Jharsuguda Engineering School, Jharsuguda

Basic Electronics

Lecturer Notes

By

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Chapter-1

Electronic Devices

Basic concept of Electronics and its application :—

Electronics is a branch of engineering which deals with current conduction through a vacuum or gas or semiconductor.

Electronics essentially deals with electronic devices and their utilisation. An electronic device is that in which current flows through a vacuum or gas or semiconductor.

Application of electronics :—

The application of electronics are unlimited. Some important applications are

→ Entertainment and Communications : TV, Radio, Mobile

→ Control and Instrumentation : Traffic light control, CRO, Multimeter.

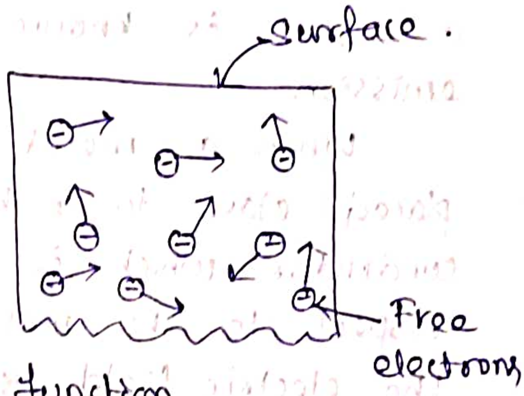
→ Applications in Medicine Science : X-Ray, ECG, MRI

→ Applications in Defence : RADAR, ships, aeroplanes, guided missiles.

Basic concept of Electron Emission & its types :—

The liberation of electrons from the surface of a substance is known as electron emission.

The metallic surface offers a barrier to free electrons and is known as surface barrier.



The amount of additional energy required to emit an electron from a metallic surface is known as work function of that metal.

There are four types of electron emission

(1) Thermionic Emission

(2) Field Emission

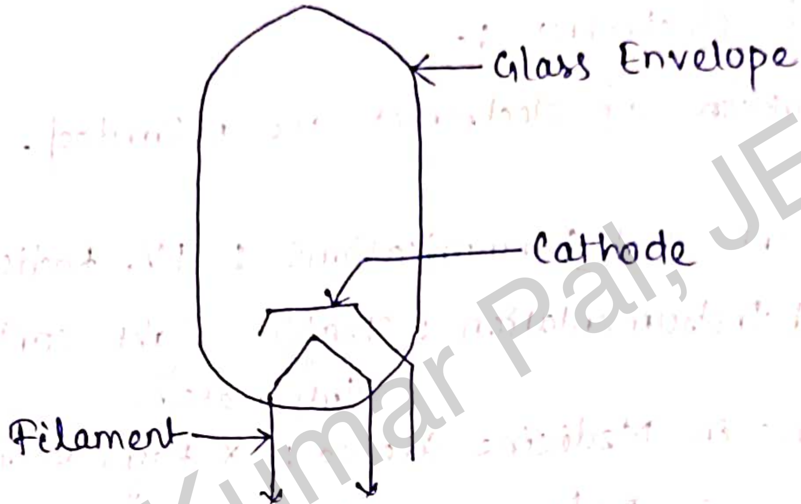
(3) Photo-electric emission

(4) Secondary emission.

1. Thermionic Emission :

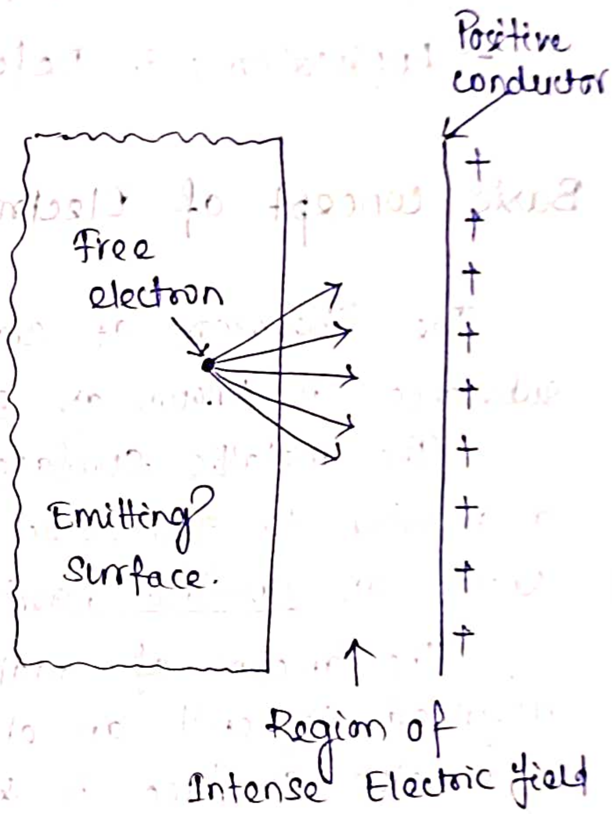
The process of electron emission from a metal surface by supplying thermal energy to it is known as thermionic emission.

In this method, the metal is heated to sufficient temperature to enable the free electrons to leave the metal surface.. The number of electrons emitted depends on the temperature. The higher the temperature, the greater is the emission of electron. This type of emission is employed in vacuum tubes.



2. Field Emission :

The process of electron emission by the application of strong electric field at the surface of a metal is known as field emission.

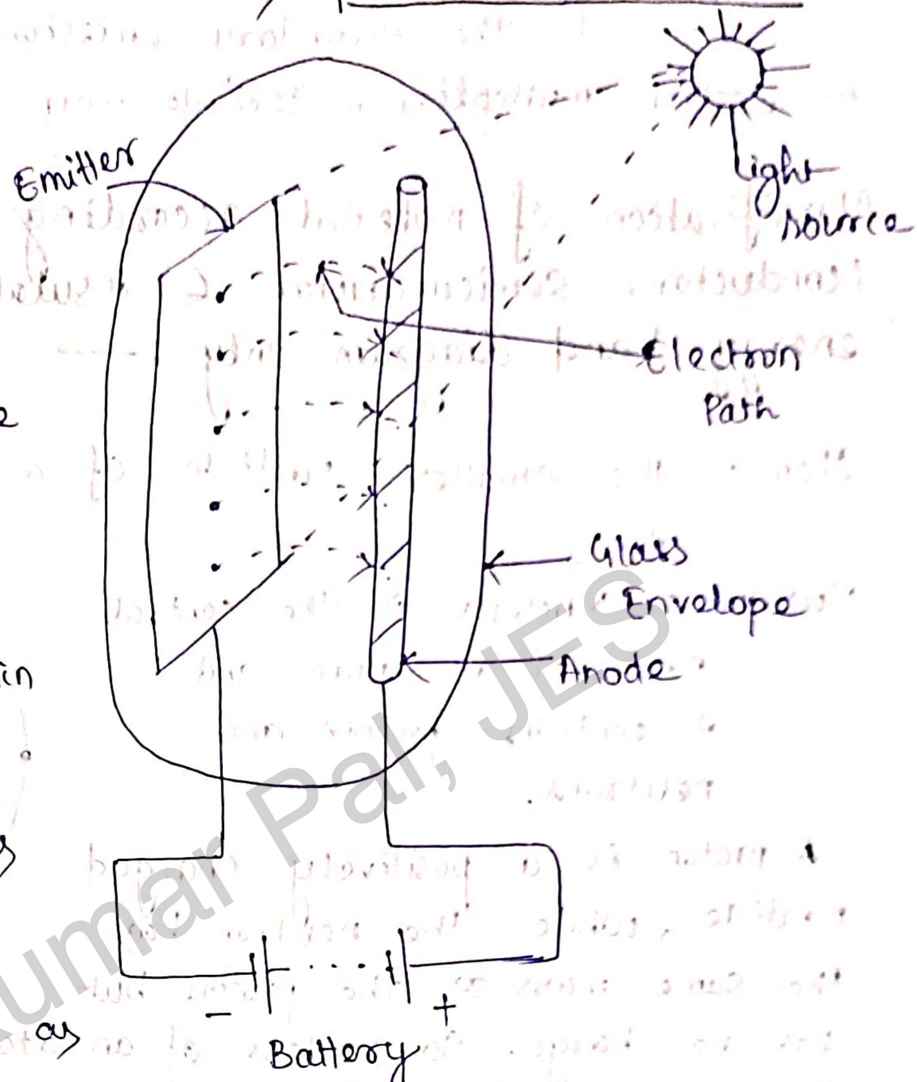


When a metal surface is placed close to a high voltage conductor which is positive with respect to the metal surface, the electric field exerts attractive force on the free electrons in the metal.

For this, very intense electric field is required to produce field emission. It is also sometimes called cold-cathod emission as it required very low temperature..

3. Photo-Electric Emission :

Electron emission from a metallic surface by the application of light is known as photo-electric emission.



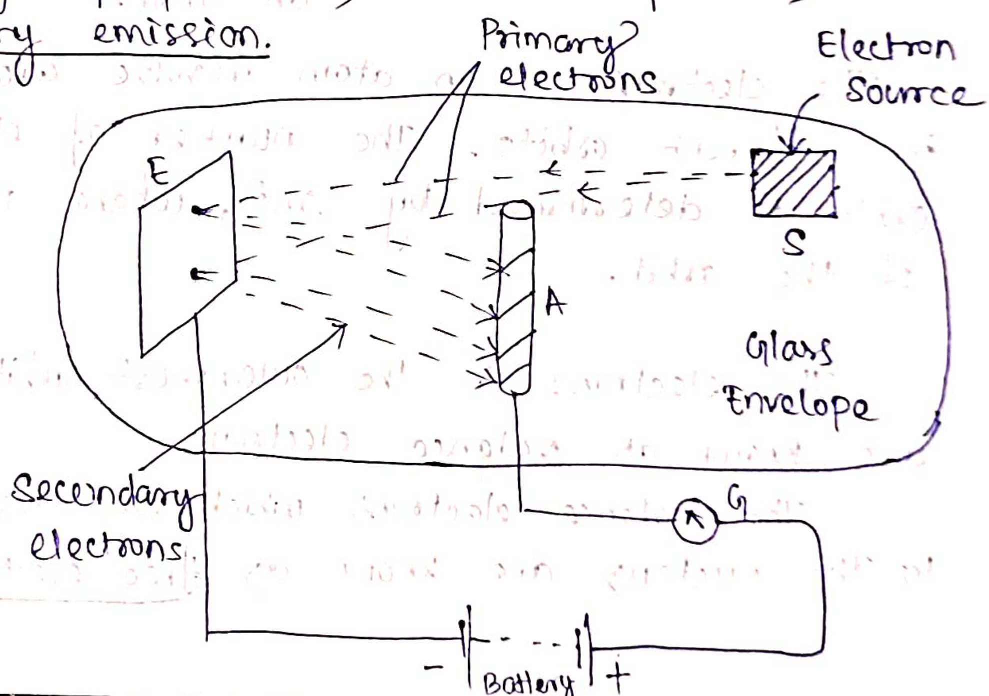
The metal surface is mainly made up of potassium, sodium etc.

When a beam of light strikes the surface of certain metals the energy of photons of light is transferred to the free electrons within the metal.

The emitted electrons are known as photo electrons and the phenomenon is known as photo electric emission.

4. Secondary Emission :

Electron emission from a metalic surface by the bombardment of high speed electrons or other particles is known as secondary emission.



When high speed electrons suddenly strike a metallic surface, they may give some or all of their kinetic energy to the free electrons in the metal.

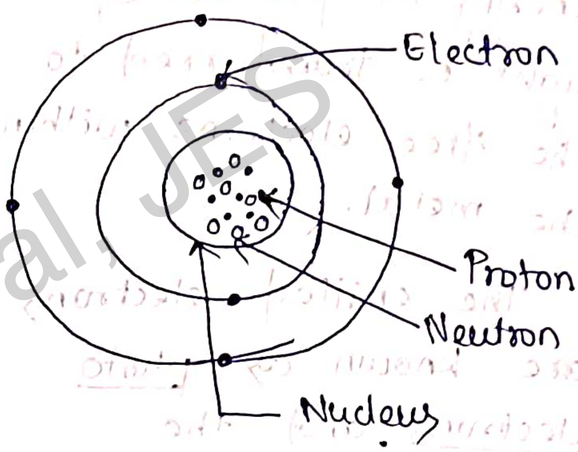
The electrons that strike the metal are called primary electrons while the emitted electrons are known as secondary electrons.

The secondary emission effects are utilised in electron multiplier, cathode ray tube etc.

Classification of material according to electrical conductivity (conductor, semiconductor & insulator) with respect to energy band diagram only :—

Atom : The smallest particle of a material is called atom.

Nucleus : Nucleus is the central part of an atom and it contains protons and neutrons.



A proton is a positively charged particle, while the neutron has the same mass as the proton but has no charge. So, nucleus of an atom is positively charged.

Atomic weight = no. of proton + no. of neutrons

Atomic number = no. of protons or electrons in an atom.

The electrons in an atom revolve around the nucleus in different orbits. The number of electrons in any orbit is determined by $2n^2$, where n is the number of the orbit.

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

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

All electrons in the conduction band are free electrons.

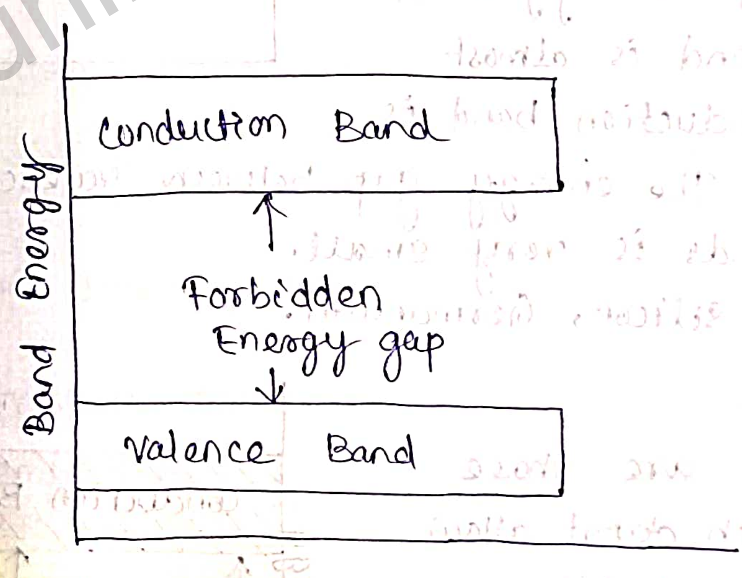
Energy Bands : The range of energies possessed by an electron in a solid is known as energy band.

Valence Band : The range of energies possessed by valence electrons is known as valence band.

Conduction Band: In some meterials, the valence electrons are loosely attached to the nucleus. At ordinary temperature, some valence electrons may get detached to become free electrons. These free electrons are responsible for the conduction of current in a conductor. So, they are called conduction electrons.

The range of energies possessed by conduction band electrons is known as conduction Band.

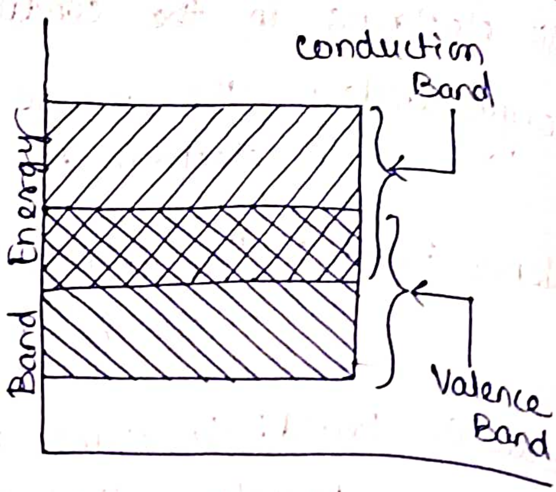
Forbidden Energy gap : The separation between conduction band and valence band on the energy level diagram is known as forbidden energy gap.



