

## \* UNIT - 1 \*

# \* DIODE AND APPLICATIONS \*

### INTRODUCTION:-

Based on conductivity materials are classified into three types. They are

- \* conductor

- \* semiconductor

- \* insulator

conductors:- The materials which allow flow of current are called conductor.

semiconductor:- The materials having conductivity in between conductors and insulators.

Example:- silicon and Germanium

insulators:- The materials which does not allow current flow are called insulators.

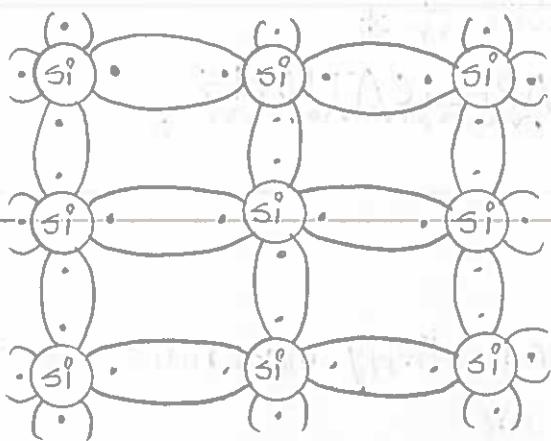
Types of semiconductors:-

There are two types of semiconductors. They are.

- \* intrinsic semiconductor

- \* Extrinsic semiconductor.

Intrinsic semiconductor:- In intrinsic semiconductor the covalent bonds are formed between 4<sup>th</sup> group elements. This semiconductor also called "pure semiconductor".



At zero temperature there are no free electrons present in the intrinsic semiconductor so at zero degree temperature it acts as a insulator. At room temperature ( $33^{\circ}\text{K}$ ) some of the electrons breaks the covalent bond and became free electrons. So, at room temperature it acts as a conductor. When electron breaks the covalent bond, holes is generated. it is having positive charge.

In intrinsic semiconductor number of elements equal to number of holes.

Extrinsic semiconductor:-

The disadvantage in intrinsic semiconductor is the current is increased due to increase in temperature. But it is not possible to increase temperature beyond certain limit.

In extrinsic semiconductor the current is increased due to increase in number of impurities. The process of adding impurities is called "Dopping".

These are two types of extrinsic semiconductor.

- \* N-type semiconductor
- \* P-type semiconductor.

## N - Type semiconductor:-

If pentavalent impurities are added to the tetravalent atoms then the semiconductor is called N-type semiconductor.

In N-type semiconductor electrons are majority charge carriers and holes are minority charge carriers. N-type semiconductor is represented with  $\text{F}^-$

## P - type semiconductor:-

If trivalent impurities are added to the tetravalent atoms. In P-type semiconductor. Holes are majority charge carriers and electrons are minority charge carriers. P-type semiconductor is represented with  $\text{E}^0$

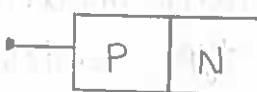
## PN junction diode:-

PN junction diode with no applied voltage or open circuit condition.

consider a piece of silicon material if one half is dopped by P-type impurity and another half is dopped by N-type impurity then A PN junction is formed.

In N-type material electrons are majority charge carriers while in P-type material holes are majority charge carriers therefore at the junction. There is a tendency of free electrons moves from N-side to p-side. similarly holes are move from p-side to N-side this process is called diffusion. As the free electrons moves from N-side to p-side the donor atoms becomes positively charged. and the holes are moves from p-side to N-side the acceptor ions become negative charge therefore

Negative charge developed on the P-side and positive charge developed on the N-side. The Negative charge on the P-side prevents further diffusion of electrons from N-side similarly positive charge on the N-side prevents further diffusion of holes from P-side. So the barrier is setup at the junction which prevents the further movement of charge carriers. These region is called depletion region. The potential at depletion region is called barrier potential (or) cutting voltage (or) knee voltage for silicon barrier potential is 0.7 volts and for Germanium is 0.3 volts.



P-type	N-type
$\ominus$	$\oplus$

↓  
depletion region  $\left\{ \begin{array}{l} Si = 0.7V \\ Ge = 0.3V \end{array} \right\}$

To overcome barrier potential external voltage source is connected to PN junction diode. This process is called biasing. There are two types of biasing. They are

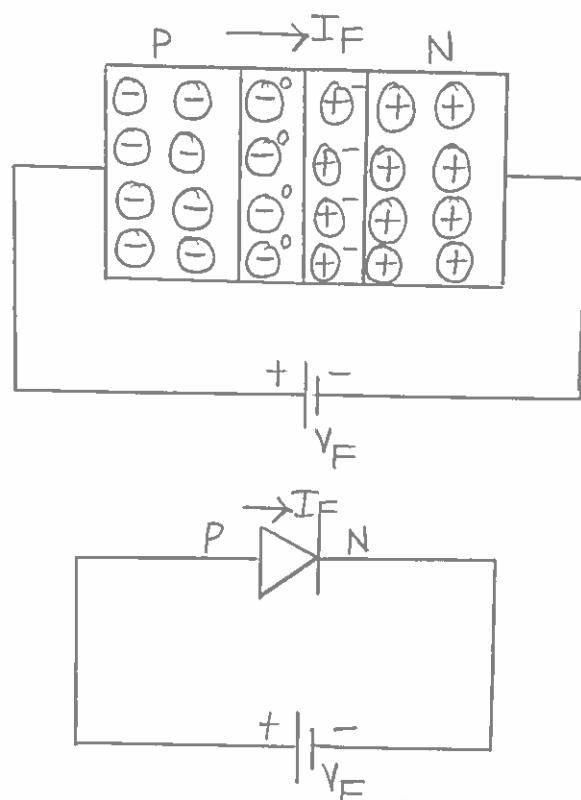
- \* Forward bias

- \* Reverse bias.

PN junction diode in forward bias:-

When the positive terminal of the battery is connected to P-side of PN junction diode and Negative terminal of the battery is connected to N side of PN junction diode then biasing is called forward bias.

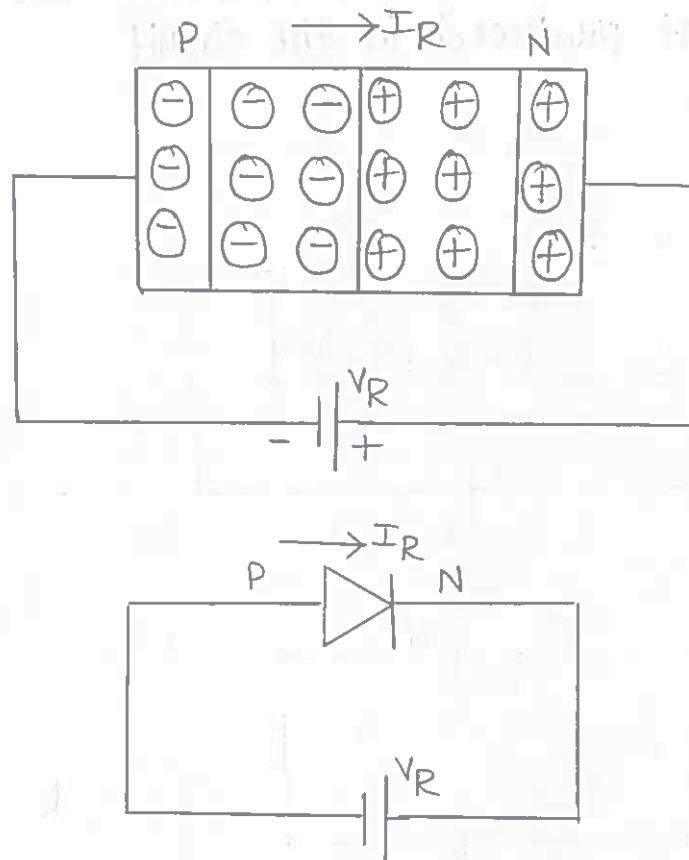
If external voltage above barrier potential at the junction then the holes move from P side to N side and electrons move from N side to P side. Due to this large amount of current produced in the circuit.



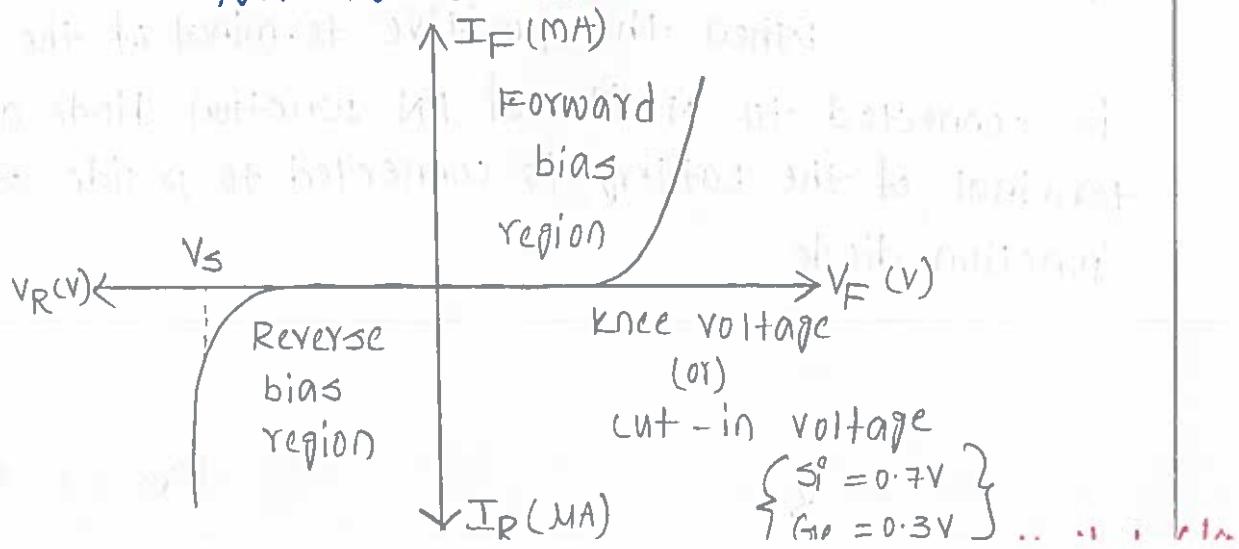
PN junction diode in Reverse bias:-

When the positive terminal of the battery is connected to N side of PN junction diode and Negative terminal of the battery is connected to P side of PN junction diode.

If P-type terminal is connected to Negative terminal of the battery then the holes move away from the junction towards Negative terminal. Similarly N-type is connected to positive terminal of the battery. electrons move away from the junction towards positive terminal. due to this depletion region width increases so no current produced in the circuit but small amount of current produced due to minority charge carriers this current is called Reverse saturation current.



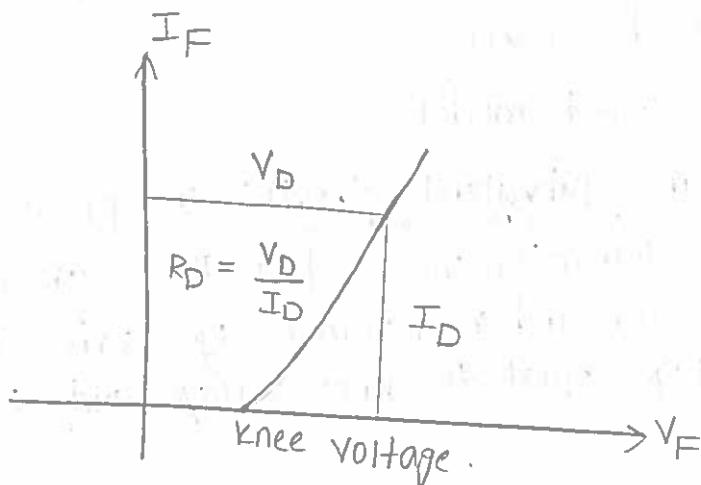
$V-I$  characteristics of PN junction diode in forward and reverse bias



Static and Dynamic resistance:-

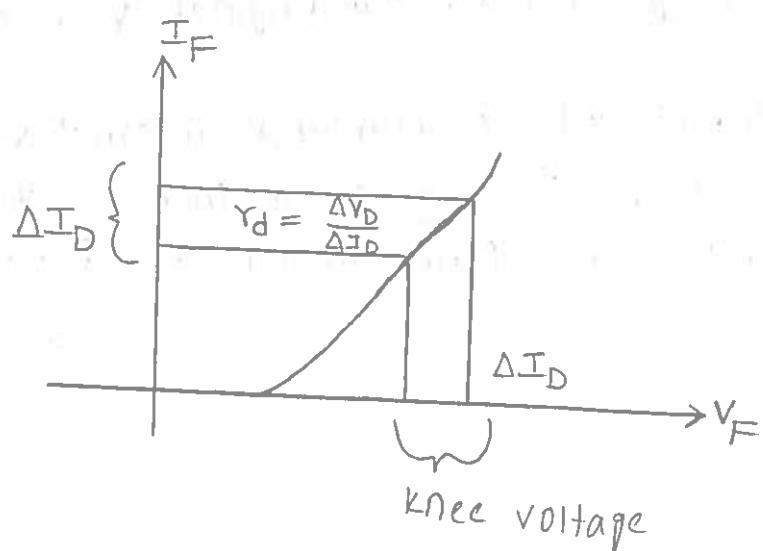
Static resistance:- static resistance also called AC resistance. It is the ratio of forward diode voltage and forward diode current

$$R_D = \frac{V_D}{I_D}$$



Dynamic resistance:- This resistance also called DC resistance. It is the ratio of changing forward voltage to the changing forward current.

$$r_D = \frac{\Delta V_D}{\Delta I_D}$$



Diode equivalent circuit:-

Equivalent circuit is defined as the device symbol can be replaced with similar circuit without effecting the actual behaviour of the circuit.

