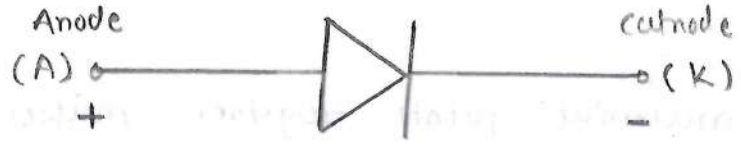
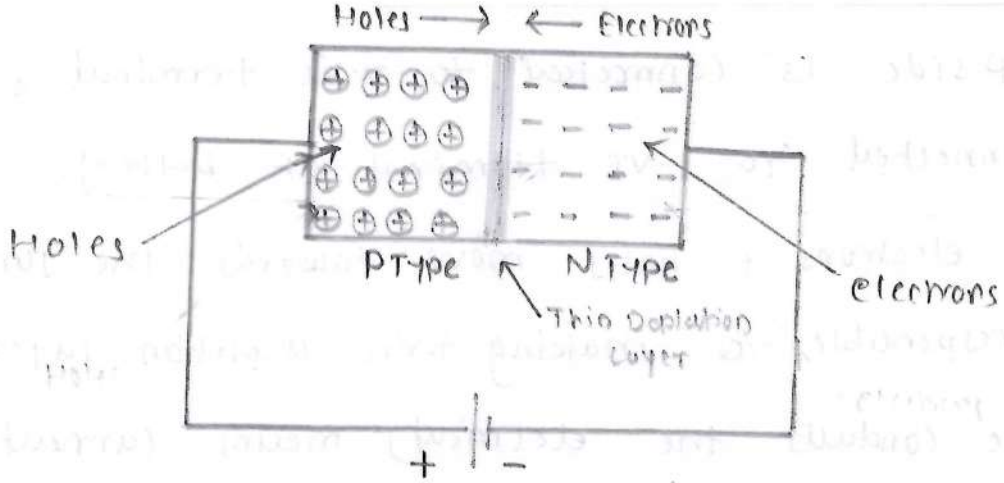
* PN Junction Diode :-



(Symbol)

- A PN Junction diode is a semiconductor device formed by joining P-Type and N-Type material.
- It allows current to flow only in a one direction from P-side (anode) to N-side (cathode). When it is in forwored biased. and blocks current in reverse direction.



* Construction :-

- A PN Junction is formed by combining P Type & N type Semiconductor material.
- P type semiconductor has holes as a majority charge carrier.
- N type semiconductor has electrons as a majority charge carrier.
- At junction electrons and holes are combine and form a depletion region. (no free charge carriers)
- This region acts like an insulator.

* working :-

- The P-type semiconductor material has holes which acts +ve charge carrier. and N-Type semiconductor material has electrons acts -ve.
- This two material joints together makes depletion region
- This depletion region acts as a barrier that stops the flow of current in reverse direction. and
- Allows flow of current in one forword direction (P→N)
- The barrier potential (cutoff voltage) for silicon is 0.7 V
- for Germinium is 0.3 V.

* forword Bias :- (+ve→ P & -ve→ N)

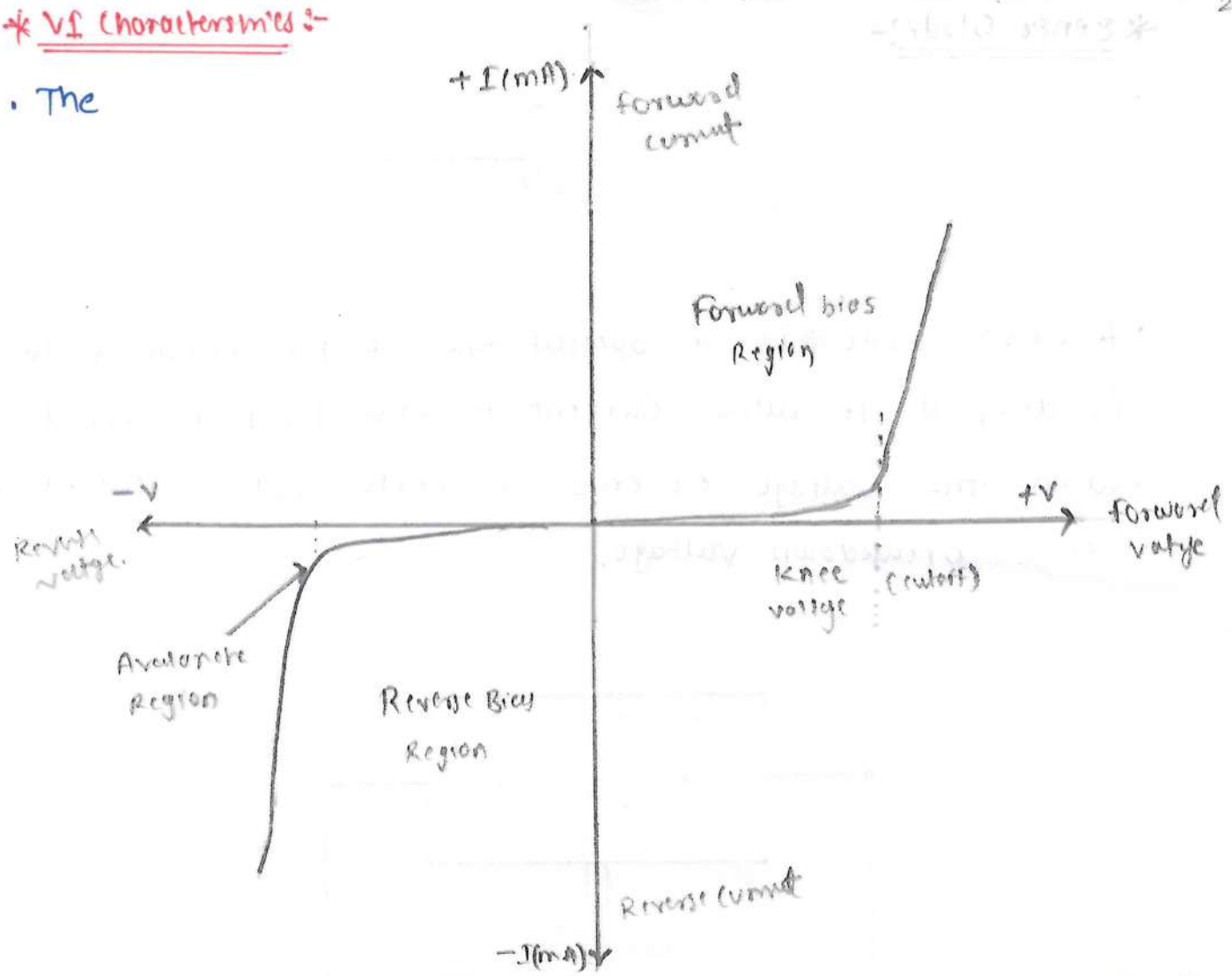
- The P side is connected to +ve terminal & N-side is connected to -ve terminal of battery.
- Then electrons & holes move towords the junction which is responcible to making thin depletion layer.
- diode conducts the electricity means current flows easily thrugh the diode
- Diode acts like closed switch.

* Reverse Bias :- (+ve→ N & -ve→ P)

- In Reverse bias P-side is connected to -ve terminal of battery & N-side is connected to +ve terminal of battery
- Charge carrier are pulled away from the junction forming a wide depletion layer
- current does not flows means diode does not conduct and acts like a open switch.

* VI Characteristics :-

• The



• The VI (Voltage - Current) Characteristics of a PN Junction diode discribe how current through the diode changes with the voltage applied across it.

• It shows how the diode behaves under forward and Reverse bias condition.

