied voltage and this current is known as drift current.

**Depletion region:** In a PN junction p-type consists of holes and n-type consists of electrons. Due to diffusion, the large number of holes from p-side diffuse to n-side and similarly, the large number of electrons from n-side diffuse to p-side.



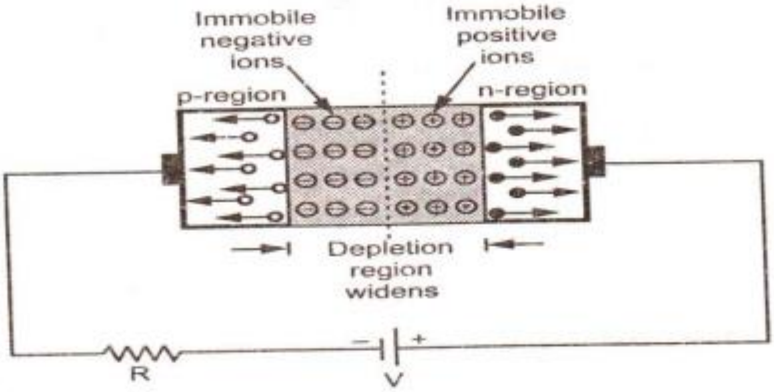
Due to this displacement, p-side looses holes and forms a negative electric field to the left side of junction and n-side looses electrons and forms a positive electric field to the right side of the junction. Because of this large movement of holes and electrons, a barrier potential is developed across the junction. Finally, the holes will combine with free electrons and gets disappear leaving negative potential at p-side near the junction. Similarly, the free electrons will combine with holes and gets disappear leaving positive potential at n-side near the junction. This region at the junction is known as depletion region.

**Forward bias:**



In forward bias, the thickness of depletion layer is very thin because p-type is connected to positive terminal and the n-type is connected to the negative terminal. This causes the holes and electrons to move freely across the junction, hence resulting in a large current.

**Reverse bias:**



In reverse bias, as the p-type is connected to the negative terminal and n-type is connected to the positive terminal, the force of attraction takes place, so the holes from p-side and the electrons from n-side moves away from the junction, thus increasing the width of depletion region. This results in a very little current, almost equal to zero. Therefore, in reverse bias the thickness of the depletion region is large.

**V-I characteristics of P-N junction Diode-**

¬ In forward characteristics- it is seen that initially forward current is small as long as the bias voltage is less than the barrier potential.

¬ At a certain voltage close to barrier potential, current increases rapidly.

¬ The voltage at which diode current starts increasing rapidly is called as cut-in voltage. It is denoted by $V\gamma$

¬ The cut-in voltage for germanium is about 0.2V while for silicon it is 0.6V.

¬ In reverse characteristics, reverse current increases initially as reverse voltage is increased. But after a certain voltage, the current remains constant equal to reverse saturation current.

¬ The voltage at which breakdown occurs is called reverse breakdown voltage denoted as $VBR$.

¬ Reverse current before the breakdown is very small and can be neglected practically.

¬ It is important to note that the breakdown voltage is much higher and practically diodes are not operated in the breakdown condition.

