B.Tech I Year

Regular Course Handbook

Subject Name: Fundamental of Electronics Engg. (Unit-1)

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B. Tech I Year [Subject Name: Emerging Domains Electronics Engineering]

UNIT-I (KEC-101/201T)

SEMICONDUCTOR DIODE AND APPLICATION

Topics to be Covered

- **Semiconductor Diode:**
  - Depletion layer.
  - V-I characteristics, ideal and practical Diodes, Diode Equivalent Circuits.
  - Zener Diodes breakdown mechanism (Zener and avalanche).
- **Diode Application:**
  - Diode Configuration, Half and Full Wave rectification, Clippers.
  - Clampers, Zener diode as shunt regulator, Voltage-Multiplier Circuits.
- **Special Purpose two terminal Devices:**
  - Light-Emitting Diodes, Photo Diodes.
  - Varactor Diodes, Tunnel Diodes, Liquid-Crystal Displays.

Classification of materials :- materials are classified in three different categories :-

i) metal or conductor धातु / कंडक्टर

ii) Semiconductor - अर्धचालक

iii) Insulator - इन्सुलेटर

Classification of semiconductor :- semi-conductors are classified in two categories

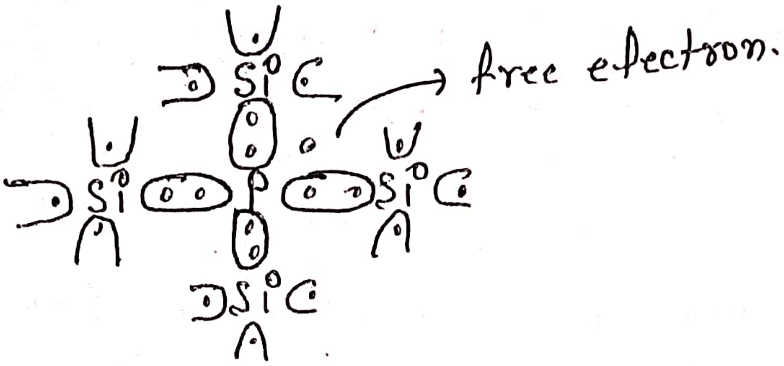
i) Intrinsic semiconductor :- A semi conductor in pure form is called intrinsic semi-conductor
आन्तरिक अर्धचालक

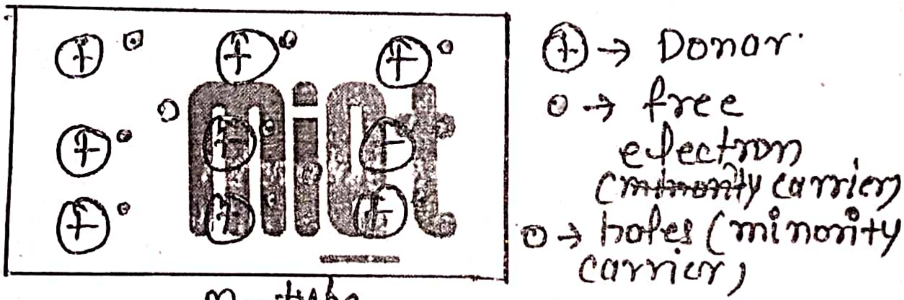
ii) Extrinsic semiconductor :- An intrinsic semi conductor is converted into extrinsic semiconductor by adding impurities. The process of adding impurities to a semi-conductor is called doping and the impure semiconductor is called extrinsic semiconductor.
वाह्य अर्धचालक

Depending on the type of impurity added, extrinsic semiconductor are further classified as :

a) n type - Semiconductor :- when a pentavalent impurity is added in pure semiconductor, the resulting semiconductor is n-type. It has electrons as majority carrier and holes as
अशुद्ध

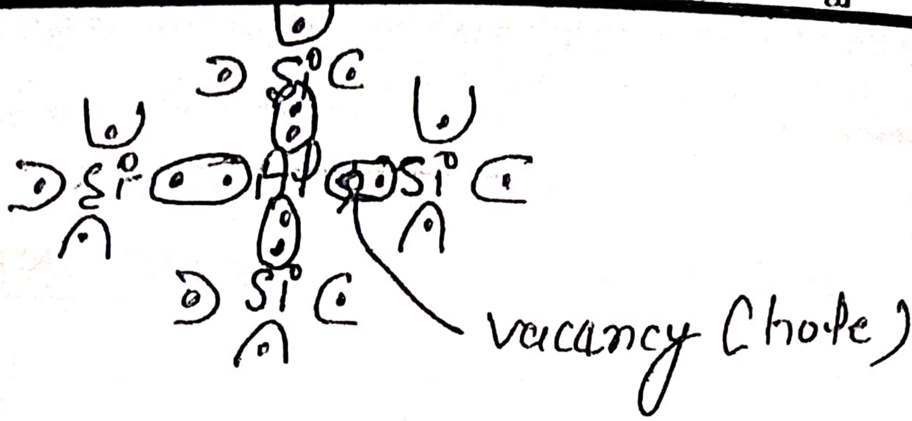
minority carrier. Here pentavalent impurity (such as P, As, Sb) provide charge carrier (e^-) for conduction and impurity is converted in to positive ion known as donar atom.

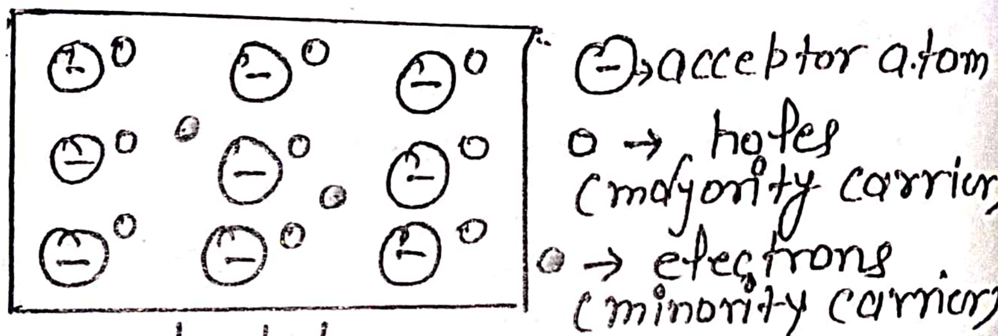




n-type

(ii) p-type :- when trivalent impurity is added in pure semiconductor, the resulting semiconductor is p-type semiconductor. It has hole as majority carrier and electron as minority carriers. Here trivalent impurity (such as (Al, B, Ga) provide charge carrier (hole) for conduction and impurity is converted into negative ion known as acceptor atom.





p-type

Ques 7: Differentiate between N-type and p-type semiconductor (2016-17)

Ans:

N type	p-type
i) Penta-valent impurities such as P, As, Sb are added.	Trivalent impurities such as (Al, B, Ga) are added.
(ii) impurities are called donar atom.	impurities are called acceptor atom.
(iii) majority carrier are electron and minority carrier are holes	majority carrier are holes and minority carrier are electrons
(iv) the donar energy level is close to conduction band.	The acceptor energy level is close to valence band

Imp
Ques 2:- Explain the effect of temperature on conductivity of semiconductor. (2015-16)

Ans:- i) At low temperature :-
- valence band is completely filled.
- conduction band is completely empty.
- so at very low temperature semiconductor behaves as an insulator ie conductivity is zero

ii) At room temperature :-
- the valence band is partially filled
- the conduction band is also partially filled.
- the energy gap between conduction band and valence band is narrow. As temperature increases conductivity of semiconductor increases.

Imp
Ques 3:- What do you mean by doping? Describe it's need.

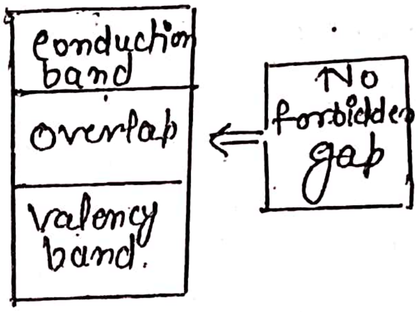
Ans:- Doping is the process of adding impurities to intrinsic semiconductor. Trivalent and pentavalent atoms are used for doping. When trivalent impurities are added then it becomes p type semiconductor. When pentavalent impurities are added then it becomes n type semiconductor.

Need of doping:- Doping is done to increase the conductivity of semiconductor devices. Doping creates extra holes or extra electrons to increase the flow of currents. So conductivity of intrinsic semiconductor increases.

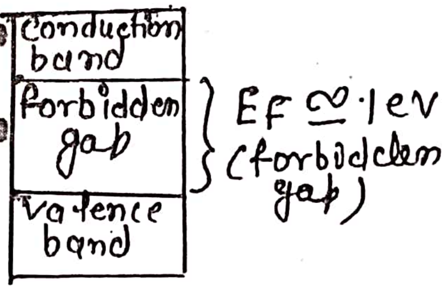
Que 4 :- classify the materials ~~wth~~ with help of energy band. (2016-17)

Ans: Based on width of forbidden gap materials are broadly classified as :-

i) conductor :- (metal) : In conductor there is no gap between valence and conduction band. Due to zero forbidden gap electrons are available in the conduction band at low temperature. Conductor allow electric current to pass.
Ex :- copper, Alluminium etc.

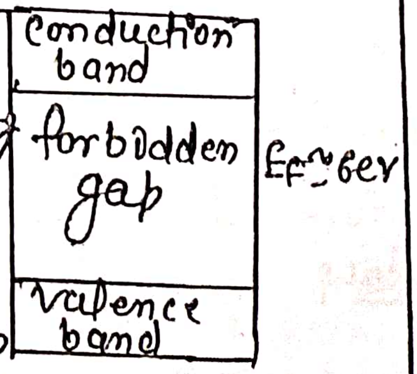


ii) Semiconductor :- semiconductor are those materials whose conductivity lies in between conductor and insulator. In semiconductor there is a gap of around 1ev between valence band and conduction band.



for Si forbidden gap Ef = 1.1ev
for Ge forbidden gap Ef = 0.7ev.

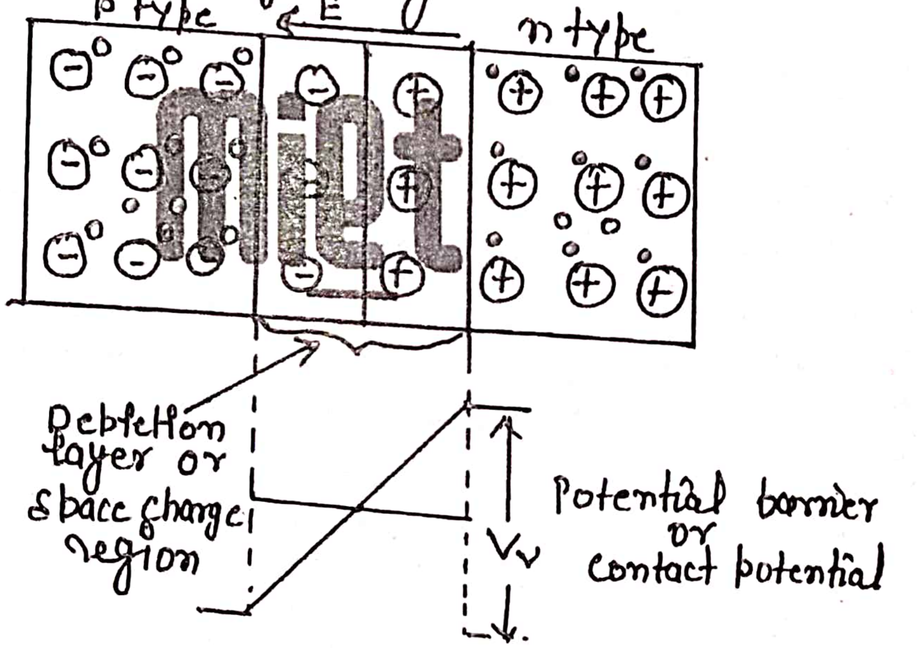
(iii) Insulator :- Insulator are those materials which have no free charge carrier at low temperature. on increasing temperature its conductivity can be improved upto some extent. In insulator there is a gap of around 6ev, which is very high. so it is difficult to move electrons from valence bond to conduction band.



Imp (2)

Ques:- 1 Define depletion layer in a diode (2015-16)

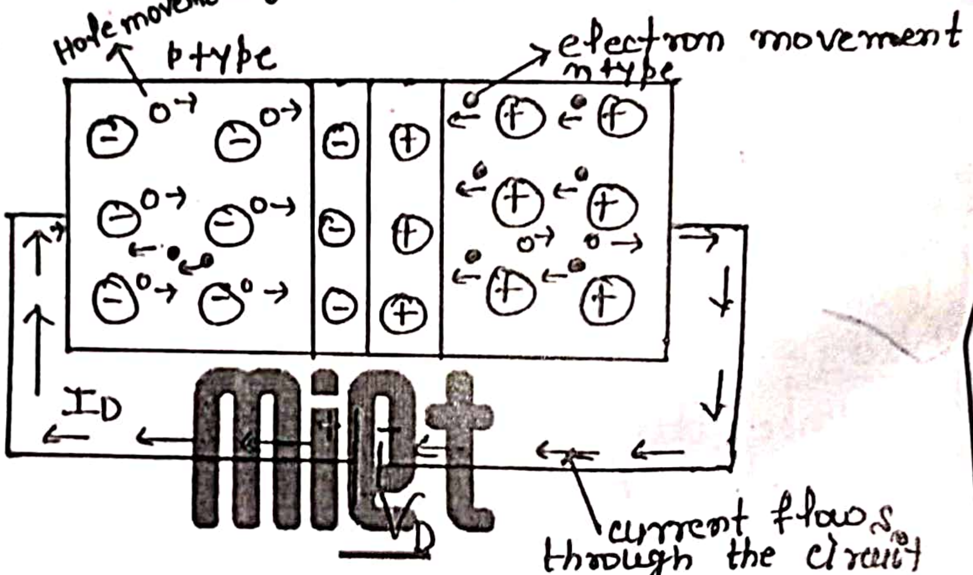
Ans:- When a p-n junction is formed then hole starts to move from p to n and electron starts to move from n to p due to concentration gradient. This is called diffusion process. An electric field is generated at the junction, which stops the further movement of electrons and holes. So, a layer of immobile ions is formed at the junction. This layer is called depletion layer or space charge region.



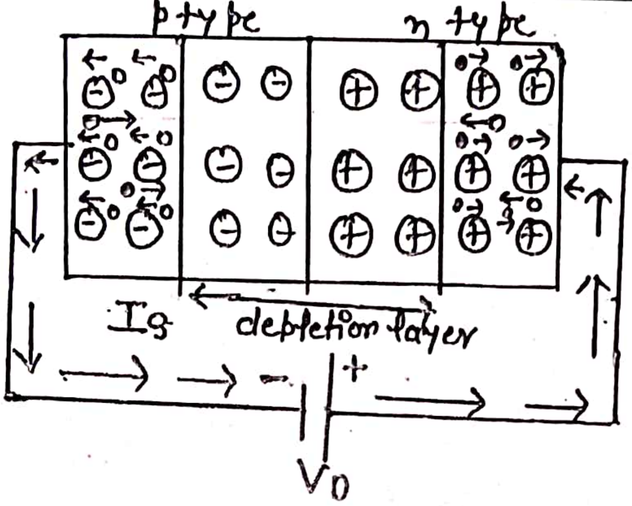
V. Imp

Ques 2:- Explain the working of p-n junction under forward bias and reverse bias condition.

Ans:- Forward bias:- In this condition p-type semiconductor is connected to positive and n type semiconductor is connected to negative terminal of battery. In forward bias majority carriers moves towards the junction and minority carrier moves away from the junction so width of depletion layer decreases. Current across the junction is due to majority carriers and it is called forward current. So forward current will be very high, forward resistance will be low and hight of potential barrier will decrease.



Reverse Bias: In this condition p-type semiconductor is connected to negative and n-type semiconductor is connected to positive terminal of battery. so majority carriers move away from the junction and minority carrier move towards the junction So width of depletion layer increases. Current across the junction is due to minority carriers and it is called reverse saturation current or leakage current. There fore current will be very low, reverse resistance will be very high and hight of potential barrier will increase.



Imp (4)

Ques 3: Explain the knee voltage. What is the knee voltage for Ge & Si? (2017-18)

Ans: A minimum positive voltage is required to start conduction in a forward biased diode. This minimum positive voltage is called knee voltage or cut-off voltage (V_γ).

for Ge, $V_\gamma = 0.3V$

for Si, $V_\gamma = 0.7V$

Imp

Shockley Diode Current Equation :

$$I_D = I_S\left[e^{(V_D/\eta V_T)} - 1\right]$$

where :

- $I_D \rightarrow$ Diode current
- $I_S \rightarrow$ Reverse saturation current or leakage current
- $V_D \rightarrow$ Diode Voltage
- $\eta \rightarrow$ Ideality factor for Ge $\eta = 1$, Si $\eta = 2$
- $V_T \rightarrow$ volt equivalent of temperature

$V_T = \frac{T}{11,600}$ volt (T should be in Kelvin)

at room temperature $V_T = 26\,mV$

V.Imp

Ques 1. Draw & explain the V-I characteristics of p-n junction diode (2016-17, 2018-19)

Ans : Diode current equation is :

$$I_D = I_S\left[e^{(V_D/\eta V_T)} - 1\right] \quad \text{---- (1)}$$

i) Unbiased condition :

$$V_D = 0$$

$$I_D = I_S\left[e^{(0/\eta V_T)} - 1\right]$$

$$= I_S\left[1 - 1\right]$$

$$I_D = 0$$

So curve passes through the origion.

ii) Forward bias condition :

$$V_D = +ve$$

$$I_D = I_S\left[e^{(+V_D/\eta V_T)} - 1\right]$$

But $e^{V_D/\eta V_T} >>> 1$

Therefore equation 1 becomes

$$I_D \cong I_S\, e^{(V_D/n V_T)}$$

Hence forward characteristics is of exponential nature.

iii) Reverse bias :-

$$V_D = -ve$$

$$I_D = I_S\left[e^{(-V_D/n V_T)} - 1\right]$$

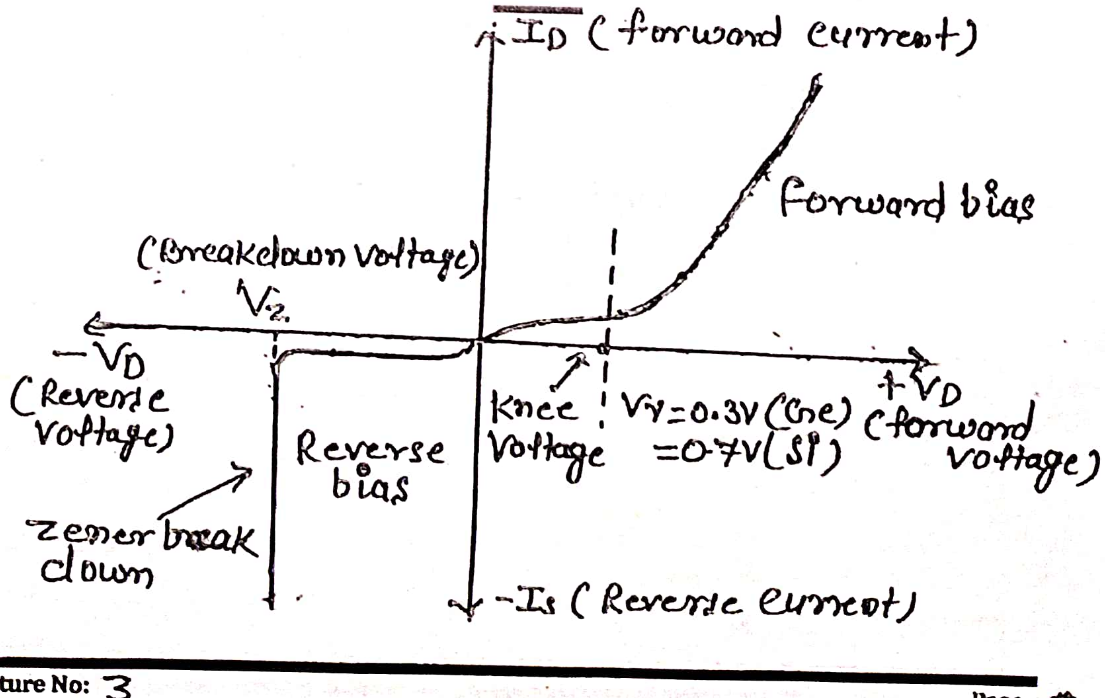
$$= I_S\left[\frac{1}{e^{(V_D/n V_T)}} - 1\right]$$

But $\frac{1}{e^{V_D/n V_T}} <<< 1$

So equation 1 becomes

$$I_D \cong -I_S$$

Therefore reverse characteristics can be represented by straight line ([illegible] quadrant)



Ques 2: Explain the effect of temperature on the V-I characteristics of p-n junction diode.

Ans: Effect of temperature:

a) Forward bias condition: In case of forward biased region the characteristics of Si diode shift to the left at a rate of 2.5 mV/°C rise in temperature and viceversa.

b) Reverse bias condition:

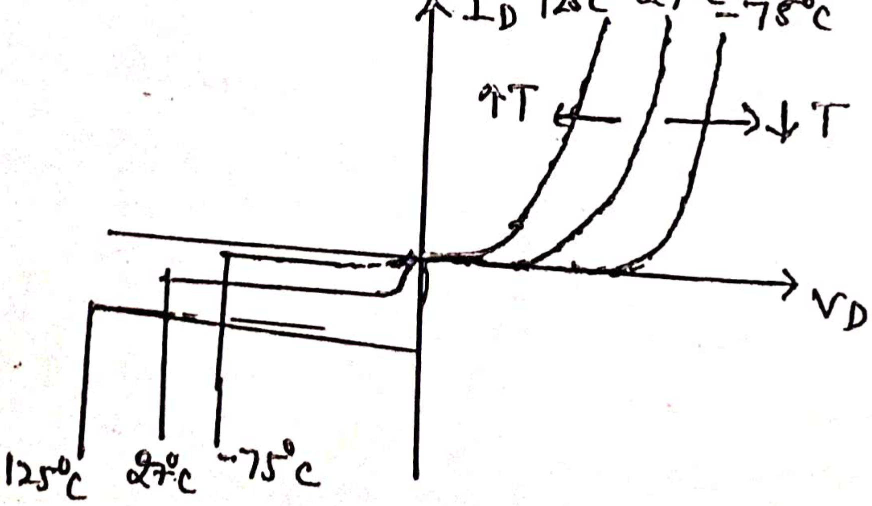
i) Reverse current: Reverse current increase with increase in temperature and Viceversa.

