UNIT 1

Syllabus **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.

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Unit Ist

Classification Of Materials according to Conductivity

(1) Conductor :- These are solids which have very low resistivity or very high Conductivity

e.g. Al, Silver etc.

(2) Insulator :- These are solids which have very high resistivity or very low conductivity

e.g. wood, Glass etc.

(3) Semiconductor :- These are solids which have resistivity or conductivity values between those of conductors and insulators.

Energy Band Diagram

→ Energy Band :- The range of energies to have an electron in a solid is known as energy band.

→ Valance Band :- The range of energies to have valance electrons is known as Valance Band

→ Conduction Band :- The range of energies to have conduction electrons is known as Conduction Band

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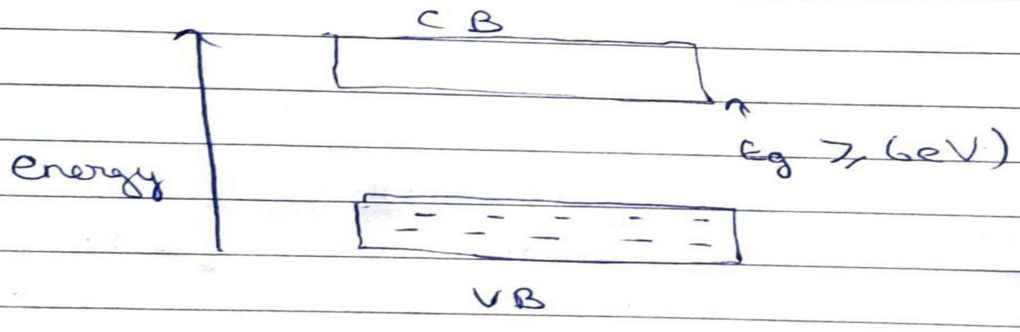
→ Forbiddern Energy gap :- The separation between conduction band and valance band on the energy level diagram is known as forbidden energy gap.

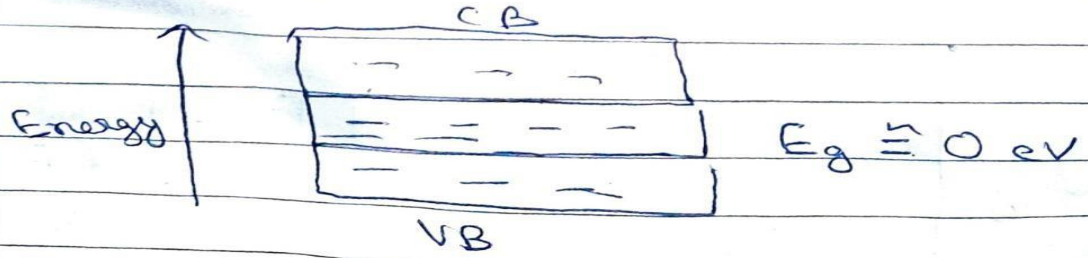
Energy Band Diagram of Insulator

In term of energy band in insulator the valence band is full while the conduction band is empty. Further, the energy gap between valence and conduction band is very large (approx more than 6 eV). Therefore a very high electric field is required to push the valence electron's to the conduction band.



Energy Band Diagram of Conductor

In terms of energy band the valence and conduction bands overlap each other. Due to this overlapping a slight potential difference across a conductor causes the free e^-s to constitute electric current.



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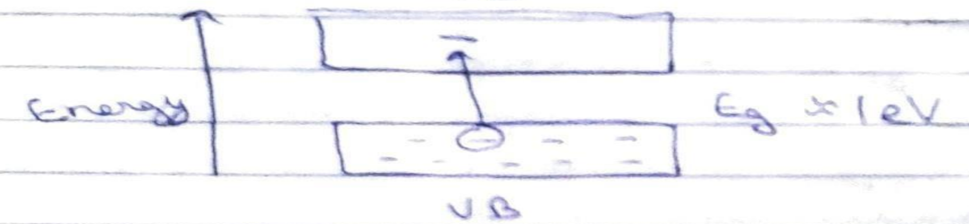
Energy band diagram of Semiconductor