* Applications of PN Junction Diode :-

• Rectification :- used to convert AC in DC supply.

• Diode use as ~~switch~~ switching elements in circuits

• PN Junction diode use in voltage regulation

• Used in signal detection and demodulation

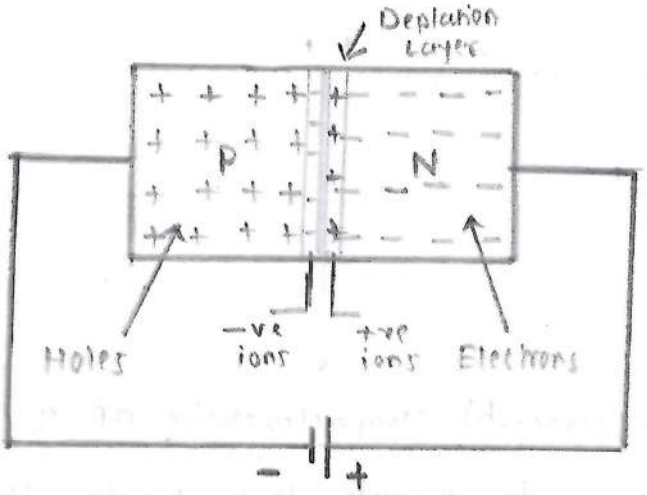
• Clipping & clamping circuits :- used to fix voltage level in circuits

• PN Junction diode used as feedback loop in amplifires.

*Zener Diode:-

(Symbol)

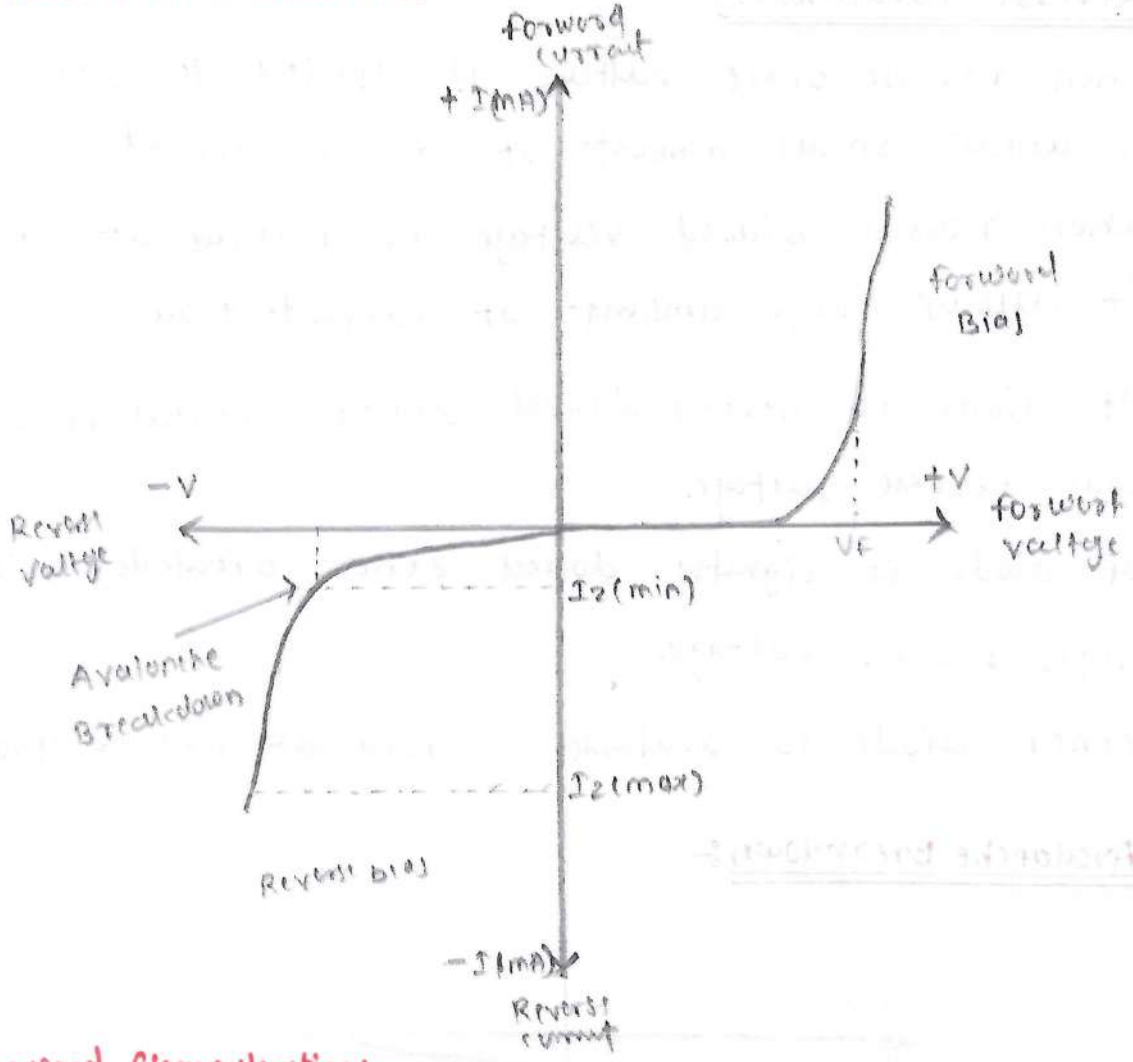
- A zener diode is a special type of PN junction diode that is designed to allow current to flow in a reverse direction
- when the voltage exceeds a certain value. (called as zener breakdown voltage.



*working:-

- As zener diode is heavily doped at depletion Layer, a electric field is strong. at forward bias condition.
- At forward bias condition zener diode works as normal PN junction Diode.
- But in reverse bias mode. a small leakage current flows through the diode as a reverse voltage is increased. and reached at breakdown voltage (V_z)
- zener breakdown for reverse bias voltage is below 6 V.
- zener breakdown is temporary & diode can reused again.

* V-I Characteristics of Zener diode



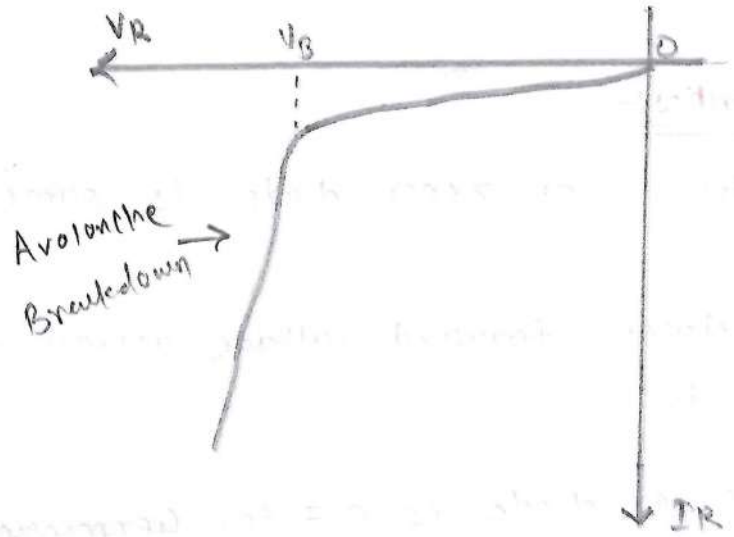
* Forward Characteristics:-

- forward characteristics of zener diode is same as PN junction diode:
- It is graph between forward voltage across diode and current flowing through it.
- cut in voltage of diode is 0.7 for ~~Germanium~~ ~~is 0.7~~. Silicon. and for Germanium is 0.3 V
- when applied voltage reached at cut in voltage diode allows large current through it.
- at that point voltage is increased slowly and current increased rapidly.
- In forward characteristics.