Let I_{S1} is the reverse current at temp. T_1 then at temp. T_2 I_{S2} can be calculated as:

$$I_{S_2} = I_{S_1} \left[2^{(T_2 - T_1)/10} \right] = I_{S_1} \left(2^{\Delta T/10} \right)$$

Generally reverse current doubles for every 10°C rise in temperature.

ii) Breakdown Voltage (V_Z): Breakdown voltage increases with increase in temperature and vice-versa.



Ques 1: the reverse saturation current of Si p-n junction diode is 10 μA at 300k. Determine the forward bias voltage to be applied to obtain diode current of 100 mA. (2017-18)

Ans:

$$I_D = I_S [e^{V_D/\eta V_T} - 1]$$

$$100\times10^{-3} = 10\times10^{-6} [e^{(V_D/2\times0.026)} - 1]$$

$$1001 = e^{V_D/0.0518}$$

taking ln on both sides

$$9.21 = \frac{V_D}{0.0518}$$

$$V_D = 0.47V$$

Ques 2: A Ge diode carries a current of 1 mA at room temperature when a forward bias of 0.15V is applied. Estimate the reverse saturation current at room temperature. (2015-16)

Ans: given $I_D = 1$ mA, $V_T = 26m$ (room temp.)

$V_D = 0.15V$, for Ge $\eta = 1$

$$I_D = I_S [e^{V_D/\eta V_T} - 1]$$

$$1\times10^{-3} = I_S [e^{(0.15/1\times25\times10^{-3})} - 1]$$

$$I_S = 3.1319 \text{ μA}$$

Ques 3: A Si diode has a saturation current of 5 nA at 25°C. what is the saturation current at 100°C.

Ans:

$$\Delta T = 100 - 25 = 75$$

$$I_{S_2} = 2^{(\Delta T/10)} \times I_{S_1} = 2^{7.5} \times 5\times10^{-9}$$

$$I_{S_2} = 905.096 \text{ nA}$$

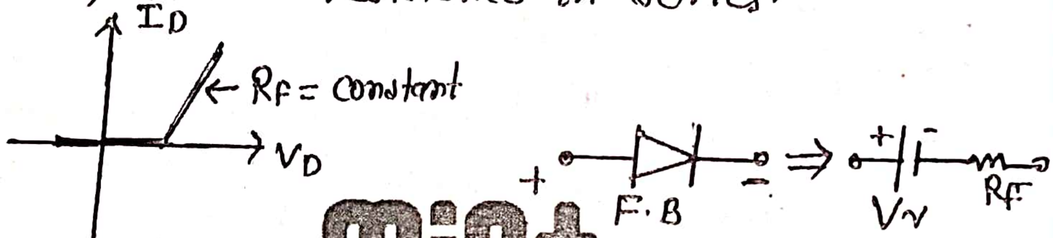
Imp.

Ques 5: Explain all the equivalent / approximation circuits of a diode. (2016-17) (2020-21)

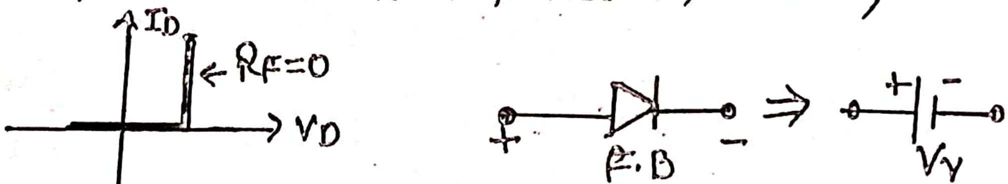
Ans: Equivalent circuits of a diode:

(i) Piecewise-linear equivalent circuits:

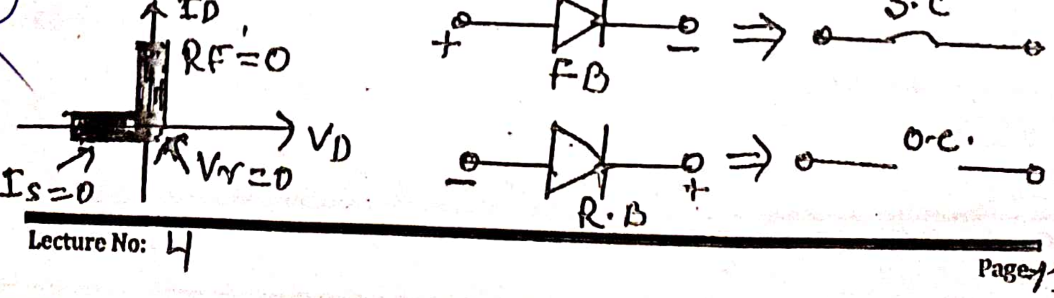
In this circuit diode non-linear characteristics is replaced by a straight line. So, resistance of diode is constant. Diode is replaced by battery with resistance in series.



(ii) Simplified equivalent circuit: Since diode forward resistance is low so it can be neglected i.e. $R_F = 0$. Diode is replaced by battery.

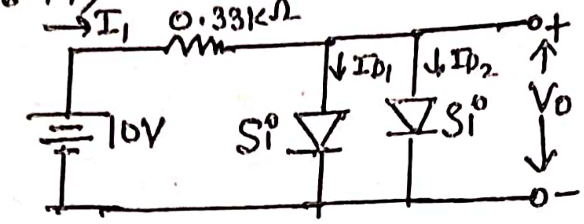


(iii) Ideal equivalent circuit: In ideal diode $R_F = 0$, $V_\gamma = 0$ and $I_S = 0$. An ideal diode can be used as a perfect switch.

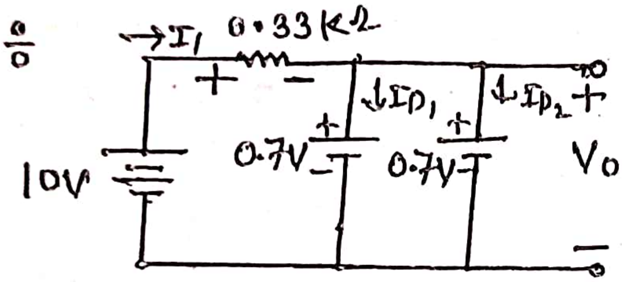


Ques1 : Determine V_o, I_1, I_D, and I_{D_2} for the parallel diode configuration shown in figure below. (2016-17)

Ans :



Ans :



Applying KVL

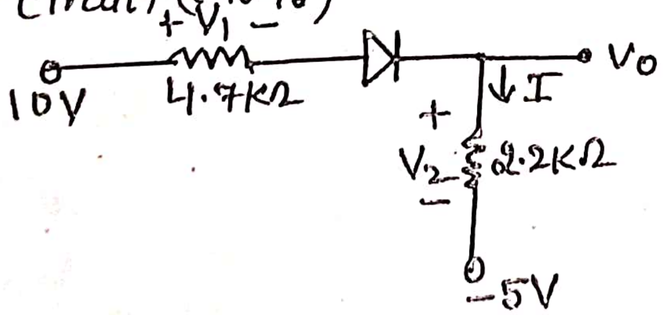
$$-0.33K\Omega \times I_1 - 0.7V + 10V = 0$$

$$I_1 = 28.18\,mA$$

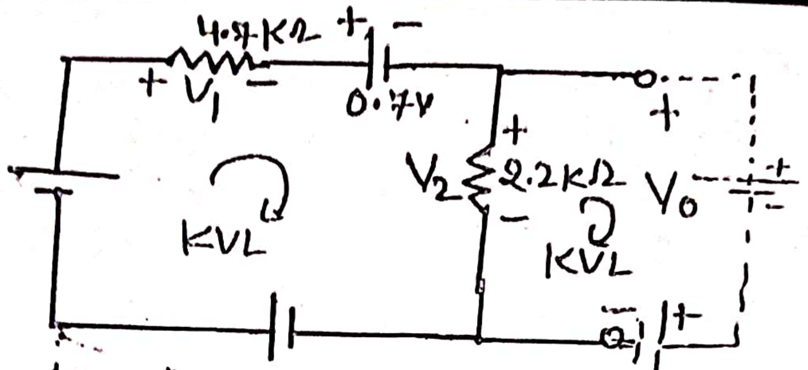
Now $I_{D_1} = I_{D_2} = \frac{I_1}{2}$

$$= \frac{28.18}{2} = 14.09\,mA$$

Ques2 : Determine I, V_1, V_2 and V_o for the following circuit. (2015-16)



Ans :



Applying KVL : $-4.7K\Omega \times I - 2.2K\Omega \times I + 5 - 10 = 0$

$I = 2.07\,mA$

So $V_1 = I R_1 = (2.07mA) \times (4.7K\Omega)$

$= 9.73V$

$V_2 = I R_2 = (2.07mA) \times (2.2K\Omega)$

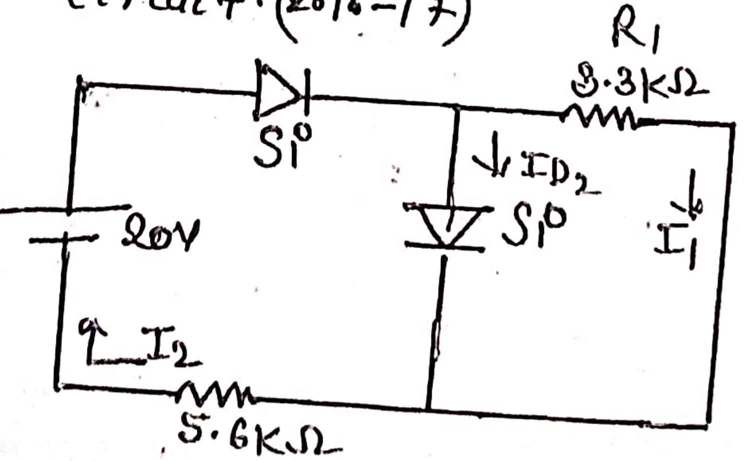
$= 4.55V$

Applying KVL : $-V_0 - 5 + 4.55 = 0$

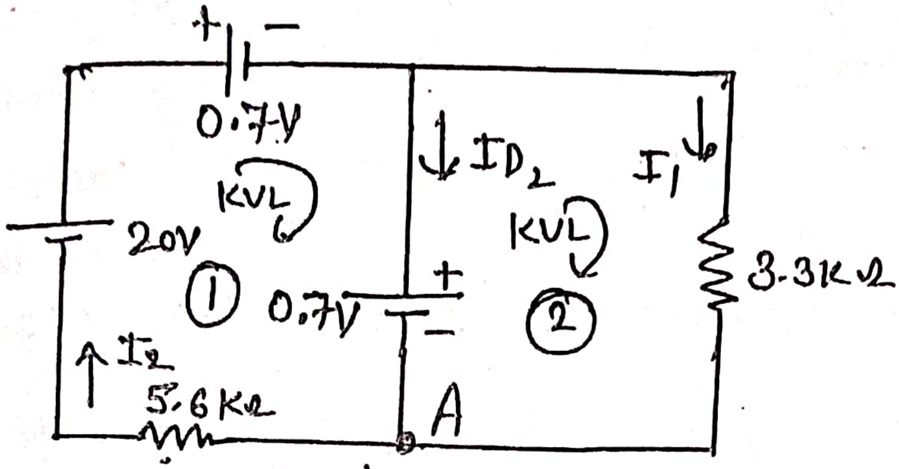
$V_0 = -0.45V$

The minun sign shows that V_0 has a polarity opposite to that appearing in figure.

Ques 30 : Determine I_1, I_2 and I_{D_2} for the following circuit. (2016-17)



Ans : Equivalent circuit :



Applying KVL in loop 1

$$-0.7V - 0.7V - 5.6k\Omega \times I_2 + 20 = 0$$

$$I_2 = 3.32mA$$

Applying KVL in loop 2

$$-0.33k\Omega\, I_1 + 0.7V = 0$$

$$I_1 = 0.212mA$$

Now applying KCL at Node A

$$I_1 + I_{D_1} = I_2$$

$$I_{D_1} = I_2 - I_1$$

$$= 3.32\,mA - 0.212\,mA$$

$$= 3.102\,mA$$

Breakdown Mechanism

⇒ Breakdown mechanism occurs in reverse-biased diode.

⇒ If applied reverse voltage is continously increased a condition come at which current increases at a very rapid rate. The reverse voltage at this condition is called breakdown voltage (V_Z).

⇒ The breakdown voltage depends upon the width of depletion layer.

⇒ The width of depletion layer depends upon the doping level.

⇒ The following two process cause junction breakdown due to increase in reverse bias voltage

(i) Zener Breakdown

(ii) Avalanche Breakdown

Ques1 :- Describe breakdown mechanism of diode. (2015-16)

Ans :- If the reverse-bias applied to p-n junction, is increased, a point will reach when the junction breaks down and reverse current rises sharply.. This specific value of the reverse bias voltage is called breakdown voltage (V_Z). The following two process cause junction breakdown.

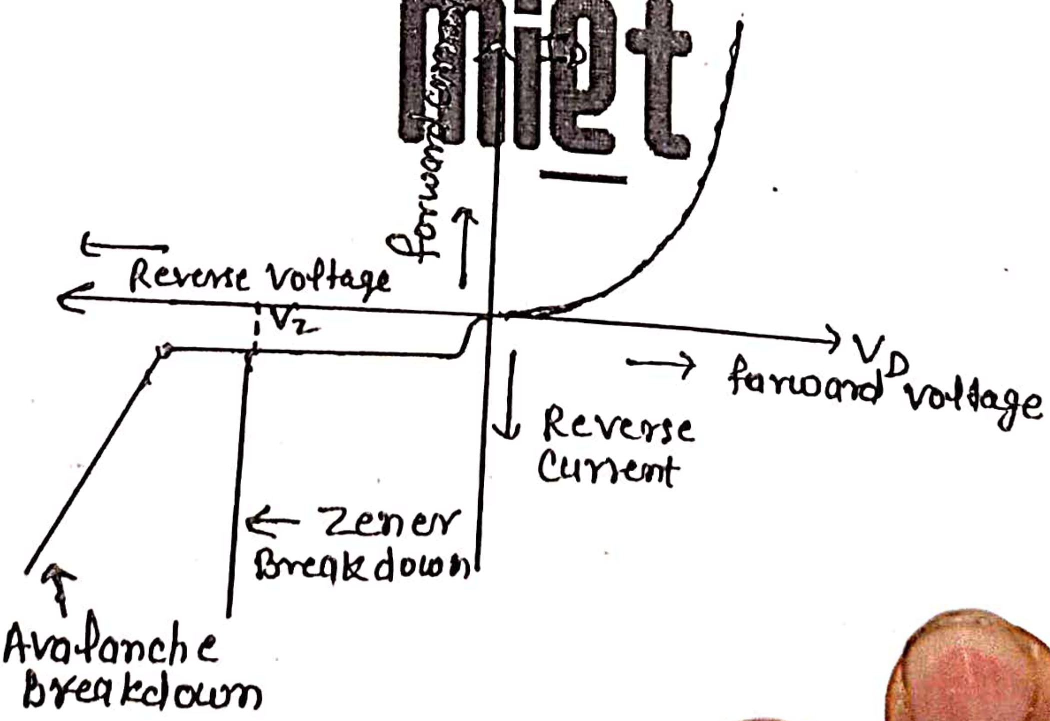
i) Zener Breakdown :- It occurs in highly doped diode. In highly doped diode width of depletion layer is narrow. So electric field is very high in the depletion layer. So force is very high. This high force pulled the valence electrons into conduction band by breaking covalent bonds. These electrons become free electrons and will constitute a large reverse current. This is called Zener breakdown. Zener breakdown occurs less than 6V. Temperature coefficient for Zener breakdown is negative i.e raising the temperature will cause smaller breakdown voltage.

(ii) Avalanche Breakdown :- It occurs in lightly doped diode. In lightly doped diode width of depletion region is wide. So electric field and force are low. This low force can not break the covalent bond.

As reverse voltage is increased the kinetic energy ($\frac{1}{2}mv^2$) of minority carriers increases. While travelling these minority carriers will collide with the stationary atoms present in depletion layer and impart some of the kinetic energy to the valence electrons. These valence electrons will break their covalent bond and jump into conduction band to become free electrons.

Now these newly generated free electrons get accelerated. They will knock some more valance electrons by means of collision. This phenomenon is called as carrier multiplication or Avalanche breakdown. Avalanche breakdown occurs greater than 6V. Temperature coefficient is positive i.e. raising the temperature will cause larger breakdown voltage.

V-I characteristics:



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Ques 2 :- Differentiate between avalanche and zener breakdown. (2020-21)

Ans :-

S.N.	Zener Breakdown	Avalanche Breakdown
1.	Occurs in highly doped diode.	Occurs in lightly doped diode.
2.	The valence electrons are pulled into conduction band due to very high electric field.	the valence electrons are pushed in to conduction band due to the energy imparted by collision of accelerated minority carrier.
3.	Tunneling effect occurs	Ionization effect occurs.
4.	occurs less than 6V	occurs greater than 6V.
5.	Zener break down's V-I characteristics is very sharp.	It is not as sharp as that zener diode
6.	Covalent bonds breaks directly	covalent bonds breaks indirectly.
7.	Temperature coefficient is negative	Temperature coefficient is positive

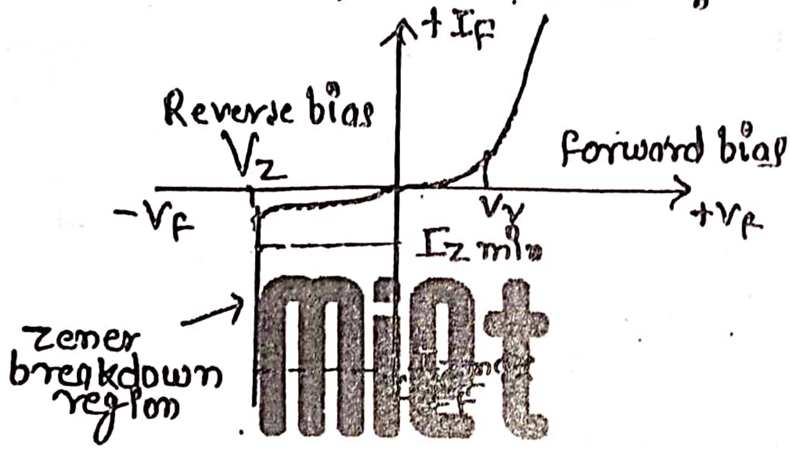
Zener diode :

⇒ Zener diode is a special diode, which is used breakdown region.

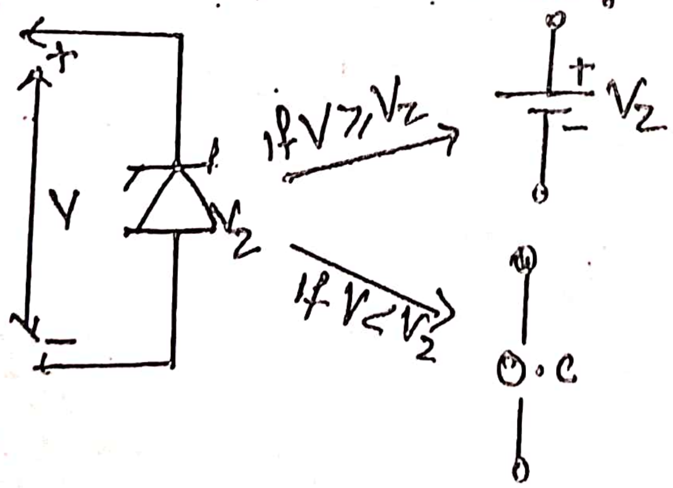
⇒ It is used for voltage regulation

Symbol

V-I characteristics of zener diode :

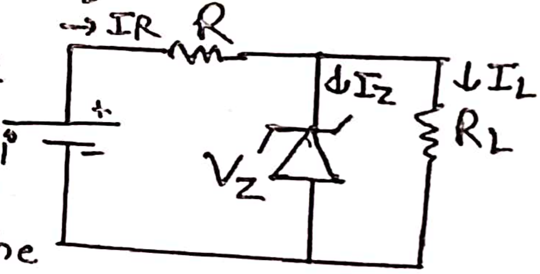


Equivalent ckt of zener diode :



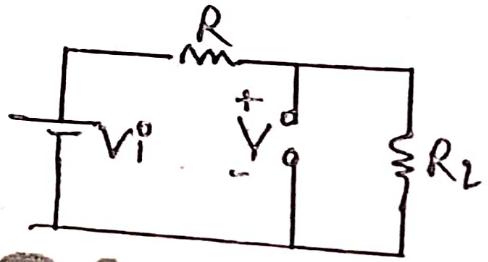
Zener diode as a shunt voltage regulator:

(i) Fixed V_i and fixed R_L



a) Determine the state of zener diode by removing it from the circuit and find the voltage across the open circuit.

$$\boxed{V = V_L = \frac{R_L V_i}{R + R_L}}$$



If $V \geq V_Z$ diode is ON

If $V < V_Z$ diode is off

b) Substitute the appropriate equivalent circuit and solve for the desired unknowns.

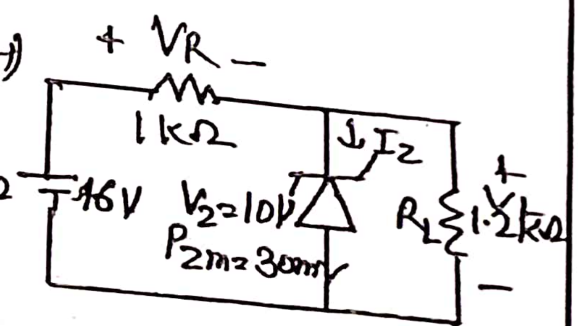
$$\boxed{V_L = V_Z}, \quad \boxed{I_R = I_Z + I_L}$$

$$\boxed{I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L}} \quad \boxed{P_Z = V_Z I_Z}$$

Ques 1: For the zener diode network find (2013-14)

a) V_L, V_R, I_Z and P_Z

b) Repeat part (a) with $R_L = 3\,k\Omega$



Ans : a) $V = \frac{R_L V_i}{R+R_L} = \frac{1.2 \times 16}{1+1.2} = 8.73V$

so diode is off.