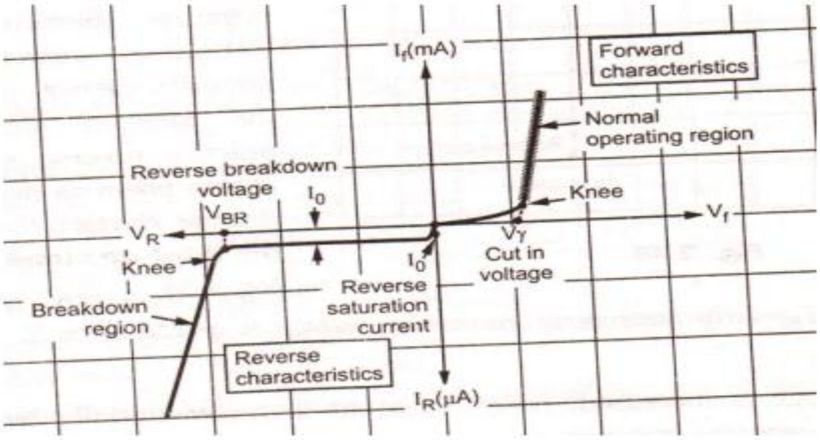


Fig: V-I Characteristics of a Diode

**Ideal Diode model:** An ideal diode is the first and simplest approximation of a real diode. It has no forward voltage drop, no reverse current and no breakdown. In fact, an ideal diode is only a theoretical approximation of a real diode. However, in a well-defined circuit, a real diode behaves almost like an ideal diode because forward voltage across the diode is small as compared to the input and output voltages.

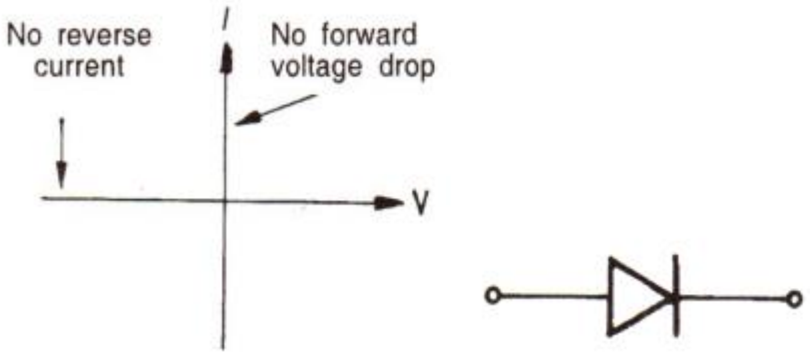


Fig: V-I Characteristics and its Equivalent Circuit of ideal Diode

**Regulated D.C power supply-**

¬ For the operation of most of the electronics devices and circuits, a d.c. source is required. So, it is advantageous to convert domestic a.c. supply into d.c. voltages.

¬ The process of converting a.c. voltage into d.c. voltage is called as rectification. This is achieved with i) Step-down Transformer, ii) Rectifier, iii) Filter and iv) Voltage regulator circuits.

¬ These elements constitute d.c. regulated power supply shown in the figure below

