Lecture Note

ON

Basic Electronics

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1st Sem

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Electronic Device:

Electronics:

The branch of engineering which deals with current conduction through a vaccum or gas or Semiconductor is known as electronics.

The function of electronic devices:

i) Rectification: The conversion ac into dc is called rectification.

ii) Amplification: The process of raising the strength of a weak signal is known as amplification.

iii) Control: Speed of a motor, voltage across refrigerator etc can be automatically controlled with help of such device.

iv) Generation: Electronic device can convert dc power into a.c power of any frequency.

v) conversion of light into electricity.

vi) Conversion of electricity into light.

Application:

i) Consumer Electronics

ii) Instrumentation & control

iii) Telecommunication

iv) Image processing

v) Military

Atomic Structure:

- All materials are composed of very small particles called as atom.

- It consists of two parts.

  i) Nucleus

  ii) Extra nucleus.

i) Nucleus: It is the central part of an atom & contains proton & neutrons.

- A proton is positively charge particle, while neutron has same mass as ~~~~ proton but has no charge.
- Therefore nucleus of an atom is positively charged.

* The sum of proton & neutron constitutes the entire weight of an atom is called "atomic weight".

ii) Extra nucleus: It is the outer part of an atom and contains electrons only.

- An electron is a negatively charge particle having negligible mass.
- The charge on an electron is equal but opposite to that on a proton.
- The number of electrons is equal to number of protons in an atom under ordinary conditions.

* Atomic Number = No. of protons or electrons in an atom.

- The electrons in an atom revolve around the nucleus in different orbits or paths.
- The number of electrons in any orbit is given by $2n^2$, where n is the number of orbit.
  i) The last orbit can not have more than 8 electrons.
  ii) The last but one orbit cannot have more than 18 electrons.

* charge of an electron, $e = 1.602 \times 10^{-19}$ coulombs
  mass of an electron, $m = 9.0 \times 10^{-31}$ kg
  Radius of an electron, $r = 1.9 \times 10^{-15}$ meter

* Mass of an electron is very small compared to its charge. Due to this property of an electron, it is very mobile & is greatly influced by electric or magnetic fields.

Energy of an Electron :

An electron moving round the nucleus possesses two types of energies
i) Kinetic energy due to motion
ii) Potential energy due to change on the nucleus.

- The energy of an electron increases as its distance from the nucleus increases.
- Thus an electron in 2nd orbit possesses more energy than electron in the 1st orbit.

Valence Electron:

The electrons in the outer most orbit of an atom are called as "Valence electrons".

i) When no of valence electrons of an atom less then 4, the material is usually a metal or conductor.

Ex: Sodium (Na) → 11 → 1
Magnesium (Mg) → 12 → 2
Aluminium (Al) - 13 → 3

ii) When no of valence electrons of an atom more then 4, then the material is usually insulatate or non-metal.

Ex: Nitrogen (N) - 7 → 5
Sulphur (S) - 16 → 6
Neon (Ne) - 10 → 8

iii) When no of valence electrons of an atom is 4, the material has both metal & non metal properties is usually a Semiconductor.

Ex: Carbon (C) - 6 → 4
Silicon (Si) - 14 → 4
Germanium (Ge) - 32 → 4

Free electrons:

The loosely attached valance electrons move at random with in the material are called "free electrons".

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

Electron Emission

Electron Emission:

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

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

* There are 4 principal methods of electron emission.

i) Thermonic emission
ii) Field emission
iii) Photo electric emission
iv) Secondary emission.

i) Thermonic Emission:

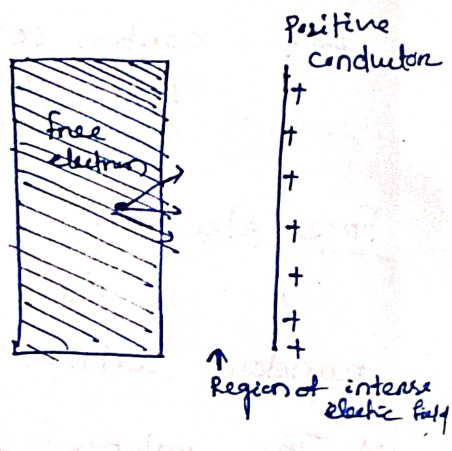
- The process of electron emission from a metal surface by supplying thermal energy (about 2500°c) to it is known as thermonic emission.

- When heat is applied to the metal, some of heat energy is converted into kinetic energy, causing accelerated motion of free electrons.

- Commonly used materials are tungsten, oxide coated cathode etc.

ii) Field Emission:

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

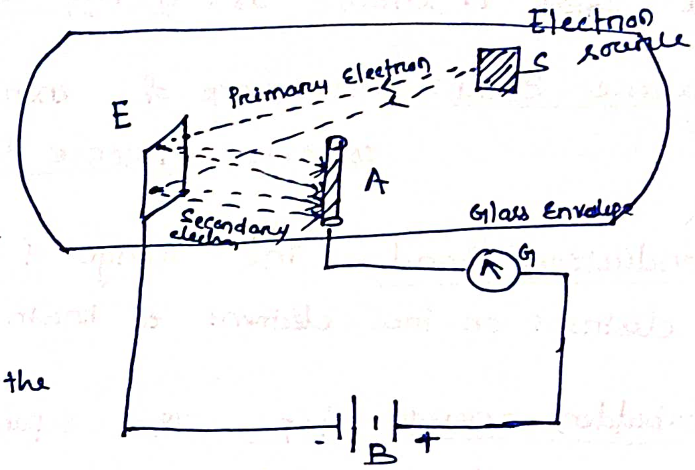


- When a metal surface is placed close to a high voltage conductor which is +ve w.r.t metal surface the electric field exerts attractive force on the free electrons in the metal.

→ This method is called cold cathode emission or auto electronic emission.

iii) <u>Secondary Emission</u>:

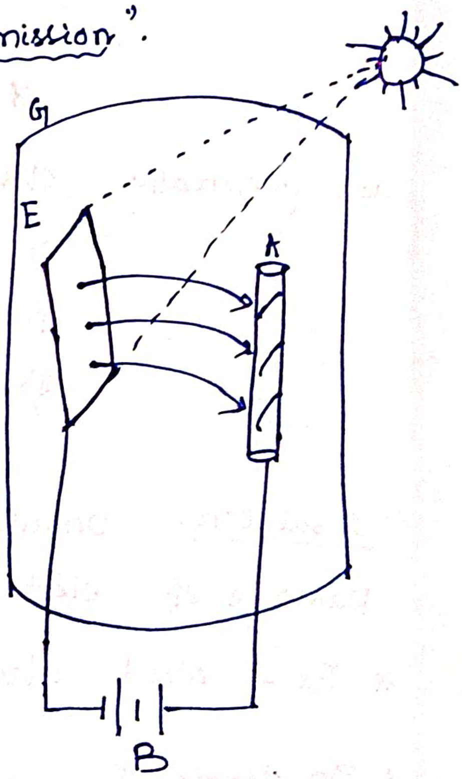
* Electron emission from a metallic surface by the bombardment of high speed electrons or other particle is known as <u>secondary emission</u>.



- When high speed electrons suddenly strike on a metallic surface E, they may give some or all their kinetic energy to the free electrons in the metal, which may cause free electrons to escape from the metal surface.
- This phenomena is called "<u>Secondary emission</u>".
- The collecting anode 'A' is positive potential w.r.t emitting surface, by battery B.

iv) <u>Photo Electric Emission</u>:

* Electron Emission from a metallic surface by the application of light is known as "<u>photo electric emission</u>".



- When a beam of light strikes / falls on the surface of a metal, the energy of photons of light is transferred to the free electrons with in the metal. Then electrons are ejected from the surface of the metal.
- The emitted electrons are known as <u>photo electrons</u> & the phenomena is known as photoelectric emission.

Energy Bands:

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

Valence Band: The range of energies possesses by valence electrons is called valence Band.

Conduction Band - The range of energies posseses by conduction electrons or free electrons is known as conduction band.

Forbidden energy Gap: The separation betⁿ conduction band and valence band on energy level diagram is known as forbidden energy gap.

Classification of Solids/Material according to electrical conductivity w.r.t energy band diagram:

* Based on electrical conductivity materials are generally classified into 3 catagories.

i) Insulator
ii) conductor
iii) Semiconductor.

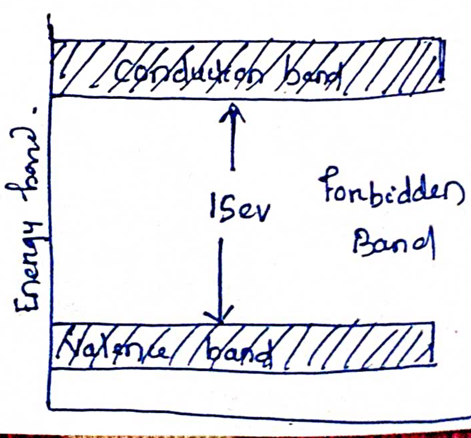
i) **Insulator:** Insulators are those substance which donot allow passage of electric current through them.

* Ex - wood, glass

* In terms of energy band, the valence band is full while the conduction band is empty.

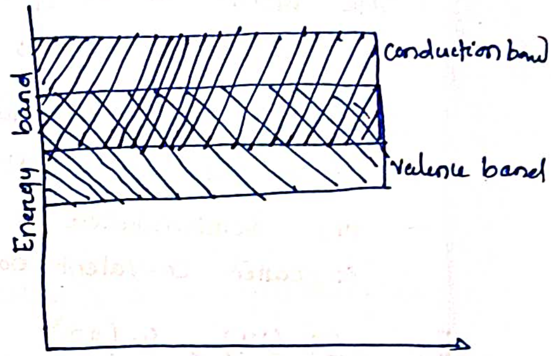
* Further the energy gap between valence & conduction band is very ~~high~~ large (i.e ≈ 15ev)

* Therefore a very high electric field is required to push valence electrons to conduction band.



II) Conductor : Conductors are those substance which easily allow the passage of electric current through them.
Ex - Copper, Aluminium

* It is because there are large number of free electrons are available in a conductor.

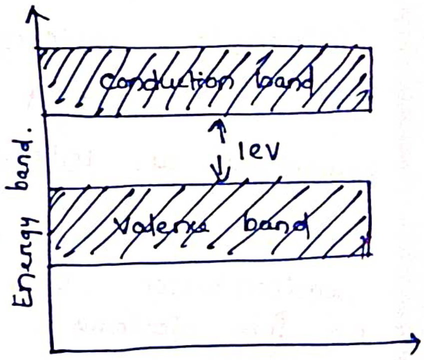


* In terms of energy band, the valence and conduction bands overlap each other.

