Electronic Devices

Electronics

The branch of engineering which deals with current conduction through a Vaccum or Gas or Semiconductor is known as Electronics.

An electronic device is that in which current flows through a vaccum or gas or Semiconductor.

Ex- Audio System, Video Systems, TV, Laptop Digital Camera, DVD Players, GPS, Mobile phone

imp **Electronic Emission**

The liberation of electrons from the surface of a substance, 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.

imp **Types of Electron Emission**

The electron emission from the surface of a metal is possible only if sufficient additional energy is supplied from some external source.

This external energy may come from a variety of sources such as heat energy, electric field, light energy or kinetic energy of the metal surface. There are four types of Electron Emission.

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① Thermonics Emission.
② Field Emission
③ Photo-electric emission.
④ Secondary Emission.

Thermonics Emission :- The process of electron emission from a metal surface by supplying thermal energy to it is known as theremonics emission.

At ordinary temperature, the energy possesed by free electrons in the metal is insufficient to espace the electron from the surface. When heat is applied to the metal, some of heat energy is converted into kinetic energy, causing accelerated motion of free electrons and they overcome the restricted surface barrier and leave the metal surface.

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 ~~exer~~ extract attractive force on the free electrons in the metal.

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Secondary Emission :- Electron emission from a metallic 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.

If the energy of the striking electrons is sufficient, it may cause free electrons to escape from the metal surface.

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

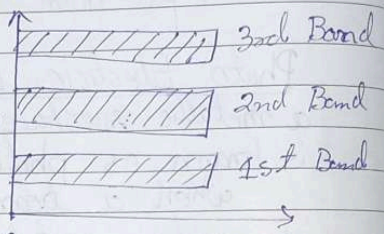
when a beam of light strikes the surface of certain metals (eg. potassium, sodium) the energy of photons of light is transferred to the free electrons with in the metal. If the energy of striking photons is greater than the work function of the metal, then free electrons will be knocked out from the surface of the metal.

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

Energy Levels & Bands

Each orbit has fixed amount of energy associated with it. The electrons moving in a particular orbit posses the energy of that orbit. The larger the orbit, the greater is its energy.

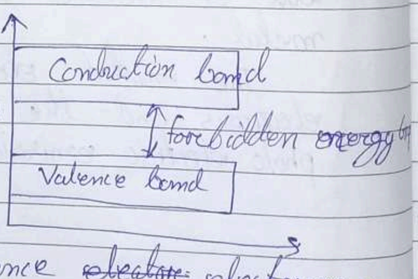
The range of energies possessed by an electron in a solid is known as energy band.



An atom is a solid is greatly influenced by the closely-packed neighbouring atoms. The result is that electrons in any orbit of such an atom can have a range of energies rather than a single energy. This is known as energy band.

Important Energy Bands in Solid :-

Valence band :-



The range of energy possess by valence electrons is known as valence band.

The electrons in the outermost orbit of an atom are known as valence ~~electore~~ electrons. This band may be completly or partially filled.

Conduction band :- The range of energies possessed by conduction band electrons is known as conduction band.

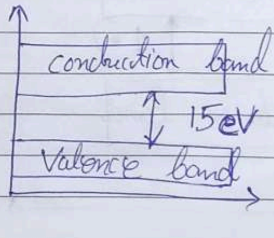
The valence electrons are loosely attached to the nucleus. Even at room temperature, some of the valence electrons may get detached to become free electrons. This electrons are present in conduction band and are called conduction electrons.

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

Classification of Solids according to Energy bands.

Insulator

Insulator (Ex- wood, glass etc) are those substance which do not allow the passage of electric current through them. In terms of energy band, the valence band is full while the conduction band is empty. The energy gap between valence and conduction bands is very large (≃15 eV). A very high electric field is required to push the valence electrons to the conduction band.



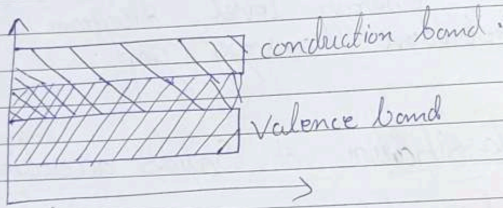
Conductors :-

Conductor (eg:- Copper, aluminium) are those substance 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 band and conduction bands overlap each other.

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

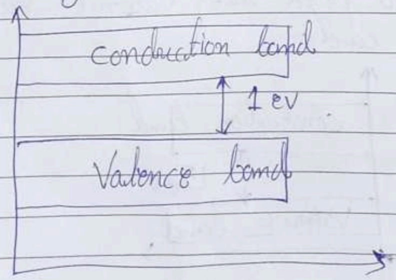


Semiconductor

Semiconductor (Ex- germanium, silicon, etc) are those substance whose electrical conductivity lies inbetween conductor and insulator.

-> 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 $\cong$ 1ev.



Semiconductor

A semiconductor is a substance which has resistivity in between insulator & conductor.

Ex - Germanium, Silicon.

Properties of Semiconductor

(1) The resistivity of semiconductor is less than insulator but more then ~~cor~~ conductor.

(2) Semiconductor have negative temperature co-efficient of resistance. The resistance of semi-conductor decreases with increase in temperature.

(3) When a suitable metallic impurity is added to a semiconductor, its current conducting ~~capail~~ capacity will change.

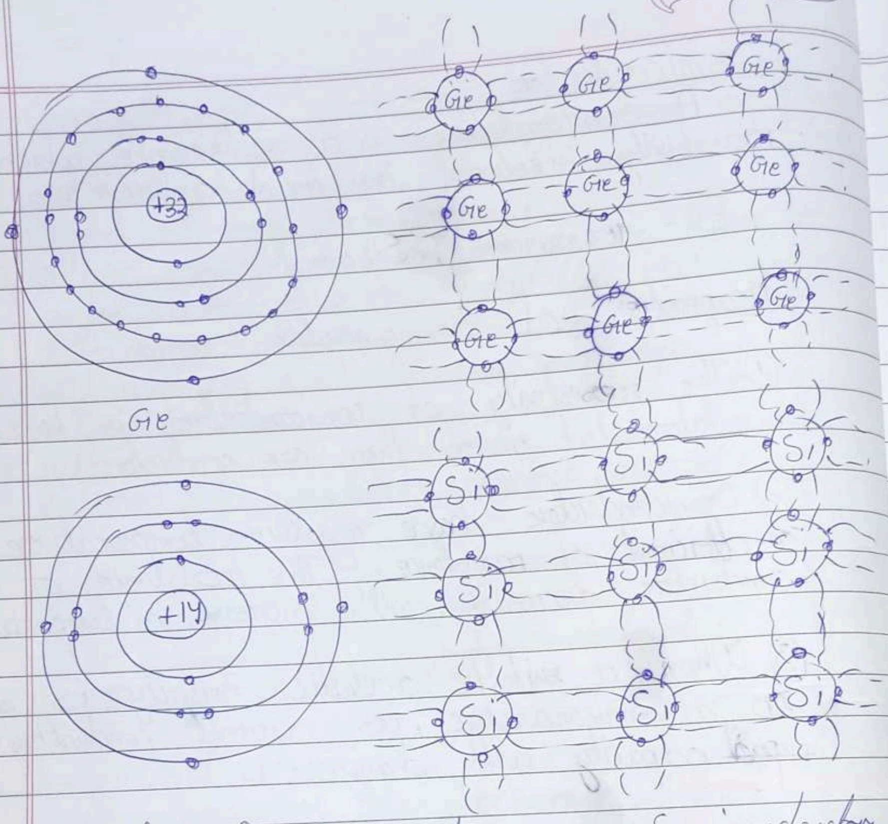
-> The semiconductor will make co-valent bond with each other.

-> They have crystal in structure.

-> The commonly used semiconductors are germanium (Ge) having atomic number - 32 and Silicon (Si) having atomic number - 14.

-> The forebidden energy gap in Silicon is 1.1 eV

-> The forebidden energy gap in Germanium is 0.7 eV



Effect of Temperature on Semiconductor

At absolute zero :- At this temperature all the electrons are tightly attached by the nucleus. The valence band is full & the conduction band is empty i.e no current will flow through the Semiconductor.

Above absolute zero :- Above absolute zero, the temperature is raised, some of the covalent band will break and Hole, electrons pairs are created and the current conduction take place inside the semiconductor.

Semiconductore are divided into 2 types.