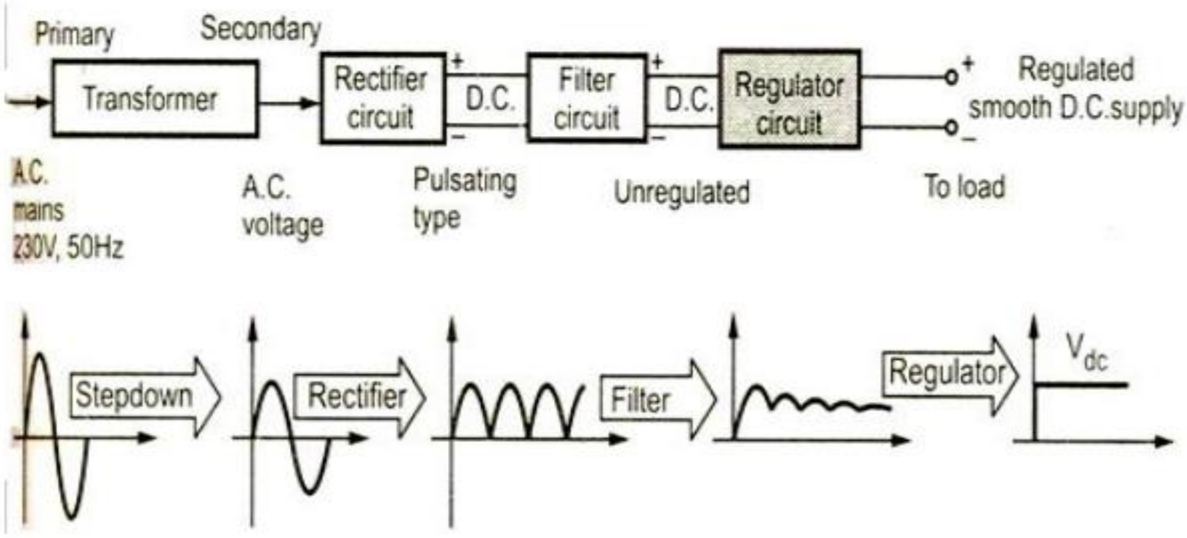


Fig. Block diagram of Regulated D.C. Power Supply

Stepdown Transformer- It steps down the high voltage A.C mains to low voltage A.C,bridge rectifier it converts A.C to D.C but the D.C output is varying. Filter- It will smooth the D.C from varying greatly to a small ripple. Regulator: It eliminates the ripple by setting D.C output to a fixed voltage.

Characteristics of a Rectifier circuit

¬ The most important consideration in designing a rectifier is the unidirectional output voltage. Rectifier enable minimum operable DC voltage at the rated current.

¬ The regulations of rectifier circuit are also good i.e.,0.1%.

¬ The rectifier is protected in the event of short circuit on the load side.

¬ Over voltage protection is incorporated.

¬ The response of rectifier to the temperature changes is minimum.

¬ Transient response of this rectifier circuit is faster i.e., in µsec.

Rectifier- Defined as converting A.C to pulsating D.C output.

Types of rectifier-i) Half wave rectifier ii) Full wave rectifier-a) Centre tap FWR b)Bridge FWR

**i) Half wave rectifier-**

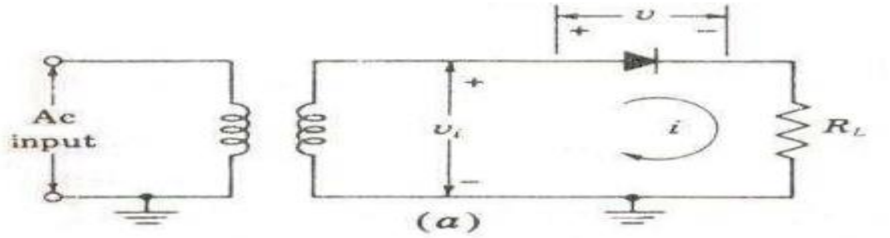
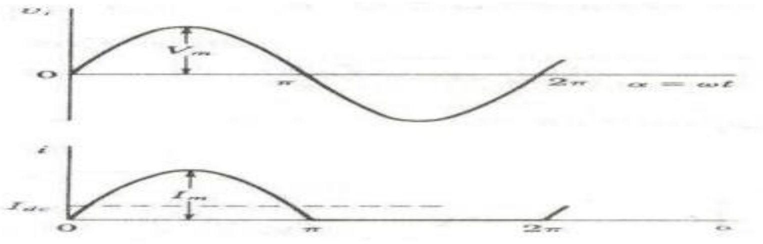