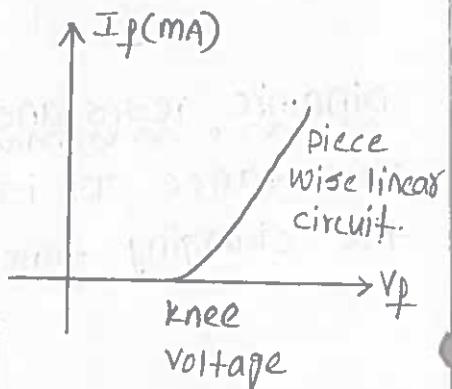
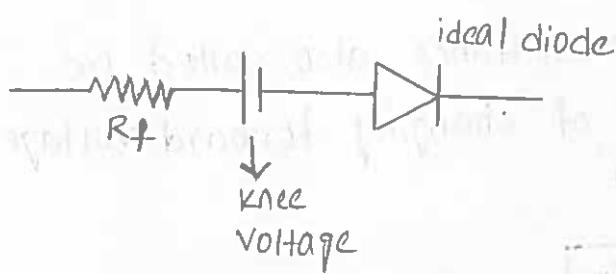
There are 3 types of equivalent circuits.

\* Piece wise linear equivalent circuit

\* Simplified circuit

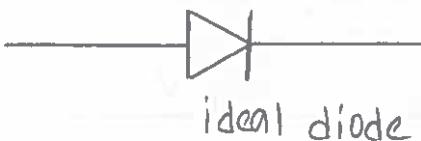
\* Ideal circuit model.

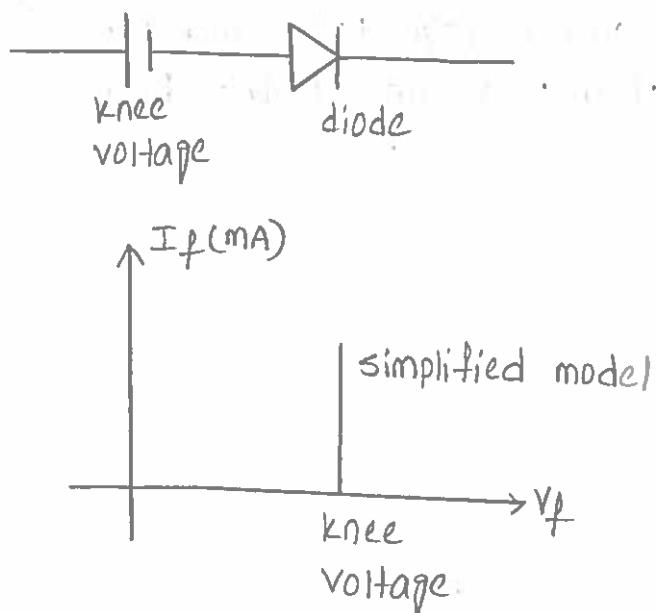
Piece wise linear equivalent circuit:- In piece wise linear circuit model the characteristics of a diode are in linear. This model consist of forward resistance  $R_f$  series with voltage source having voltage equal to knee voltage and series with ideal diode.



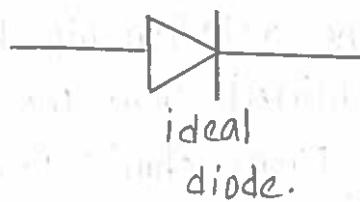
The V-I characteristics of piece wise linear model are approximately equivalent to original V-I characteristics of a diode.

Simplified model:- If we consider internal resistance of a forward bias diode is very small then it should be determinated. The resultant model should be called simplified model.

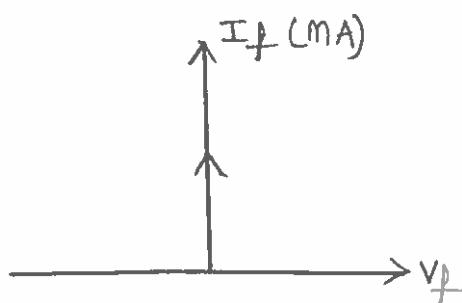




ideal diode model:- In the simplified circuit we ignore barrier potential then the resultant circuit is called ideal diode model.



In the ideal diode model the diode is replaced with short circuit in forward bias and open circuit in reverse bias.



LOAD LINE ANALYSIS:-

The use of the load line construction allows the graphical analysis of many circuits including devices which are much more complicated than the PN diode. TWO plots are needed to determine the operating point of the diode. TWO plots are needed to determine

the operating point of the diode. One plot is drawn using Kirchhoff's current and voltage laws and other is by plotting the volt-ampere characteristic of the diode.

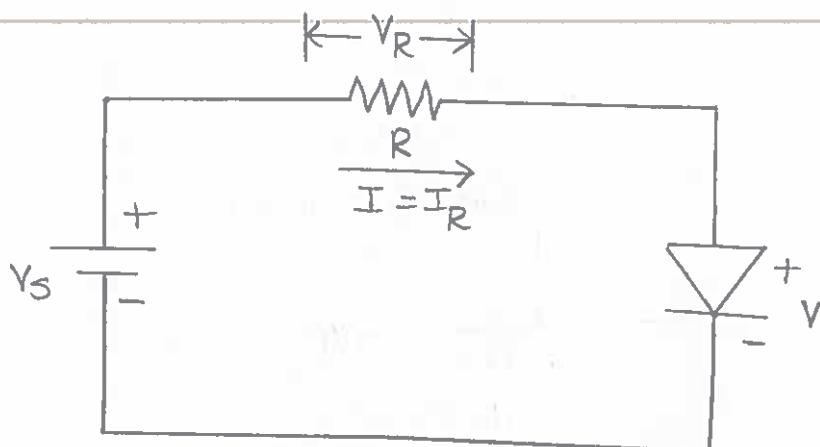


Fig:- Simple diode circuit

From KCL,  $I = I_R$  and from KVL,  $V + V_R = V_S$  as shown in above figure. The relationship between diode current  $I$  and voltage  $V$  is obtained from the diode characteristics curve as shown in Figure. From ohm's law, the current through the resistor and the voltage across the resistor are linearly related as shown in figure.

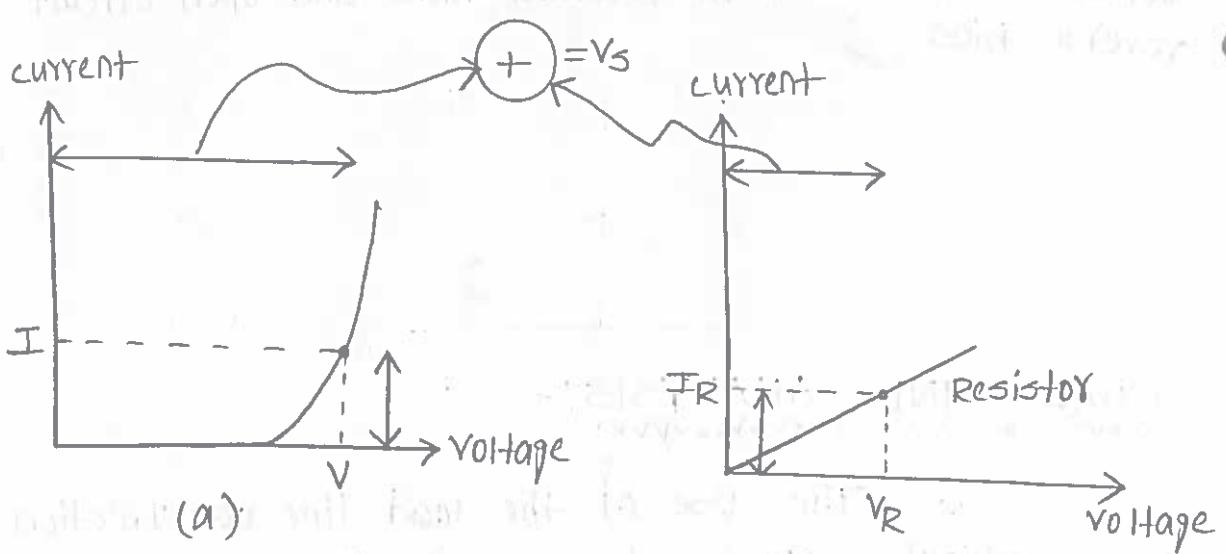


Fig:- Diode characteristics  
for the circuit

Fig:- Output across  
resistor.

To draw the load line, flip the resistor curve horizontally such that the slope of the curve is  $-1/R$  and push the two curves, as shown in figures (a) and (b), together horizontally until the Y-axis are  $v_s$  apart.

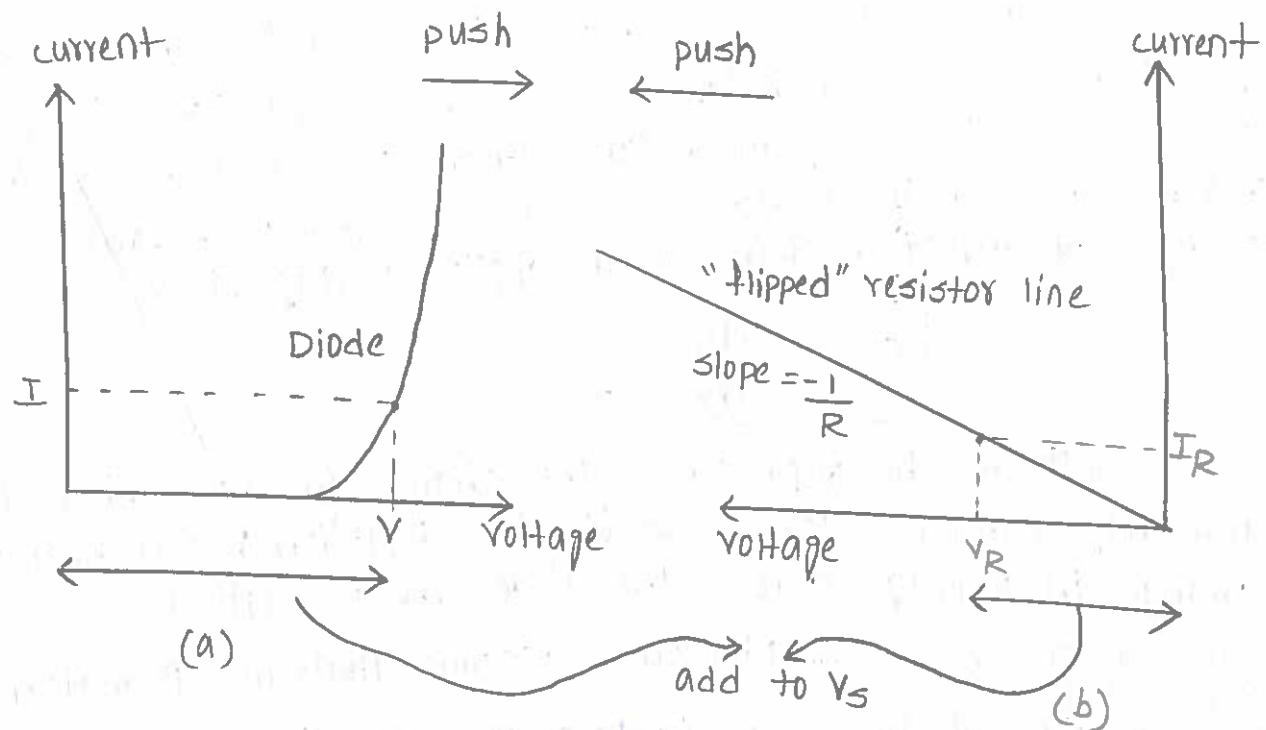


Fig:- (a) Forward voltage -current characteristics of a diode  
 (b) Flipped resistor line with slope  $= -\frac{1}{R}$

The intersection point of the flipped resistor line called load line and the diode static characteristics curve is the operating point of the device, as shown in figure.

