PART-B: BASIC ELECTRONICS ENGINEERING

UNIT-1

SEMI CONDUCTOR DEVICES

Introduction - Evolution of Electronics - Vacuum tubes to nano Electronics - Characteristics of PN Junction Diode - Zener Effect - Zener Diode and its characteristics. Bipolar Junction Transistor - CB, CE, CC Configuration and characteristics - Elementary Treatment of Small Signal CE Amplifier.

Introduction:

- Electronics :- The electrons which flows through the conductors gives us electric current.
- The current can be produced with the help of batteries or generators. This current can be used for various purpose.
- The generation, control and transmission (both DC and AC) of the current ranging from few micro amperes to hundreds of amperes.

- The flow of electrons has been regulated and controlled in electronic devices. This is also called as signal, message data or any other..

It has wide range of applications such as rectification, Amplification, power generation, Communication etc.

Evolution of Electronics:-

It deals with the current flow in Semi Conductors. Most electronic Components are very Small, and require Small direct Current (DC) Voltages (3-12V DC).

– Deals with the Current flow in conductors. Electrical Components tends to be larger, and use alternating Current (AC) Voltages (230V AC).

Evolution of Electronics is mainly through 3 Key Components
1. The Vacuum tube
2. The transistor
3. Integrated circuits.

– In 1883, Thomas alwa Edison discovered that, electrons will flow from one metal Conductor to another through Vacuum – Edison Effect

– In 1904 John fleming applied Edison effect in inventing two element electron tube called Vacuum tube. diode.

– In 1906, following this, Lee De Forest developed a three element tube called Vacuum triode. This was the real begining of electronics.
(Anode, Cathode, Grid Control)

– In 1927, Marconi invented radio which was the primary form of education and entertainment.

– In 1947, the transistor was invented by John Bardeen, Walter brattain and William Shockley in Bell Laboratories.

* This invention revolutionized electronics industry due to its features such as light weight, low cost, less power, reliability etc. which reduces the size of electronic devices.

In 1956, Another break-through happened at Bell laboratories, invented Thyristor also called Silicon controlled Rectifier (SCR).

In. 1958, Jack kilby an engineer of Texas Instruments demonstrated the first IC.

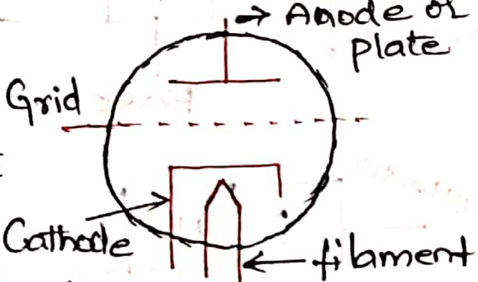
* large no. of electronic Components could be fabricated together on a Single Chip (Beginning of microelectronics revolution).

Vacuum Tubes to Nano-electronics:-

Electronics: A field of Science and technology, Engineering, which deals with electron devices and their utilization. Electron Device means "A device in which conduction takes place by the movement of electrons.

First Generation - Vaccum Tubes:

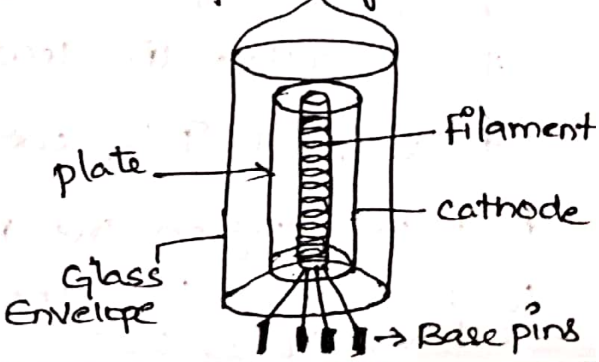
Vacuum tubes (also known as thermionic Values) usually consist of the following component.



1. Cathode (K)
2. Anode (P), also known as the plate
3. Control Grid (G).
4. Filament (F), Sometimes called the heater.

Cathode: It releases Electrons into free space.
Anode: positive biased. It produces a strong electric field between the Cathode and the anode.
Filament: It heats up the Cathode to sufficient temperature
Direction of the Current: opposite to the direction of the movement of electrons.
Grid: It controls the amount of electrons flowing to the anode.

In electronics, A Vaccum Tube is a device that controls electric current flow in a high vaccuum between electrodes to which an



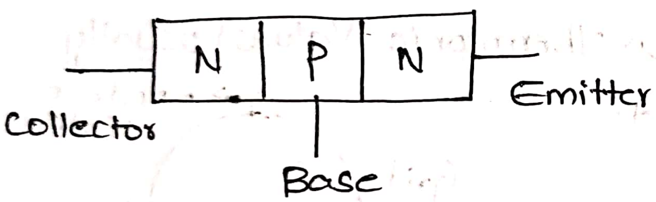
electric potential difference has been applied.

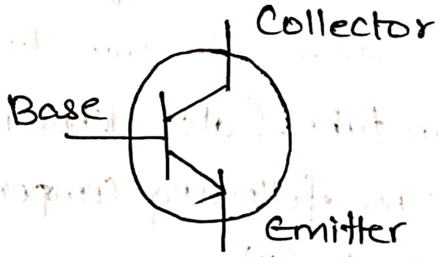
There are many types of Vacuum tubes depending on their use. They are essentially used for a number of fundamental electronic functions such as Signal Amplification and Current Rectification.

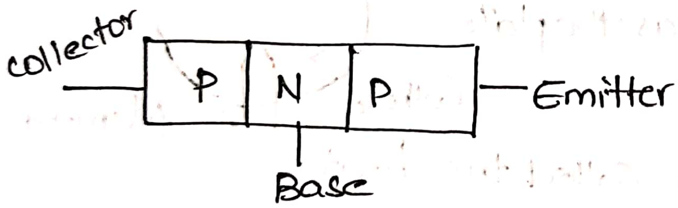
Second Generation : Transistors:-

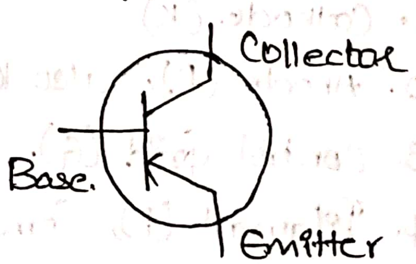
* used to amplify electrical Signals and in switching circuits.

* use of germanium and Silicon Semi-Conductor materials gain more popularity and wide acceptance in different electronic circuits.









Third generation: Integrated Circuits:

In 1958, Jack kilby of Texas Instruments and Roberts Noyce of fair Child Semi conductor Cor-poration independently thought a way to reduce circuit size further.

* The entire electronic circuit, got integrated on a single piece of solid material.

* Resulted in low Cost, Size and weight.

* Digital ICs were yet another, robust IC development

* Depending on the number of Components (Transistors) to be integrated they were Categorized as SSI, MSI, LSI, VLSI, ULSI.

Small Scale Integration (SSI):

In this technology, 1-10 transistors were fabricated on a single chip. eg: Gates, flipflops.

Medium Scale Integration (MSI):

* 10 or 500 transistors Could be integrated on a Single chip. Eg: 4- bit microprocessors.

Large Scale Integration (LSI):

* 500- 20,000 transistors Could be integrated on a Single chip: Eg: 8-bit microprocessors, RAM, ROM.

VLSI (Very Large): Fourth Generation (Microprocessor)

20,000 to 10,00,000 transistors can be accommodated

Eg: 16-32 bit microprocessors.

ULSI (Ultra large):

In this technology, more than one million transistors Can be accommodated eg: Intel 486 and pentium processors.

* **Moletronics:-** It is the combination of molecules and electronics. It is a new technology after ULSI which uses molecules to perform the function of electronics Components such as Diodes, Transistors logic gates etc.

* **Micro electronics:-** It refers to study and manufacture of Very Small electronic design and Components (micrometer size).

Nano electronics:

It refers to the use of nanotechnology in electronics components (nano size). Nano electronics involves working with structures on the nanometer scale, offering potential advantage such as improved performance Energy efficiency and novel functionalities.

Advantages:

1. Reduced size and scale of machine.
2. Advanced properties of semi conductors can be determined.
3. Computer consumes less energy.
4. High speed and capacity memory.
5. Allows circuit to be more accurate on the atomic level.

Disadvantages:

1. Negative Enviromental Impact
2. Health problems
3. Weapons that are dangerous and easily accessible.
4. Costly.

Semi Conductors:

The Solid materials are Classified into three types from the Consideration of current carrying capabilities,

(i) Conductors
(ii) Insulators and
(iii) Semi - Conductor.

Conductors:

* In general all metals are good conductors.
* The purpose of Conductor is to allow electrical current to flow with minimum resistance.
* They allows electrons to flow easily inside them from atom to atom.

Eg:- Copper, Gold, Silver, Iron, bronze.

Insulators:

* Insulators are used to prevent the flow of electricity.
* Insulating materials such as glass, Rubber, plastic, polyethylene are called dielectric.
* Insulators are those in which Valence electrons are bound very tightly. so very large electric field is required to remove them. Due to this reason insulators does not allow electricity through them. Eg. Wood, plastic, Ceramic.

Semi - conductor:

Materials which are neither Conductors nor insulators. i.e., whose electrical properties lies between conductors and insulators.

Some common Semi-Conductors

Elements ⇒ Si- Silicon, Ge- Germanium

Compound ⇒ GaAs - Galluim Arsenide,

Gap- " phosphide,

AlAs - Aluminium Arsenide.

Alp - Aluminium phosphide.

Types of Semi-Conductors:

They are two types of Semi Conductors.

1. Intrinsic Semiconductor.
2. Extrinsic Semiconductor.

Semi conductors
↓

Intrinsic Semiconductor

Semiconductors that are free of doping impurities

Ex: Germanium, Silicon.

↓

pure form of Ge, Si

$(n_e = n_h = n_i)$

N-Type	P-Type
N - Nitrogen	Ga - Gallium
Bi - Bismuth	B - Boron
P - phosphorous	Al - Aluminium
As - Arsenic	In - Indium
Sb - Antimony	

Extrinsic Semiconductor

Semiconductors formed after adding impurities

↓

N-Type

pentavalent Impurity

(5 Valance electron)

Eg:- N, Bi, P, As, Sb..etc

Donar Impurity - ND

$(n_e >> n_h)$ (electrons ↓, holes ↳)

P-Type

Trivalent Impurity

(3 valance electrons)

Eg:- Ga, B, In, Al

~~Donar~~ acceptor Impurity - N_A

$(n_h >> n_e)$

Doping:- Doping is a process of adding a certain amount of specific Impurities called dopands.

Holes:- When an electron gets free from a covalent bond (slavis of electron) it creates a vacancy in the bond. This vacancy (center of electron deficiency) acts as a positive center know as hole.

Intrinsic Semi conductors having very low conductivity as the number density of electrons and holes in pure semi conductors is very low.

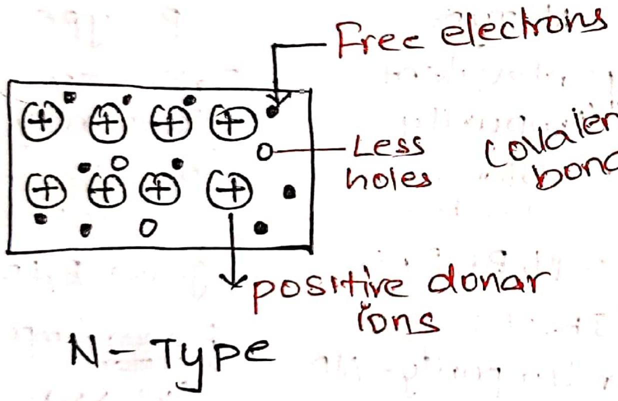
Extrinsic Semi Conductors:

Semiconductors in their pure form are not very useful because of their low conductivity. In order to increase their conductivity, Impurities are added to them.

N-Type Semiconductors:

— When a pure semiconductor of Si or Ge (tetra valent) is doped with a group(V) pentavalent Impurities like arsenic (As), antimony(Sb), phosphorous (P) etc. n-type Semi conductor is obtained.

The pentavalent Impurities atoms are known as donor atoms.



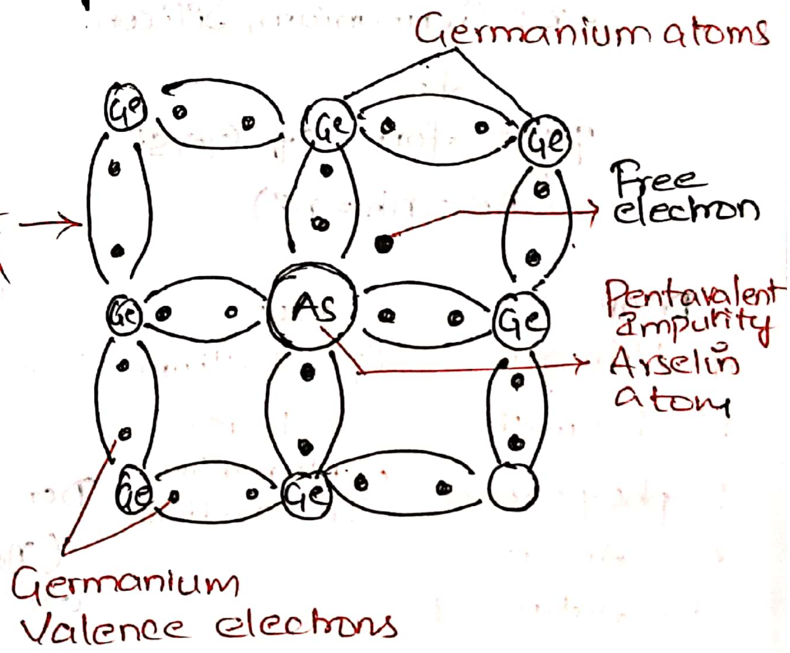


Fig: N-Type Semi conductor.

Fig shows the crystal structure obtained when pentavalent arsenic impurity is added with pure germanium crystal. The four valence electrons of arsenic atom form covalent bonds with electrons of neighbouring four germanium atoms. The fifth electron of arsenic atom is loosely bound. This electron can move about almost as freely as an electron in a conductor and hence it will be the carrier of ~~ele~~ current.

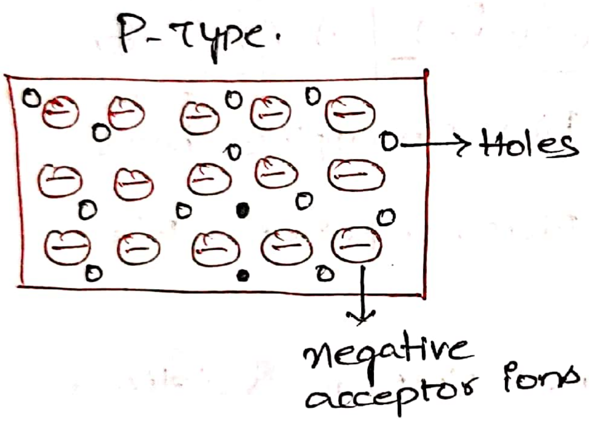
In n-type, the no. of electrons increases, compared to the available number of charges carriers in intrinsic Semi conductor. This is because, the available larger no. of electrons increases the rate of recombination of electrons with holes.

(2)

Hence, "Free electrons are the majority charge carriers and holes are the minority charge carriers".

P-Type Semi conductors:-

When a small amount of trivalent impurity (such as indium, boron (or) gallium) is added to a pure semiconductor crystal, the resulting semi conductor crystal is called p-type.



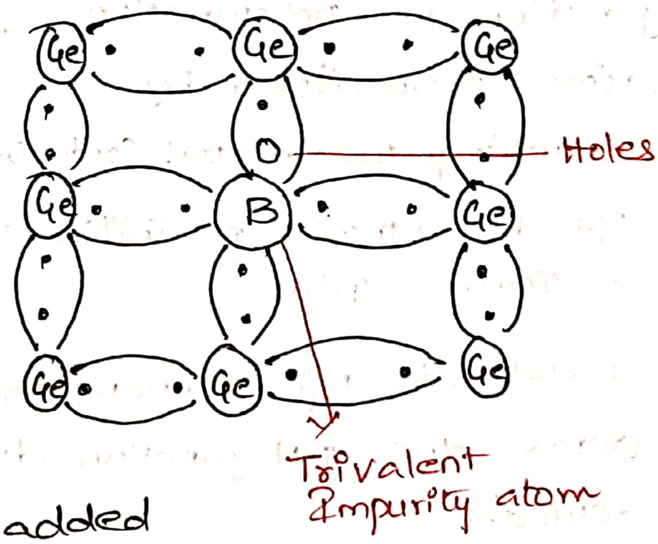


Fig:- When Trivalent impurity is added with pure Germanium Crystal.

The Three Valance electrons of the boron atom form covalent bonds with valance electrons of three neighbourhood germanium atoms. In the fourth covalent bond, only one valence electron is available from germanium atom and there deficiency of one electron which is called a hole. Hence for each boron atom added, one hole is created. Since the holes can accept electrons from neighbourhood, the impurity is called acceptor.

The holes may be filled by the electron from a neighbouring atom, creating a hole in the position

From where the electron moves. Since the hole is associated with a positive charge moving from one position to another, this is called P-Type.

Hence, holes are the majority charge carriers and free electrons are the minority carriers.

Characteristics of PN Junction Diode:

PN Junction Diode: [NO applied bias]

PN Junction Diode is a two terminal device, the difference between PN Junction and PN Junction diode is obtained by attaching two metal contacts.

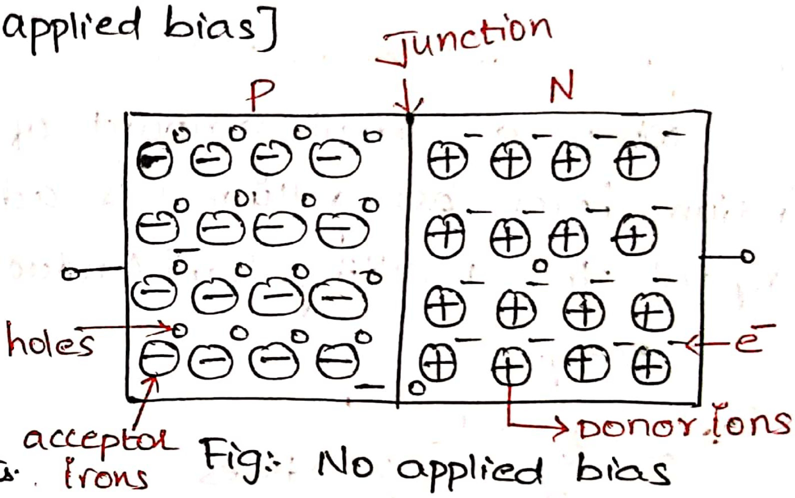


Fig: No applied bias

It has three posibilities: 1. No Bias, 2. Forward Bias. 3. Reverse Bias.

Bias: Biasing is where the external voltage is delived across the PN Junction diode. (To turn on the electronic device).

PN Junction constitutes a rectifier (AC to DC) which permits the easy flow of charge in one direction but restrains the flow in opposite direction.

* The p-type Semiconductor has more holes and less electrons. The n-type has more electrons and less holes. therefore, at the Junction, the electrons in the N-side have a tendency to move towards the p-side.
* Similarly the holes on the p-side have a tendency to move towards the n-side.
* According to that, the electron and holes recombine,

with each other, to form region at the junction.
It is called "depletion region".

* as the recombination takes place, immobile ions will surface out because of diffusion.