1. Intrinsic Semiconductore.
2. Extrinsic Semiconductore.

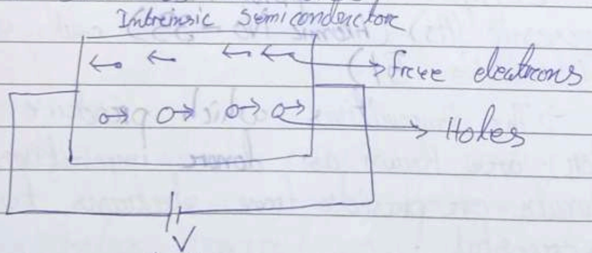
Intrinsic Semiconductore

A Semiconductore in an extremely pure form is known as an intrinsic semiconductore.

In an intrinsic semiconductore, even at room temperature, hole-electron paires are created when electric field is applied across an intrinsic semiconductore, the current conduction takes place by two processes by free electrons and holes

→ The free electrons are produced due to the breaking up of some covalent bonds by thermal energy.

→ At the same time, holes are created in the covalent bonds. Under the influence of electric field, conduction through the semiconductore is by both free electrons and holes.



Extrinsic Semiconductore

→ A Semiconductore in impure from is known as Extrinsic Semiconductore.

→ To increase the conductivity of a pure Semiconductor we add the suitable impurity to it. Then it is called impurity or extrinsic semiconductor

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

→ Depending upon the type of impurity added extrinsic semiconductors are classified into 2 types.
(1) n-type Semiconductor
(2) 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.

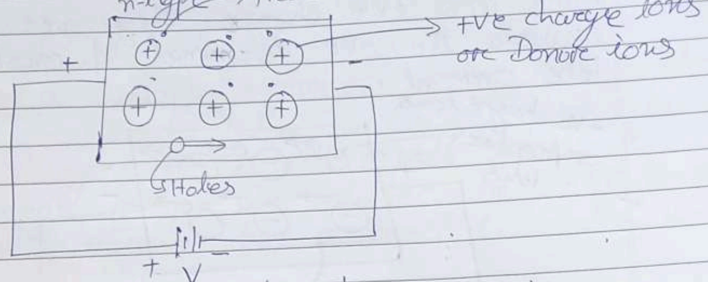
The addition of pentavalent impurity provides a large number of free electrons in the semiconductor crystal.

Example of pentavalent impurity are arsenic (As) (Atomic No - 33) and antimony (Sb) (Atomic No - 51)

→ The impurities which produce n-type Semiconductor are known as donor impurities because they donate or provide free electrons to the semiconductor crystal.

→ The current conduction in n-type Semiconductor is predominantly by free electrons, when potential difference is applied across the n-type semiconductor.

the free electrons in the crystal will be directed towards the positive terminal, constitute electric current.



In n-type majority charge carriers are free electrons & minority charge Carriers are Holes. A +ve charge ions are created due to lack of electron in the atom.

P-type Semiconductor

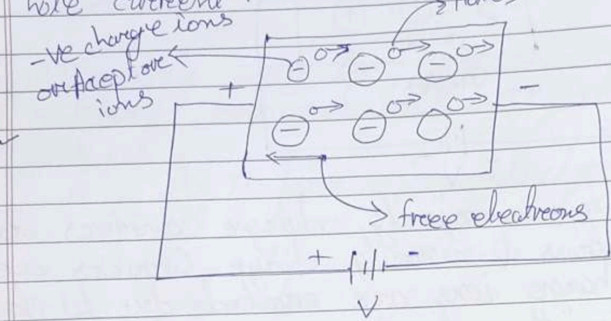
When a small amount of trivalent impurity is added to a pure semiconductor. It is called p-type Semiconductor.

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

The example of trivalent impurity are gallium (Ga) Atomic No - 31. Indium (In) Atomic No :- 49.

→ This impurity which produce p-type semiconductor are known as acceptor impurity because the holes created can accept the electrons.

→ The current conduction in p-type semiconductor is perdominantly by holes. when potential difference is applied to p-type semiconductor, the holes are shifted from one co-valent band to another. As the holes are +ve charge they are directed towards the -ve terminal & constituting hole current.



In p-type majority charge carriers are Holes & minority charge carriers are free electrons. A -ve charge ions are Acceptor ions are created due to excess of electron in the atom.

p-n Junction

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

→ n-type material has a high concentration of free electrons while p-type material has a high concentration of holes.

→ At the junction, there is a tendency for the free electrons to diffuse over to the p-side and holes to the n-side. The process is called ~~drift~~ diffusion.

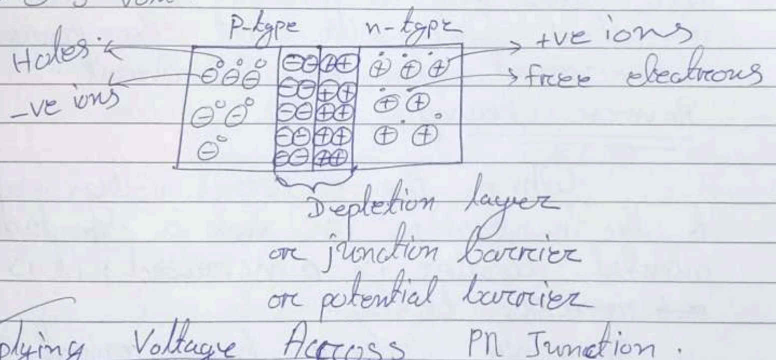
→ As the free electrons move across the junction from n-type to p-type, positive donor ions are uncovered i.e they are robbed of free electrons. A positive charge is built on the n-side of the junction.

→ When a sufficient no. of donor and acceptor ions is uncovered, further diffusion is prevented.

→ +ve charge on n-side repels holes to cross from p-type to n-type and -ve charge on p-side repels free electrons to enter from n-type to p-type.

→ A barrier is set up against further movement of charge carriers i.e holes and electrons. This is called potential barrier or junction barrier V_0.

→ The potential barrier is of the order 0.1 to 0.3 volt.

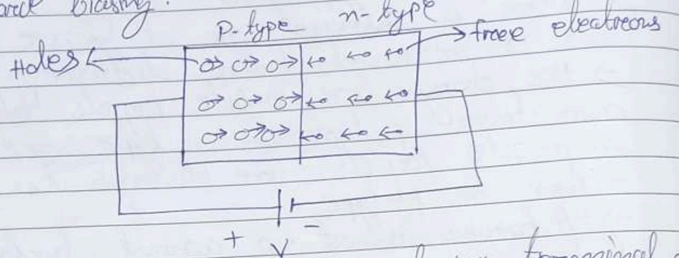


V.Q. Applying Voltage Across PN Junction.

The potential difference across a pn junction can be applied in two ways:

① Forward biasing
② Reverse biasing.

(1) Foreward biasing :- When external voltage applied to the junction in such a direction that it cancels the potential barrier, thus permiting current to flow, it is called foreward biasing.



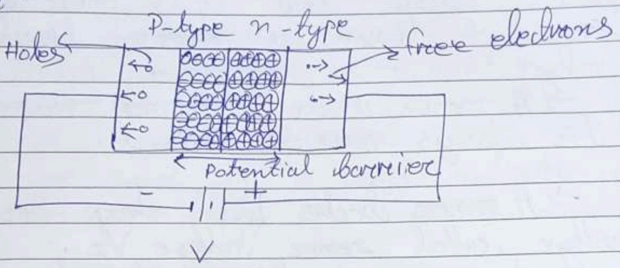
To apply foreward bias, connect +ve terminal of the battery to p-type and -ve terminal to n-type.
→ The applied foreward voltage acts against the field due to potential barriers. So the resultant field will omit the barriers and current flow in the circuit.

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, connect -ve terminal of the battery to p-type and +ve terminal to n-type.

→ The applied Reverse bias voltage acts alone the field due to potential barrier. So the resultant field will increase the barrier and current will not flow in the circuit.



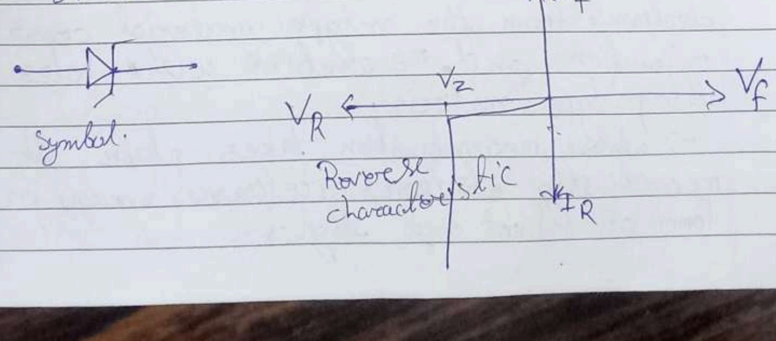
Zener Diode

A properly doped ~~cy~~ crystal diode which has a sharp break down voltage is known as a zener diode.

The break down or zener voltage depends upon the amount of doping. If the diode is heavily doped, depletion layer will be thin and consequently the break down of the junction will occur at a lower reverse voltage.