- Due to overlapping, a slight potential difference across a conductor causes the free electrons to constitute electric current.

III) Semiconductor :

* Semiconductors are those substances whose electrical conductivity lies between conductor and insulators.
Ex : Silicon ($_{14}$), Germanium ($_{32}$).

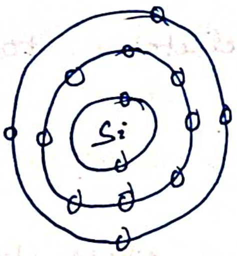


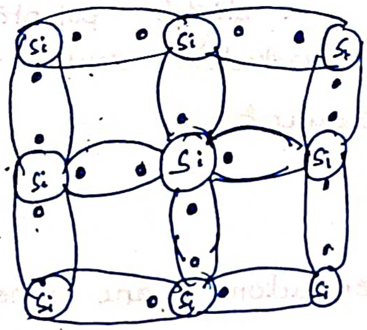
- In terms of energy band diagram the valence band is almost filled and conduction band is almost empty.
- Further, the energy gap between valence & conduction band is very small.
- Therefore smaller electric field (smaller than insulators and larger than conductors) is required to push the electron from valence band to conduction band.
- Semiconductors are negative temperature co-efficient of resistance.

Bonds in Semiconductor :

- The atoms of every elements are held together by bonding action of valence electrons.
- This bonding is due to fact that it is tendency of each atom to complete its last orbit by acquiring 8 electrons in it.
- In semiconductor, bonds are formed by sharing of valence electrons is called co-valent bonds.

Ex. Si (14), Ge (32)





Intrinsic Semiconductor :

* A semiconductor in an extremely pure form is known as an intrinsic semiconductor.

- At absolute zero temp (0°c), all the electrons are tightly held by the semiconductor atoms as covalent bonds are very strong & there are no free electrons
- As temp rises, at room temperature (25°c) some of the covalent bonds in the semiconductor break due to thermal energy supplied
- It is setting up free electrons. Under the influence of electric field, these free electrons consitute electric current.
- The removal of one electron, in covalent bond, leaves a vacancy or missing electron in covalent bond.
- A missing electron in a covalent bond is known as "hole"
- The missing electron in which is positively charged.
- Therefore thermal energy creates hole-electron pair.

* In Intrinsic semiconductor, current conduction takes place by two process i.e by free electrons & by holes.
* Intrinsic semiconductor has little current capacity at room temp.

Extrinsic Semiconductor:

To increase conducting properties, a small amount of suitable impurity added to a pure semiconductor. Then it is called as extrinsic semiconductor.

* The process of adding impurities to a Semiconductor is known as doping.

- Generally for 10^8 atoms of semiconductor, one impurity atom is added.

- The impurities which are added / used in doping ~~[illegible]~~ is known as dopant.

- The purpose of adding impurity is to increase either the number of holes or free electrons in semiconductor crystals.

*- There are two types of Extrinsic semiconductor based upon types of impurity added.

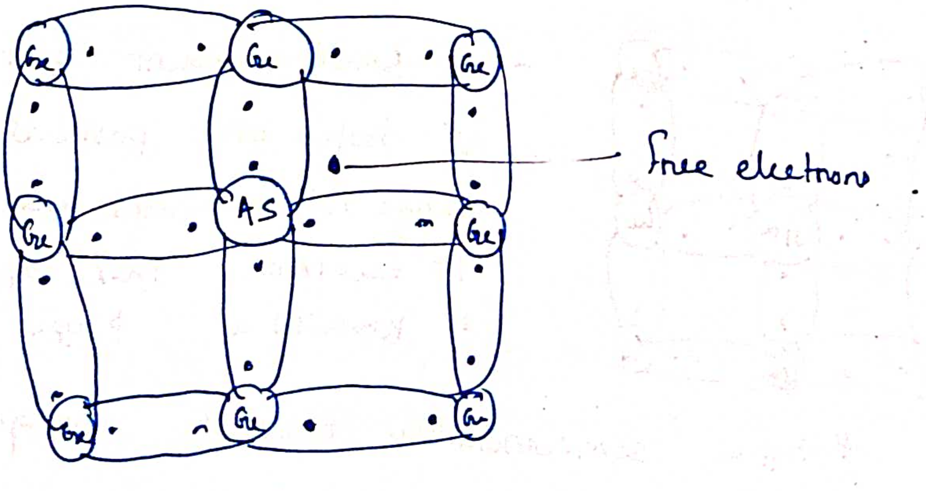
i) ~~Pentavalent~~ n-type Semiconductor

ii) P-type Semiconductor.

N type Semiconductor:

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

- Ex: Pentavalent impurities are As (33), Antimony (51)



- Such ~~type~~ impurities which produce n type semiconductor are known as <u>donor</u> impurities because they donate or provide free electrons to the semiconductor crystal.

- Many new free electrons are produced by addition of pentavalent impurity.

- Thermal energy of room temp still generates a few hole-electron pairs.

- Due to predominance of electron over holes, it is called n-type semiconductors.

- In n type semiconductor electrons are majority charge carrier where as holes are minority charge carrier.

- As electrons are -vely charge, such semiconductor is known as N-type semiconductor.

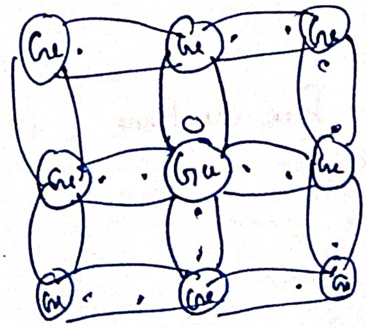
<u>P type Semiconductor:</u>

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

* Ex: of trivalent impurities of are gallium (31) indium (49)

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

- Such impurities which produce p type semiconductor are known as acceptor impurities because the holes created can accept the electrons.

- 

- ~~A small amount pent~~
- As holes are positively charged & large no of holes are present compare to electrons, this type of semiconductor is known as P type semiconductor.

- In P type semiconductor majority charge carriers are holes & minority charge carriers are electrons.

Difference between vaccume tube & Semiconductor :

Vaccume tube	Semiconductor
1. The size of vaccume tube is big	1. It's size is small .
2. It's weight is heavy	2. It's weight is light
3. Fragil in mechanical construction	3. Rugged in mechanical construction
4. Operation is complex	4. Operation is easy
5. Heating power is required.	5. Heating power not requires .
6. It's life period is short .	6. It's life period is very long
7. High operating voltage is required .	7. Low operating voltage is required .
8. It is mostly used in very high output power & high frequency operation.	8. It is mostly used in low and medium power and frequency application .

Integrated circuit :

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

- The size of an IC is extreamly small .

Advantages:

1) Low power requirement .
2) Low cost .
3) The circuit layout is greatly simplified .
4) Greater ability to operate at extreme value of temperature .
5) Extreamly small size
6) Increase reliability .

Disadvantages:

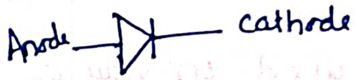
1) If any component in an IC goes out of order, the whole IC has to be replaced by the new one.

2) It is not economical to fabricate capacitance exceeding 30pF.

3) It is not possible to fabricate inductors or transformers on it.

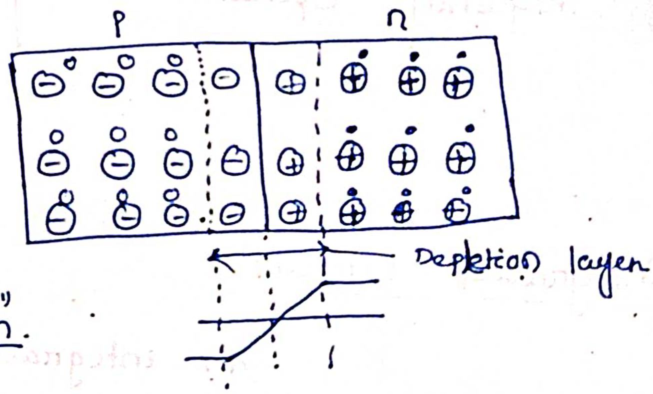
PN Junction Diode:

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



Working Principle:

→ When p-n junction formed, at the junction, there is a tendency of free electrons to diffuse over to p side & holes to n side.

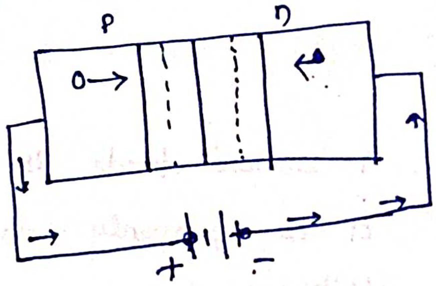


→ This process is called "diffusion".

- As the free electrons move across the junction from n type to P type, positive donor ions are uncovered.
- Holes are filled by free electrons & uncover negative acceptor ions.
- When sufficient ~~amount~~ of number of donor & acceptor ions are is uncovered, diffusion is prevented.
- Thus barrier is set up against further movement of charges carriers. This is called potential barrier or Junction barrier of Depletion layer.

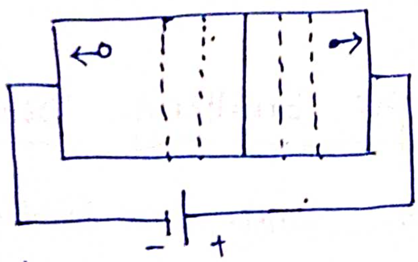
Forward Biasing:

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

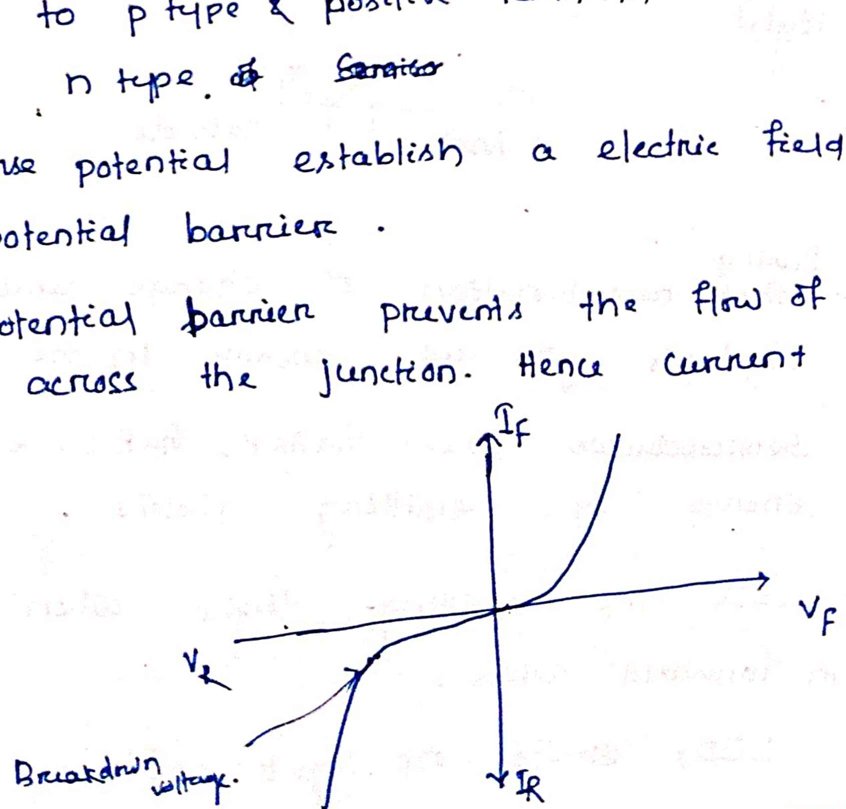


- To apply forward bias, positive terminal of battery connected to P-type and, negative terminal of battery connected to n-type.
- The applied forward potential establish a electric field, which reduced the potential barrier.
- As potential barrier voltage is very small, therefore, by applying a small forward voltage, current flows in the ckt. This is called forward current.
- At some forward voltage (0.7V for Si & 0.3V for Ge) the potential barrier is altogether eliminated and current starts flowing in the ckt.