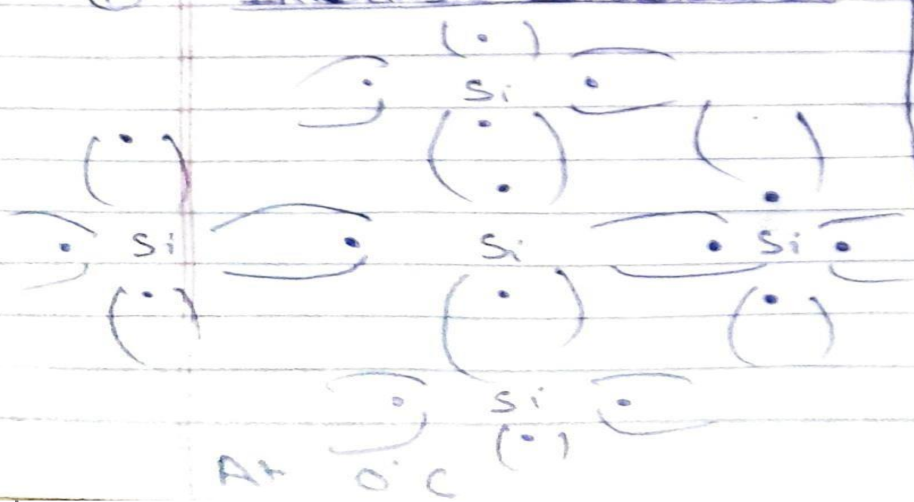
In terms of energy band the valence band is almost filled and conduction band is almost empty. Further the energy gap between valence and conduction band is very small (≈ 1 eV). Therefore small electric field is required to push the e⁻ from the valence band to the conduction band.

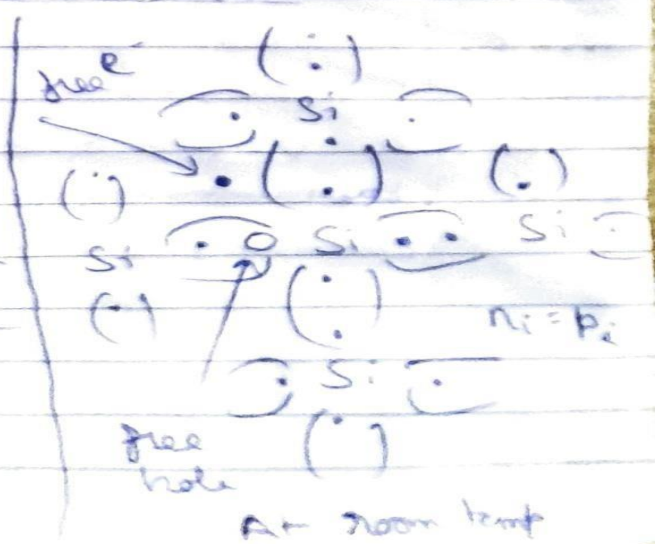


Note :- At low temperature the valence band is completely filled and conduction band is completely empty. Therefore a semiconductor virtually behaves as an insulator at low temperature. However at room temp some electrons cross over the conduction band imparting little conductivity to the semiconductor.

Classification of semiconductor

① Intrinsic Semiconductor





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A semiconductor in an extremely pure form is known as intrinsic semiconductor.

In an intrinsic semiconductor even at room temperature hole-electron pair are created. When electric field is applied across an intrinsic semiconductor, the current conduction takes place by two process namely; by free e^- and holes. The free electrons are produced due to the breaking up of some covalent bonds by thermal energy. At the same time, holes are created in the covalent bonds. Therefore the total current inside the semiconductor is the sum of currents due to free e^- and holes.