* Reverse characteristics:

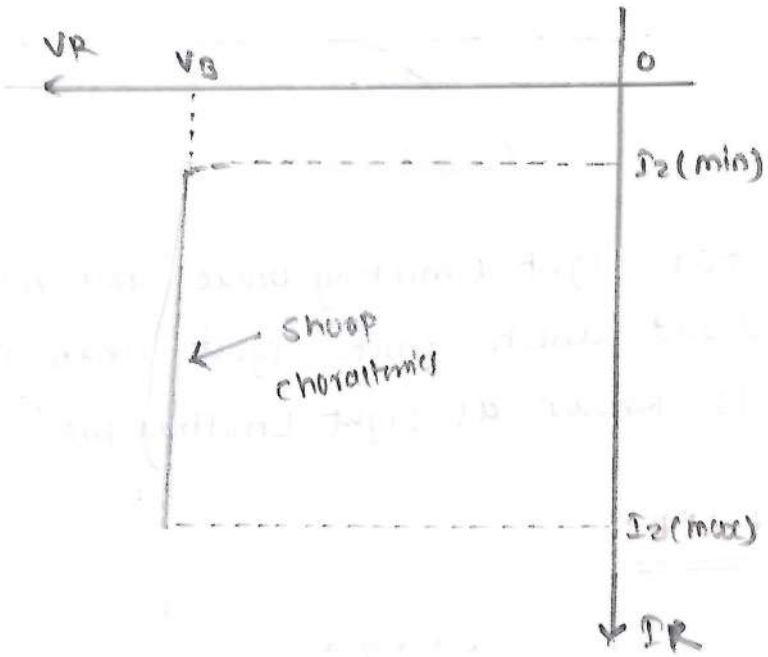
- when reverse bias voltage is applied to zener diode it allow small amount of leakage current.
- when reverse biased voltage is reached at zener voltage it allows large amount of current flow.
- If diode is heavily doped zener breakdown occurs a low reverse voltage.
- If diode is lightly doped zener breakdown occurs a high reverse voltage.
- zener diode is available in range of 1.8V to 400V.

* Avalanche Breakdown:-



- Avalanche Breakdown occurs due to lightly doped PN junction diode
- In which external voltage cannot destroy depletion region.
- The depletion layer can be destroyed by only minority charge carriers
- due to high reverse voltage large number of minority charge carrier are generated.
- large number of minority charge carrier causes sudden increase in reverse current leads to breakdown.
- high speed minority carrier causes junction breakdown known as "Avalanche Breakdown".

* Zener Breakdown:-

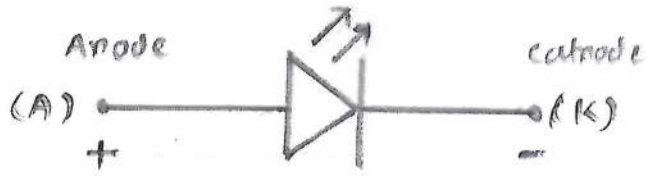


- In a zener diode zener breakdown occurs when PN junction diode is heavily doped
- Heavily doped PN junction diode have narrow depletion region.
- when reverse voltage is increased, voltage across PN junction also increase.
- due to which large number of minority charge carrier are generated & responcible to flow large current trough it.(PN junction diode)
- This breakdown is called as zener breakdown. and can be represented by sharp or straight line. breakdown.

* Applications:-

- zener diode use in voltage regulator to maintain constant o/p voltage.
- used as overvoltage protection by limiting high voltage
- provide stable reference voltage. in ADC-DAC converters.
- Used to clip or limit voltage of waveform at set level.
- In logic circuit & timer circuit for fast switching at specific voltage.

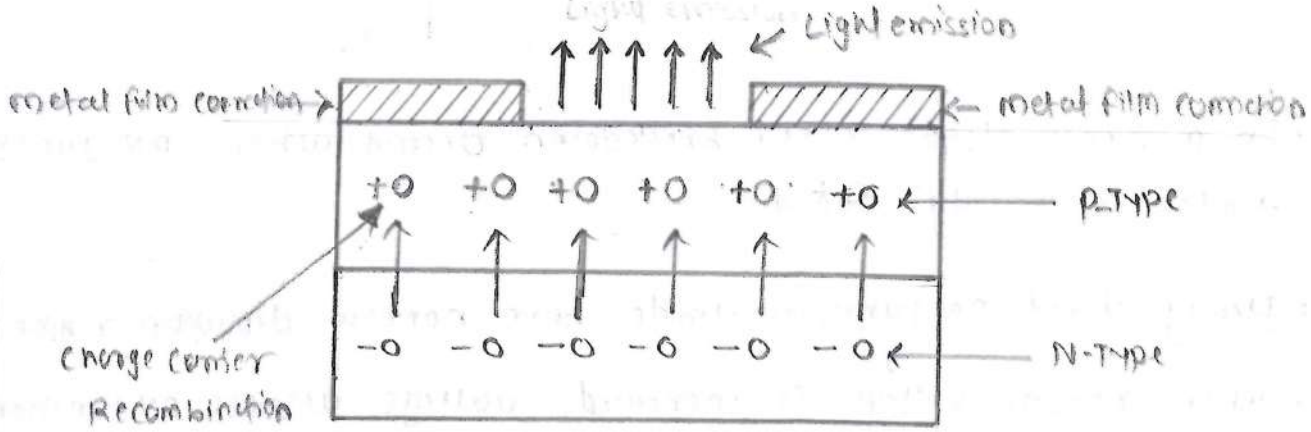
*LED (Light Emitting Diode)



(LED Symbol)

- LED stands for Light Emitting Diode. and nothing but a PN junction diode which emits light when it is in forward bias mode is known as Light Emitting Diode (LED)

*Construction of LED :-

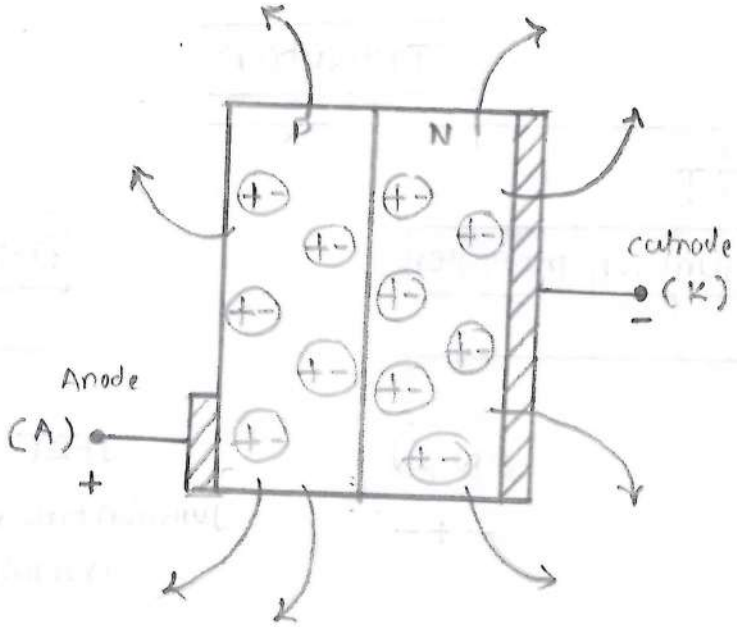


(Light Emitting Diode)

- Construction of LED is mentioned above.:-
- LED is made of semiconductor material like Gallium arsenide (~~GA~~(GaAs), Gallium phosphide (GaP), Gallium Arsenide phosphide (GaAsP).
- It Contains A P N junction where recombination of electrons and holes occurs.
- The entire chip is enclosed in a transparent or coloured plastic dome which is used to protect the LED. and focuses and directs emitted light.
- a reflective layer is added behind the chip to enhance brightness.