Reverse Biasing:

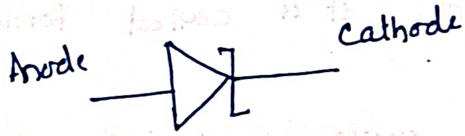


* When the external voltage applied to the junction is in such a direction that potential barrier is increased, it is called reverse biasing.
- To apply reverse bias, negative terminal of battery connected to p type & positive terminal of battery connected to n type. ~~&~~ ~~Semico~~
- The applied reverse potential establish a electric field which increases potential barrier.
- The increased potential barrier prevents the flow of charge carrier across the junction. Hence current does not flow.



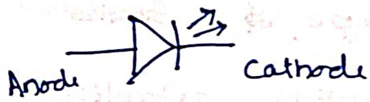
Zener Diode:

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



- A zener diode is like an ordinary diode except that it is properly doped so as to have a sharp breakdown voltages.
- A zener diode has sharp breakdown voltage, called zener voltage V_Z.
- A zener diode is always reverse connected i.e it is always reverse biased.

Light Emitting Diode (LED):

- It emits a fairly narrow bandwidth of visible (usually red, orange, yellow or green) or invisible (infrared) light.
- 

- During recombination of charge carrier at PN junction electrons give up energy in the form of heat or light.
- Semiconductor like GaAsP, GaP, electrons give up their energy by emitting photons.
- LEDs are emitting light when they are connected in forward bias.
- LEDs emits no light when reverse biased.

Gallium Arsenide (GaAs) ——

Gallium Arsenide phosphide (GaAsP) – Yellow/ Red

Gallium Phosphide (GaP) —— Green / Red

I . INGaN —— Blue

* It is a semiconductor device that emits light when current flows through it .

- The colour of the light is determined by the energy required for electrons to cross the bandgap of the semiconductor .

Electronic Circuit

Rectifier:

An electronic device that converts alternating current into direct current is called a rectifier.

→ Rectifier is used for telephone & Laptop charging, T.V & other electronics equipments.

- Based upon configuration & operation rectifier is two types.

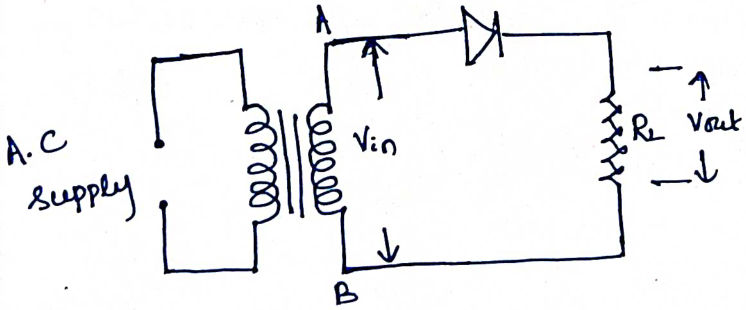
i) Half wave rectifier

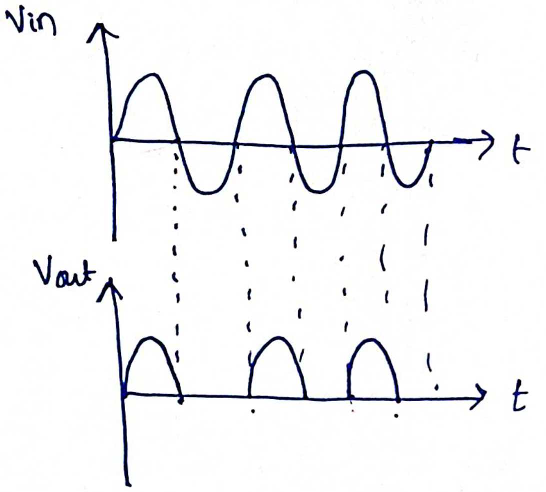
ii) Full wave rectifier → Centre-Tap Full wave Rectifier; Full wave Bridge Rectifier

Half wave Rectifier:

In half wave rectifier, it conducts current during positive half-cycle of input a.c supply.

Ckt diagram:





Circuit Details:

→ A halfwave rectifier is consist of a single crystal diode,

→ The ac supply connected in series with diode & load resistance R_L.

- The ac supply is given through a transformer.

Operation:

* During the positive half-cycle of input a.c voltage terminal A becomes positive w.r.t terminal B.

- This makes the diode forward biased and hence it conduct current.

- During the negative half-cycle of a.c input voltage, terminal A becomes negative w.r.t terminal B,

- This makes the diode reverse biased and hence current does not conduct.

* So the diode conducts during positive half cycle. So Dc output is obtained across RL.

Advantages:

i) circuit operation is simple.

ii) Only one diode is used.

Disadvantages:

i) An elaborate filtering is required to produce steady ~~stable~~ direct current.

ii) The a.c supply delivers power only half the time. Therefore, the output is low.

Full wave Rectifier:

* In fullwave rectifier, current flows through the load in the same direction for both half cycle of input a.c voltage.

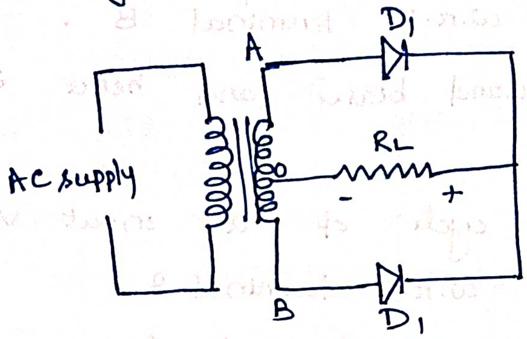
- There are two circuits are commonly used for full-wave rectification.

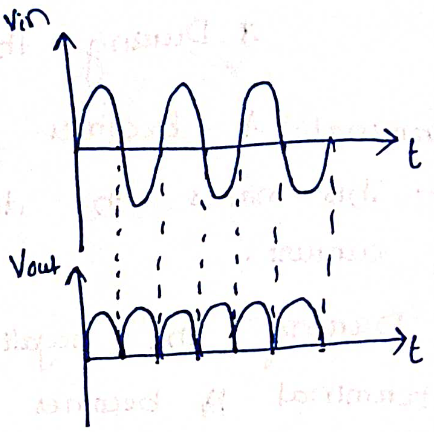
i) Centre-tap full wave rectifier

ii) Full-wave Bridge rectifier.

i) Centre - Tap Full wave Rectifier :

Circuit Diagram:





Circuit Details:

* centre - tap Full wave rectifier is consists of two diodes D_1 and D_2, a load resistor R_L connected with a Centre - tap transformer.

Operation:

* During positive half cycle, terminal A is positive w.r.t B.
  - This makes the diode D_1 forward biased & diode D_2 reverse biased.
  - Therefore diode D_1 conducts current while diode D_2 doesnot conduct current. The current flows across load Resistor R_L.

* During negative half cycle, terminal A is negative w.r.t B.
  - This makes the diode D_1 reverse biased & diode D_2 forward biasw.
  - Therefore diode D_2 conducts current while diode D_1 does not conduct current. The current flows across the load resistor R_L.

Advantages:

i) Rectifier conducts current in both direction of ac supply voltage. So high efficiency.

Disadvantages:

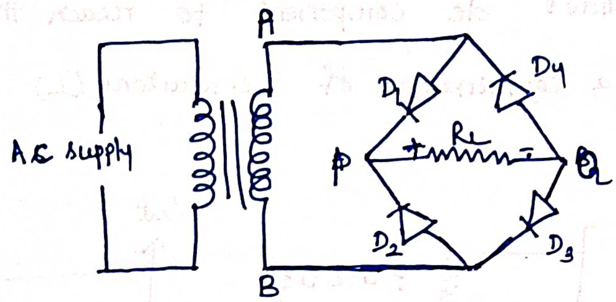
i) Dc output is small.

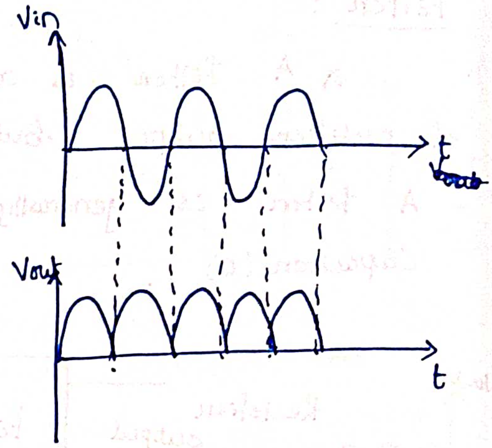
ii) It is difficult to locate the centre tap on the secondary winding.

iii) The diodes used must have high PIV.

ii) Full-Wave Bridge Rectifier:

Circuit Diagram:





Circuit Details:

- It contains 4 diodes D1, D2, D3 and D4 which are connected to form a bridge.
- The need of centre-tap transformer is eliminated.

Operation:

* During positive half cycle terminal A is positive w.r.t B.
- This makes the diode D1 and D3 forward biased where as diode D2 & D4 are reverse biased.
- Therefore diode D1 & D3 conduct current while D2 & D4 does not conduct current. The current flows across RL from P to Q.