The process of movement of charge carriers from higher concentration to lower concentration generates diffusion current.

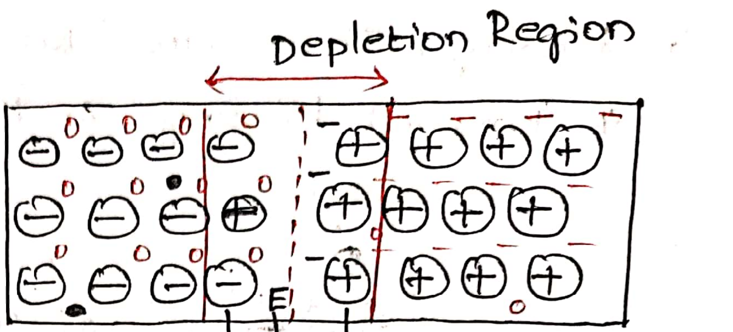


Fig: No bias condition

* When the free electrons move from n-type to p-type, the donor ions becomes positive immobile ions (+ve charged). similarly when the holes move from P-type to n-type, acceptor ions become negative charged. These two charges, on either side make a potential ~~(differen)~~ across the depletion region called "barrier potential". (or) The electric field is formed in the depletion region acts as a barrier.

The barrier potential aids the flow of minority carriers and opposes the flow of majority carrier through the junction. ~~The movement caused by variation in the carrier concentration is called di~~

The movement caused by electric fields is called as drift current.

due to this opposite effects, no change carriers are flow through the junction at normal conditions.

ie, drift current = diffusion current

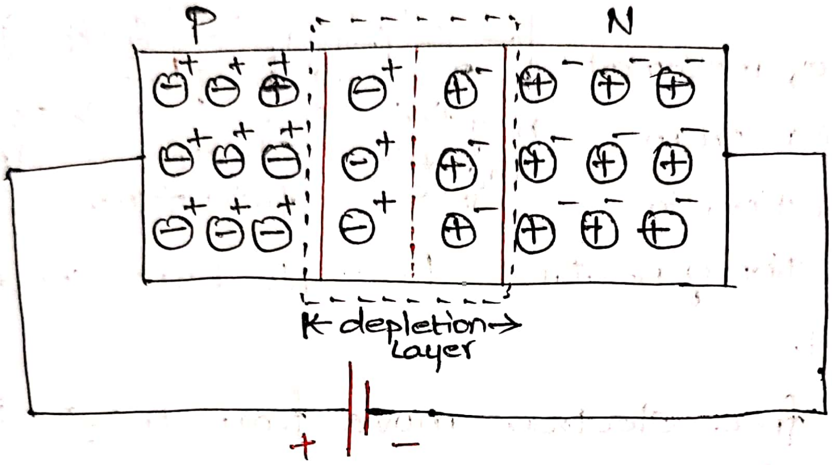
∴ Net current = 0

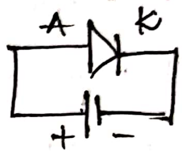
∴ no current carrying charges.

Working of P-N Junction Diode:

The conduction of any diodes depends on their biasing. These are two types biasing, known as 1. Forward biasing 2. Reverse Biasing.

Forward Biasing:





operation:

— under forword bias, the positive terminal of the battery is connected to p-type and the negative terminal of battery is connected to N-type material of barrier diode.

— under forword bias condition, the applied positive Voltage repels the holes in p-type and holes moves towords the junction.

— Similarly, the applied negative Voltage repels the electrons in n-type region and electrons move towords the junction.

— This reduces the width of depletion region and also the barrier potential.

— If the applied voltage is greater than barrier potential, the majority carriers on both regions move towords the junction. It makes the current flow through the junction and the amount of current depends upon the magnitude of applied potential.

for silicon; $V_{BP} = 0.7V$, for germanium Ge $V_{BP} = 0.3V$

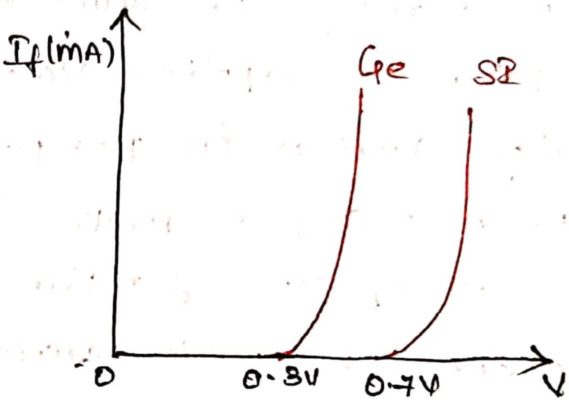
BP = Barrier potential.

$V_{FB} > V_{BP}$ - flow of electrons.

$V_{FB} < V_{BP}$ - No flow of electrons.

V-I characteristics.

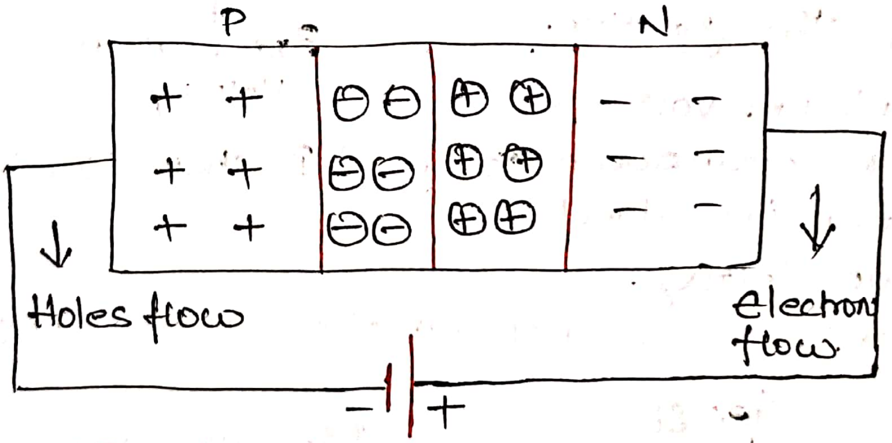
* When the applied Voltage potential is less than cut-in (or) threshold Voltage, the current flow is very low. The cut in Voltage is 0.3V for Ge and 0.7V for Si.



VI characteristics of FB.

* At the cut-in voltage, the applied potential overcomes the barrier potential, increases the current rapidly.

Reverse Biasing:-



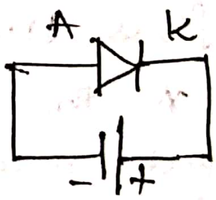


Fig: Reverse Bias Conditions.

* In reverse biasing, the positive terminal of the battery is connected to n-type and the negative terminal of battery is connected to the P-type material of the diode.

7* Under reverse bias condition, the major carriers with P and N region are moved towards the battery.

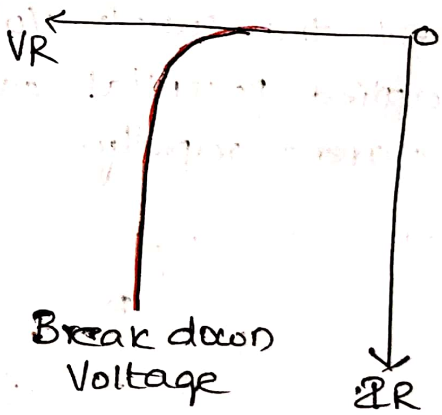
* The holes in P-type and the electrons in n-type region move to the negative and positive terminals of the battery. Hence, the width of the depletion region is increased, which prevents the flow of majority carriers through the junction.

* When the applied voltage is slowly increased the minority carriers in ~~pe~~ p-region and the minority carriers in n-region make a ~~sign~~ small amount of current flow through the junction. This current is called "Reverse Saturation current."

VI characteristics (RB)

* When the applied reverse voltage is further increased, breakdown occurs the junction. Now large reverse current flows through the junction.

* The minimum voltage that needs to breakdown occurs in the junction is called break down voltage.



VI characteristics of RB

VI characteristics of PN junction diode (complete)

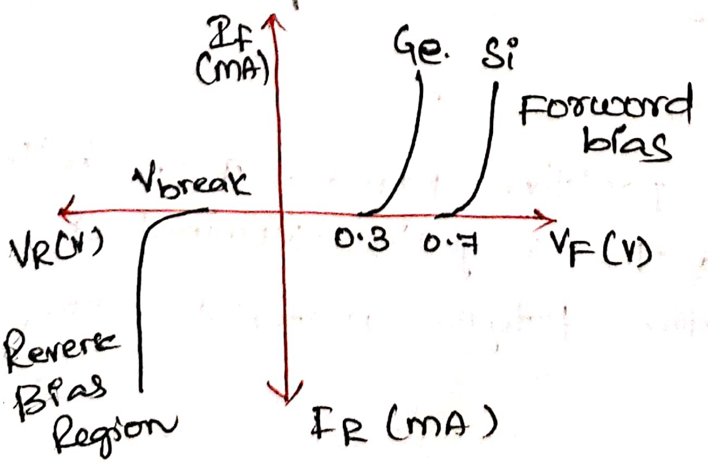


Fig: VI characteristics of FB and RB

Advantages

1. low cost
2. High efficiency
3. Fast switching speed
4. Wide operating temperature range.
5. High Reliability.

Disadvantages

1. Reverse voltage is limited.
2. Non-linear characteristics in current - Voltage
3. High Reverse leakage current.

Applications:-

1. Rectification of Input and Output Signals
2. Clipping and clamping
3. Voltage Regulation.
4. used for LED lighting
5. Solar cell applications.

Zener Effect: is a type of electrical breakdown that occurs in reverse bias PN Jn

- In general purpose of PN junction diode, the doping is light; as a result of this the breakdown Voltage is high. If a p and N region are heavily doped than the breakdown Voltage can be reduced.

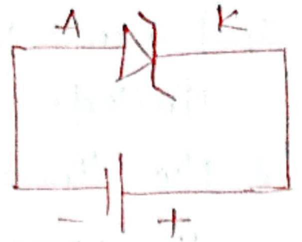
* When the doping is high (or) heavy, even the reverse breakdown Voltage is low, the electric field at barrier will be so strong thus the electrons in the covalent bonds can break away from the bonds. This effect is known as Zener effect.

Zener diode:

A diode which exhibits the Zener effect is called a Zener diode (or) Voltage reference (or) voltage regulator (or) break down diode.

Hence it is defined as a reverse biased heavily doped PN junction diode which operates in

In break down region.



Circuit diagram for reverse bias

Symbol

The Zener diodes have been designed to operate at Voltage ranging from a few Volts to Several hundred Volts.

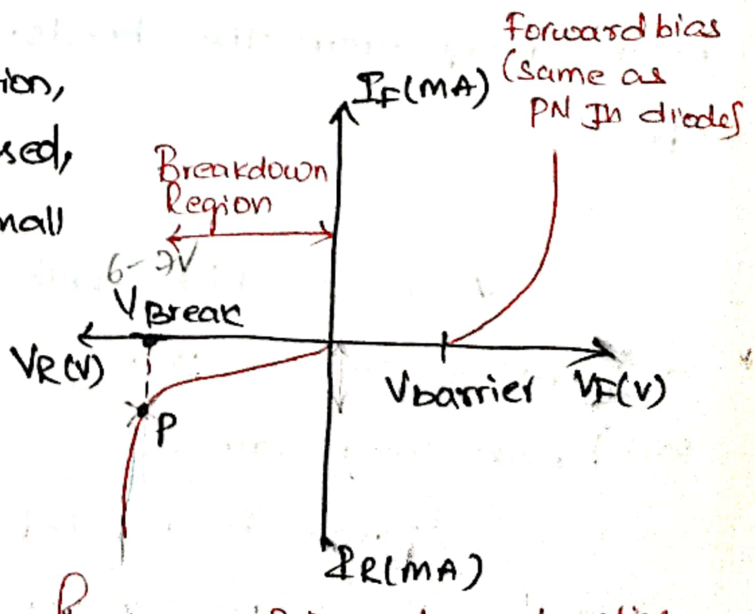
* The operation of Zener diode is same as that of an ordinary PN junction diode in forward bias Condition. But in Reverse biased Condition, breakdown may occur in the junction of the diode. The break down Voltage depends upon the amount of doping.

* Heavily doped diodes breakdown at low Voltage Levels, Similary lightly doped diodes break down at high voltage.

V-I characteristics:

* Under reverse bias Condition, the reverse Voltage (V_R) is increased, the reverse current (I_R) remains small upto the "knee" region of curve point 'P'.

* At this point the effect of breakdown process begins. From the bottom of the knee,



Reverse Bias characteristics.

The breakdown Voltage (V_z) remains essentially Constant. This ability of diode is called regulating ability.

(a) There is a minimum Value of Zener called breakdown Current, which must be maintained inorder to keep the diode in break down region. When the Current is reduced below knee curve the Voltage changes drastically and the regulation is Lost.

(b) There is a maximum Value of current designated as $I_{Z(max)}$ above which the diode may be damaged.

Applications:

* As Voltage regulators
* As fixed reference Voltage in power Supplies and transistor biasing.
* As clippers in Wave-Shaping Circuits.

Difference between PN Junction and Zener Diode:-

	PN Junction Diode	Zener Diode.
1.	It is a Semi-conductor diode which is formed when n-type and P-type Semi-Conductor Crystals are joined together.	It is also a Silicon special PN junction diode which differs from rectifier diode in the sense operated in reverse break down.
2.		
3.	The electricity flows in one direction.	It flows in both the directions.
4.	The reverse bias permanently damages the depletion region.	The reverse bias makes the electricity flow in both the direction.

5. It is lightly doped, hence the depletion region is Large.	It is heavily doped, hence the depletion region is narrow.
6. It is used for rectification.	It is used for voltage regulation.

Bipolar Junction Transistor :-

* Transistor is a three terminal device: Base, Emitter and Collector.

* The amplification in the transistor is achieved by passing input current signal from a region of low resistance to a region of high resistance. This concept of transfer of resistance has given the name:- Transfer-resistor (Transistor)

* The current conductor in bipolar transistor is because of both the type of charges carriers, holes and electrons. Hence this called Bipolar Junction Transistor (BJT).

* In BJT output current is controlled by input current and hence it is a current controlled device.

Types of BJT:

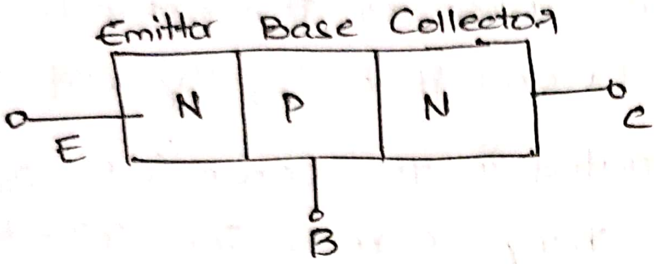
1. N-P-N Type
2. P-N-P Type.

Advantages of BJT:-

1. Low operating Voltage
2. Higher Efficiency
3. Small size and ruggedness
4. Does not require any filament power.

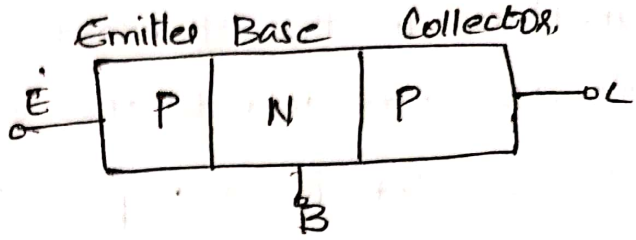
Structure of Bipolar Junction Transistor:

* When a transistor is formed by sandwiching a single p-region between two n-regions is called N-P-N transistor. The P-N-P transistor has a single N-region between two P-regions.



(a) N-P-N

Majority charge carriers - Electrons
Minority charge carriers - Holes

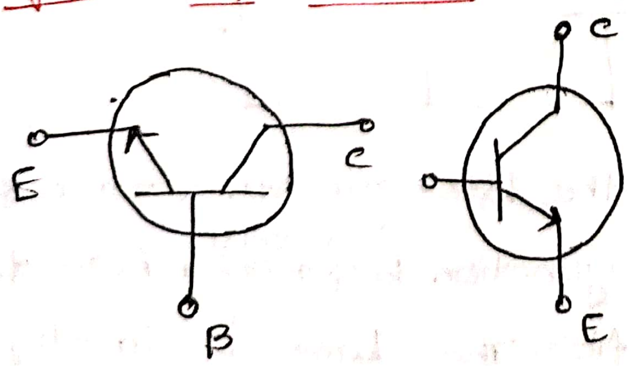


(b) P-N-P.

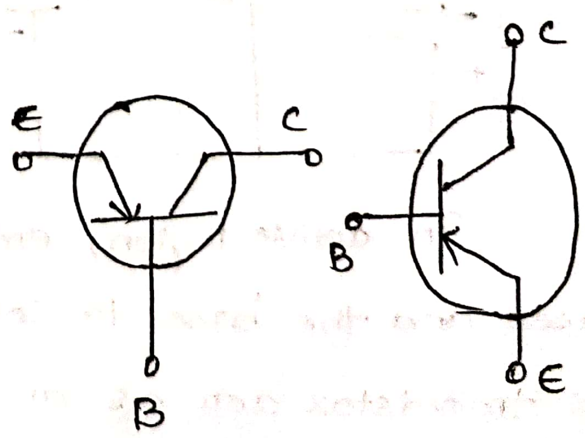
Majority charge carriers - Holes
Minority charge carriers - Electrons

* The middle region of each transistor type is called the base of the transistor. This region is very thin (25 micro size) and lightly doped.
* The process by which impurities are added to a pure semi conductor is called doping.
* The emitter region is heavily doped and the collector region is moderately doped, but the doping level in emitter is slightly greater than that of collector.

Symbol of Transistor:



(a) N-P-N



(b) P-N-P

Emitter: It is a region situated in one side of transistor, which supplies a charge carriers (electrons (OR) holes) to the other two regions. It is a heavily doped region.

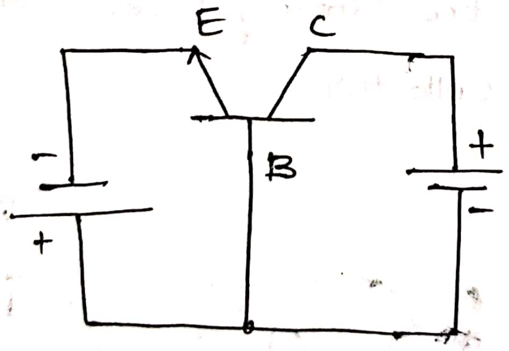
Base: It is a middle region that forms two PN junctions in the transistor. The base of transistor is thin as compared to the emitter and it is lightly doped.

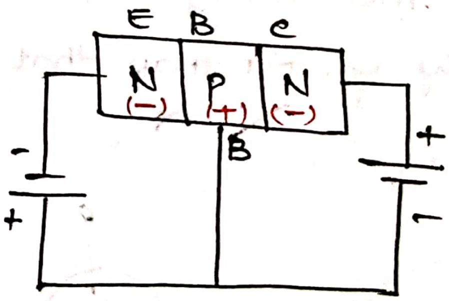
Collector: It is a region situated in the other side of transistor which collects the charge carriers. The collector of transistor is always larger than the emitter and base. The doping level is intermediate between emitter and base.

Transistor Biasing:

A suitable DC voltage is applied across the transistor terminals is called Biasing. Each junction of a transistor may be forward biased (OR) Reverse biased independently.