② Extrinsic Semiconductor:-

When a small amount of impurity is added to a pure semiconductor it becomes extrinsic semiconductor. The intrinsic semiconductor has little current conductivity at room temperature, to make it suitable for electronic applications we must change its conducting properties. This is achieved by adding a small amount of suitable impurity to a semiconductor. The process of adding impurity to a semiconductor is known as doping. The purpose of adding impurity is to increase either the number of free e^- or holes in the s/c crystal. Depending upon the type of impurity added extrinsic semiconductor are classified into:-

① n type ② p type

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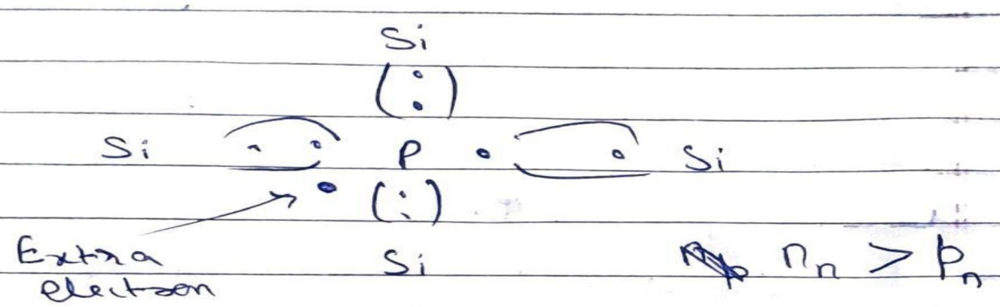
n-type Semiconductor

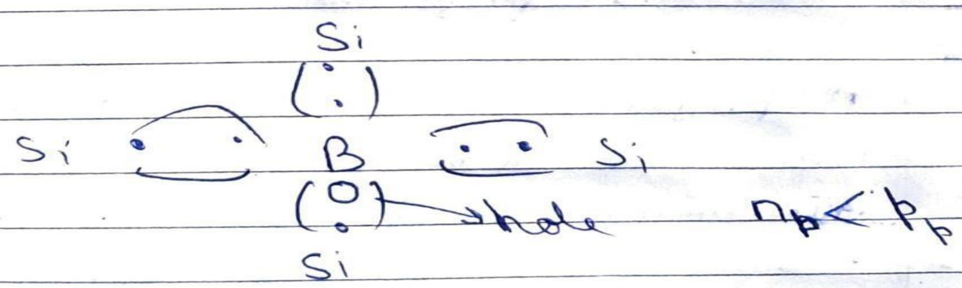
When a small amount of pentavalent impurity is odded to a pure semiconductor, it is known as n-type semiconductor.



The addition of pentavalent impurity provides a large number of free electrons in the semiconductor. Pentavalent impurities are arsenic, antimony, Bismuth, Phosphorous etc. Such impurities which produce n-type semiconductor are known as donor impurities

p-type semiconductor

When a small amount of trivalent impurity is added to a pure semiconductor, it is called p-type S/c



The addition of trivalent impurity provides a large number of holes in the semiconductor. Trivalent impurities are gallium, indium, boron etc. Such impurities which produce p-type S/c are known as acceptor impurities

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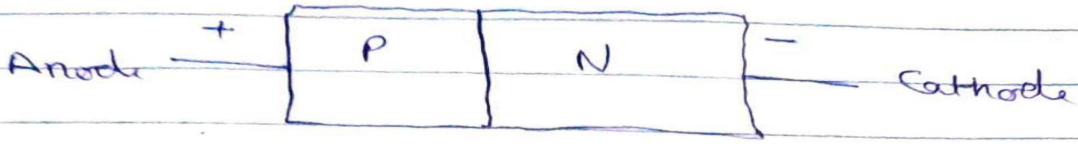
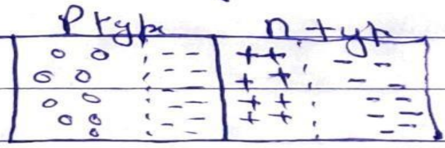
PN Junction diode



When a p type and n type S/C properly join together it forms pn junction ~~...~~ After the formation of junction a large difference in carrier density exists which results holes in the p side tends to diffuse into n-side leaving behind ~~in the n side~~ trivalent ion and e^-s in the n-side are tends to diffuse into p side ~~leaving~~ leaving behind pentavalent ion. Due to this charge separation a layer of −ve charge in p type and +ve charge in n type near the junction created. These layers of +ve and −ve charge form the depletion layer



Once pn junction formed and depletion layer created the diffusion of free e^- stops.