According to electrical conductivity materials can be classified as
(1) Conductors
(2) Semiconductors
(3) Inseulators

1. Conductors :—

Conductors are those substances which easily allow the passage of electric current through them. It is because there are a large number of free electrons available in a conductor.

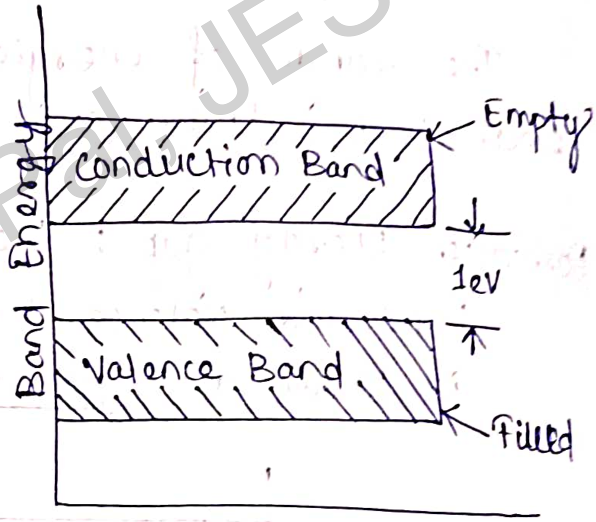


In terms of energy band, the valence and conduction bands overlap each other. Due to this overlap, by applying a small electric field, current conduction is possible.

Examples : Copper, Aluminium.

2. Semiconductors :—

Semiconductors are those substances whose electrical conductivity lies between conductors and insulators.



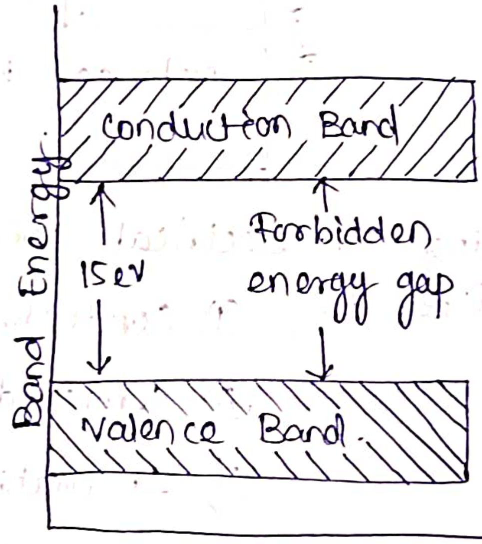
In terms of energy band, the valence band is almost filled and conduction band is almost empty. The energy gap between valence and conduction bands is very small.

Examples : Silicon, Germanium.

3. Insulators :—

Insulators are those substances which donot allow the passage of electric current through them.

Examples : wood, paper, glass.



In terms of energy band, the valence band is full while the conduction band is empty. The energy gap between valence and conduction band is very large. So, a very high electric field is required to push the valence electrons to the conduction band.

Semiconductor :—

A semiconductor is a substance which has resistivity in between conductors and insulators. Eg: Silicon, Germanium.

Properties :—

(i) The resistivity of a semiconductor is less than an insulator but more than a conductor.

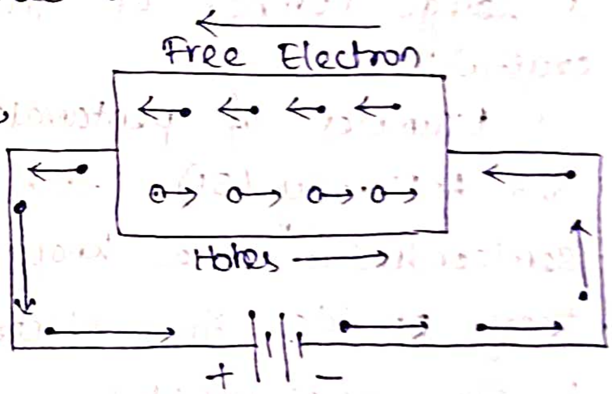
(ii) Semiconductor have negative temperature co-efficient of resistance.

(iii) When a suitable metallic impurity is added to a semiconductor, its current conducting properties change appreciably.

Semiconductors can be classified into two categories
(i) Intrinsic Semiconductor
(ii) Extrinsic Semiconductor.

(i) Intrinsic Semiconductor :—

A semiconductor in an extremely pure form is known as Intrinsic semiconductor.



(Intrinsic Semiconductor)

In an intrinsic semiconductor, at room temperature, hole-electron pairs are created. When electric field is applied across the intrinsic semiconductor, the current conduction takes place by two processes, ie by free electrons and holes.

So, the total current inside the semiconductor is the sum of currents due to free electrons and holes. But the total current is very little for practical application.

(ii) Extrinsic Semiconductor :—

The intrinsic semiconductor has little current conduction capability at room temperature. To increase its conductivity, a suitable impurity is added to a semiconductor. Then it is called extrinsic semiconductor.

The process of adding impurities to a semiconductor is known as doping. The impurity which is used for doping is known as dopant.

Depending upon the type of impurity added, extrinsic semiconductors are classified as

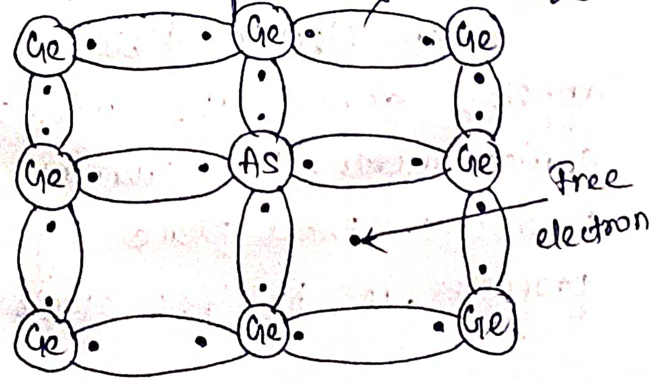
(a) n-type semiconductor
(b) p-type semiconductor

(a) n-type Semiconductor :—

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

The addition of pentavalent impurity provides a large number of free electrons in the semiconductor crystal.

Examples of pentavalent impurities are Arsenic (33) and Antimony (51). Such impurities which produce n-type semiconductor are known as doner impurities because they provide free electrons to the semiconductor crystal.



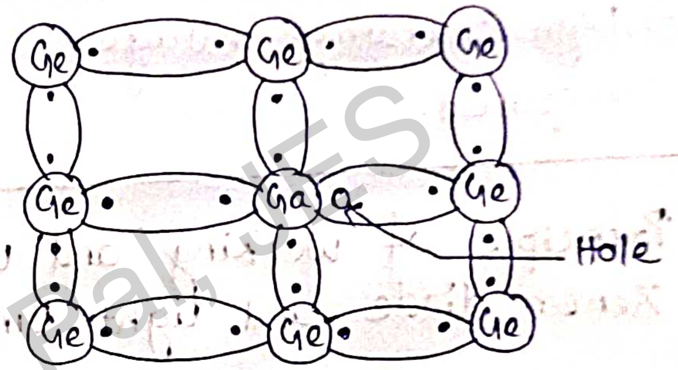
In n-type semiconductor, the majority charge carriers are electrons and the minority charge carriers are holes.

(b) p-type Semiconductor :—

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

The addition of trivalent impurity provides a large number of holes in the semiconductor.

Examples of trivalent impurities are Gallium and Indium. Such impurities which produce p-type semiconductor are known as acceptor impurities because the holes created can accept the electrons.



The current conduction possible in reverse bias due to minority charge carrier.

In p-type semiconductor, the majority charge carriers are holes and the minority charge carriers are electrons.

Difference between Intrinsic & Extrinsic Semiconductor :—

Intrinsic Semiconductor	Extrinsic Semiconductor
(1) Semiconductor in a pure form is called intrinsic semiconductor	(1) Semiconductor in which are doped with impurity is called extrinsic semiconductor.
(2) Here the charge carriers are produced only due to thermal agitation.	(2) Here the charge carriers are produced due to impurities and may also be produced due to thermal agitation.
(3) They have low electrical conductivity.	(3) They have high electrical conductivity.
(4) They have low operating temperature.	(4) They have high operating temperature.
(5) At 0K, Fermi level exactly lies between conduction band and valence band.	(5) At 0K, Fermi level exactly lies closer to conduction band in 'n' type semiconductor and lies near valence band in p-type semiconductor.
Eg: Si, Ge etc.	Eg: Si and Ge doped with Al, In, P, As etc

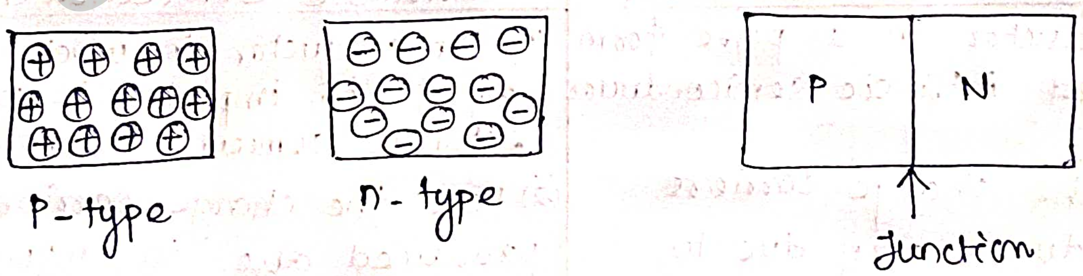
Difference between Vacuum tube and Semiconductor :—

Vacuum Tube	Semiconductor
(1) It is big in size.	(1) It is small in size.
(2) It is heavy in weight.	(2) It is light in weight.
(3) It has short life.	(3) It has long life.
(4) Heating filament is required.	(4) Heating filament is not required.
(5) operation is delayed.	(5) operation is faster.
(6) It is a high power device.	(6) It is a low power device.
(7) High operating voltage required.	(7) low operating voltage required.

Principle of working and use of PN junction diode, Zener diode and light Emitting Diode (LED) :—

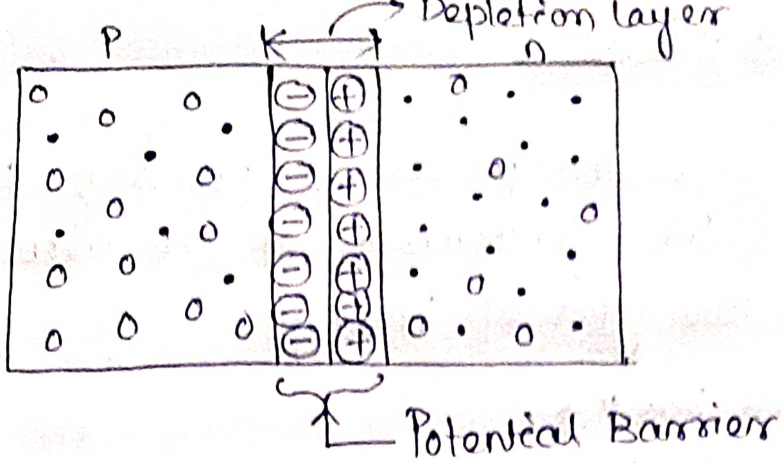
PN Junction Diode :—

When a p-type semiconductor is suitably joined to n-type semiconductor, the contact surface is called p-n junction.



When it is formed the electron from n-type semiconductor move to the p-type and hole from p-type move to n-type.

This phenomenon creates a space charge region at the junction or depletion region at the junction.



At the instance of PN junction formation, the free electrons near the junction in the n-region begin to diffuse across the junction into the p-region where they combine with holes near the junction. This creates a layer of positive charges near the junction.

As the electrons move across the junction, the p-region losses holes as the electrons and holes combine. This creates a layer of negative charges near the junction. These two layers of positive and negative charges form the depletion region.

Then the electric field is developed due to flow of electrons and holes. Hence the potential difference is create at junction which create a potential barrier.

The more of the height of potential barrier the more opposition for the charges to flow.

The typical barrier potential is approximately

for silicon, $V_0 = 0.7V$.

for germanium; $V_0 = 0.3V$.

Working of PN junction :

Biasing :

Biasing is the process of providing DC voltage which helps in the functioning of the circuit.

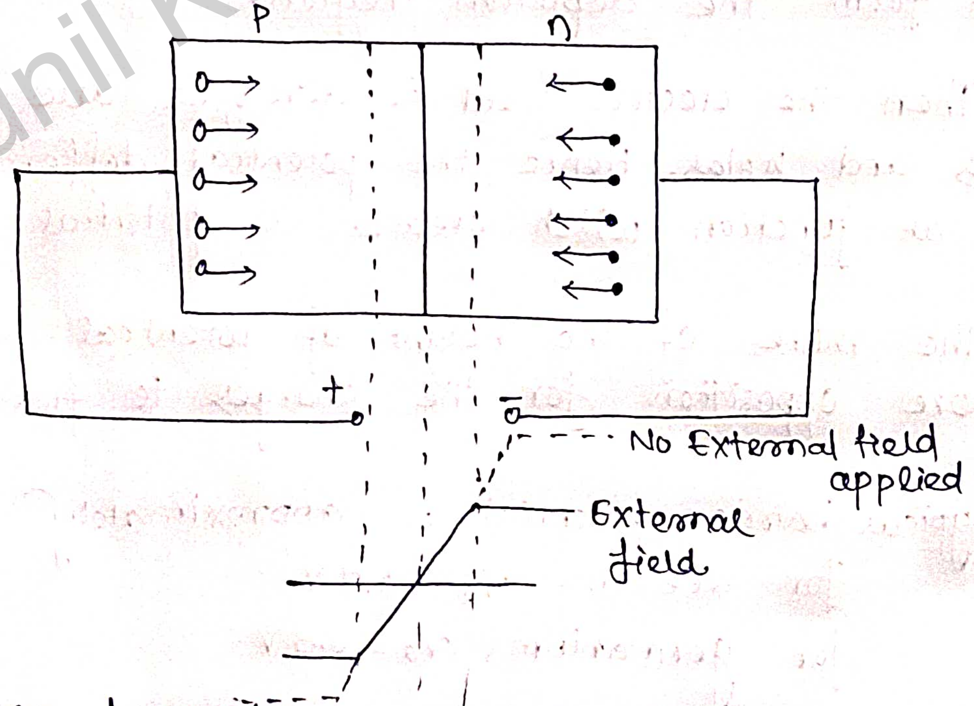
There are two types of biasing

(1) Forward Biasing
(2) Reverse Biasing

Forward Biasing

When a positive terminal is connected to p-side and -ve terminal is connected to n-side of a PN junction, through an external battery, then it is said to be forward biased.