1. Forward - Active Region:-



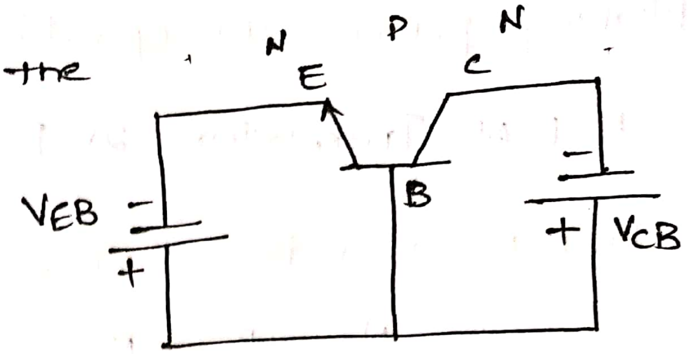


In active region, emitter to the base junction is forward biased and the base to collector junction is ~~forward~~ reverse biased. The transistor acts as an amplifier. The base is directly proportional to the emitter and collector.

Forward - (-ve) to N-side
Reverse - (+ve) to N-side.

② Saturation:

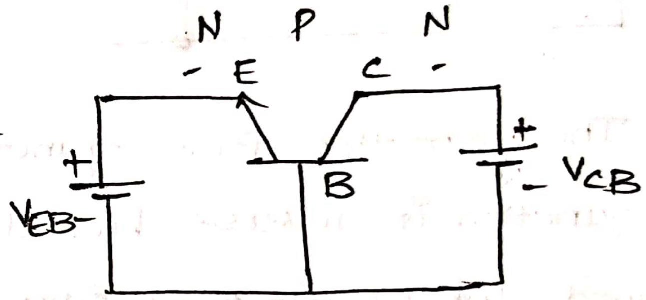
In this mode, both the emitter-base junction and collector-base junction of a transistor are forward biased. In this mode, the transistor has a very large value of current.



In this mode, the transistor acts is operated at closed switch. ($I_C = I_E$).

3. Cut-OFF :-

In this mode, both the Emitter-Base and Collector-Base junction of a transistor are reverse biased. In this mode, the transistor has practically zero current.



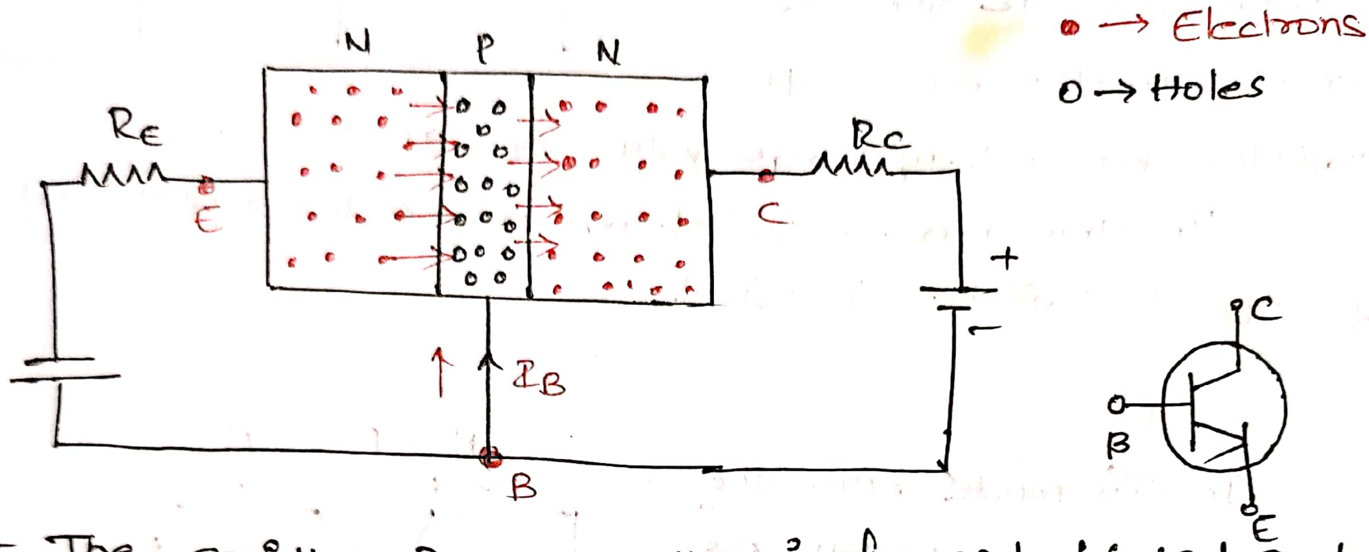
In this mode, the transistor acts as open switch.

Region	Emitter-base junction	Collector-base junction.
Active	Forward biased	Reversed biased
CutOFF	Reverse biased	Reversed biased
Saturation	Forward biased	Forward biased.

Working principle (or) operation of Transistor:-

1. N-P-N Transistor 2. P-N-P Transistor.

1. N-P-N Transistor (operation).

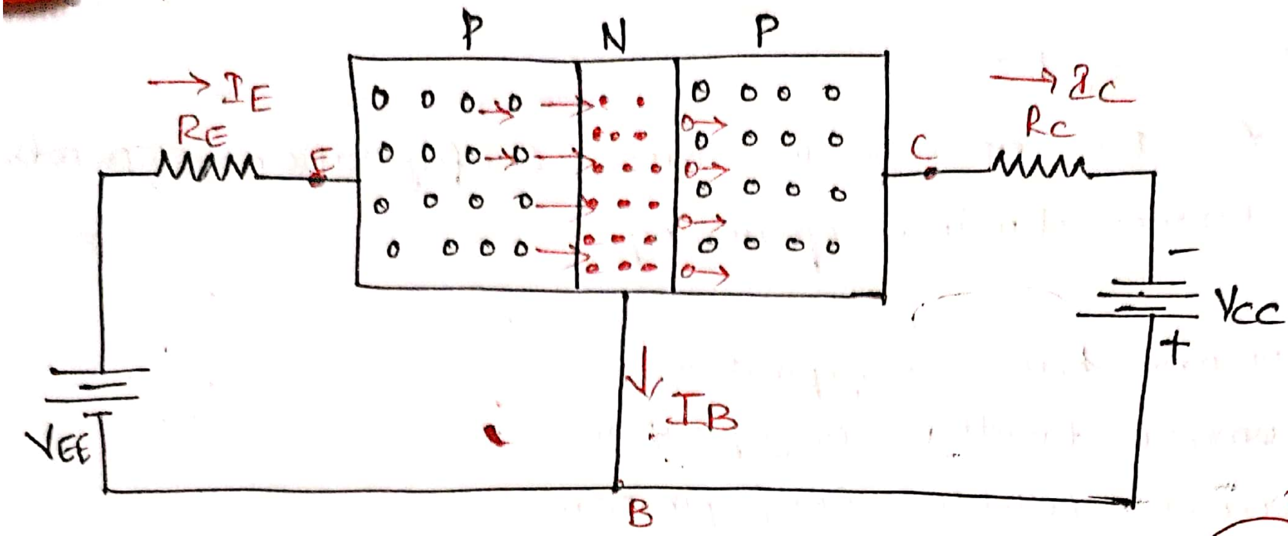


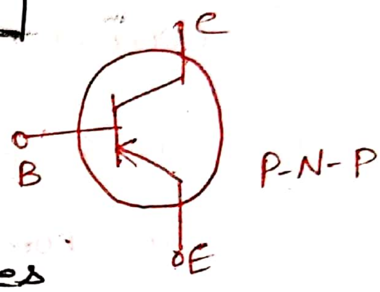
- The emitter-Base junction is forward biased and CB junction is reverse biased. Due to E.B junction forward biased lot of electrons from emitter entering the base region.
- The base region is lightly doped with p-type impurity. So the number of holes in the base region is very small. Due to this electron-hole recombination is less (i.e) few electrons (<5%) combine with holes to constitute base current (I_B).
- The remaining electrons (>95%) cross over into collector region, to constitute collector current (I_C).

Thus, collector current is larger than base current.

$$\boxed{I_E = I_B + I_C}$$

P-N-P Transistor:





– The E-B junction is Forward biased and CB junction is reverse biased. Due to E-B junction is forward biased lot of holes from emitter entering the base region and electrons from base to emitter region. This constitutes Emitter current (I_E).

* ~~The fear~~ ·

* Base is lightly doped with N-type impurity. So the number of electrons in the base region is very small. Due to this electron-hole recombination is less. i.e., few holes (<5%) combine with electrons to constitute base current (I_B).

The remaining large number of holes (>95%) move through the collector region to the negative terminal of DC source. This constitutes collector current. Thus the hole flow constitutes the dominant current in a PNP Transistor.

TRANSISTORS CONFIGURATIONS:

Configuration of BJT:-

A BJT operate in Various Configurations depends on the common terminal grounding.

Types:

1. Common-Base Configuration
2. Common-Emitter Configuration
3. Common-Collector Configuration.

Common-Base Configuration:

In common-base configuration, the base terminal is common to both input and output terminals. The base is at ground potential.

The input resistance is low in this configuration whereas the ouput resistance is high. It attains the voltage gain upto 100.

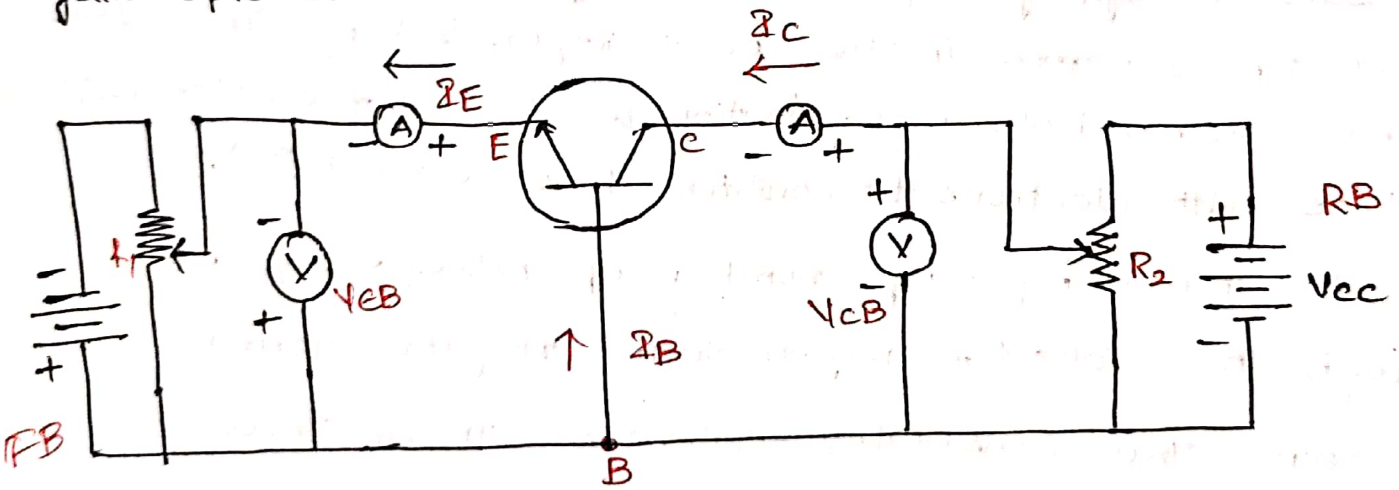
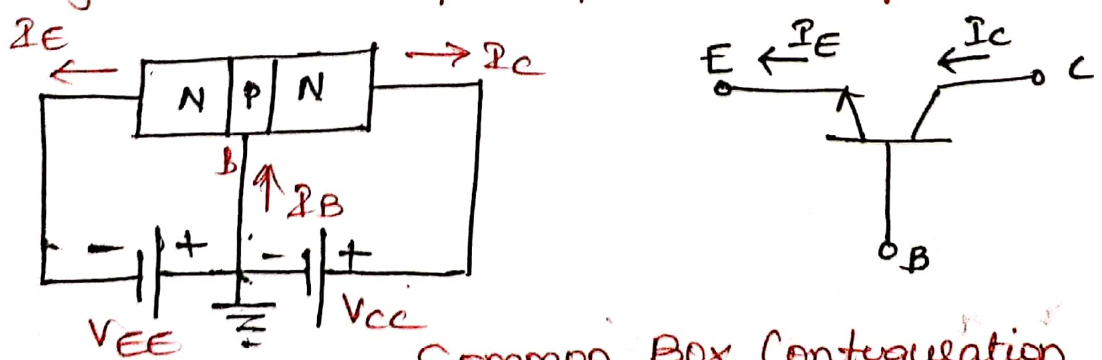


Fig: Circuit Diagram for CB Configuration.



Common Box Configuration

Input Characteristics :-

* The input characteristics of NPN transistor is drawn between base emitter Voltage (V_{EB}) and emitter Current (I_E). at the output of Constant Collector-base Voltage (V_{CB}).

* When $V_{CB}=0$, the emitter-base junction is forward biased, So that emitter current I_E increases rapidly with small increase in emitter base Voltage (V_{EB}).

* When V_{CB} is increased, the depletion region between base and collector gets increased which reduces the width of the base region.

* This effect results in an increase of emitter current (I_E). Therefore, the curve shift towards the left as V_{CB} is increased.

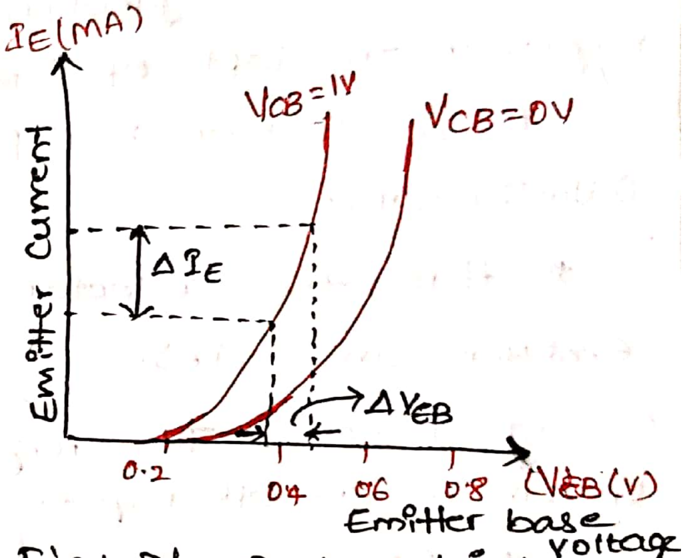


Fig: I/p VI characteristics.

Output characteristics :

* The output characteristics drawn between the output Voltage (V_{CB}) and output ~~Voltage~~ Current (I_C) for Various levels of input Current (I_E).

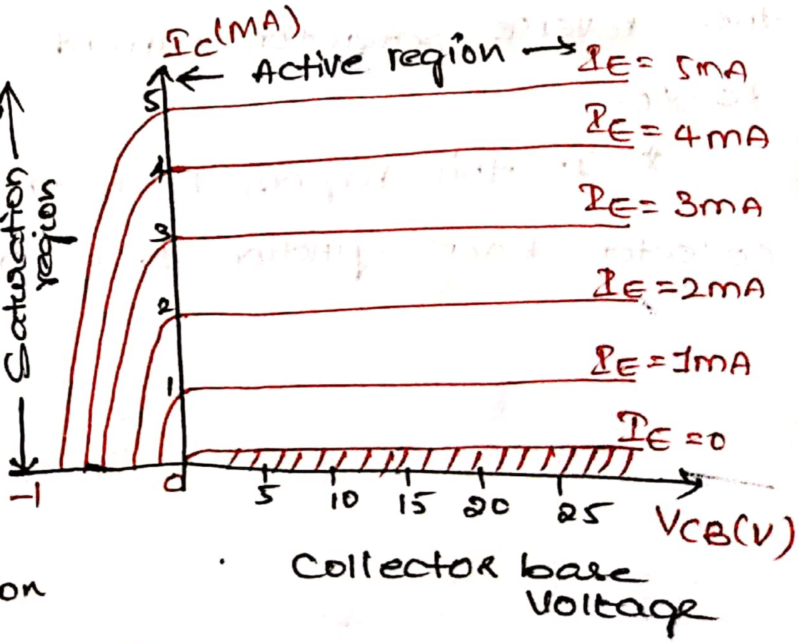


Fig:- O/p VI characteristics

* It has three regions: Active, Cut-off and Saturation Region.

Active Region:

(a) In active region, the emitter base junction is forward biased and collector base junction is reversed biased.

(b) In this region, collector current is approximately equal to emitter current ($I_E \approx I_C$) and transistor works as an amplifier.

(c) The collector current (I_C) is almost independant on collector - base voltage (V_{CB}) and the transistor can be said to work as constant - current source.

2. Saturation Region: In this region both emitter base junction and collector base junction are forward biased. It is the region in the left of $V_{CB} = 0$.

* I_C increases exponentially as V_{CB} increases towards 0 volts (zero).

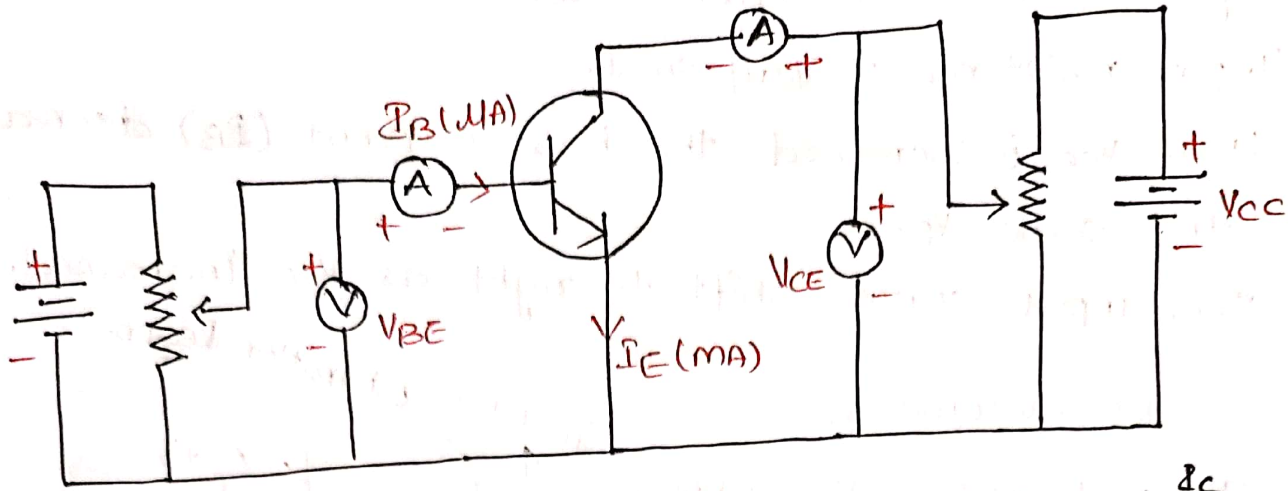
* Here, the collector current (I_C) is independent of emitter current (I_E).

Cut-off region: * The region below the curve $I_E = 0$ is known as cut-off region.

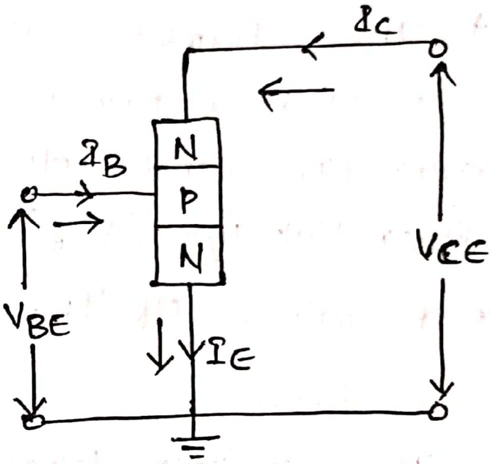
* If $I_E = 0$, the collector current I_C is only due to the reverse saturation current which is negligibly small $I_C \simeq 0$.