A lightly doped diode has a higher breakdown voltage when an ordinary crystal diode is properly doped so that is has a ~~shap~~ sharp break down voltage, it is called a zener diode.

→ The figure shows the symbol and V-I characteristics of a zener diode.



→ A zener diode is like an ordinary diode except that it is properly doped so as to have a sharp break down voltage.

→ A zener diode is always reverse connected. it is always reverse biased.

→ A zener diode has sharp break down voltage, called zener voltage V_Z.

→ when forward biased, its characteristics are just those of ordinary diode.

Light Emitting Diode (LED)

A light Emitting Diode is a diode that give off visible light when forward biased.

→ Light emitting diodes are not made from silicon or germanium but are made by using ~~elect~~ elements like gallium, phosphorous and arsenic.

→ By Varying the quantities of these elements it is possible to produce light of different wavelengths with colour that include red, green, yellow and blue.

→ when LED is forward biased the electrons from the n-type material cross the pn 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.

→ In materials like gallium arsenide, the number of photons of light energy is sufficient to produce quite intense visible light.

LED are used as a power indicator & seven segment display.

Vaccum tubes	Semiconductor
① Bulky (Large in Size)	① Usually smaller in size
② Higher operating voltage required	② Lower operating voltage required.
③ Glass tubes are fragile	③ It is made up metal.
④ Cathode electron-emitting materials are used up in operation.	④ Normal potential difference are required for operation
⑤ Tubes can be easily replace by user.	⑤ we can't replace single component; the total IC is to be change.

IC

An Integrated circuit (IC) Sometimes called a chip or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors capacitor and transistor are fabricated.

An IC can function as an amplifier, oscillator, timer, counter, computer memory or microprocessor.

IC are used as power amplifier, operational amplifier, voltage comparators, multiplier, flips-flops, timer, counter, micro controller etc.

ELECTRONIC CIRCUITS

Diode as Rectifier

Rectifier are the circuit which convert the Alternating Current to the Direct Current.

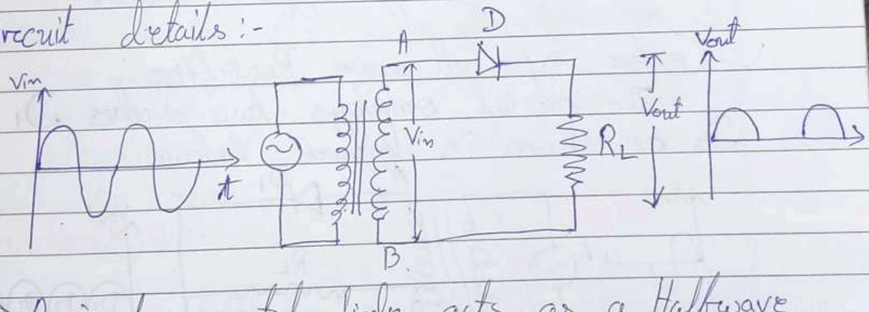
Rectifier are of two types.
(1) Half wave Rectifier.
(2) Full wave Rectifier.

Half wave Rectifier

→ Half wave Rectifier conducts current only during positive half cycles of input ac supply.

→ No current is conducted in the -ve half cycles and hence no voltage appears across the load.
→ Current always flows in one direction.

Circuit details :-



→ A single crystal diode acts as a Halfwave Rectifier.
→ The a.c supply to be rectified is applied in series with the diode and load Resistance R_L.
→ AC supply is given through a transformer.

Operation :- During the positive half cycle of input a.c voltage, end A becomes +ve with respect to end B. This makes the diode forward biased and hence it conducts current. During the negative half cycle end A is negative with respect to end B. Diode is reverse biased and it conducts no current.

Full wave Rectifier

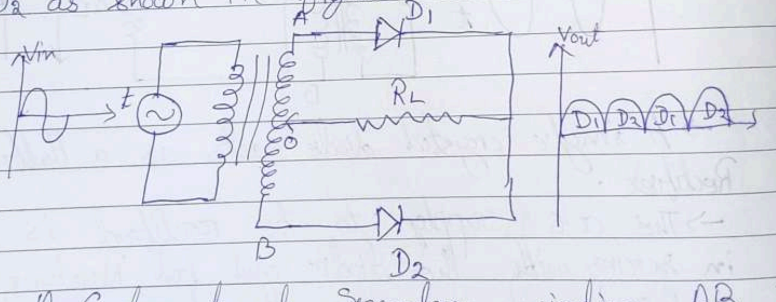
In full wave Rectifier current flows through the load in the same direction for both half cycles of input a.c voltage.

So a full wave rectifier utilises both half cycle of input a.c voltage to produce the d.c output. The following two circuit are commonly used for full wave rectifier.

1. Center tap full wave Rectifier
2. Full wave bridge type Rectifier.

Center tap full wave Rectifier :-

The circuit employs two diodes D_1 and D_2 as shown in figure below.



A Center taped Secondary winding AB is used with two diodes connected so that each uses one half cycles of input a.c voltage.

Diode D_1 utilises the a.c voltage across the upper half (OA) of secondary winding for rectification while diode D_2 uses the lower half winding OB.

→ During the +ve half cycle of secondary voltage, the pt 'A' of the secondary winding becomes positive and pt B is negative. This makes the diode D_1 forward biased and diode D_2 reverse biased.

→ Therefore diode D_1 conducts while diode D_2 does not. The conventional current flow is through diode D_1, load resistor R_L and the upper half of secondary winding.

→ During the -ve half cycle, pt A of the secondary winding becomes -ve and pt B is +ve. Therefore diode D_2 conducts while diode D_1 does not. The conventional current flow is through diode D_2 load Resistor R_L and lower half winding.

→ So it may be seen that current in the load R_L is in the same direction for both half cycles of input a.c voltage.

Therefore d.c is obtained across the load R_L. So polarities of the d.c output across the load should be same.

Disadvantage :-

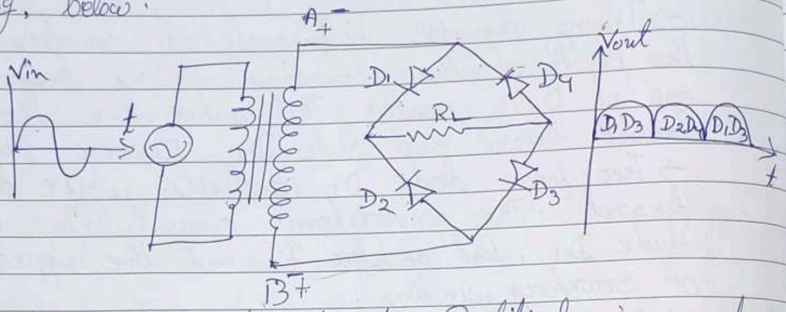
① It is difficult to ~~lead~~ locate the center tap on secondary winding.

② The d.c output is same as each diode utilise only one half of the transformer secondary voltage

③ The diode use most have high peak inverse voltage.

Full wave Bridge Rectifier :-

It contains four diode D_1, D_2, D_3 & D_4 connected to form bridge as shown in fig. below.



The ac supply to be Rectified is apply to the diagonally opposite ends of bridge through the transformer.

-> The other two ends of the bridge the load Resistance R_L is connected.

-> During the +ve half cycle of secondary voltage the pt A of the secondary winding is +ve and pt B is -ve.

-> This makes diode D_1 and D_3 forward bias while diode D_2 and D_4 are Reverse bias.

-> Therefore D_1 and D_3 conducts and will be series through the load R_L. The conventional current flow is ~~slow~~ As $A \to D_1 \to R_L \to D_3 \to B$.

-> During the -ve half cycle of secondary voltage pt B is +ve and A is -ve. This makes diode D_2 and D_4 forward bias where as Diode D_1 and D_3 Reverse bias

-> Therefore the Diode D_2 & D_4 conduct. This two Diode will be in series through the load R_L and the conventional current

will flow from $B \rightarrow D_2 \rightarrow R_L \rightarrow D_4 \rightarrow A$.
-> for both the half cycle the current is flowing in the load in same direction and we get the output is one direction at the load.

Advantage

① The need for center taped transform is ~~limite~~ eliminate
② The output is twice that of the center tap circuit for the same secondary voltage.
③ The PIV is one half that of the center tap circuit (for same d.c output)

Disadvantage :-
① It required four diode.
② As during each half cycle of a.c input two diodes that conductes are in series therefore voltage droped in the internal resistor of the rectifing unit will be twice as great as in the centre tap circuit.