*Working of LED :-

- As we know that LED is nothing but a PN junction diode which emits light in forward bias manner
- This semiconductor device has two sides one side is anode (+ve) and other is cathode (-ve).
- When electricity flows through LED electrons moves and combine with holes in semiconductor material.



- when electrons combines with holes they release energy in the form light. in that manner Light Emitting diode conducts and releases the energy in the form of Light.
- The colour of light depends on type of material is used

*Applications of LED :-

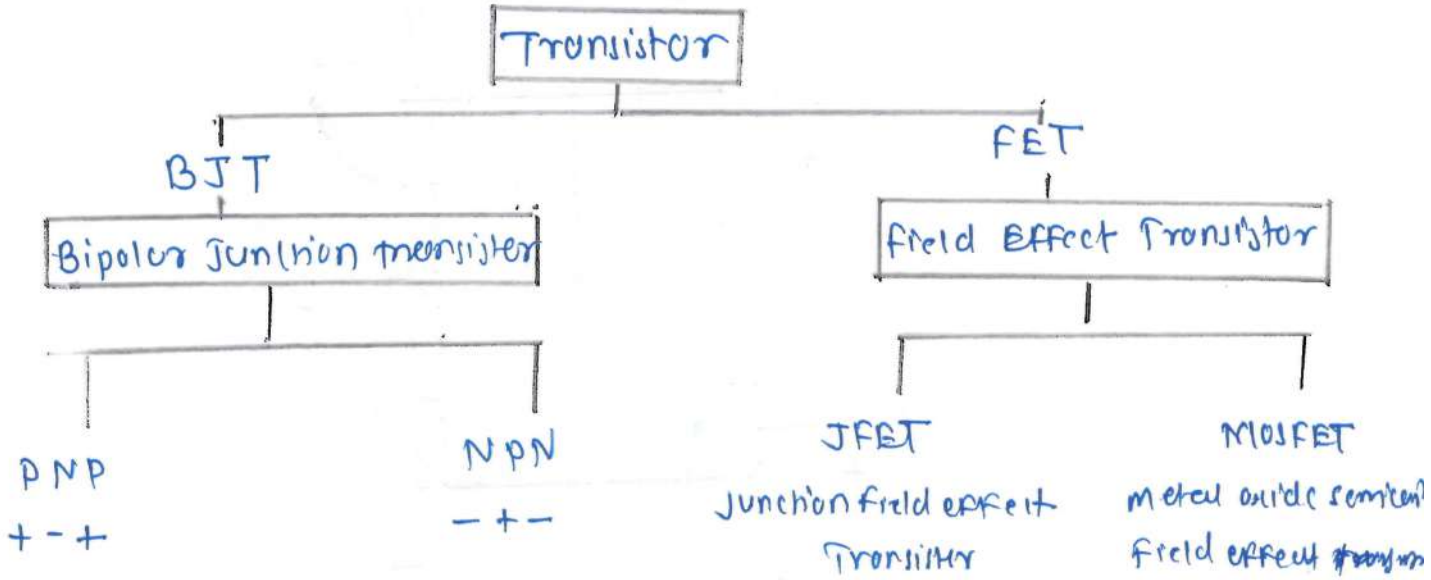
- mostly LED is used as light bulb.
- In motorcycle or automobile industry.
- Used is smartphones
- Used in digital cameras as flash light
- Used in many types of disply pannels in mobile or TVs.

*Transistor:-

- (Transfer + Resistor = Transistor)

Transister is a three terminal semiconduter device which transfer signal from low resistance to high resistance

- It can control the flow of elecric current or, it can
- switch or increases, streng~~th~~ of weak signal.
- This property of transistor is called as amplification.

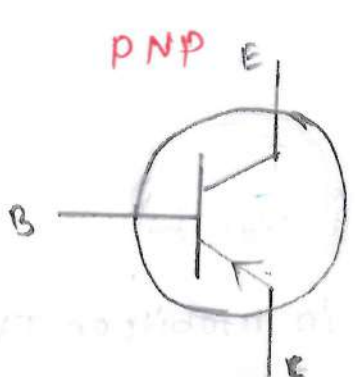


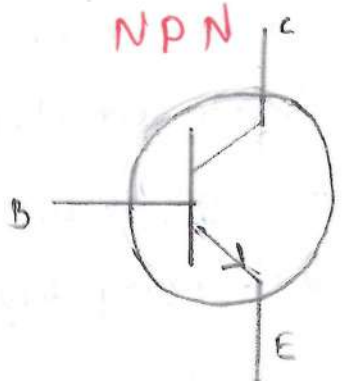
1) UJT (Unipolar junction Transister)

operation include either electrons or holes, means current conduction due to to mejority charge carrier.

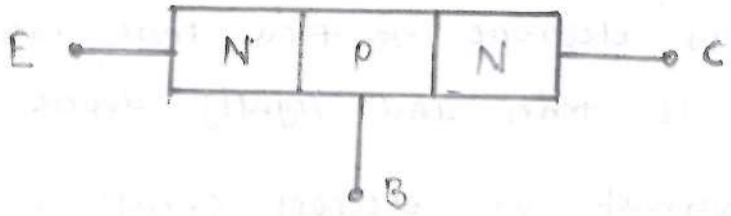
2) BJT (Bipolar Junction Transistor):-

operation involve both electrons and holes, means current conduction due to both mejority and minority charge carrier.





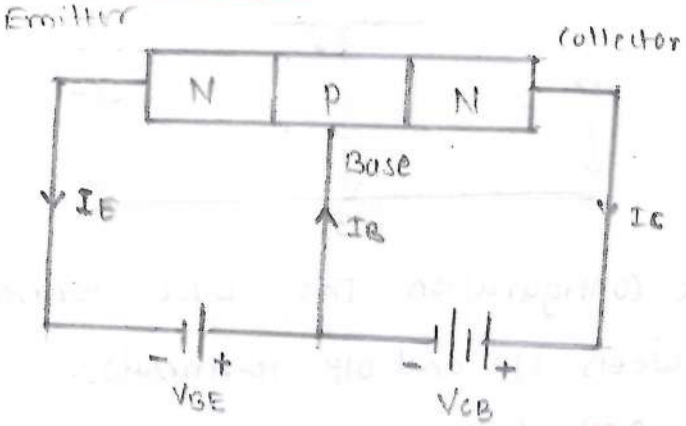
* Construction of NPN Transistor:-



BJT has three regions known as Emitter base & collector In NPN Transister emitter terminal is connected to N-Type material (Heavly Doped).

- Base terminal is is ~~sandwich betw~~ both ~~A~~ P type material which are lightly doped and in thin layer & collector terminal is connected to N-TYPE material. which is moderatly daped. & in a large size.
- means In NPN Transistor one P-TYPE material is present between two N-TYPE maberial.
- NPN Transister is basically used ~~transfer~~ weak signals into strong signals.

* working of NPN transistor:-



- NPN transister works by controling large current between from collector and emitter by using small current at base
- Emitter emits electrons. base control the flow of electrons in thin layer & collector collects the electrons.