* In this region, both the emitter-base junction and collector - base junction of a transistor are reverse biased.

Common - Emitter Configuration:-



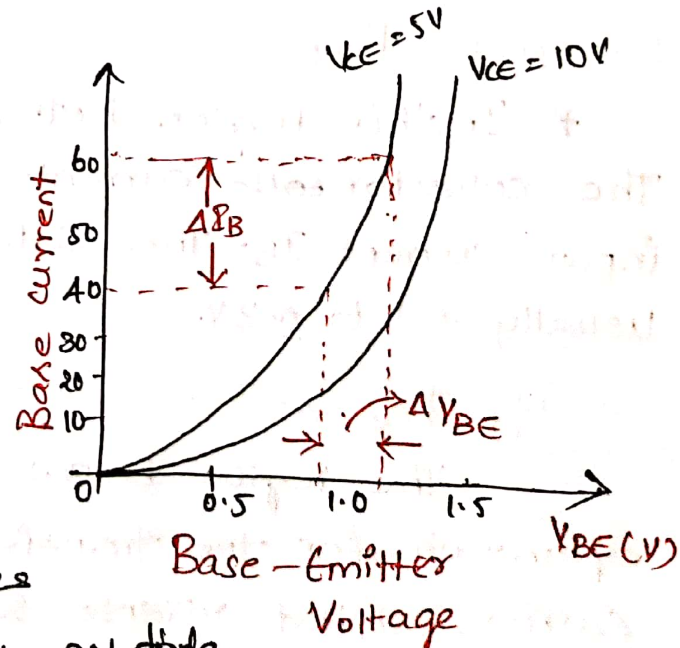
In this configuration, the emitter terminal is common to input and output.



* The input signal is applied between the base terminal and emitter terminal and the output signal is taken out from the collector and emitter terminals.

* The value of base current is always less than the collector current (I_C). So the value of DC current is greater than unity.

Input Characteristics:



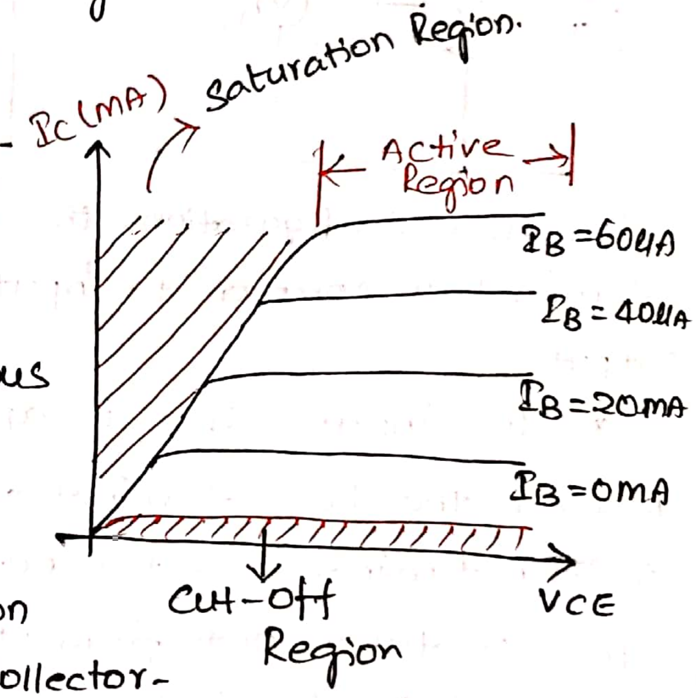
* The graph is drawn between the input voltage V_{BE} and the input current I_B by keeping the output voltage V_{CE} as constant and repeated for different values.

* The overall shape resembles the forward characteristics of PN diode.

* Base current (I_B) increases rapidly after the cut-in-Voltage with small increment in VBE.
* Input resistance is very small.
* When V_{CE} is increased, the base current (I_B) decreases for the same V_{BE}.
* The input curve shift to right as V_{CE} increased.

Output Characteristics:-

* The characteristics shows the relation between Collector current (I_C) and collector-Emitter Voltage (V_{CE}) for Various fixed Values of I_B.



Active Region:-

* The Emitter base Junction (JE) is forward biased and Collector-Emitter Junction is reverse biased.
* The Collector Current (I_C) rise more sharply with increasing V_{CE} is linear region.

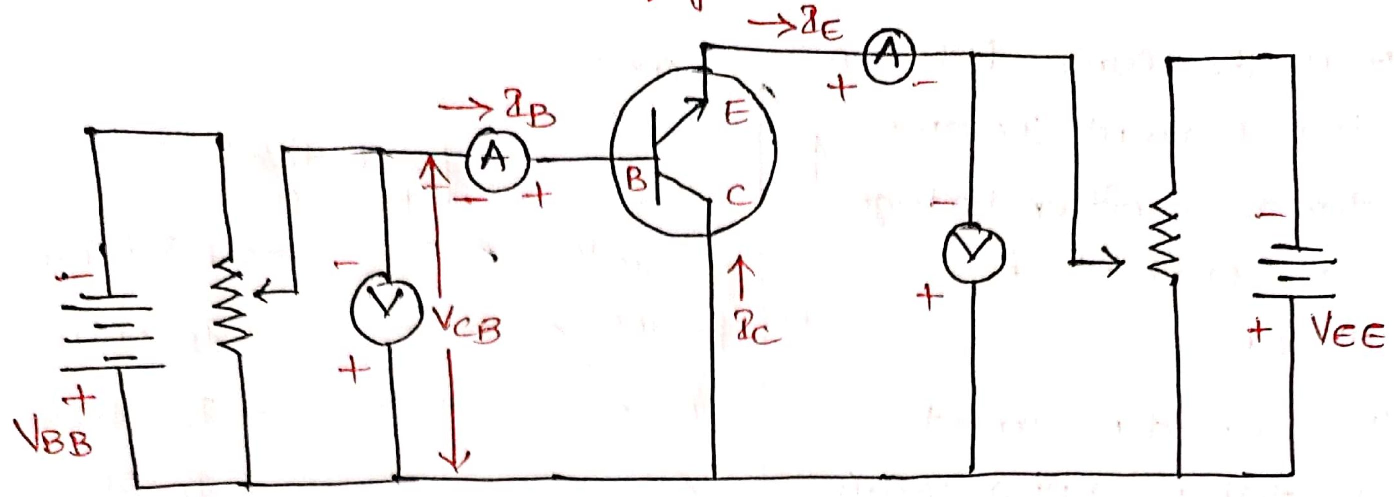
Saturation Region:-

* In this region both Junctions are forward biased. The collector ~~colle~~ current I_C does not depend upon the input current I_B. The saturation value of Vce ($V_{CE(sat)}$) usually 0.1 to 0.3V.

Cut-Off Region:-

The region below $I_B = 0$ is the cut-off region of operation for the transistor. I_C will flow due to minority carriers called reverse saturation current (I_{CEO}). In this region, both the Junctions are reverse biased.

Common-collector Configuration:-



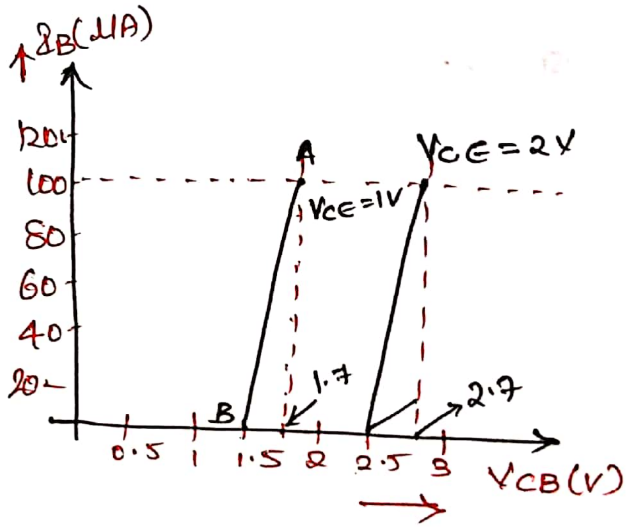
In this configuration, input is applied between base and collector and output is taken from emitter and collector.

Here, Collector of the transistor is common to both input and output circuits and hence the name common Collector Configuration. It is also known as emitter follower configuration.

Input Characteristics

The input characteristics is a graph of input current I_B Vs input Voltage V_{CB} (Collector base Voltage) at constant V_{CE}.

* The base current is taken along y-axis and collector base voltage is taken along x-axis.

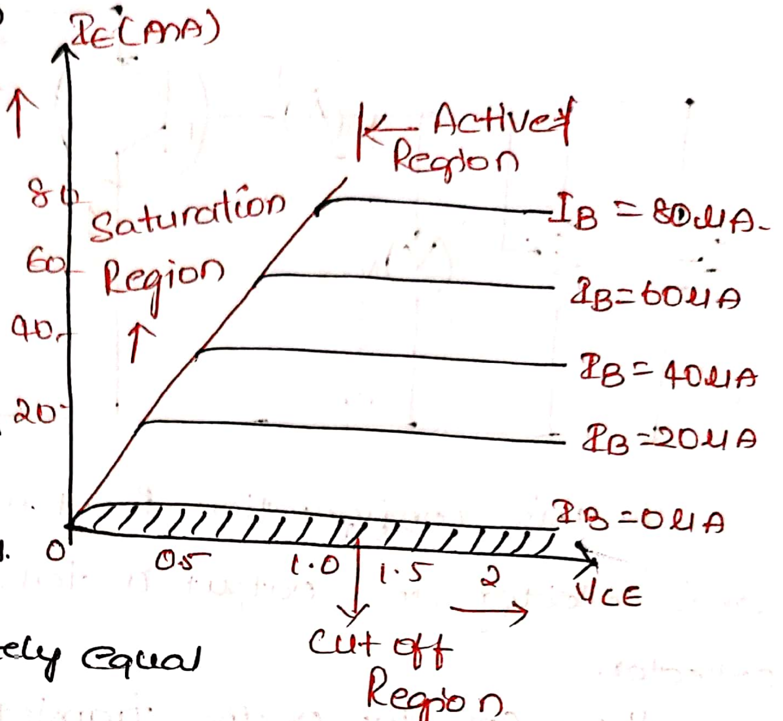


* The input characteristics are quite different from either Common base (or) common emitter input characteristics. This different is due to the fact that the input voltage V_{CB} is largely determined by the level of collector to emitter voltage V_{CE}.

Output Characteristics:-

* It is the curve between Emitter current I_E and Collector to emitter Voltage V_{CE} at constant base current I_B.

* The Emitter current I_E is taken along y-axis and collector to emitter Voltage (V_{CE}) along x-axis.

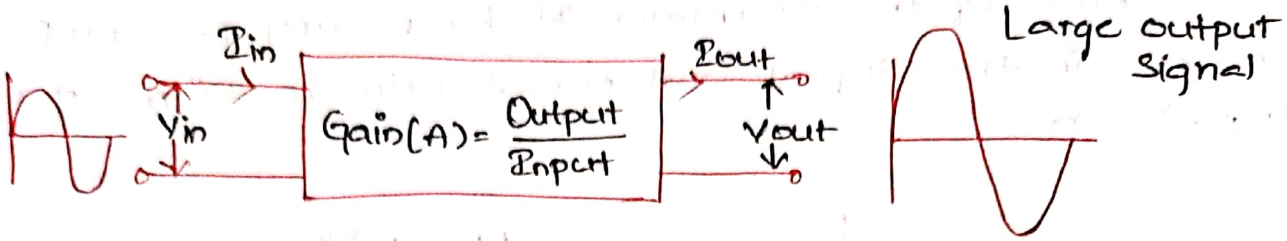


* Since, I_C is approximately equal to I_E, CC characteristics are practically similar to those of the common emitter output characteristics.

* The output resistance of CC configuration is low (80Ω).

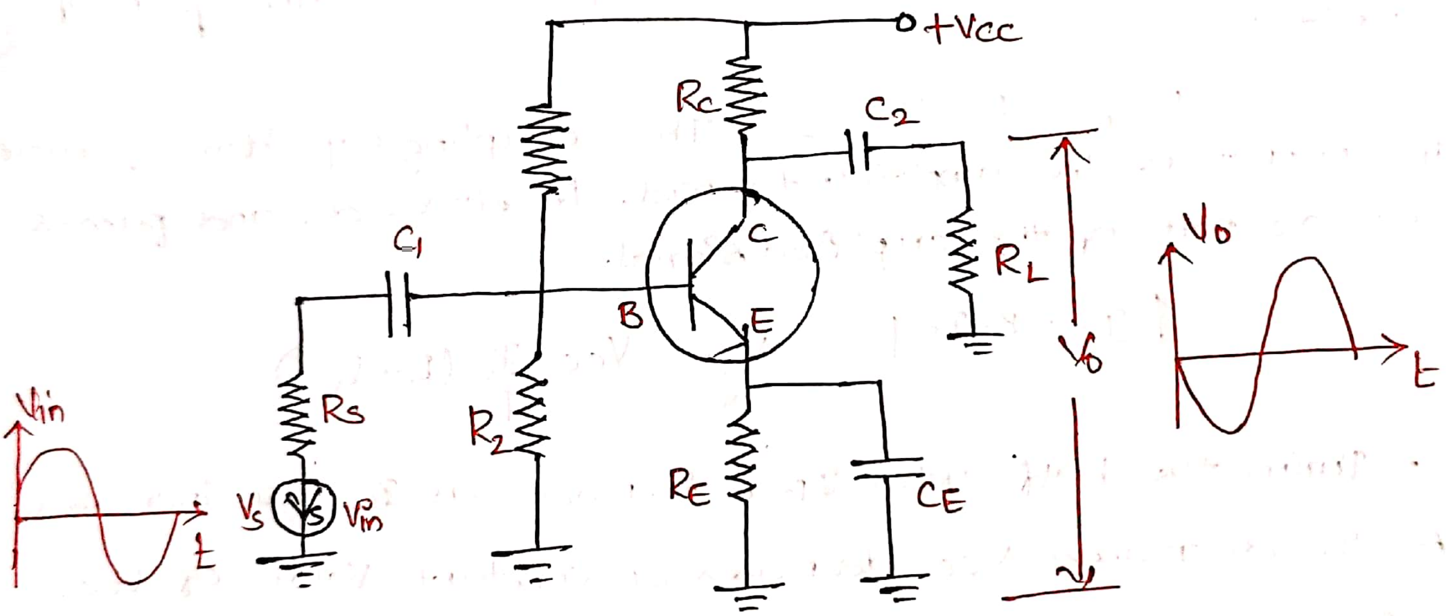
Elementary Treatment of Small Signal Amplifier:

An amplifier is an electronic device or circuit which is used to increase the magnitude of the signal applied to its input.



Amplifiers can be sub-divided into,
(a) Small Signal amplifier (b) large Signal Amplifier.

Common Emitter Amplifier Circuit:



The task of small signal amplifier is to amplify a weak electrical signal (Voltage (or) current) to a large value of V (or) I.

Amplifier Type – Input Signal – Output Signal – Transfer Ratio (o/p / i/p)

(i) Voltage	Voltage	Voltage	Voltage (No dimension)
current	current	Current	current (No dimension)

Biasing Circuit:- The resistances R_1, R_2 and R_E forms the voltage divider biasing circuit for the CE amplifier. It sets the proper operating point for the CE amplifier.

Input Capacitor (C_1):- This capacitor couples the signal to the base of the transistor. It blocks any DC component present in the signal and passes only ac signal for amplification.

Emitter Bypass Capacitor (CE):- An emitter bypass capacitor CE is connected in parallel with emitter resistance, R_E to provide a low reactance path to the amplified ac signal passing through RE will cause a voltage drop across it. This will reduce the output voltage, reducing the gain of amplifier.

Output Coupling Capacitor C_2:- The coupling capacitor C_2 couples the output of the amplifier to load. It blocks dc and passes only ac port of the amplified signal.

$\uparrow I_C = B \cdot I_B \uparrow$ $V_{CE} \downarrow = V_{CC} - I_C \uparrow (R_C + R_E)$

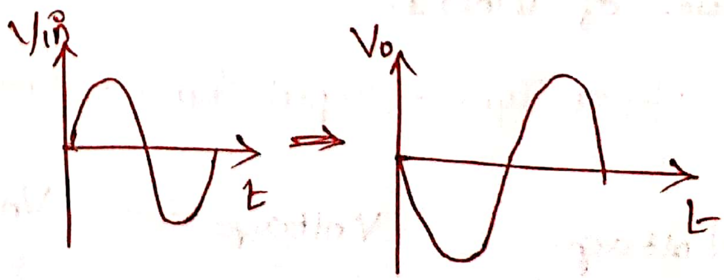
- During +ve half cycle, I_B is increases as I_C also increases. As I_C decreases V_{CE} decreases at constant value of V_{CC}.

- During -ve half cycle, I_B decrease as I_C also decreases. As I_C decreases V_{CE} increases at constant value of V_{CC}.

$I_C = B \cdot I_B \downarrow$

$V_{CE} \uparrow = V_{CC} - I_C \downarrow (R_C + R_E)$

(It produces Reverse Phase shift)



UNIT- II

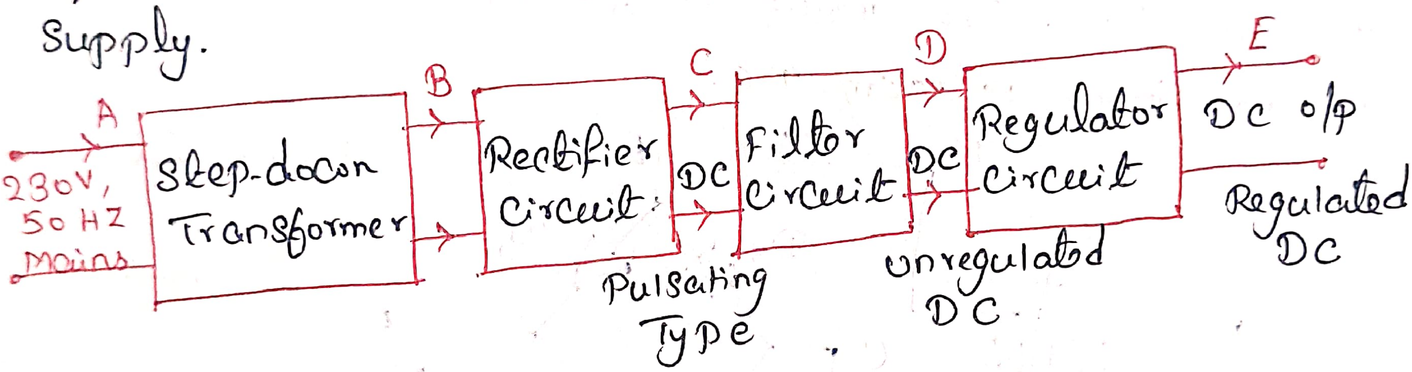
BASIC ELECTRONIC CIRCUITS AND INSTRUMENTATION:

Rectifiers and Power Supplies: Block diagram description of a DC power supply, Working of a Full Wave Bridge Rectifier, Capacitor filter (No Analysis), Working of simple Zener voltage Regulator, Amplifiers: Block diagram of Public Address System, Circuit diagram and working of Common Emitter (RC Coupled) amplifier with its frequency response. Electronic Instrumentation: Block diagram of an electronic instrumentation system.