Filter

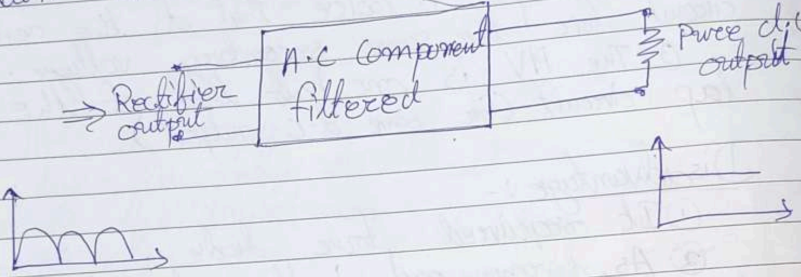
A filter circuit is a device which remove the a.c component of rectifier output but allows the d.c components to reach the load.

-> A filter circuit generally a combination of Inductors (L) and Capacitor (C).

The filtering action of L & C depends upon the basic electrical principle.

→ A capacitor passes a.c readily but doesn't pass d.c at all. On the other hand an Inductor opposes ac but allows d.c to pass ~~through~~ through it.

The ~~bo~~ block diagram of filter ckt is shown below.



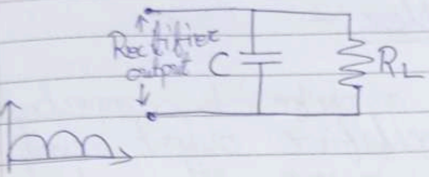
Types of filter Circuits :-

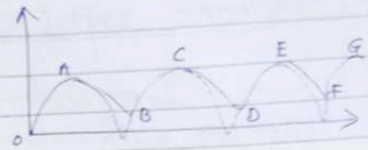
The most commonly used filter circuits are

1. Capacitor filter
2. Choke input filter.
3. Capacitor input filter or π filter.

Capacitor filter :-

The figure of capacitor filter is shown below.





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 applyed across the capacitor.

-> As the Rectifier voltage increases it charges the capacitor and also supply current to the load. At the end of quater cycle, the capacitor is charge to the peak value of the rectifier voltage Vm upto pt A.

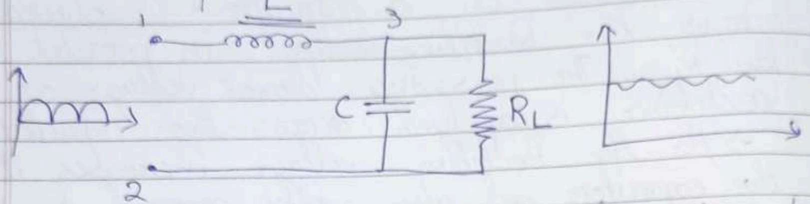
-> Now the rectifier voltage starts to decrease. As this occurs the capacitor discharge through the load and voltage across it, i.e across parallel combination of RC, decrease as shown as AB in figure.

-> The voltage across load will decreases only slightly because immediately the next voltage peak comes and recharge the capacitor.

-> This process is repeated again and again and the output voltage wave form become ABCDEFG. It may seen that very little ripple is left in the output.

Choke input filter:-

It consist of a choke L connected in series with the rectifier output and a filter capacitor C across the load.



→ Only a single filter section is shown but several identical section are often use to reduce pulsation as effectively as possible.

→ The pulsating output of the rectifier is applied across terminal 1 and 2 of the filter circuit.

→ The pulsating output of the rectifier contants a.c & d.c components. The choke offers high opposition to the passes of a.c component and negligible opposition to the d.c component.

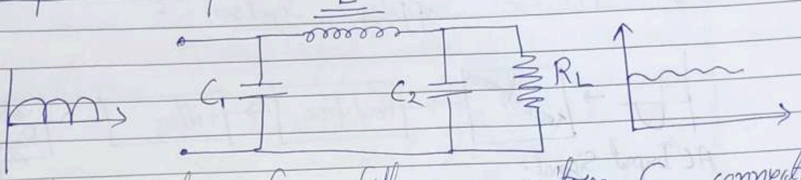
→ The result is that most of the a.c component appers across the choke ~~with~~ while whole of d.c component passes through the choke on it's way to load.

→ At terminal 3, the rectifier output contants d.c components and the remaining part of a.c components.

→ Now the low reactance of filter capacitor bypasses the a.c components but prevents the d.c component to flow throughs it.

-> Therefore only d.c component reaches the load. In this way the filter ~~ck~~ circuit has filtered out the ~~d.c~~ a.c components from the rectifier output.

Capacitor input filter or π filter



It consists of a filtering capacitor C_1 connected across the Rectifier output. A choke L in series and another filter capacitor C_2 connected across the load.

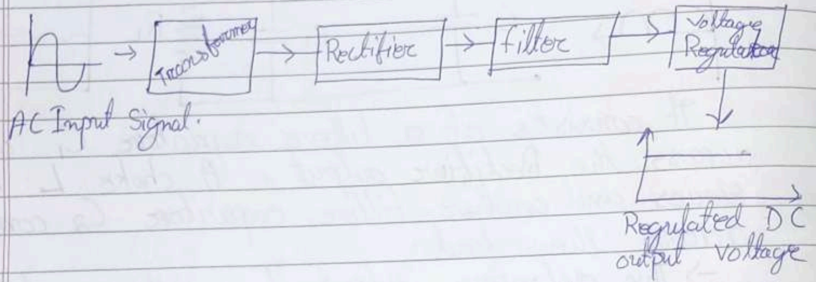
-> The pulsating output from the rectifier is applyed across the input terminal. The filtering action of three components i.e C_1, L & C_2 of the filter is descreided below.

-> The filter Capacitor C_1 offers low ~~reat reactan~~ reactance to a.c component of rectifier output while its offers infinite reactance to the d.c componement. Therefore capacitor C_1 bypasses an appreciable amount of a.c component while the d.c component continues it journey to the choke L.

-> The choke L offers high rectance to the a.c components but it offers almost zero rectance to the d.c component. Therefore it allow the d.c component to flow through it, while on by pass it ac components is block.

→ The filter capacitor C_2 bypasses the a.c components which the choke has failed to block. Therefore only d.c component appears ~~across~~ across the load and that is what we desire.

DC Power Supply System :-



The electrical power is almost exclusively generated, transmitted and distributed in the form of ac because of economical consideration but for operation of most of the electronic devices and circuits, dc supply is required.

→ Dry cells and batteries can be used for this purpose. They have the advantages of being portable and ripple free but their voltage are low. They need frequent replacement and are expensive in comparision to conventional dc power supplies.

→ Almost all electronic equipment include a circuit that converts ac supply into dc supply. The part of equipment that converts ac into dc is called DC power supply.
→ The input of the power supply there is a power transformer. It is followed by a rectifier (a diode circuit) a smoothing filter and then by a voltage regulator circuit.
→ from the block diagram, the basic power supply is constituted by four elements i.e. transformer, a rectifier, a filter and a regulator put together. The output of the dc power supply is used to provide a constant dc voltage across the load.

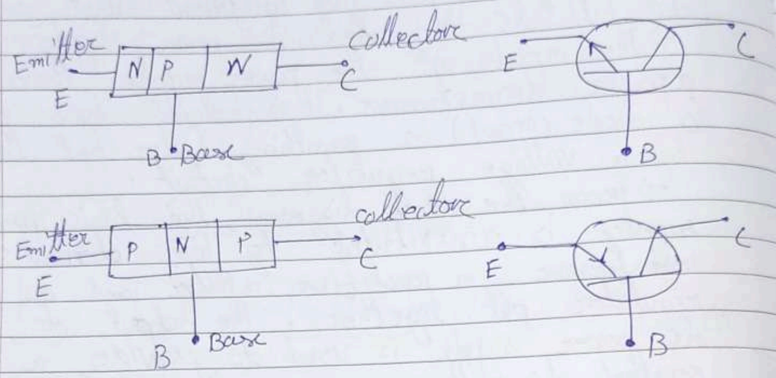
TRANSISTOR :-

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

The transistors are of two types
(i) n-p-n ~~tr~~ transistor (ii) p-n-p transistor.

A transistor (p-n-p or n-p-n) has three section of doped semiconductor. The section on the one side is the emitter and the section on the opposite side is the collector. The middle section is called the base and forms two junction between the emitter and collector.

The diagram and Symbols of NPN and PNP transistor is shown below.



Note:- In the symbol arrow head is always at the emitter. The direction indicates the conventional direction of current flow.

Emitter:- The main function of this region is to supply majority charge carriers (either electrons or holes) to the base and hence it is more heavily doped in comparison to other regions

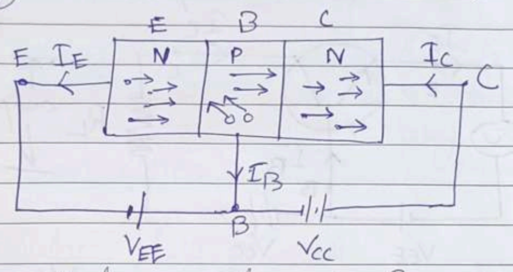
Base:- The middle section of the transistor is known as base. This is very lightly doped. and is very thin as compared to either emitter or collector. So that it may pass most of the injected charge carriers to the collector.