$V_L = V = 8.73\ V$

$V_R = V_i - V_L = 16V - 8.73V = 7.27V$

$I_Z = 0$

$P_Z = V_Z \times I_Z = 0W$

b) $V = \frac{R_L V_i}{R+R_L} = \frac{3 \times 16}{1+3} = 12V$

so diode is ON

$V_L = V_Z = 10V$

$V_R = V_i - V_L = 16 - 10 = 6V$

$I_L = \frac{V_L}{R_L} = \frac{10V}{3k\Omega} = 3.33mA$

$I_R = \frac{V_R}{R} = \frac{6V}{1k\Omega} = 6mA$

$I_Z = I_R - I_L$

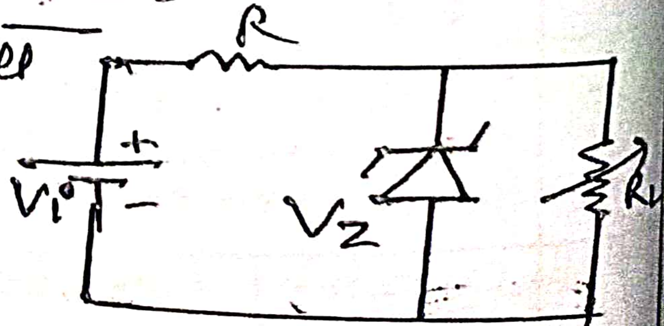
$= 6mA - 3.33mA$

$= 2.67mA$

$P_Z = V_Z I_Z = (10V)(2.67mA) = 26.7mW$

(ii) fixed V_i and variable R_L :

To determine R_{Lmin} that will turn the zener diode ON we put $V_L = V_Z$



$\Rightarrow V_L = V_Z = \frac{R_L V_i}{R+R_L}$

$R_{Lmin} = \frac{R \cdot V_Z}{V_i - V_Z}$, $I_{Lmax} = \frac{V_Z}{R_{Lmin}}$

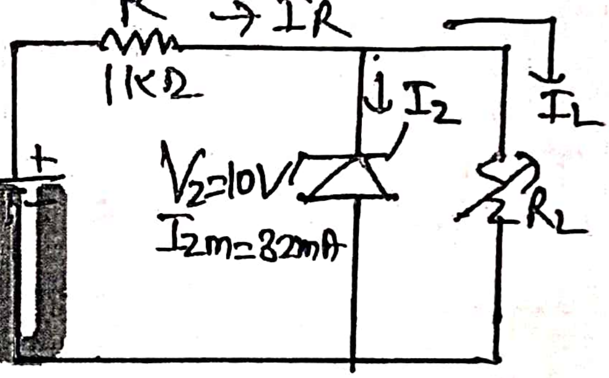
For calculating R_{Lmax} we have to calculate I_{Lmin} as:-

$$I_{Lmin} = I_R - I_{ZM} \quad , I_R = \frac{V_R}{R} , V_R = V_i - V_Z$$

$$R_{Lmax} = \frac{V_Z}{I_{Lmin}}$$

(13)

Ques :- In the following figure determine the range of R_L and I_L that will result in V_{RL} being maintained at 10V. (2014-15, 2017-18, 2020-21)



Ans:- $V_L = V_Z = \frac{R_L V_i}{R + R_L}$

$$R_{Lmin} = \frac{R \cdot V_Z}{V_i - V_Z} = \frac{1 \times 10}{50 - 10}$$

$$R_{Lmin} = \frac{10\,k\Omega}{40} = 250\,\Omega$$

$$I_{Lmax} = \frac{V_Z}{R_{Lmin}} = \frac{40}{250} = 40\,mA$$

$$V_R = V_i - V_Z = 50V - 10V = 10V$$

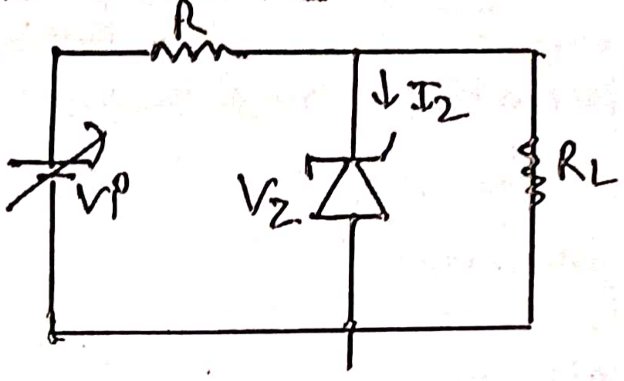
$$I_R = \frac{V_R}{R} = \frac{40V}{1k\Omega} = 40\,mA$$

$$I_{Lmin} = I_R - I_{ZM}$$

$$= 40\,mA - 32\,mA = 8\,mA$$

$$R_{Lmax} = \frac{V_Z}{I_{Lmin}} = \frac{10V}{8\,mA} = 1.25\,k\Omega$$

(iii) Variable V_i and fixed R_L



The minimum voltage V_i that will turn ON the diode is calculated as:

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}$$

$$V_{i\,min} = \frac{(R_L + R) \cdot V_Z}{R_L}$$

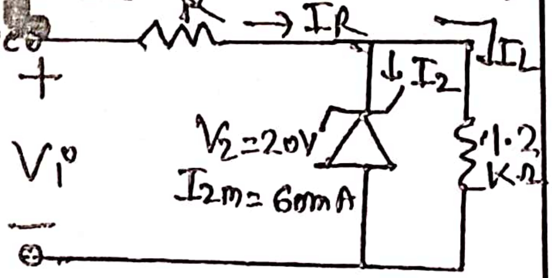
The maximum voltage $V_{i\,max}$ is calculated as:

$$I_{R\,max} = I_{ZM} + I_L$$

$$V_{i\,max} = V_{R\,max} + V_Z$$

$$V_{i\,max} = I_{R\,max} \cdot R + V_Z$$

Ques 3: Find the range of values of V_i that will maintain the Zener diode ON state. (2015–16, 2016-17, 2018-19)



Ans: The minimum turn-on voltage is determined as:

$$V_L = V_Z = \frac{R_L \cdot V_i}{R_L + R}$$

$$V_{i\,min} = \frac{(R_L + R)\, V_Z}{R_L}$$

$$V_{i\,min} = \frac{(1200\Omega + 220\Omega)\, 20V}{1200\Omega}$$

$$\simeq 23.67V$$

$$I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L} = \frac{20V}{1.2\,k\Omega} = 16.67mA$$

$$I_{R\,max} = I_{ZM} + I_L = 60mA + 16.67mA = 76.67mA$$

$$V_{i\,max} = I_{R\,max} R + V_Z$$

$$= (76.67mA) \times 0.22k\Omega + 20V$$

$$= 36.87V$$

Rectifier :- A rectifier is a device that converts alternating voltage (current) to pulsating direct voltage (current).

⇒ Rectifier are classified into two category:-

1) Half wave rectifier :- A half wave rectifier is defined a type of rectifier that only allows half wave voltage to produce a unidirectional load current.

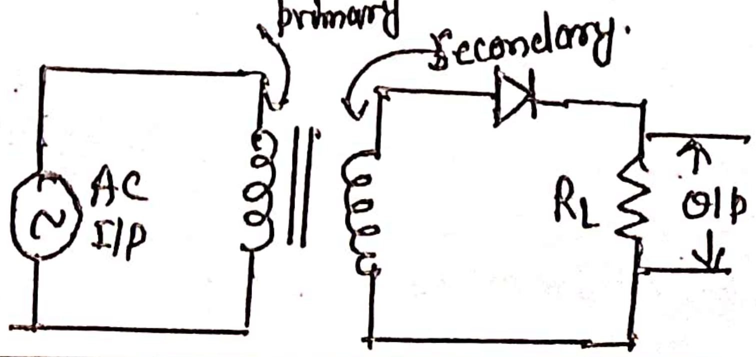
2) Full wave rectifier :- FWR rectify both the positive and negative half cycles of an input alternating wave form. FWR can be further classify into two category.

i) Centre-tapped full wave rectifier

ii) Full wave bridge rectifier.

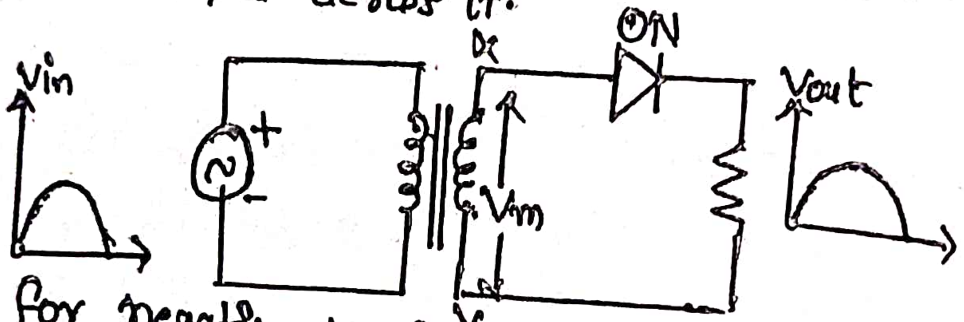
Ques 1 :- Explain the working of half wave rectifier. (2015-16)

Ans :- A half wave rectifier consists of step down transformer, diode and load resistance. Input is applied across primary winding of transformer and output is taken out from load resistance R_L.



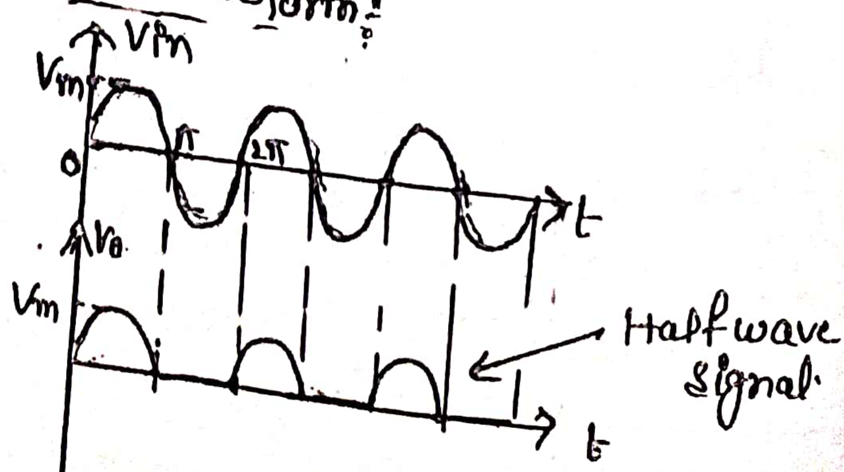
Working:

(i) For positive half cycle: During the +ve half cycle the end X of the secondary winding is +ve and end Y is −ve. So diode is forward biased. So current flows through the load R_L and a voltage is developed across it.



(ii) For negative half cycle: During the −ve half cycle the end X of the secondary winding is −ve and end Y is +ve. So diode is reverse biased. Therefore no flow of current through R_L. Hence output voltage is zero.

Half wave Rectifier waveform:



Ques 2:- Derive the value of I_{dc}, V_{dc}, I_{rms}, V_{rms} for half wave rectifier.

Ans:- (i) DC or Average output (load) current I_{dc}:-

let $V = V_m \sin\theta$ is the voltage across the secondary winding.

So the circuit current $i = \frac{V_m}{R_L + r_f}\sin\theta = I_m \sin\theta$

where R_L = load resistance

r_f = diode resistance.

$$I_{dc} = \frac{1}{2\pi}\int_0^{2\pi} I_m \sin\theta \cdot d\theta$$

$$= \frac{1}{2\pi}\int_0^{\pi} I_m \sin\theta \, d\theta + \underbrace{\int_{\pi}^{2\pi} I_m \sin\theta \, d\theta}_{\Rightarrow 0}$$

$$= \frac{I_m}{2\pi}\left[-\cos\theta\right]_0^{\pi}$$

$$= \frac{I_m}{2\pi}\left[-\cos\pi + \cos 0\right] = \frac{I_m}{2\pi}\left[-(-1)+1\right] = \frac{I_m}{2\pi} \times 2$$

$$\boxed{I_{dc} = \frac{I_m}{\pi}}$$

(ii) DC or Average output (load) voltage V_{dc}:-

$$V_{dc} = I_{dc} \times R_L$$

$$= \frac{I_m}{\pi} \times R_L$$

$$= \frac{V_m}{\pi(R_L + r_f)} \times R_L$$

If $r_f = 0$ $\boxed{V_{dc} = \frac{V_m}{\pi} = 0.318\, V_m}$

If diode is not ideal

$$\boxed{V_{dc} = \frac{V_m - V_r}{\pi} = 0.318(V_m - V_r)}$$

(iii) rms output (load) current I_{rms} :-

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi}(I_m \sin\theta)^2 d\theta}$$

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

$$= \sqrt{\frac{I_m^2}{4\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^{\pi}}$$

$$= \sqrt{\frac{I_m^2}{4\pi}\left[(\pi - 0) - \left(\frac{\sin 2\pi}{2} - \frac{\sin 2\times 0}{2}\right)\right]}$$

$$\boxed{I_{rms} = \frac{I_m}{2}}$$

(iv) rms output voltage or load voltage V_{rms} :-

$$V_{rms} = I_{rms} \times R_L$$

$$= \frac{I_m}{2} \times R_L$$

$$= \frac{V_m}{2(R_L + r_f)} \times R_L$$

if $r_f = 0$

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

Ques 3 :- Explain ripple factor & derive the expression for halfwave rectifier. (2015-16) (2020-21)

Ans :- The output of rectifier has ac component (ripple) and dc component both. Ripple factor measure, how much amount of ac component is present in the output. So the effectiveness of a rectifier depends on the magnitude of ripple in the output. smaller the ripple more effective is the rectifier.

"Ripple factor is defined as the ratio of rms value of ac. component to the dc component in the rectifier."

$$\gamma = \frac{I_{ac}}{I_{dc}}$$

but $I_{ac} = \sqrt{I_{rms}^2 - I_{dc}^2}$

dividing both sides with I_{dc}

$$\frac{I_{ac}}{I_{dc}} = \frac{1}{I_{dc}}\sqrt{I_{rms}^2 - I_{dc}^2}$$

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

for Half wave rectifier $I_{rms} = \frac{I_m}{2}$, $I_{dc} = \frac{I_m}{\pi}$

$$\gamma = \sqrt{\left(\frac{\frac{I_m}{2}}{I_m/\pi}\right)^2 - 1}$$

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

$$\boxed{\gamma = 1.21}$$

So ripple factor of halfwave rectifier is very high.

Ques: Derive the expression for rectification efficiency or Power conversion efficiency for half wave rectifier.

Ans: Rectification efficiency is defined as the ratio of dc output power and ac input power.

$$\eta = \frac{\text{dc o/p Power}}{\text{ac I/P Power}} = \frac{P_o(dc)}{P_o(ac)} \quad —(1)$$

Now $P_o(dc) = I^2_{dc} \times R_L = \left(\frac{I_m}{\pi}\right)^2 \times R_L \quad —(2)$

$P_o(ac) = I^2_{rms} \times (R_L + r_f)$

$= \left(\frac{I_m}{2}\right)^2 \times (R_L + r_f) \quad (3)$

putting the value of (2) & (3) in (1)

$$\eta = \frac{\left(\frac{I_m}{\pi}\right)^2 \times R_L}{\left(\frac{I_m}{2}\right)^2 \times (R_L + r_f)}$$

$$= \frac{4 \times R_L}{\pi^2 \times (R_L + r_f)}$$

if $r_f = 0$

$$\eta_{max} = \frac{4}{\pi^2}$$

$$\boxed{\eta_{max} = 40.6\ \%}$$

So efficiency of halfwave rectifier is low.

Imp

Ques 1 : what is peak inverse voltage (PIV) ?

Ans : It is maximum reverse voltage that can be applied across a diode with out damaging it. P.I.V of the diode should be greater than the input applied voltage.

for halfwave rectifier PIV = V_m (voltages across secondary winding)

Ques 2 : what is ripple frequency?

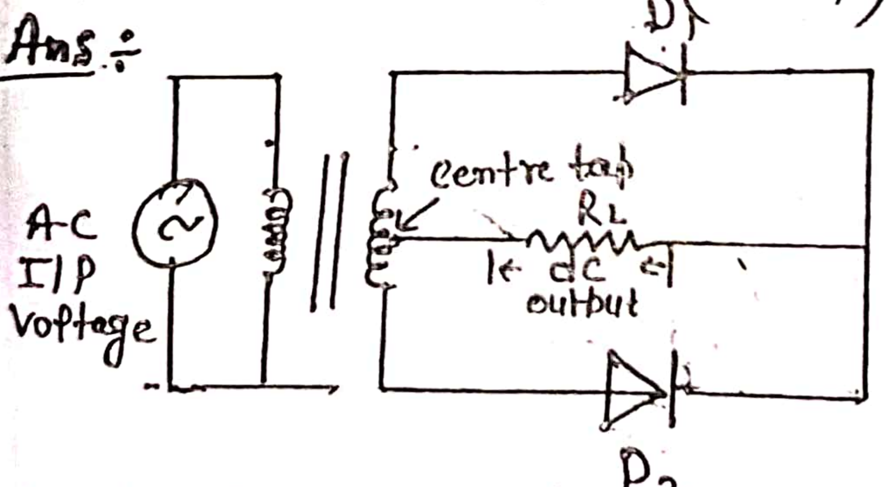
Ans : It is the frequency of output wave in a rectifier. It is ~~also~~ called output frequency.

For Half wave rectifier ripple frequency $(f_r) = f_i$

Imp

Ques 3 : Explain the working of centre tapped full wave rectifier. (2013-14)

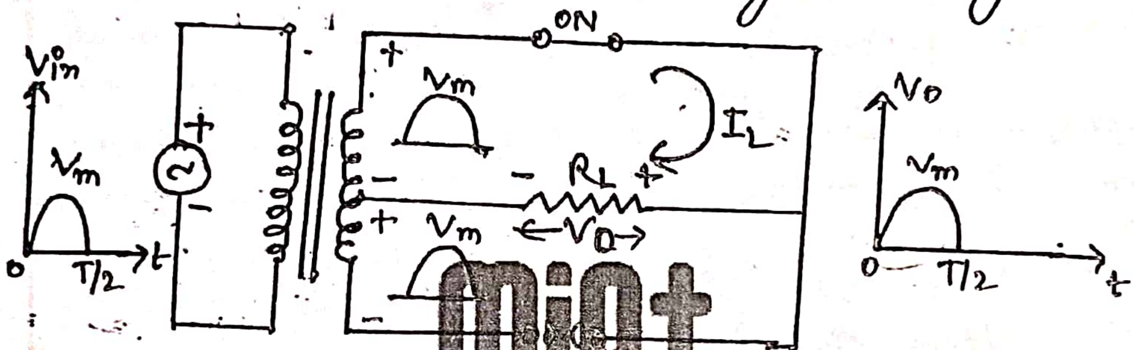
Ans :



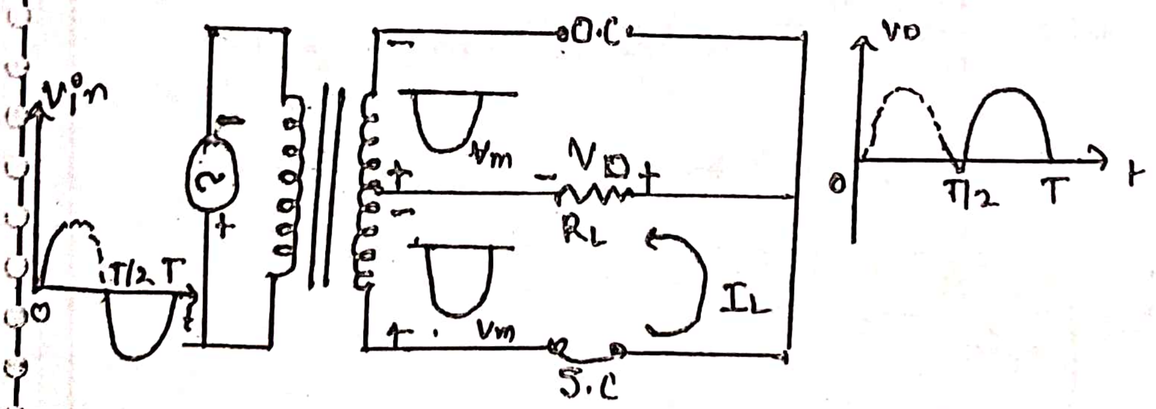
centre tapped rectifier have a centre tapped step down transformer, two diode D_1, D_2 and load resistance R_L. In centre tapped transformer secondary winding is divided in two equal halfs.

Working :- (i) For positive half cycle

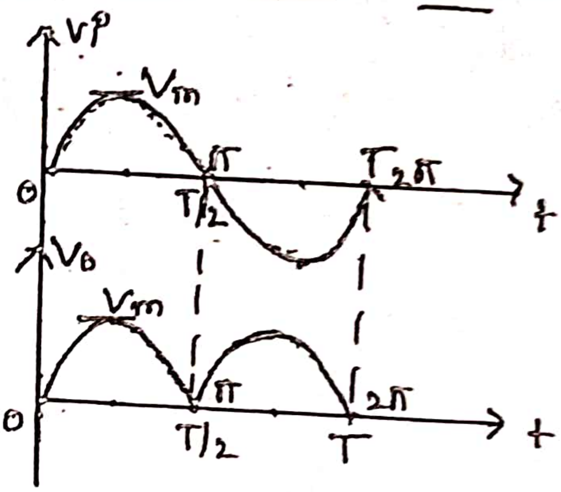
In positive half cycle diode D_1 is forward biased and D_2 is reverse biased. So D_1 is ON and D_2 is off. Current flows through the upper half of secondary winding.



(ii) For negative cycle :- In negative cycle diode D_1 is reverse biased and diode D_2 is forward biased. So D_1 is off and D_2 is ON. Current flows through the lower half of secondary windings.



Input and output wave of rectifier :



Ques 4 : Derive the value of I_{dc}, V_{dc}, I_{rms}, V_{rms} for centre tapped rectifier. (for Bridge rectifier also)

Ans : let $v = V_m \sin\theta$ is the voltage across half of the secondary winding.

then circuit current $= \left(\frac{V_m}{R_L + r_f}\right)\sin\theta$

$= I_m \sin\theta$

where $R_L \rightarrow$ load resistance
$r_f \rightarrow$ Diode forward resistance.