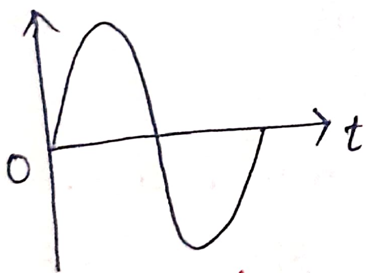
Block Diagram Description of DC Power Supply :-

Definition :- A regulated power supply converts unregulated AC (alternating current) to a constant DC (Direct current). It ensures that the output remains constant even if the input changes. It is also known as linear power supply.

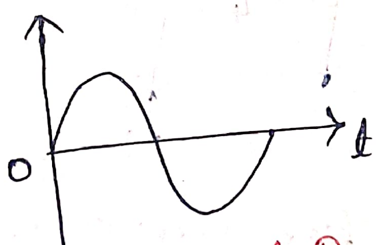
The unit containing the circuits which convert the ac supply voltage into dc regulated voltage at required level is termed as DC regulated power supply.



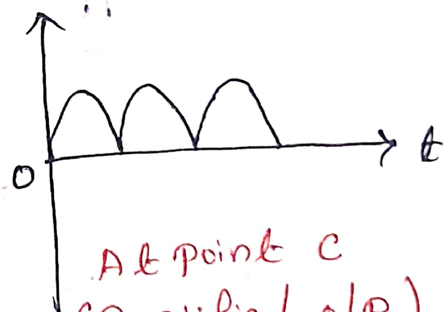
Block Diagram



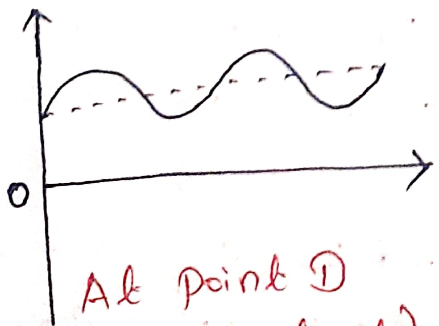
At point A



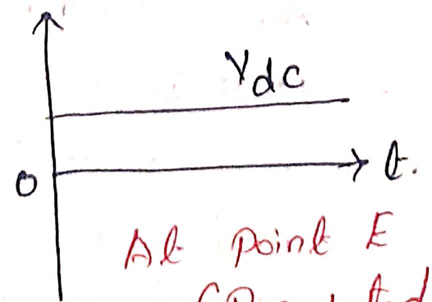
At Point B
(step down)



At point C
(Rectified o/p).



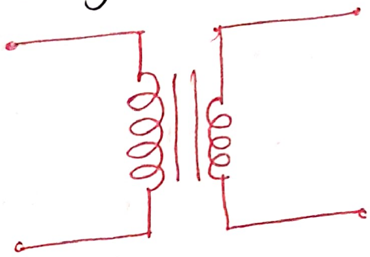
At Point D
(Filter output)



At point E
(Regulated DC)

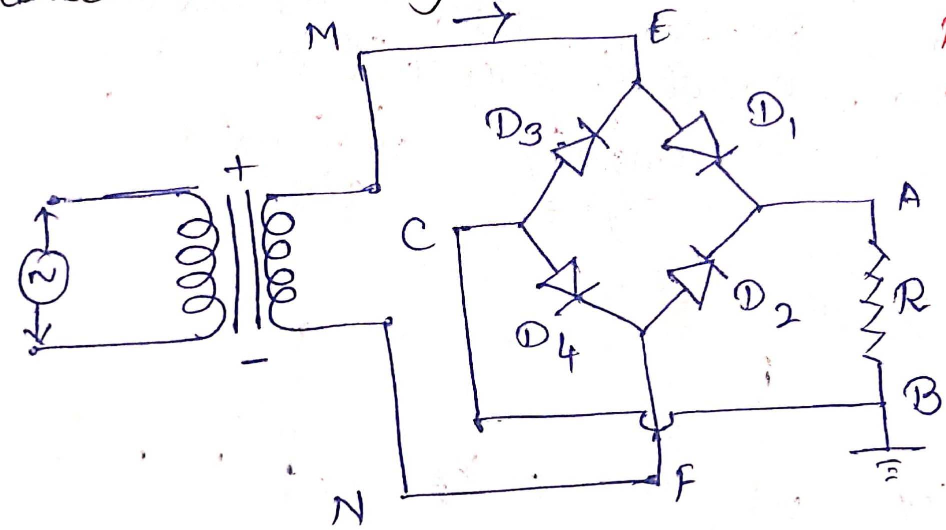
1. Step down Transformer :-

A step-down transformer will step down the voltage from the ac mains to the required voltage level. The turns ratio of the transformer is so adjusted so as to obtain the required voltage value. The output of the transformer is given as an input to the rectifier circuit.



2. Rectification :-

It is the process of converting an alternating voltage or current into corresponding Dc quantity. The input is Ac whereas its output is unidirectional pulsating Dc.



Full - Wave Rectifier Bridge.

* A bridge rectifier consists of 4 P-N diodes.

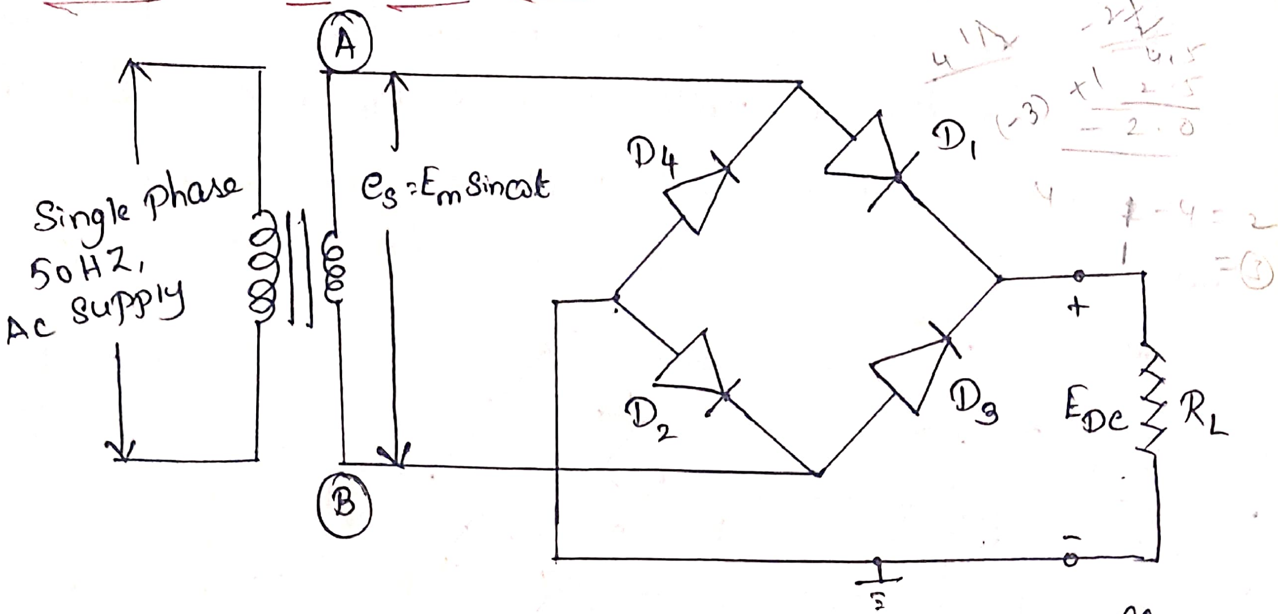
In positive half cycle of the supply, the voltage induced across the secondary of the electrical transformer i.e. VMN is positive. Therefore, point E is positive with respect to F. Hence, diodes D_3 and D_2 are reverse biased and diodes D_1 and D_4 are forward biased. The diode D_3 and D_2 will act as open switch and diodes D_1 and D_4 will act as closed switch.

and will start Conducting. Hence a rectified wave form appears at output of rectifier. When a Voltage induced in Secondary i.e. VMN is negative then D_3 and D_2 are forward biased and D_1 and D_2 are reverse biased and a positive voltage appears at the input of filter.

3. Filtration :- Since the output of the rectifier is a pulsating direct voltage which has very high ripple Content. Hence, the raw output of the rectifier is undesirable. Inorder to get a pure ripple free direct voltage, a DC filter circuit is used. Different types of filters are used such as Capacitor Filter, LC filter, Choke input, π filter. Therefore, the filter circuit Converts the pulsating direct voltage into the Constant direct voltage having almost zero ripple Content.

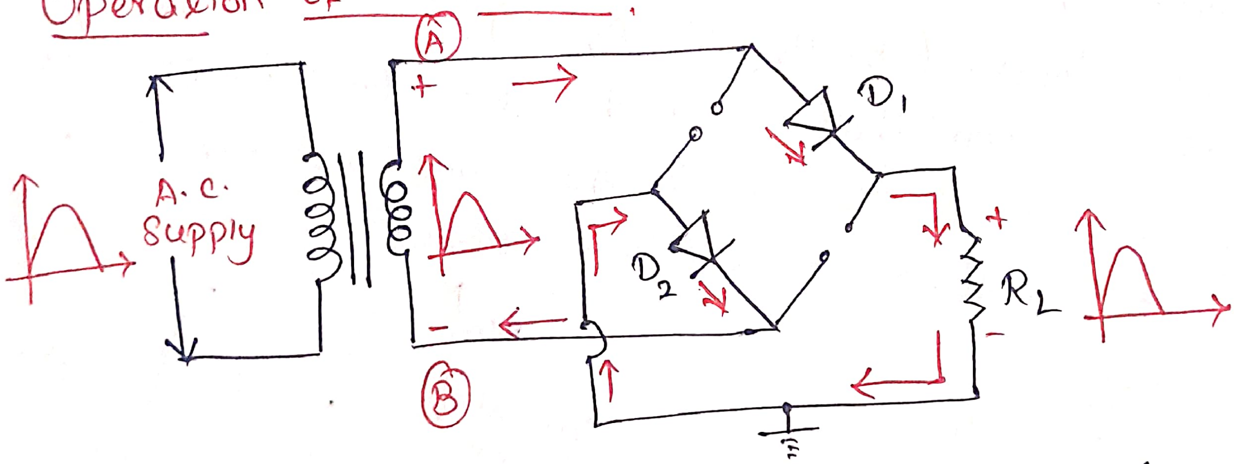
4. Voltage Regulator :- It monitors and Corrects the fluctuations in the output voltage of power supply. The output of filter is fed to regulator circuit. The voltage regulator maintains the DC voltage Constant at the output terminals. Various types of regulator circuits are zener diode shunt regulator, Transistor shunt Regulator, Variable IC regulators are Commonly used in different regulated power supplies as the voltage regulator.

Working of Full Wave Bridge Rectifier :-



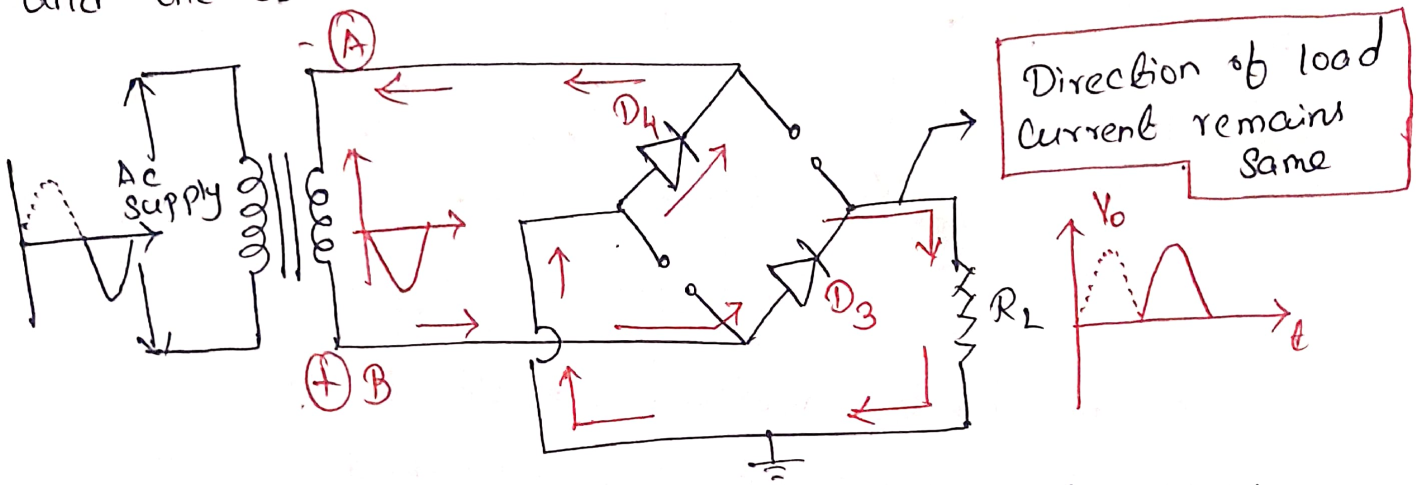
* The bridge rectifier circuit is essentially a full-wave rectifier circuit, using four diodes forming the four arms of an electrical bridge.
* The main advantage of this circuit is that it does not require a centre tap on the secondary winding of the transformer.

Operation of the Circuit :-



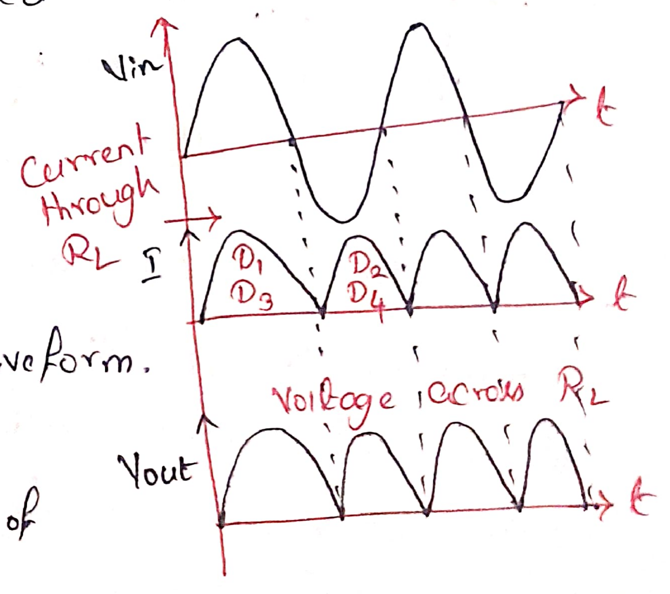
When an AC supply is switched ON, the alternating voltage Vin appears across terminals AB of the secondary winding of transformer which needs rectification. During the positive half cycle of the

Secondary voltage, end A becomes positive and end B becomes negative. The diodes D_1 and D_2 will be forward biased, while D_3 and D_4 reverse biased. The two diodes D_1 and D_2 conduct in series with the load and the current starts to flow. (A - D_1 - R_L - D_2 - B)



In the next half cycle, when the polarity of ac voltage reverses hence point B becomes positive and A becomes negative. The diodes D_3 and D_4 are forward biased, while D_1 and D_2 reverse biased. Now the diodes D_3 and D_4 conduct in series with the load and the current flows. (B - D_3 - R_L - D_4 - A).

It is seen that in both cycles, the direction of load current is flowing in the same direction, hence we get a full-wave rectified output.



Advantages:

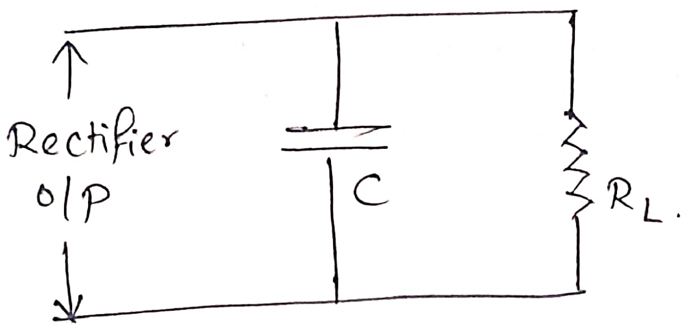
1. Large DC o/p.
2. Efficiency is higher.
3. High output voltage.
4. utilize both halves of AC waveform.

Dis-Advantages:

1. It undergoes large amount of power loss.

CAPACITOR FILTER (No ANALYSIS) :-

Capacitor Filter:-

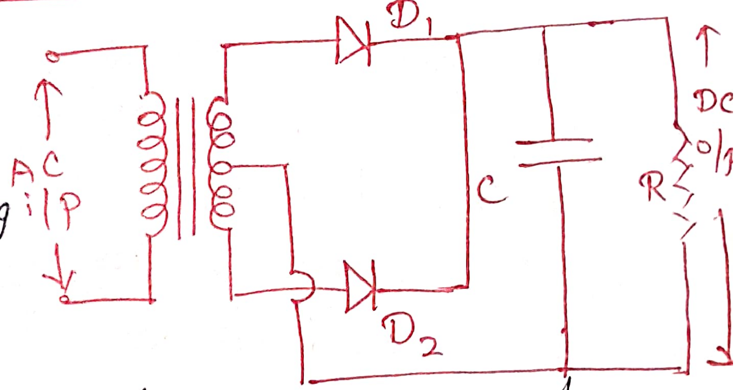


The capacitor does not permit DC to flow through it.

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 0 \times C} = \text{infinite}.$$

The features of capacitor filter like low cost, less weight, small size & good characteristics. It is applicable for small load currents.

Full Wave Rectifier with capacitor filter:-



The main function of rectifier is to convert an AC into DC, by allowing current flow through it one direction only

It is often used in radio, television and computer that require a steady constant DC voltage. Its o/p is smoothened by an electronic filter such as capacitor.

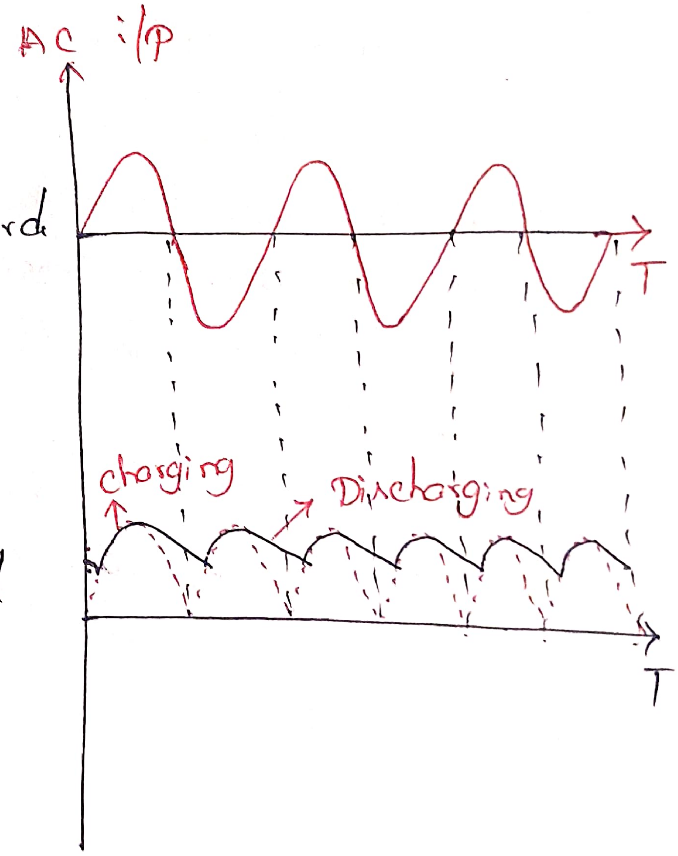
Working:-

Once the i/p AC voltage is applied throughout the positive half cycle, the diode D_1 gets forward biased and permits flow of current while Diode D_2 gets reverse biased & blocks the flow of current.