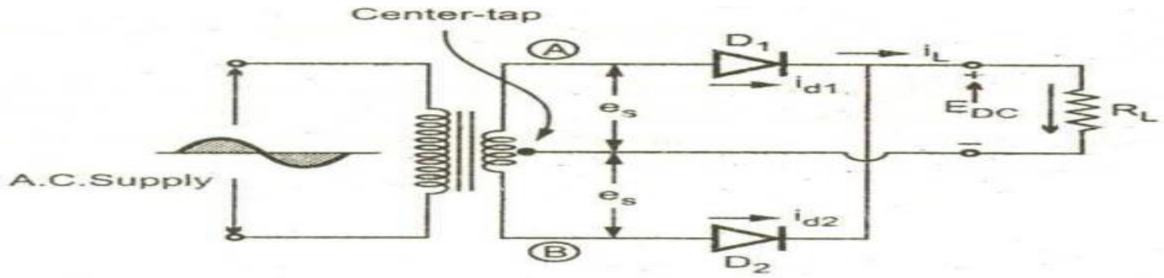
Fig. HWR without capacitor filter



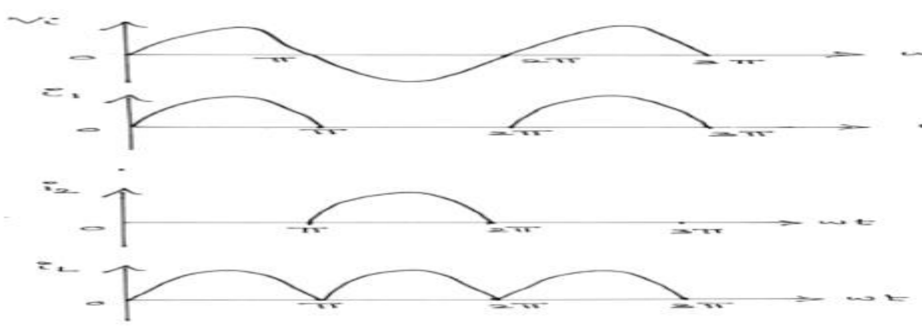
Operation:

¬ For the positive half-cycle of input a.c. voltage, the diode D is forward biased and hence it conducts. Now a current flow in the circuit and there is a voltage drop across RL. The waveform of the diode current (or) load current is shown in figure. For the negative half-cycle of input, the diode D is reverse biased and hence it does not conduct. Now no current flows in the circuit i.e., i=0 and Vo=0. Thus, for the negative half-cycle no power is delivered to the load.

**FWR with centre tap connection-**



➢ The individual diode currents and the load current waveforms are shown in figure below:



**Operation:** ¬ During positive half of the input signal, anode of diode D1 becomes positive and at the same time the anode of diode D2 becomes negative. Hence D1 conducts and D2 does not conduct. The load current flows through D1 and the voltage drop across RL will be equal to the input voltage.

¬ During the negative half cycle of the input, the anode of D1 becomes negative and the anode of D2 becomes positive. Hence, D1 does not conduct and D2 conducts. The load current flows through D2 and the voltage drop across RL will be equal to the input voltage.

¬ It is noted that the load current flows in the both the half cycles of ac voltage and in the same direction through the load resistance.

## Bridge rectifier

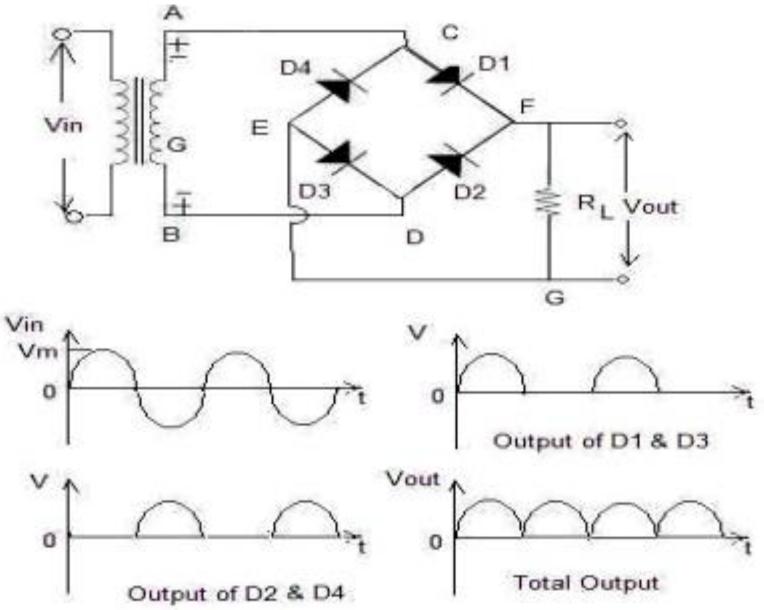


Fig. Bridge rectifier circuit and waveforms

Operation:

¬ For the positive half cycle of the input ac voltage diodes D1 and D3 conduct, whereas diodes D2 and D4 do not conduct. The conducting diodes will be in series through the load resistance RL, so the load current flows through the RL.