Collector

The main function of the collector is to collect majority charge carriers through the base, This is moderately doped.

Operation of npn transistor.

The emitter junction is forward bias because electrons are repelled from the -ve emitter battery terminal V_{EE} towards the junction.



The collector junction is Reverse bias because electron are flowing away from the base junction towards the +Ve collector battery terminal V_{CC}.

The electron in the emitter region are repelled from the -ve terminal of the Battery toward the emitter junction. Since the potential barrier at the junction reduce due to forward bias and base region is very thin and lightly doped. Electrons ~~complete~~ combine with the hole in p-region and are lost as charge carrier.

Now the electrons in n-region readily swept up by the +ve collector voltage V_{CC}.

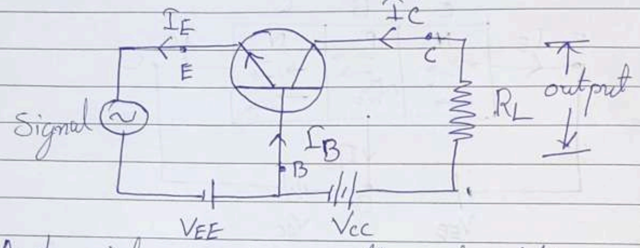
for every electrons flowing out the collector and entered the positive terminal of battery V_{cc}.

So by the we have the reealtion

$$I_E = I_B + I_C$$

where I_E = emitter Current
I_B = base Current
I_C = collector Current.

Transistor as an Amplifier :-



A transistor raises the strength of a weak signal and thus acts as an amplifier. The figure shows the basic circuit of a transistor amplifier. The weak signal is applied between emitter - base junction and output is taken across the load R_C connected in the collector circuit.

→ In order to achieve faithful amplification the input circuit should always remain forward biased.

→ A d.c. voltage V_{EE} is applied in the input circuit in addition to the signal as shown.

→ This d.c voltage is known as bias voltage and its ~~voltage~~ mangnitude is such that is always keeps the input circuit forward biased regardless of the polarity of the signal.

As the input circuit has low resistance therefore, a small change in signal voltage causes an appreciable change in emitter current. This cause almost the same change in collector current due to transistor action.

The collector current flowing through a high load resistance R_C produces a large voltage across it.

Thus a week signal applied in the input circuit appears in the amplified form in the collector circuit. This way a transistor acts as an amplifier.

Transistor Connections

There are three terminals emitter, collector & Base. To connect the device in a circuit we required four terminals 2 for input & 2 for output. As in transistor we have 3 terminal. So one terminal is common to both input and output.

According to that transistor can be connected in three ways.

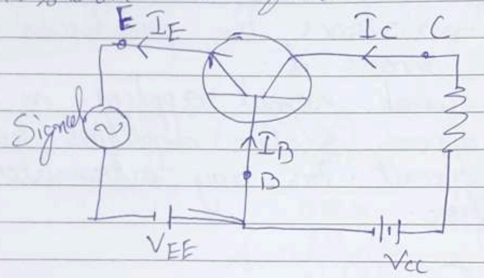
1. Common base connection.
2. Common emitter connection.
3. Common collector connection.

Common Base Connection

In this circuit arrangement, input is applied between emitter and base and output is taken from collector and base.

Here, base of the transistor is common to both input and output circuits and hence the name common base connection.

A common base npn transistor circuit is shown in figure.



The current amplification factor (α)

It is the ratio of output current to input current. In a common base connection the input current is the emitter current I_E and output current is the collector current I_C.

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. i.e

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

The value of α is always less than unity. practical values of α in commercial transistor range from 0.9 to 0.999.

Expression for collector current :-

The whole of emitter current does not reach the collector. As electron-hole combinations occuring in base area, gives rise to base current. More over, as the collector-base junction is reverse biased, therefore some leakage current flows due to minority carriers.

So the total collector current consists of

$$I_C = \alpha I_E + I_{leakage}$$

αI_E is part of emitter current which reach the collector.

$$\alpha = \frac{I_C}{I_E} \Rightarrow I_C = \alpha I_E$$

$I_{leakage}$ is the reverse leakage current at collector base junction.

It is clear that if $I_E = 0$, a small leakage current still flows in the collector current this is I_{CBO} i.e collector-base current with emitter open.

$$I_C = \alpha I_E + I_{CBO}$$

$$\Rightarrow I_E = I_C + I_B$$

$$\Rightarrow I_C = \alpha(I_C + I_B) + I_{CBO}$$

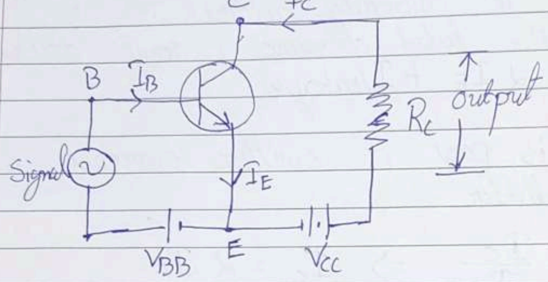
$$\Rightarrow (1-\alpha) I_C = \alpha I_B + I_{CBO}$$

$$\Rightarrow I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$$

Common Emitter Connection:-

In this circuit arrangement input is applied between base and emitter and output is taken from the collector and emitter. Here emitter of the transistor is common to both input and output circuits and hence the name common emitter connections.

The fig shows common emitter npn transistor circuit



Base Current amplification factor(β):-

In common emitter connection, input current is I_B and output current is I_C.

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

i.e. $$\beta = \frac{\Delta I_C}{\Delta I_B}$$

β is approaches to infinity. In other word, the current gain in common emitter connection is very high.

Relation between α and β

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \& \quad \alpha = \frac{\Delta I_C}{\Delta I_E}$$

we known $I_E = I_B + I_C$

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

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

Substituting the value of ΔI_B in β we have

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

Dividing the numerator and denominator of R.H.S by ΔI_E we have

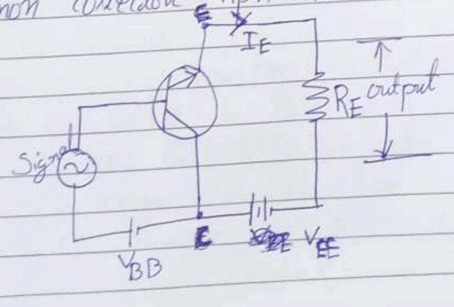
$$\beta = \frac{\frac{\Delta I_C}{\Delta I_E}}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}} = \frac{\alpha}{1-\alpha}$$

$$\text{So } \beta = \frac{\alpha}{1-\alpha}$$

Common collector Connection

In this circuit arrangement, 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 circuits and hence the name common collector connection. The figure shows common collector npn transistor circuit.



Current amplification factor (γ) :-

In common collector circuit, input current is the base current I_B and output current is the emitter current I_E. Therefore, current amplification in this circuit is

The ratio of change in emitter current (ΔI_E) to the change in base current (ΔI_B) is known as current amplification factor in common collector (CC) arrangement i.e

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

This circuit ~~prod~~ provides about the same current gain as the common emitter circuit as $\Delta I_E \cong \Delta I_C$. However it's voltage gain is always less than 1.

Relation between γ and α and β

$$\gamma = \frac{1}{1-\alpha} = \beta + 1$$

Transistor Biasing

Among the basic function of a transistor is its amplification. for faithful amplification the three conditions must be satisfied.

① The emitter base junction should be forward biased.

② The collector base junction should be reverse biased.

③ There should be proper zero signal collector current.

→ The proper flow of zero signal collector current and the maintenance of proper collector emitter voltage during the passage of signal is know as transistor biasing.

→ A transistor is biased either with the help of battery or associating a circuit with transistor.

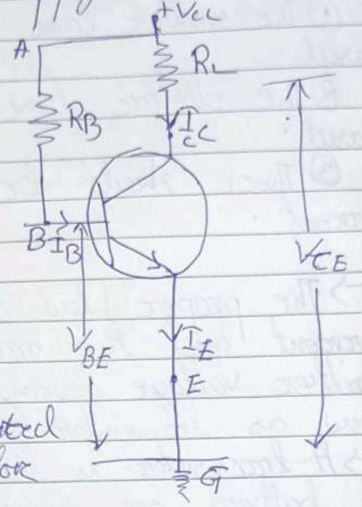
Different methods for transistor biasing

from the point of view of simplicity and economy only one source of supply (instead of two V_{BB} and V_{CC}) in the output circuit is used. Some of the methods used for providing bias for a transistor are as follows.