(i) DC or average output (load) current I_{dc} :

$$I_{dc} = \frac{1}{\pi}\int_0^{\pi} I_m \sin\theta = \frac{I_m}{\pi}\left[-\cos\theta\right]_0^{\pi}$$

$$= \frac{I_m}{\pi}\left[-\cos\pi + \cos 0\right]$$

$$= \frac{I_m}{\pi}\left[-(-1)+1\right] = \frac{I_m}{\pi} \times 2$$

$$\boxed{I_{dc} = \frac{2 I_m}{\pi}}$$

(ii) Dc or average output (load) voltage V_{dc}:

$$V_{dc} = I_{dc} \times R_L$$

$$= \frac{2I_m}{\pi} \times R_L$$

$$= \frac{2V_m}{\pi(R_L + r_f)} \times R_L$$

If $r_f = 0$

$$\boxed{V_{dc} = \frac{2V_m}{\pi} = 0.636\,V_m}$$

If diode is ideal:

$$\boxed{V_{dc} = \frac{2(V_m - V_r)}{\pi} = 0.636\,(V_m - V_r)}$$

(iii) rms output (load) current I_{rms}:

$$I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (I_m \sin\theta)^2\, d\theta}$$

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

$$= \sqrt{\frac{I_m^2}{2\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^{\pi}}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\left[(\pi - 0) - \left(\frac{\sin 2\pi}{2} - \frac{\sin 2\times 0}{2}\right)\right]}$$

$$\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$$

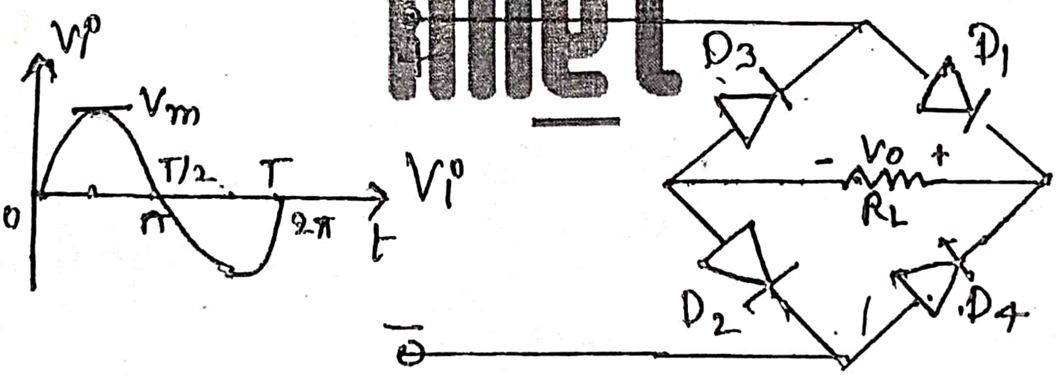
(iv) rms output (load) voltage V_{rms} :

$$V_{rms} = I_{rms} \times R_L$$
$$= \frac{I_m}{\sqrt{2}} \times R_L$$
$$= \frac{V_m}{\sqrt{2}(R_L + r_f)} \times R_L$$

If $r_f = 0$ $\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$

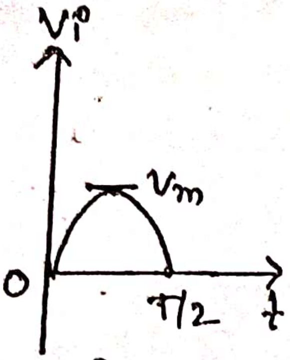
Ques 5 : Explain the working of bridge rectifier. (2014-15, 2016-17, 2017-18, 2020-21)

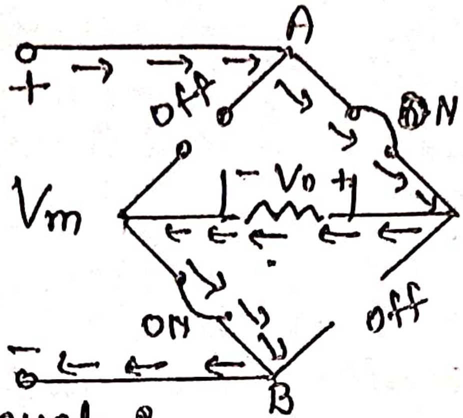
Ans : The bridge rectifier uses four diodes, which are connected in bridge pattern.

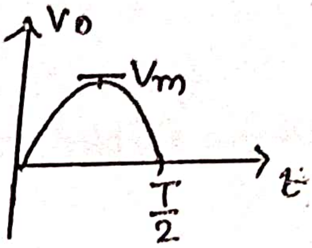


Working : (i) For positive cycle :

In positive cycle end A is +ve and end B is −ve. So diode D_1, D_2 are forward biased and D_3, D_4 are reverse biased. So D_1, D_2 are ON and D_3, D_4 are off. Current flows through D_1, D_2 and give the output across load resistance.

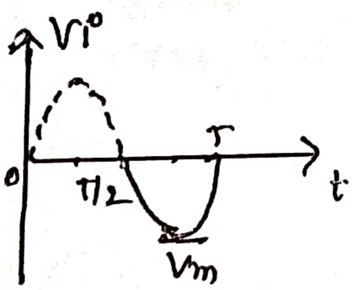


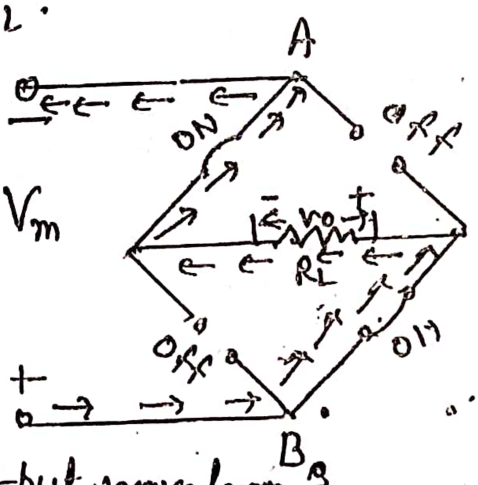


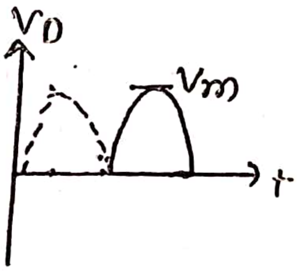


(ii) for -ve cycle :

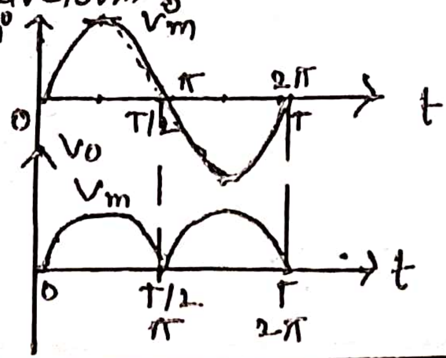
In negative cycle end A is -ve and end B is +ve. So diodes D_1, D_2 are reverse biased and D_3, D_4 are forward biased. So D_1, D_2 are off and D_3, D_4 are ON. current flows through D_3, D_4 and give the output across load resistance R_L.







Input and output waveform :



Imp.

Ques6 :- Derive the expression for ripple factor for centre tapped rectifier or bridge rectifier. (2014-15, 2020-21)

Ans :- Ripple factor(r) :-

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

For full wave rectifier $I_{rms} = I_m/\sqrt{2}$, $I_{dc} = \frac{2I_m}{\pi}$

$$r = \sqrt{\left(\frac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1}$$

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

$$\boxed{r = .48}$$

Imp.

Ques7 :- Derive the expression for rectification efficiency for centre tapped rectifier or bridge rectifier (2014-15)

Ans :- Rectification efficiency :-

$$\eta = \frac{\text{dc o/p Power}}{\text{ac I/P power}} = \frac{P_o(dc)}{P_i(ac)}$$

$$= \frac{I_{dc}^2 \times R_L}{I_{rms}^2 \times (R_L + r_f)}$$

$$= \frac{\left(\frac{2I_m}{\pi}\right)^2 \times R_L}{(I_m/\sqrt{2})^2 \times (R_L + r_f)}$$

$$\eta = \frac{.812}{1 + \frac{r_f}{R_L}}$$

If $r_f = 0$

$$\eta_{max} = .812$$
$$= 81.2\%$$

Imp

Ques8: what is PIV. write the value of PIV for half wave and full wave rectifiers (2020-21)

Ans: It is the maximum reverse voltage that can be applied across a diode without damaging it.

- for half wave rectifier $PIV = V_m$
- for centre tapped rectifier $PIV = 2V_m$
- for Bridge rectifier $PIV = V_m$

Ques8: what is ripple frequency. write the value for half wave and full wave rectifiers.

Ans: It the frequency of output wave in a rectifier. It is also called output frequency.

- for half wave rectifier $f_r = f_i$
- for centre tapped rectifier $f_r = 2f_i$
- for Bridge rectifier $f_r = 2f_i$

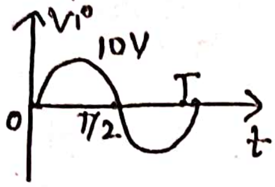
Quesⁿ: Compare Halfwave and full wave rectifier (2015-16)

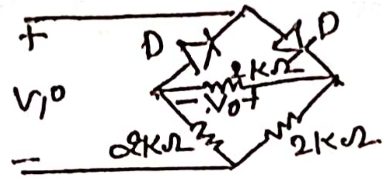
Ans :-

S.N.	Parameters	Halfwave rectifier	Full wave	
			centre tapped Rectifier	Bridge Rectifier
1	operation	conducts during positive half cycles	conducts during both the half cycles	conducts during both the half cycles
2.	Vdc	V_m/π	$2V_m/\pi$	$2V_m/\pi$
3.	Vrms	$V_m/2$	$V_m/\sqrt{2}$	$V_m/\sqrt{2}$
4.	Ripple factor	1.21	0.48	0.48
5.	Efficiency	40.6 %	81.2%	81.2%
6.	PIV	V_m	$2V_m$	V_m
7	Ripple freq.	$f_r = f_i$	$f_r = 2f_i$	$f_r = 2f_i$
	Irms	$I_m/2$	$I_m/\sqrt{2}$	$I_m/\sqrt{2}$

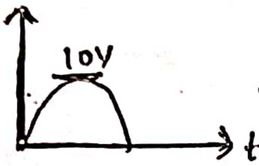
27

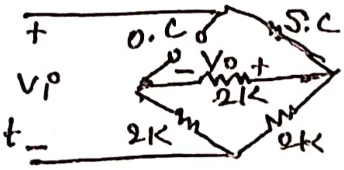
Ques: Determine the output wave form for the following figure and calculate the o/p dc level and required PIV of each diode (2017-18)



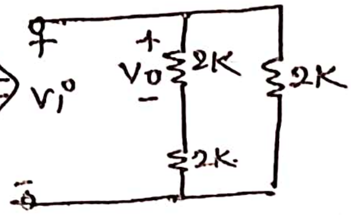


Ans: for +ve cycle:





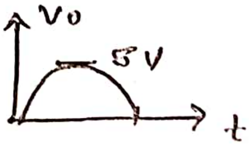
$\Rightarrow$



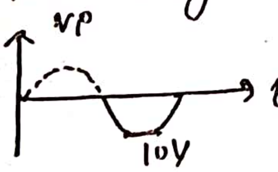
$V_o = \frac{1}{2} V_i$ or $\frac{1}{2} V_{i\,max}$

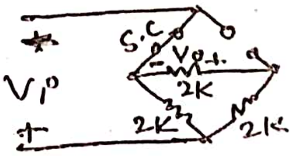
$V_o = \frac{1}{2} \times 10$

$V_o = 5V$

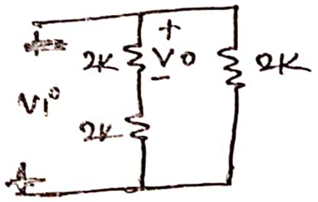


for −ve cycle:





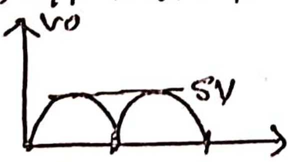
$\Rightarrow$



$V_o = \frac{1}{2} V_i$ or $\frac{1}{2} V_{i\,max}$

$V_o = \frac{1}{2} \times 10 = 5V$

So o/p wave form



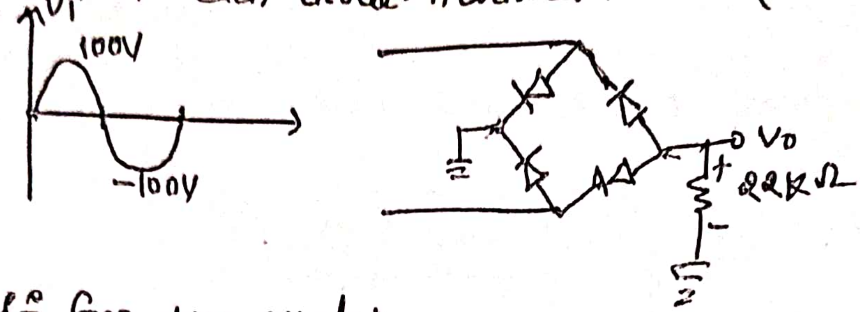
$V_{dc} = \frac{2V_m}{\pi} = 0.636 V_m$

$= 0.636 \times 5$

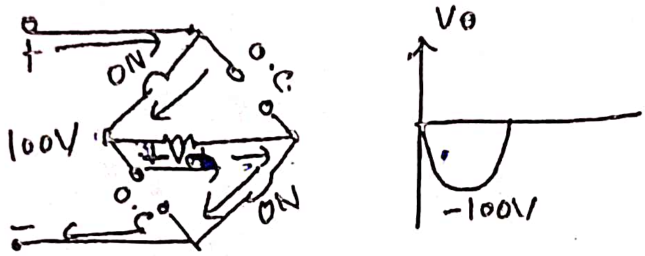
$= 3.18V$

PIV = 5V

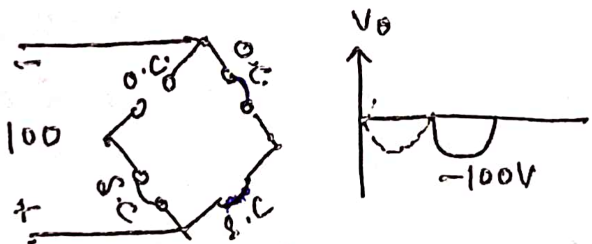
Ques:- 2 Determine V_o and required PIV rating of each diode. All diodes are ideal. (2014-15, 2017-18)



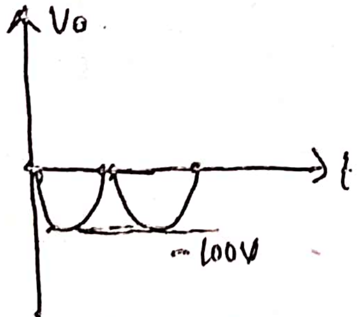
Ans:- for +ve cycle:



for -ve cycle:-



So o/p waveform



Required PIV = 100V

12

Ques 3 A diode having internal resistance $r_f = 20\Omega$ is used for half wave rectification. If the applied voltage $V = 50\sin\omega t$ and load resistance $R_L = 800\Omega$ find (i) I_m, I_{dc}, I_{rms} (ii) ac power I/P and dc power O/P (iii) dc O/P voltage (iv) efficiency of rectification. (2016-17)

Ans: given $V = 50\sin\omega t$

So $V_m = 50V$

(i) $I_m = \frac{V_m}{R_L + r_f} = \frac{50}{800+20} = 61 mA$

$I_{dc} = I_m/\pi = 61/\pi = 19.4 mA$

$I_{rms} = I_m/2 = 61/2 = 30.5 mA$

(ii) ac power I/P $= (I_{rms})^2 (R_L + r_f)$

$= \left(\frac{30.5}{1000}\right)^2 \times (800+20) = 0.763 W$

dc O/P power $= I_{dc}^2 \times R_L = \left(\frac{19.4}{1000}\right)^2 \times 800 = 0.301 W$

(iii) dc O/P voltage $= I_{dc} \times R_L$

$= 19.4 mA \times 800\Omega = 15.52 V$

(iv) efficiency of rectification $= \frac{0.301}{0.763} \times 100$

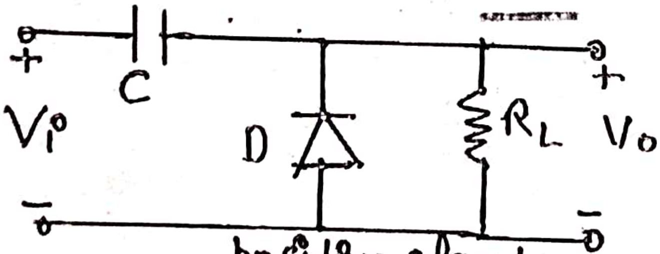
$= 39.5\%$

Ques1 : Explain clamber circuit. (2016-17, 2018-19)

Ans: clamber is a circuit made of diode, capacitor and a large value resistance. clampler circuit shifts the dc level of input ac signal either upword or downward. In clamping process the shape as well as the peak to peak value of input ac signal remains unchanged. Clamber circuits are of three types.

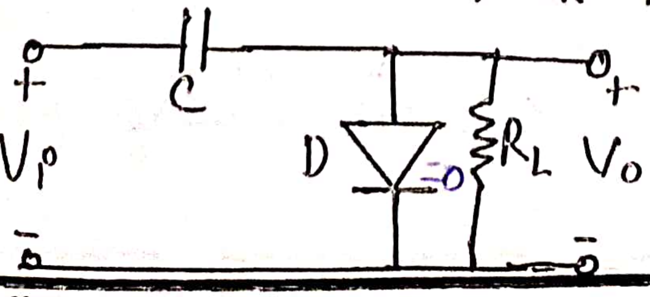
i) positive clamber ii) Negative clamber (iii) Biased clamber

i) positive clamber: when the clamber circuit shifts ac signal in upword direction then clamber is called positive clamber.

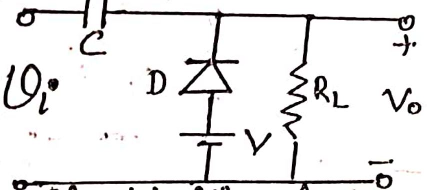


positive clamber

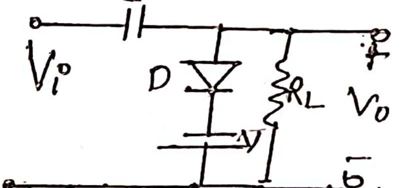
(ii) Negative clamber: when the clamber circuit shift the ac signal in downward direction, then the clamber is known as negative clamber.



(iii) **Biased clamper:-** If dc supply is also present in the clamper circuit then such type of clamper is called biased clamper.
Biased clamper is of two type.
a) Positive biased clamper.
b) Negative biased clamper

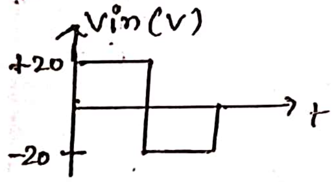


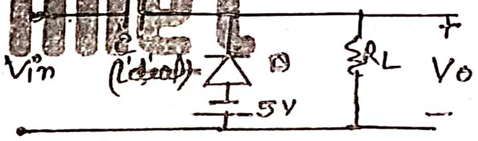
Biased positive clamper



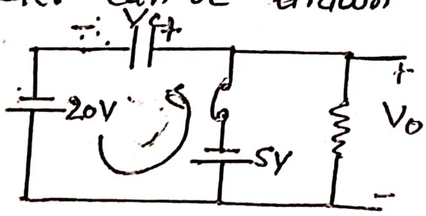
Biased Negative clamper

Ques2:- Draw output waveform. (2014–15)





Ans:- The operation of clamper ckt begins in that part of the i/p signal where diode is ON.
So for $V_{in} = -20$ (negative cycle) diode is ON & ckt can be drawn as:-

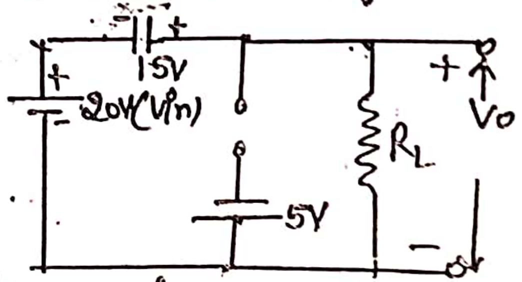


Applying KVL in the ckt

$$-V_c + 5 - 20 = 0$$

$$\boxed{V_c = 15V}$$

In clamper circuits, when capacitor is fully charged, diode will be reverse biased and remains open after charging of capacitor. Now ckt can be redrawn as:–

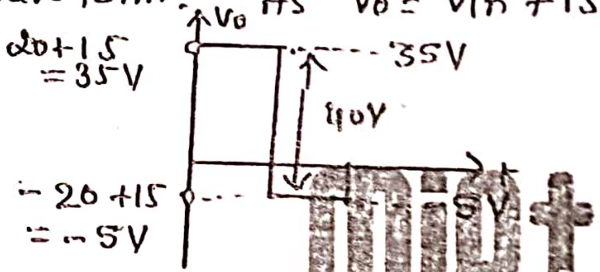


Applying KVL in the CKt

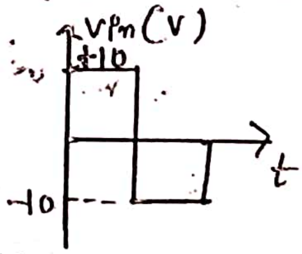
$+15 - V_0 + V_{in} = 0$

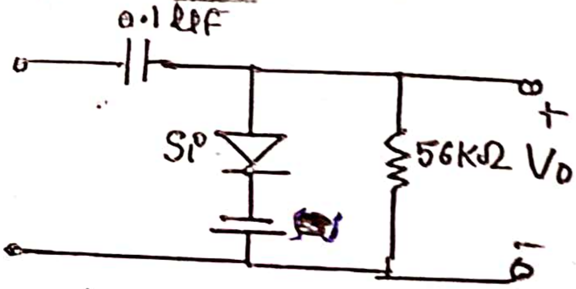
$\boxed{V_0 = V_{in} + 15}$

O/P wave form: As $V_0 = V_{in} + 15$

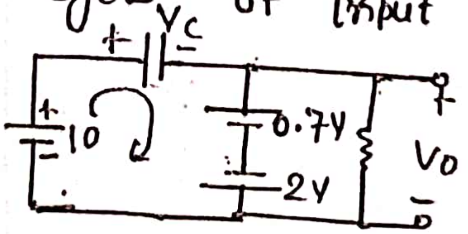


Ques:–3 Draw the o/p wave form. (2016–17)





Soln:– clamping operation starts in positive cycle of input signal.



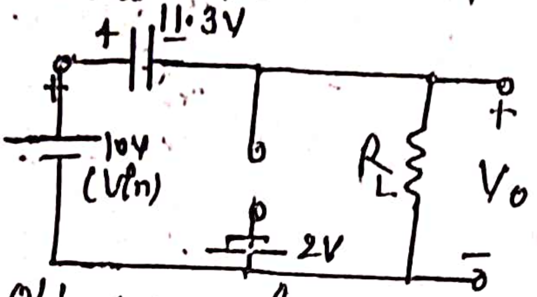
let capacitor is charged upto V_c.

Applying KVL in the circuit

$-V_c - 0.7 + 2 + 10 = 0$

$\boxed{V_c = 11.3V}$

After complete charging of the capacitor the diode remains open (reverse biased).