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



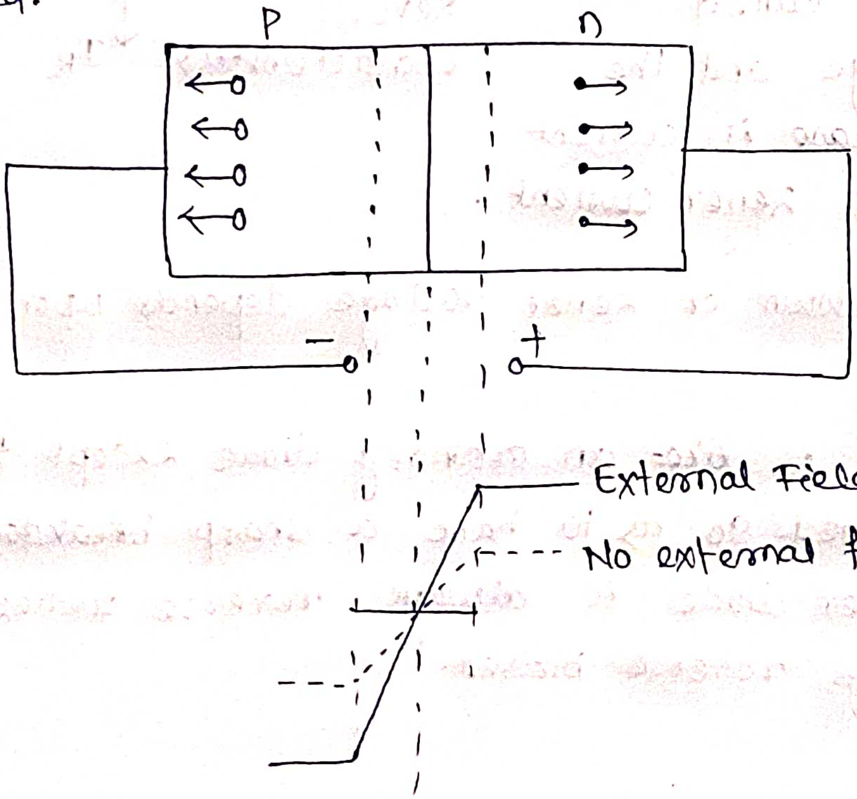
To apply forward bias connect positive terminal of the battery to p-type and negative terminal to n type. The applied forward potential establishes the electric field which acts against the field due to potential barrier.

Therefore, the resultant field is weakened and the barrier height is reduced at the junction. As potential barrier voltage is very small (0.1 to 0.3V), therefore, a small forward voltage is sufficient to completely eleminate the barrier.

Once the potential barrier is eliminated by the 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.

<u>Reverse Biasing</u>:- "When the external D.C. voltage applied to the junction is in such a direction that potential barrier is increased, it is called reverse biasing."

To apply reverse bias, connect negative terminal of the battery to p-type and positive terminal to n-type. It is clear that applied reverse voltage establishes an electric field which acts in the same direction as the field due to potential barrier. Therefore, the resultant field at the junction is strengthened and the barrier height is increased.



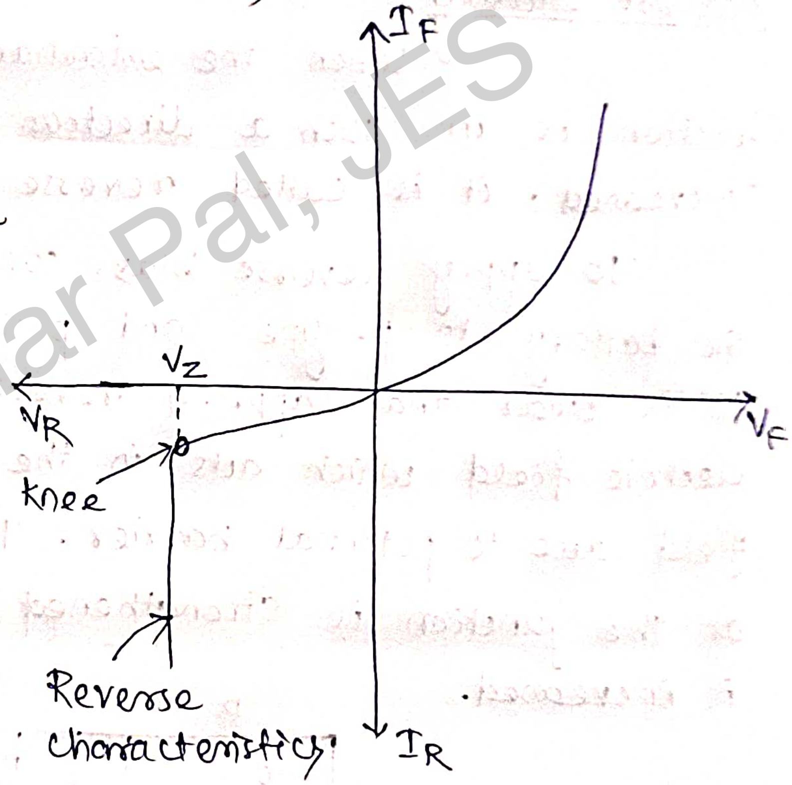
The increased potential barrier prevents the flow of charge carriers across the junction. Thus, a high resistance path is established for the entire circuit and hence the current does not flow.

Zener Diode:

A properly doped crystal diode which has a sharp breakdown voltage is known as a zener diode.

(Symbol of zener diode)

When the reverse bias on a crystal diode is increased, a critical voltage called breakdown voltage is reached where the reverse current increases sharply to a high value.



The breakdown voltage is sometimes called zener voltage and the sudden increase in current is known as zener current.

The breakdown or zener voltage depends upon the amount of doping.

A Zener diode is like an ordinary diode except that is properly doped so as to have a sharp breakdown voltage.

A zener diode is always reverse connected, means it is always reverse biased.

A zener diode has sharp breakdown voltage, called zener voltage (V_Z). When forward biased, its characteristics are just those of ordinary diode. The zener diode is not immediately burnt just because it has entered the break-down region.

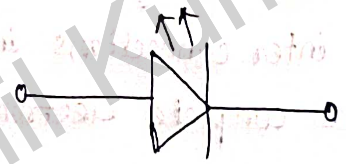
Applications: voltage regulator, stabilizer etc.

Light Emitting Diode (LED):

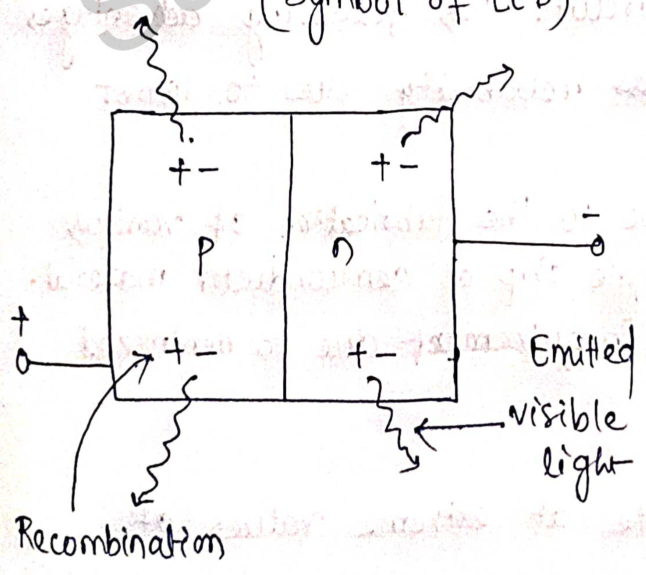
A light emitting diode (LED) is a diode that gives off visible light when forward biased.

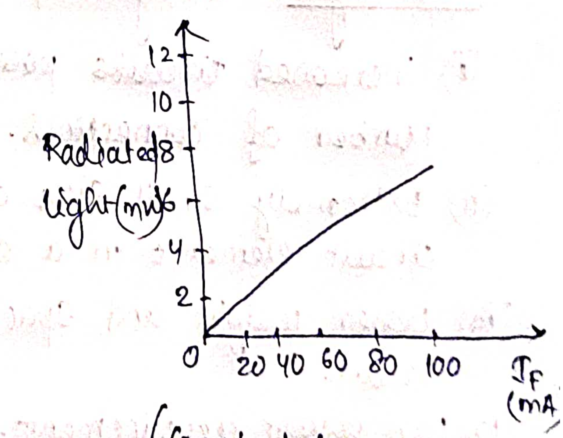
LEDs are made from gallium, phosphorus and arsenic. By varying the quantities of these elements, it is possible to produce light of different wavelengths with colours that include red, green, yellow and blue.

When a LED is manufactured using gallium arsenide, it will produce a red light. If the LED is made from gallium phosphide, it will produce a green light.



(Symbol of LED)





(Graph between radiated light and the forward current of the LED)

→ In this graph, the intensity of radiated light is directly proportional to the forward current of LED.

When light emitting diode (LED) is forward biased, the electrons from the n-type material cross the P.N junction and recombine with holes in the p type material.

When recombination takes place, the recombining electrons release energy in the form of heat and light.

Application: Power indicator, Home applience, Decoration, seven segment display.

Advantages: low voltage, longer life and fast on-off switching.

Disadvantages: slight excess voltage will damage the LED.

Integrated Circuits (ICs) & its advantages:

An integrated circuit is one in which circuit components such as transistors, diodes, resistors, capacitors etc are automatically part of small semiconductor chip.

An integrated circuit consists of a number of circuit components and their inter connections in a single small package to perform a complete electronic function.

Advantages: Integrated circuits has following advantages

(i) Increased ~~circuits possess~~ reliability due to lesser number of connections.

(ii) Extremely small size due to the fabrication of various circuit elements in a single chip of semiconductor material.

(iii) Lesser weight and space requirement due to minimized circuit.

(iv) Low power requirements.

(v) Greater ability to operate at extreme values of temperature.

(vi) Low cost.

(vii) The circuit layout is greatly simplified.

Disadvantages :

The disadvantages of integrated circuits are :

(i) If any component in an IC goes out of order, the whole IC has to be replaced by new one.

(ii) It is not possible to fabricate inductors and transformers on the surface of semiconductor chip.

(iii) It is not possible to produce high power ICs.

(iv) There is a lack of flexibility in an IC.

Applications :

computer, laptops, TV, mobile, voltage regulator, electronic devices etc.

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Assignment - 1

1. What is electronics and what are the applications of electronics?
2. Classify the materials according to electrical conductivity with respective energy band diagram.
3. Differentiate between Intrinsic and Extrinsic Semiconductor.
4. Differentiate between vacuum tube and semiconductor.
5. Define PN junction diode and explain its working.
6. Define Zener diode and explain its working.
7. Explain working of LED and write its applications.
8. Define integrated circuit and write its advantages and disadvantages.

Rectifier :-

Rectifier is an electronic device which converts alternating current into direct current.

Rectification:-

The process of converting alternating current into direct current is called rectification.

→ Rectifier is of two types.

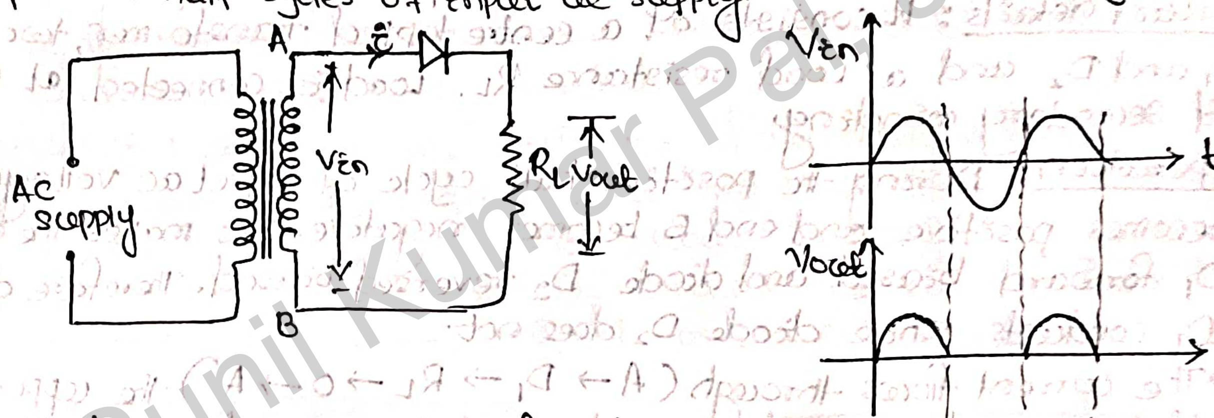
(i) Half wave Rectifier
(ii) Full wave Rectifier

→ Again full wave rectifier is of two types.

(i) centre-tap full wave Rectifier
(ii) full wave Bridge Rectifier.

Half wave Rectifier

→ In half wave rectification the rectifier conducts current only during the positive half cycles of input ac supply.



Circuit details: It consists of a diode, a transformer and load resistance R_L. Generally ac supply is given through a transformer.

Operation: During positive half cycle of input ac voltage, end A becomes positive and end B becomes negative. This makes the diode forward biased and hence it conducts current. and the current flows through the load R_L.

→ During negative half cycle end A is negative and end B is positive. This makes diode reverse biased and does not conduct.

→ Therefore current flows through the diode during positive half cycles only.

→ The output obtained across R_L is pulsating in nature.

Advantage:

→ Easy to design.
→ Less costly.

Disadvantage

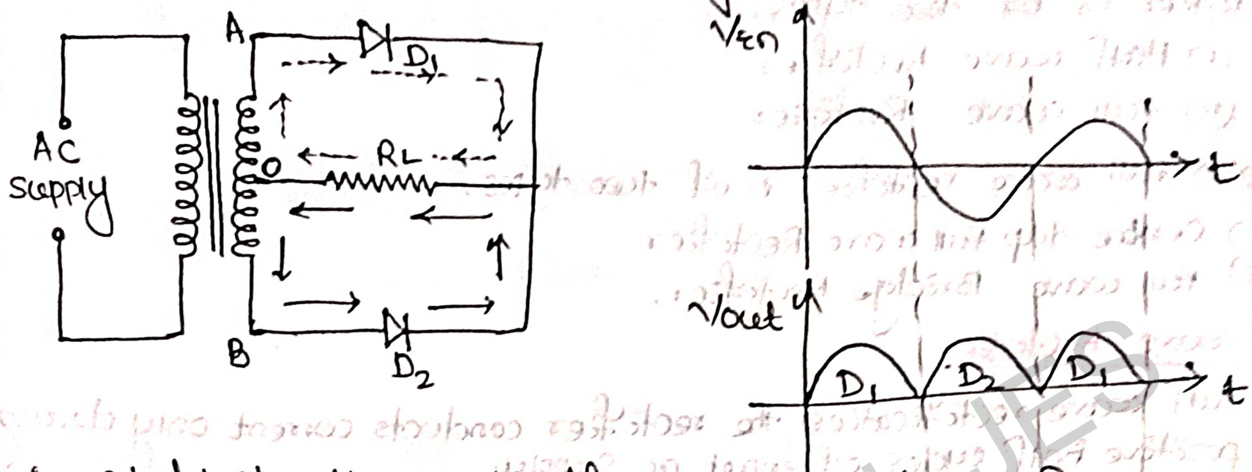
→ output is low.
→ output is pulsating dc. so filter circuit is required to get pure dc.

Rectifier efficiency $\eta = \frac{\text{dc power output}}{\text{Input ac power}}$

$\eta\% = 40.6\%$

Centre-Tap full wave Rectifier

In full-wave rectification, current flows through the load for both half cycles of input ac voltage.



Circuit details: It consists of a centre tapped transformer, two diodes D_1 and D_2 and a Load resistance R_L. Load is connected at centre of secondary winding.

Operation: During the positive half cycle of input ac voltage, end A becomes positive and end B becomes negative. This makes the diodes D_1 forward biased and diode D_2 reversed biased. Therefore diode D_1 conducts while diode D_2 does not.