(1) Base resistor method.
(2) Collector to Base bias.
(3) Base bias with collector and emitter feedback.
(4) Voltage divider bias.

Base resistor method

An NPN transistor connected in CE configuration with resistor biased. In this method a high resistance R_B is connected between positive terminal of supply V_{cc} and base of the transistor.



The base emitter junction is forward biased.

Here we find the value of R_B such that the required collector current flows under zero signal conditions.

Let I_c be the required zero signal collector current.

Considering the closed circuit ABEGA and applying the kirchhoff's voltage law we have:

$$I_B R_B + V_{BE} = V_{CC}$$

$$\Rightarrow I_B R_B = V_{CC} - V_{BE} \Rightarrow R_B = \frac{V_{CC} - V_{BE}}{I_B} \quad \text{--- (1)}$$

$$I_B = \frac{I_c}{\beta} \quad \text{--- (2)}$$

Substituting the value of I_B in eqn (1)

we have $R_B = \left(\frac{V_{CC} - V_{BE}}{I_c}\right)\beta$ --- (3)

As V_{BE} is generally very small as compared to V_{CC}

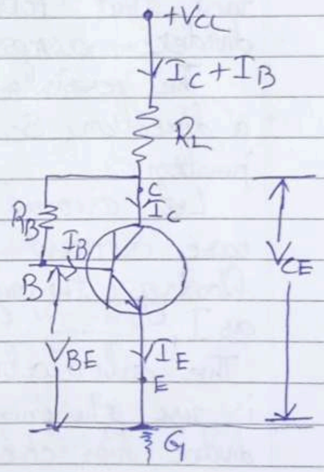
$$R_B = \frac{\beta V_{cc}}{I_c}$$

Hence this method is sometimes called as fixed bias method.

Collector to Base Bias

The circuit of an NPN transistor connected in CE configuration with collector to base bias. This circuit is same as base bias circuit except that the base resistor R_B is returned to collector rather than to V_{cc} supply.

This circuit, there is considerable improvement in the stability.



The required value of R_B needed to give the zero signal current I_c can be calculated.

voltage drop across $R_L = (I_c + I_B) R_L$
$\simeq I_c R_L$

from the figure

$I_c R_L + I_B R_B + V_{BE} = V_{cc}$

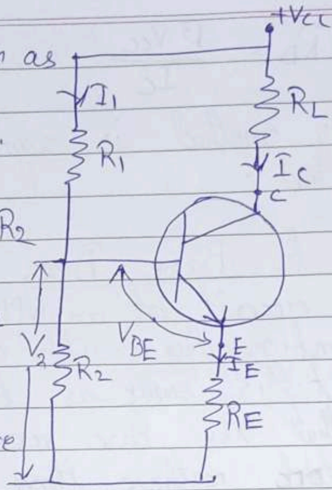
$\Rightarrow I_B R_B = V_{cc} - V_{BE} - I_c R_L$

$$\Rightarrow R_B = \frac{(V_{cc} - V_{BE} - I_c R_L)}{I_c} \beta$$

1.6 Voltage Divider Bias or Self Bias

A very commonly used biasing arrangement is self-bias or emitter bias. The circuit arrangement is shown in fig.

This is also known as Universal bias & stabilization circuit.
In this method two resistance R_1 & R_2 are connected across supply voltage V_{cc} & R_2 provide biasing.



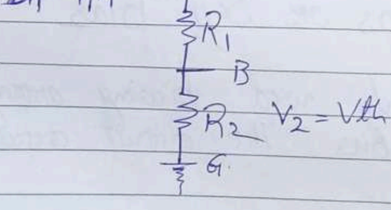
→ The emitter resistance R_E provides stabilization.

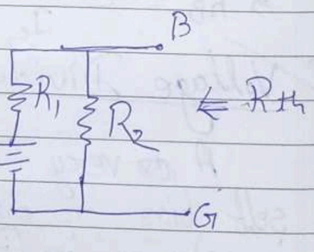
→ The name voltage divider is derived due to fact that resistors R_1 & R_2 from a potential divider across V_{cc}.

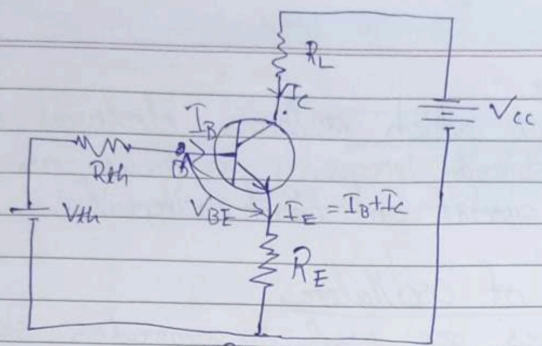
The resistance R_E causes a voltage drop in a direction so as to reverse bias the emitter junction.

Let current I_1 flows through R_1. As the base current I_B is very small, the current flowing through R_2 can also be taken as I_1.

The calculation of collector current I_C is use thevenin equivalent circuit of voltage divider bias ckt.







$$V_2 = V_{th} = \left(\frac{R_2}{R_1 + R_2}\right) V_{CC} \quad \text{— (1)}$$

$$R_{th} = R_1 \parallel R_2 = \frac{R_1 R_2}{R_1 + R_2} \quad \text{— (2)}$$

Applying KVL to the base emitter circuit.

$$V_{th} = I_B R_{th} + V_{BE} + (I_B + I_C) R_E \quad \text{— (3)}$$

Applying KVL to the emitter - collector circuit we have

$$V_{CE} = V_{CC} - I_C (R_L + R_E) \quad (I_C >> I_B) \quad \text{— (4)}$$

we have $I_C = \dfrac{V_{CC} - V_{CE}}{R_L + R_E}$

Substituting this value of I_C in the eqn (3)

$$V_{th} = I_B R_{th} + V_{BE} + R_E \left(I_B + \frac{V_{CC} - V_{CE}}{R_L + R_E}\right)$$

$$V_{th} = I_B R_{th} + V_{BE} + R_E I_B + \frac{V_{CC} R_E}{R_L + R_E} - \frac{V_{CE} R_E}{R_L + R_E} \quad \text{— (5)}$$

from eqn (5) we can calculate the value of collector ~~valu~~ voltage V_{CE} for each value of I_B.

Oscillator

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

Application of Oscillators

-> Oscillators are used to generates signal.
-> Used as a local oscillator to transform the RF signal to IF signals in a receiver.
-> Used to generate RF carrier in a transmitter
-> Used to generate clocks in digital system.
-> Used as sweep circuits in TV sets and CRO

Types of Oscillators

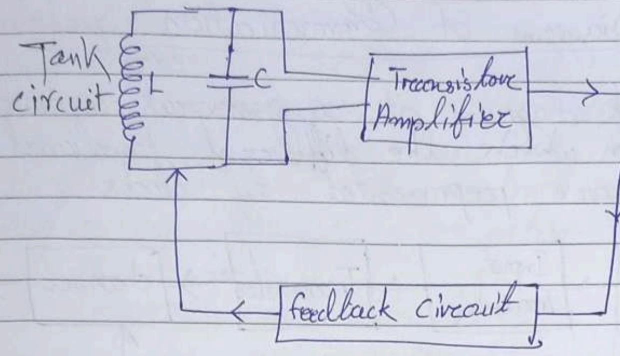
1- Wien Bridge Oscillator
2- RC Phase - shift Oscillator.
3- LC Oscillator.
4- Crystal Oscillator.
5- Colpitt's Oscillator.
6- Tuned Collector Oscillator.
7- Hartly Oscillator.

Essential of Transistor Oscillator

The figure shows the block diagram of an oscillator. It's essential components are

① Tank Circuit
② Transistor amplifier
③ feedback circuit.

BLOCK DIAGRAM of OSCILLATOR



Tank Circuit:- It consists of Inductore coil(L) Connected in parallel with capacitore (C). The frequency of ~~oscillatore~~ oscillations in the circuit depends upon the values of inductance of the coil and capacitace of the capacitore.

Transistore amplifier : The transistore amplifier receives d.c power from the battery and changes it into a.c power fore supplying to the tank circuit. The oscillations occuring in the tank circuit are applied to the input of the transistore amplifiore. Because of the amplifying properties of the transistore, we get increased output of these oscillator.