- when small voltage is applied to base emitter junction (V_{BE}) it becomes forward bias, due to forward bias.
- which allows electrons to flow from emitter into base because it is thin and lightly doped.
- This movement of electrons creats a large collector current (I_C) control by base current (I_B).
- The total current flow equation:-

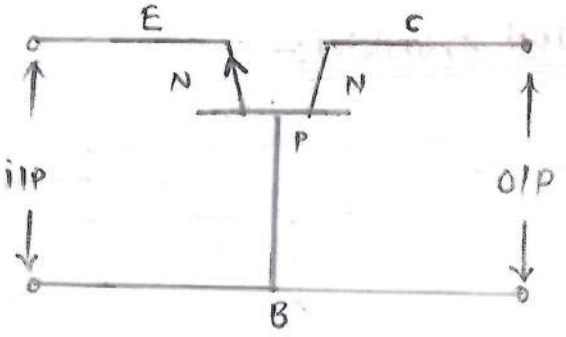
$$\therefore \boxed{I_E = I_C + I_B}$$

* Transistor operating modes:-

Mode	Base Emitter Junction	Collector Base Junction	Application
Active Mode	forward Biased	Reverse Biased	Amplifire
cutoff Mode	Reverse Biased	Reversed Biased	Switch (off)
saturation Mode	forward Biased	forward Biased	Switch (on)

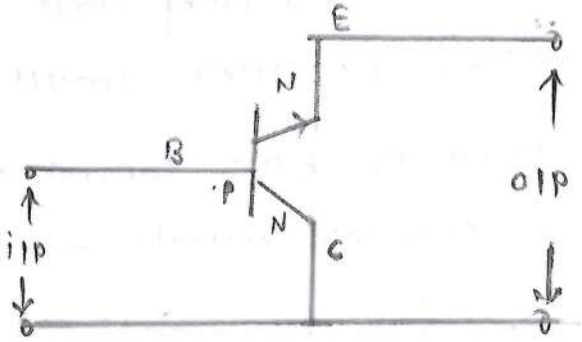
* Configurations of BJT:-

1) Common Base Configuration:-



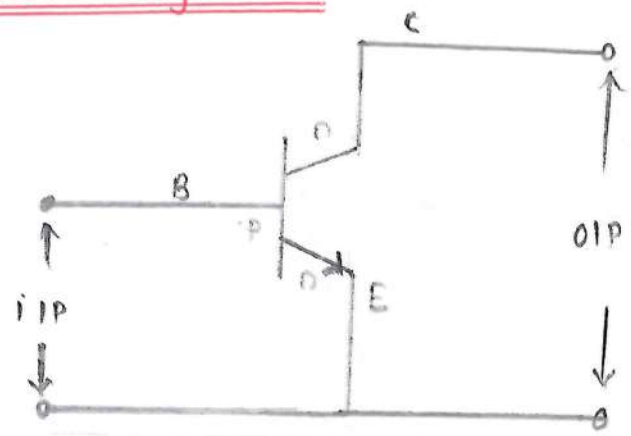
In Common Base Configuration the base terminal of transistor is common between i/p and o/p terminals:.

2) Common Collector Configuration:-



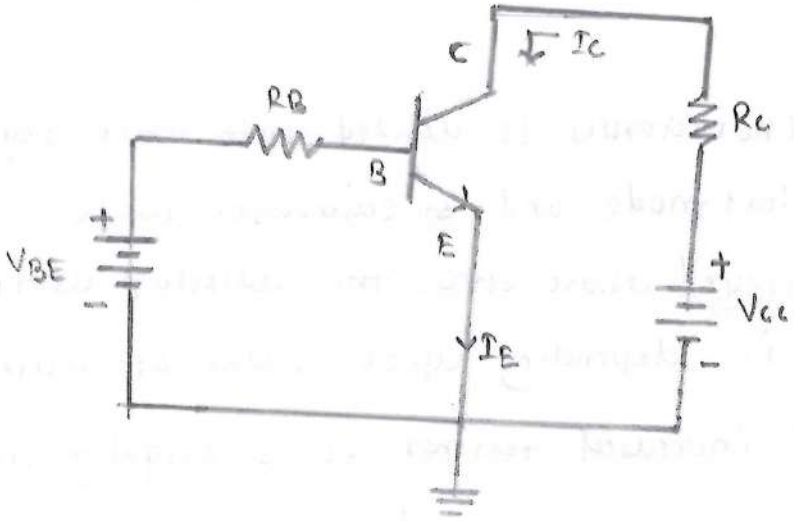
In common collector configuration collector terminal of transistor is common between input & output terminal of transistor.

* Common Emitter Configuration:-



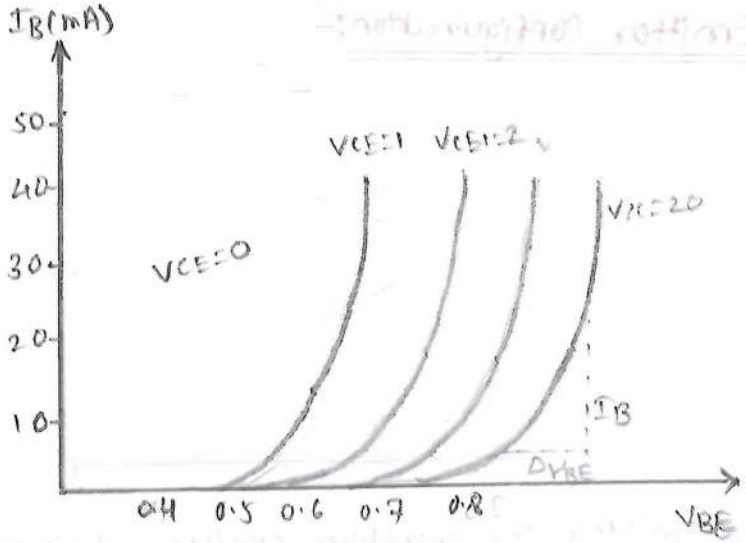
- In common emitter configuration emitter terminal of the transistor is common between input & output terminal of transistor.

* Characteristics of transistor in CE:- (Input)



- In common emitter configuration emitter terminal is common for i/p & o/p
- It is characteristics between Base emitter voltage (V_{BE}) to Base current (I_B) as collector emitter terminal is common. (V_{CE}).
- If we increase base to emitter voltage (V_{BE}) in small steps and record the value of Base current (I_B). then knee voltage is below means base current is very small
- Beyond knee voltage base current (I_B) increases in Base emitter volt (V_{BE}) for constant collector emitter voltage (V_{CE}).
- V_{CE} is increased above V_f curve shifts downwards

∴ o/p resistance. expressed as $R_O = \frac{\Delta V_{BE}}{\Delta I_B}$.



* Output Characteristics:-

It is graph between collector emitter voltage (V_{CE}) to collector current (I_C) as base current is constant.

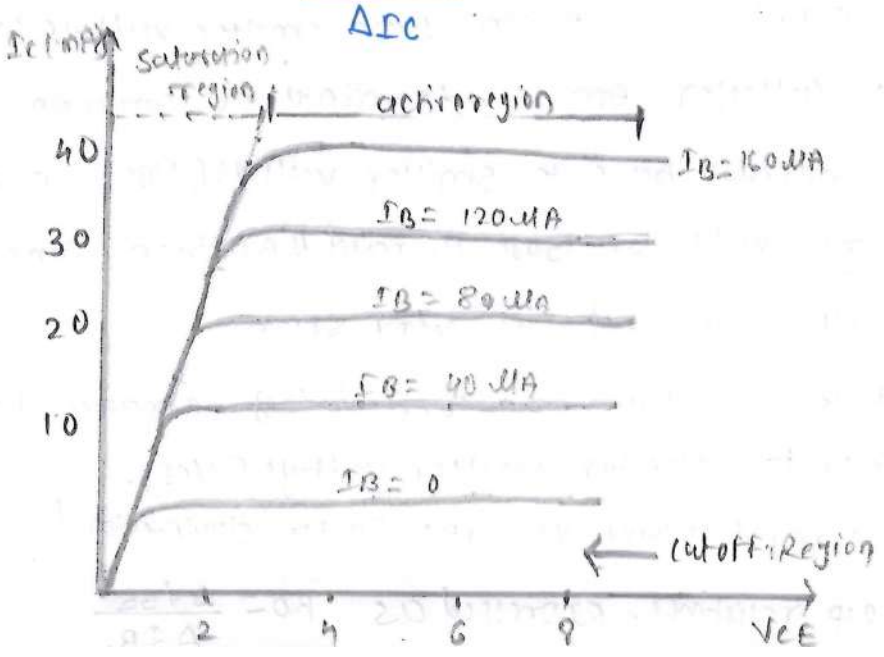
If we increase collector to emitter voltage (V_{CE}) in small steps and mark value of I_C.