→ The current flows through ($A \to D_1 \to R_L \to O \to A$) the upper half of the secondary winding as shown by the dotted arrows.

→ During negative half cycle of input ac voltage, end A becomes negative and end B becomes positive. This makes the diodes D_1 reverse biased and diode D_2 forward biased. Therefore diode D_2 conducts while diode D_1 does not.

→ The current flows though ($B \to D_2 \to R_L \to O \to B$) the lower half of the secondary winding as shown by the solid arrows.

→ The current in the Load R_L is in the same direction for both half cycles of input ac voltage. Therefore same output is obtained for both the half cycles.

Advantages

→ output is high than half wave rectifier.

Disadvantages

→ It is difficult to locate the centre tap on the secondary winding

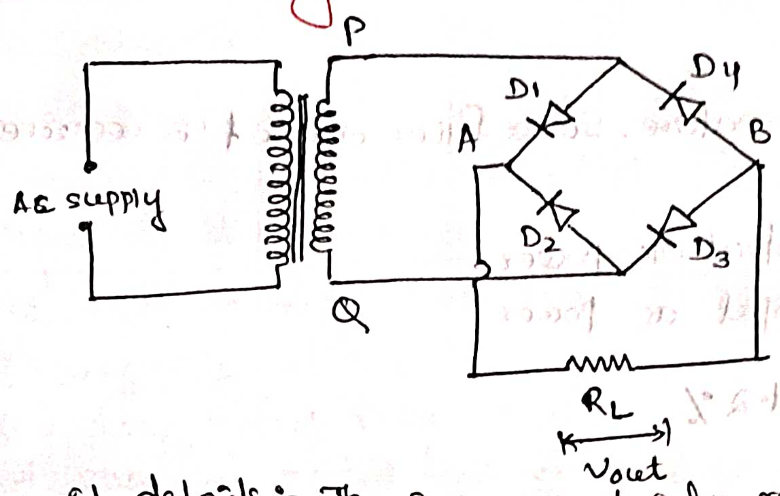
→ The diodes used must have high peak inverse voltage ($PIV = 2V_m$)

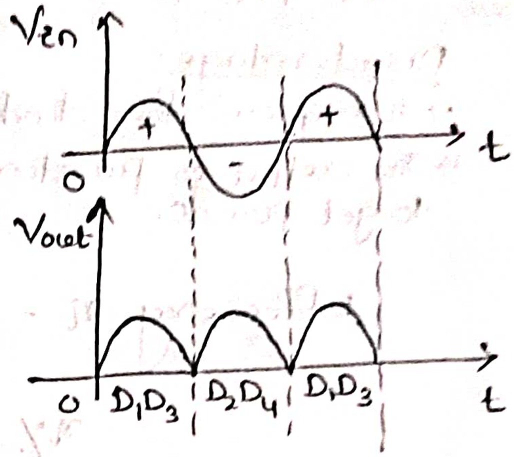
→ The dc output is smaller than full wave bridge rectifier.

Efficiency $\eta = \frac{\text{dc power output}}{\text{Input ac power}}$

$\eta\% = 81.2\%$

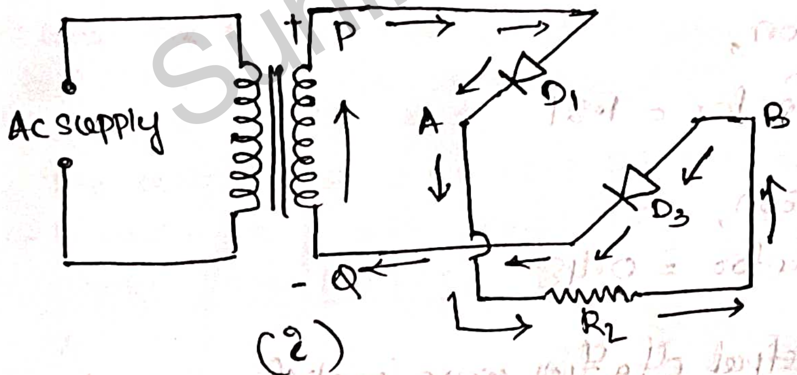
Full wave Bridge Rectifier :-



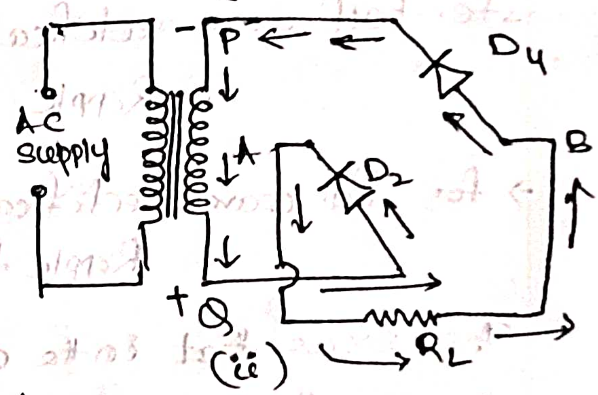


Circuit details :- The full wave bridge rectifier contains four diodes D_1, D_2, D_3 and D_4 connected to form bridge as shown in fig. The a.c supply to be rectified is applied to the diagonally opposite ends of the bridge through the transformer. Between other two ends A and B the load resistance R_L is connected.

Operation : During positive half cycle of secondary voltage, the end P becomes positive and end Q becomes negative. This makes diodes D_1 and D_3 forward biased while diodes D_2 and D_4 reverse biased. Therefore only diodes D_1 and D_3 conduct. The current flows through $P \to D_1 \to A \to R_L \to B \to D_3 \to Q \to P$ as shown in fig(i) below.



(i)



(ii)

→ During negative half cycle of secondary voltage, the end P becomes negative and end Q becomes positive. This makes Diodes D_2 and D_4 forward biased and diodes D_1 and D_3 reverse biased. Therefore only diodes D_2 and D_4 conduct. The current flows through $Q \to D_2 \to A \to R_L \to B \to D_4 \to P \to Q$ as shown in fig (ii).

→ The current flows through the load R_L in the same direction for the positive half cycle and negative half cycle. Therefore same dc output is obtained across the load R_L.

Advantages:-

- The need for centre-tapped transformer is eliminated.
- The output is twice that of centre tap full wave rectifier
- The PIV is less than the centre-tap full wave rectifier.

Disadvantage:-

- It requires four diodes.
- The output is pulsating in nature. So a filter circuit is required to get pure dc.

$$\text{Efficiency } \eta = \frac{\text{output dc power}}{\text{Input ac. power}}$$

$$\eta\% = 81.2\%$$

Ripple factor:-

The unwanted ac component present in the rectified dc output is known as ripple.

- The ratio of r.m.s value of ac component to the dc component in the rectifier output is known as ripple factor.

$$\text{Ripple factor} = \frac{\text{r.m.s value of ac component}}{\text{value of dc component}} = \frac{I_{ac}}{I_{dc}}$$

- for half wave rectification,

$$\text{Ripple factor} = 1.21$$

- for full wave rectification,

$$\text{Ripple factor} = 0.48$$

This shows that in the output of a full wave rectifier, the dc component is more than ac component.

Filter circuit

→ A filter circuit is a device which removes the ac component of rectifier output but allows the dc component to reach the load.

→ A filter circuit is generally a combination of inductors (L) and capacitors (C).

→ A capacitor passes ac but blocks the dc component.

→ An inductor passes dc but blocks the ac component.

Types of filter circuit

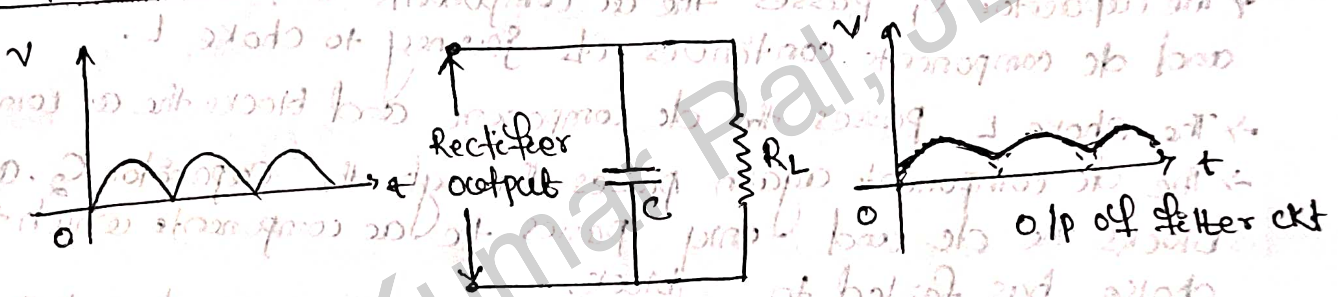
The most commonly used filter circuits are:

(i) capacitor filter

(ii) choke input filter

(iii) capacitor input filter or π-filter.

Capacitor filter



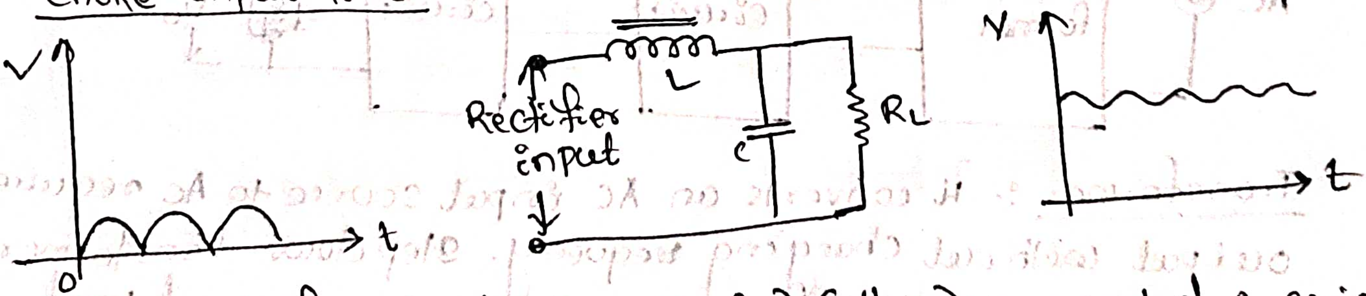
→ It consists of a capacitor C placed across the rectifier output in parallel with load R_L.

→ When the input is applied to the capacitor, it passes the ac components but blocks the dc components which again passes to the load R_L and the output is obtained.

→ The output contains very little ripple.

→ Because of less cost, small size it is used.

Choke-input filter



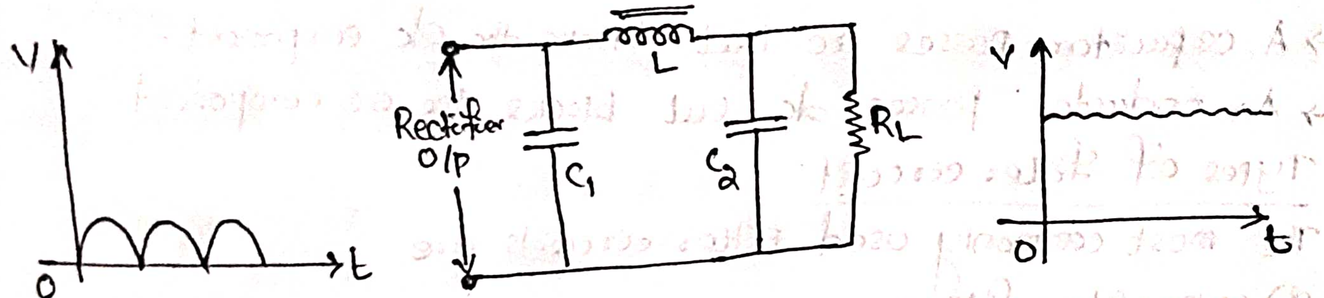
→ It consists of an inductor coil (L) (choke) connected in series with the rectifier output and a filter capacitor C across the load.

→ The pulsating dc is applied to the filter circuit. The choke allows dc component but blocks the ac component.

→ Then the dc component passed to the capacitor. capacitor passes the ac components if any present in the dc and only dc component blocked by the capacitor to reach the load.

→ The dc output obtained at the load is more improved than the capacitor filter.

Capacitor input filter or π-filter



→ It consists of a filter capacitor C_1 connected across the rectifier output, a choke L in series and another filter capacitor C_2 connected across the load.

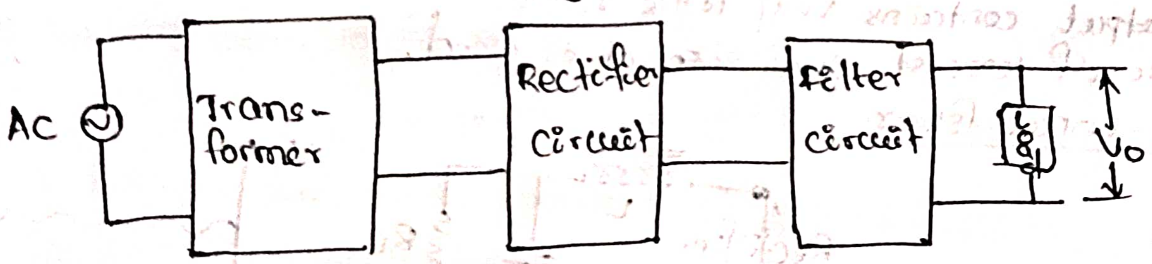
→ The capacitor C_1 passes the ac components and blocks the dc component and dc components continues its journey to choke L.

→ The choke L passes the dc component and blocks the ac component

→ The dc components again passes through the capacitor C_2. capacitor blocks the dc and only passes the ac components which the choke has failed to block.

→ Therefore only dc component appears across the load and that is what we desire.

DC power supply system (unregulated)



Transformer :- It converts an AC input source to AC required output without changing frequency. Step down transformer reduces amplitude of ac voltage to required level.

Rectifier :- Rectifier is an electronic circuit consisting of diodes which carries rectification process. It converts alternating voltages or current into corresponding dc quantity. Here the output is pulsating dc.

Filter circuit : The output of rectifier is pulsating dc which is having very high ripple so to eliminate the ripples from the pulsating dc filter circuit is used. Normally π filter is used. and the pure dc is given to the load.

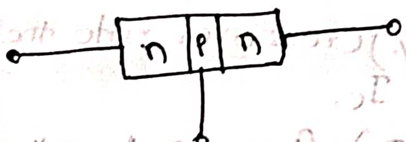
Transistor

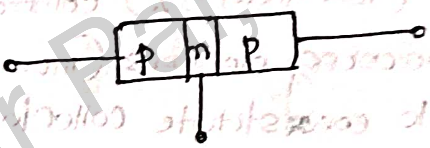
Transistor is an electronic or semiconductor device which transfers a signal from low resistance to high resistance.

→ A transistor consists of two pn junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types. Accordingly there are two types of transistors namely
(i) n-p-n transistor (ii) p-n-p transistor.

→ An n-p-n transistor is composed of two n-type semiconductors separated by a thin section of p-type.

→ A p-n-p transistor is formed by two p-sections separated by a thin section of n-type.



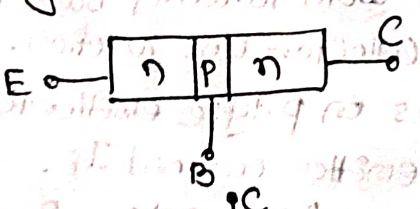


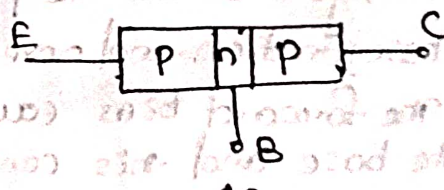
→ In a transistor, there are two pn junctions, three terminals named as Emitter, Base and collector.