Note: A pn junction is known as ~~crystal~~ diode. It is a two terminal unidirectional semiconductor device. This pn junction does not allow flow of current. To make it suitable for electronics circuit we need to biasing pn diode. These are :-

① Forward biasing
② Reverse biasing

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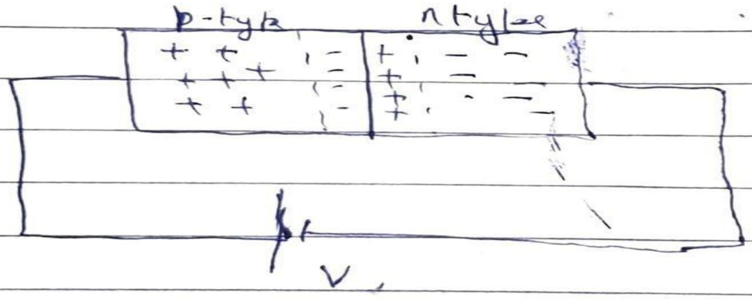
Forward biasing

In a diode when -ve voltage is applied to the n-type and +ve voltage is applied to the p-type material than the basing is called forward biasing
Like charges repel, so the +ve free e⁻ are pushed towards the pn junction Similarly the holes are repelled by the positive termial of the battery. If the voltage pushing the e⁻ and holes has sufficient strength to overcome the depletion zone the e⁻ and holes combine at the junction and current passes through the diode
The forward voltage at which the depletion region vanishes and the current in diode raises rapidly is called 'Knee voltage'



Reverse Biasing

In a diode when +ve voltage is applied to n-type and -ve voltage is applied to p-type material than the basing is called Reverse Biasing
The negative termial attracts the +ve holes in the ptype and the +ve terminal attracts the free e⁻s in the n type. All charge carriers are pulled away from pn junction which creates a larger depletion region
But there is a small reverse leakage current because of minority carries which is independent of reverse supply voltage called Reverse saturation current.

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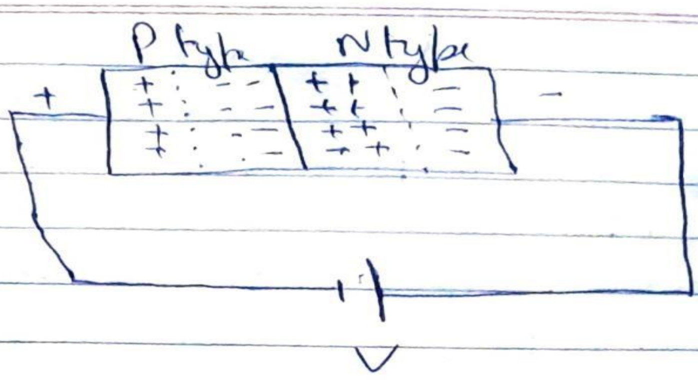
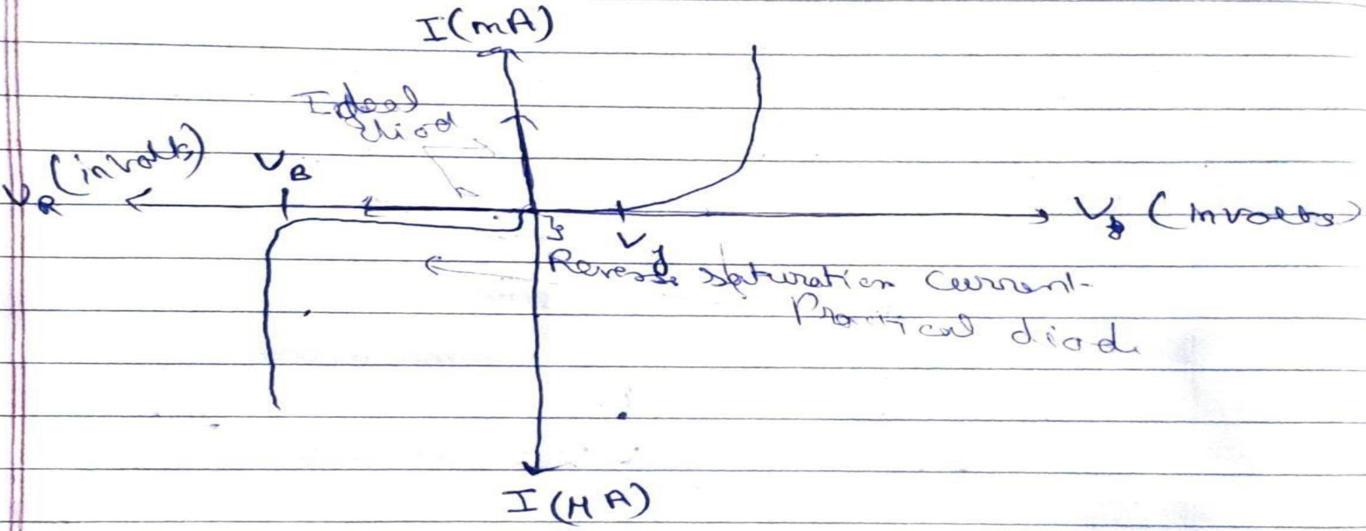