The Diode D_1 gets the filter and energizes the capacitor. But, the capacitor charging will occur just when the voltage which is applied is superior to the capacitor voltage. So when the voltage is switched on, then the capacitor will get charged immediately.

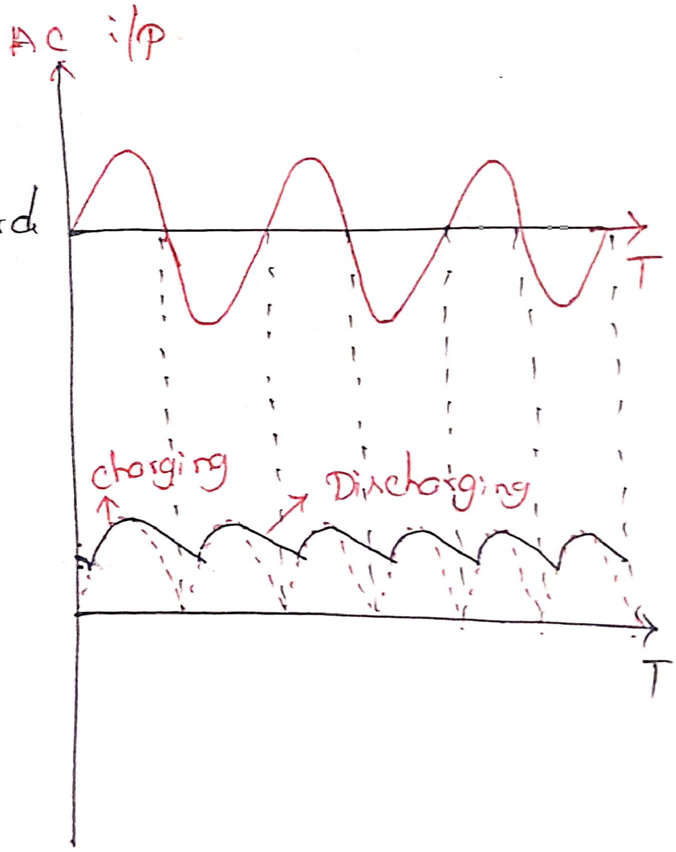
The capacitor includes a highest charge at the quarter waveform in positive half cycle. At this end, the voltage supply is equivalent to the voltage of capacitor. Once the AC voltage begins falling & turns into less than the voltage of capacitor, it begins discharging gradually.

As the i/p voltage gets negative supply, the D_1 gets reverse bias but D_2 is forward bias. The flow of current in the second diode gets filter to charge capacitor and the process will be continuous for charging and discharging.



The Diode D_1 gets the filter and energizes the Capacitor. But, the Capacitor charging will occur just when the voltage which is applied is Superior to the Capacitor voltage. So when the Voltage is switched on, then the capacitor will get charged immediately.

The Capacitor includes a highest charge at the quarter waveform in positive half cycle. At this end, the Voltage supply is equivalent to the Voltage of Capacitor. Once the AC voltage begins falling & turns into less than the voltage of capacitor, it begins discharging gradually.



As the i/p Voltage gets negative supply, the D_1 gets reverse bias but D_2 is forward bias. The flow of current in the second diode gets filter to charge capacitor and the process will be continuous for charging and discharging.

Zener Diode As a Voltage Regulator :-

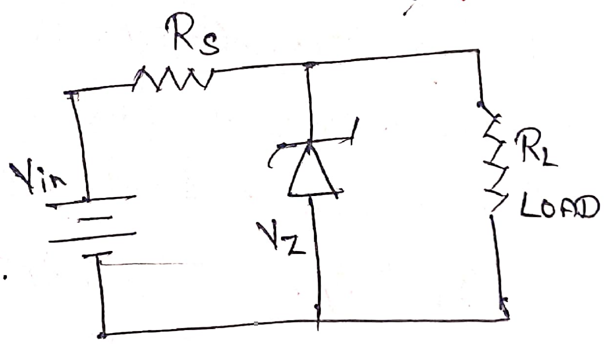
It is a Silicon Semi-Conductor with a
PN junction that is specifically designed to work in
reverse biased Condition. When forward biased, it
behaves like a normal signal diode, but when the
reverse voltage is applied to it, the voltage remains
Constant for a wide range of currents. Due to
this, it is used as voltage regulator in d.c. Circuit.

The Primary objective of zener diode as a
voltage regulator is to maintain a Constant Voltage.
Eg. If V_z is 5V, the voltage becomes Constant
at 5V, and it does not change.

Symbol

Working :-

There is a Series
resistor Connected to the
Circuit inorder to limit
the Current in the diode.
It is Connected to
positive terminal of DC. The Zener
diode is connected parallel to the load and make it
reverse bias, and once the zener diode exceeds knee
voltage, the voltage across the load will become Constant.
When the minimum input voltage is known, it
is easier to choose a zener diode with a voltage
approximately equal to load voltage, i.e., $V_z = V_L$.



CIRCUIT DIAGRAM

The value of series resistor, $R_S = (V_L - V_Z) I_L$.

$$I_S = I_Z + I_L.$$

1. LOAD Constant :- (I_L is Constant)

By Varying input voltage, the current across resistor increases and current flows through Zener diode (I_Z) also increases which increases the voltage drop across resistor.

Varying $V_{in} \Rightarrow I_S \uparrow\downarrow \Rightarrow I_Z \uparrow\downarrow$

$V_S \uparrow\downarrow$ (Voltage Drop across Resistor).

BUT V_o = Constant $V_o = V_{in} - (I_S \times R_S)$

2. Vin Constant :- (Vary Load).

As input voltage is Constant, by varying the load the current across ~~across~~ the load (I_L) increases. As I_L increases, the current flowing through diode also increases and it maintains I_S as Constant.

$I_L \uparrow\downarrow \Rightarrow I_Z \uparrow\downarrow$ ∴ I_S = Constant

$I_S R_S$ is also Constant.

V_o = Constant

* To Vary (or) regulate output Voltage.
* To Keep the output Voltage Constant at the desired value inspite of variations of supply Voltage.

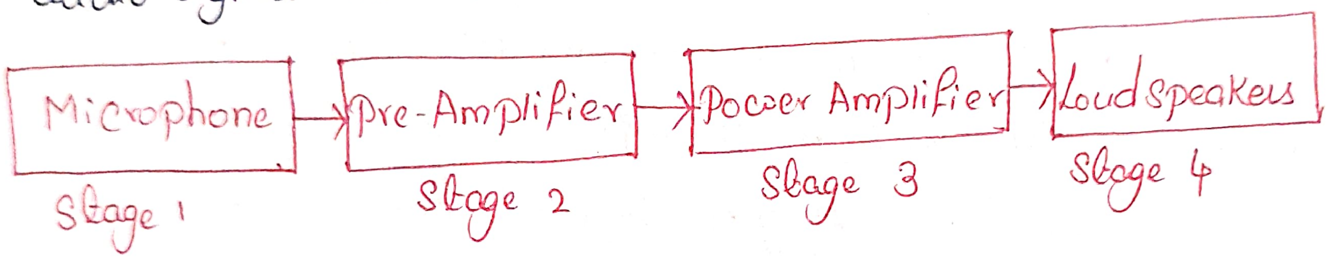
De-MERITS :-

1. More Power Loss in R_S.
2. Less Efficiency
3. o/p Voltage Cannot be Varied.

Block Diagram of Public Address System:-

A Public Address (PA) System is an electronic Sound amplification and distribution system with a microphone, amplifier and loud speaker.

- It is an electronics system in which Converts into electrical signal by microphone.
- The electrical audio signals are amplified and fed into another transducer the loudspeaker which converts the audio signals into the sound wave.



Microphone (Transducer):-

It is a electrical transducer it pick up sound wave and converts into the electrical variations called audio signal.

Pre-Amplifier:- It Consists of

a) Mixer b) Voltage Amplifier c) Processing Circuit.

Mixer:- The output of microphone is fed into the mixer stage, the mixer stage is to effectively isolate different channels from each other before feeding into the main amplifier.

Voltage Amplifier: It further amplifies the output of the circuit

Processing Circuit: These circuit have master gain control and the tone controls

Driver Amplifier: It gives voltage amplification to the signal to such an extent that when fed to the next stage of the internal resistance of that stage is reduced

Power Amplifier: The power amplifier gives the desired power amplification to its input signal. The push pull type of power amplifier is generally used because this type eliminates the even harmonics from the output of amplifier and avoids the core saturation of the output transformer

Loud Speaker: It converts electrical audio signal into pressure variation resulting in sound

Applications: used in

- Sports meet
- Public meeting
- Auditorium
- Concerts / Functions
- Railway station
- Airports
- Hospitals & Factories etc

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Applications:- used in

* Sports meet
* Public meeting
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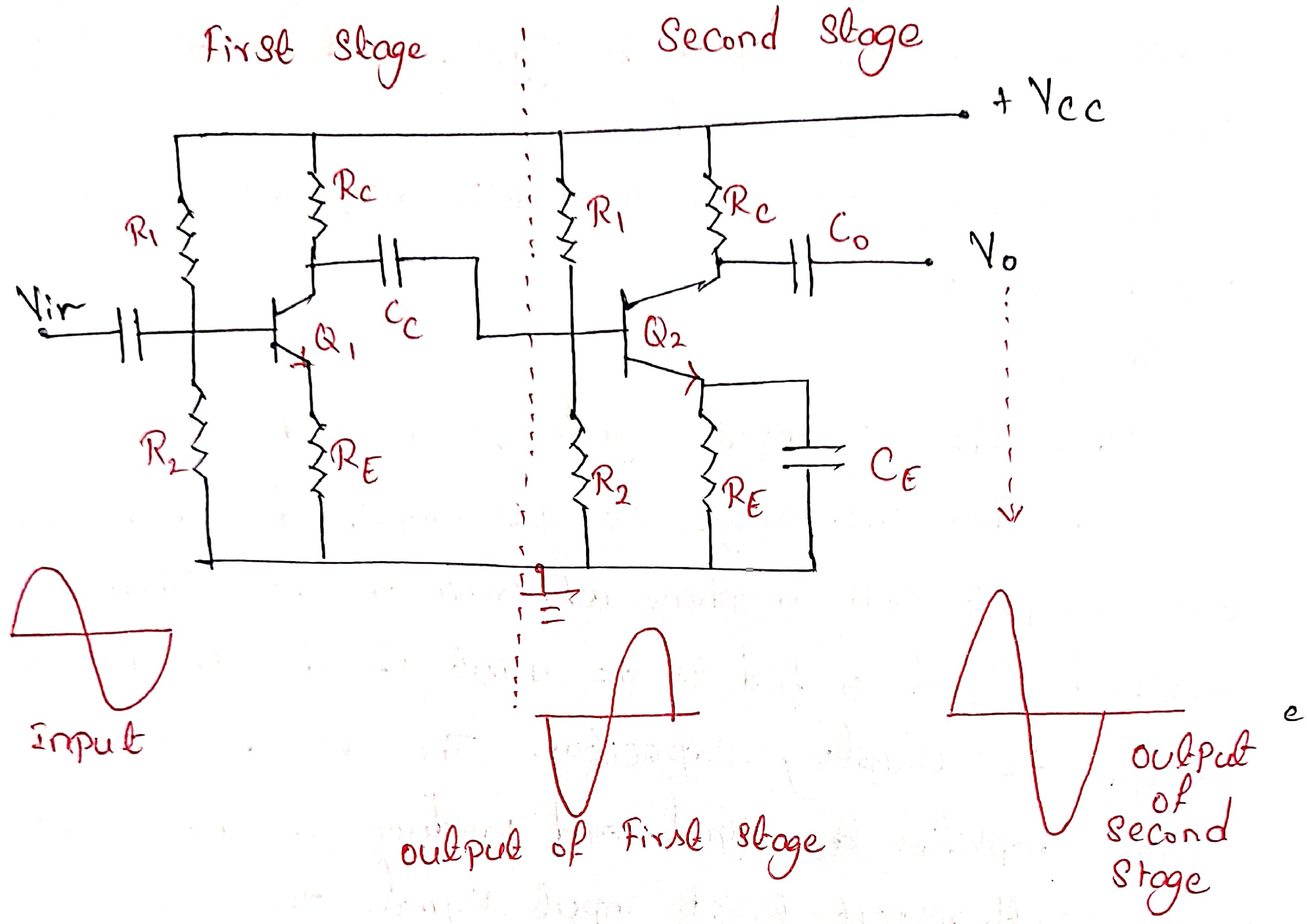
* Railway station
* Airports
* Hospitals & Factories etc.

Circuit diagram and working of Common Emitter (RC Coupled amplifier) with its frequency response :-



Due to its low cost and excellent audio fidelity over a wide range of frequencies, an RC coupled amplifier is the most popular type of coupling used in amplifier. It is usually used for a multi-stage amplifier. for voltage amplification.

* A Coupling capacitor (C_c) is connect the output of first stage to the input of second stage and this continues when more stages are connected. it is achieved by a C_c followed by a connection to a shunt resistor, therefore such amplifiers are known as

resistance- Capacitance (or) RC Coupled amplifier.

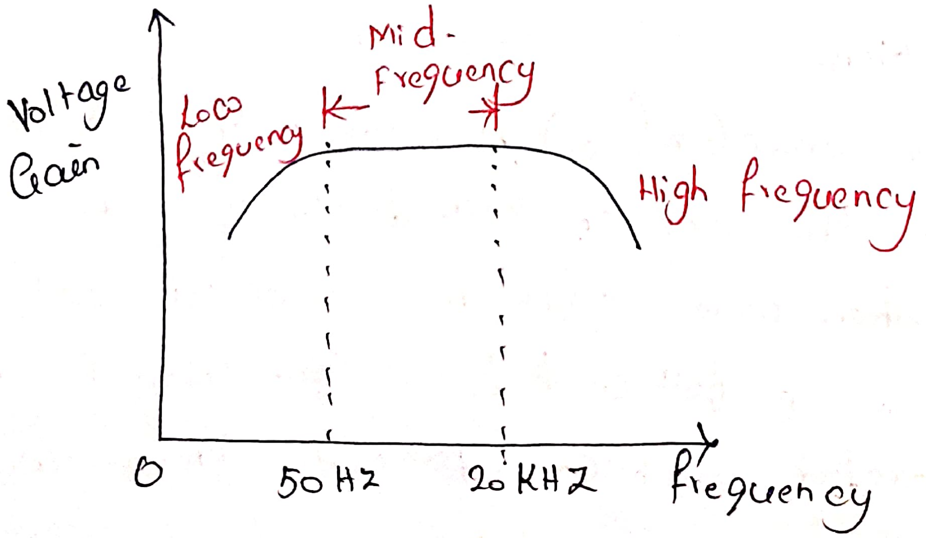
* The resistances R_1, R_2 and R_E form the biasing and stabilisation of network. The emitter bypass capacitor offers low resistance path to signal, without this voltage gain of each stage would be lost.

* The coupling capacitor transmits only a.c. signal but blocks d.c.

Working :-

When the ac input signal is applied to the input of the first stage, it gets amplified and appears at its output with a phase difference of 180°. This amplified signal is fed to the input of the second stage through the coupling capacitor. The second stage further amplifies the signal and produces a phase shift of 180° with respect to its input signal. The signal is inverted twice and the input and output of two stage CE amplifier are inphase.

Frequency Response :-



At low frequencies, the coupling capacitor C_c offers high reactance X_c. Hence it allows only a small part of the signal to pass from one stage to the next stage. Thus gain is less at low frequencies.

At high frequencies, the coupling capacitor C_c offers low reactance and acts like a switch. Hence, due to loading effect of the next stage increases and the gain decreases.

In mid-frequencies, the effect of coupling capacitor is such that it maintains a constant voltage gain. When the frequency increases, the capacitive reactance decreases, which tries to increase gain. As the capacitive reactance decreases, the loading effect of next stage reduces the gain. The voltage gain remains constant as the two factors cancel each other.

Advantages:

* Distortion is minimum
* overall gain is high
* Has good frequency response and its cost less.

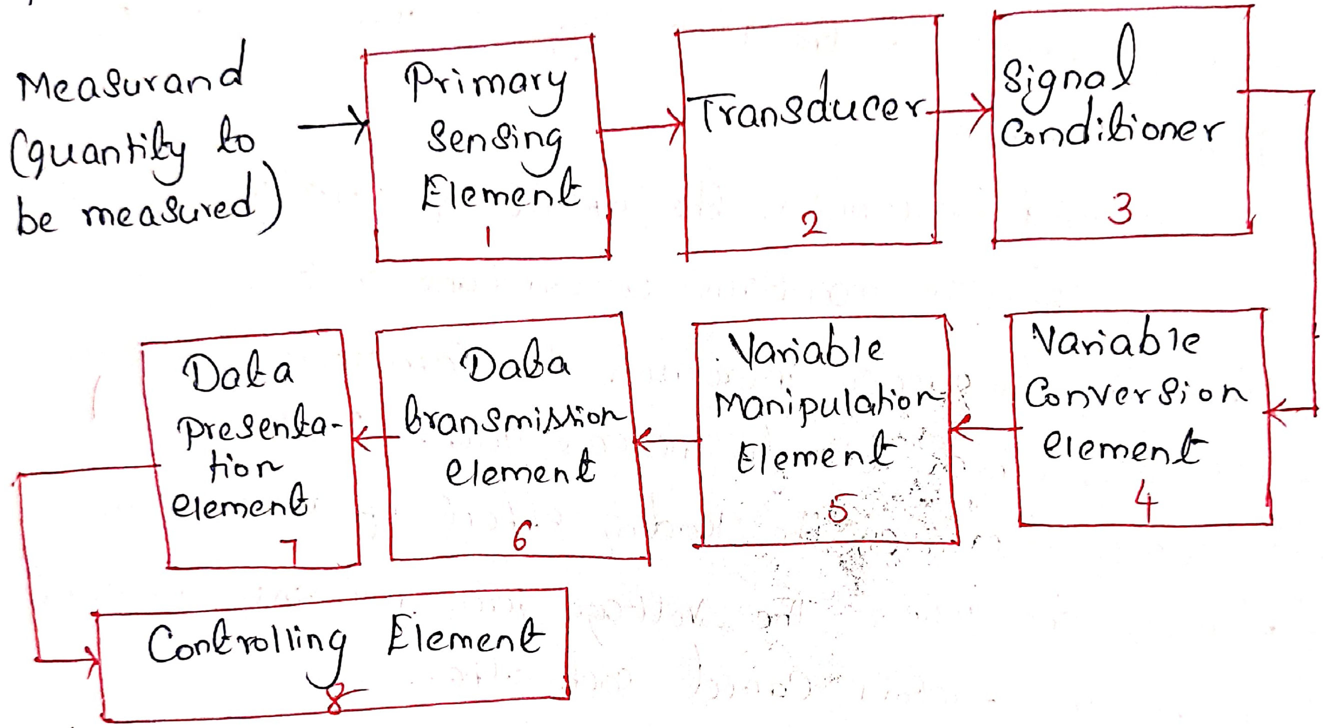
Dis-Advantages:

* Low voltage and power gain
* Poor Impedance matching
* It has the tendency to become noisy with time.
* It has narrow band width.