Then output characteristics is divided into three regions. namely Activemode, cutoffmode, and ~~st~~ saturation mode

- As V_{CE} is increased above zero, the collector current I_C increased rapidly which is depending upon value of Base current (I_B)
- when V_{CE} is increased ~~further~~ further I_C is slightly increased.

∴ o/p resistance is expressed as

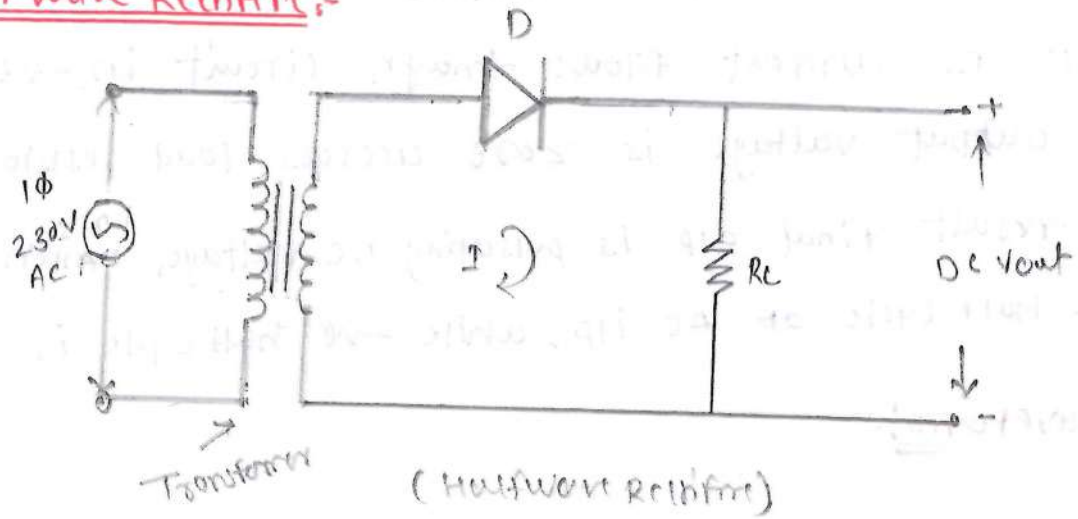
$$R_O = \frac{\Delta V_{CE}}{\Delta I_C}$$



* Rectifire :-

- Rectifire is an electronic device or circuit that converts alternating (AC) current or voltage into direct current (DC)
- It allows current to flow in only one direction producing an unidirectional output. (Ac into pulsating DC)

* Half Wave Rectifire :-



(Halfwave Rectifire)

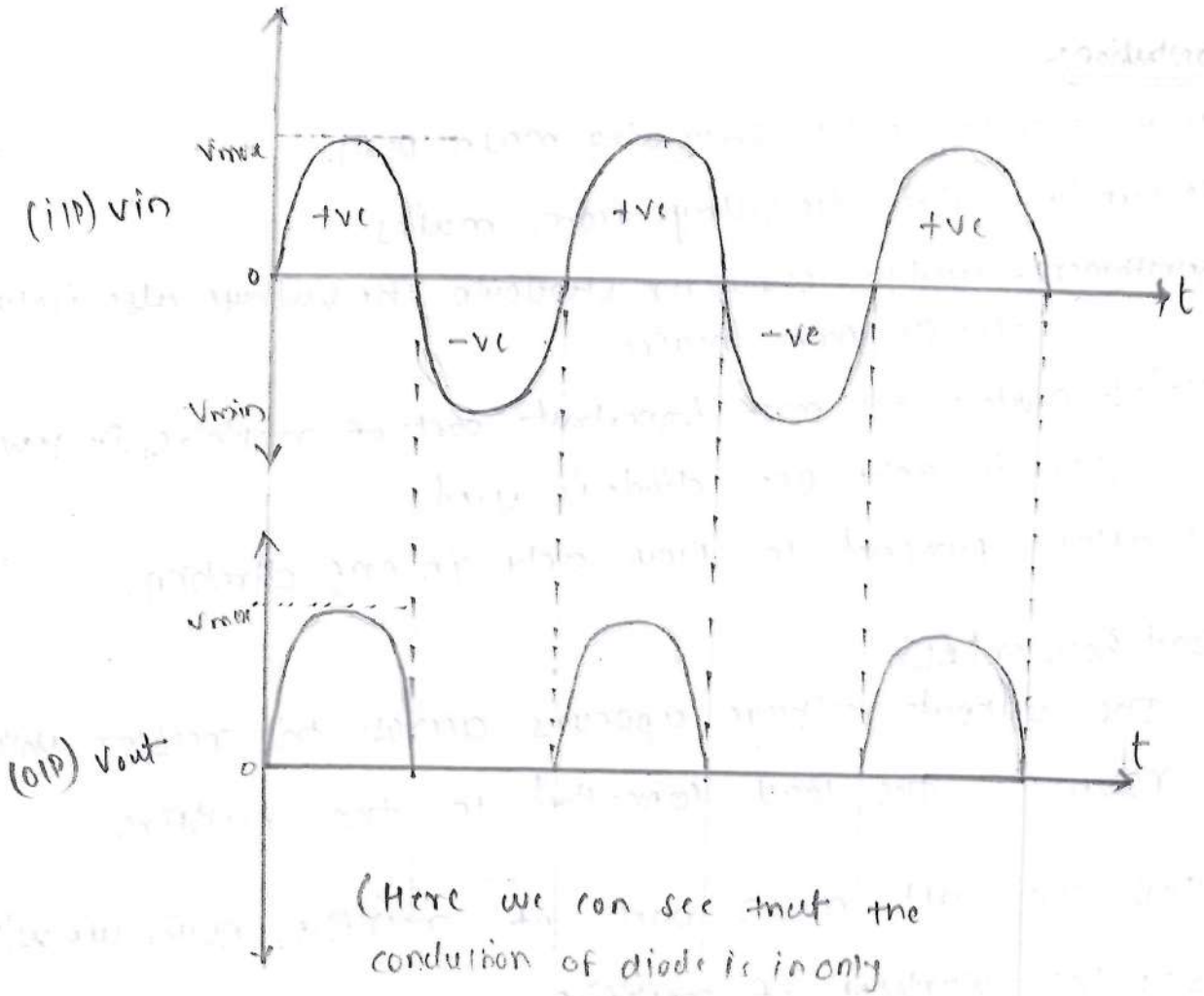
* Construction :-

- Hafwave rectifire has following main parts.
- AC supply :- Gives i/p voltage from mains
- Transformer :- used to stepup or stepdown the voltage also isolates the circuits from mains
- Diode :- Diode is the most important part of rectifire. In HWR There is only one diode is used.
  It allows current to flow only in one direction.
- Load Resistor (RL)
  The output voltage appears across this resistor which represents the load connected to the rectifire
- This are all main parts of rectifire, now. we will see the working of rectifir.