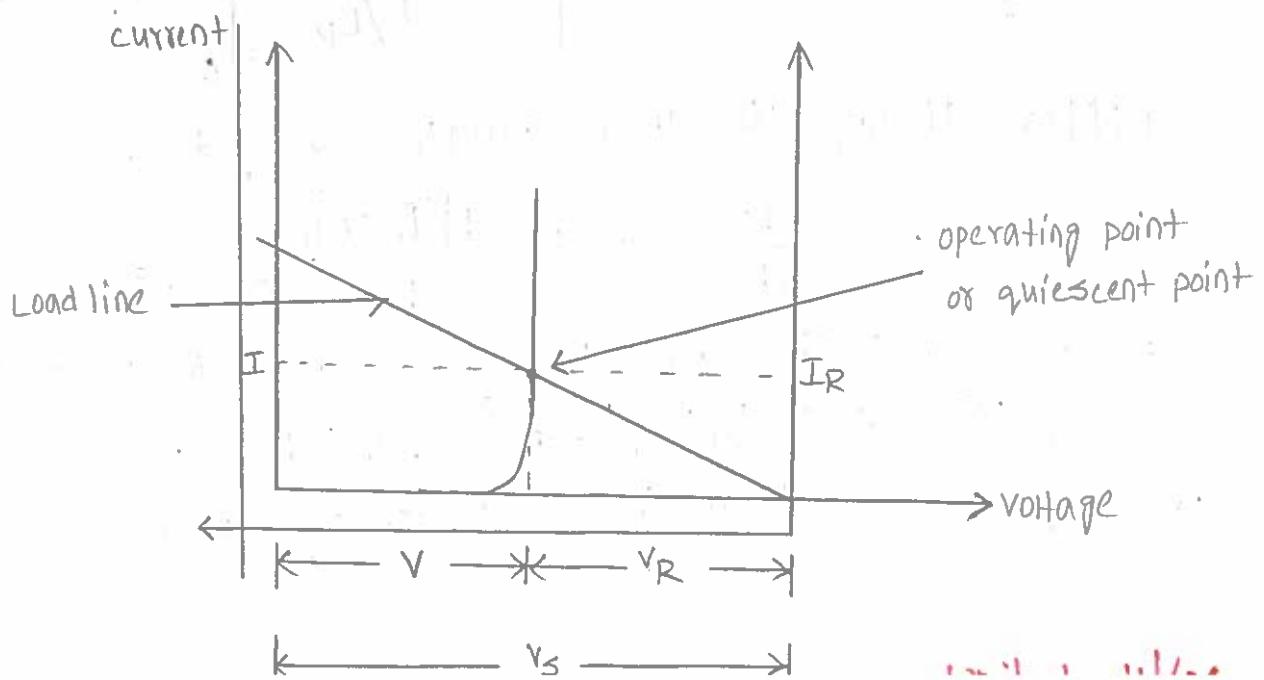


Fig) - Intersection point of the load line with the voltage-current characteristic of the diode.

\* Diffusion capacitances :-

The capacitance that exists in a forward biased junction is called a diffusion or storage capacitance ( $C_D$ ), whose value is usually much larger than  $C_T$ , which exists in a reverse-biased junction. This is also defined as the rate of change of injected charge with applied voltage, i.e.,

$$C_D = \frac{dQ}{dV}$$

Where  $dQ$  represents the change in the number of minority carriers stored outside the depletion region when a change in voltage across the diode,  $dV$  is applied.

\* Calculation of  $C_D$  :- Let us assume that the P material in one side of the diode is heavily doped in comparison with the N side. Since the holes move from the P to the N side, the hole current  $I \approx I_{pn}(0)$

The excess minority charge  $Q$  existing on the N side is given by

$$Q = \int_0^{\infty} A e P_n(0) e^{-x/L_p} dx = \left[ \frac{A e P_n(0) e^{-x/L_p}}{-1/L_p} \right]_0^{\infty} = L_p A e P_n(0)$$

Differentiating the above equation, we get

$$C_D = \frac{dQ}{dV} = A e L_p \frac{d[P_n(0)]}{dV} \rightarrow ①$$

We know that the diffusion hole current in the N-side is  $I_{pn}(x) = A e D_p P_n(0) / L_p e^{-x/L_p}$ . The hole current crossing the junction into the N-side with  $x=0$  is

$$I_{Pn(0)} = \frac{AeD_p P_n(0)}{L_p}$$

Therefore,

$$I = \frac{AeD_p P_n(0)}{L_p}$$

$$P_n(0) = \frac{IL_p}{AeD_p}$$

Differentiating the above equation w.r.t. "v", we get

$$\frac{d[P_n(0)]}{dv} = \frac{dI}{dv} \frac{L_p}{AeD_p} \rightarrow \textcircled{2}$$

upon substituting in equation  $\textcircled{2}$  in equation  $\textcircled{1}$  we get

$$C_D = \frac{dQ}{dv} = \frac{dI}{dv} \frac{L_p^2}{D_p}$$

Therefore,  $C_D = gT$ , where  $g = \frac{dI}{dv}$  is the diode conductance and  $T = \frac{L_p^2}{D_p}$  is the mean life time of holes in the N-region.

From diode current equation,  $g = \frac{I}{\eta V_T}$

Therefore,

$$C_D = \frac{\tau I}{\eta V_T}$$

where  $\tau$  is the mean life time for holes and electrons.

Diffusion capacitance  $C_D$  increases exponentially with forward bias or, alternatively, that it is proportional to diode forward current,  $I$ . The values

of  $C_D$  range from 10 to 1000 pF, the larger values being associated with the diode carrying a larger anode current, I.

The effect of  $C_D$  is negligible for a reverse-biased PN junction. As the value of  $C_D$  is inversely proportional to frequency, it is high at low frequencies and it decreases with the increase in frequency.

TRANSITION OR SPACE CHARGE [OR DEPLETION REGION]

\* CAPACITANCE ( $C_T$ ) \*

Under reverse bias condition, the majority carriers move away from the junction, thereby uncovering more immobile charges. Hence the width of the space-charge layer at the junction increases with reverse voltage. This increase in uncovered charge with applied voltage may be considered a capacitive effect. The parallel layers of oppositely charged immobile ions on the two sides of the junction form the capacitance  $C_T$ , which is expressed as

$$C_T = \left| \frac{dQ}{dV} \right|$$

where  $dQ$  is the increase in charge caused by a change in voltage  $dV$ . A change in voltage  $dV$  in a time  $dt$  will result in a current  $I = dQ/dt$  given by

$$I = C_T \frac{dV}{dt}$$

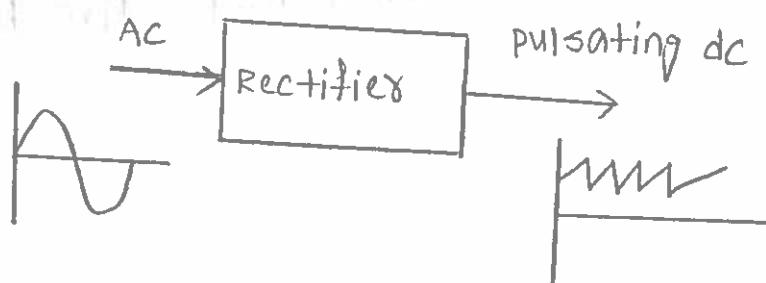
Therefore  $C_T$  is important while considering a diode or a transistor as a circuit element. The quantity  $C_T$  is called the transition, space-charge, barrier or depletion region capacitance.

## APPLICATIONS OF DIODE:-

- \* It is used as a switch
- \* It is used in a rectifier circuit to convert AC voltage into pulsating dc voltage
- \* It is used in clipper circuits to remove certain part of input ac signal.
- \* It is used in clamper circuits to shift the waveform to certain level.

## RECTIFIER:-

Rectifier is a circuit which is used to convert AC signal into pulsating dc signal.

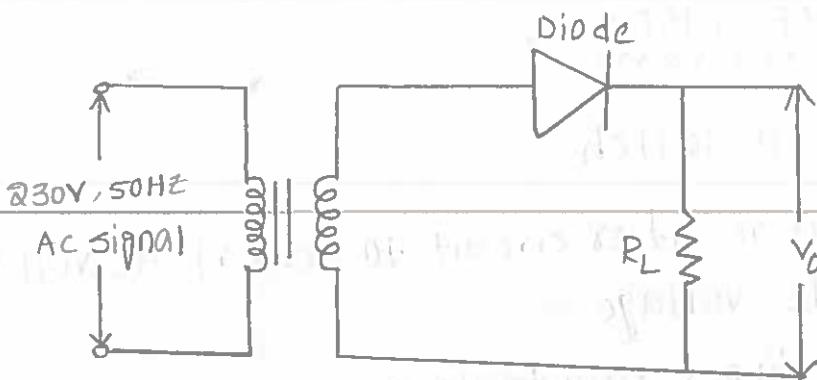


Rectifiers are Three types . They are

- \* Halfwave Rectifier
- \* Fullwave bridge Rectifier
- \* Fullwave center tapped Rectifier.

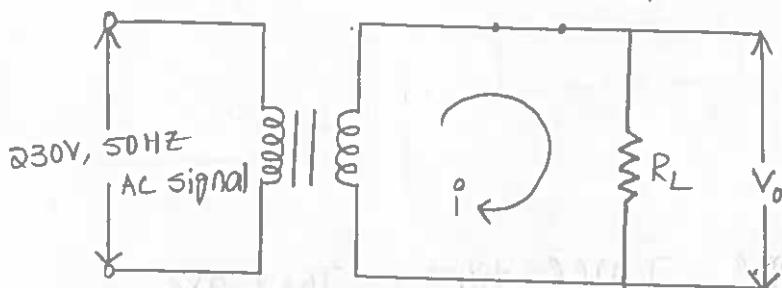
## HALFWAVE RECTIFIER:-

The halfwave rectifier circuit consist a step-down transformer and a diode in series with "RL".

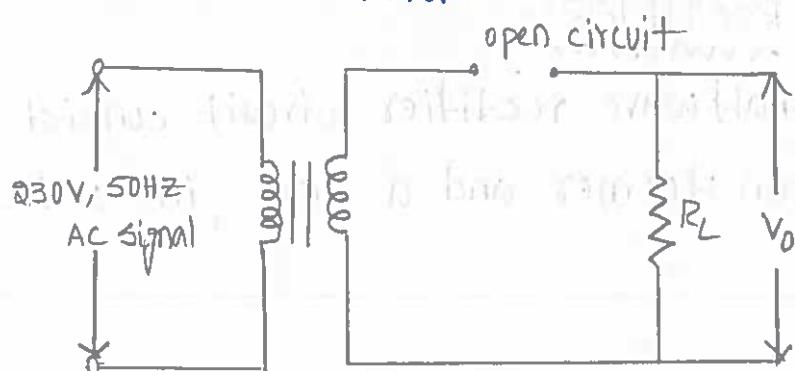


At 230 Volts Ac signal is given as a input to the primary side of a transformer. the transformer converts 230V Ac into desire lower level.

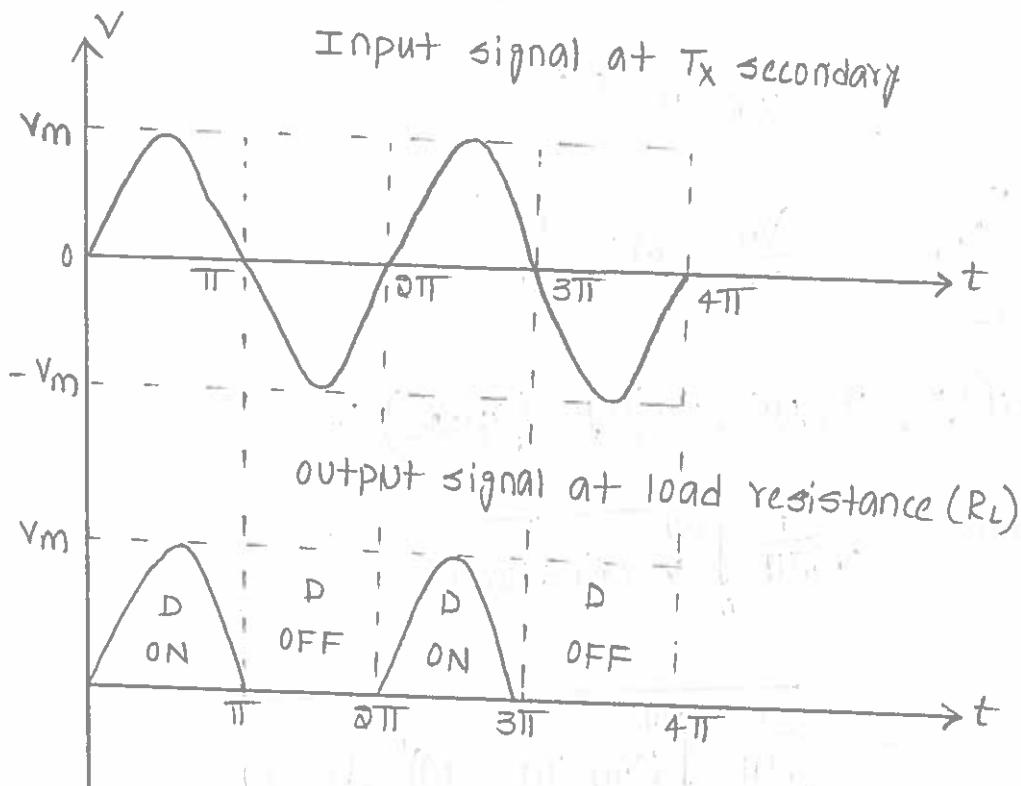
Assuming the diode is ideal during the positive half cycle diode "D" becomes forward bias and it act as a short circuit or closed switch. so the current flows in the circuit and output voltage produced acrossed load resistor i.e., that is positive half cycle.