* During negative half cycle terminal A is negative w.r.t B.
- This makes the diode D2 & D4 forward biased where as diode D1 & D3 reverse biased.
- Therefore diode D2 & D4 conduct current while diode D1 & D3 does not conduct current. The current flows across RL from P to Q.

Advantages:

i) The need of centre-tap transformer is eliminated.

ii) The output is twice that of centre-tap ckt for the same secondary voltage.

iii) The PIV is one-half of centre-tap circuit.

Disadvantage:

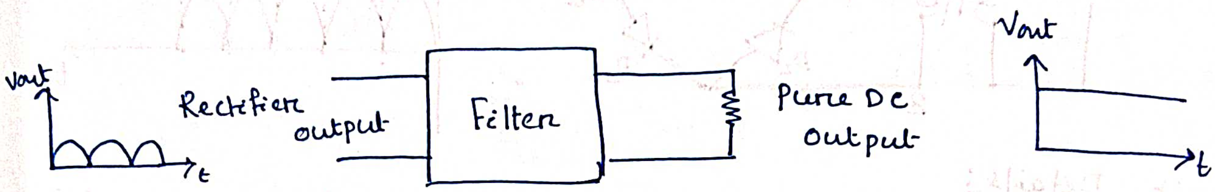
i) It required four diodes

ii) Voltage drop in the internal resistance of the rectifier is twice than centre tap ckt.

Filter :

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

- A filter is generally a combination of inductors (L) and Capacitor (C).



- A capacitor passes ac readily but does not pass dc at all

$$X_C = \frac{1}{2\pi f C}$$

- An inductor opposes ac but allows dc to pass through it.

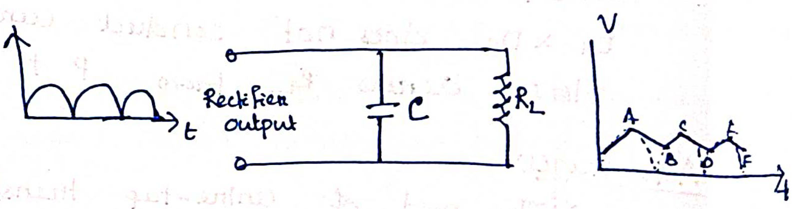
$$X_L = 2\pi f L$$

- There are 3 types of filter.

i) Capacitor filter
ii) Choke input filter
iii) π filter

i) Capacitor filter:

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



→ The pulsating direct voltage of the rectifier is applied across the capacitor.

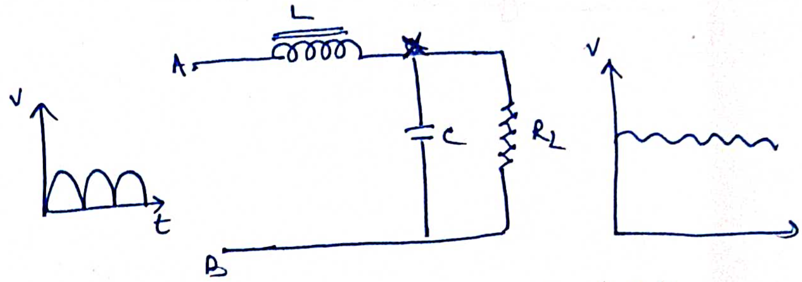
- As the rectifier voltage increases, it charges the capacitor and supplies current to the load.

→ Now the ~~capacitor~~ rectifier voltage starts to decrease. So the capacitor discharge through load and voltage across it starts to decrease.

→ The voltage across load will decrease only slightly because immediately next voltage peak comes & recharge the capacitor.

→ This filter is extremely popular due to its low cost, small size, little weight & good characteristics.

ii) Choke Input Filter:



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

→ The pulsating output of the rectifier is applied across terminal A & B. Pulsating output of rectifier contains ac & dc components.

→ The choke offers high opposition to the passage of ac component a negligible opposition to the dc component.

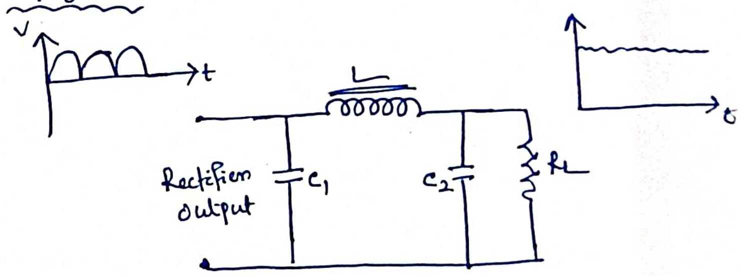
→ So choke passes dc & block ac components.

→ At terminal X, the rectifier output contains dc component & remaining part of ac component.

→ The capacitor c bypass the ac components & prevents dc component to flow through it.

→ Therefore only dc components reaches the load.

iii) π Filter or Capacitor Input Filter:



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

→ While pulsating output from the rectifier applied across C_1, it offers low reactance to ac component while infinite reactance to dc component.

→ Therefore C_1 bypasses appreciable ac component. While dc component continues its journey to the choke L.

→ The choke L allows dc components to flow through it while the unbypassed ac component is blocked.

→ The filter capacitor C_2 bypasses the ac components which the choke has failed to block.

* Therefore only dc components appears across the load.

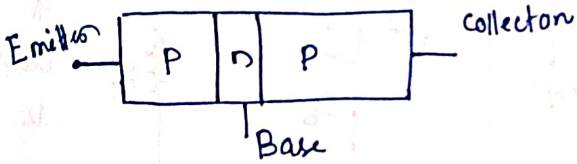
Transistor

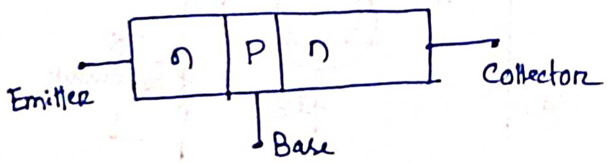
Transistor:

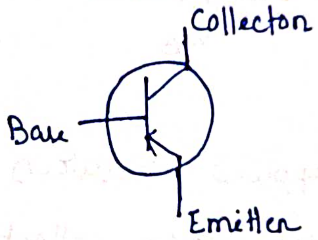
* A transistor consists of two pn junctions formed by sandwiching either p type or ntype semiconductor between a pair of opposite types.

- There are two types of transistors namely
  i) npn transistor
  ii) pnp transistor.

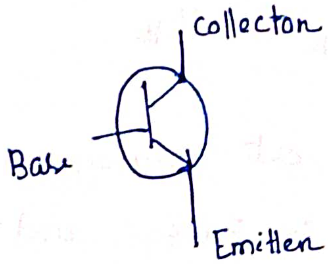
- A transistors has two pn junction & three terminals namely Emitter, Base & collector.







(pnp transistor)



(npn transistor)

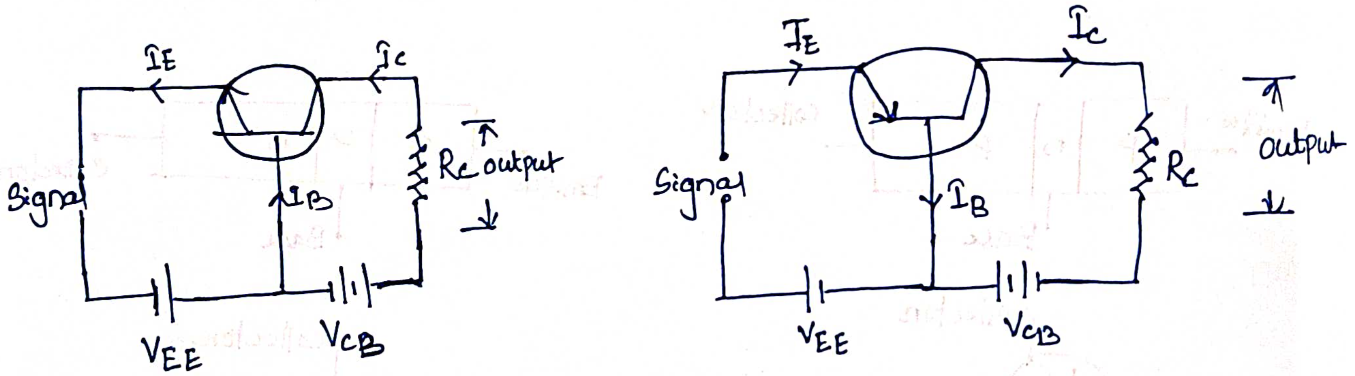
- The emitter is heavily dopped so that it can inject a large number of charge carriers (electrons or holes) into the base.
- The base is lightly dopped and very thin; It passes most of the injected charge carriers to the collector.
- The collector is moderately doped.
- The emitter-base junction is always forward biased where as collector-base junction is always reverse biased.

$$I_E = I_B + I_C$$

Types of transistor Configuration :

- When a transistor is to be connected in a ckt, it requires four terminals ; two for input & two for the output .
- So one terminal of transistor common to both input and output terminals .
- Accordingly , a transistor can be connected in 3 ways
  - i) Common Base Connection
  - ii) Common Emitter Connection
  - iii) Common Collector Connection .

i) Common Base Connection :



- In this ckt arrangement, input is applied between emitter & Base and output is taken from collector and base .
- Here base of the transistor is common to both input and output ckt .

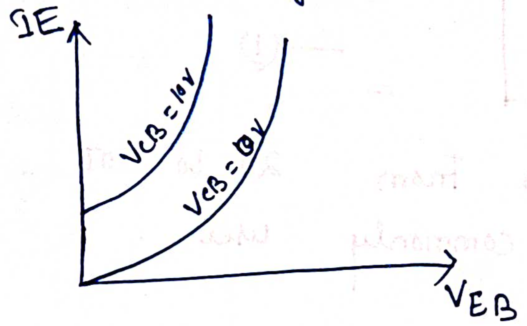
* Current amplification factor :

The ratio of change in collector current to change in Emitter current at constant collector base voltage is known as current amplification factor.

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$ with constant V_{CB} .

- The current amplification factor is less than unity.
- Practical values of α in commercial transistor ranges from 0.9 to 0.99.

Input characteristics: It is the curve between emitter current I_E & emitter-base voltage V_{EB} at constant V_{CB}.