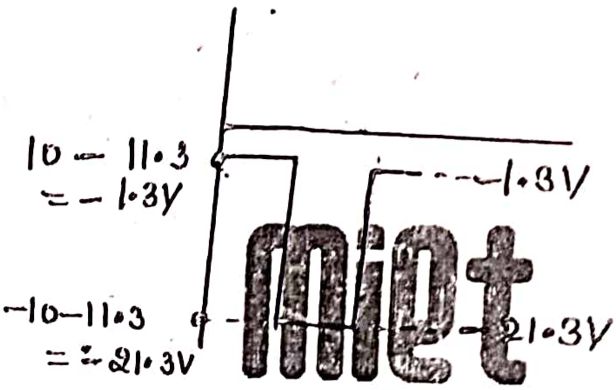


Applying KVL

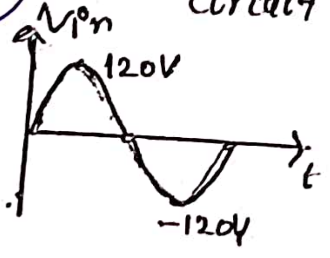
$-11.3V - V_o + V_{in} = 0$

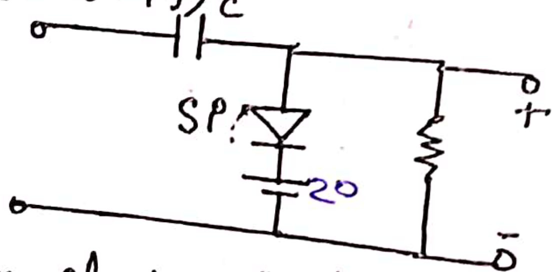
$\boxed{V_o = V_{in} - 11.3V}$

O/p wave form:

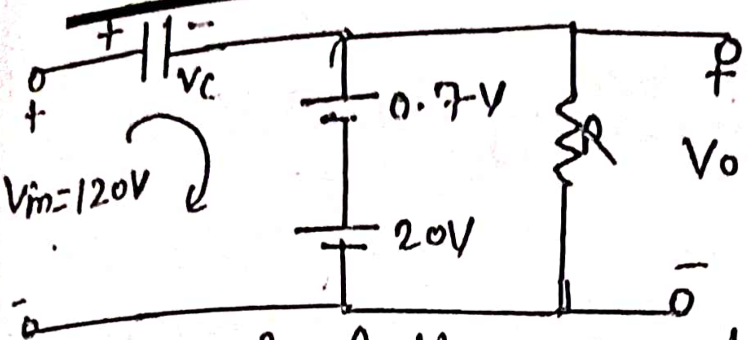


14 Ques 4: Sketch the output for the given clamper circuit (2018−19)





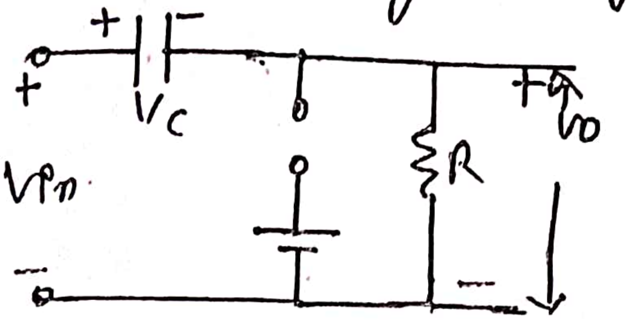
Soln: In the above clamper circuit charging of capacitor will start when $V_{in} > 20$ and continue till $V_{in} = +120V$ (V_{in}). So to obtain the voltage upto which C will be charged apply KVL in the ckt.



$$-V_C + 120 - 0.7V - 20 = 0$$

$$V_C = 99.3V$$

when C is fully charged :



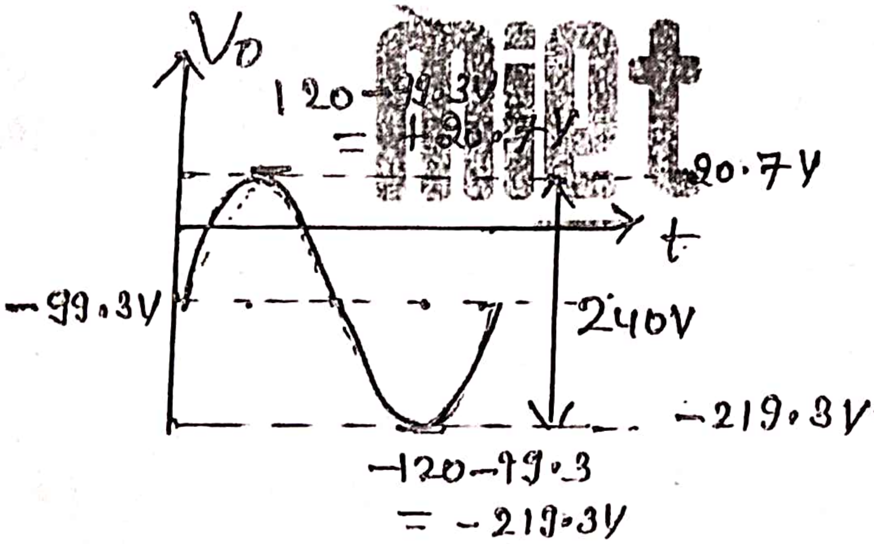
Applying KVL.

$$-V_C - V_o + V_{in} = 0$$

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

$$= V_{in} - 99.3V$$

O/p wave form :



Voltage multiplier circuit :- Voltage multiplier circuit produce a dc voltage that is some multiple of the peak ac input voltage. on the basis of multiplying factor voltage multiplier circuit can be classified as:-

i) Voltage doubler

ii) Voltage tripler

iii) voltage Quadrupler

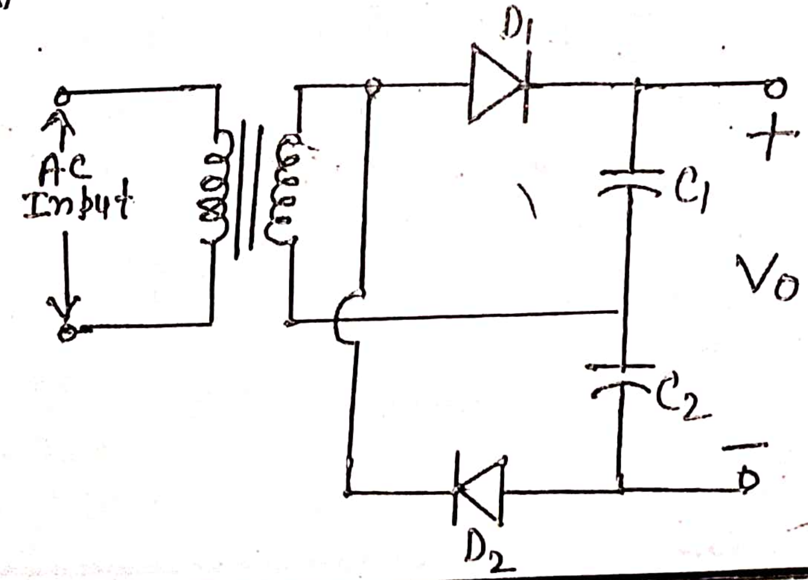
Now voltage doubler is again classified as:-

1) Half wave voltage doubler

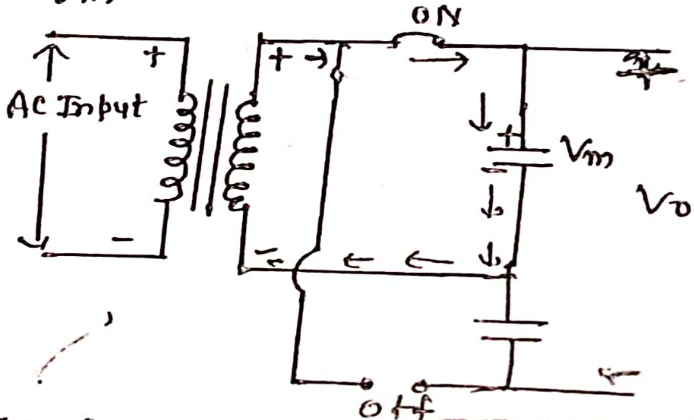
2) Full wave voltage doubler.

Ques:-1 :- Explain the working of full wave voltage double circuit. (2014-15, 2016-17, 2020-21)

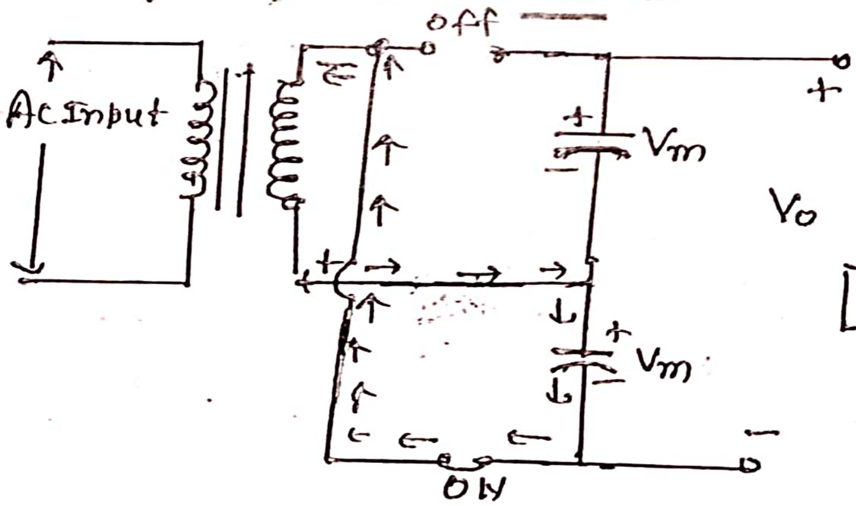
Ans:-



Working:- (i) for positive cycle:- In positive cycle D_1 is forward biased but D_2 is reverse biased. So capacitor C_1 charges up to voltage V_m



(ii) for negative cycle:- In negative cycle D_1 is reverse biased but D_2 is forward biased. So capacitor C_2 charges up to voltage V_m

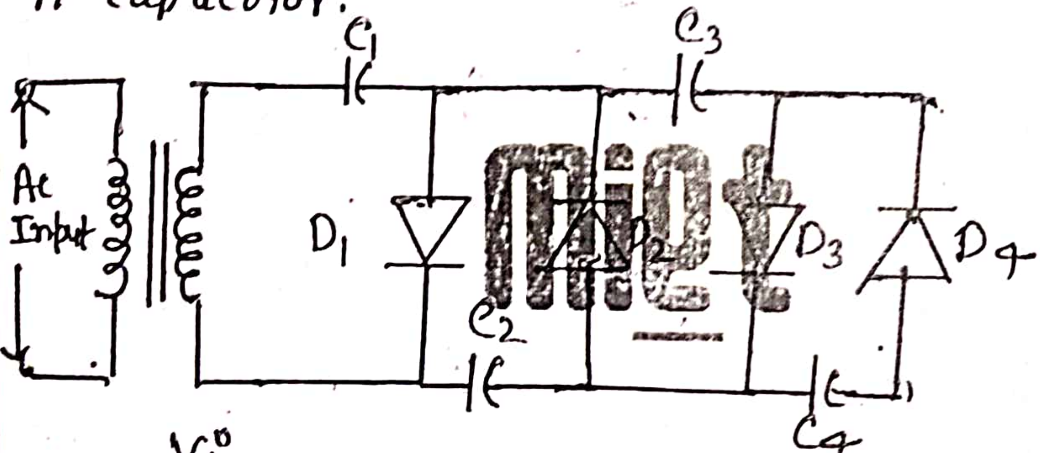


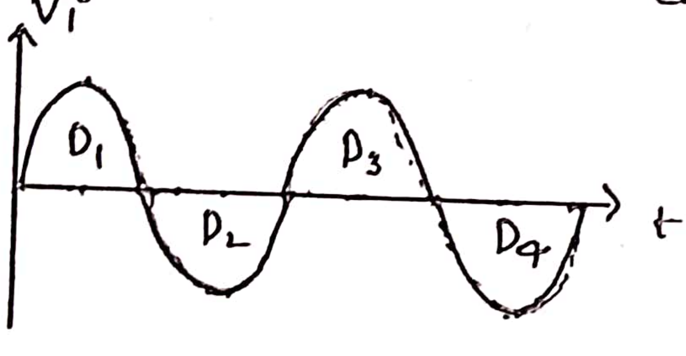
So
$V_o = V_{C_1} + V_{C_2}$
$= V_m + V_m$

$\boxed{V_o = 2V_m}$

7 Ques 2:- Explain the multiplier circuit (Half wave double, tripler, Quadrupler). (2014-15, 2015-16, 2017-18)

Ans:- this circuit diagram is a general voltage multiplier circuit. It can perform function of voltage doubler, tripler and quadrupler. So for doubler two diode and two capacitor are needed, for tripler three diodes and three capacitor are needed. If we need nV_m at output we have to use n- diode & n capacitor.





Working:- for first positive cycle:-
D_1 is ON. So capacitor C_1 charges up to voltage V_m. $V_{C_1} = V_m$

(ii) for first negative cycle:
D_2 is ON. So capacitor C_2 charges up to voltage $2V_m$

Applying KVL

$$V_m + V_{C_2} - V_m = 0$$
$$V_{C_2} = 2V_m$$

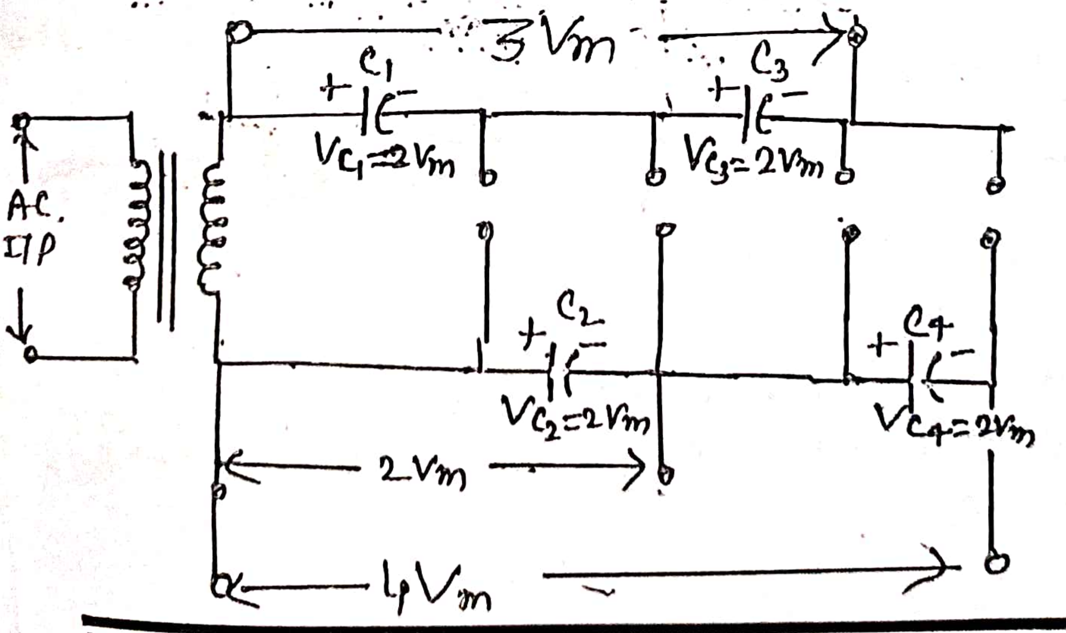
(iii) for second positive cycle:
D_3 is ON. So capacitor C_3 charges up to voltage $2V_m$.

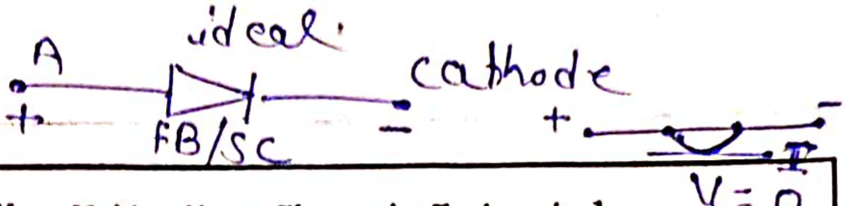
Applying KVL

$$-V_m + 2V_m - V_{C_3} + V_m = 0$$
$$V_{C_3} = 2V_m.$$

(iv) for second negative cycle:
D_4 is ON. So capacitor C_4 charges up to voltage $2V_m$

Applying KVL: $-V_m - 2V_m + V_{C_4} + 2V_m - V_m = 0$
$$V_{C_4} = 2V_m$$





Imp.

Ques:- Explain clipper circuits.

Ans:- Clippers are circuit made of diode, resistance and dc supply. Clippers can remove or clipp-off some portion of input ac signal without distorting remaining part of the signal.

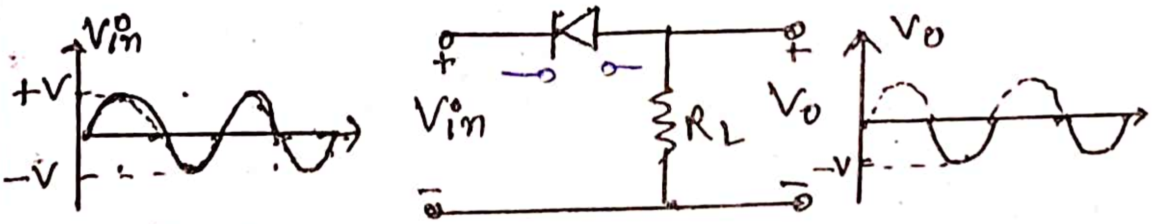
Types of clipper circuit:- Clipper are of following type.

(i) Positive clipper (ii) Negative clipper

(iii) Biased clipper

(i) **Positive clipper:-** A positive clipper removes the positive half cycle of the input ac voltage. Positive clipper is of two type:

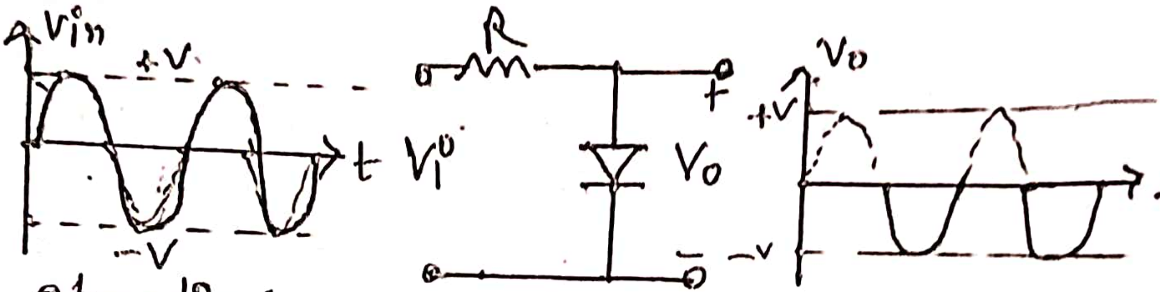
(a) **Series positive clipper:-**



Operation:-

- In positive cycle diode is reverse biased so diode is off and output will be zero
- In negative cycle diode is forward biased so diode is ON and output will be negative input cycle $\boxed{V_o = V_i}$

b) Shunt positive clipper:-

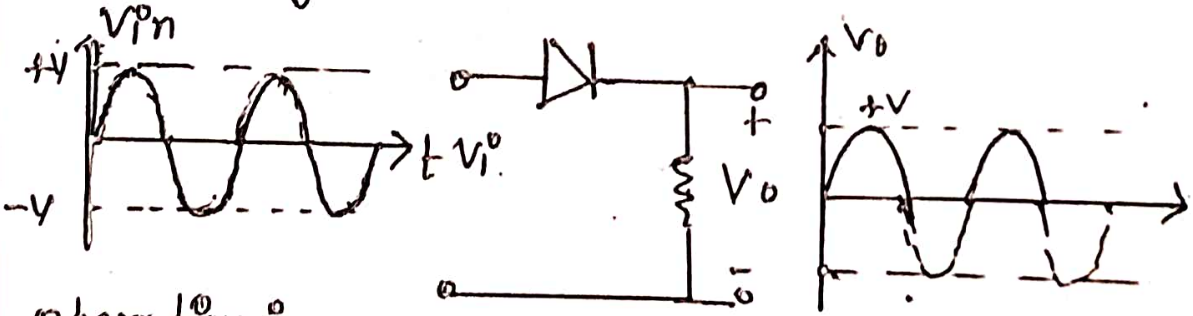


Operation:-

- In positive cycle diode is forward biased. So diode is ON and output will be zero.
- In negative cycle diode is reverse biased. So diode is off and output will be negative input cycle. So $\boxed{V_o = V_i}$

ii) Negative clipper:- A negative clipper ... the negative half cycle of input voltage. Negative clipper is of two type:-

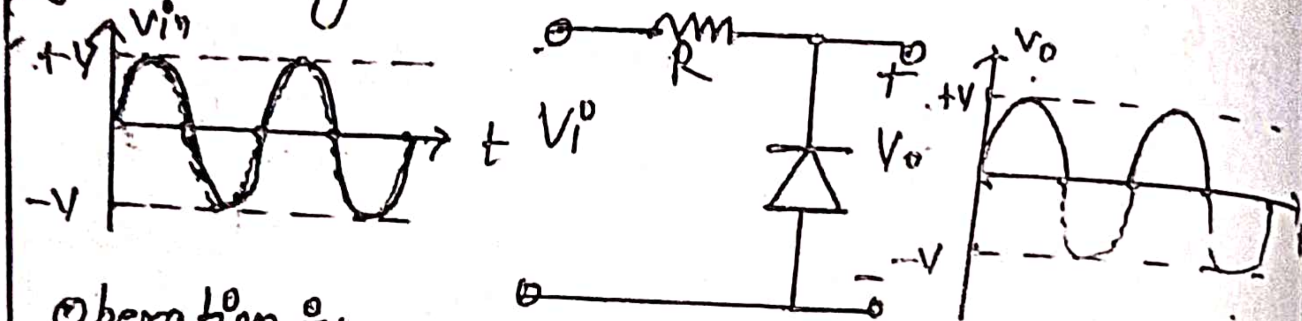
a) series Negative clipper:-



Operation:-

- In positive cycle diode is forward biased. So diode is ON and output will be equal to input voltage. So $V_o = V_i$
- In negative cycle diode is reverse biased. So diode is off. So output will be zero.

b) shunt negative clipper:

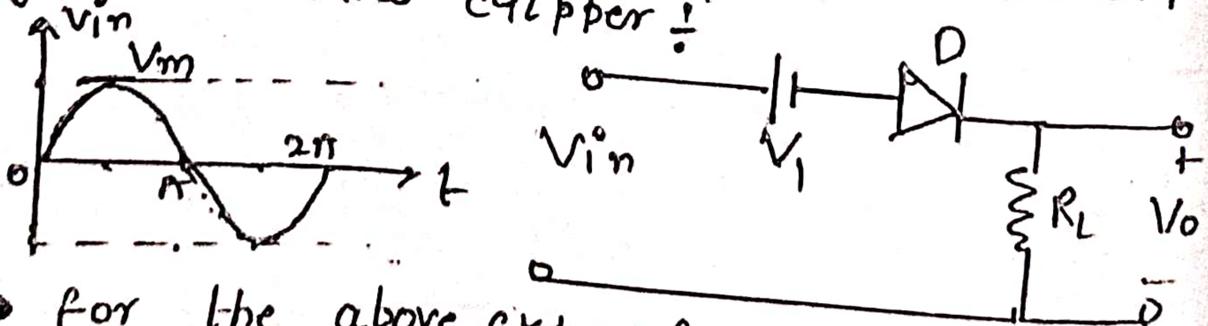


Operation:

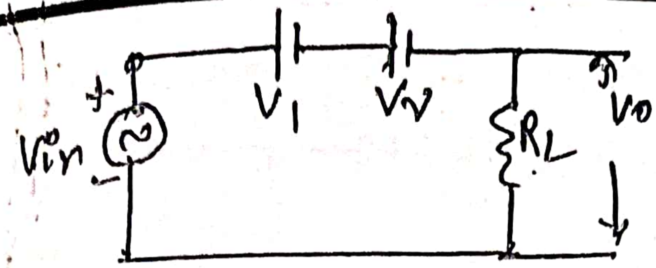
- In positive cycle diode is reverse biased. So diode is off and output voltage will be equal to input voltage. So $V_o = V_i$
- In negative cycle diode is forward biased. So diode is ON and output voltage will be zero.

iii) Biased clipper. Biased clipper is used to clip off or remove a small portion of positive cycle or negative cycle or both. This is achieved by adding a battery in series with diode. Biased clipper is of two type:
i) series biased clipper
ii) shunt biased clipper

a) series biased clipper:



- For the above ckt; if $V_{in} - V_1 > V_\gamma$ or $V_m > V_1 + V_\gamma$ then diode is ON and replace by V_γ.