During the Negative half cycle diode "D" becomes reverse bias and it act as a open circuit or open switch so NO current flows in the circuit and the output is "zero" across load resistor.



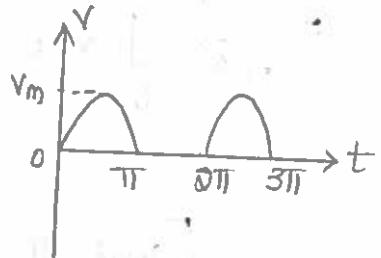
## WAVEFORM OF HALF WAVE RECTIFIER:-



AVERAGE VOLTAGE (or) DC VOLTAGE ( $V_{dc}$ ):-

$$V_{dc} = \frac{1}{2\pi} \int_0^{2\pi} v(t) d(\omega t)$$

$$v(t) = V_m \sin(\omega t)$$



$$V_{dc} = \frac{1}{2\pi} \int_0^{2\pi} V_m \sin(\omega t) d(\omega t)$$

$$= \frac{1}{2\pi} \left[ \int_0^{\pi} V_m \sin(\omega t) d(\omega t) + \int_0^{2\pi} 0 d(\omega t) \right]$$

$$= \frac{1}{2\pi} V_m \int_0^{\pi} \sin(\omega t) d(\omega t)$$

$$= -\frac{1}{2\pi} V_m \left[ \cos(\omega t) \right]_0^{\pi}$$

$$= -\frac{1}{2\pi} V_m [-1 - 1]$$

$$= +\frac{1}{2\pi} V_m (4)$$

$$V_{dc} = \frac{V_m}{\pi} \text{ (or)} \frac{I_m}{\pi}$$

RMS. voltage or AC. voltage. ( $V_{RMS}$ ) :-

$$V_{RMS} = \sqrt{\frac{1}{2\pi} \int_0^{\pi} v^2(t) d(\omega t)}$$

$$= \sqrt{\frac{1}{2\pi} \int_0^{\pi} (V_m \sin(\omega t))^2 d(\omega t)}$$

$$= \sqrt{\frac{1}{2\pi} \int_0^{\pi} V^2 m \sin^2 \omega t d(\omega t) + \int_0^{\pi} d(\omega t)}$$

$$= \sqrt{\frac{V_m^2}{2\pi} \int_0^{\pi} \sin^2 \omega t \cdot d(\omega t)} \quad \left[ \because \sin^2 \theta = \frac{1 - \cos 2\theta}{2} \right]$$

$$= \sqrt{\frac{V_m^2}{2\pi} \int_0^{\pi} \left( \frac{1 - \cos 2(\omega t)}{2} \right) d\omega t}$$

$$= \sqrt{\frac{V_m^2}{4\pi} \left[ \omega t - \frac{\sin 2(\omega t)}{2} \right]_0^{\pi}}$$

$$= \sqrt{\frac{V_m^2}{4\pi} [(0-\pi) - (0-0)]}$$

$$= \sqrt{\frac{V_m^2}{4\pi} \cdot \pi}$$

$$= \frac{V_m}{2}$$

$$\therefore V_{rms} = \frac{V_m}{2} \text{ (or)} \quad \frac{I_m}{2}$$

EFFICIENCY:-

It is defined as ratio of output dc power to the input ac power.

$$\eta = \frac{P_{dc}}{P_{ac}} \quad [P_{ac} = VI]$$

$$\therefore \eta = \frac{P_{dc}}{P_{ac}} \times 100 = V \cdot \frac{V}{R}$$

$$\therefore \eta = \frac{V^2_{rms}/R_L}{V^2_{rms}/R_L} \times 100 \quad \therefore P_{ac} = V_{rms}/R_L$$

$$= \frac{(V_m/\pi)^2}{(V_m/2)^2} \times 100$$

$$= \frac{V^2_{rms}/\pi^2}{V^2_{rms}/4} \times 100$$

$$= \frac{1/\pi^2}{1/4} \times 100$$

$$= \frac{4}{\pi^2} \times 100$$

$$\eta = 40.6\%$$

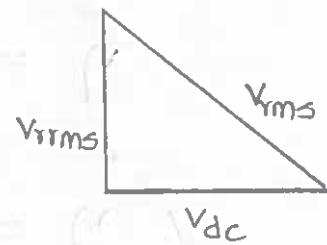
Halfwave Rectifier converts 40.6% of Ac signal into DC signal.

### RIPPLE FACTOR:-

It is the ratio of rms value of Ac component to the DC component in the rectifier output.

$$\Gamma = \frac{V_{rms}}{V_{dc}} \text{ (or) } \frac{I_{rms}}{I_{dc}}$$

$$\Gamma = \sqrt{\frac{V_{rms}^2 - V_{dc}^2}{V_{dc}^2}}$$



$$\Gamma = \sqrt{\frac{V_{rms}^2 - V_{dc}^2}{V_{dc}^2}}$$

$$V_{rms}^2 = V_{rms}^2 + V_{dc}^2$$

$$V_{rms} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

$$\Gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

(11)

Ripple factor for halfwave rectifier:-

$$\Gamma = \sqrt{\frac{(\sqrt{m}/\alpha)^2}{(\sqrt{m}/\pi)^2} - 1}$$

$$= \sqrt{\frac{m^2/4}{m^2/\pi^2} - 1}$$

$$= \sqrt{\frac{\pi^2}{4} - 1}$$

$$\boxed{\Gamma = 1.21}$$

PROBLEMS:-

In halfwave rectifier an AC voltage of peak value  $\alpha 4V$  is connected in series with silicon diode and load resistance of  $480\Omega$ . if the forward resistance of the diode is  $20\Omega$  find average load current & RMS value of load current

Given that:-

$$\text{PEAK value } (V_m) = \alpha 4V$$

$$R_L = 480\Omega$$

$$R_f = 20\Omega$$

$$I_{dc} = \frac{Im}{\pi}$$

$$I_{rms} = \frac{Im}{2}$$

$$V = IR$$

$$I = \frac{V}{R}$$

$$I_m = \frac{24}{480+80} = \frac{24}{500} = 0.048$$

$$I_m = 48 \text{ mA}$$

$$I_{dc} = \frac{0.048}{\pi} = 0.015$$

$$I_{dc} = 15 \text{ mA}$$

$$I_{rms} = \frac{0.048}{\sqrt{2}} = 0.024$$

$$I_{rms} = 24 \text{ mA}$$

Efficiency:-

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{I_{dc}^2 (R_L + R_f)}{I_{rms}^2 (R_L + R_f)}$$

$$= \frac{(0.015)^2 \times (500)}{(0.024)^2 \times (500)}$$

$$= \frac{0.1125}{0.288}$$

$$\eta = 40.6\%$$

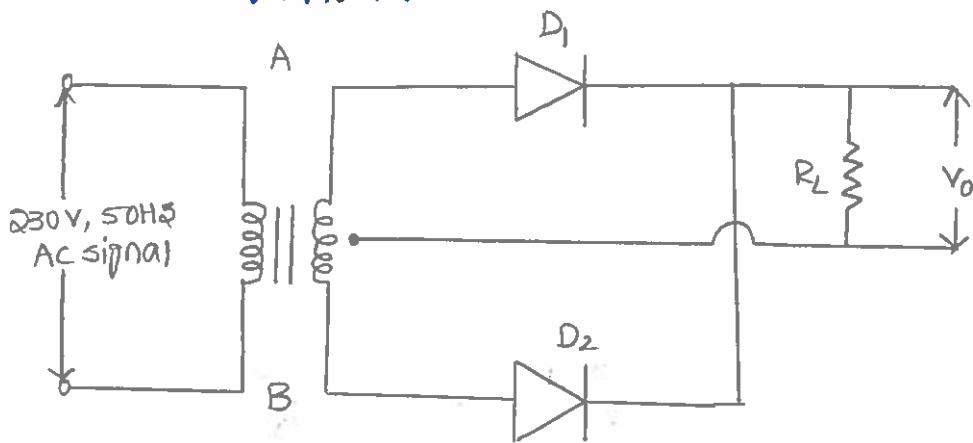
Ripple factor:-

$$\Gamma = \sqrt{\left(\frac{V_{rms}}{I_{dc}}\right)^2 - 1}$$

$$= \sqrt{\left(\frac{0.024}{0.015}\right)^2 - 1}$$

$$\Gamma =$$

## FULL WAVE RECTIFIER:-

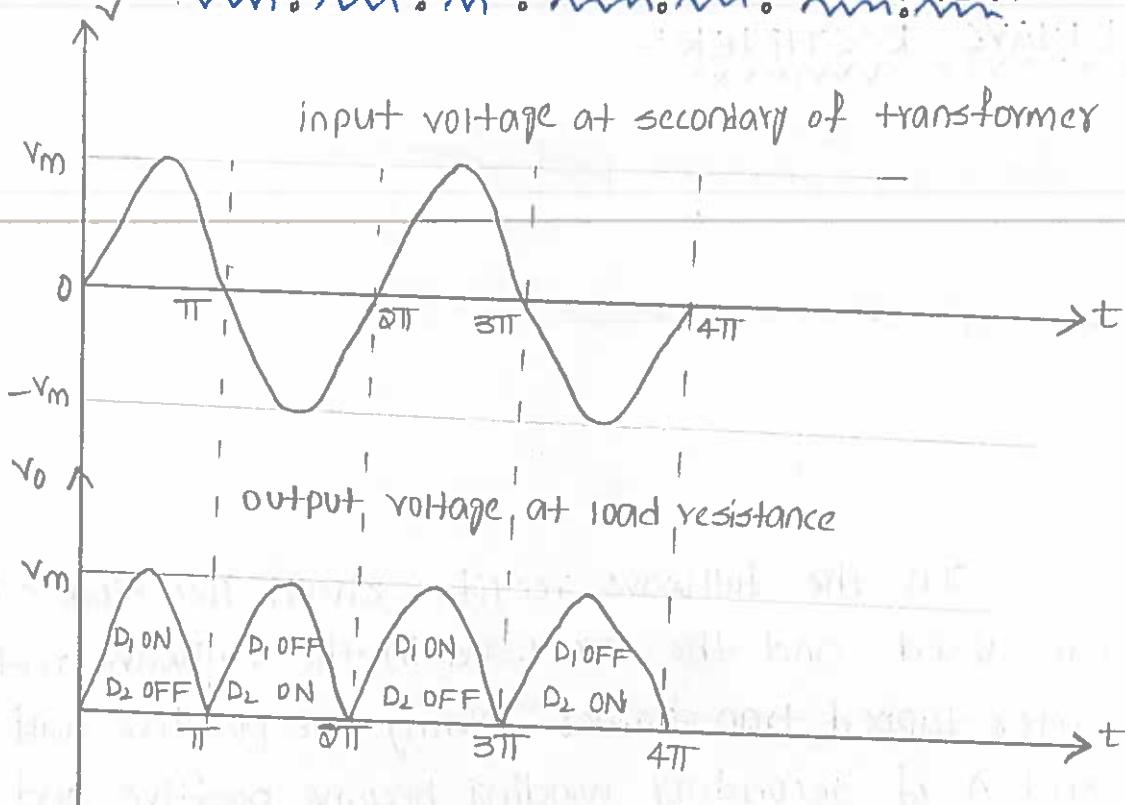


In the full wave rectifier circuit two diodes  $D_1$  and  $D_2$  are used, and the TX used in the full wave rectifier is center tapped transformer. During the positive half cycle the end A of secondary winding becomes positive and end B becomes negative. Due to this Diode  $D_1$  forward bias and diode  $D_2$  reverse bias. Therefore  $D_1$  is conducts and  $D_2$  does not conduct.

So, the output voltage produces load Resistor due to diode  $D_1$ .

During the Negative half cycle end A of secondary voltage become negative and end B become positive, so the diode  $D_1$  reverse bias. Diode  $D_2$  forward bias. Therefore diode  $D_1$  does not conduct and diode  $D_2$  conducts and the output produced across load resistor due to diode  $D_2$ .