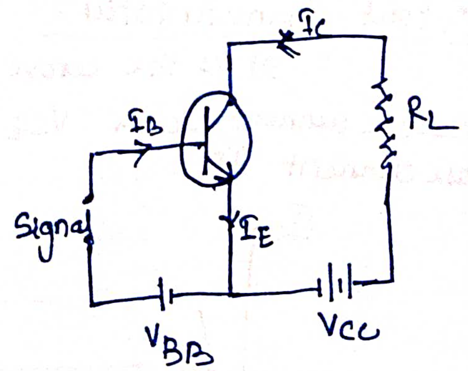


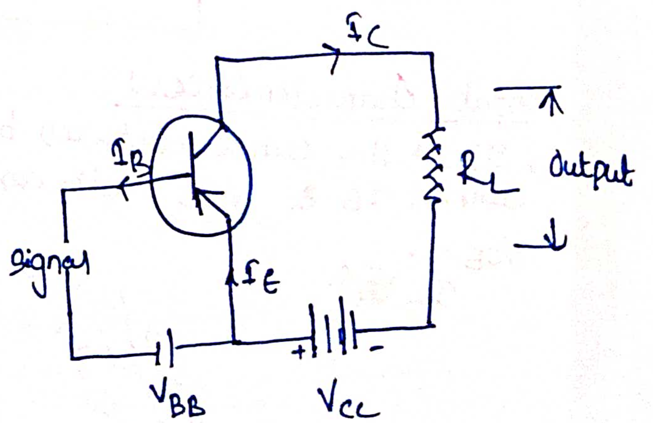
Output characteristics: It is the curve between collector current I_C & collector-base voltage V_{CB} at constant I_E.

ii) Common Emitter Connection:

* In this configuration, input is applied between base and emitter and output is taken from the collector and emitter.

- Here emitter is common to both input and output ckt.





Base Current Amplification Factor (β) :

The ratio of change in ~~curre~~ collector current to change in base current is known as base current amplification factor.

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{—(1)}$$

The value of β ranges from 20 to 500. So this type of configuration is most commonly used.

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

and $I_E = I_B + I_C$

$\Rightarrow \Delta I_E = \Delta I_B + \Delta I_C$

$\Rightarrow \Delta I_B = \Delta I_E - \Delta I_C$

substitute the value ΔI_B in equⁿ (1)

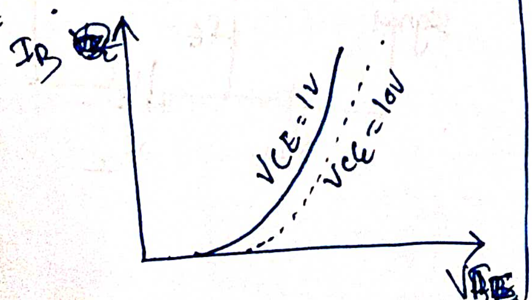
$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

$$\Rightarrow \beta = \frac{\frac{\Delta I_C}{\Delta I_E}}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}}$$

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

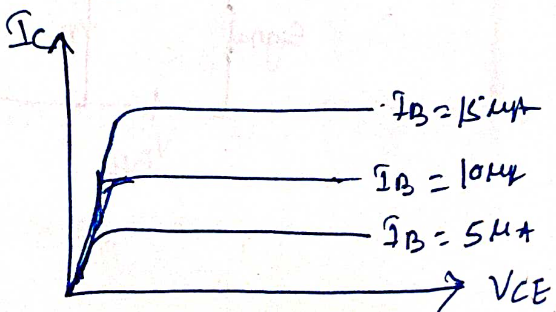
Input characteristics:

→ It is the curve between base current I_B & V_{BE} with constant V_{CE}.



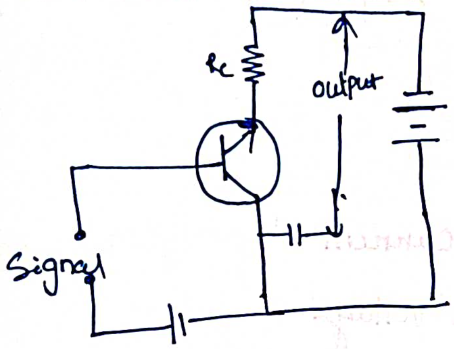
Output characteristics:

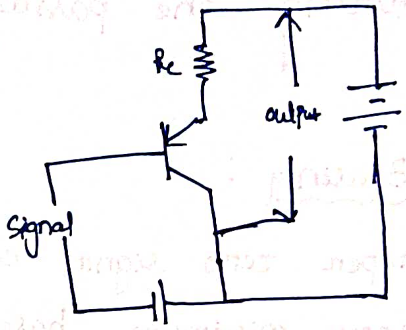
It is the curve between collector current I_C & V_{CE} at constant base current I_B.



iii) Common Collector Connection :

- In this configuration input is applied between base and collector while output is taken between the emitter and collector.
- Here collector of the transistor is common to both input and output ckts.





Current amplification factor :

The ratio of change in emitter current to the base current is known as common amplification factor.

$$\gamma = \frac{\Delta I_E}{\Delta I_B} \quad \text{--- (2)}$$

We ~~know~~ know that $\gamma = \frac{\Delta I_E}{\Delta I_B}$, $\alpha = \frac{\Delta I_C}{\Delta I_E}$ and

$$I_E = I_B + I_C$$

$$\Rightarrow \Delta I_E = \Delta I_B + \Delta I_C$$

$$\Rightarrow \Delta I_B = \Delta I_E - \Delta I_C$$

By substituting value of ΔI_B in eqn (2) we get

$$\gamma = \frac{\Delta I_E}{\Delta I_E - \Delta I_C}$$

$$\Rightarrow \gamma = \frac{\frac{\Delta I_E}{\Delta I_E}}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}}$$

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

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

$$\Rightarrow \gamma = \frac{\Delta I_B + \Delta I_C}{\Delta I_B}$$

$$\Rightarrow \gamma = \frac{\frac{\Delta I_B}{\Delta I_B} + \frac{\Delta I_C}{\Delta I_B}}{\frac{\Delta I_B}{\Delta I_B}}$$

$$\Rightarrow \boxed{\gamma = 1 + \beta}$$

Transistor Biasing

Transistor Biasing :

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

Need of Biasing :

i) Proper zero signal collector current.
ii) Proper minimum base-emitter voltage
iii) Proper minimum VCE at any instant.

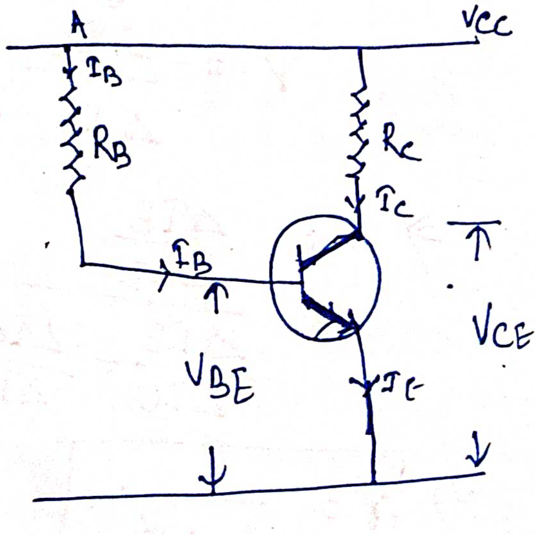
→ The basic purpose of transistor biasing is to keep the base-emitter junction properly forward biased & collector-base junction properly reverse biased during the application of signal.

Methods of transistor Biasing :

There are 3 methods of transistor biasing.

i) Base resistor method
ii) Biasing with feedback resistor
iii) Voltage-divider bias

i) Base resistor Method :



- In this method, a high resistance RB is connected base and positive end of supply.
- Hence the required zero signal base current is provided by Vcc & it flows through RB.

- Now base is positive w.r.t emitter i.e base emitter junction is forward biased.

- The required value of zero signal base current I_B can be made to flow by selecting ~~proper~~ proper value of base Resistor R_B.

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

$$\Rightarrow \boxed{I_C = \beta I_B}$$

By applying KVL, we get

$$V_{CC} - I_B R_B - V_{BE} = 0$$

$$\Rightarrow I_B R_B = V_{CC} - V_{BE}$$

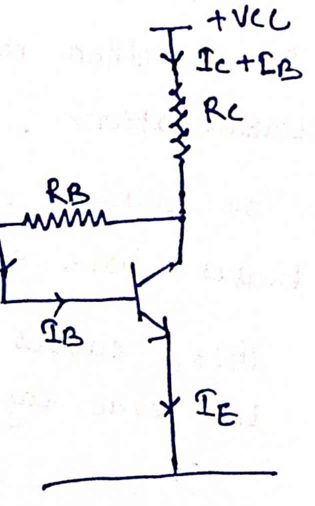
$$\Rightarrow \boxed{R_B = \frac{V_{CC} - V_{BE}}{I_B}}$$

As V_{CC} & I_B are known & V_{BE} is quite small compared to V_{CC}

$$\boxed{R_B = \frac{V_{CC}}{I_B}}$$

Advantages: i) Biasing ckt is very simple
ii) Calculations are simple

ii) Biasing with feedback Resistor:



- In this method, one end of R_B is connected to base & other end to the collector.
- Hence the required zero signal Base current is determined by V_{CB}.
- V_{CB} forward biases the base-emitter junction & hence base current I_B flows through R_B.
- This causes the zero signal collector current to flow in the ckt.

By applying KVL

$$V_{CC} - (I_C + I_B) R_C - I_B R_B - V_{BE} = 0$$

$$\Rightarrow V_{CC} - I_C R_C - I_B R_B - V_{BE} = 0 \quad (\because I_B << I_C \text{ so negligible.})$$

$$\Rightarrow I_B R_B = V_{CC} - I_C R_C - V_{BE}$$

$$\Rightarrow \boxed{R_B = \frac{V_{CC} - I_C R_C - V_{BE}}{I_B}}$$

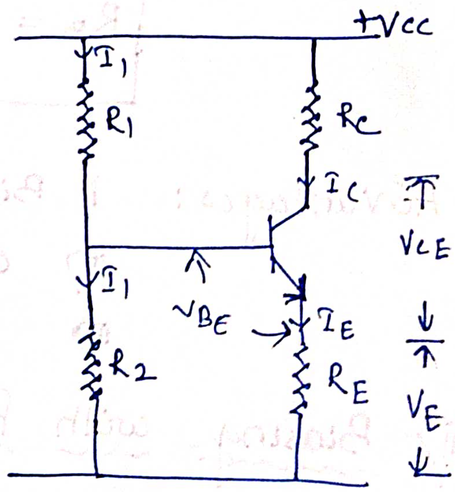
OR $V_{CE} = V_{BE} + V_{CB}$

$$\Rightarrow V_{CB} = V_{CE} - V_{BE}$$

$$\Rightarrow I_B R_B = V_{CE} - V_{BE}$$

$$\Rightarrow R_B = \frac{V_{CE} - V_{BE}}{I_B} \quad \text{where } I_B = \frac{I_C}{\beta}$$

iii) Voltage divider Bias Method:



- This method is widely used for providing biasing & stabilisation.
- In this method two resistance R_1 & R_2 are connected across the supply voltage V_{CC} & provide biasing.
- The emitter resistance R_E provides stabilisation.
- The voltage drop across R_2 forward biases base emitter junction.
- This causes base current & hence collector current flow in zero signal condition.