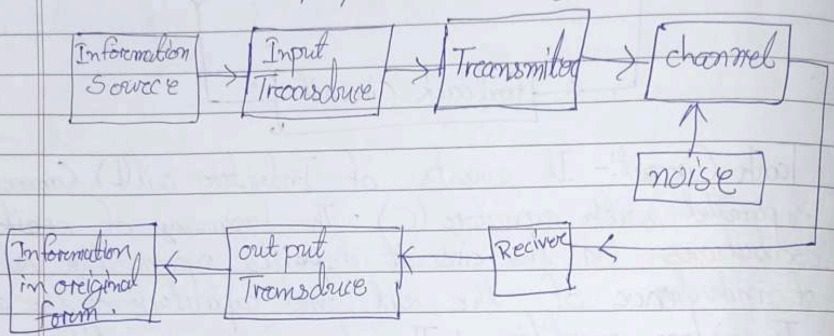
This amplified output of oscillations is due to the d.c power supplied by the battery. The output of the transistore can be supplied to the tank circuit to meet the losses.

feedback circuit :- The feedback circuit supplies a part of collectore energy to the tank circuit in correct phase to ~~act~~ ~~aid~~ add the oscillations i.e it provides positive feedback.

Communication System (3)

Q. Block Diagram of Communication System

→ The block diagram of a general communication system, in which the different functional elements are represented by blocks.



→ In the most fundamental sense, communication involves the transmission of information from one point to another through any process is called communication.

→ The essential components of a communication system are information source, input transducer, transmitter, communication channel, receiver and destination.

Information Source :- A communication system serves to communication a message or information, This information originates in the information source.

Input Transducer :- The message from the information source may or may not be electrical in nature. In case when the message produce by the information source is not electrical in nature, an input transducer is used to convert it into a time-varying electrical signal.

Transmitter :- The function of the transmitter is to process the electrical signal from different aspects. for example in radio broadcasting the electrical signal obtained from sound signal is processed to restrict its range of audio frequencies and is often amplified.

The channel and the Noise:- The term channel means the medium through which the message travels from the transmitter to the receiver. The function of the channel is to provide a physical connection between the transmitter and the receiver.
Noise is an unwanted signal which tend to interface with the required signal.

Receiver :- The main function of the receiver is to reproduce the message signal in electrical form from the distorted received signal.
Destination :- Destination is the final stage which is used to convert an electrical message signal into its original form.

Modulation :-
The process of changing some characteristic (Ex amplitude, frequency or phase) of a carrier wave in accordance with the intensity of the signal is known as Modulation.
-> In modulation, some characteristic of carrier wave is changed in accordance with the intensity of the signal.

Need of Modulation :-

Modulation is extremely necessary in communication system due to the reasons:-

① Practical antenna length:- Theory shows that in order to transmit a wave effectively, the length of the transmitting antenna should be approximately equal to the wavelength of wave.

$$\text{wave length} = \frac{\text{velocity}}{\text{frequency}} = \frac{3 \times 10^8}{\text{frequency (Hz)}}$$

$$= \text{meter}$$

To transmit the audio frequency directly the length of the antenna is too long. So to reduce the length we required to increase the frequency.

② 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. As the audio signal frequency are small. So these cannot be transmitted over large distance if radiated directly into space.

③ wireless communication :- At audio frequencies radiation is not practicable because the efficiency of radiation is poore. However, efficient radiation of electrical energy is possible at high frequencies for this reason, modulation is always done in communication system.

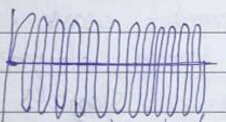
Types of modulation

There are three basic, types of modulation
1. Amplitude modulation
2. frequency modulation
3. Phase modulation.

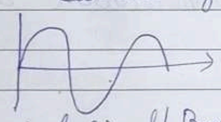
Amplitude Modulation (AM)

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

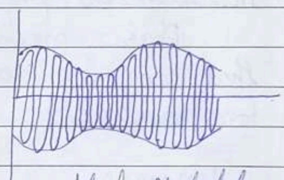
In amplitude Modulation, only the amplitude of the carrier wave is changed in accordance with the intensity of the signal and the frequency of the modulation wave remains same.



carrier high frequency



original signal / Base band signal

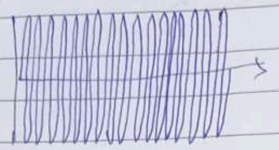


Amplitud Modulation

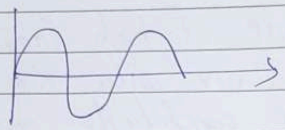
Frequency Modulation (FM)

when the frequency of carrier wave is changed in accordance with the intensity of the signal, it is called frequency modulation (FM).

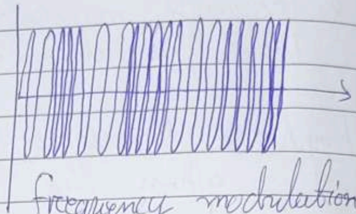
In frequency modulation, only the frequency of the carrier wave is changed in accordance with the signal and the amplitude of the modulated wave remains the same. The frequency variation of carrier wave depends upon the instantaneous amplitude of the signal.



carrier wave



original Signal.

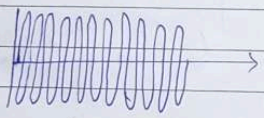


frequency modulation.

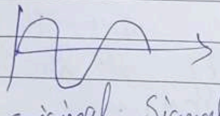
Phase modulation

Phase modulation is a modulation pattern that encodes information as variations in the instantaneous phase of a carrier wave.

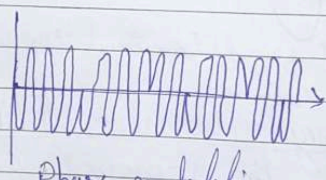
Phase modulation is a form of modulation that can be used for radio signals used for a variety of radio communication applications.



carrier wave



original Signal



Phase modulation

Demodulation

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

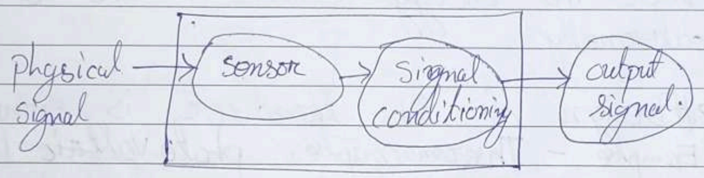
Transducer and Measuring Instruments.

Transducer:-

Transducer is a device that changes the physical properties / attributes of a non-electrical signal into an electrical signal which can be measure.

→ The process of energy conversion in transducer is known as transduction.

→ In other way, we can say that transducer is a device that is capable of converting a physical quantity into a proportional electrical quantity.



→ Sensor detects the physical changes and provides the proportional output to the signal conditioning

→ The signal conditioning improves the strength of the signal.

Example of transducer :- Thermocouple, Microphone, Loudspeaker, ~~Stare~~ strain Gauge.

→ Sensor is a device that measures the physical ~~quat~~ quantity (heat, light, sound) into an easily measurable form (Voltage or current)

Types of transducer

-> Active and Passive Transducer.
-> Analog and Digital Transducer.
-> Primary and Secondary Transducer.

Active Transducer:-

-> The transducer which generates the output in the form of voltage or current without any external energy source is known as active transducer.

-> Here no energy source is connected externally

-> Design of this transducer is simple.
Example - Thermocouple, photo voltaic Cell.

Passive Transducer:-

The transducer whose internal parameter like capacitance, resistance and inductance changes because of the input signal.

-> Here additional or external source of energy is required.
Ex - Thermistores.

Photo Electric Cell

-> A device used to convert light energy into electrical energy is called photo electric Cell.

→ It is based on the principle of photo-electric effect.

Types of Photo Electric Cell

1. Photo Emissive cell
2. Photo Voltaic cell.
3. Photo conductive Cell.

Photo Emissive Cell

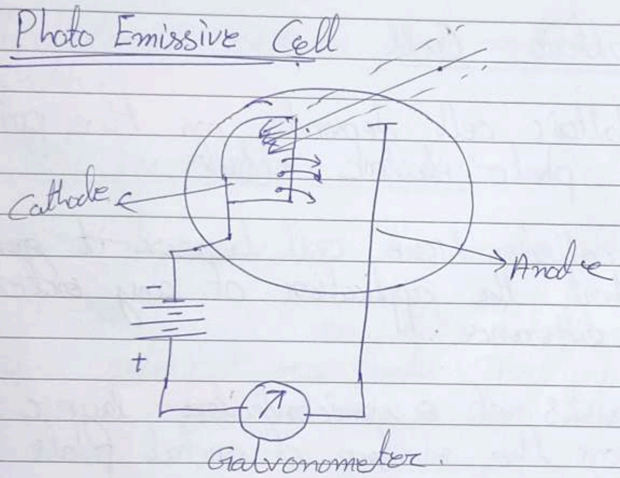


Photo Emissive cell can be of two types -

1. Vaccum type
2. Gas filled type.

→ Photo emissive cell consist of two electrodes → Cathode and Anode.

→ Cathode is coated with photo sensitive material like sodium, pottasium.

→Anode is made with nickle or platinum.

→Photo electrons moves from the cathode towards anode.