V I characteristics of pn diode



Breakdown in Reverse bias

① Zener Breakdown ② Avalanche Breakdown

Zener Breakdown

It occurs in highly doped diode. In highly doped diode width of depletion region is narrow. So electric field is very high in the depletion region. Due to very high electric field when reverse biased voltage & increase to a certain value the heavy electric field would cause

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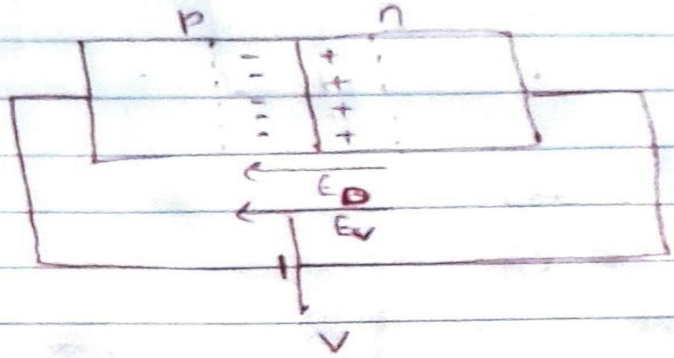
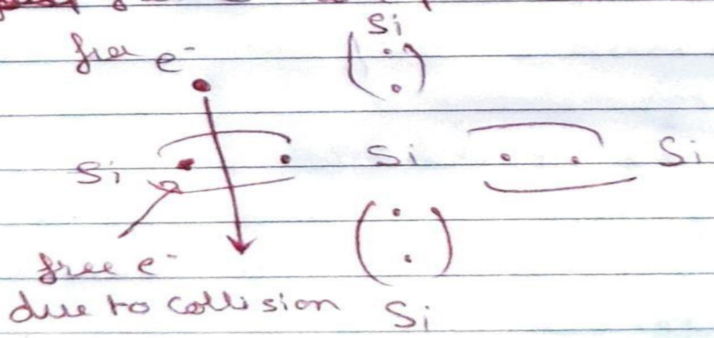
Due to these electric field ions of N-type are move towards p-type. Due to these movement ~~ate~~ conductivity occurs.



Avalanche Breakdown

It occurs in lightly doped diode.
~~The process occurs when~~ When we inc. reverse voltage the kinetic energy of minority carriers incs. These accelerated minority carriers will collide with the stationary atoms and impart some of the kinetic energy to the valence e^- present. These valence e^- will break their covalent bonds and ~~pass~~ free e^--hole pair created.