Let current flowing through R_1 & R_2 is I_1. As base current I_B is very small,

$$I_1 = \frac{V_{CC}}{R_1 + R_2}$$

voltage drop across R_2, is V_2

$$V_2 = I_1 R_2$$
$$= \frac{V_{CC}}{R_1+R_2} \cdot R_2$$

By applying KVL $V_2 = V_{BE} + V_E$

$$\Rightarrow V_2 = V_{BE} + I_E R_E$$
$$\Rightarrow I_E R_E = V_2 - V_{BE}$$
$$\Rightarrow \boxed{I_E = \frac{V_2 - V_{BE}}{R_E}}$$

Since $I_E \approx I_C$

$$I_C = \frac{V_2 - V_{BE}}{R_E}$$

So I_C does not depend upon β. Though I_C depends upon V_{BE} but $V_2 >> V_{BE}$ so I_C is independent of V_{BE}. Thus I_C in this ckt is almost independent of transistor parameters & hence good stabilisation.

Again $V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$

$$\Rightarrow V_{CC} - I_C R_C - V_{CE} - I_C R_E = 0 \quad (\because I_E \approx I_C)$$
$$\Rightarrow V_{CC} = I_C R_C + V_{CE} + I_C R_E$$
$$\Rightarrow V_{CC} = V_{CE} + I_C(R_C + R_E)$$
$$\Rightarrow \boxed{V_{CE} = V_{CC} - I_C(R_C + R_E)}$$

Amplifier :

* An electronic device which increase the strength of weak signal is known as amplifier.

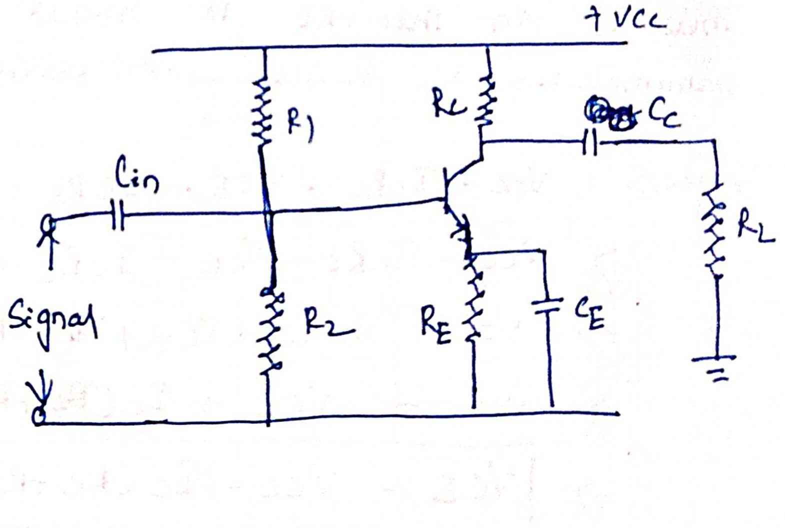
→ This increase in magnitude of the signal without any change in shape is known as faithful amplification.

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

Single stage Transistor Amplifier.

* When only one transistor with ~~associated~~ associated circuitary is used for amplifying a weak signal, the ckt is known as single stage transistor amplifier

ckt diagram:



ckt description:

→ The resistance R_1, R_2 & R_E form biasing & stabilisation circuit.

- An electrolytic capacitor Cin is used to couple the signal to the base of the transistor.
- The capacitor Cin allows only ac signal to flow, but isolates the signal source from R_2.

→ An emitter bypass capacitor C_E is used ~~to~~ in parallel with R_E to provide a low reactance path to amplified ac signal.

- Otherwise R_E will cause voltage drop across it & reduced output ~~o/p~~.

- The coupling capacitor C_c couples one stage of amplification to the next stage.

Operation :

* When a weak ac signal is given to the base of transistor, a small base current (which is a.c) start flowing.

* Due to transistor action ($I_C = \beta I_B$) a much larger ac current flows through the collector load R_C.

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

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

Oscillator

Oscillator: An electronic device which generates oscillations of desired frequency is known as <u>Oscillator</u>.

- Oscillators are two types based on its oscillations.
  - i) Sinusoidal oscillator
  - ii) Nonsinusoidal oscillator.

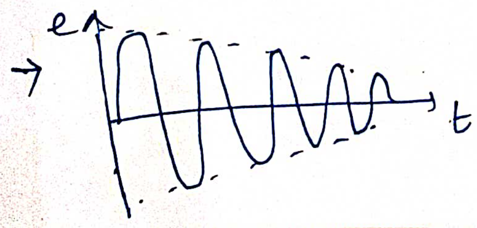
* An electronic device which generates sinusoidal oscillations of desired frequency is known as sinusoidal oscillators.

* Based on method of energy supplied sinusoidal oscillators are ~~divided~~ classified as
  - i) Tuned collector oscillator
  - ii) Colpitt's oscillator
  - iii) Hartley oscillator
  - iv) Phase shift oscillator
  - v) Wien bridge oscillator
  - vi) Crystal oscillator.

* An electronic device which generates non sinusoidal (rectangular) oscillations of desired frequency is known as non sinusoidal oscillator.

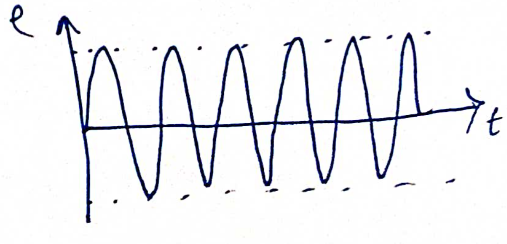
Damped Oscillations

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

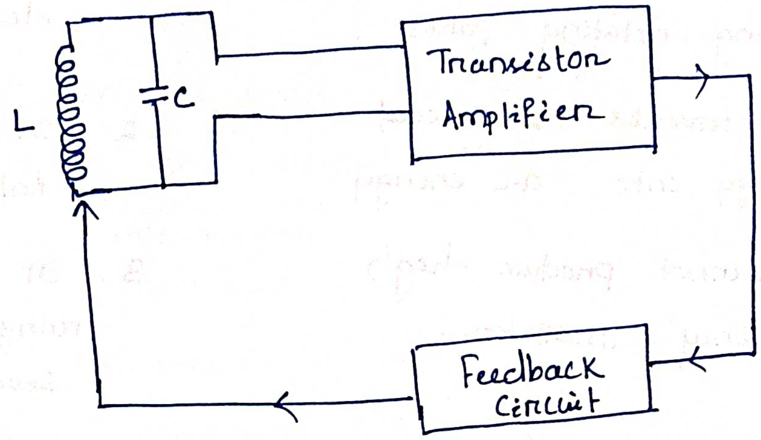


Undamped Oscillations.

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



Block diagram of Oscillator:



- This figure shows the block diagram of an oscillator. Its ~~essential~~ ~~parts~~ essential components are
  i) Tank Circuit
  ii) Transistor amplifier
  iii) Feedback circuit.

i) Tank Circuit: It consists of inductance coil (L) in parallel with capacitor (C). The frequency of oscillations in the ckt depends upon the value of the inductance of the coil & capacitance of the capacitor.

ii) Transistor Amplifier: The transistor amplifier receives dc power from the battery and changes it into ac power for supplying to the tank circuit. The oscillations occuring in the tank circuit are applied to the input of the transistor. Due to amplifying properties, transistor amplifier produces increased output. The output of the transistor can be applied to the tank circuit to meet the losses.

iii) 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.

Barkhausen Criterion: It states that the positive feedback should such that it produce continuous undamped oscillations at output of an amplifier.

$\beta . A_v = 1$

Alternator	Oscillator
1. It is a mechanical device having rotating parts.	1. It is a non rotating electronic device.
2. It converts mechanical energy into a.c energy	2. It converts dc energy into ac energy.
3. It cannot produce high frequency oscillation.	3. It can produce oscillations ranging from a few Hz to several MHz.

Advantages of Oscillator:

1. Oscillator is a non-rotating device. So little wear & tear hence longer life.
2. Due to absence of moving parts, Operation is quite silent.
3. It produce oscillations from small to extreamely high frequencies.
4. The frequency of oscillations can be easily changed when desired.
5. Good frequency stability.
6. It has very high efficiency.

Communication System

Introduction:

* Communication is simply the process of conveying message at a distance or communication is the basic process of exchanging information.

* The electronic equipments which are used for communication purpose are called communication equipments.

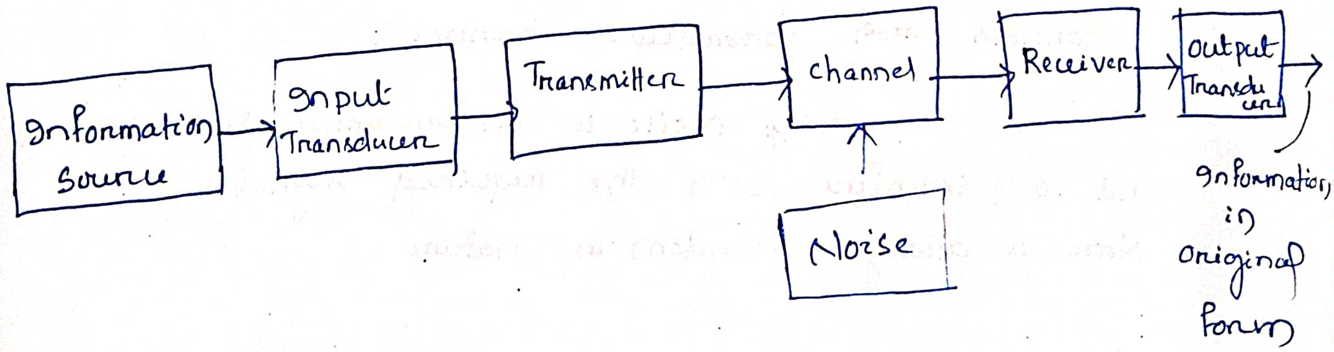
→ Different communication equipments when assembled together form a communication system.

Ex: Mobile communication, radar communication, computer etc.

Elements of a communication System:

The purpose of communication system is to transmit an information bearing signal from one place to another.

Block diagram:



i) Information Source:

* The message or information which is to be transmitted is originates in information Source.

- The function of information source is to produce required message which has to be transmitted.