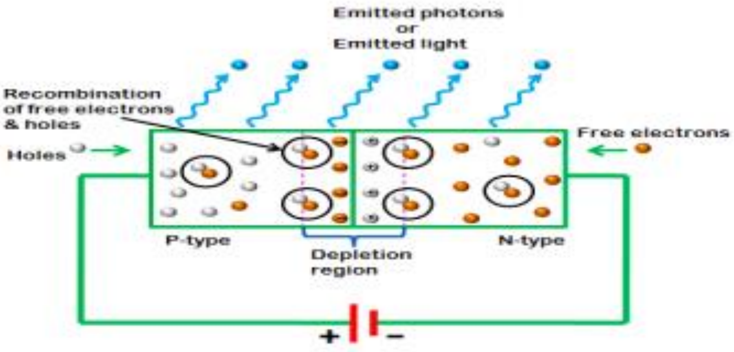
¬ During the negative half cycle of the input ac voltage diodes D2 and D4 conduct, whereas diodes D1 and D3 do not conduct. The conducting diodes D2 and D4 will be in series through the load resistance RL and the current flows through the RL, in the same direction as in the previous half cycle. Thus, a bidirectional wave is converted into a unidirectional wave.

## Comparison between rectifier circuits:

| S.No. | Parameter | Half wave | Full Wave | Bridge |
|---|---|---|---|---|
| 1 | Number of Diodes | 1 | 2 | 4 |
| 2 | Average dc current, $I_{dc}$ | $\frac{I_m}{\pi}$ | $\frac{2I_m}{\pi}$ | $\frac{2I_m}{\pi}$ |
| 3 | Average dc voltage, $V_{dc}$ | $\frac{V_m}{\pi}$ | $\frac{2V_m}{\pi}$ | $\frac{2V_m}{\pi}$ |
| 4 | RMS current, $I_{rms}$ | $\frac{I_m}{2}$ | $\frac{I_m}{\sqrt{2}}$ | $\frac{I_m}{\sqrt{2}}$ |
| 5 | DC Power output, $P_{dc}$ | $\frac{I_m^2 R_L}{\pi^2}$ | $\frac{4I_m^2 R_L}{\pi^2}$ | $\frac{4I_m^2 R_L}{\pi^2}$ |
| 6 | AC Power input, $P_{ac}$ | $\frac{I_m^2(R_L + R_f + R_s)}{4}$ | $\frac{I_m^2(R_L + R_f + R_s)}{2}$ | $\frac{I_m^2(R_L + 2R_f + R_s)}{2}$ |
| 7 | Max. rectifier efficiency(η) | 40.6% | 81.2% | 81.2% |
| 8 | Ripple factor (γ) | 1.21 | 0.482 | 0.482 |
| 9 | PIV | $V_m$ | $2V_m$ | $V_m$ |
| 10 | TUF | 0.287 | 0.693 | 0.812 |
| 11 | Max. load current ($I_m$) | $\frac{V_m}{R_L + R_f + R_s}$ | $\frac{V_m}{R_L + R_f + R_s}$ | $\frac{V_m}{R_L + 2R_f + R_s}$ |
| 12 | Ripple frequency | f | 2f | f |