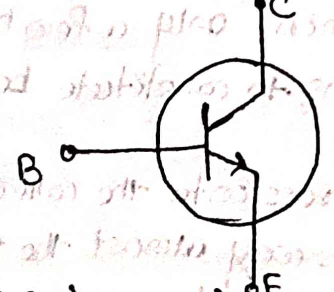
Emitter :- The section that supplies or emits the charge carriers (electrons or holes) is called the emitter. The emitter is highly doped and medium in size.

Base :- The middle section which forms two pn junctions between the emitter and collector is called the base. It is lightly doped and narrow in size.

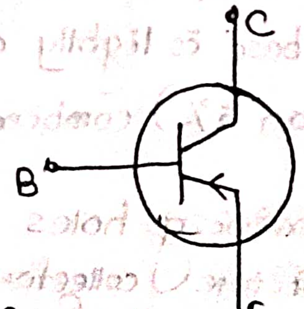
Collector:- The section that collects the charges (electrons or holes) is called the collector. The collector is always reverse biased. It is moderately doped and larger in size.





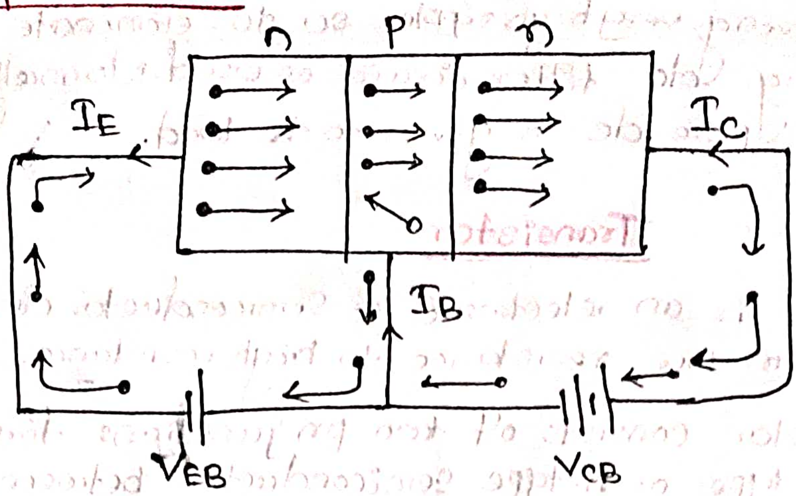


(n-p-n transistor)



(p-n-p transistor)

Working of npn transistor



→ The figure shows the npn transistor with forward bias to emitter-base junction and reverse bias to collector-base junction.

→ The forward bias causes the electrons in the n-type emitter to flow towards the base. This constitutes the emitter current I_E.

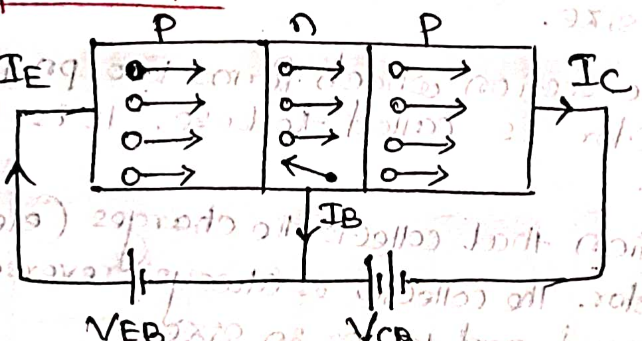
→ As these electrons flow through the p-type base, they tend to recombine with holes. As the base is lightly doped and very thin only few electrons (less than 5%) combine with holes to constitute base current I_B.

→ The remaining electrons (more than 95%) cross over into the collector region to constitute collector current I_C.

→ In this way almost the entire current (I_E) flows in the collector circuit. The emitter current is the sum of collector and base current

$$I_E = I_B + I_C$$

Working of pnp transistor



→ The figure shows the pnp transistor with forward bias to emitter-base junction and reverse bias to collector-base junction.

→ The forward bias causes the holes in p-type emitter to flow towards the base and this constitutes the emitter current I_E.

→ As the base is lightly doped and very thin, only a few holes (less than 5%) combine with the electrons to constitute base current I_B.

→ The remaining holes (more than 95%) cross into the collector region to constitute collector current I_C. In this way almost the entire emitter current flows in the collector circuit.

The emitter current is the sum of collector and Base current

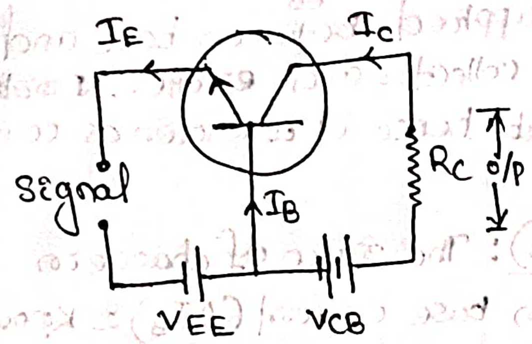
$$I_E = I_B + I_C.$$

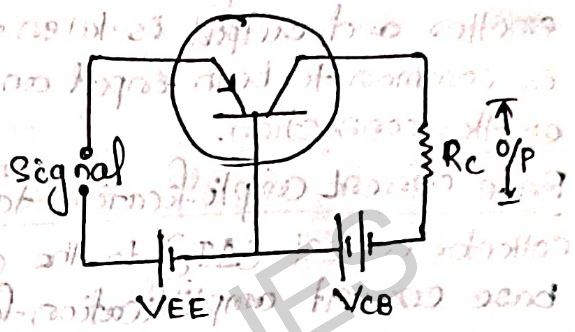
Transistor configuration

A transistor can be connected in a circuit in three ways.

(i) common Base (CB) connection
(ii) Common Emitter (CE) connection
(iii) Common Collector (CC) connection

Common Base connection





→ In this arrangement, input is applied between emitter and base and output is taken from collector and base. Here Base is common to both input and output circuits and hence the name is Common Base connection.

Current amplification factor (α) :- The ratio of change in collector current to the change in emitter current at constant collector base voltage V_{CB} is known as current amplification factor (α).

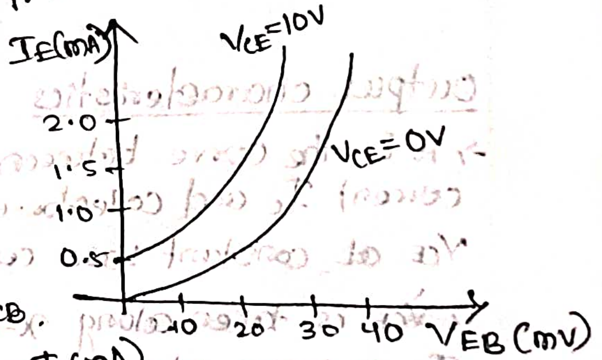
$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad \text{at constant } V_{CB}$$

The value of α ranges from 0.9 to 0.99.

Input characteristics:

→ It is the curve between emitter current I_E and emitter base voltage V_{EB} at constant Collector-base voltage V_{CB}.

→ Input resistance $r_i = \frac{\Delta V_{BE}}{\Delta I_E}$ at constant V_{CB}.

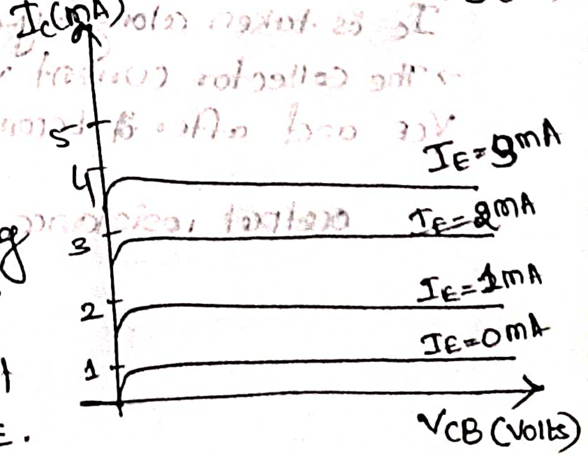


output characteristics

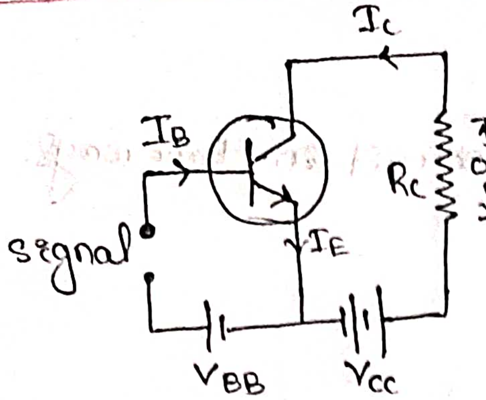
→ It is the curve between collector current I_c and collector base voltage V_{CB} at constant emitter current I_E.

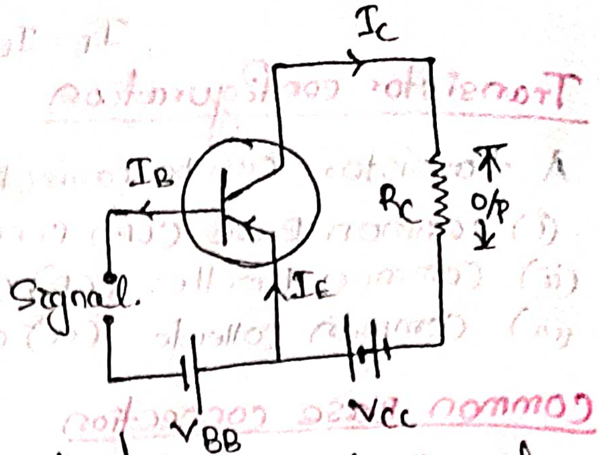
→ The collector current I_c ~~varies~~ is taken along y-axis and V_{CB} is taken along x-axis.

→ output resistance $r_o = \frac{\Delta V_{CB}}{\Delta I_C}$ at constant I_E.



Common Emitter connection





→ In this arrangement, Input is applied between base and emitter and output is taken from the collector and emitter. Emitter is common to both input and output hence it is known as common emitter connection.

Base current amplification factor (β): The ratio of change in collector current (ΔI_C) to the change in base current (ΔI_B) is known as base current amplification factor.

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

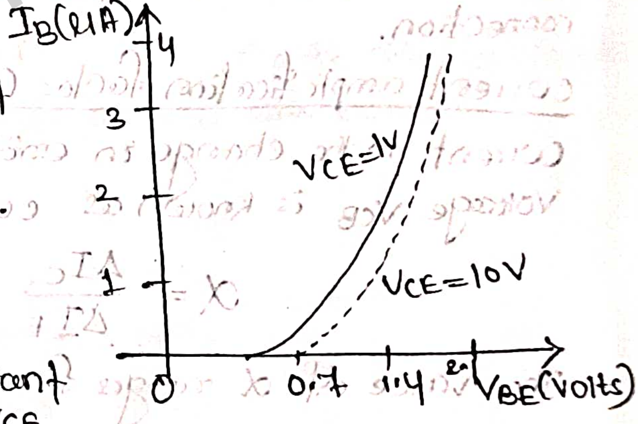
→ The value of β ranges from 20 to 500.

Input characteristics

→ It is the curve between base current I_B and base emitter voltage V_{BE} at constant collector emitter voltage V_{CE}.

→ I_B is taken along y-axis and V_{BE} is taken along x-axis.

→ Input resistance $r_i = \frac{\Delta V_{BE}}{\Delta I_B}$ at constant V_{CE}

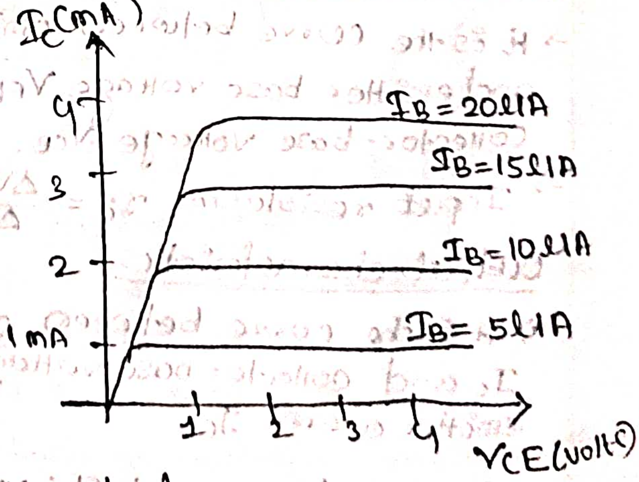


Output characteristics

→ It is the curve between collector current I_C and collector-emitter voltage V_{CE} at constant base current I_B.

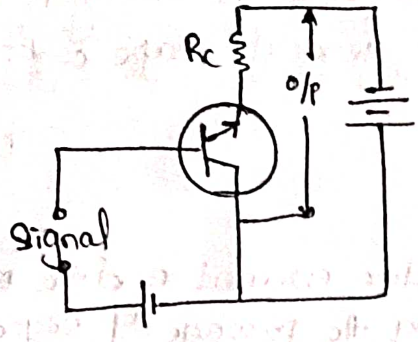
→ V_{CE} is taken along x-axis and I_C is taken along y-axis.

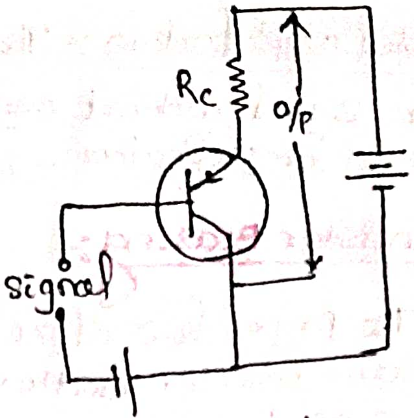
→ The collector current varies with V_{CE} and after it becomes constant



output resistance $r_o = \frac{\Delta V_{CE}}{\Delta I_C}$ at constant I_B.

Common collector connection





→ In this arrangement, input is applied between base and collector while output is taken between the emitter and collector. Here collector of transistor is common to both input and output hence it is known as common collector connection.

→ Current amplification factor (γ): The ratio of change in emitter current (ΔI_E) to the change in base current (ΔI_B) is known as current amplification factor γ.

$$\gamma = \frac{\Delta I_E}{\Delta I_B}$$

Relation between α and β

We know $\alpha = \frac{\Delta I_C}{\Delta I_E}$ and $\beta = \frac{\Delta I_C}{\Delta I_B}$, $I_E = I_B + I_C$

$$\alpha = \frac{\Delta I_C}{\Delta I_B + \Delta I_C}$$

Dividing ΔI_B in numerator and denominator, we get

$$\alpha = \frac{\Delta I_C / \Delta I_B}{(\Delta I_B + \Delta I_C)/\Delta I_B}$$

$$\alpha = \frac{\Delta I_C / \Delta I_B}{\frac{\Delta I_B}{\Delta I_B} + \frac{\Delta I_C}{\Delta I_B}}$$

$$\boxed{\alpha = \frac{\beta}{1+\beta}}$$

or $$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

Dividing ΔI_E in numerator and denominator, we get

$$\beta = \frac{\Delta I_C/\Delta I_E}{(\Delta I_E - \Delta I_C)/\Delta I_E} = \frac{\Delta I_C/\Delta I_E}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}}$$

$$\Rightarrow \boxed{\beta = \frac{\alpha}{1-\alpha}}$$

faithful amplification :- The process of raising the strength of a weak signal without any change in its general shape is known as faithful amplification.