2. Input Transducer:

* A transducer is a device which convert one form of energy into another form.

* The message from the information source may or may not be electrical in nature.

→ So input transducer is used to convert ~~message~~ information or message ~~signal~~ into electrical signal.

Ex: Microphone.

3. Transmitter:

- The function of transmitter is to process the electrical signal from different aspects such as modulation, amplification etc.

- Modulation is the main function of transmitter.

4. The channel & Noise:

- Channel means the medium through which the message travels from transmitter to receiver.

- The function of the channel is to provide a physical connection between the transmitter and receiver.

- There are two types of channels namely point to point channels and broadcast channel.

- * Noise is an unwanted signal which tend to interfere with the required signal.

- Noise is always random in nature.

5. Receiver:

The function of receiver is to reproduce the message signal in electrical form from the distorted received signal.

- The reproduction of the original signal is accomplished by a process known as demodulation.

6. Destination: / Output transducer:

- Destination is the final stage which is used to convert an electrical message signal into its original form.

Ex: Loudspeaker - which convert electrical signal into original sound signal.

Modulation:

* The Process of changing some characteristic of carrier in accordance with baseband or modulating signal is known as modulation.

* The information bearing signal is known as baseband or modulating signal.

* The carrier frequency is greater than modulating frequency.

* The process of extracting original signal from modulated signal is known as demodulation.

Need of Modulation:

1. Practical length of antenna:

To transmit a wave effectively the length of the transmitting antenna should be equal to the wavelength of the wave.

where c = Velocity of light
f = Frequency of wave.

$$\lambda = \frac{c}{f}$$

Let f = 20 KHz so

$\lambda = \frac{3 \times 10^8}{20 \times 10^3}$ = 15000 meter

which is practically impossible.

if f = 1000 kHz then $\lambda = \frac{3 \times 10^8}{1000 \times 10^3}$ = 300 meter

So the size of antenna reduced & practically possible.

ii) <u>Operating Range</u>: The energy of wave depends on its frequency. Greater the frequency wave, greater the energy possess by it, ∴ So operating range of communication increases.

iii) <u>Avoid Mixing of signals</u>: By using multiplexing technique more no of signals can transmitted through a single channel without mixing.

iv) <u>Reduction of Noise</u>: Noise is a unwanted signal which affects the transmitted signal. But effect of noise is reduced if frequency increased. So By using modulation effect of noise is reduced.

V.V.Imp Types of Modulation:

Modulation is the process of changing some characteristic of carrier wave in accordance with baseband signal.

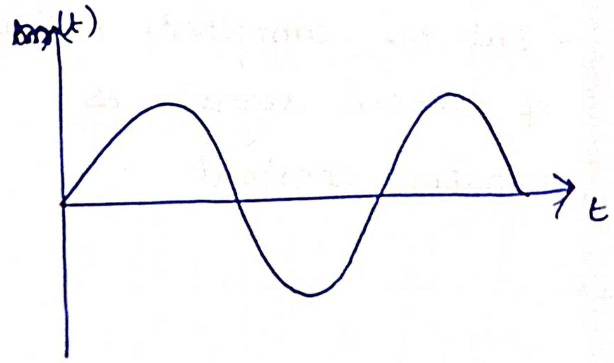
- These characteristics are amplitude, frequency or phase.
- Based upon the characteristic modulations are 3 types

i) Amplitude Modulation
ii) Frequency Modulation
iii) Phase Modulation.

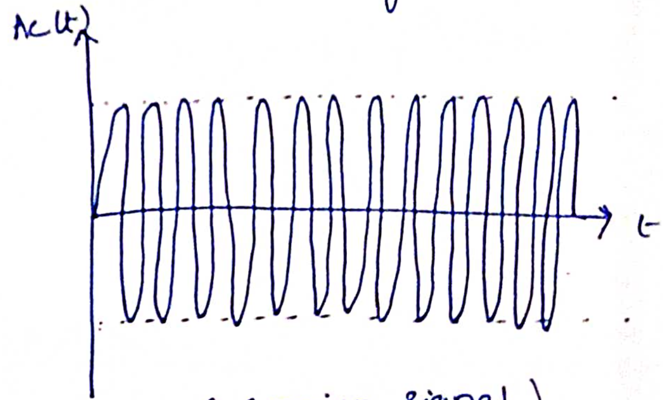
i) Amplitude Modulation:

The process of modulation in which amplitude of carrier signal change in accordance with intensity of baseband signal is known as **Amplitude Modulation**.

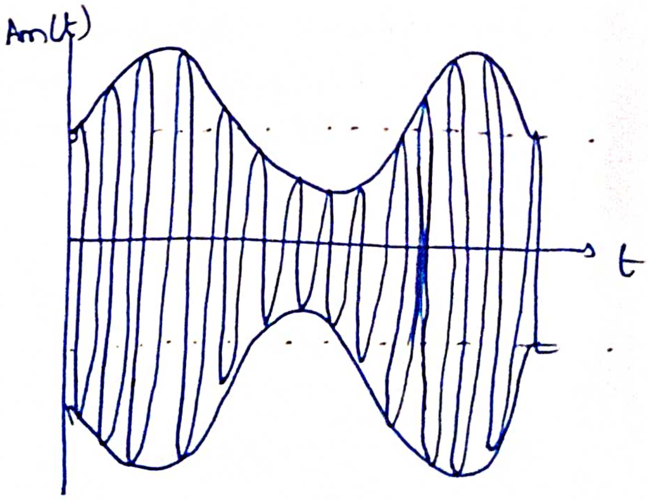
* In amplitude modulation only amplitude of carrier signal is changed.
* But the frequency and phase of carrier signal is constant.



(Base band or Modulating signal.



(carrier signal)

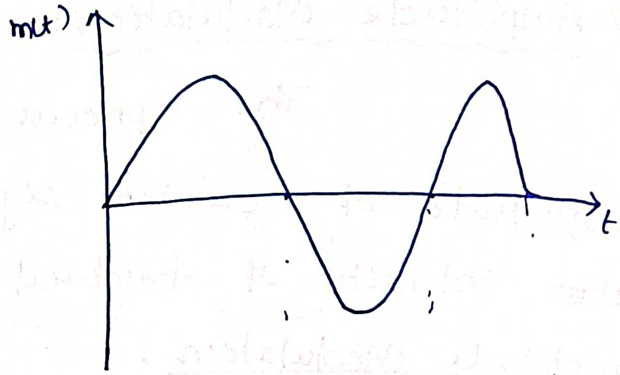


(Modulated signal)

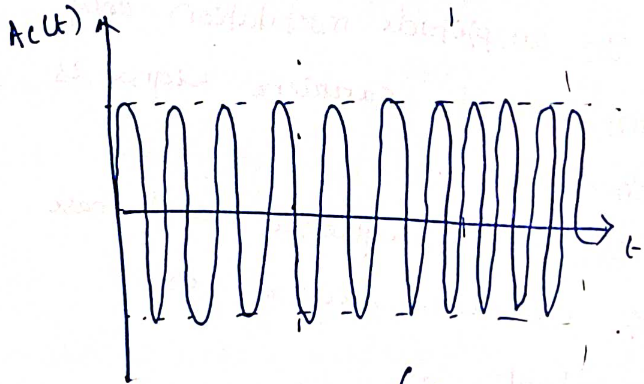
ii) Frequency Modulation:

The process of modulation in which frequency of carrier signal is changed with the intensity of base band signal is known as **Frequency Modulation**.

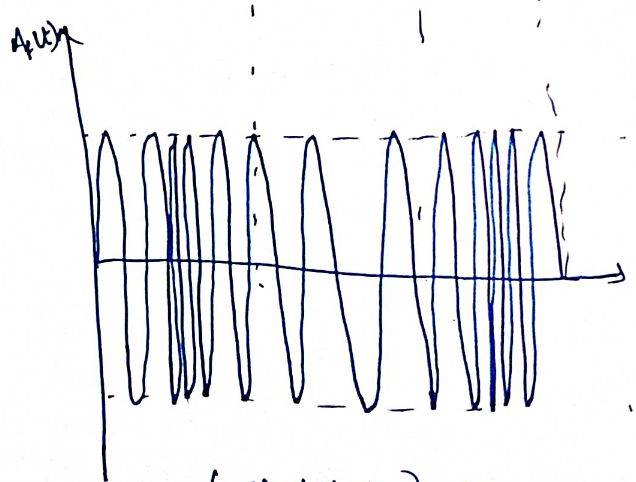
- In frequency modulation frequency of carrier wave changed.
- But the amplitude & phase of carrier signal is remain constant.



(Base band signal)



(Carrier signal)

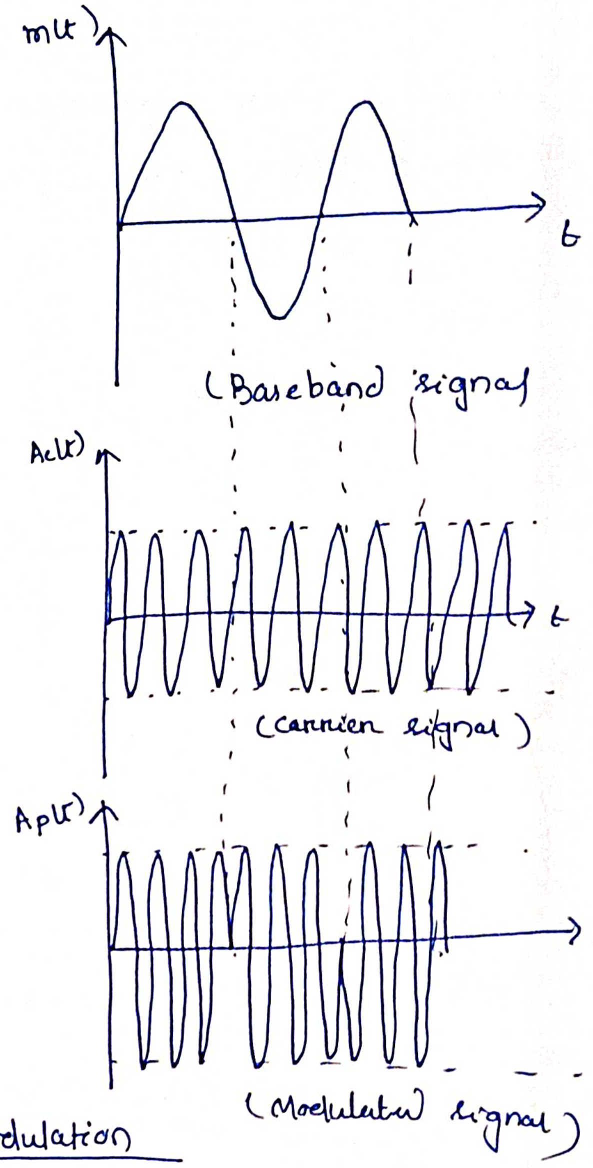


(Modulated signal).

iii) Phase Modulation:

* The process of modulation in which phase of the carrier signal is changed with the intensity of baseband signal is known as phase modulation.