**Light Emitting Diode (LED)-**

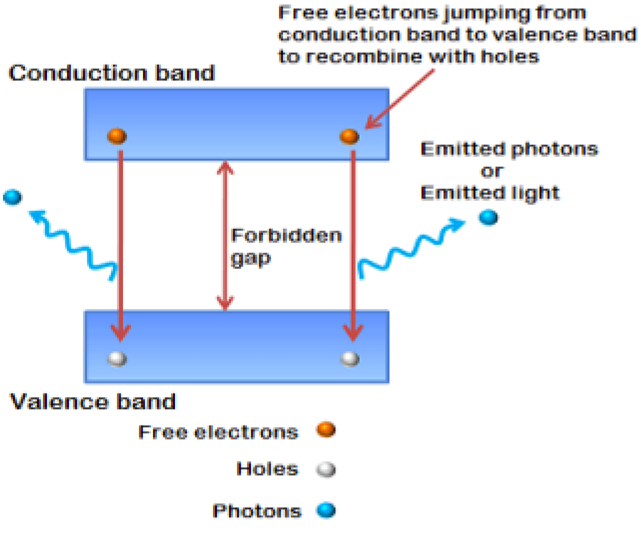
Light Emitting Diode (LED) works only in forward bias condition. When Light Emitting Diode (LED) is forward biased, the free electrons from n-side and the holes from p-side are pushed towards the junction. When free electrons reach the junction or depletion region, some of the free electrons recombine with the holes in the positive ions. We know that positive ions have less number of electrons than protons. Therefore, they are ready to accept electrons. Thus, free electrons recombine with holes in the depletion region. In the similar way, holes from p-side recombine with electrons in the depletion region.



Light Emitting Diode (LED)

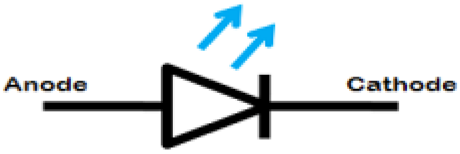
Physics and Radio-Electronics

Because of the recombination of free electrons and holes in the depletion region, the width of depletion region decreases. As a result, more charge carriers will cross the p-n junction. Some of the charge carriers from p-side and n-side will cross the p-n junction before they recombine in the depletion region. Thus, recombination takes place in depletion region as well as in p-type and n-type semiconductor.



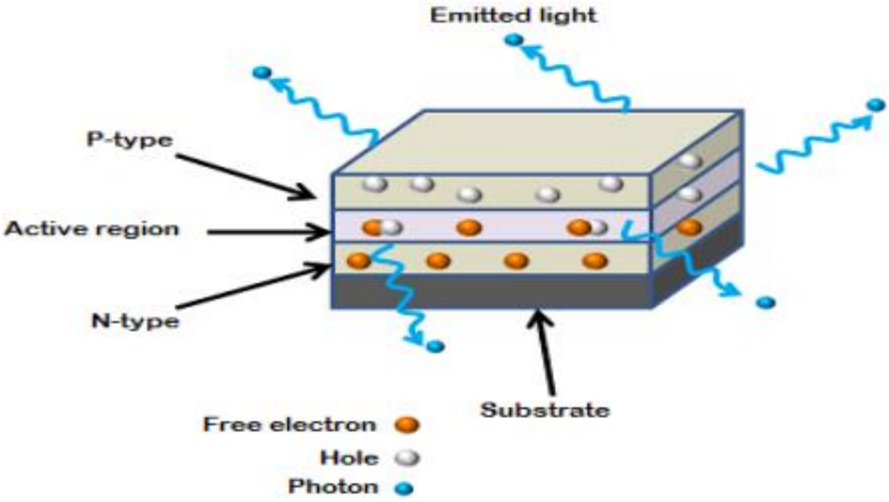
Process of light emission in LED

Physics and Radio-Electronics



LED symbol

**LED construction** One of the methods used to construct LED is to deposit three semiconductor layers on the substrate. The three semiconductor layers deposited on the substrate are n-type semiconductor, p-type semiconductor and active region. Active region is present in between the n-type and p-type semiconductor layers.



Construction of LED

When LED is forward biased, free electrons from n-type semiconductor and holes from p-type semiconductor are pushed towards the active region. When free electrons from n-side and holes from p-side recombine with the opposite charge carriers (free electrons with holes or holes with free electrons) in active region, an invisible or visible light is emitted.

**Advantages of LED**- 1. The brightness of light emitted by LED is depends on the current flowing through the LED. Hence, the brightness of LED can be easily controlled by varying the current. This makes possible to operate LED displays under different ambient lighting conditions.