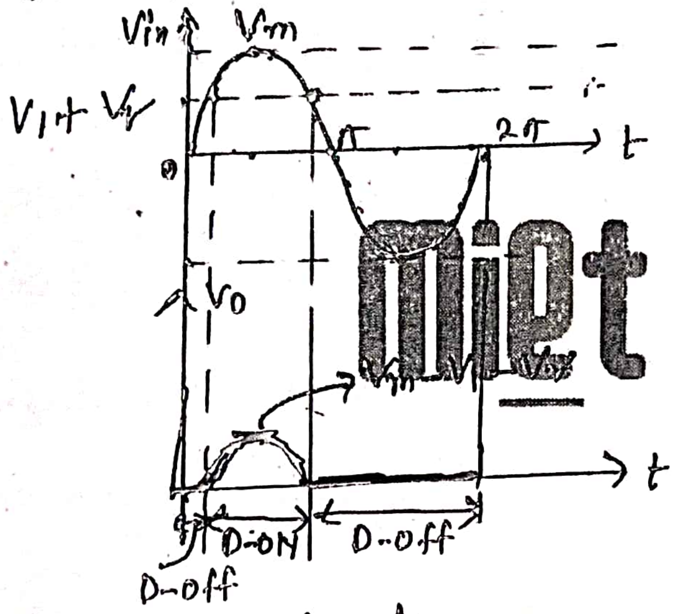


$$\boxed{V_o = V_{in} - V_1 - V_\gamma}$$

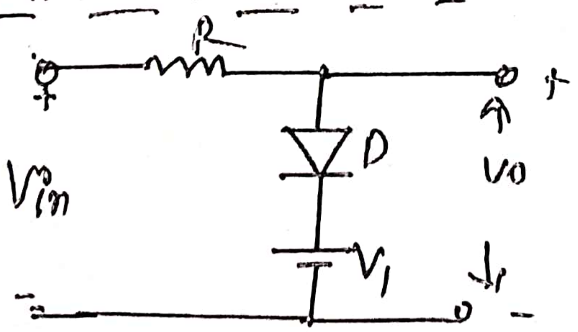
- If $V_{in} - V_1 \le V_\gamma$ then diode is off and replace by open circuit. In this case

$$\boxed{V_o = 0}$$

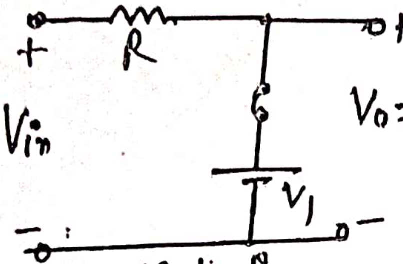
o/p wave form:



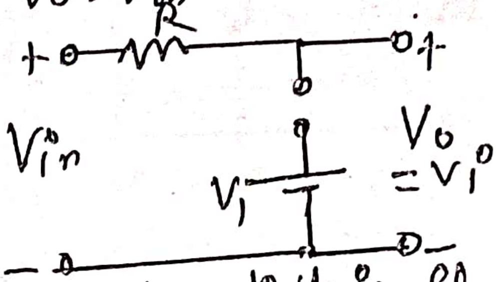
b) shunt biased clipper:



- If diode is ON then $V_o = V_1$
- If diode is off, then $V_o = V_{in}$



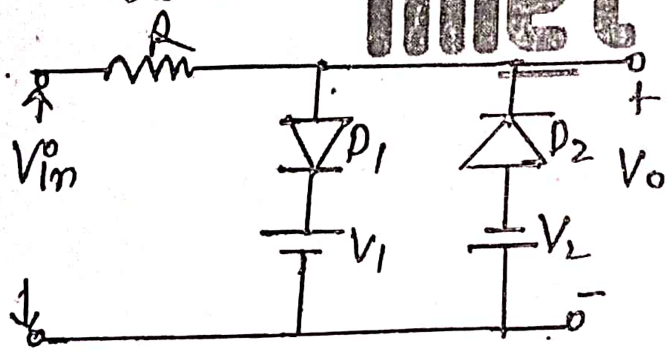
when diode is ON

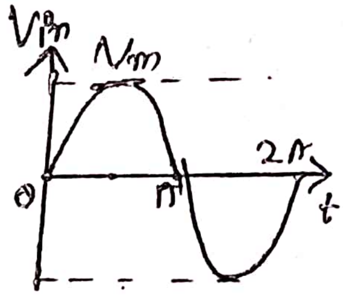


when diode is off.

⇒ Two way or combinational clipper:

In two way or combinational clipper two diodes are in parallel branch. The orientation of diode is such that both the diodes can not be in ON condition simultaneously.



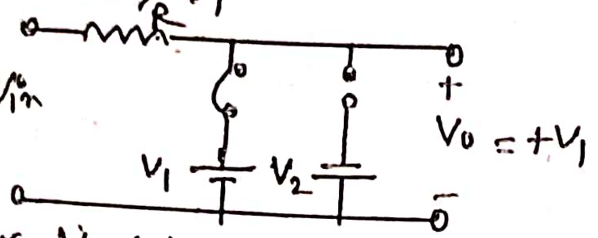


Here:

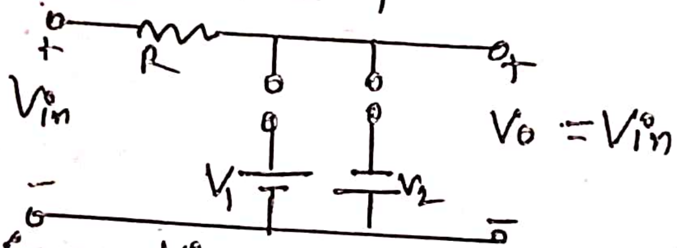
When $V_{in} > V_1 \Rightarrow D_1$ is ON & D_2 is off

$V_{in} < -V_2 \Rightarrow D_1$ off & D_2 is ON

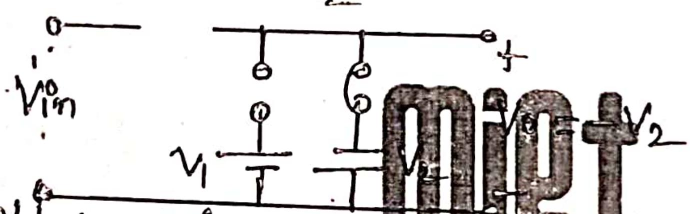
$-V_2 \le V_{in} \le V_1 \Rightarrow$ Both diodes are off for $V_{in} > V_1$



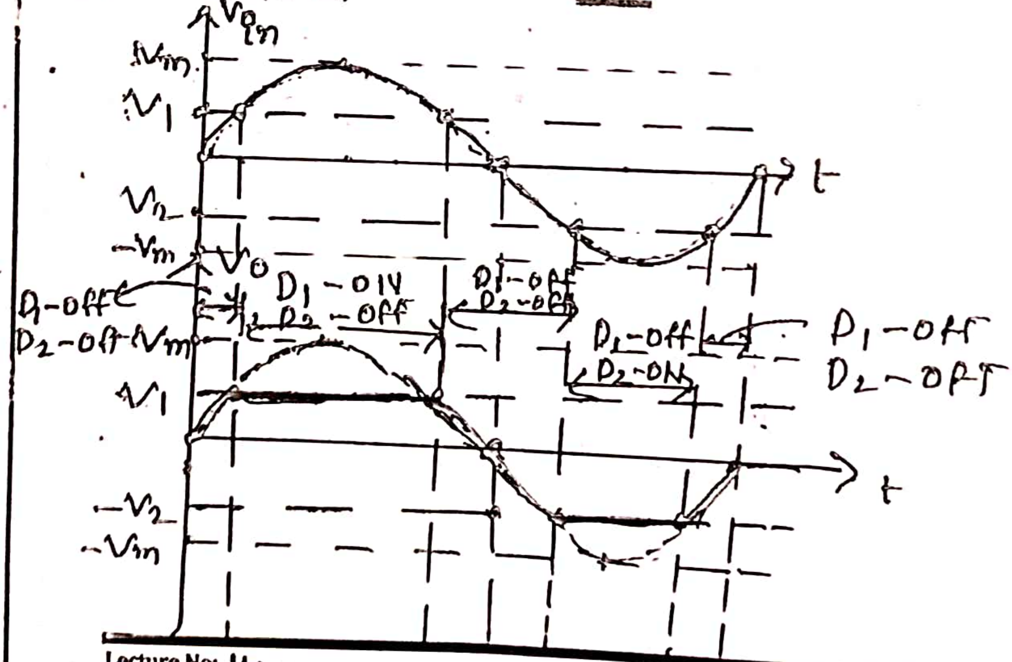
for $-V_2 \le V_{in} \le V_1$



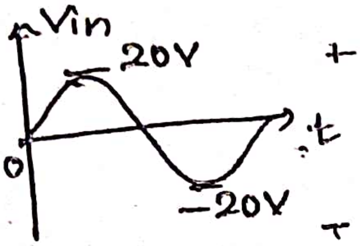
for $V_{in} < -V_2$

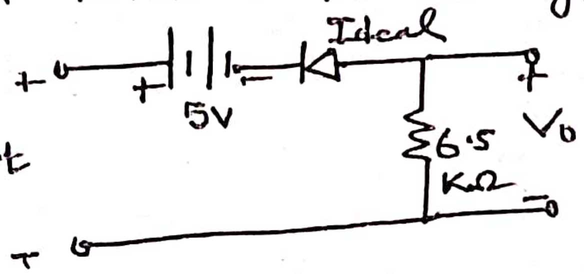


O/p wave form

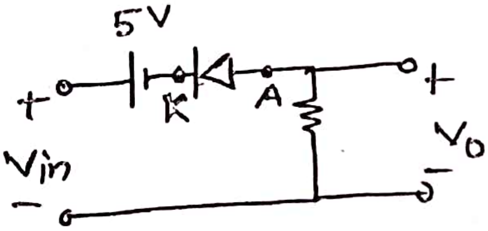


Q Determine & Sketch V_o for the given network. (2014-15)





Sol^n

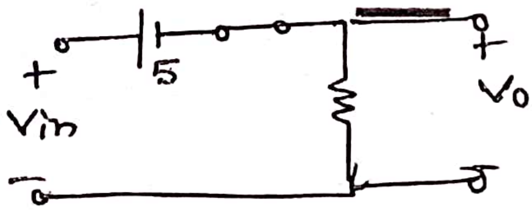


As the diode is ideal,

for $V_{in} - 5 < 0 \Rightarrow$ Diode is ON

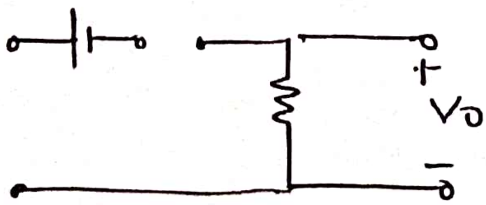
& for $V_{in} - 5 \geq 0 \Rightarrow$ Diode is OFF.

So, For $V_{in} - 5 < 0$ or $V_{in} < 5V$, the ckt diagram will be –



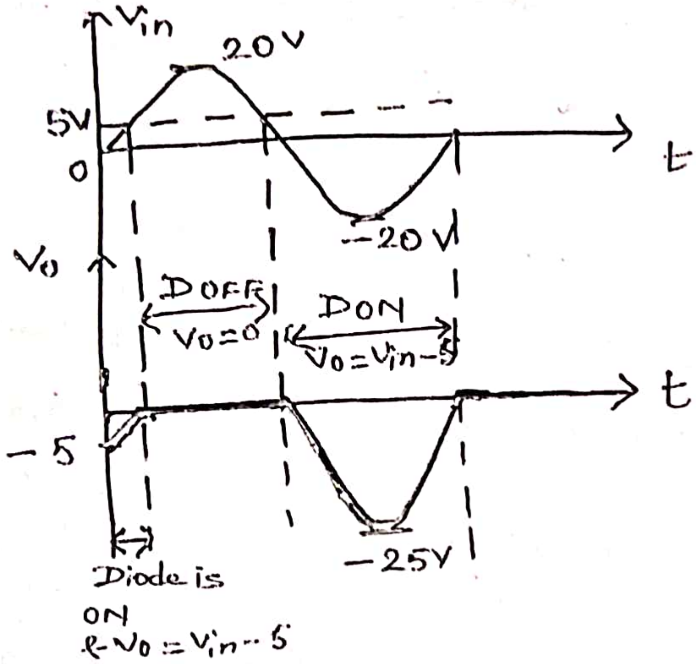
So, $V_o = V_{in} - 5$

For $V_{in} - 5 \geq 0$, the ckt diagram will be –

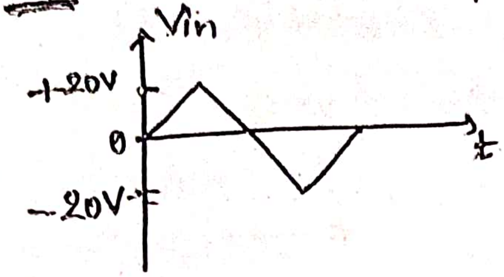


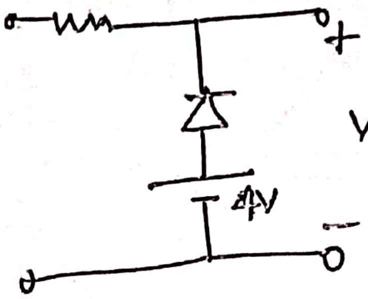
So, $\underline{V_o = 0V}$

O/p wave form :-


V_{in}
20V
5V
0
t
−20V
V_o
D OFF
$V_o = 0$
D ON
$V_o = V_{in} - 5$
t
−5
−25V
Diode is ON
& $V_o = V_{in} - 5$

Q. Draw the output waveform – (2020-21)



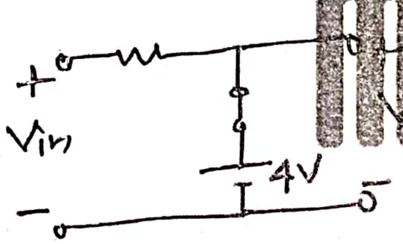


Let the diode given in the ckt is ideal.

Then for $V_{in} - 4 < 0 \Rightarrow$ Diode is ON.

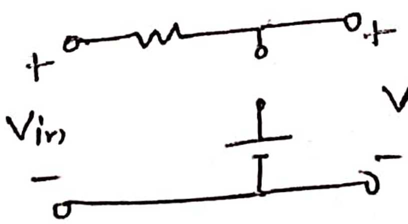
& for $V_{in} - 4 \geq 0 \Rightarrow$ Diode is OFF.

So, for $V_{in} - 4 < 0$ or $V_{in} < 4V$, the ckt is –



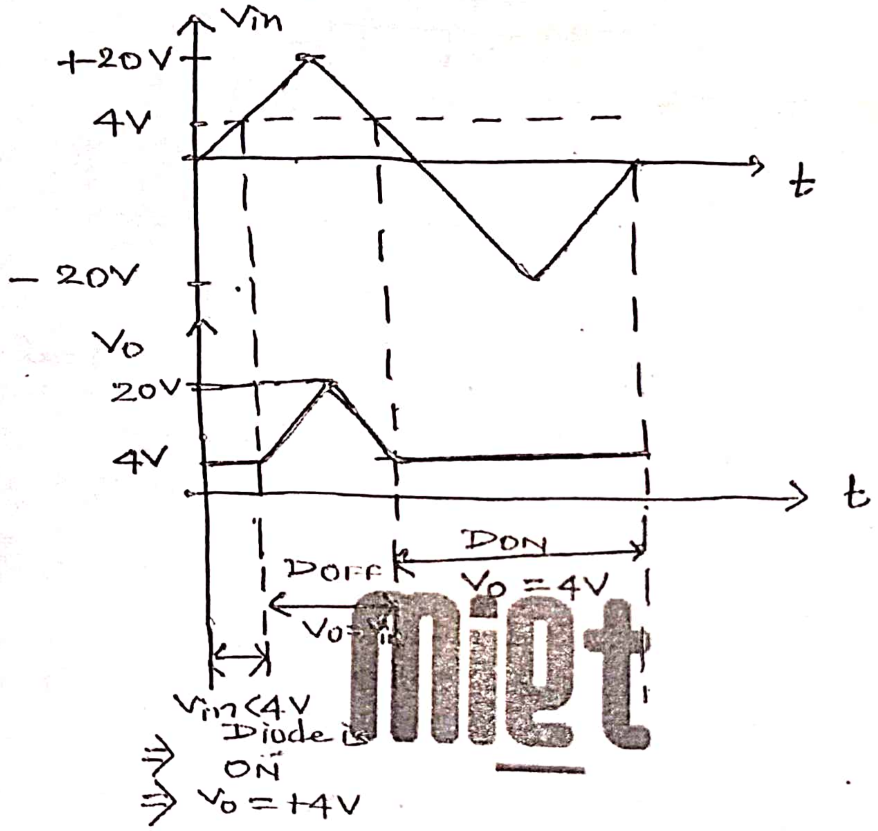
Here, $V_o = +4V$

& for $V_{in} - 4 \geq 0$ or $V_{in} \geq 4V$, the ckt is –

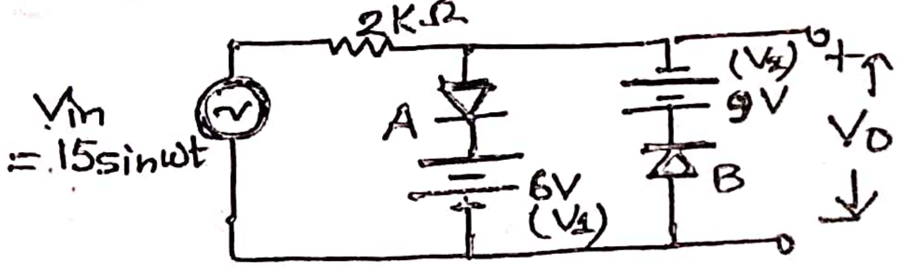


Now, $V_o = V_{in}$

O/p Waveform

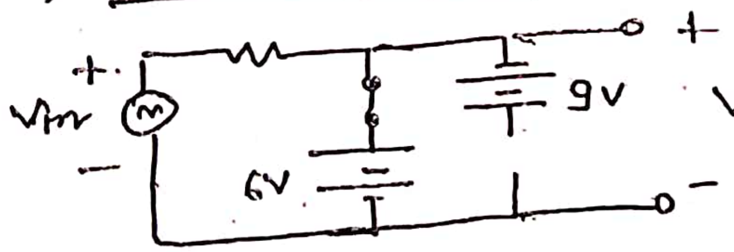

Vin
+20V
4V
t
– 20V
Vo
20V
4V
t
DON
DOFF
Vo = 4V
Vo=Vin
Vin<4V
Diode is
ON
⇒ Vo = +4V

Q. Explain the function of the circuit shown in fig. & draw the output waveform. (2015-16, 2016-17)



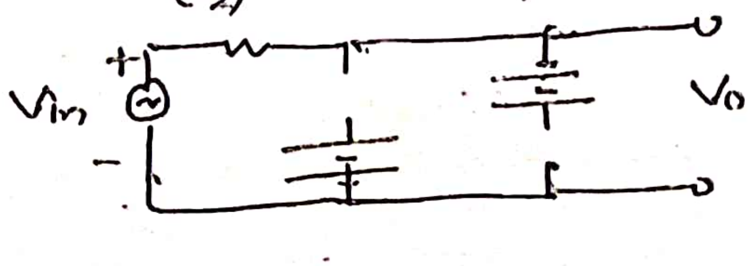
Sol^n The ckt shown above is a two way clipper circuit which is also called combinational clipper. As a clipper remove some part of input ac signal above or below a certain reference level, here this circuit has two reference levels $+V_1$ & $-V_2$. The ckt removes the part of i/p ac signal greater than V_1 & less than $-V_2$, while between these levels the ac signals remains unchanged.