## WAVEFORM OF FULLWAVE RECTIFIER! -



## DC VOLTAGE OR AVERAGE VOLTAGE! -

$$V_{dc} = \frac{1}{\pi} \int_0^{\pi} v(t) dt$$

$$V_{dc} = \frac{1}{\pi} \int_0^{\pi} V_m \sin(\omega t) d(\omega t)$$

$$= \frac{1}{\pi} \left[ \int_0^{\pi} V_m \sin(\omega t) d(\omega t) \right]$$

$$= \frac{1}{\pi} V_m \int_0^{\pi} \sin(\omega t) d(\omega t)$$

$$= \frac{1}{\pi} V_m \left[ \cos \omega t \right]_0^{\pi}$$

$$= \frac{1}{\pi} V_m [1 - 1]$$

$$= \frac{1}{\pi} V_m [-2]$$

$$V_{dc} = \frac{2V_m}{\pi}$$

RMS VOLTAge (OR) AC VOLTAge:-

$$V_{rms} = \sqrt{\frac{1}{\pi} \int_0^{\pi} v^2(t) d(wt)}$$

$$= \sqrt{\frac{1}{\pi} \int_0^{\pi} (V_m \sin wt d(wt))^2 dt}$$

$$= \sqrt{\frac{1}{\pi} \int_0^{\pi} V_m^2 \sin^2 wt d(wt)}$$

$$= \sqrt{\frac{V_m^2}{\pi} \int_0^{\pi} \sin^2 wt d(wt)}$$

$$\left[ \because \sin^2 \theta = \frac{1 - \cos 2\theta}{2} \right]$$

$$= \frac{V_m^2}{\pi} \sqrt{\int_0^{\pi} \left( \frac{1 - \cos 2wt}{2} \right) d(wt)}$$

$$= \sqrt{\frac{V_m^2}{2\pi} \left( wt - \frac{\sin 2wt}{2} \right) \Big|_0^{\pi}}$$

$$= \sqrt{\frac{V_m^2}{2\pi} (\pi - 0) - (0 - 0)}$$

$$= \sqrt{\frac{V_m^2}{2\pi}} (\pi)$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

## EFFICIENCY!-

$$\eta = \frac{P_{dc}}{P_{ac}}$$

$$\therefore \eta = \frac{P_{dc}}{P_{ac}} \times 100$$

$$\therefore \eta = \frac{P_{dc}}{P_{ac}} \times 100$$

$$\therefore \eta = \frac{V^2_{dc}/RC}{V^2_{rms}/RL} \times 100$$

$$= \frac{(\Omega V_m / \pi)^2}{(V^2 m / \sqrt{\Omega})^2} \times 100$$

$$= \frac{4r^2m^2/\pi^2}{V^2m^2/\Omega}$$

$$= \frac{4/\pi^2}{1/\Omega}$$

$$= \frac{4}{\pi^2} \times \frac{\Omega}{1}$$

$$= \frac{8}{\pi^2}$$

$$= \frac{8}{\pi^2} \times 100$$

$$\boxed{\eta = 81 \cdot \Omega}$$

## RIPPLE FACTOR:-

$$\Gamma = \frac{V_{rms}}{V_{dc}} \text{ (or)} \frac{I_{rms}}{I_{dc}}$$

$$\Gamma = \sqrt{\frac{(V_m/\sqrt{2})^2}{(\Delta V_m/\pi)^2} - 1}$$

$$= \sqrt{\frac{V_{rms}^2/2}{4V_{rms}^2/\pi^2} - 1}$$

$$= \sqrt{\frac{1/2}{4/\pi^2} - 1}$$

$$= \frac{1}{2} \times \frac{\pi^2}{4}$$

$$= \sqrt{\frac{\pi^2}{8} - 1}$$

$$\boxed{\Gamma = 0.48}$$

## PROBLEMS:-

A diode whose internal resistance is  $20\Omega$  is to supply power to a  $100\Omega$  load from  $110$  Volts RMS source of supply. determine peak load current, dc load current, ac load current.

Given that:-

$$R_i = 20\Omega$$

$$R_L = 100\Omega$$

$$V_{rms} = 110V$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$V_m = 110 \times \sqrt{2}$$

$$V_m = 155.5V$$

$$V = IR$$

$$I_m = \frac{V_m}{R} = \frac{110 \times \sqrt{2}}{120} = \frac{155.5}{120} = 1.29A$$

$$I_m = 1.29A$$

$$I_{dc} = \frac{\alpha I_m}{\pi} = \frac{\alpha \times 1.29}{3.14} = \frac{0.58}{3.14} = 0.18A$$

$$I_{dc} = 0.18A$$

$$I_{ac} = \frac{I_m}{\sqrt{2}} = \frac{1.29}{\sqrt{2}} = 0.91A$$

$$I_{ac} = 0.91A$$

In halfwave rectifier an ac voltage of peak value 120V is connect in series with silicon diode and load resistance is  $480\Omega$  and forward resistance diode is  $40\Omega$  find average load current and RMS value of load current

Given that:-

$$V_m = 120V$$

$$R_L = 480\Omega$$

$$R_f = 40\Omega$$

$$I_{dc} = \frac{I_m}{\pi}; I_{rms} = \frac{I_m}{\alpha}$$

$$V = IR$$

$$I_m = \frac{V_m}{R} = \frac{1\Omega}{480+40} = \frac{1\Omega}{520} = 0.002A$$

$$I_m = 0.002A$$

$$I_{dc} = \frac{0.002}{3.14} = 7.34 \times 10^{-3} A$$

$$I_{dc} = 7.34 \times 10^{-3} A$$

$$I_{rms} = \frac{0.002}{\sqrt{2}} = 0.0011A$$

$$I_{rms} = 0.0011A$$

A Full wave rectifier having peak inverse voltage 30V and having Load Resistance  $480\Omega$  if the forward resistance in the diode is  $20\Omega$  find ac current and dc current , efficiency and Ripple factor.

Given that:-

$$\text{peak inverse value} = 30V = \frac{30}{2} = 15V$$

$$R_L = 480\Omega$$

$$R_f = 20\Omega$$

$$V_m = \frac{30}{2}$$

$$V_m = 15V$$

$$I_m = \frac{V_m}{R} = \frac{15}{500} = 0.03$$

$$I_m = 0.03 A$$

$$I_{ac} = \frac{I_m}{\sqrt{2}} = \frac{0.03}{\sqrt{2}} = 0.021 A$$

$$I_{ac} = 0.021 A$$

$$I_{dc} = 0.019 A$$

$$I_{dc} = \frac{\omega I_m}{\pi} = \frac{\omega (0.03)}{\pi} = \frac{0.06}{3.14}$$

$$I_{dc} = 0.019 A$$

Efficiency:-

$$\eta = \frac{P_{dc}}{P_{ac}} \times 100$$

$$\eta = \frac{I^2_{dc} (R_L + R_i)}{I^2_{ac} (R_L + R_i)} \times 100$$

$$\eta = \frac{(0.019)^2}{(0.021)^2} \times 100$$

$$\eta = 81.8$$

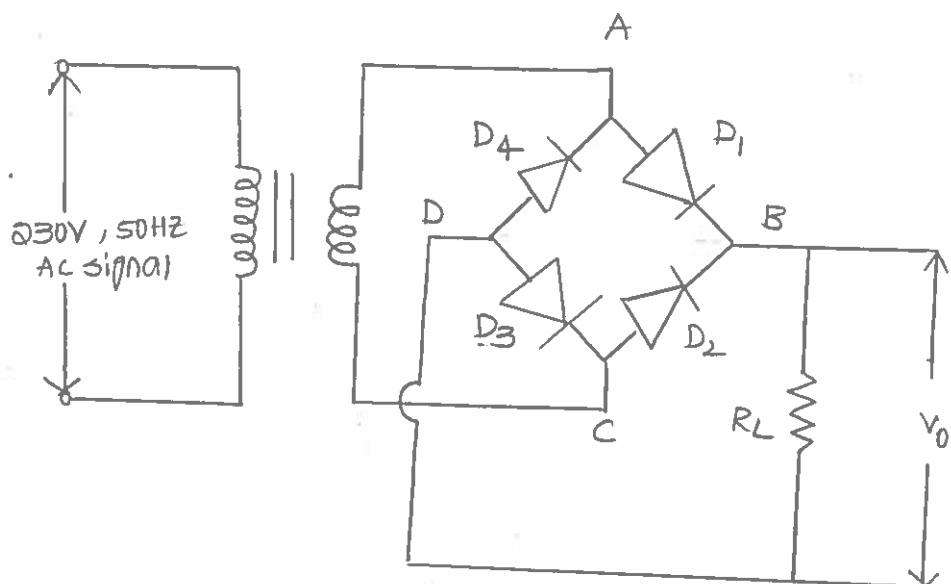
Ripple factor:-

$$\Gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

$$= \sqrt{\frac{(0.021)^2}{(0.019)^2} - 1}$$

$$\boxed{\Gamma = 0.4}$$

BRIDGE RECTIFIER:-

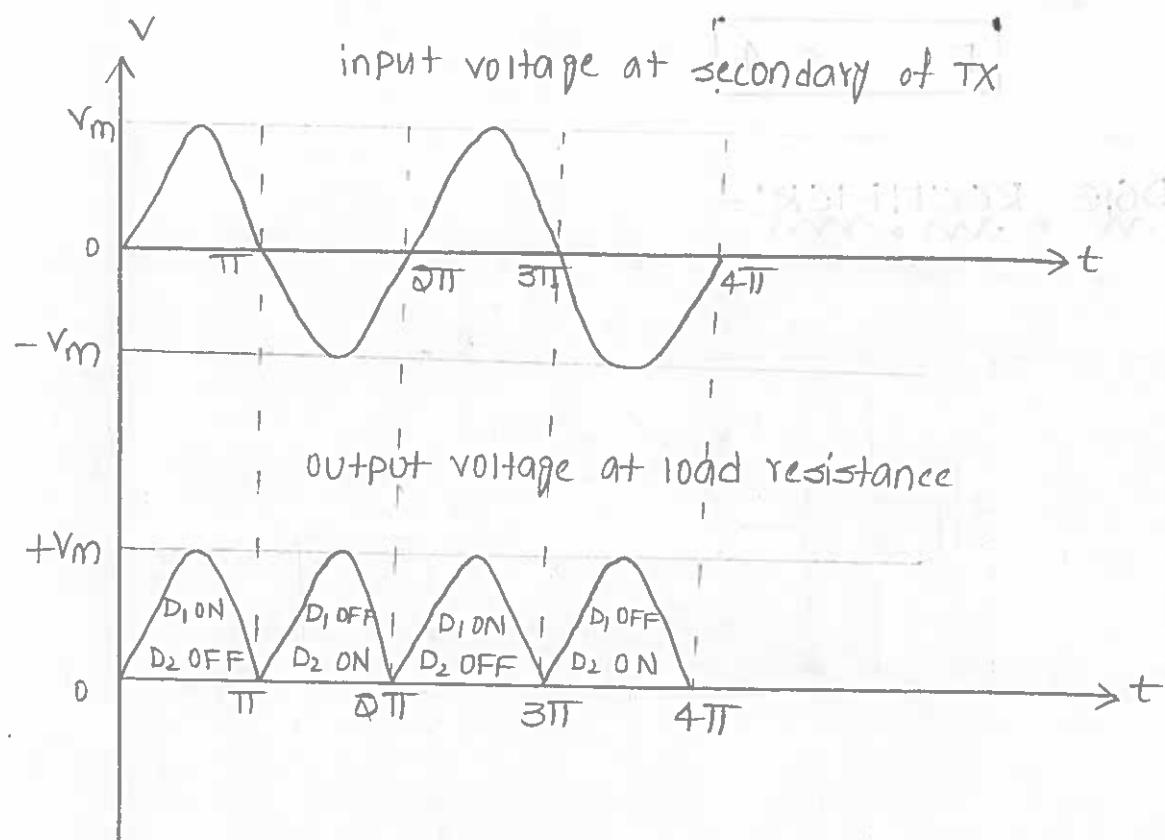


The bridge rectifier circuit consists of step down transformer, 4 diodes  $D_1, D_2, D_3, D_4$  and load Resistor  $R_L$ . 4 diodes  $D_1, D_2, D_3, D_4$  form a bridge in the circuit.

During the positive half cycle diode  $D_1$  and  $D_3$  are forward bias and  $D_2$  &  $D_4$  are reverse bias. so the diode  $D_1, D_3$  are act as a short circuit. Hence whereas  $D_2$  &  $D_4$  are act as a open circuit.

Hence the current flows through the load resistor  $R_L$  through diode  $D_1$  &  $D_3$ .