2. Light emitting diodes consume low energy.

3. LEDs are very cheap and readily available.

4. LEDs are light in weight.

5. Smaller size.

6. LEDs have longer lifetime.

7. LEDs operates very fast. They can be turned on and off in very less time.

8. LEDs do not contain toxic material like mercury which is used in fluorescent lamps.

9. LEDs can emit different colors of light.

**Disadvantages of LED**

1. LEDs need more power to operate than normal p-n junction diodes.

2. Luminous efficiency of LEDs is low. Applications of LED The various applications of LEDs are as follows 1. Burglar alarms systems 2. Calculators

3. Picture phones

4. Traffic signals

5. Digital computers

6. Multimeters

7. Microprocessors

8. Digital watches

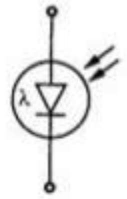
9. Automotive heat lamps

10. Camera flashes

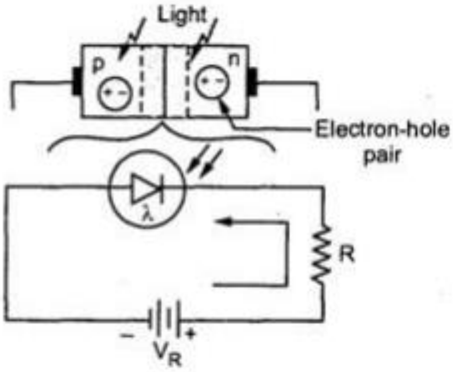
11. Aviation lighting

**Photo Diode**

The photodiode is a semiconductor p-n junction device whose region of operation is limited to the reverse biased region. The Fig shows the symbol of photodiode while the Fig shows the working principle of photodiode. The photodiode is connected in reverse biased condition. The depletion region width is large. Under normal condition, it carries small reverse current due to minority charge carriers. When light is incident through glass window on the p-n junction, photons in the light bombard the p-n junction and some energy is imparted to the valence electrons. Due to this, valence electrons are dislodged from the covalent bonds and become free electrons. Thus more electron-hole pairs are generated. Thus total number of minority charge carriers increases and hence the reverse current increases. This is the basic principle of operation of photodiode.



(a) Symbol



(b) Principle of operation

The reverse current without light in diode is in the range of micro amperes. The change in this current due to the light is also in the range of micro amperes. Thus such a change can be significance observed in the reverse current. If the photodiode is forward biased, the current flow through it is in mA. The applied forward biased voltage takes the control of the current instead of the light. The change in forward current due to light is negligible and can not be noticed. The resistance of forward biased diode is not affected by the light. Hence to have significant effect of light on the current and to operate photodiode as a variable resistance device, it is always connected in reverse biased condition.

Advantages The advantages of photodiode are-

1.Can be used as variable resistance device.

2.Highly sensitive to the light.

3.The speed of operation is very high. The switching of current and hence the resistance value from high to low or otherwise is very fast.

Disadvantages The various disadvantages of photodiode are,

1.The dark current is temperature dependent

2.The overall photodiode characteristics are temperature dependent hence have poor

3.temperature stability.

4.The current and change in current is in the range of 1 which may not be sufficient to drive other circuits. Hence amplification is necessary. Photodiode Applications The two commonly used systems using photodiode are alarm system and a counting system.

**Assignment question on Unit-1**

1. Explain evolution of electronics and effect of it on industry, society.
2. Explain N-type and P-type semiconductors.
3. Define Diffusion and Drift current
4. Explain forward and reverse biasing of P-N junction with necessary diagrams
5. Explain the V-I characteristics of PN Junction Diode.
6. Draw and explain the block diagram of Regulated Power Supply.
7. Draw and explain Half wave Rectifier with waveform.
8. Draw the circuit diagram of a FWR, a) With centre tap connection and b) Bridge connection and explain its operation.
9. Compared between HWR and FWR.
10. Explain construction and working of LED.
11. Explain photo diode with its advantage and disadvantage