Here, for $V_{in} > 6V\ (V_1)$



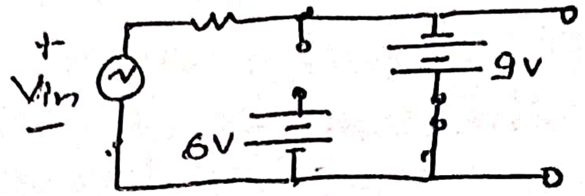
$V_o = +6V$

For $-9\ (V_2) \le V_{in} \le 6\ (V_1)$



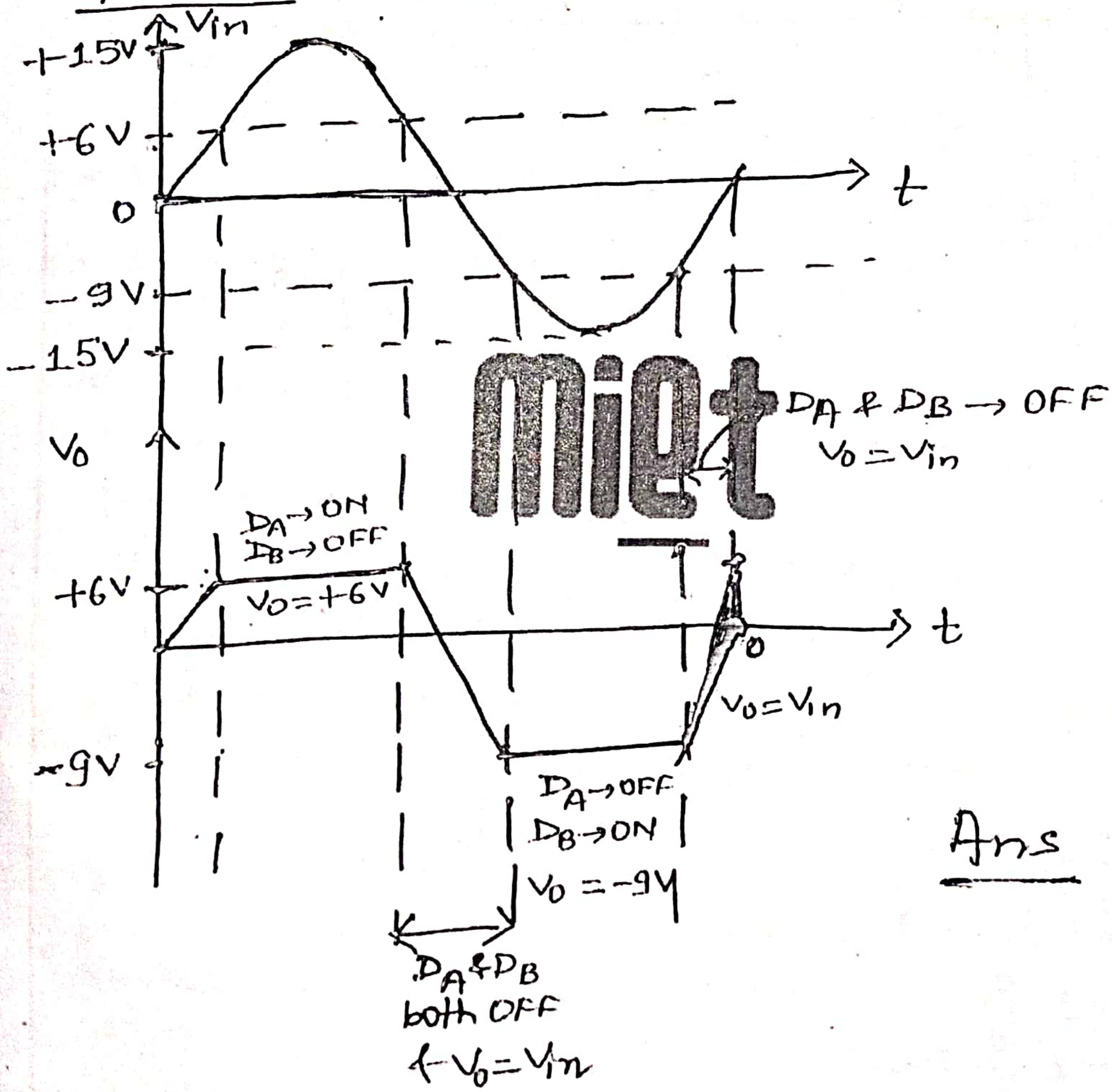
$V_o = V_{in}$

For, $V_{in} < -6V$



$V_o = -9V$

O/P Waveform



Ans

Imp 17

Ques-1 : What is varactor diode. Also give the Application. (2015-16, 2016-17, 2020-21)

Ans : Varactor diode (VARICAP) : It is special purpose diode which can be used as a variable capacitor in microwave circuit.

Symbol.

Working :

Varactor diode is used in reverse bias condition. In reverse bias, the P-region and N-region act like the plate of capacitor. While the depletion region act like dielectric. So there exists a capacitance, space charge capacitance or depletion region capacitance. It is given by

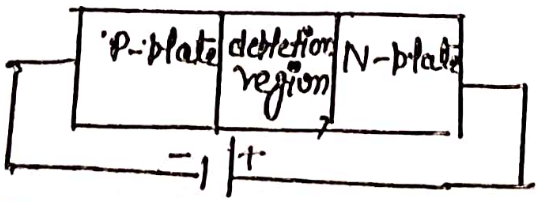
$$C_T = \frac{\epsilon A}{W}$$

$\epsilon \rightarrow$ permittivity of semiconductor

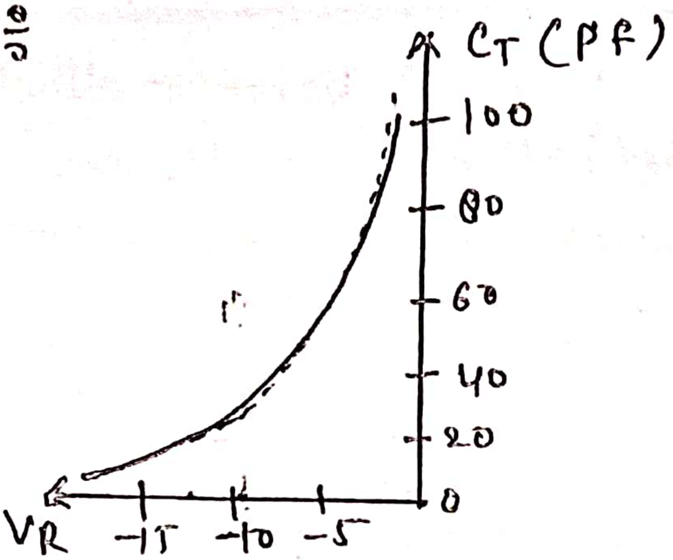
$A \rightarrow$ Area of cross section

$W \rightarrow$ Width of depletion region

As the reverse bias applied to the diode increase, the width of depletion region (W) increases. So C_T decreases and viceversa. Therefore capacitance can be controlled by applied voltage.



Characteristics :-

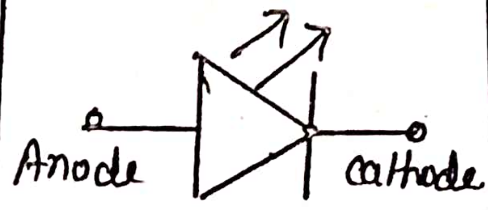


Application :-
1) FM modulator 2) Tunning circuit 3) In TV Reciver 4) In Radio Receiver.

Imp
Ques 2 :- Explain the principle of operation of LED. (2016-17, 2017-18)

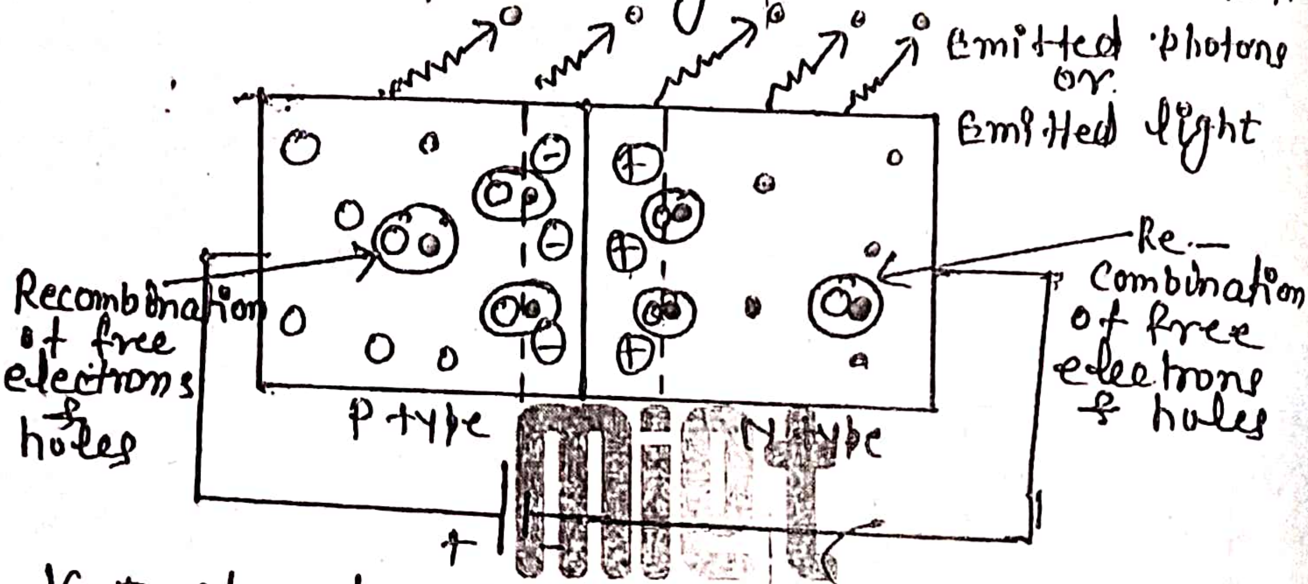
Ans :- light Emitting diode (LED) is a photo electronic device which converts electrical energy into light energy. material like gallium, phosphorus and arsenic are used for the manufacturing of LED.

S.N.	material	Colour
1.	GaN	Blue (at 5V)
2.	GaIN	White (at 4V)
3.	GaAsP	Red (at 1.8V)
4.	GaAsP	orange (at 2V)
5	GaP	Green

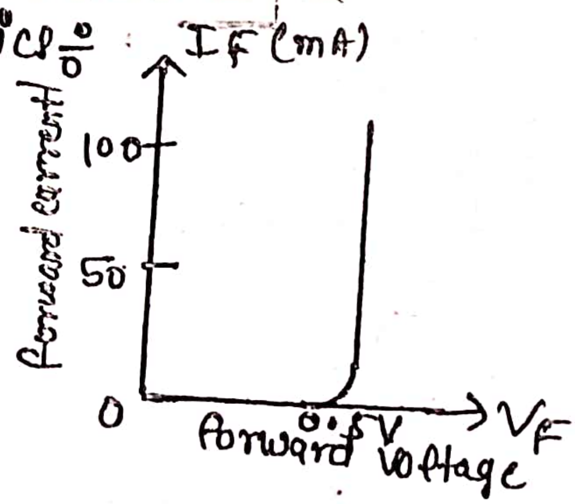


Symbol

Working: When LED is forward biased then hole in p type and electron in n-type start to cross the junction and recombine with each other. Simple diode (Ge, Si) produce heat in recombination process. But LED produce light in recombination.



V-I characteristics:



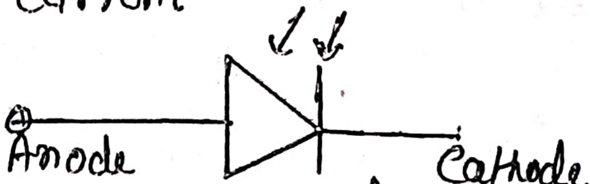
Application:

1) Used in digital clocks
2) Used in calculators
3) Used in mobile, TV displays
4) Used in seven segment displays

Imp (16)

Ques 3: What is photo-diode. Explain working and gives application.

Ans: A photo diode is a semiconductor p-n junction device that converts light into an electric current.



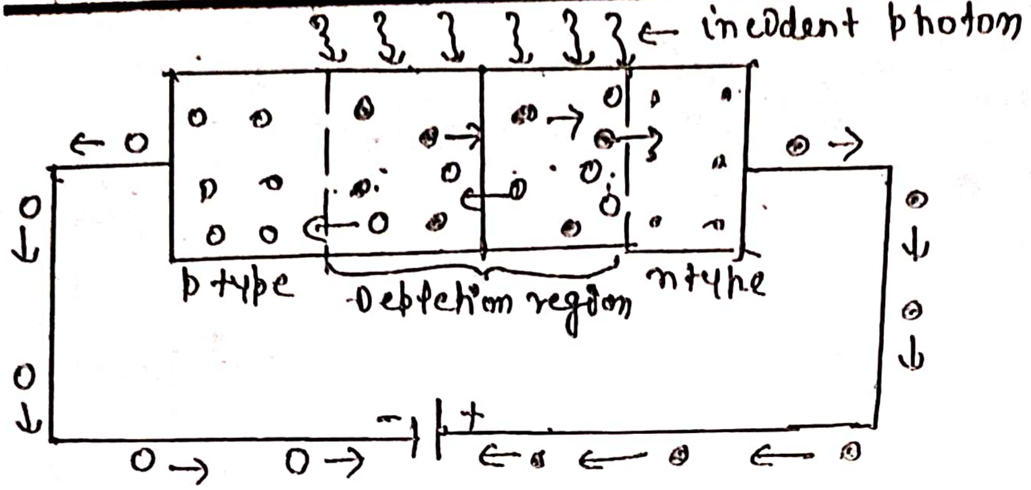
Symbol.

Working:

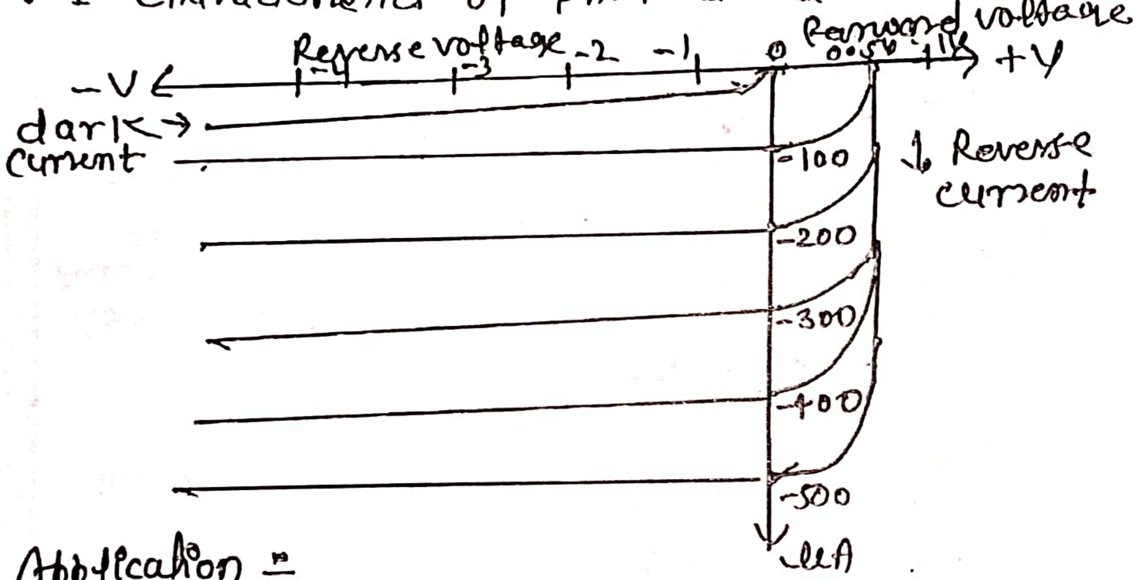
⇒ When a light or photon is used to illuminate p-n junction than photon hits the immobile ions present in the depletion layer

⇒ If energy of photon is greater than 1.1 eV than covalent bond will break. So electron hole pair are generated.

⇒ Due to electric field, electron-hole pair move away from the junction. Hence holes move to anode and electrons move to the cathode to produce photo current. This entire process is know as photo-electric effect.



V-I characteristics of photo diode.



Application :-

1) optical communication system
2) medical devices
3) Solar cell pannels
4) Smoke detectors
5) Camera light meters and street lights.

V.Imp

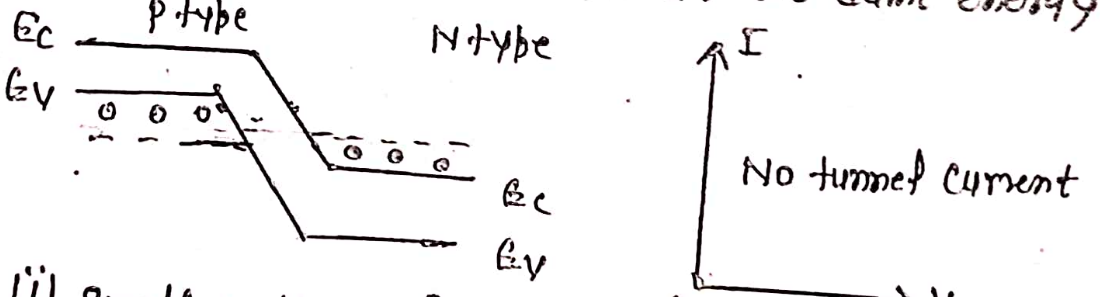
18 Ques:- 5 Explain working and characteristics of tunnel diode with the help of neat diagram (2015-16, 2016-17, 2017-18)

Ans:- A tunnel diode is a heavily p-n junction diode. the doping of tunnel diode is 1000 times greater than simple diode. so depletion layer is very narrow and is of the order of 10nm.

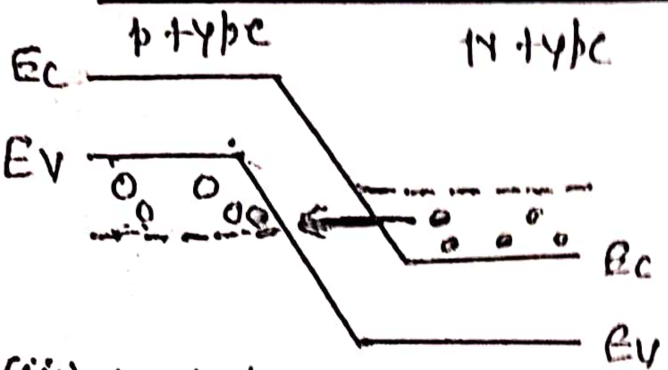
In tunnel diode, electric current is caused by "Tunneling" or "Tunnel effect".

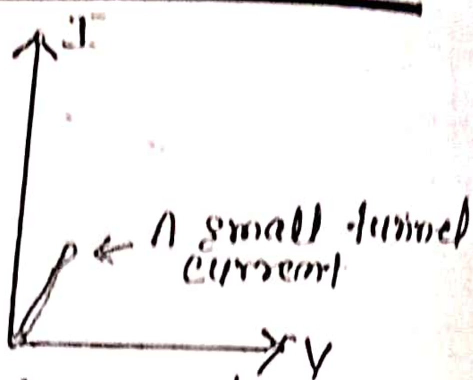
Working of tunnel diode:-

i) Unbiased tunnel diode:- Due to high doping the conduction band of n type overlaps with the valence band of p type material. Because of this overlapping the conduction band electrons & valence band holes are at the same energy level.

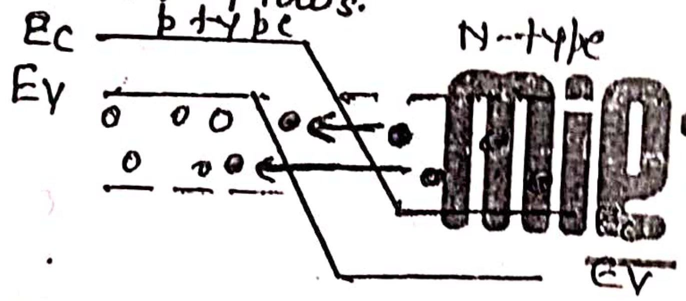


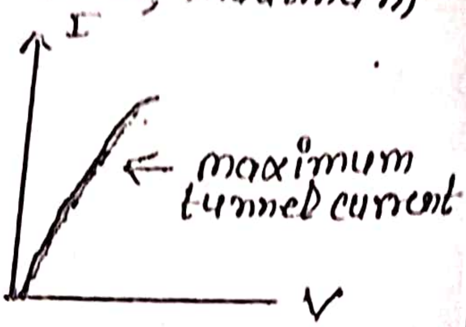
ii) Small voltage is applied:- when a small voltage is applied, then a small number of electrons in the conduction band of n region will tunnel to the empty states of the valence band in p region. This will create a small forward bias tunnel current.



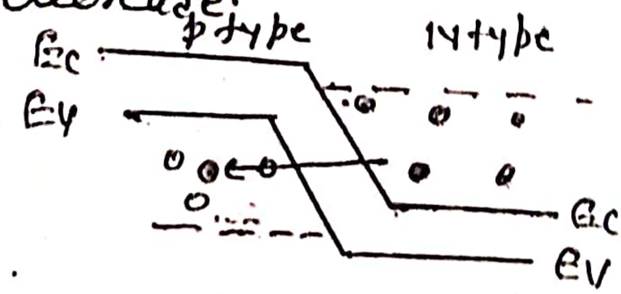


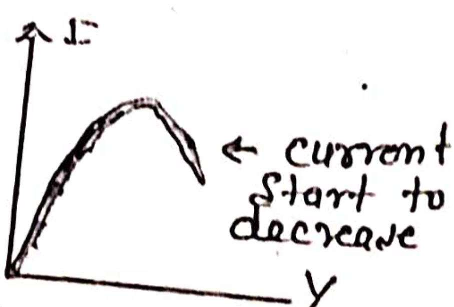
(iii) Applied voltage is slightly increased :- when the voltage applied is slightly increased, the energy level of n-side conduction band becomes exactly equal to the energy level of a p side valance band. As a result, maximum current flows.



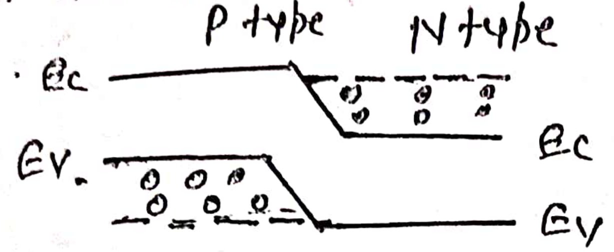


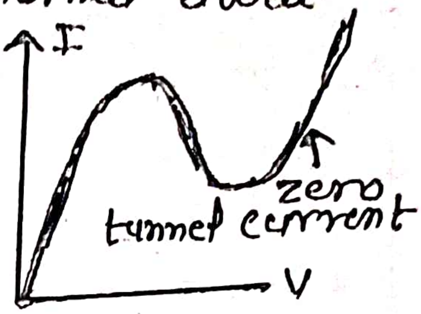
(iv) Applied Voltage is further increased :- A slight misalign of the conduction band and valance band takes place. so current start to decrease.