During Negative half cycle  $D_2$  &  $D_4$  are forward bias  $D_1$  &  $D_3$  are Reverse bias the diode  $D_2$  &  $D_4$  are act as short circuit . Where  $D_1$  &  $D_3$  are act as open circuit . Hence the current flows through load resistor  $R_L$  through diode  $D_2$  &  $D_4$ .



### PEAK INVERSE VOLTAGE:-

The Maximum reverse bias voltage that the diode can with stand without entering into the breakdown region is known as peak inverse voltage.

For halfwave rectifier peak inverse is  $V_m$

$$PIV = V_m$$

peak inverse voltage for center tapped full wave rectifier is  $2V_m$

$$PIV = 2V_m$$

Peak inverse voltage for bridge rectifier is  $V_m$

$$PIV = V_m$$

~~Advantages of Halfwave rectifier:-~~

- \* simple circuit

- \* low cost

~~Disadvantages of Halfwave rectifier:-~~

- \* less efficiency (40.6%)

- \* High Ripple factor (1.21)

~~Advantages of Fullwave rectifier:-~~

- \* More efficiency compared to halfwave rectifier (81.2%)

- \* Low Ripple factor (0.48)

~~Disadvantages of Fullwave rectifier:-~~

- \* circuit is bulky due to center tapped transformer

- \* High cost

- \* peak inverse voltage is high.

~~Bridge rectifier Advantages:-~~

- \* simple circuit due to no center tapped transformer

- \* peak inverse voltage is less.

~~FILTERS:-~~

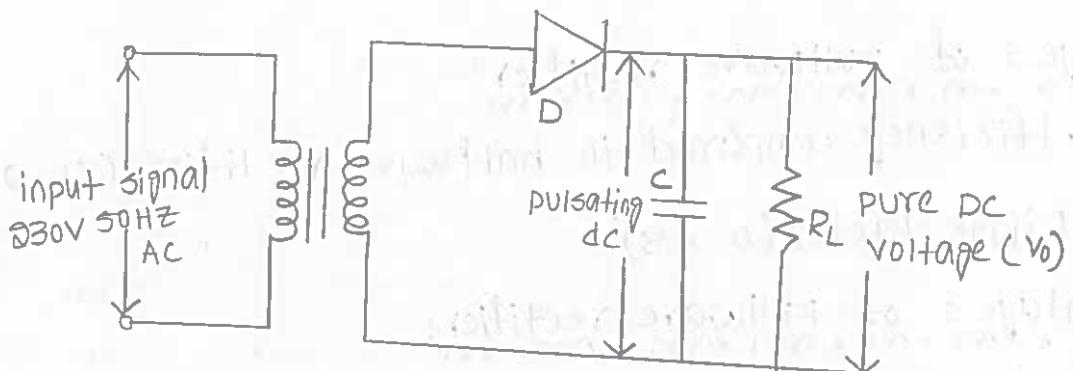
Filters are used to convert pulsating dc into pure dc.

## Different types of filters:-

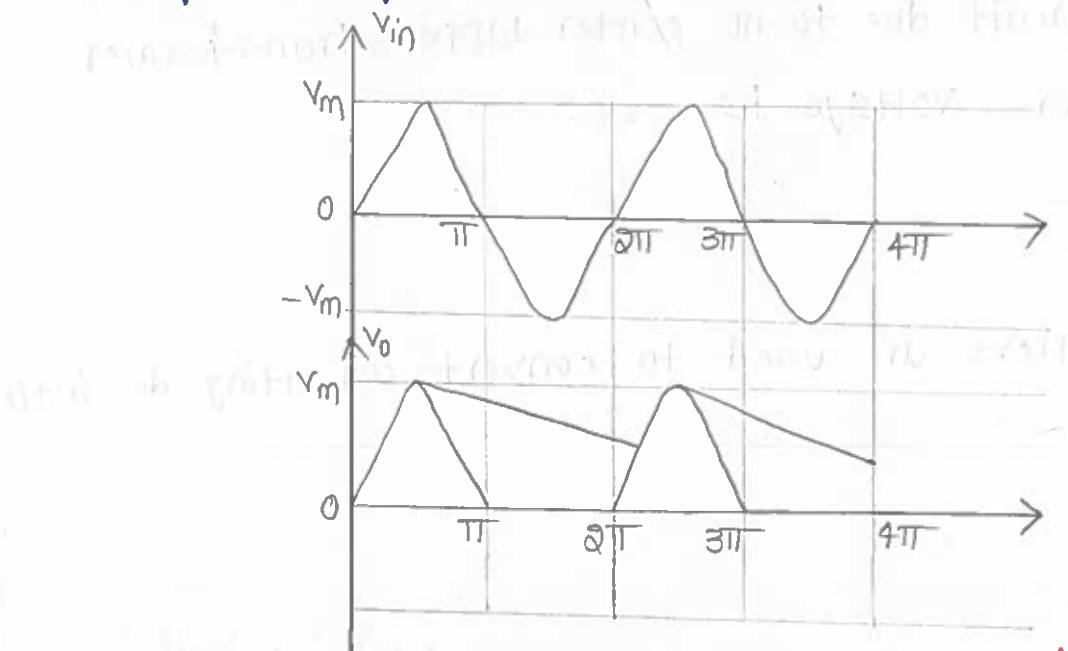
- \* capacitor filter
- \* inductor filter
- \* LC filter
- \* CLC filter (or) pie section filter.

## CAPACITOR FILTER:-

The capacitor Allow the AC signal and opposes the flow of dc signal this property is utilized for converting pulsating dc into pure dc.



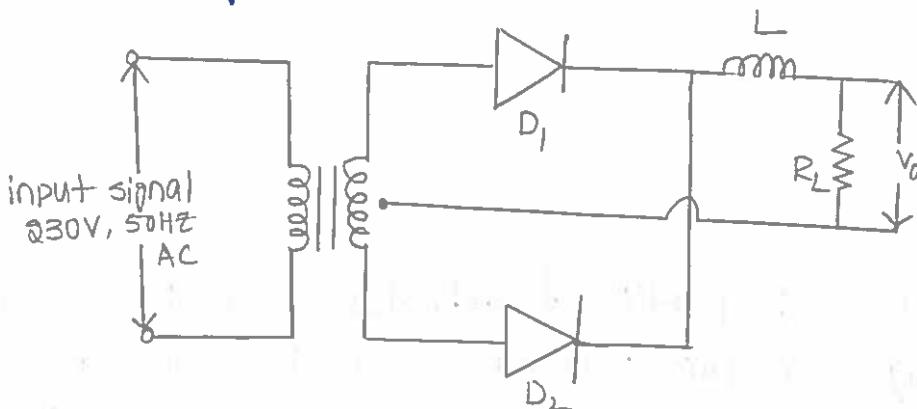
During the positive half cycle Diode (D) becomes forward bias and the current flows through the circuit so the capacitor charges to the maximum voltage ( $V_m$ ) during the negative halfcycle Diode (D) becomes reverse bias so the capacitor disconnect from the circuit. hence the capacitor discharges through the load resistor.



## (8)

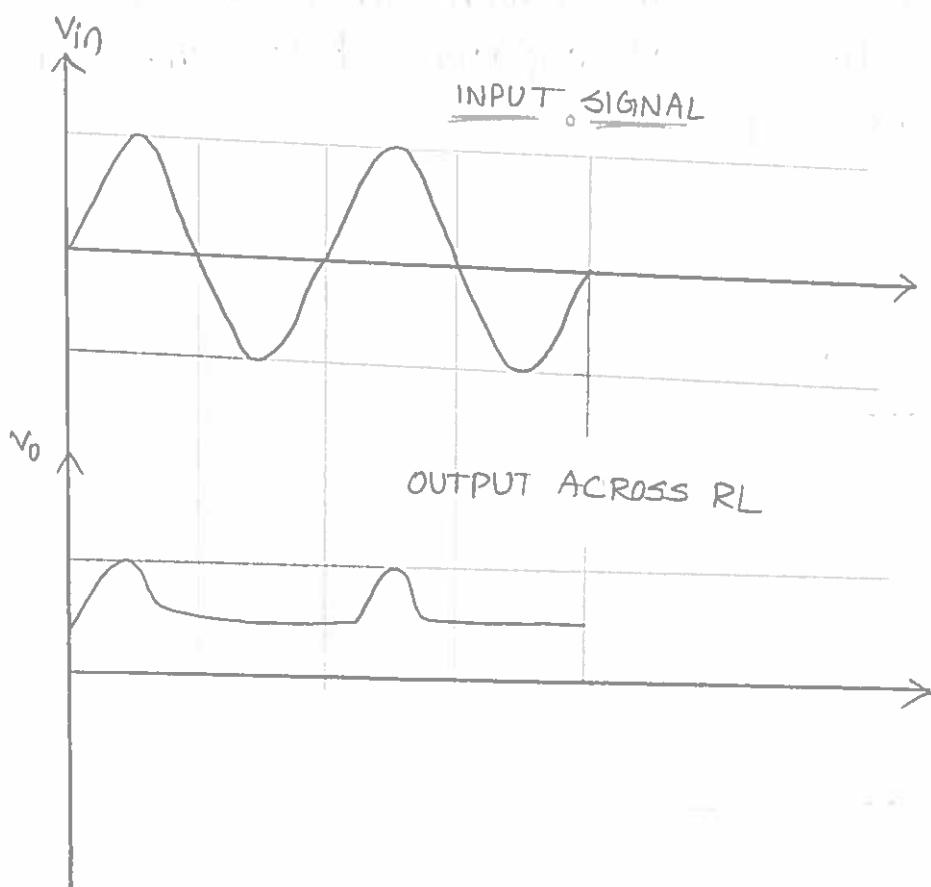
### INDUCTOR FILTER

Basic property of inductor is it does not allow sudden changes in the current or it does not allow ac signal. and it allows dc component this property is used to convert pulsating dc to pure dc.

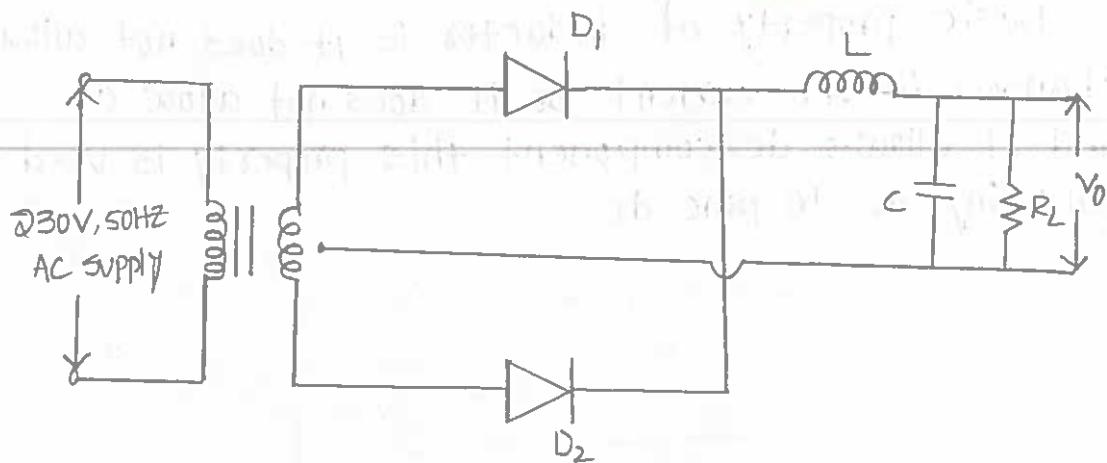


The output across the rectifier contains both ac component & dc component.

Which is applied to the inductor filter. The inductor filter oppose the ac component and allows only dc component to the output. so the output across load resistor is pure dc.