Transistor Biasing :-

The proper flow of zero signal collector current and the maintenance of proper collector-emitter voltage during the passage of signal is known as transistor Biasing.

→ For faithful amplification, a transistor amplifier must satisfy three basic conditions namely

(i) proper zero signal collector current
(ii) Proper Base-emitter voltage at any instant
(iii) proper Collector-emitter voltage at any instant

Stabilisation

The process of making operating point independent of temperature changes or variations in transistor parameters is known as stabilisation.

→ The collector current changes rapidly when
(i) the temperature changes
(ii) the transistor is replaced by another of the same type.

→ when the temp. changes or transistor is replaced, the operating point also changes. However for faithful amplification, it is essential that operating point remains fixed.

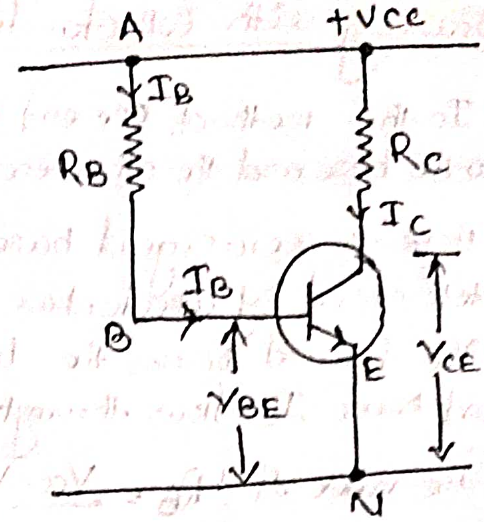
→ once stabilisation is done, i.e operating point is fixed. A good biasing circuit always ensures the stabilisation of operating point

Methods of transistor Biasing:

The following are the most commonly used methods of obtaining transistor biasing.

(i) Base Resistor method
(ii) Emitter Bias method
(iii) Biasing with collector-feedback resistor
(iv) Voltage-divider bias.

Base Resistor Method:



- In this method, a high resistance R_B is connected between the base and +ve end of supply for npn transistor.
- The required zero signal base current is provided by V_{cc} and it flows through R_B.

$$R_B = \frac{V_{cc} - V_{BE}}{I_B}$$

Since V_{BE} is very small as compared to V_{cc},

$$R_B = \frac{V_{cc}}{I_B}$$

- R_B can always be found directly. This method is sometimes called fixed bias method.

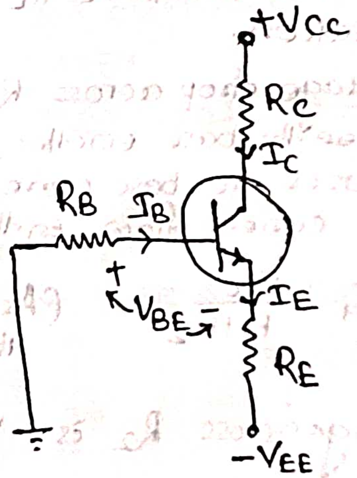
Advantages:-

- circuit is very simple as only one resistance R_B is required.
- Biasing condition can easily be set.

Disadvantage:-

- This method provides poor stabilisation.
- The stability factor is very high. Therefore, there are strong chances of thermal runaway.

Emitter Bias circuit:-



- In this method, it uses two separate dc voltage sources; one positive (+Vcc) and other negative (-VEE). Normally the two supply voltages will be equal.
- There is a resistor R_E in the emitter circuit.
- The expression of collector current is

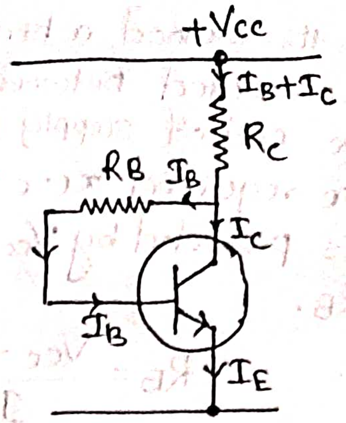
$$I_c = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta}$$

if $R_E >> R_B/\beta$, $I_c = \frac{V_{EE} - V_{BE}}{R_E}$ This condition makes I_c independent of β.

if $V_{EE} >> V_{BE}$, $I_c = \frac{V_{EE}}{R_E}$, This condition makes I_c independent of V_{BE}.

- If I_c is independent of V_{BE} and β, the Q point is not affected. Thus emitter bias can provide stable Q point if properly designed.

Biasing with Collector-feedback Resistor



→ In this method, one end of R_B is connected to the base and the other end to the collector.

→ Here the zero signal base current is determined by collector base voltage V_{CB}.

→ V_{CB} forward biases the base-emitter junction and hence I_B flows through R_B.

The value of $R_B = \dfrac{V_{CC} - V_{BE} - I_C R_C}{I_B}$

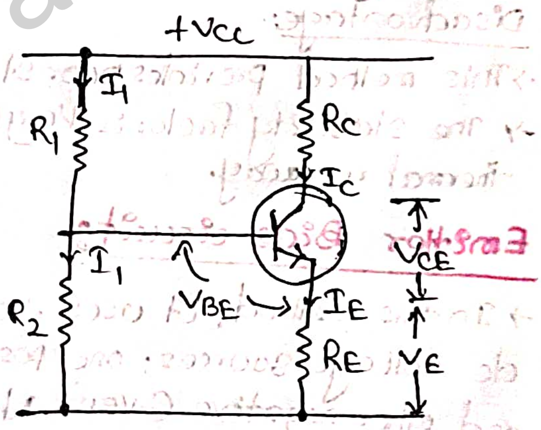
or $R_B = \dfrac{V_{CE} - V_{BE}}{I_B}$

→ In this method some stabilisation occurs as compared to base resistor method.

→ Here stability factor is also high therefore operating point may change.

→ This method provides a negative feedback which reduces the gain of the amplifier.

Voltage Divider Bias



→ In this method, two resistances R_1 and R_2 are connected across the supply voltage Vcc and provide biasing.

→ The emitter resistance R_E provides stabilisation.

→ The voltage drop across R_2 forward biases ~~on~~ the base emitter junction. This causes the base current and hence collector current flow in the zero signal condition.

→ $I_1 = \dfrac{V_{CC}}{R_1 + R_2}$ (As base current is very small, it can be assumed that current flowing through R_2 is I_1)

→ Voltage across R_2 is $V_2 = \left(\dfrac{V_{CC}}{R_1 + R_2}\right) R_2$

The expression of $I_C = \dfrac{V_2 - V_{BE}}{R_E}$ $(I_E \simeq I_C)$

Practically $V_2 >> V_{BE}$

so $I_C = \dfrac{V_2}{R_E}$

so I_C is independent of V_{BE} and β.

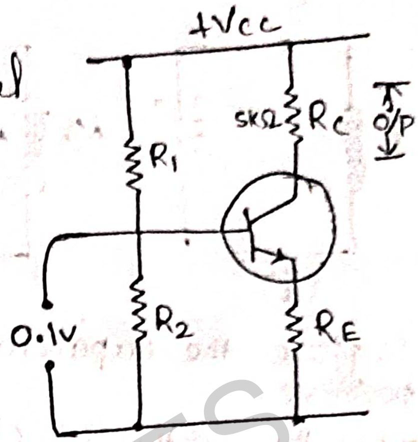
$V_2 = V_{BE} + I_C R_E$ $(I_E \simeq I_C)$

if I_C increases due to temperature the voltage drop across RE i.e $I_C R_E$ increases. But V_2 is fixed so V_{BE} decreases and it causes I_B to decrease. The reduce in I_B also changes I_C to decrease to its original value

→ Here excellent stabilisation is provided by R_E.

→ Stability factor is very small (≈1) so, it provides maximum thermal stability

Single stage transistor Amplifier



→ When only one transistor with associated circuitry is used for amplifying a weak signal the circuit is known as single stage transistor amplifier.

→ When a weak ac signal is given to the base of transistor, a small base current starts flowing.

→ Due to transistor action high value of collector current ($I_C = \beta I_B$) flows through the load.

→ As the value of R_C is quite high, therefore, a large voltage appears across the R_C.

→ Thus a weak signal applied in the base circuit appears in amplified form in the collector circuit. In this way transistor acts as an amplifier.

Sinusoidal oscillators:

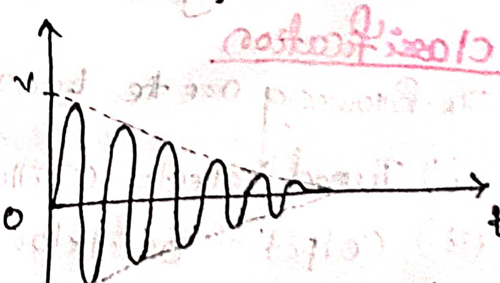
An electronic device that generates sinusoidal oscillations of desired frequency is known as a "sinusoidal oscillator".

→ Oscillator can produce sinusoidal or non-sinusoidal (square) waves.

Types of sinusoidal oscillations

It can be of two types (i) Damped oscillations
(ii) undamped oscillations.

(i) Damped oscillations



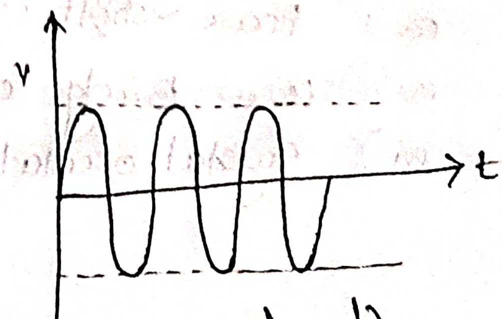
(damped)

→ The electrical oscillation whose amplitude goes on decreasing with time are called damped oscillations.

→ Some energy is lost during each oscillation.

(ii) Undamped oscillations

→ The electrical oscillations whose amplitude remains constant with time are called undamped oscillations.

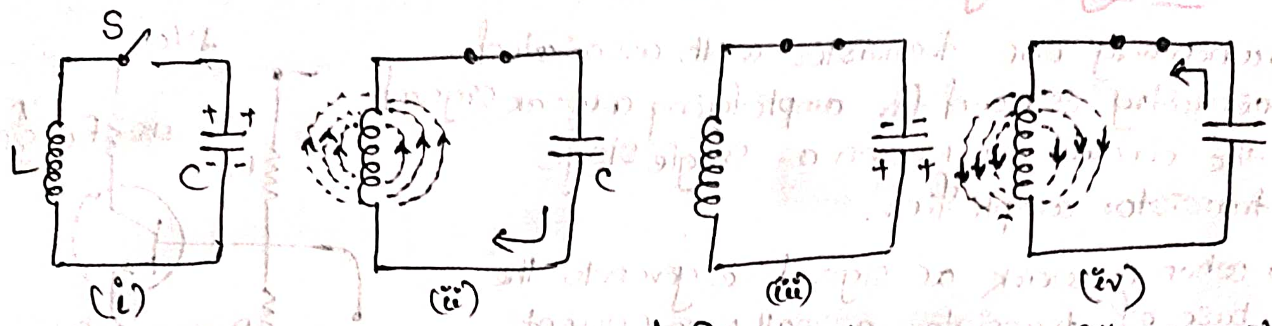


(undamped)

Oscillatory circuit

A circuit which produces electrical oscillations of any desired frequency is known as an oscillatory circuit or tank circuit.

→ A simple oscillatory circuit consists of a capacitor (C) and inductance coil (L) in parallel as shown in fig.



→ Suppose the capacitor is charged from a dc source with upper plate positive.

→ When the switch S is closed, the capacitor will discharge through inductance and electron flow will be in the direction of arrow. This current flow sets up magnetic field around the coil.

→ The circuit current will be maximum when the capacitor is fully charged. At that time electrostatic energy is zero but the magnetic field energy around the coil is maximum.

→ Once the capacitor is discharged, the magnetic field will begin to collapse and produce a counter emf. The result is that the capacitor is now charged with opposite polarity.

→ Again the capacitor now begins to discharge, current flow flowing in the opposite direction.

→ The sequence of charge and discharge results in alternating motion of electrons or an oscillating current. This interchange of energy between L and C is repeated over and again resulting in the production of oscillations.

→ The frequency of oscillation is given by $f_r = \frac{1}{2\pi\sqrt{LC}}$

Classification

The following are the transistor oscillators commonly used.

(i) Tuned collector oscillator

(ii) Colpitt's oscillator

(iii) Hartley oscillator

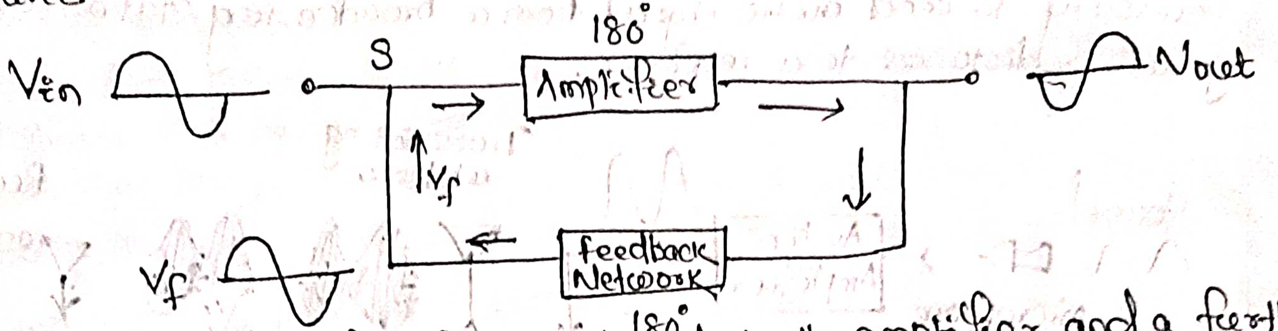
(iv) Phase shift oscillator

(v) Wien Bridge oscillator

(vi) Crystal oscillator.

Positive feedback Amplifier – oscillator

A transistor amplifier with proper positive feedback can act as an oscillator. i,e it can generate oscillations without any external signal source.



→ A phase shift of 180° is produced by the amplifier and a further phase shift of 180° is introduced by feedback network.

→ The circuit needs only a quick trigger signal to start the oscillations. Once the oscillations have started, no external signal source is needed.

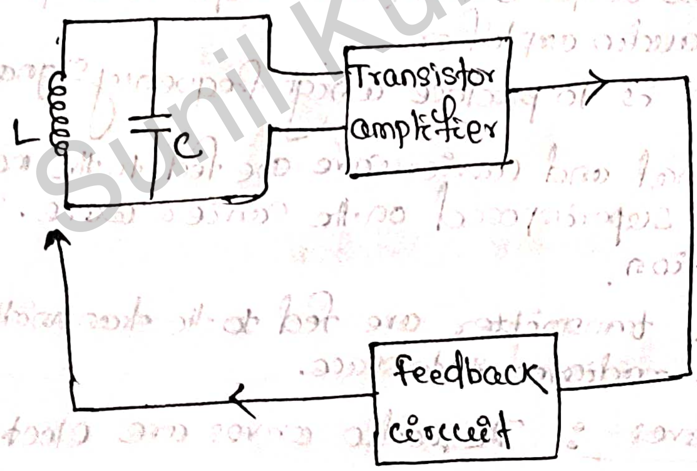
→ In order to get continuous undamped output from the circuit, the following condition must be met :

$$m_v A_v = 1$$

where A_v = voltage gain of amplifier without feedback
m_v = feedback fraction.