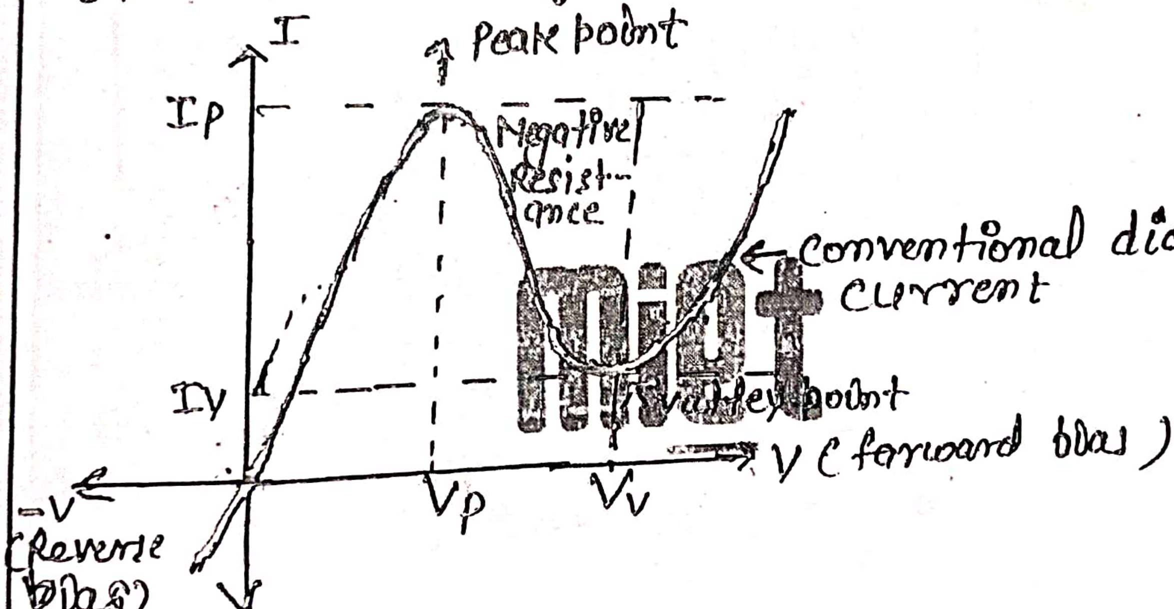


(V) Applied voltage is largely increased :- At this point the conduction band and valance band no longer overlap and tunnel diode operates in the same manner as a normal diode.





Complete V-I characteristics of tunnel diode :-



Advantage of tunnel diode :-

- Long life
- High speed operation
- low noise
- low power consumption

Disadvantage of tunnel diode :-

- Tunnel diode can not be fabricated in large numbers.
- Being a two terminal device, the input and output are not isolated from one another

Application of tunnel diode :-

- Tunnel diode are used as logic memory storage device.
- Tunnel diode are used in relaxation oscillator ckts.
- Tunnel diode is used as an ultra high speed switch.
- Tunnel diode are used in FM receivers.

Symbol

Ques 5 :- Explain the construction, working principle of LCD. Also give it application and advantange. (2016-17, 2018-19, 2020-21)

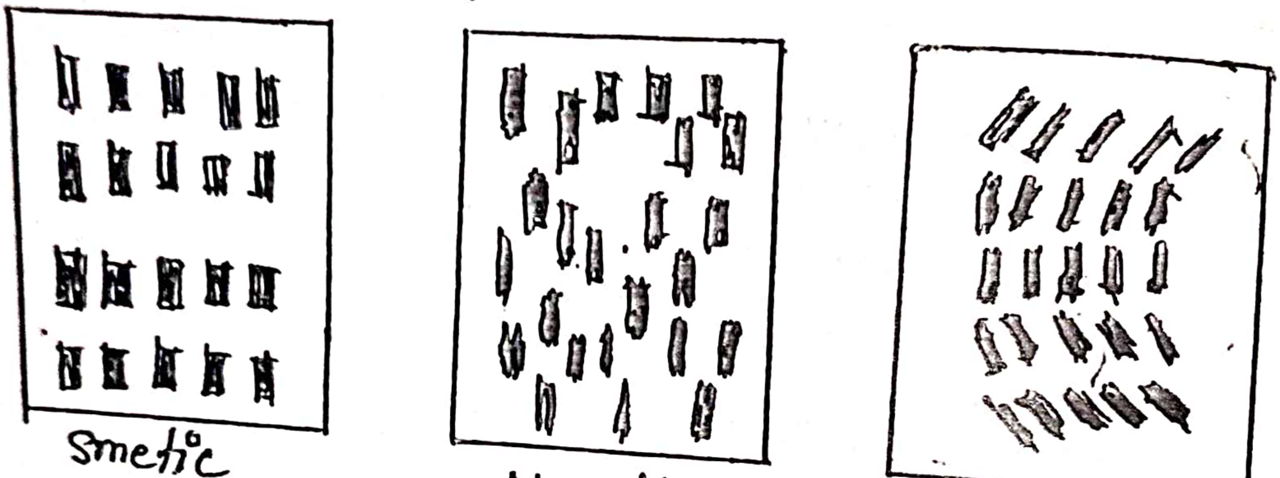
Ans :- Liquid crystal display (LCD) uses a speeval type of material called liquid crystals. these material have the property of liquid and solid. the term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid.

the crystal is made of organic molecules which are rod like molecules defines the direction of the liquid crystal. ON the basis of different arrangements of these rod liquid crystal can be divided in three categories.

1) Smetic :- In this structure the rod like molecules are arranged in layers. and with in each layer there is orientation order over a long range.

2) Nematic :- In this structure the order between layers of molecule is lost but the orientation order is maintained.

3]· Cholestric:- In this crystals the rod like molecules in each layer are oriented at a different angle with in each layer.

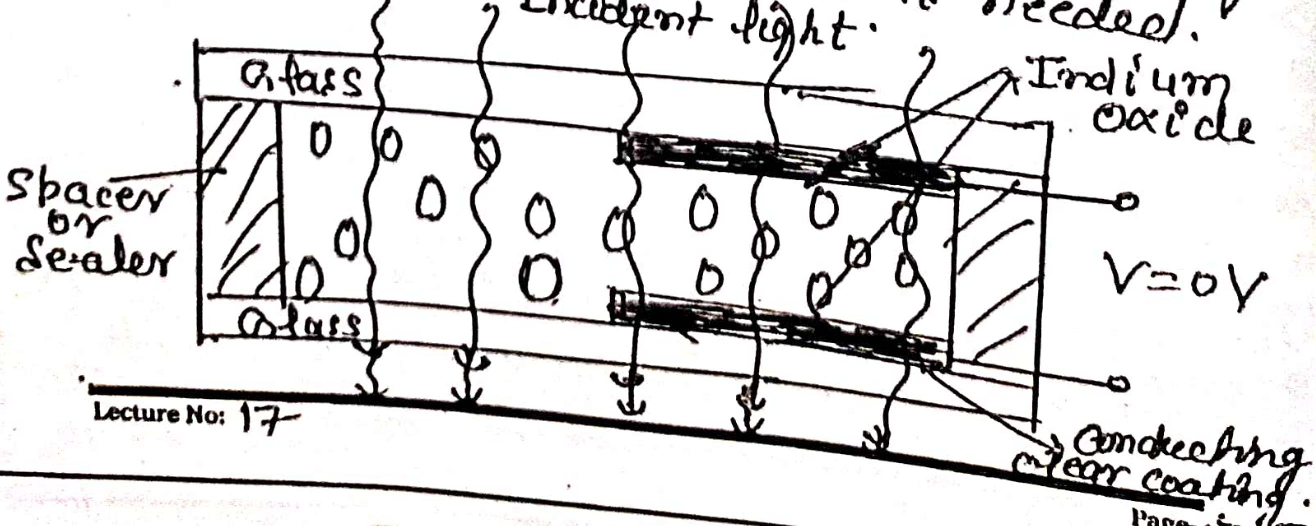


Smetic　　Nematic　　Cholestroc.

Working:- (i) Nematic liquid crystal with no applied bias

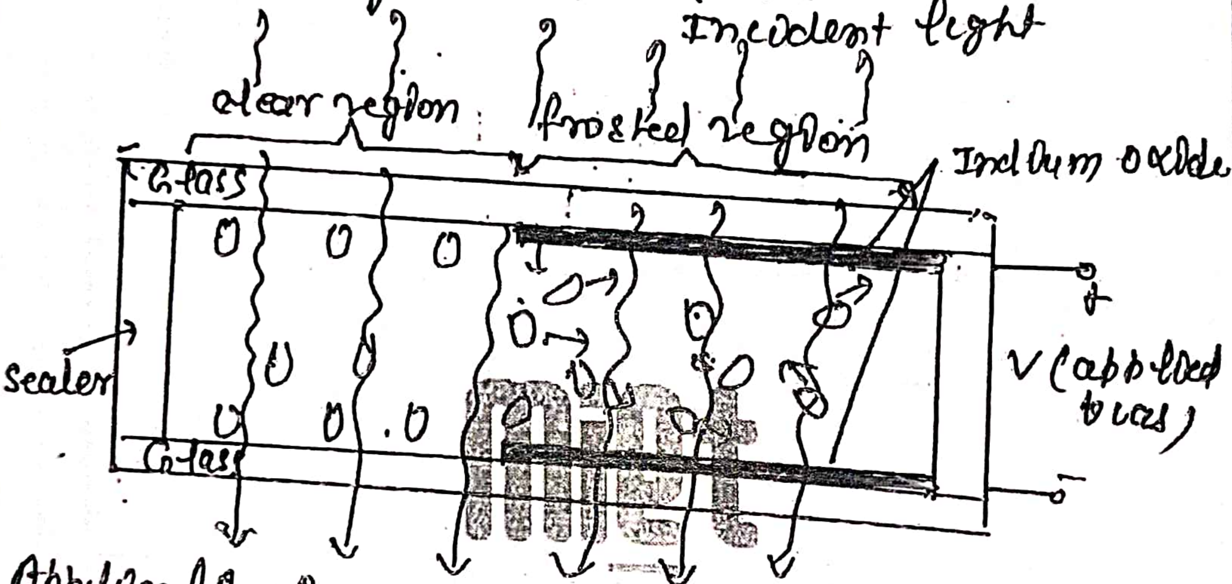
→ When no voltage is applied to plates the molecules of liquid crystal (Nematic) are parallel or perpendicular to the glass plate, so display looks transparent.

⇒ LCD does not produce it's own light so an external light source is needed.



(ii) Nematic liquid crystal with applied bias:
when a voltage is applied the arrangement of molecules distributed. So, two regions are formed.

i) frosted region: It shows the light.
ii) clear region: It looks transparent



Application:
1) used in digital clocks 2) used in calculator
3) used in mobile, TV display 4) used in eight segment display.

Advantage of LCDs

- less power consumption
- low cost
- uniform brightness with good contrast
- low operating voltage & current

Disadvantage of LCDs

- Poor reliability
- limited temperature range
- slow speed
- Requires an AC drive.

5 Year's

University Previous Questions

(Questions Bank)

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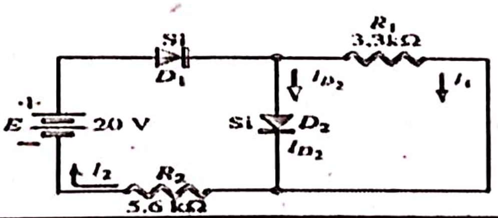
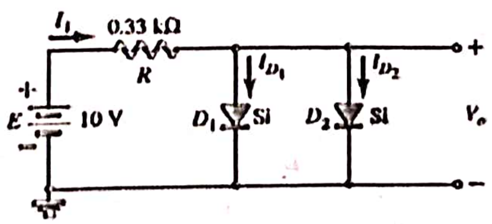
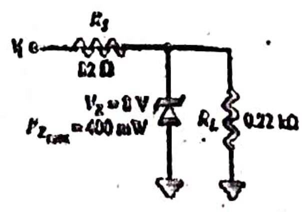
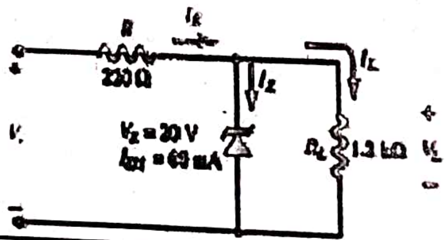
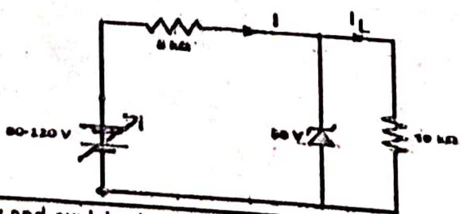
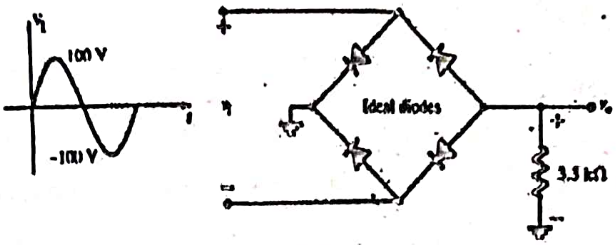
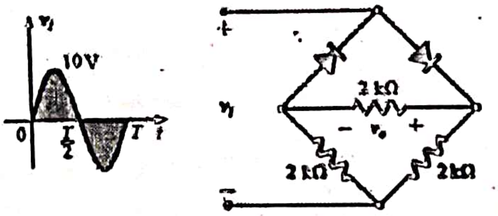
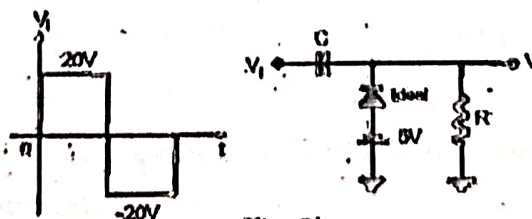
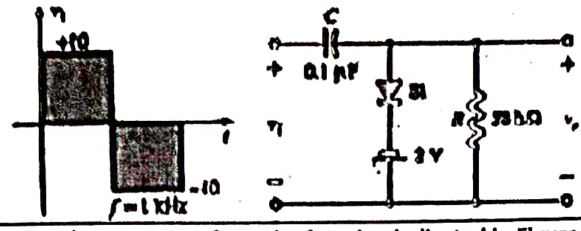
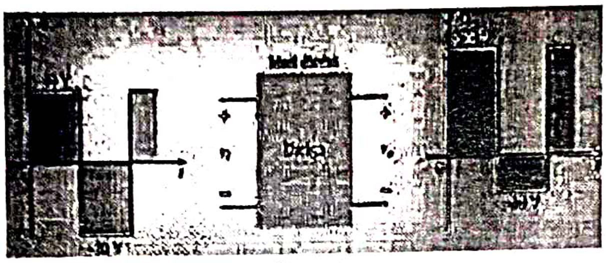
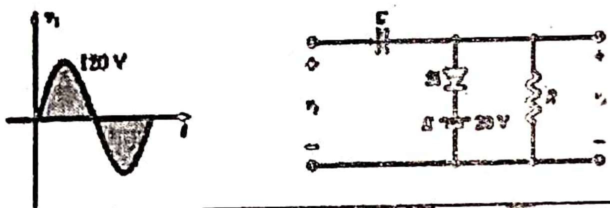
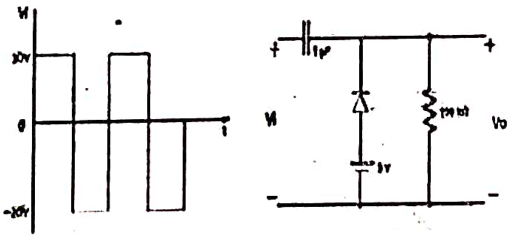
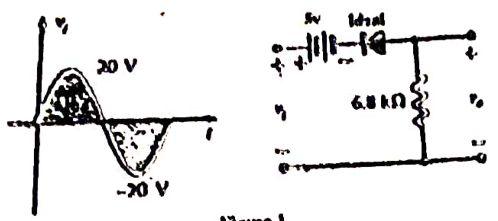
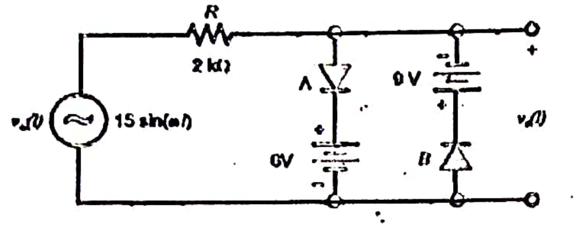
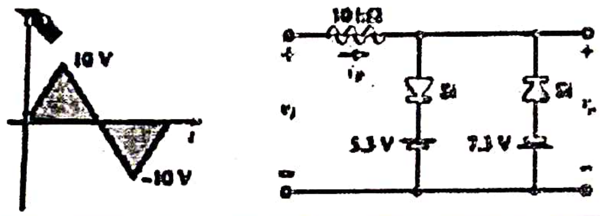
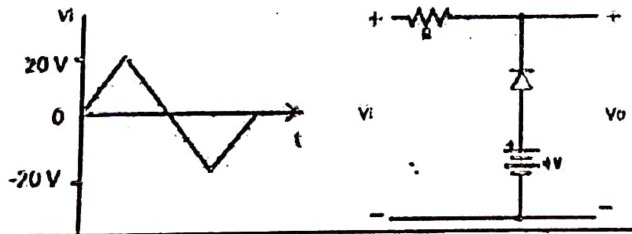
S. No	5 Years AKTU University Examination Questions	Unit-1	
	Questions	Session	Lecture No
1	Compare the properties of Si and Ge.	2015-16	1
2	Why Si is preferred over Ge for the manufacturing of electronics devices.	2015-16	1
3	Explain the effect of temperature on conductivity of semiconductor.	2015-16	1
4	Differentiate between N-type and P-type semiconductor.	2016-17	1
5	Classify the materials with help of energy band	2016-17	1
6	What you mean by doping? Describe its need.	2018-19, 2020-21	1
7	Define depletion layer in a diode	2015-16	2
8	Explain the Knee voltage. What is the knee voltage for Ge, Si?	2017-18	2
9	Draw & explain the V-I characteristic of a P-N junction diode. Also describe the effect of temperature on the V-I characteristic of a P-N junction diode.	2016-17, 2018-19	3
10	The reverse saturation current of Si p-n junction diode is 10 uA at 300K. Determine the forward bias voltage to be applied to obtain diode current of 100 mA.	2017-18	4
11	A Ge diode carries a current of 1 mA at room temperature when a forward bias of 0.15 V is applied. Estimate the reverse saturation current at room temperature.	2015-16	4
12	Give all the equivalent/approximation circuits of a diode	2016-17	4
13	Draw the V-I characteristics of an ideal diode in forward and reverse bias conditions.	2020-21	4
14	For the following circuit Determine I_1, I_2, and I_{D2} for the following figure. 	2016-17	5
15.	Determine V_o, I_1, I_{D1} and I_{D2} for the parallel diode configuration shown in fig 	2015-16	5
16	Explain input and output characteristics of the Zener diode.	2015-16 Odd	6
17	Describe breakdown mechanism of diode.	2015-16 Even	6

18	How V-I characteristics of p-n junction diode is differ from Zener diode?	2016-17	6
19	Differentiate between avalanche and Zener breakdown.	2020-21	6
20	Design a voltage regulator that maintains am output voltage of 20 V across a 1KΩ load with an input that will vary between 30V and 50V. That is, determine the proper value of R_s and maximum current I_{ZM}.	2014-15	7
21	For the network of Fig.2 determine the range of V_i that will maintain V_L at 8V and not exceed the maximum power rating of Zener diode.  Figure 2	2015-16	7
22	Determine the range of V_i that for the Fig. that will maintain the Zener diode in on state. 	2016-17	7
23	For a Zener Voltage regulator, determine the range of R_L and I_L that willresult in V_o beingmaintained at 10V. Given V_{in} = 50V, R = 1K Ω, I_{ZM} =32mA.(2016-17)	2017-18	7
24	For the Zener voltage regulator, determine the range of V_i that will maintain the Zener diode in On state: Take R_L = 1.2 KΩ, R = 220 Ω, V_Z = 20 V, I_{ZM} = 60 mA.	2018-19	7
25	For the circuit shown below, determine the value of maximum andminimum Zener diode current. 	2020-21	7
26	Draw and explain the working of bridge rectifier with input and output waveforms. Calculate efficiency and ripple factor.	2014-15	8,9
27	For a half wave rectifier derive an expression for ripple factor.	2015-16	8,9
28	Differentiate between half wave and full wave rectifier.	2015-16	8
29	Draw the circuit and discuss the working of full wave bridge rectifier with suitable input -output waveforms. What is PIV of bridge rectifier?	2016-17 2017-18 2020-21	8
30	Why bridge type full wave rectifier is preferred over center tapped fullwave rectifier. State two reasons.(2020-21)	2020=21	8

31	What is the ripple factor? What is the value of RF for half wave and full wave rectifier?	2016-17	9
32	Define the term ripple factor. What is the value of the ripple factor for a half wave rectifier and a full wave rectifier?	2020-21	9
33	Determine V_o and required PIV rating of each diode for the configuration of Fig. 2.  Fig.2	2014-15	10
34	Sketch V_o for the network of Fig. 3 and determine the peak inverse voltage of each diode.	2015-16	10
35	In a full wave rectifier, the load resistance is 2 K Ω, rf = 400 Ω. Voltage applied to each diode is 240Sinωt. Find (i) Peak value of current i.e. Im (ii) DC value of current i.e.I_{dc} (iii) RMS value of current i.e. Irms (iv) Efficiency (v) Ripple Factor.	2016-17	10
36	Determine the output waveform for the given network below. Also determine the output dc level and compute PIV of each diode.  	2017-18	10
37	Differentiate between Clipper and Clamper circuit.	2016-17 2018-19	11,14
38	Sketch V_o for the given network shown in Fig. 3 for the input shown.  Fig. 3	2014-15	12

39	Determine V_o for the following figure 	2016-17	12
40	Design a clamper to perform the function indicated in Figure 3.  Figure 3	2017-18	12
41	Sketch the output for the given clamper circuit with shown in figure below. 	2018-19	12
42	Determine the output waveform of the following circuit, by presenting all the necessary calculations which have been done to determine this output. 	2020-21	13
43	With the help of necessary diagram differentiate between half wave and full wave doubler.	2014-15	13
44	Describe with the help of circuit diagram working of voltage tripler circuit.	2015-16	13
45	Describe the working of voltage multiplier circuit.	2017-18	13
46	With help of a neat diagram, explain the working of a voltage doubler circuit.	2016-17 2020-21	13
47	Determine and sketch V_o for the given network shown in Fig. 1.	2014-15	15

	 Figure 1		
48	Explain the function of the circuit of Fig. 2 and draw the output waveform.  Fig-2.	2015-16 2016-17	15
49	Define clipper circuit. Sketch the output for the circuit given below for the given input. 	2017-18	14, 15
50	Determine the output waveform of the following circuit 	2020-21	15
51	Explain working and characteristics of Tunnel diode with the help of neat diagram.	2015-16 2016-17 2017-18	16
52	What is a Varactor diode, give applications also?	2015-16 2016-17 2020-21	17
53	Explain the principle of operation of LED	2016-17 2017-18	17
54	Explain the construction, working principle of LCD. Also give its application and advantages.	2016-17 2018-19 2020-21	17