*Working :-

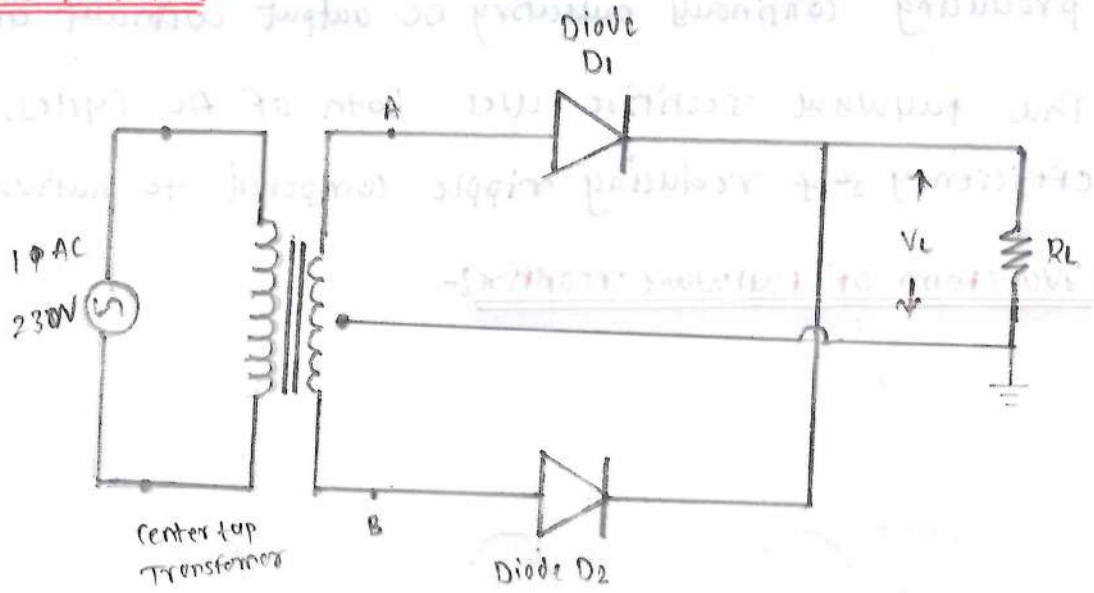
- During +ve half cycle of AC i/p diode become forward biased & starts the conducting current.
- During –ve half cycle of AC input the same diode become reverse biased. & does not conduct & no current flows ~~from~~ in ~~that~~ condition.
- Since no current flows ~~through~~ circuit in –ve half cycle the output voltage is zero accross load resistor RL.
- As result final o/p is pulsating DC voltage, which include only +ve half cycle of AC i/p, while –ve half cycle is blocked.

*Waveform :-



(Here we can see that the conduction of diode is in only +ve half cycle of AC input)

* Full-Wave-Rectifier:-



(Full Wave Rectifier)

• Construction:-

- fig. shows construction of fullwave rectifier, which uses two diodes namely D_1 and D_2, to convert both +ve & -ve halfcycles into pulsing DC
- The transformer has center-tapped secondary winding, each winding feeding one diode into two equals.
- A load resistor RL is connected across the output where the rectified voltage is obtained.
- Center tapped acts as a grounding or reference point

*Working:-

During +ve half cycle of Ac input:-

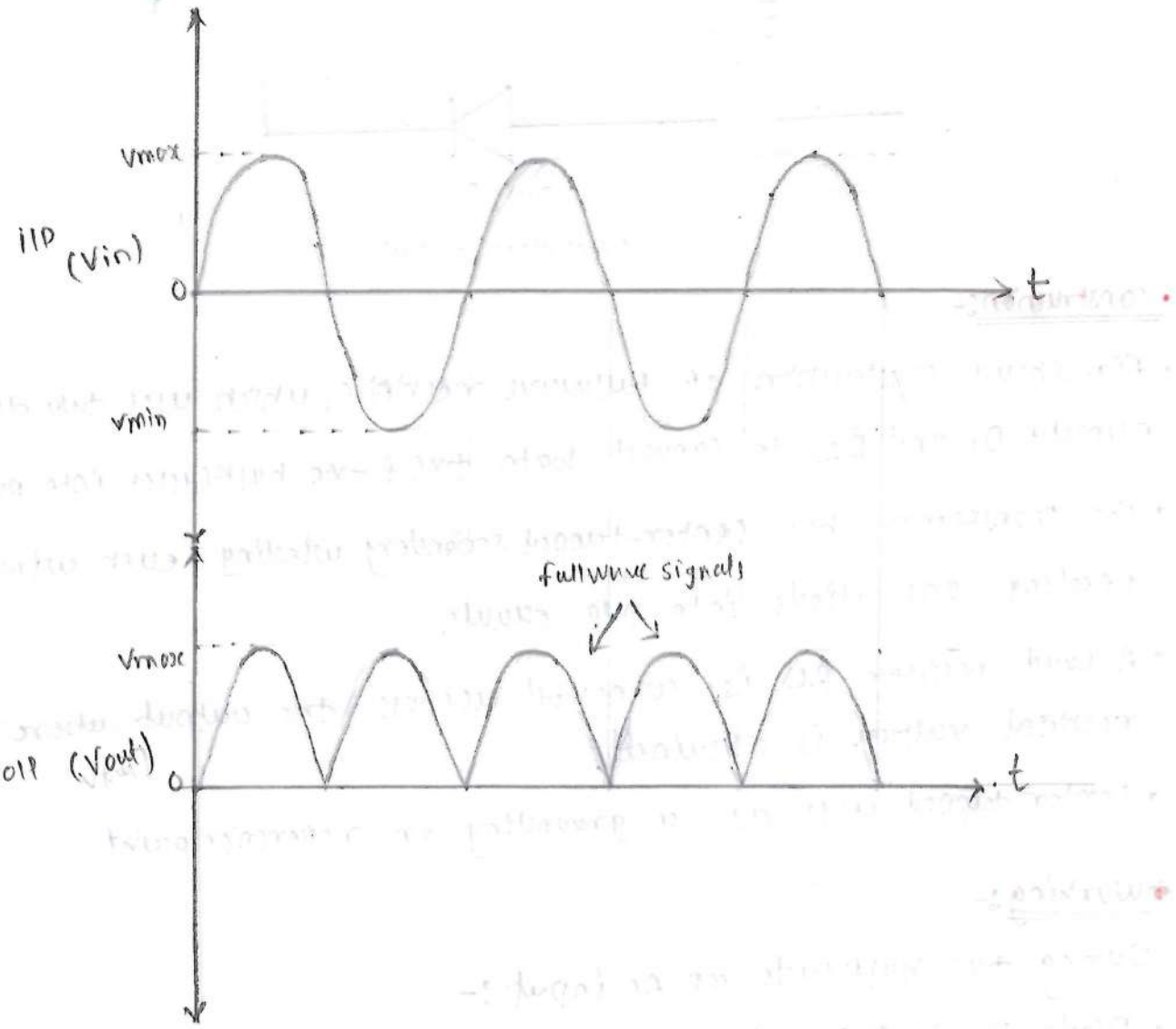
- Diode D_1 is ~~or~~(+ve) forward biased and conducts current through the load.
- Diode D_2 becomes (-ve) reverse biased and remains off.

During -ve halfcycle of AC i/p:-

- Diode D_2 (+ve) & forward biased & conduct current through the RL
- Diode ~~D2~~ D_1 (-ve) & reverse biased & does not conduct
- In both half cycle the current through the load resistor flows in the same direction.

- producing continously pulsatiry DC output without any zero gap.
- Thus fullwave rectifire uses both of AC cycles, improving efficiency & reducing ripple compared to halfwave rectifire.