Drawback of Photo emissive cell :-

Photo emissive cell doesnot vary linearly with the intensity of light.

Application :- used in television and fire Alarm.

Photo Voltaic Cell

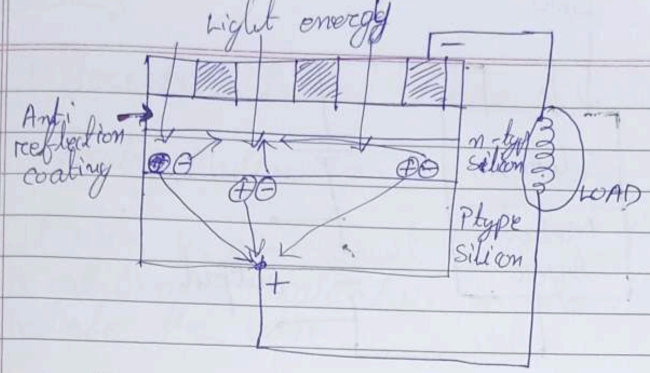
→Photo Voltaic cell depends on the principle of inner photo electric effect.

→It is called true cell because it generates emfs without the application of any external potention difference.

→It consists of a semiconductor layer formed on the surface of metal plate by heat treatment.

→A film of semi-transparent metal is coated over the semiconductor.

→Current is proportional to the intensity of incident light.



Advantage :- It requires no external voltage for its operation.

Application :- Used in photo meters and illumination meter.

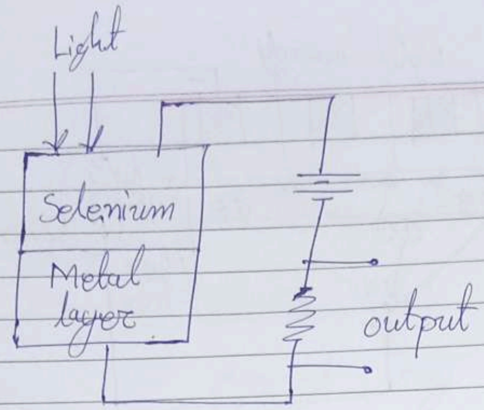
Photo Conductive Cell :-

→ It is depends on the inner photo electric.

→ It consist of a thin film of semiconductor like selenium or ~~Photo~~ Thallium Sulphide placed below a thin film of semitransparent metal.

→ The iron base and the transparent metal film is connected through a battery and resistance.

→ When light falls on the cell its resistance decreases and hence current starts flowing in the external circuit.



Application
→ Used in automatic street light.
→ Used as security devices.

Multimeter

→ A multimeter or a multitester is also known as (volt - ohm - ~~milli~~ mili ammeter) is a electronic measuring instrument that combines several measuring function in one unit.

→ Multimeter can be of two type :-
① Analog Multimeter.
② Digital Multimeter.

Application of Multimeter

→ Used to trouble shoot the electronic circuit.

→ Used to test different electronic component.
→ Used to measure voltage, current and resistance.

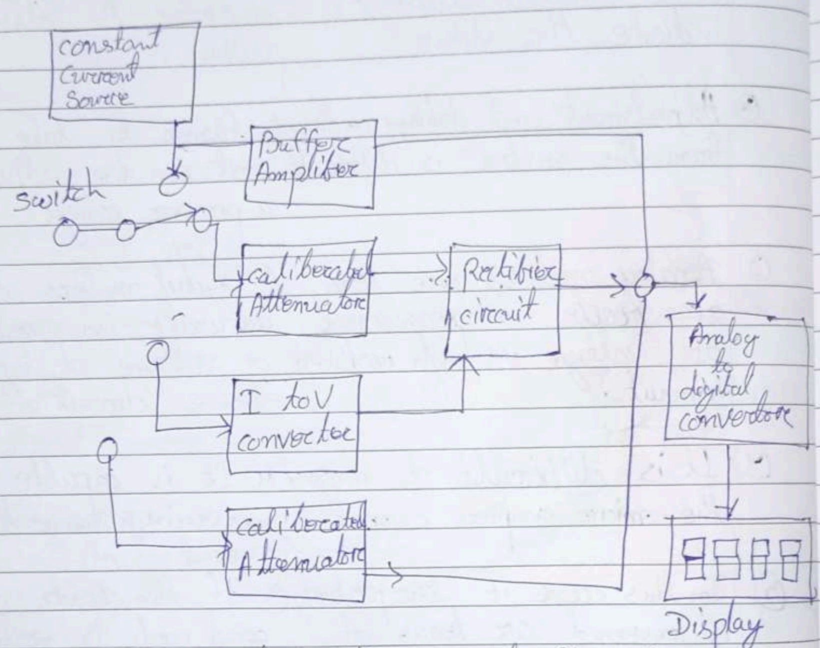
→ Used in temperature and environmental application.

Differentce between Analog and Digital Multimeter.

Analog Multimeter.	Digital Multimeter.
(1) It uses a pointer and a calliberated scale to indicate the value	(1) It uses digital display inorder to show the value.
(2) Adjustment and taking reading from the meter is difficult.	(2) Easier to take the reading and can be adjusted to a proper range.
(3) Analog meters are less accureate in measurment of voltage in high resistance circuit.	(3) Digital meters are more accurate in measurement of voltage of high resistance circuit.
(4) It is difficult to measure the micro ampere current.	(4) It is capable of measuring micro ampere current.
(5) In this case if the polarity is reversed or leads of the prob is reversed then it doesnot show any pointer variation.	(5) If the leads of the ~~prod~~ prob is ~~very~~ reverse then we can observe the magnitude with a negative sign.

Block diagram of Digital Multimeter :-

• The digital multimeter basically consist of LCD display range selector switch, analog to digital converter.



→ To measure resistance the current flow from a constant current source through the unknown resistore and the voltage across the resistore is complified and provided to the analog to digital converter.

→ To measure resistance the current flow from a constant current source through the unknown resistance and voltage across the resistore is amplified and provided to the analog to digital converter.

→ To measure unknown AC voltage the voltage is first attenuated the suitable range and provided to the rectifier and the DC signal is provided analog to digital converter and shown in display.

CRO (Calthode Ray Oscilloscope)

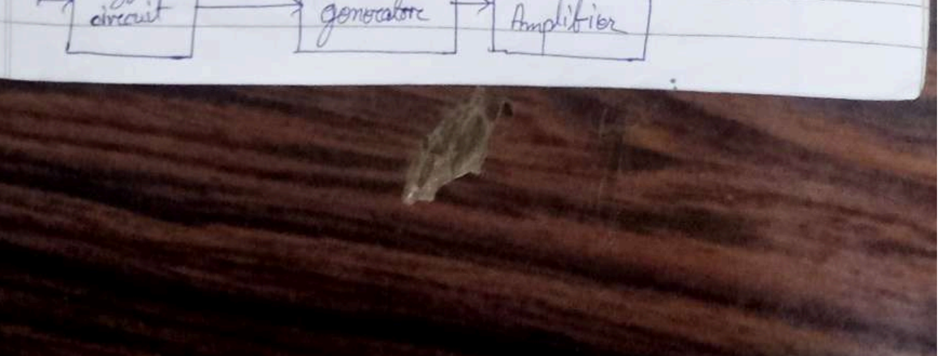
Oscilloscope is an electronic test instrument that allows the observation of time varing signal voltage.

→ Oscilloscope are used to observe the change of an electrical signal over time.

→ The signal is calliberated against a graph.

Application :- Oscilloscope are used for voltage measurement, current measurement, frequency measurement used in science, hardware, used in medicine, used in telecommunication.

Block diagram of CRO



CRT (Cathode Ray Tube).

→ It consist of electron gun assembly (Electron gun focusing anode, ~~ext~~ control grid) and vertical and horizontal deflection plates.

→ The electron beam are produced from the electron gun and accelerated to a high velocity and we get visible spot on the screen.

Vertical Amplifier :-

The input signal are amplified ~~too~~ by the vertical amplifier which passes the entire band of frequency.

Time base generator :-

The time base generator circuit uses a unijunction transistor which produces the sweep.

→ The saw tooth voltage produced by the time base circuit is required to deflect the beam in horizontal section.

Horizontal Amplifier :-

The saw ~~thy~~ tooth voltage produced by the time-base circuit is amplified by the horizontal amplifier before it applied to the horizontal deflection.

Trigger Circuit :- When the signals are given the trigger circuit actives the time base generator it provides the precession for sweep operation.

→ By using the trigger circuit the input signal and the sweep frequently be syncronised.

Power Supply :-

A high voltage supply provided to the CRT and low voltage is provided to the other part of the circuit.

→ Basically a flourescent screen is used which retain the light for ~~sem~~ sometime.

—x—