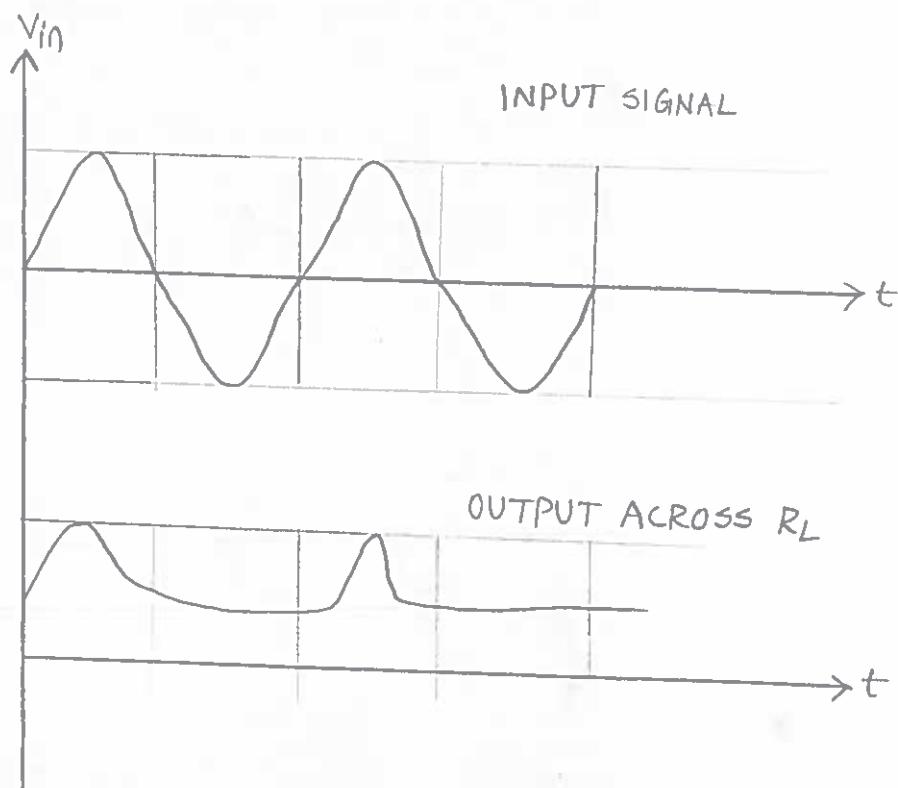


## LC FILTER OR L SECTION FILTER



Basic property of inductor is it doesn't allow sudden changes in the current or it does not allow AC signal and it allows DC component. This property is used to convert pulsating DC to pure DC.

The output across the rectifier contains both AC and DC components which is applied to the input of inductor filter oppose the AC and allows DC to the capacitor. The capacitor which allows AC to the ground and blocks the DC at capacitor filter. The output at load Resistor is pure DC.



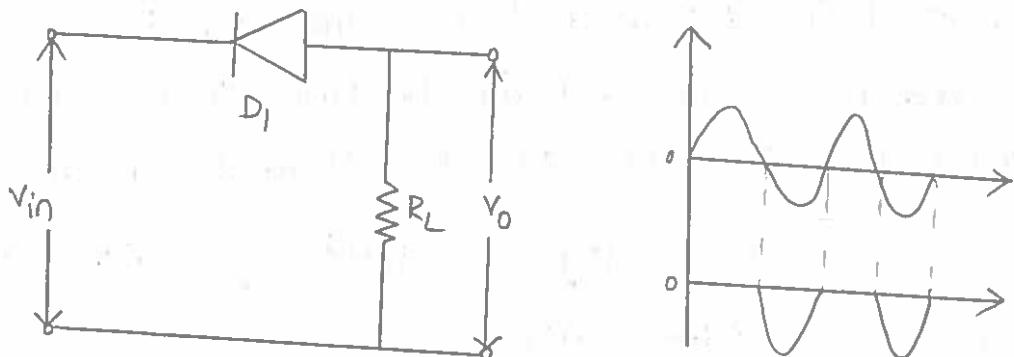
## CLIPPER:-

Clipper is used to remove certain portion of input signal.

### TYPES OF CLIPPERS:-

- \* Series positive clipper
- \* Series Negative clipper
- \* Parallel positive clipper
- \* Parallel Negative clipper.

### SERIES POSITIVE CLIPPER:-



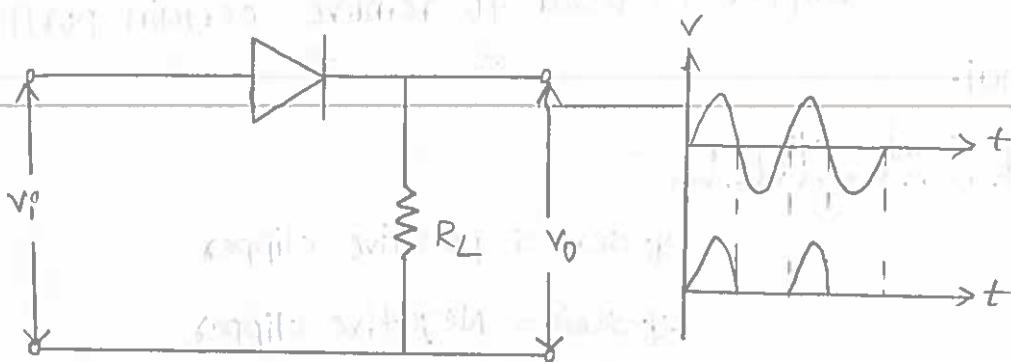
In series clipper the diode is connected in series between input and output terminals.

During positive half cycle diode becomes reverse bias. The circuit become short circuit. The current at the load resistance the current does not flow in the circuit.

During Negative half cycle diode becomes forward bias. The circuit become open circuit.

The output of series positive clipper contains only negative half cycles.

series . Negative . clipper! -



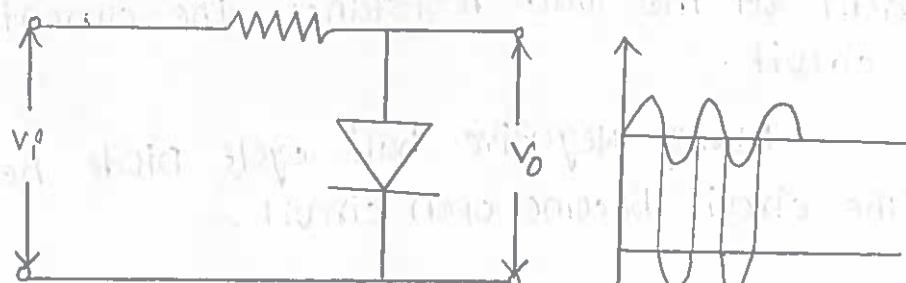
In series clipper the Diode is connected in series between input and output terminals.

During the positive half cycle the diode is connected in forward bias. The circuit becomes forward bias. The circuit become short circuit. The current will produce at the Load Resistor.

During Negative half cycle . The diode become reverse bias . The circuit become open circuit.

The output of series Negative clipper contains negative half cycles.

parallel . positive . clipper! -



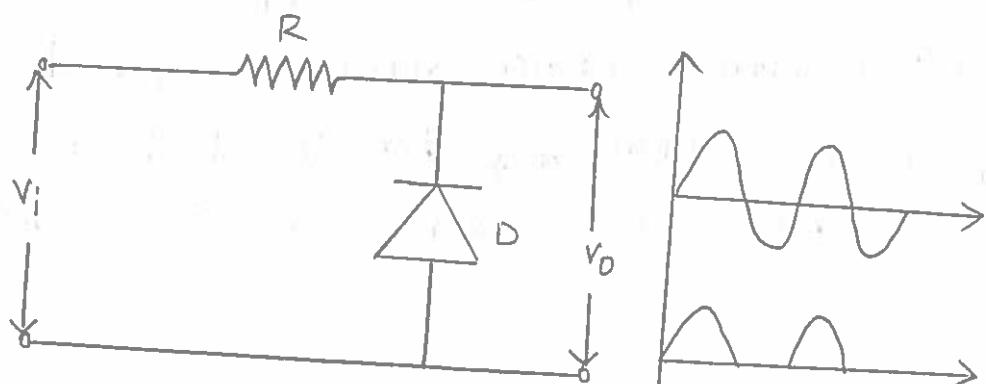
In parallel clipper diode is connected in parallel between input and output.

During the positive half cycle Diode "D" becomes forward bias and it is replaced with short circuit. So current flows in the circuit and total positive voltage drop at the Resistor hence output voltage across diode is zero.

During the Negative half cycle Diode "D" becomes reverse bias and it is replaced with open circuit. So NO current flows in the circuit and total negative voltage drop across diode hence the output voltage across the diode is Negative halfcycle.

In the parallel positive clipper only negative half cycles appeared at the output.

parallel. Negative. clipper! -

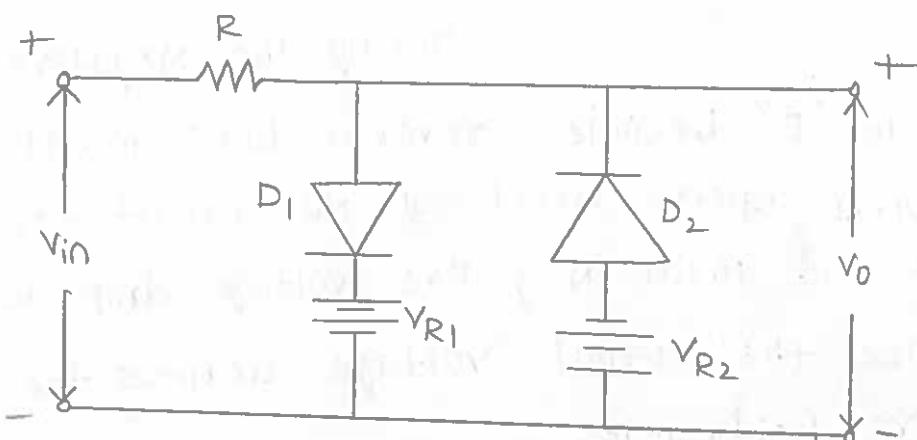


In parallel clipper the Diode 'D' is connected in parallel between input and output.

During the positive half cycle diode "D" becomes reverse bias and it is replaced with open circuit. So current does not produce in the circuit.

During the negative half cycle diode 'D' becomes forward bias and so current flows in the circuit.

clipping at two independent levels:-



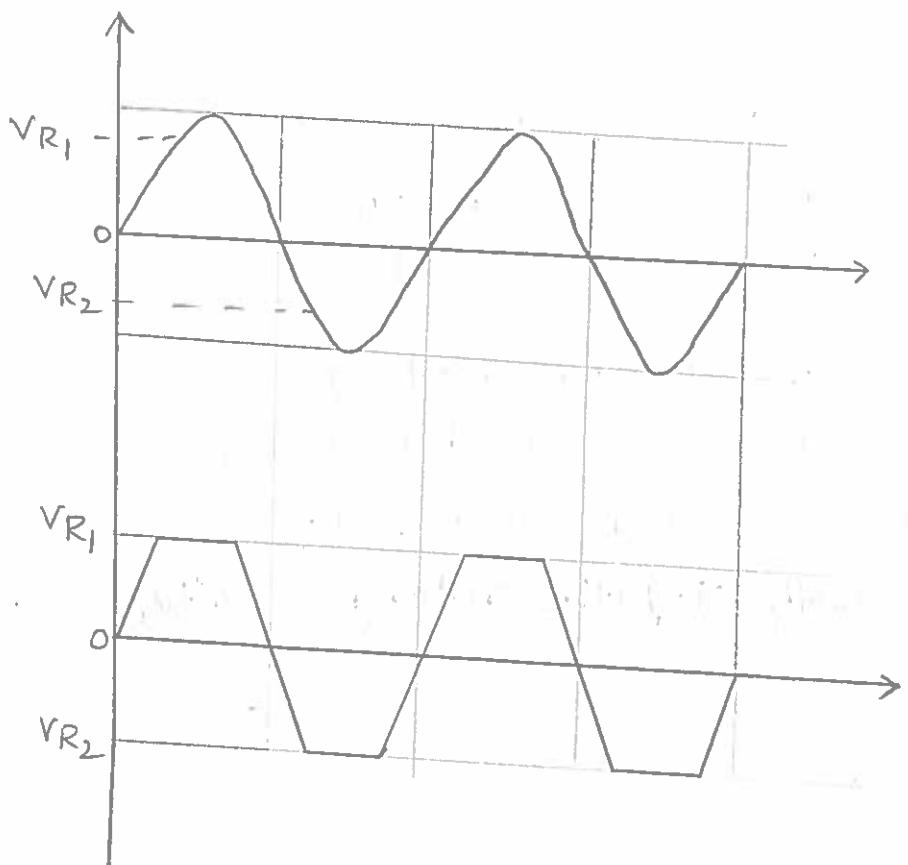
clipping can be achieve either above or below certain reference levels using series or shunt clippers. Diode clippers can also be used in pairs to achieve clipping at two independent levels.

Let the diode  $D_1$  and  $D_2$  connected in parallel with reference voltages  $V_{R1}$  and  $V_{R2}$ . When  $V_{in}$  is less than  $V_{R2}$  then the diode  $D_2$  becomes forward bias and  $D_1$  becomes reverse bias so the output voltage  $V_o = V_{R2}$ .