Scanned with OKEN Scanner

Block Diagram of an Electronic Instrumentation System:-

The process of instrumentation deals with various types of instruments to record, monitor, indicate and control of various physical parameters such as temperature, pressure, PH ~~level~~, value etc.,



1. **Primary Sensing Element:** The quantity under measurement becomes the input to the primary sensing element.
2. **Transducer:** In case, the primary sensing element has a "non-electrical" input, it is converted into an electrical signal by means of a transducer. It converts an energy in one form to the other form.
3. **Signal Conditioner:-** It converts the output of transducer into a quantity suitable for next block. The process involved in signal conditioning may be rectification, modulation etc.,

4. Variable Conversion Element :- Sometimes, the electrical signal needs conversion. If the input is in analog form and the next stage can accept only in digital form, in that case in this block, we will require an Analog to Digital Convertor (ADC).

5. Variable Manipulation Element :- This block further "manipulates" the signal obtained into a form acceptable to the next block. eg., It can amplify the signal to the required level.

6. Data Transmission Element : When elements of an instrument are to be physically seperated, it becomes necessary to transmit data from one element to other.

7. Data Presentation Element (Display) :- This displays the quantity under measurement in a suitable form. Eg., In analog (or) digital, which can be understood by observer (or) operator.

8. Controlling Element :- In case, a "control device" is employed, then it become necessary to apply some "feed back" to the input system.

* Note that all the stages may not be required in all processes, moreover their sequence may also be changed as per the need.

1	a)	What is number system? explain the different types of number systems

A **Number system** or **numeral system** is defined as an elementary system to express numbers and figures. It is the unique way of representing of numbers in arithmetic and algebraic structure.

Types of Number Systems
Based on the base value and the number of allowed digits, number systems are of many types. The four common types of Number systems are:

- **Decimal Number System**
- **Binary Number System**
- **Octal Number System**
- **Hexadecimal Number System**

Decimal Number System
A number system with a base value of 10 is termed a Decimal number system. It uses 10 digits i.e. 0-9 for the creation of numbers. Here, each digit in the number is at a specific place with a place value of a product of different powers of 10. Here, the place value is termed from right to left as the first place value called units, second to the left as Tens, so on Hundreds, Thousands, etc. Here, units have a place value of 100, tens have a place value of 101, hundreds as 102, thousands as 103, and so on.

For example, 12265 has place values as,
$(1 \times 10^4) + (2 \times 10^3) + (2 \times 10^2) + (6 \times 10^1) + (5 \times 10^0)$
$= (1 \times 10000) + (2 \times 1000) + (2 \times 100) + (6 \times 10) + (5 \times 1)$

$= 10000 + 2000 + 200 + 60 + 5$

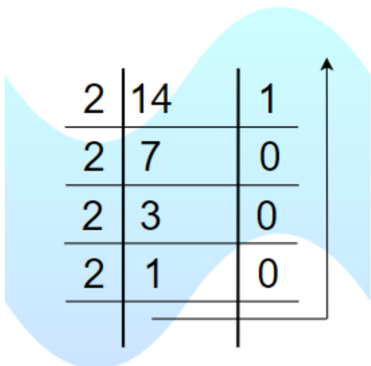
$= 12265$

Binary Number System
A number System with a base value of 2 is termed a Binary number system. It uses 2 digits i.e. 0 and 1 for the creation of numbers. The numbers formed using these two digits are termed Binary Numbers. The binary number system is very useful in electronic devices and computer systems because it can be easily performed using just two states ON and OFF i.e. 0 and 1.

Decimal Numbers 0-9 are represented in binary as 0, 1, 10, 11, 100, 101, 110, 111, 1000, and 1001

For example, 14 can be written as 1110, 19 can be written as 10011, and 50 can be written as 110010.

Example of 14 in the binary system



Here 14 can be written as 1110

Octal Number System

Octal Number System is one in which the base value is 8. It uses 8 digits i.e. 0-7 for the creation of Octal Numbers. Octal Numbers can be converted to Decimal values by multiplying each digit with the place value and then adding the result. Here the place values are 80, 81, and 82. Octal Numbers are useful for the representation of UTF8 Numbers. Example,

$(81)_{10}$ can be written as $(121)_8$
$(125)_{10}$ can be written as $(175)_8$

Hexadecimal Number System

A number System with a base value of 16 is known as Hexadecimal Number System. It uses 16 digits for the creation of its numbers. Digits from 0-9 are taken like the digits in the decimal number system but the digits from 10-15 are represented as A-F i.e. 10 is represented as A, 11 as B, 12 as C, 13 as D, 14 as E, and 15 as F. Hexadecimal Numbers are useful for handling memory address locations. Examples,

$(185)_{10}$ can be written as $(B9)_{16}$
$(5440)_{10}$ can be written as $(1540)_{16}$
$(4265)_{10}$ can be written as $(10A9)_{16}$

Hexa decimal	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**	**D**	**E**	**F**
Decimal	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**

Binary Base-2	Decimal Base-10	Hexa-Decimal Base-16	Octal Base-8	BCD Code	Gray Code
0000	0	0	0	0	0000
0001	1	1	1	1	0001
0010	2	2	2	2	0011
0011	3	3	3	3	0010
0100	4	4	4	4	0110
0101	5	5	5	5	0111
0110	6	6	6	6	0101
0111	7	7	7	7	0100
1000	8	8	10	8	1100
1001	9	9	11	9	1101
1010	10	A	12	---	1111
1011	11	B	13	---	1110
1100	12	C	14	---	1010
1101	13	D	15	---	1011
1110	14	E	16	---	1001
1111	15	F	17	---	1000

<table>
<tr><td></td><td>b)</td><td>Convert the $(555)_{10}$ into binary, octal and Hexadecimal number systems.</td></tr>
<tr><td></td><td></td><td>1 (b) Convert the $(555)_{10}$ into binary, octal and Hexadecimal number system.

(i) $(555)_{10} = (?)_2$
2 | 555 − 1 (LSB)
2 | 277 − 1
2 | 138 − 0
2 | 69 − 1
2 | 34 − 0
2 | 8 − 1
2 | 4 − 0
2 | 2 − 0
1 − 0
(MSB)
$(555)_{10} = (1000101011)_2$

(ii) $(555) = (?)_8$
8 | 555 = 69, 552, 3 (LSB)
8)69(8, 64, 5
8)8(1 (MSB), 8, 0
$(555) = (1053)_8$

(iii) $(555)_{10} = (?)_{16}$
16)555(34, 544, 11 (LSB) → B
16)34(2 (MSB), 32, 2
$(555)_{10} = (22B)_{16}$</td></tr>
<tr><td>2</td><td></td><td>Convert the following into binary to decimal, decimal into hexa decimal
i) $(1101.1)_2$
ii) $(1100.001)_2$
iii) $(5386.34)_{10}$
iv) $(214.35)_{10}$</td></tr>
</table>

2. Convert the following into binary to decimal, decimal into hexadecimal.

(i) $(1101.1)_2$ (ii) $(1100.001)_2$

(iii) $(5386.34)_{10}$ (iv) $(214.35)_{10}$

(i) $(1101.1)_2 = (?)_{10}$

$(1101.1)_2 = (1\times2^3)+(1\times2^2)+(0\times2^1)+(1\times2^0)+(1\times2^{-1})$

$= (1\times8)+(1\times4)+(0\times2)+(1\times1)+(1\times0.5)$

$= 8+4+0+1+0.5$

$= (13.5)_{10}$

$$\boxed{(1101.1)_2 = (13.5)_{10}}$$

(ii) $(1100.001)_2 = (?)_{10}$

$(1100.001)_2 =$

$= (1\times2^3)+(1\times2^2)+(0\times2^1)+(0\times2^0)+(0\times2^{-1})+(0\times2^{-2})+(1\times2^{-3})$

$= (1\times8)+(1\times4)+0+0+0+0+(0.125)$

$= 8+4+0.125$

$= (12.125)_{10}$

$$\boxed{(1100.001) = (12.125)_{10}}$$

(iii) $(5386.34)_{10} = (?)_{16}$

Integer part = 5386

16) 5386 (336
5376
10 (LSB) → A

16) 336 (21
336
0

16) 21 (1 (MSB)
16
5 — (~~MSB~~)

Conti

Fractional part = 0.34

$0.34\times16 = 5.44 \Rightarrow 5$ (MSB)

$0.44\times16 = 7.04 \Rightarrow 7$

$0.04\times16 = 0.64 \Rightarrow 0$

$0.64\times16 = 10.24 \Rightarrow 10$ (LSB) → A

$$\boxed{(5386.34)_{10} = (150A.570A)_{16}}$$

		(iv) $(214.35)_{10} = (?)_{16}$ Integer part = 214 $16 \overline{) 214}$ (13 (MSB) → D 208 6 (LSB) $(214)_{10} = (D6)_{16}$ Fractional part = $(0.35)_{10}$ $0.35 \times 16 = 5.6 \rightarrow 5$ Remainder (MSB) $0.6 \times 16 = 9.6 = 9$ Remainder $0.6 \times 16 = 9.6 \rightarrow 9$,, $0.6 \times 16 = 9.6 \rightarrow 9$,, (LSB) $(0.35)_{10} = (5999)_{16}$ $(214.35)_{10} = (D6.5999)_{16}$
3		Explain about Logic gates with symbols and truth table.

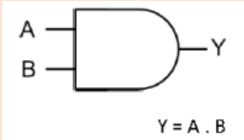
Logic Gates and truth tables

These are devices that implement a Boolean function, that is they perform logical operations on one or more logical inputs to produce a single logical output. Every terminal has one of the two binary conditions: low (0) and high (1) represented by different voltage levels.

AND Gates:

When at all inputs are high (1) the output will be high (1).

Input X	Input Y	Output
1	1	1
1	0	0
0	1	0
0	0	0

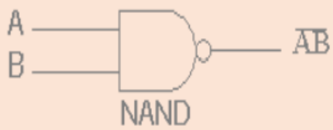


A dot (.) is used to show the AND operation i.e. A.B - Bear in mind that this dot is sometimes omitted i.e. AB

NAND Gates:

"NOT AND", hence when at least one input is high (1) the output is high(1). If both inputs are high (1) the the output is low (0).

Input X	Input Y	Output
1	1	0
1	0	1
0	1	1
0	0	1



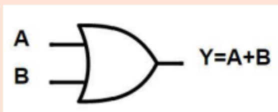
It is represented as A.B (or $\overline{AB}$) with a bar over the top. In the exam we put ¬ with the object of interest in brackets AFTER the ¬ instead of the bar. NOT is applied after AND.

This is a NOT-AND gate which is equal to an AND gate followed by a NOT gate. Or two NOT gates followed by an OR gate.

OR Gates:

When one or more of the inputs is high (1) the output will be high (1).

Input X	Input Y	Output
1	1	1
1	0	1
0	1	1
0	0	0



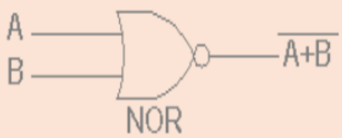
It is represented as A + B.

Be careful + means OR.

NOR Gates:

When any one of the inputs is high (1), the output will be low (0). If both inputs are low (0), the output is high (1).

Input X	Input Y	Output
1	1	0
1	0	0
0	1	0
0	0	1

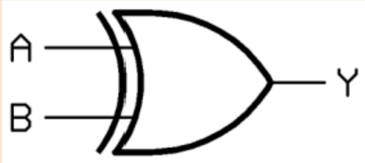


It is represented as NOT(A or B), hence ¬(A + B), or $\overline{A + B}$

XOR Gates:

`Exclusive Or gates'. These will only ever give an output that is high (1) when either, not both of the inputs is h (1).

Input X	Input Y	Output
1	1	0
1	0	1
0	1	1
0	0	0

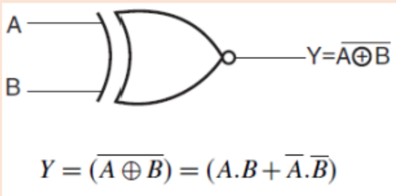


It is represented as A⊕B. Where the encircled plus '⊕' is sued to show the XOR operation.

XNOR:

`Exclusive NOT OR', does the opposite to an XOR gate. It will give a low (0) output if either, but not both, of th inputs is high (1). Only when the inputs are the same state (both 1 or both 0) will the output be high (1). If only one input is high then the output will be low.

Input X	Input Y	Output
1	1	1
1	0	0
0	1	0
0	0	1



It is represented as ¬(A⊕B). Where the XOR function is applied before the NOT operation.

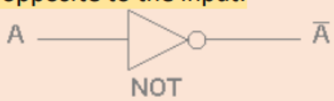
Sometimes = A.B + (¬A.¬B)

ame as an AND gate paralleled with an AND gate that has both inputs inverted by 2 NOT gates. This is then fed into an OR gate.

NOT Gates:

Sometimes called an inverter. The output is the opposite to the input.

Input X	Output
1	0
0	1



It is represented as ¬ followed by item(s) of interest in brackets. Or by a bar drawn over items being inverted.

A NOT gate can be created with NAND gate where the inputs are linked so identical. Therefore when the single input is low (0), creates two identical conditions - 2 low inputs (0). The output is high Since at least one low input is required for a high output (1).

4	a)	What is BCD codes and what are the various BCD codes

Binary Coded Decimal, or **BCD**, is another process for converting decimal numbers into their binary equivalents.

- It is a form of binary encoding where each digit in a decimal number is represented in the form of bits.
- This encoding can be done in either 4-bit or 8-bit (usually 4-bit is preferred).
- It is a fast and efficient system that converts the decimal numbers into binary numbers as compared to the existing binary system.
- These are generally used in digital displays where is the manipulation of data is quite a task.
- Thus BCD plays an important role here because the manipulation is done treating each digit as a separate single sub-circuit.

The BCD equivalent of a decimal number is written by replacing each decimal digit in the integer and fractional parts with its four bit binary equivalent.the BCD code is more precisely known as 8421 BCD code , with 8,4,2 and 1 representing the weights of different bits in the four-bit groups, Starting from MSB and proceeding towards LSB. This feature makes it a

weighted code , which means that each bit in the four bit group representing a given decimal digit has an assigned weight.
Many decimal values, have an infinite place-value representation in binary but have a finite place-value in binary-coded decimal. For example, 0.2 in binary is .001100… and in BCD is 0.0010. It avoids fractional errors and is also used in huge financial calculations.
Consider the following truth table and focus on how are these represented.

Truth Table for Binary Coded Decimal

DECIMAL NUMBER	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

There are different types of BCD codes; however, the 8421 code is the most popular one. In this article, we will highlight three different types of BCD codes, such as 8421, 2421, and Excess-3. Both 8421 and 2421 are weighted code, whereas Excess-3 is not weighted.

Decimal digit	8421	2421	Excess-3
0	0000	0000	0011
1	0001	0001	0100
2	0010	0010	0101
3	0011	0011	0110
4	0100	0100	0111
5	0101	1011	1000
6	0110	1100	1001
7	0111	1101	1010
8	1000	1110	1011
9	1001	1111	1100
Unused code words / Invalid codes			
	1010	0101	0000
	1011	0110	0001
	1100	0111	0010
	1101	1000	1101
	1110	1001	1110
	1111	1010	1111

Different Decimal Codes

The above table shows the binary code groups for different BCD representations. Using 4 binary bits, a total of 16 numbers can be represented. However, for BCD, 10 decimal digits (0 through 9) need to be represented. Therefore, there are six unused code words / invalid codes for all BCD representations, as shown above.

As stated earlier, both 8421 and 2421 are **weighted codes,** where each decimal digit can be found from its code word by assigning a fixed weight to each code word bit. For example, the weights of four bits of 8421 code are 2^3, 2^2, 2^1, and 2^0. So, decimal digit 5 in 8421 is “0101”, which is $0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 5$.

Both 2421 and Excess-3 codes are **self-complementing codes**. This means that the code word for the 9s’ complement of any digit can be obtained by complementing the individual bits of the digit’s code word. For example, decimal digit 2 in Excess-3 is “0101”. If we complement “0101”, then it will be “1010”, which is the Excess-3 code of decimal digit 7 (check the above table). Since 7 is 9s’ complement of 2, this shows that Excess-3 code is self-complementing.

b) Perform the following Decimal addition to 8421 BCD code.

i)48+58,

ii)186+237

4(b) perform the following Decimal addition to 8421 BCD Code 5

(i) 48+58 (ii) 186+237.

(i) 48+58

48 →		0100	1000	→ BCD code for 48
58 →		0101	1000	→ BCD code for 58
106		1010	0000	→ Invalid BCD
	(1)	0110	0110	→ Add '6' to get Valid BCD
	1000	0000	0110	→ Valid BCD code for 106.
	1	0	6	

(ii) 186+237.

186 →	0001	1000	0110	→ BCD Code for 186
237	0010	0011	0111	→ BCD Code for 237
423	0100	1100	1101	→ 13 → add 6 for 13 to get valid BCD
Valid BCD ← 4		0110 (1)	0110 (1)	
	0100	0010	0011	→ Valid BCD for 423.
	4	2	3	

5	a)	Convert the following into Gray code. i) $(1001100)_2$ ii) $(110101110)_2$

5 (b) Convert the following into gray code:-

(i) $(1001100)_2$ (ii) $(110101110)_2$

(i) $(1001100)_2$

Sol: Record MSB and add MSB to the next of the LSB as follows.

$1 \oplus 0 \oplus 0 \oplus 1 \oplus 1 \oplus 0 \oplus 0$

↓

1 1 0 1 0 1 0

$(1001100)_2 = (1101010)_{Grey}$.

(ii) $(110101110)_2$

Sol: Record MSB and add MSB to the next of the LSB as follows.

$1 \oplus 1 \oplus 0 \oplus 1 \oplus 0 \oplus 1 \oplus 1 \oplus 1 \oplus 0$

↓

1 0 1 1 1 1 0 0 1

$(110101110)_2 = (101111001)_{Grey}$

	b)	What is Hamming code and how does it work?
		A Hamming code is a linear error-correcting code named after its inventor, Richard Hamming. Hamming codes can detect up to two bit errors, and correct single-bit errors. This method of error correction is best suited for situations in which randomly occurring errors are likely, not for errors that come in bursts.

Definitions of the components/Keywords:

• For a Hamming code, the minimum distance is exactly 3.
- Hence, the code is capable of correcting all the error patterns with a single error or detecting all the error patterns of two or fewer errors.

• A Single Parity Check (SPC) code is a linear block code with a single parity check digit which can detect single bit errors.
- The parity bit is appended to the information bits and is set to 1 if the number of ones in the information bits is odd and is set to 0 if the number of ones in the information bits is even. Thus the resultant codeword which consists of the information bits and the parity bit will have an even number of ones.
- An even parity check which involves taking modulo 2 sum of all the received bits and checking if it zero can detect single bit errors.

•Hamming code extends this by using multiple even parity checks to correct single bit errors.
- To correct a single bit error it is sufficient to know the location of the error since correction involves flipping the bit at the error location
- In the Hamming code, we conduct multiple even parity checks and for each one of them we output 1 if they fail and 0 if they pass
- We want the sequence of 1's and 0's to form the binary representation of the error location in the received vector.

• For a (7,4) Hamming code,
- the first even parity check should involve all the odd numbered locations 1,3,5,7 because these locations have a 1 in the least significant bit of their binary representations
- the second even parity check has to involve locations 2,3,6,7 because these locations have a 1 in the next to least significant bit of their binary representations
- the third even parity check has to involve locations 4,5,6,7
- at least one of the bit in each set of locations is a parity bit which will be 0 or 1 in order to make the number of ones in the locations even.