* Waveform of fullwave rectifire:-

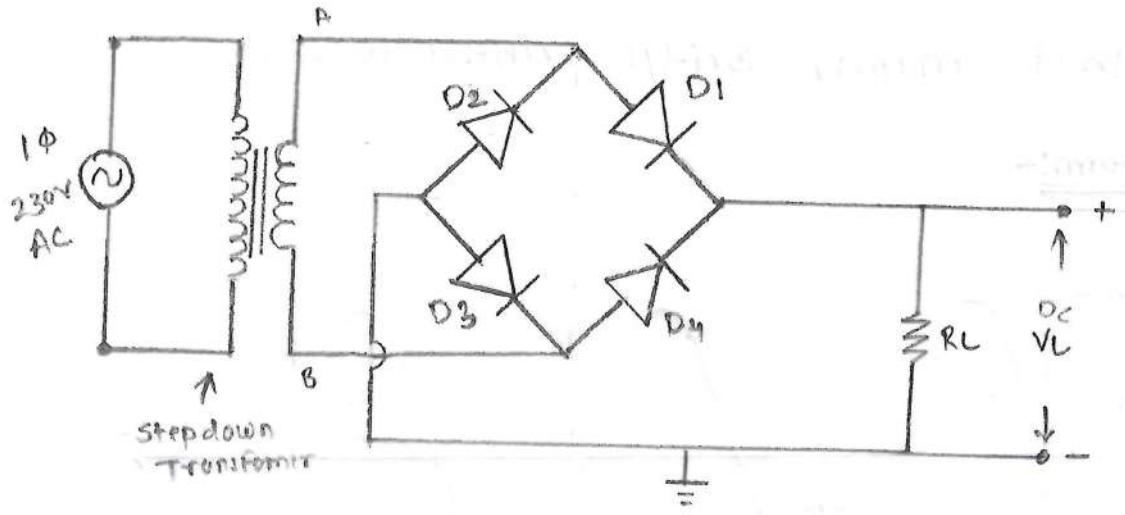


- **Note:-**

In ~~full wave~~ rectifire, during the process of rectification there is some ripples are presents which are AC components of DC or fluctuation remains in ~~o/p~~ output of rectifire They can remove by using filters.

* Bridge Rectifire :-

- A Bridge rectifire is a circuit that converts both cycle of AC into pulsating DC, using four diodes namely D_1 D_2, D_3 D_4 in a bridge arrangement, without needing center tapped transformer.



(Bridge Rectifire)

• Construction :-

- A Bridge rectifire uses four diodes namely D_1 D_2 D_3 D_4. This diodes are connected in a closed loop configuration, forming a bridge.
- Load Resistor RL is connected across the other two corners of the bridge.
- no center tapped transformer is required, which simplifies transform design.

• Working :-

- The Bridge rectifire converts both half cycles of AC into the unidirectional (DC) current across the load.
- +ve half cycle of AC input :-

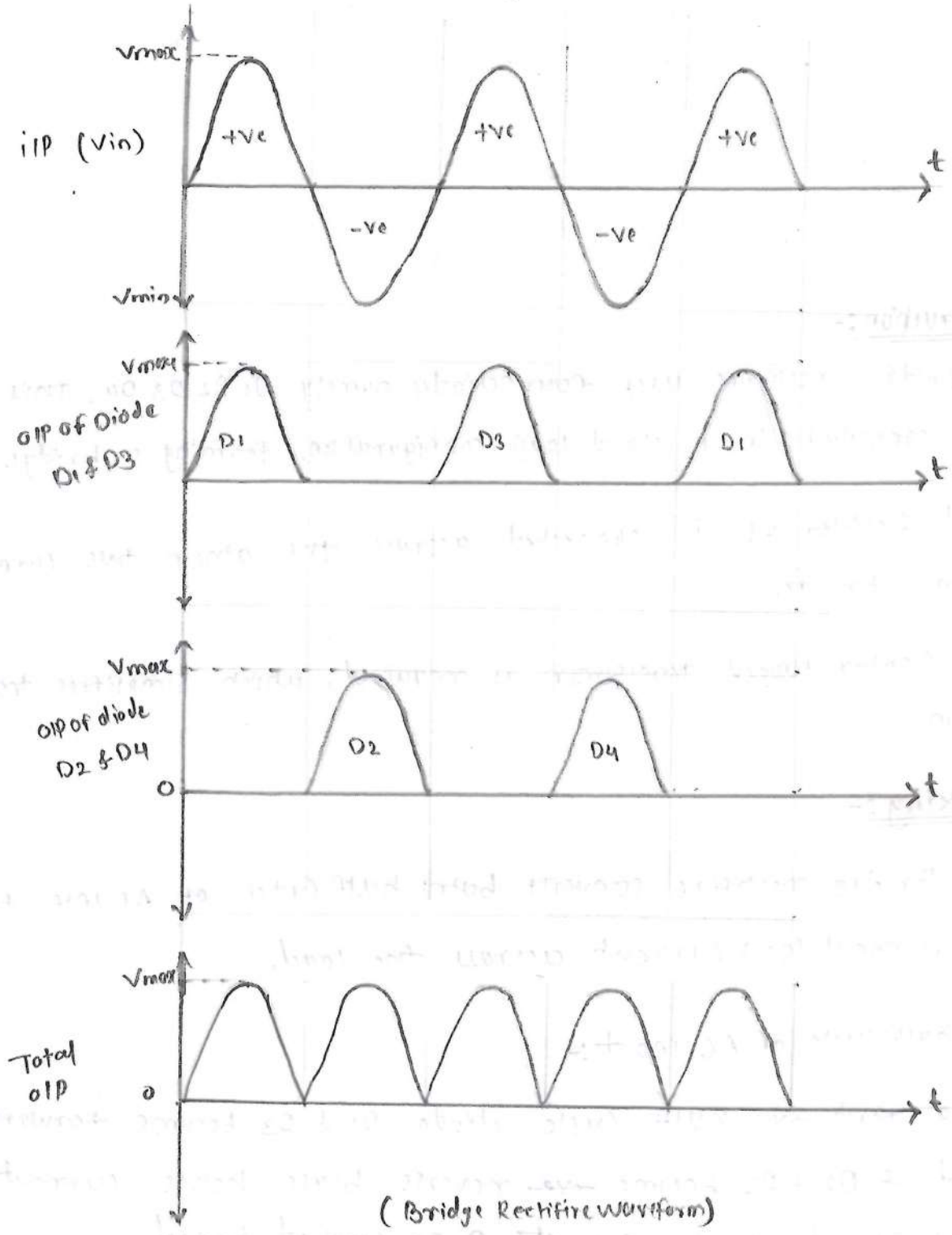
During first +ve half cycle diode D_1 & D_3 become forward biased & D_2 & D_2 become ~~-ve~~ reverse biase hence current conduction at RL in only at D_1, D_3 forward biased.

-ve half cycle of AC input

During -ve half cycle of AC input Diode D_2 & D_4 become forword biased and diode D_1 & D_3 become reversed biased, hence diode conducts ~~at~~ on D_2, D_4 forword biased at load resistance RL i'n ~~front~~.

· In that manner Bridge rectifire works.

* **Waveform:-**



(Bridge Rectifire Waveform)

Parameter	Half wave	full wave	Bridge
No of diode	1	2	4
AC Cycle Utilized	only the half	Both half cycle	Both half cycle
O/P frequency	same f	2f	2f
O/P voltage	Low	Higher (with centre tap)	Higher
Ripple factor	1.21	0.48	0.48
Efficiency	40.6%	81.2%	81.2%
PIV	Vmax	2Vmax	Vmax
Circuit complexity	Simple	Moderate	More complex
Cost	Low	Medium	Higher [4 diode]

27/6/25

27/6/25