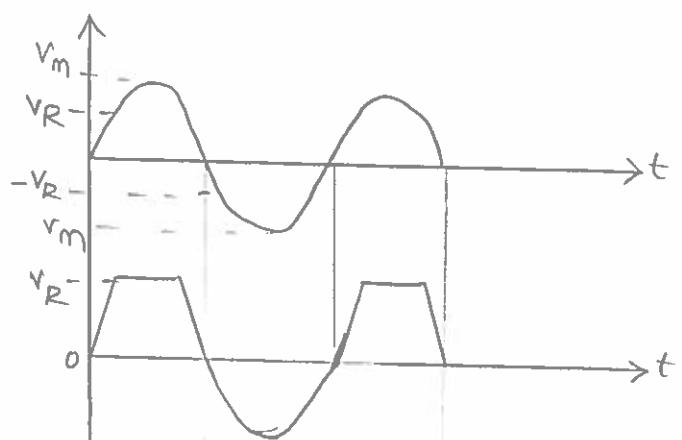
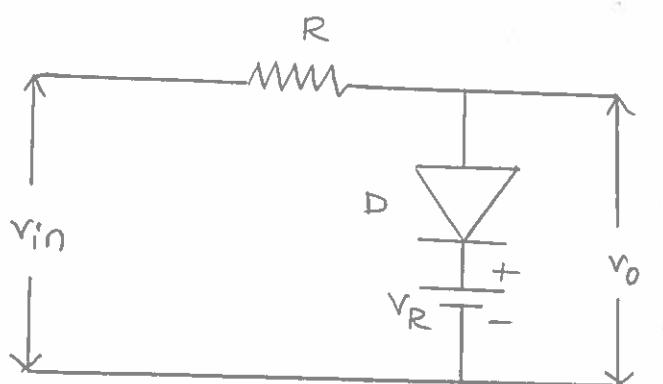
When  $V_{R2}$  less than  $V_o$  less than  $V_{R1}$  then the both diodes  $D_1$  and  $D_2$  becomes reverse bias and the output voltage is equal to input voltage  $V_o = V_{in}$ .

(21)

When  $v_i$  greater than  $v_{R1}$  then the diode  $D_1$  forward bias and diode  $D_2$  becomes reverse bias so the output voltage  $v_o = v_{R1}$ .



Shunt clipper with positive reference voltage:-

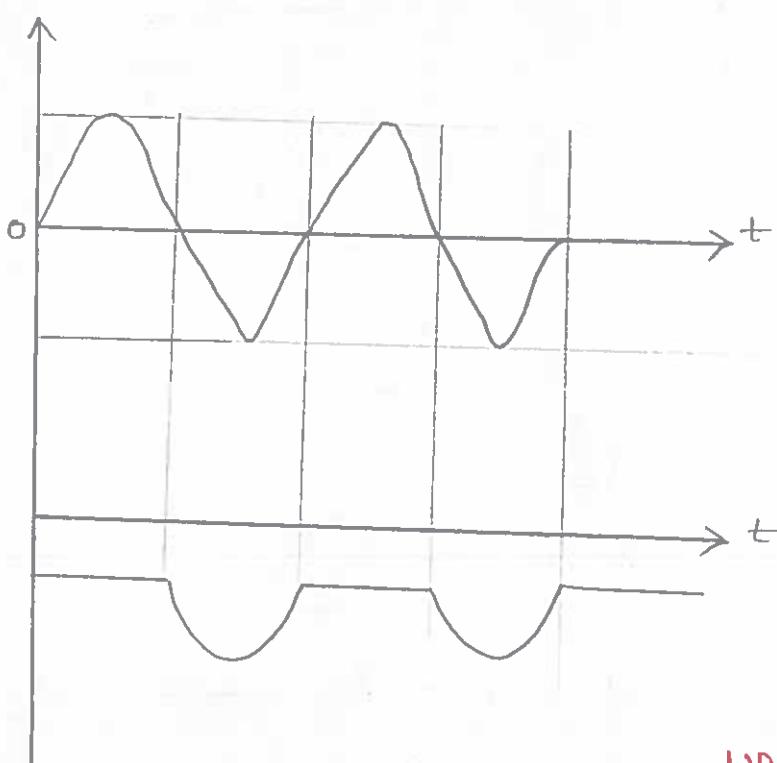
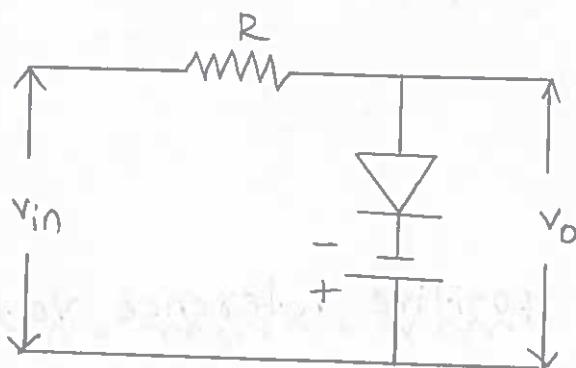


During the positive half cycle when  $V_{in}$  less than  $V_R$  Diode "D" becomes reverse bias and it is replaced with open circuit so the output voltage is equal to input voltage.

When  $V_{in}$  greater than  $V_R$  Diode "D" becomes forward bias and it is replaced with short circuit so the output is equal to reference voltage  $V_R$ .

During the Negative half cycle Diode "D" becomes reverse bias and it is replaced with open circuit so the output voltage is equal to input voltage.

shunt. clipper. with. Negative. reference. voltage:-



(22)

During positive half cycle diode "D" becomes forward bias. so it is replaced with short circuit. so the output voltage equal to  $V_o$  is equal to  $V_R$ .

During negative half cycle when  $V_{in}$  is less than  $V_R$  then the diode "D" forward bias. so it is replaced with short circuit. so the output voltage is  $V_o$  equal to  $-V_R$ .

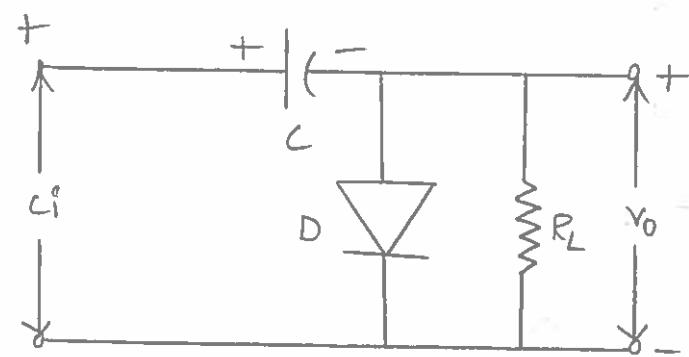
When  $V_{in}$  greater than  $V_R$  then the diode "D" reverse bias so it is replaced with open circuit so the output voltage is equal to input voltage.

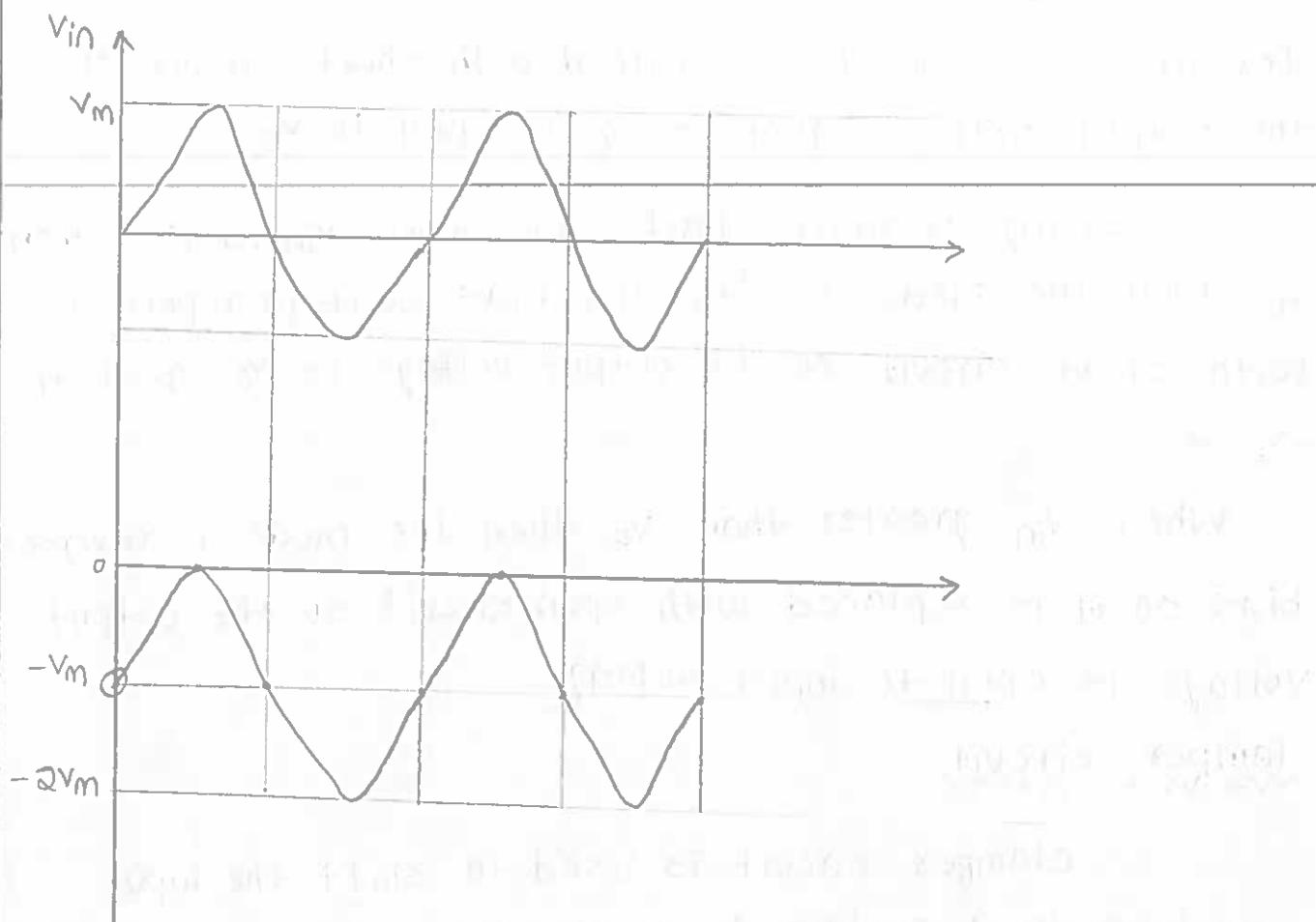
Clamper circuit:-

Clamper circuit is used to shift the input waveform to a certain dc level. There are two types of clamper circuit.

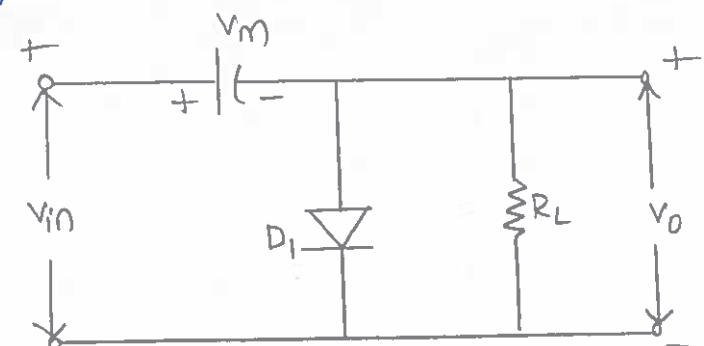
- \* Negative clamper circuit
- \* Positive clamper circuit.

Negative clamper circuit:-





Negative clapper circuit consist capacitor ideal diode and load resistor  $R_L$ . consider sinusoidal input having maximum voltage  $V_m$ . During the positive half cycle diode "D" becomes forward bias and capacitor charges to the maximum voltage  $V_m$  and output voltage is zero.



$$-V_o + V_m + V_o = 0$$

$$V_o = V_{in} - V_m$$

When input voltage is zero then  $v_o = -v_m$

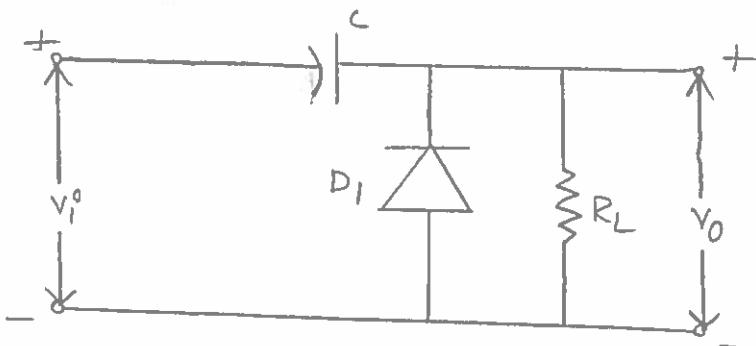
When input voltage is  $v_m$  there output voltage is zero.

When input voltage is  $-v_m$  then

$$v_o = -\bar{v}_m$$

In Negative clamping circuit Negative DC level introduced in the output waveform

positive clamping circuit:-



positive clamping circuit consists of capacitor, ideal diode and load resistor  $R_L$ . Consider sinusoidal input having maximum voltage  $v_m$ . During the positive half cycle diode "D" becomes reverse bias and capacitor charges to the maximum voltage  $v_m$  and output waveform.

In positive clamping circuit positive DC level introduced in the output waveform.