This relation is called Barkhausen criterion.

Essentials of Transistor oscillator



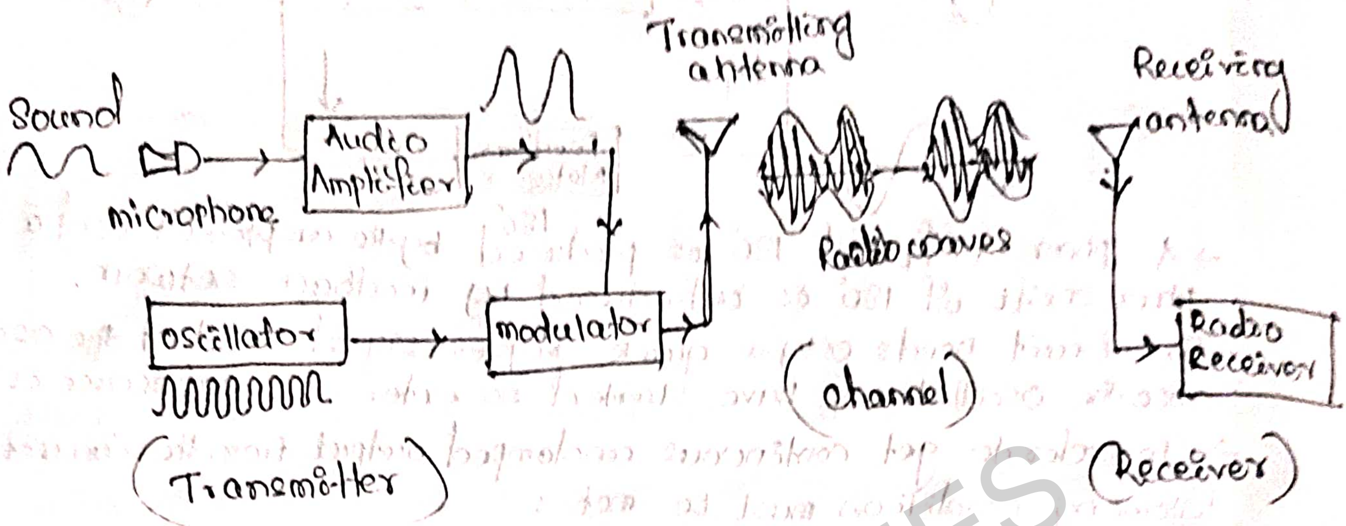
Tank circuit : It consists of inductance coil (L) connected in parallel with capacitor (C).

Transistor amplifier: Transistor amplifier receives dc power from the battery and changes it into ac power for supplying to the tank circuit. The output of the transistor can be supplied to tank ckt to meet the loses.

Feedback circuit:- The feedback circuit supplies a part of collector energy to the tank circuit in correct phase to aid the oscillations i,e it provides positive feedback.

Unit: 5 Communication System

The process in which sending and receiving of information occurs is called communication. In radio transmission, it is necessary to send audio signal from a broadcasting station over great distances to a receiver.



The entire arrangement can be divided into ~~four~~ three parts i.e transmitter, transmission of radio waves and radio ~~waves~~ receiver.

1. Transmitter: It is an important equipment which is responsible for transmission of signal.

→ microphone converts sound waves into electrical waves. The audio signal from the microphone is quite weak and requires amplification. so it is amplified by audio amplifier.

→ The function of oscillator is to produce a high frequency signal called carrier wave.

→ The amplified audio signal and carrier wave are fed to the modulator. Here the audio signal is superimposed on the carrier wave. This process is called modulation.

→ The radio waves from the transmitter are fed to the transmitting antenna where these are radiated into space.

2. Transmission of radio waves: The radio waves are electromagnetic waves. The antenna radiates the radio waves in space in all directions.

3. Radio Receiver: on reaching the receiving antenna. Here the radio waves are first amplified and then signal is extracted from them by the process of demodulation.

→ The signal is amplified by audio amplifiers and then fed to the speaker for reproduction into sound waves.

Modulation:-

The process of changing some characteristics (e.g amplitude, frequency or phase) of a carrier wave in accordance with the intensity of the signal is known as modulation.

Need for modulation

(i) Practical antenna length: Because of modulation, due to high frequency antenna size reduces and can be designed easily.

(ii) operating Range: The energy of a wave depends upon its frequency. The greater the frequency of the wave, the greater the energy possessed by it.

(iii) wireless communication: Efficient radiation of electrical energy is possible at high frequency. Hence modulation is always done in communication system.

Types of modulation:

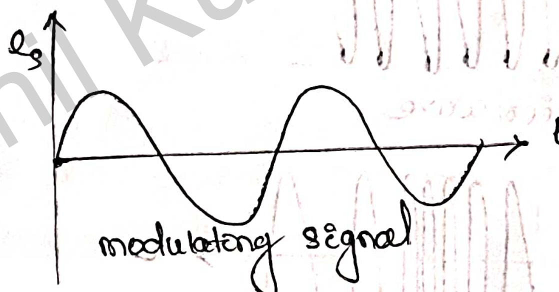
There are three Basic types of modulation, namely

(i) amplitude modulation
(ii) Frequency modulation
(iii) phase modulation.

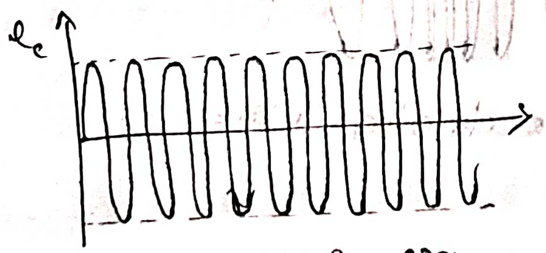
Amplitude modulation:-

When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the signal, it is called amplitude modulation.

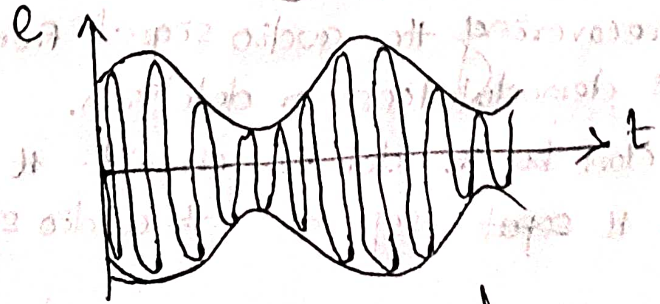
→ The frequency and phase are remain constant.



modulating signal



carrier wave



Amplitude modulated wave.

Signal is represented as $e_s = E_s \cos \omega_s t$

Carrier is represented as $e_c = E_c \cos \omega_c t$

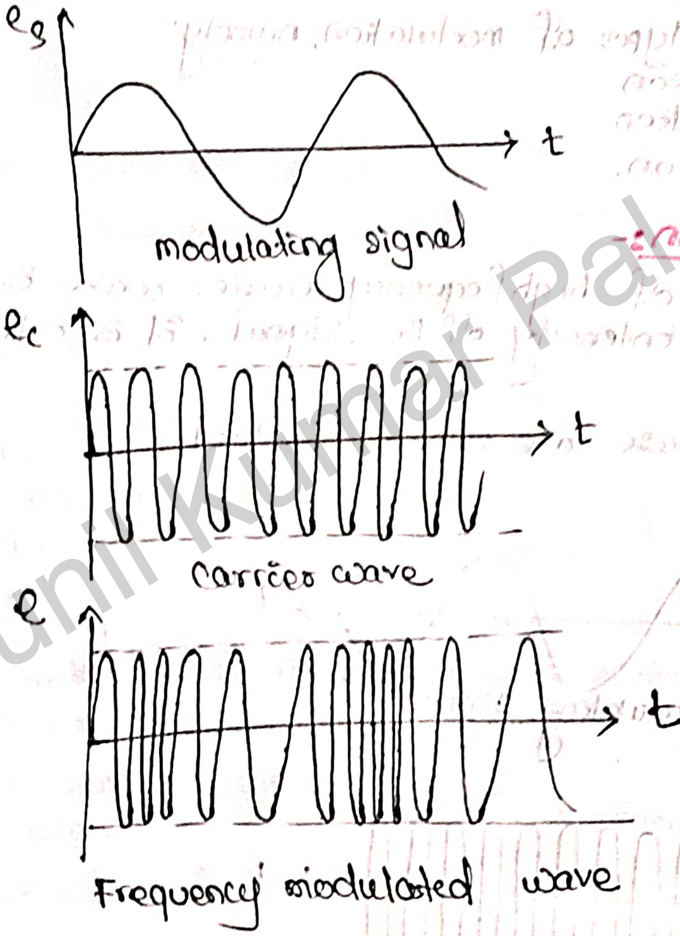
Amplitude modulated is represented as

$$e = E_c(1 + m\cos \omega_s t)\cos \omega_c t$$

Frequency modulation :

When the frequency of carrier wave is changed in accordance with the intensity of the signal, it is called frequency modulation.

→ The amplitude and phase are remain constant.



Demodulation

→ The process of recovering the audio signal from the modulated wave is known as demodulation or detection.

→ Demodulation is done by the detector circuit. It rectifies the modulated wave. It ~~sepates~~ separates the audio signal from the carrier.

Amplitude modulation	Frequency modulation
→ The amplitude of carrier wave is varied in accordance to modulating signal.	→ The frequency of the carrier wave is varied in accordance to modulating signal.
→ It has two sidebands.	→ It has infinite number of sidebands
→ The frequency and phase remain constant or same	→ The amplitude and phase remain constant or same
→ Its modulation index varies from 0 to 1	→ Its modulation index is always greater than 1.
→ It can transmit over long distances, have a large range.	→ It can transmit over long distances, have a smaller range
→ It is more noisy, has poor sound quality	→ It is less noisy, has better sound quality
→ It has simple circuit design	→ It has complex circuit design
→ It is less costly	→ It is more costly
→ wastage of power is more	→ No wastage of power.
→ It operates in the medium and high frequency	→ It operates in the upper VHF and UHF range.
→ It is used in picture for TV broadcasting	→ It is used in sound for TV broadcasting

Unit: 4 | Transducers and Measuring Instruments

Transducer:-

→ The transducer is a device which can be used to convert a non-electrical physical quantity like temperature, sound, or light into an electrical signal such as voltage and current.

→ It can convert one form of energy to another form.

Classification of Transducer:-

- Active and passive Transducer
- Analog and digital Transducer
- Primary and secondary Transducer
- Transducer and Inverse Transducer
- Resistive Transducer
- Capacitive Transducer
- Inductive Transducer
- Piezoelectric Transducer
- Pressure Transducer
- Temperature Transducer
- Ultrasonic Transducer

Active Transducer:- These transducers does not need any external power source for its operation so it can be called a self generating transducer. They produce an analog voltage or current when stimulated by some physical form of energy.

Example: Thermocouple, photovoltaic cells,

Passive Transducer: This type of transducer needs an external power source for energy conversion.

Example: Thermistor, Strain gauge

Primary and secondary transducer: Certain Transducers have mechanical as well as an electrical device, the mechanical device converts the physical quantity to be measured into mechanical signal and such mechanical device is called as primary Transducer.

→ The electrical device then converts this mechanical signal into a corresponding electrical signal such electrical signals are called Secondary Transducers.

Transducers and Inverse Transducers :

A Transducer can convert non-electrical quantity into electrical quantity while an inverse transducer can convert electrical quantity to a non-electric quantity.

Analog and Digital Transducer :

→ In an analog transducer with the variation of input, there is a continuous variation of output. These type of transducers convert the input quantity into an analog output. Ex:- Thermocouple

→ In digital transducer with the variation of input, there is a digital or discrete type of output. Ex:- Digital encoder.

Resistive Transducer :- Resistance transducers are transducers in which resistance changes due to change in some physical phenomenon.

Ex: potentiometer, strain gauge, Thermistor

Capacitive Transducer :- Capacitive transducers are the ~~transducer~~ capacitors with variable capacitance they are used for measuring linear displacement. In this transducer the capacitance change due to the change in some physical phenomenon into an electrical signal.

Inductive Transducer :- These Transducers work on the principle of magnetic induction. A Tachometer is an inductive transducer which converts speed or velocity into an electric signal.

Piezoelectric transducer : The function of this transducer is to convert mechanical energy to electrical energy and then electrical into mechanical energy.

Pressure transducer : It is used to measure pressure of the specific quantities like gas or liquids by changing the pressure into electrical energy.

Temperature Transducer : This is an electrical device that is used to convert the temperature of the device into another quantity like electrical energy pressure or mechanical energy, then the quantity will be sent to the control device for controlling the temperature of the device.

Ultrasonic Transducer: This transducer will convert electrical signals to ultrasound waves. It can also be used to measure the distance of the sound based on reflection.

Sensor: The sensor is a device that measures the physical quantity (i.e heat, light, sound etc) into an easily readable signal (voltage, current etc).

→ Sensor senses the physical changes occur in the sorrounding.

Transducer	Sensor
→ The transducer is a device which, when actuates transforms the energy from one form to another	→ Its function is to sense the physical changes occurs in the sorrounding and converting it into a readable quantity.
→ Its components are Sensor and signal conditioning	→ Its component is sensor itself
→ Examples are Thermistor, Potentiometer, Thermocouple etc	→ Examples are Proximity sensor, Magnetic sensor, Accelerometer sensor, light sensor etc

Photo-electric ~~emissive~~ Transducer:

→ The photoelectric Transducer converts the light energy into electrical energy. It is made of semiconductor material.

→ The photoelectric transducer uses a photosensitive element, which ejects the electrons when the beam of light absorbs through it.

→ The absorption of light energises the electrons of the material and hence the electrons start moving.

→ The photoelectric transducers are classified into

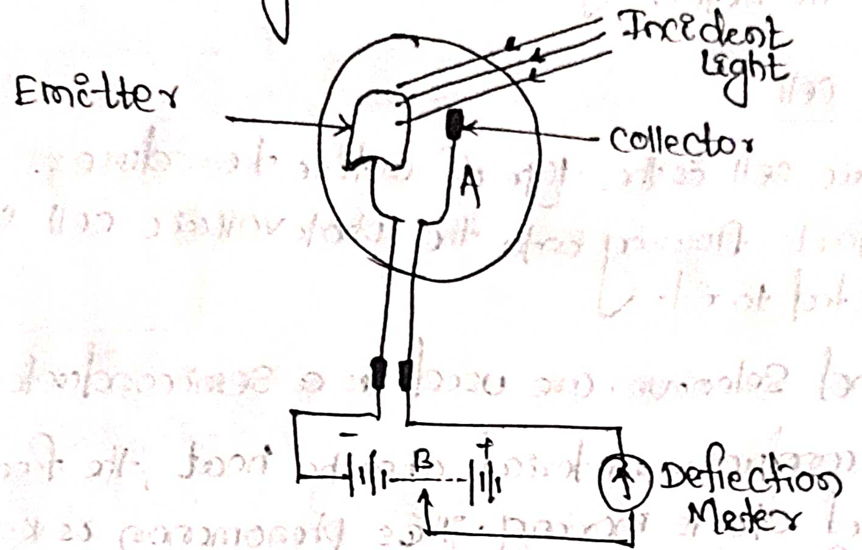
(i) Photoemissive cell

(ii) photoconductive cell

(iii) photo-voltaic cell.