• Here 1,2,4 are the parity bits and 3,5,6,7 are the information bits

1	2	3	4	5	6	7
P_1	P_2	U_3	P_4	U_5	U_6	U_7

If a single error happens in a Hamming Code, the sequence of failed and passed even parity checks or **syndrome** gives the binary representation of the location of the single bit error. If syndrome is all zeros then assume that no error occurred

6		Encode the binary word 1011 into seven bit even parity hamming code?

6. Encode the binary word 1011 into seven bit even parity hamming code?

Concept:

Hamming code (7,4) code: It is a linear error-correcting code that encodes four bits of data into seven bits, by adding three parity bits.

Hamming code:-

Bits	1	2	3	4	5	6	7
Transmitted bits	P_1	P_2	D_1	P_3	D_2	D_3	D_4

$$P_1 = D_1 \oplus D_2 \oplus D_4$$

$$P_2 = D_1 \oplus D_4 \oplus D_3$$

$$P_3 = D_2 \oplus D_4 \oplus D_3$$

Sol: Given data 1011,

i.e., $D_1 = 1; D_2 = 0; D_3 = 1; D_4 = 1$

We can write;

$$P_1 = D_1 \oplus D_2 \oplus D_4 = 1 \oplus 0 \oplus 1 = 0$$

$$P_2 = D_1 \oplus D_4 \oplus D_3 = 1 \oplus 1 \oplus 1 = 1$$

$$P_3 = D_2 \oplus D_4 \oplus D_3 = 0 \oplus 1 \oplus 1 = 0$$

Then the transmitted final code is

P_1	P_2	D_1	P_3	D_2	D_3	P_4
0	1	1	0	0	1	1

i.e., ~~10101~~ 0110011

7		Explain Basic Theorems and properties of Boolean Algebra

Basic definition:

Boolean algebra is a mathematical System, may be defined with a set of elements, a set of operators, and a number of assumptions and postulates(or) Axiomatics.

A set of elements is any collection of objects, usually having a common property.

A = {1, 2, 3, 4} indicates that set A has the elements of 1, 2, 3 and 4

A binary operator defined on a set S of elements is a rule that assigns, to each pair of elements from 'S', a unique element from 'S'.

Here,

* + denotes the logical OR operation
* · denotes the logical AND operation
* ¯ denotes the logical NOT operation
* 0 and 1 denotes the logic FALSE and TRUE respectively.

In addition to these operations, there are some derived operation such as NAND, NOR, EX-OR, EX-NOR that are also performed in Boolean algebra.

AND operation:

The AND operation in Boolean algebra is similar to the multiplication in ordinary algebra.

It is logical operation performed by AND Gate. 19

$$A \cdot A = A$$

$$A \cdot 0 = 0 \rightarrow \text{Null Law}$$

$$A \cdot 1 = A \rightarrow \text{identity law.}$$

$$A \cdot \bar{A} = 0$$

OR operation:-

The OR operation in Boolean Algebra is performed by OR gate.

$$A + A = A$$

$$A + 0 = A \rightarrow \text{Null law}$$

$$A + 1 = 1 \rightarrow \text{identity law.}$$

$$A + \bar{A} = 1$$

NOT operation:-

The NOT operation in Boolean algebra is similar to the complementation or inversion in ordinary algebra. The NOT operation is indicated by a bar (¯) over the variable.

$$A \xrightarrow{NOT} \bar{A} \text{ (complementation law)}$$

and $\bar{\bar{A}} = A \Rightarrow$ double complementation law.

Laws of Boolean Algebra (or) Boolean properties.

The basic laws of Boolean algebra - the commutative laws for addition and multiplication, the associative laws for addition and multiplication, and the distributive law are the same as in ordinary algebra.

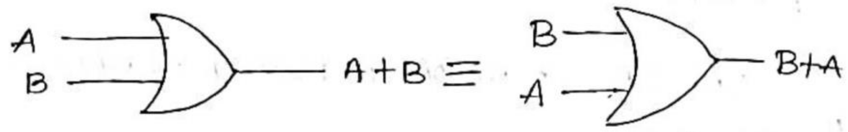
Commutative laws:- The commutative property says that Binary operations AND and OR may be applied left to Right or right to left.

The commutative law of addition for two variables is written as

$$A \cdot B = B \cdot A$$
$$A + B = B + A.$$

A AND B = B AND A
OR = OR

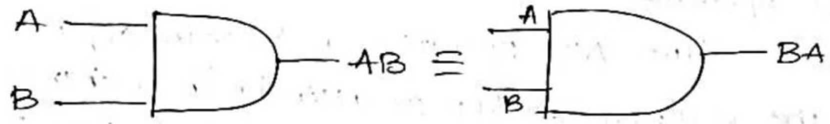
$$A + B = B + A$$



The commutative law of multiplication for two Variables is

$$A \cdot B = B \cdot A$$

This Law States that the order which the Variables are AND makes no difference.

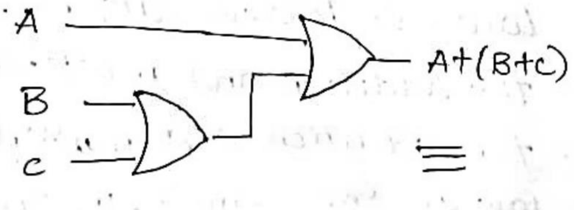


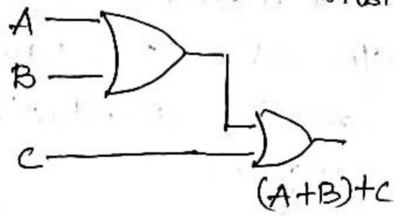
Associative law:-

The associative Law of addition is written as follows for three variables.

$$A + (B + C) = (A + B) + C$$

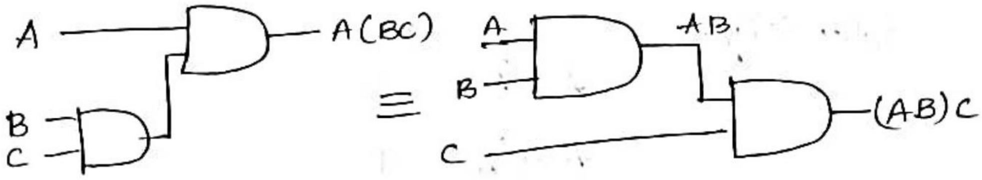
The associative property says that given three boolean variables, that may be ANDed or ORed right to left or left to right. $(A \cdot B)C = A \cdot (B \cdot C)$
$(A+B)+C = A+(B+C)$





The associative law of multiplication is written as follows for three variables:- 20

$A(BC) = (AB)C$

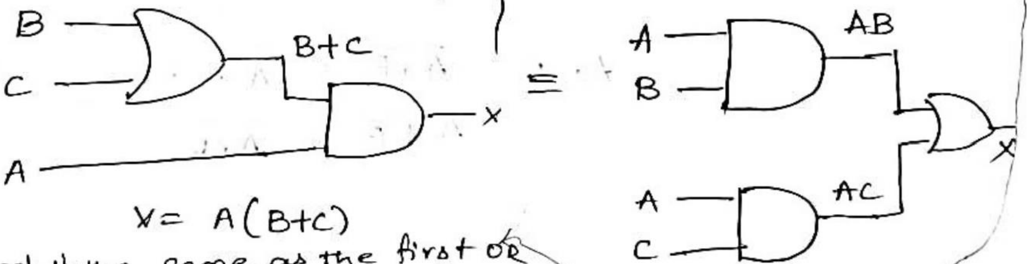


Distributive Law:-

(The distributive law is written for three variables as follows:) The distributive property says that given three boolean variables, the first AND the result of the second OR the third is the same as the first AND the second OR the first AND the third. $A \cdot (B+C) = A \cdot B + A \cdot C$, Also the first OR the result of second AND the third is the same as the first OR the second AND the result of the first OR the third. A OR (B AND C) = (A OR B) AND (A OR C).

$A(B+C) = AB + AC$

~~AB+AC~~



$X = A(B+C)$ $X = AB+AC$

Identity: The identity property says that any value A AND the OR identity always returns A and that any value A OR the AND identity always returns A.

$A \cdot 1 = A$

$A + 0 = A$

Complement: The complement property says that any value AND the complement of that value equals the OR identity and that any value OR the complement of that value equals the OR identity.

$$A \cdot \bar{A} = 0$$

$$A + \bar{A} = 1$$

De morgan's law:

De Morgan's law says that the complement of A AND B is the same as the complement of A OR the complement of B, and the complement of A OR B is the same as the complement of B AND the complement of A.

$$\overline{A \cdot B} = \bar{A} + \bar{B}$$

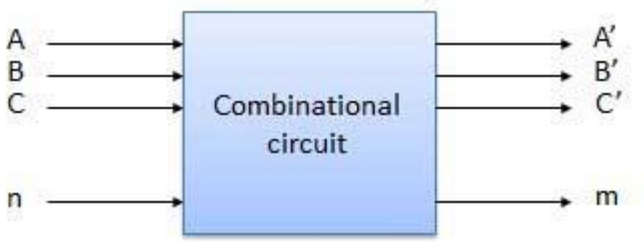
$$\overline{A + B} = \bar{A} \cdot \bar{B}$$

8 Define combinational circuit? Explain Half Adder and Full Adder with truth table.

Combinational circuit is a circuit in which we combine the different gates in the circuit, for example encoder, decoder, multiplexer and demultiplexer. Some of the characteristics of combinational circuits are following −

- The output of combinational circuit at any instant of time, depends only on the levels present at input terminals.
- The combinational circuit do not use any memory. The previous state of input does not have any effect on the present state of the circuit.
- A combinational circuit can have an n number of inputs and m number of outputs.

Block diagram

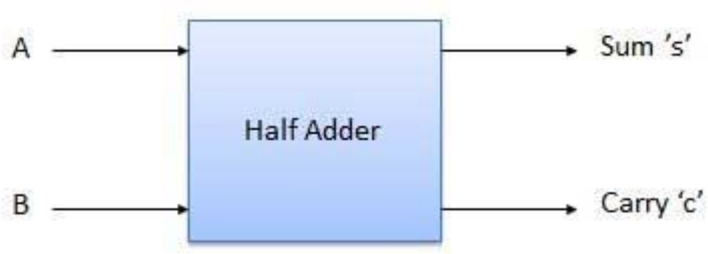


We're going to elaborate few important combinational circuits as follows.

Half Adder

Half adder is a combinational logic circuit with two inputs and two outputs. The half adder circuit is designed to add two single bit binary number A and B. It is the basic building block for addition of two **single** bit numbers. This circuit has two outputs **carry** and **sum**.

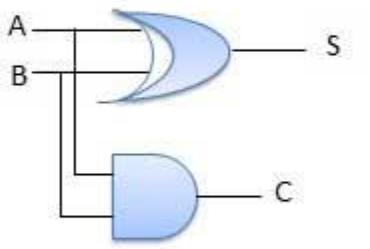
Block diagram



Truth Table

Inputs		Output	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

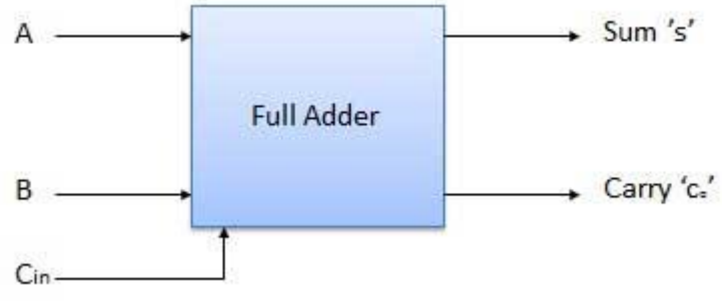
Circuit Diagram



Full Adder

Full adder is developed to overcome the drawback of Half Adder circuit. It can add two one-bit numbers A and B, and carry c. The full adder is a three input and two output combinational circuit.

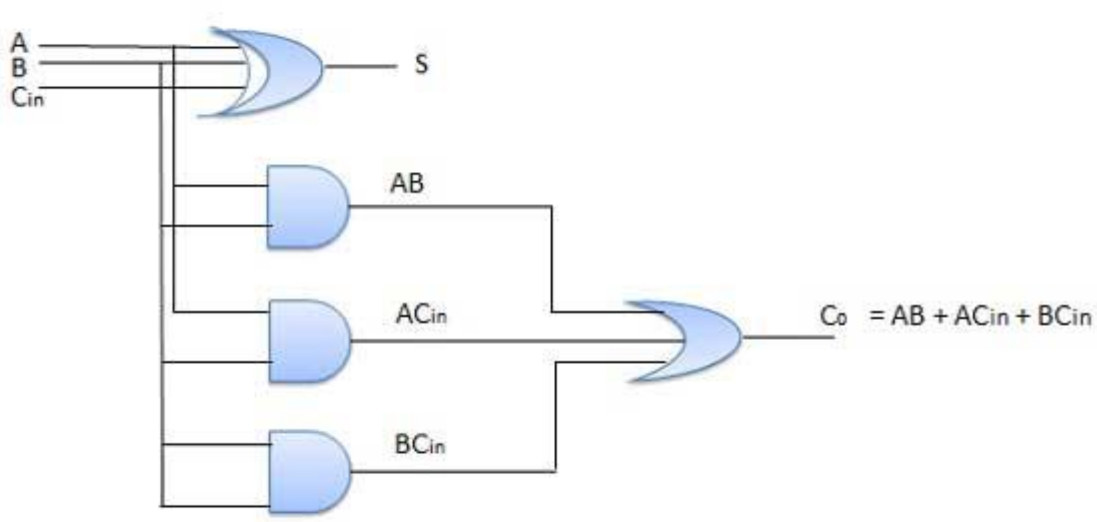
Block diagram



Truth Table

Inputs			Output	
A	B	C_{in}	S	C_o
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

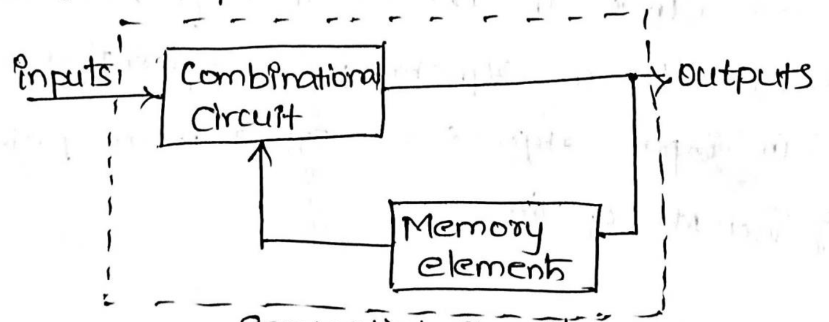
Circuit Diagram



9 Define sequential circuit. And explain about Flip flops, registers, and counters.

Sequential Circuit:

It consist of a series of various inputs and outputs. ~~depend on a~~ Here, the output depend on a combination of both the present inputs as well as the previous outputs. This previous output get treated in the form of the present state.



Sequential circuit.

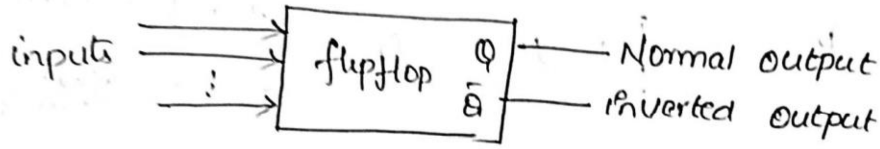
The memory element are connected to the combinational circuit as a feedback path as shown in figure.

A sequential logic consist of two parts.

- The memory elements i.e., flipflop which is made up of an assembly of logic gates.
- The combinational logic circuits needed to produce the excitation inputs to the memory element and to produce the required outputs.

Flip-flop:

A flip flop is a memory element that is capable of storing one bit of information. A flip flop has two inputs



A flip flop can maintain a binary state for an unlimited period of time as long as -

- power is supplied to the circuit
- or until it is directed by an input signal to switch states.

A flipflop is also called as Bistable multivibrator because it has two stable states either 0 or 1.

Registers:

A register is a group of flip flop. ~~can~~ A flip flop can store 1-bit information. So an n-bit registers has a group of n-~~bit~~ flip flop and is capable of storing any binary information/number containing n-bits.

The flip flop is nothing but a binary cell capable of storing one bit ~~information~~ infomation, and can be connected together to perform counting operations. Such a group of flip flops is called counter. So, that the group of flipflops can be used to store a word, which is called ~~mat~~ Register.

Counters

A program counter is a register in a computer processor that contains the address (location) of the instruction being executed at the current time. As each instruction gets fetched, the program counter increases its stored value by 1. After each instruction is fetched, the program counter points to the next instruction in the sequence. When the computer restarts or is reset, the program counter normally reverts to 0.

In computing, a program is a specific set of ordered operations for a computer to perform. An instruction is an order given to a computer processor by a program. Within a computer, an address is a specific location in memory or storage. A register is one of a small set of data holding places that the processor uses.

10 a) Explain differences between combinational and sequential circuits.

COMBINATIONAL CIRCUITS	SEQUENTIAL CIRCUITS
Output depends only on the present value of the inputs.	Output depends on both the present and previous state values of the inputs
These circuits will not have any memory as their outputs change with the change in the input value.	Sequential circuits have some sort of memory as their output changes according to the previous and present values.
There are no feedbacks involved.	In a sequential circuit the outputs are connected to it as a feedback path.
Used in basic Boolean operations.	Used in the designing of memory devices.
Implemented in: Half adder circuit, full adder circuit, multiplexers, de-multiplexers, decoders and encoders.	Implemented in: RAM, Registers, counters and other state retaining machines.

b) Perform the following addition using excess-3 code

i)386+756

ii)12+38

(i) 386 + 756

$(386)_{10} \Rightarrow$

	0011	1000	0110	→ BCD code
	0011	0011	0011	→ add Excess-3 to the above BCD
	0110	1011	1001	

$(756)_{10} \Rightarrow$

carry	111	111	11	
	0111	0101	0110	→ BCD for 756
	0011	0011	0011	→ Excess-3 add
	1010	1000	1001	→ Excess-3 Code for 756

$(386+756)_{10} = (?)_{Excess-3}$

carry	111	111	1	
	0110	1011	1001	→ Excess-3 for 386
1	1010	1000	1001	→ Excess-3 for 756
0001	0001	0100	0010	
1	1	4	2	

  386
+ 756
1142

$(386+756)_{10} = (1142)_{E}$

$(386+756)_{10} = (0001\ 0001\ 0100\ 0010)_{Excess-3}$ (1 1 4 2)

(ii) 12+38

$(12)_{10}$ =

0001	0010	→	BCD for 12
0011	0011	→	add Excess-3 for 12
0100	0101	→	Excess-3

$(38)_{10}$ =

0011	1000	→	BCD for 38
0011	0011	→	add excess-3 for 38
0110	1011		
6	11		

$(12+38)_{10} = (\,?\,)_{Excess-3}$

0100	0101	→	Excess-3 for 12
0110	1011	→	Excess-3 for 38
1011	0000		

Invalid ← 1011

	1011	0000	
−	0011		→ Less 3 to the 1011 to get Valid Excess3 number.
	1000	0000	
+		0011	
	1000	1011	→ Excess-3 code
	8	3	

12
38

50
+33

83

$(12+38)_{10} = (1000\ \ 1011)_{Excess-3}$