- In phase Modulation phase of carrier signal changed.
- But the amplitude & frequency of carrier signal ~~change~~ remain constant.



Difference betn Modulation & Demodulation

Modulation	Demodulation
1) The process of changing some characteristic of carrier signal in accordance with baseband signal is known as modulation.	1) The process of extracting baseband signal from modulated signal is known as demodulation.
2) It is done at transmitter side.	2) It is done at receiver side.
3) It convert low frequency signal to high frequency signal	3) It convert high frequency signal to low frequency signal.
4) This process is simple	4) This process is complex compared to modulation.
5) Ex: Balance Modulator	5) Ex: Armstrong Method.

~~Source~~.

- A movable soft iron core is placed inside the former.

Operation:

- Due to transformer principle, voltage induced in the Secondary winding are E_{S1} & E_{S2}. The output is taken difference of two secondary voltage. i.e

~~$E_0 = E_{S1}$~~ $$E_0 = E_{S1} - E_{S2}$$

- When the core is at normal position without any movement then voltage induced in both the secondary winding are equal which results in net output is equal to zero.

$$E_0 = E_{S1} - E_{S2} = 0$$

- When an external force is applied a steel iron core tends to move left side direction then emf voltage induced in secondary coil 1 is greater when compared to the emf produced in secondary coil 2.

Therefore $E_0 = E_{S1} - E_{S2}$

- ~~When~~ Similarly when iron core move right side, the o/p of secondary voltage is unequal.

$$E_0 = E_{S2} - E_{S1}$$

- Hence the amount of voltage difference is proportional to displacement of core inside the transformer.

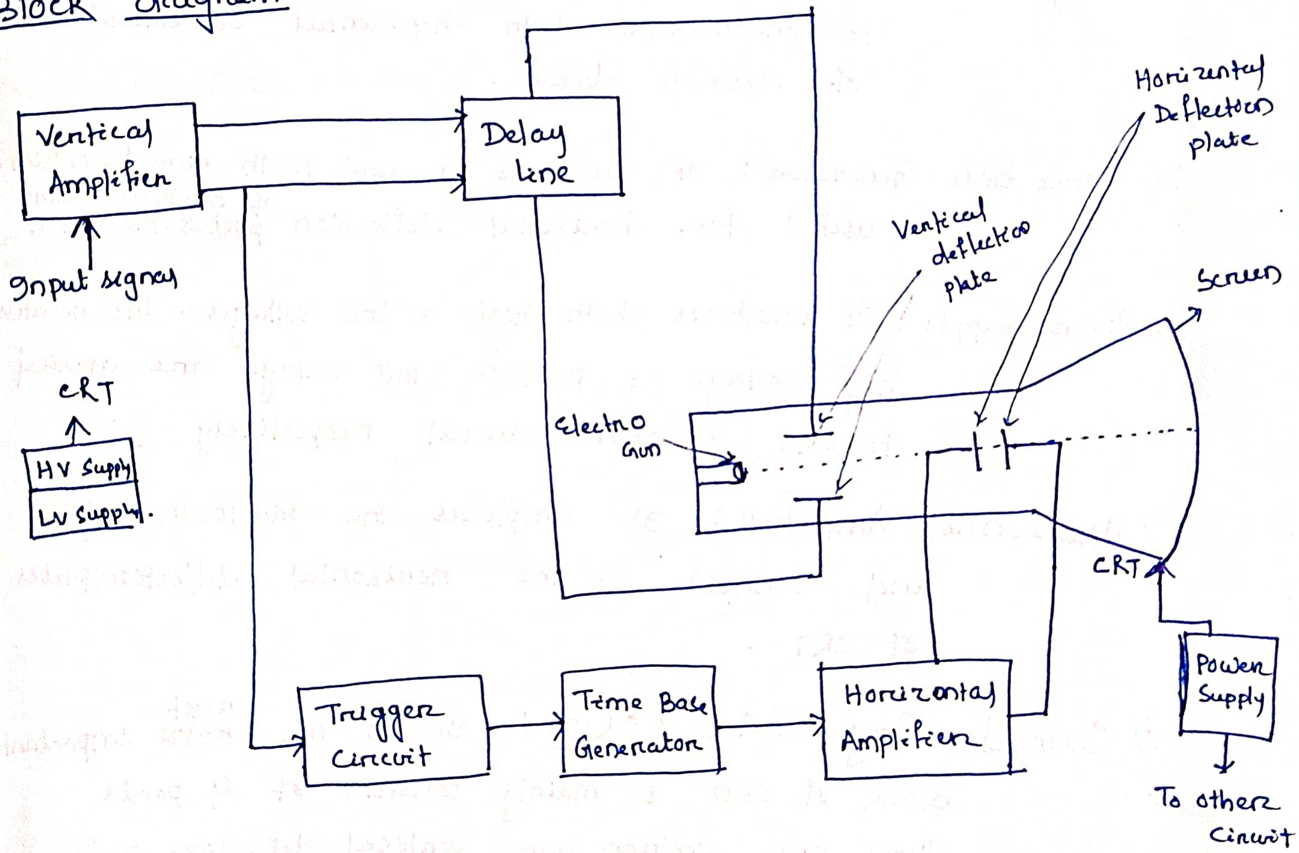
Transducer and Measuring Instruments

v.imp

CRO :

- The cathode Ray Oscilloscope (CRO) is an electronic device which is giving a visual indication of signal wave form.
- It is widely used for trouble shooting radio & television receiver as well as for labortary work involving research and design.

Block diagram :



* In oscilloscope, the electrons are emitted from a cathode accelerated to a high velocity, and brought to focus on a fluorescent screen.
- The screen produces a visible spot where electron beam strikes.

The function of each block of CRO is

i) Vertical Amplifier : It amplifies the input signal, which is to be displayed on the screen of CRT.

ii) Delay line : It provides some amount of delay to the signal, which is ~~obtained~~ ~~applied~~ obtained at the output of vertical amplifier. This delayed signal is then applied to vertical deflection plates of CRT.

iii) Trigger Circuit : It produces a triggering signal in order to synchronize both horizontal & vertical deflections of electron beam.

iv) Time Base Generator : It produces a saw tooth signal, which is useful for horizontal deflection ~~plates~~ of electron beam.

v) Power Supply : It produces both high & low voltages. The negative high voltage & positive low voltage are applied to CRT & other circuit respectively.

vi) Horizontal Amplifier : It amplifies the sawtooth signal and connects to the horizontal deflection plates of CRT.

vii) Cathode Ray Tube (CRT) : It is the ~~major~~ most important block of CRO & mainly consists of 4 parts. Those are electron gun, vertical deflection plate, horizontal deflection plates and fluorescent Screen. The electron beam which is produced by an electron gun get deflected in both vertical and horizontal direction by a pair of vertical deflection plate and a pair of horizental deflection plate respectively. Finally, the deflected beam will appear as a Spot on the fluoreseent Screen.

Sai Ram

LVDT (Linear Variable Differential Transformer / Transducer)

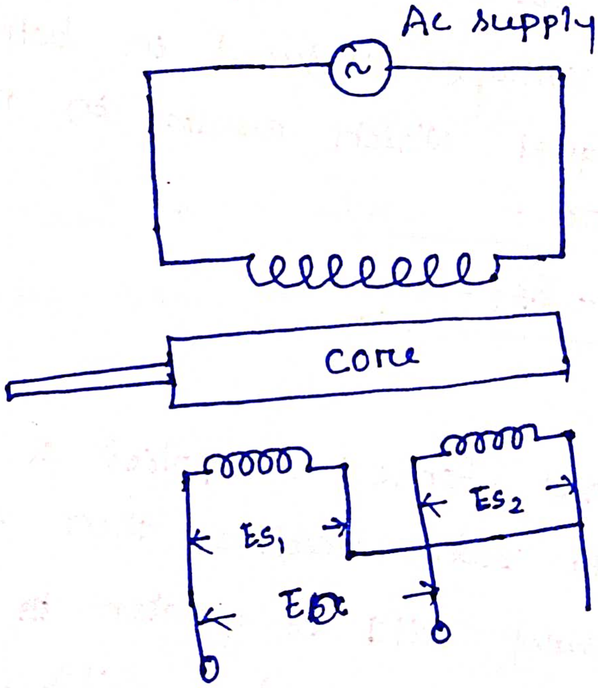
→ LVDT is an inductive transducer to translate/convert the linear motion into electrical signal.

Principle Operation:

→ LVDT works under the principle of mutual induction, and the displacement which is non electrical energy is converted into an electrical energy.

~~Construction~~

Fig :



Construction:

- It consists of a transformer having single primary winding 'P' and two secondary winding S_1 & S_2 wound on a cylinderical former.
- The secondary winding has equal number of turns but they are opposite to each other.
- The primary winding is connected to an ac source.

Advantages:

→ LVDT is a high output & high sensitive instrument having very good linearity.

- It provides less friction, low hysteresis & gives low power consumption.

Disadvantages:

- Very high displacement is required for generating high voltage.
- Performance is affected by vibration.
- It also affected by temp. changes.

Applicatⁿ:

- LVDT is used to measure force, weight & pressure.
- It is also used to measure thickness of materials.

Transducer

Transducer:

- Transducer is a device which converts energy or information from one form to another.
- The transducer may be mechanical, electrical, magnetic, optical, chemical, thermal, nuclear or combination any two or more of these.

Transducer should meet the following requirements.

1) Ruggedness: It should capable of withstanding over load.
2) Linearity: Its i/p - o/p c/s should be linear.
3) Repeatability: It should reproduce same output signal when same i/p signal is applied again & again under fixed environmental condition e.g pressure, temp, humidity.
4. High output signal Quality: The quality of output signal should be good.
5. High reliability & stability: It should give minimum error in measurement for temp variation, vibration & other changes in surrounding.

Classification of Transducer:

The transducer may be classified in various ways such as on the basis of electrical principle involved, methods of application, methods of energy conversion used, nature of output signal etc.

1) Primary & Secondary Transducers:
on the basis of applications transducer are 2 types i.e Primary Transducer & Secondary transducer.

→ When the input signal is directly sensed by the transducer & physical phenomena is converted into electrical form directly then such a transducer is called primary transducer, Ex: Pressure measurement by bourdon Tube