Photoemissive cell :

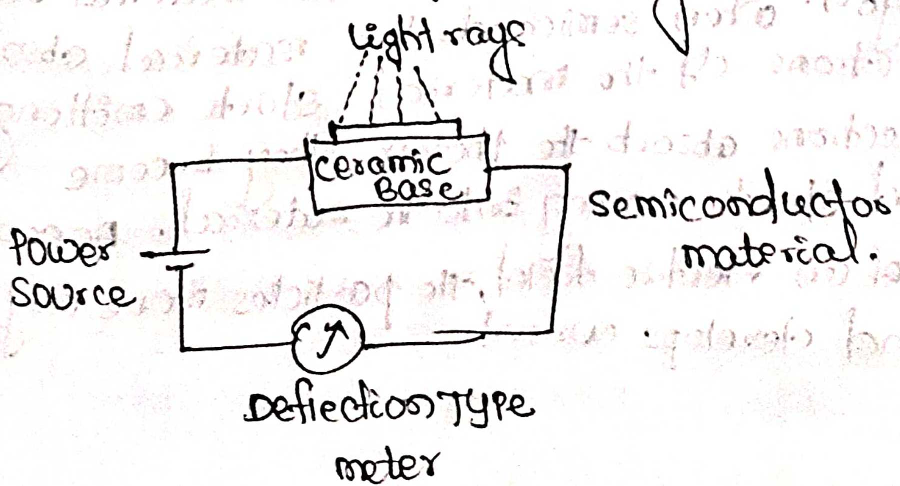
- The photoemissive cell converts the photons into electric energy
- It consists the anode rod and the cathode plate. The anode and cathode are coated with a photoemissive material called caesium antimony.



- When the radiation of light fall on cathode plates the electrons starts flowing from anode to cathode.
- Both the anode and the cathode are sealed in a closed, opaque evacuated tube.
- When the radiation of light fall on the sealed tube, the electrons start emitting from the cathode and moves towards the anode.
- The anode is kept to the positive potential. Thus the photoelectric current starts flowing through the anode
- The magnitude of the current is directly proportional to the intensity of light passes through it

Photoconductive cell :

- The photoconductive cell converts the light energy into an electric current. It uses the semiconductor material like cadmium selenide, Ge as a photo sensing element.



→ When the beam of light falls on the semiconductor material, their conductivity increases and the material works like a closed switch.

→ The current starts flowing into the material and deflects the pointer of the meter.

Photo-voltaic cell

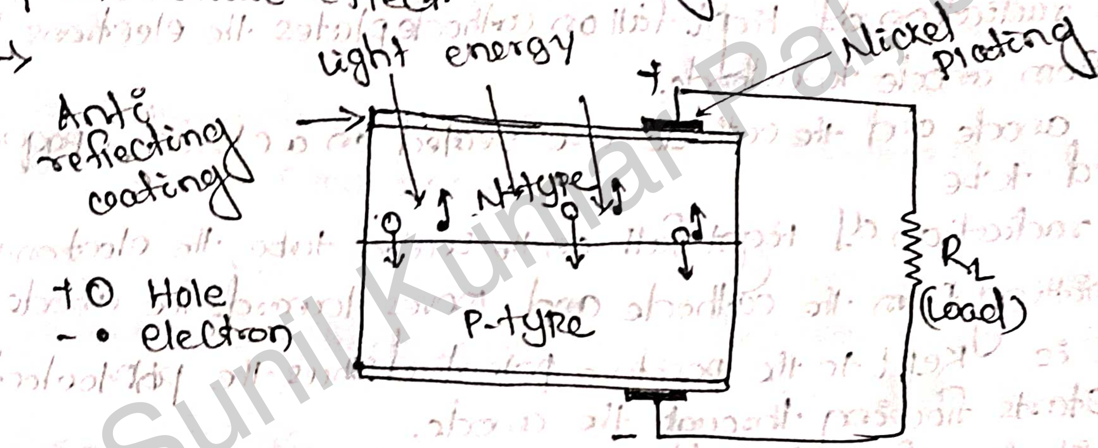
→ The photovoltaic cell is the type of active transducer.

→ The current starts flowing into the photovoltaic cell when the load is connected to it.

→ The silicon and selenium are used as a semiconductor material.

→ When the semiconductor material absorbs heat, the free electrons of the material starts moving. This phenomenon is known as photovoltaic effect.

→



→ The upper surface of the cell is made of the thin layer of the P-type material so that the light can easily enter into the material.

→ The metal rings are placed around P-type and N-type material which acts as positive and negative terminals.

→ The light incident on the semiconductor material may be passed through it. When semiconductor material absorbs light, the electrons of the material starts emitting.

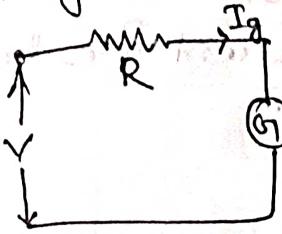
→ When the electrons absorb the photons, they become energised and starts moving into the material. Because of the effect of an electric field, the particles move only in the one direction and develops current.

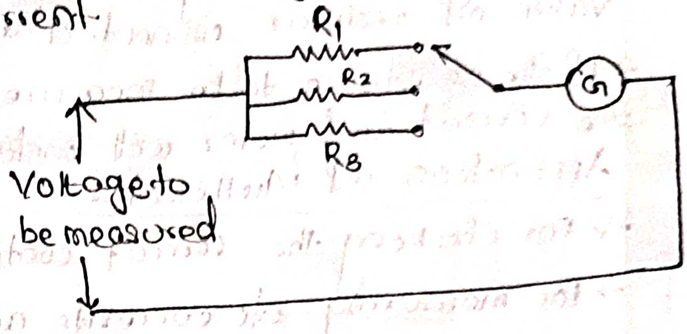
Multimeter

A multimeter is an electronic instrument which can measure resistances, currents, and voltages. It can be used for measuring dc as well as ac voltages and currents.

(i) Multimeter as voltmeter :- When a high resistance is connected in series with a galvanometer, it becomes a voltmeter.

→ A high resistance R connected in series with the galvanometer of resistance G. I_g is the full scale deflection current.





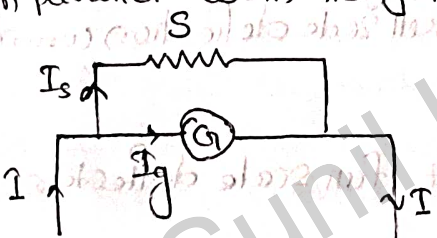
$$V = I_g R + I_g G$$

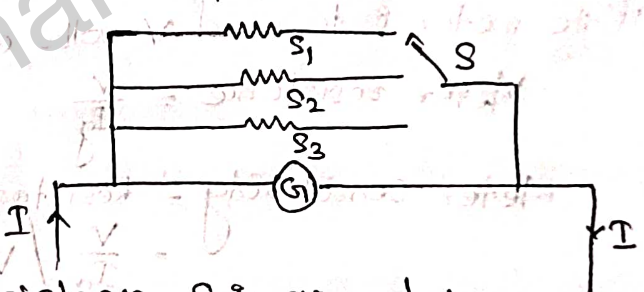
$$V = I_g (R+G)$$

$$\frac{V}{I_g} = R+G \Rightarrow R = \frac{V}{I_g} - G$$

→ For maximum accuracy, a multimeter is always provided with a number of voltage ranges.

Multimeter as Ammeter : When low resistance is connected in parallel with a galvanometer it becomes an ammeter. A low resistance S is connected in parallel with the galvanometer





The required value of shunt resistance S is given by

$$I_s S = I_g G$$

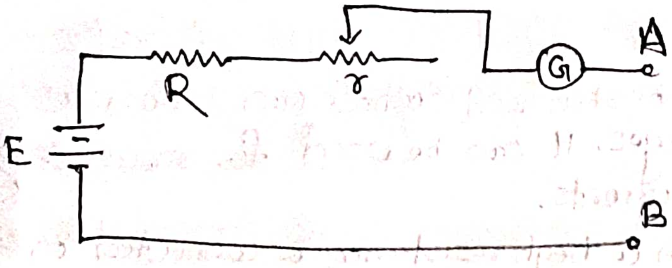
$$\frac{I_s}{I_g} = \frac{G}{S} \quad \text{or} \quad \frac{I_s}{I_g} + 1 = \frac{G}{S} + 1$$

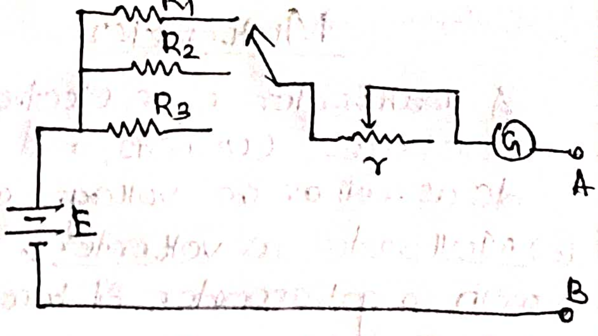
$$\Rightarrow \frac{I_s + I_g}{I_g} = \frac{G+S}{S}$$

$$\Rightarrow \frac{I}{I_g} = \frac{G+S}{S}$$

→ A number of low resistances in parallel with the galvanometer to provide a current ranges.

Multimeter as ohmmeter : A fixed resistance R and a variable resistance r are connected in series with the battery and galvanometer. The fixed resistance R limits the current within the range desired and variable resistance r is for zero-adjustment reading. The resistance to be measured is connected between terminals A and B.





→ The current flowing through the circuit will depend upon the value of resistor connected across the terminals.

→ If the resistance to be measured is high, lower current flows through the circuit and meter will indicate lower reading.

Application of Multimeter

→ For checking the circuit continuity

→ For measuring dc currents and ac currents

→ for measuring dc voltages

→ for measuring ac voltages across power supply transformers.

→ Sensitivity of Multimeter:

The resistance offered per volt of full scale deflection by the multimeter is known as multimeter sensitivity.

If the meter is to read V volts and I_g is full scale deflection current,

$$\text{Meter resistance} = \frac{V}{I_g}$$

$$\text{Meter sensitivity} = \text{Resistance per volt full scale deflection}$$

$$= \frac{V}{I_g} \Big/ V = \frac{1}{I_g}$$

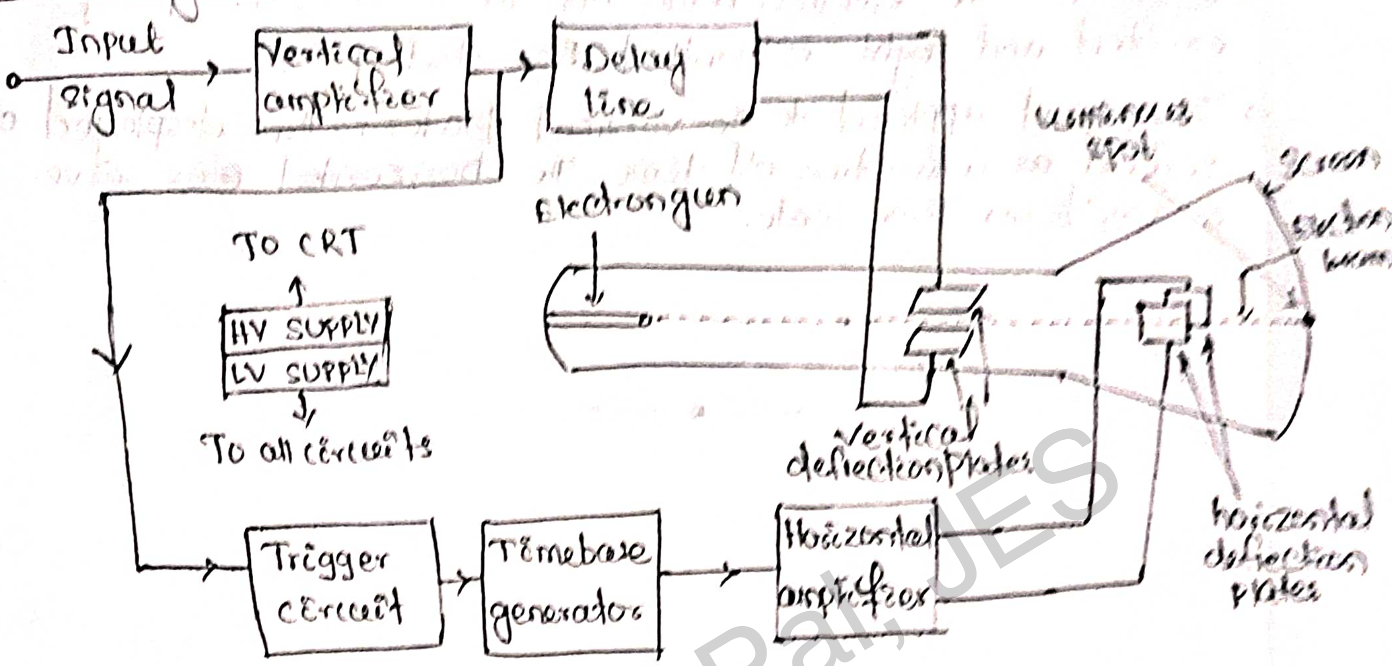
→ If the sensitivity of a multimeter is high, it will measure the voltage accurately.

Analog Multimeter	Digital Multimeter
→ Its display shows the measured quantity by deflection of pointer scale	→ The display of digital multimeter represents the value in the form of digits.
→ Accuracy is low	→ Accuracy is high.
→ Low cost	→ High cost.
→ size is large	→ size is small
→ ADC circuit is not present	→ ADC circuit is present
→ They are calibrated manually.	→ They are calibrated automatically
→ It accepts only one input signal per operation.	→ Have ability to accept multiple input signals.

Cathode Ray Oscilloscope (CRO)

The cathode Ray oscilloscope is a common laboratory instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies.

Block diagram :-



Vertical amplifier: The input signals are amplified by the vertical amplifier. Usually the vertical amplifier is a wideband amplifier which passes the entire band of frequencies.

Delay line: This circuit is used to delay the signal for a period of time in the vertical section of CRT.

Time Base Generator: Time base generator is used to produce the sweep. The sawtooth voltage produced by the time base circuit is required to deflect the beam in the horizontal section.

Trigger circuit: The signals which are used to activate the trigger circuit are converted to trigger pulses for the precision sweep operation whose amplitude is uniform. Hence input signal and sweep frequency can be synchronized.

Horizontal Amplifier: The sawtooth voltage produced by the time base circuit is amplified by the horizontal amplifier before it is applied to horizontal deflection plates.

power supply: The voltages required by CRT, horizontal amplifier and vertical amplifier are provided by power supply block.

Cathode Ray Tube: It is the heart of the oscilloscope. when the electrons emitted by the electron gun strikes the phosphor screen, a visual signal is displayed on the CRT.

→ The cathode ray is a beam of electrons which are emitted by heated cathode and accelerated towards the fiourescent screen.

→ Between the electron gun and the fluorescent screen are two pair of metal plates: horizontal and vertical deflection plates.

→ The combination of these two deflections allows the beam to reach any portion of the fluorescent screen.

→ whenever the electron beam hits the screen, the phosphor is excited and light is emitted from that point.

→ The signal applied to the vertical plates is thus displayed on the screen as a function of time. The horizontal axis serves as a uniform time scale.

—•—