Equivalent ckt of diode

→ ~~Ideal diode~~

Forward baised

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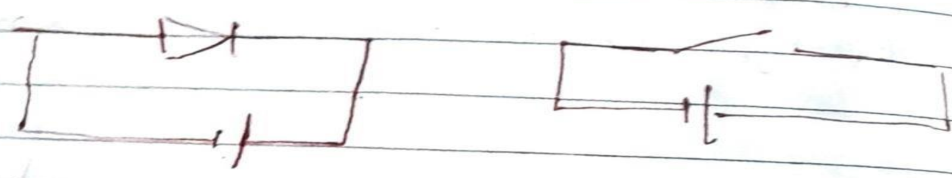
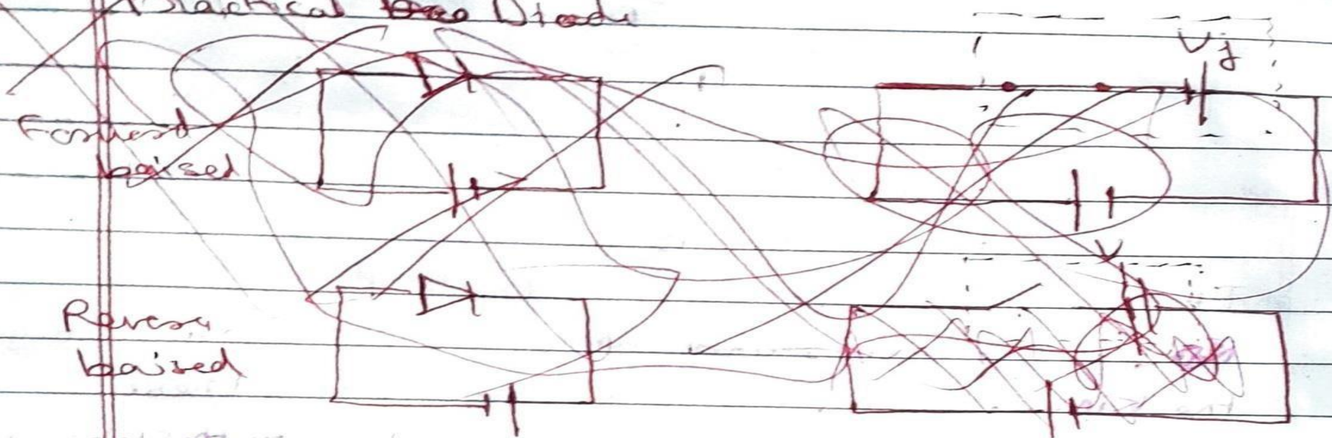
Reverse baised



Practical Diode



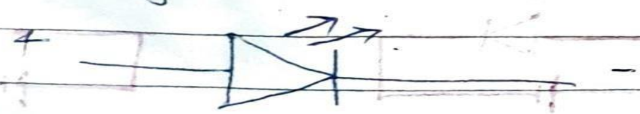
Ideal and Practical diode

In forward biased ideal diode work as a conductor where as in practical diode there is no conduction untill the value of input voltage reaches the forward voltage (V_j)

In Reverse biased ideal diode work as a insulator while in practical diode there is some leakage current or reverse saturation current due to minority carries

Special Purpose Diode

① Light Emitting Diode (LED)



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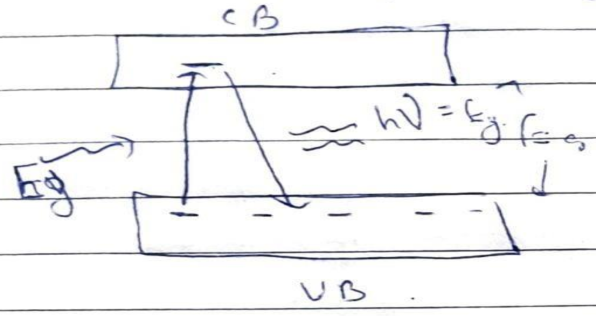
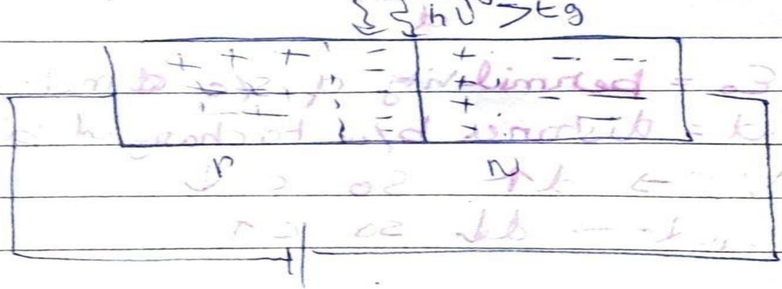
It is a heavily dopped PN junction diode which converts electrical energy to light energy



Energy is required to take an e^- from valence band to conduction band, i.e. to generate e-hole pair. Conversely energy is emitted when an e^- and hole recombine. In S/c like Si, Ge this recombination energy is emitted in the form of heat but is S/c like GaAs (Gallium Arsenide), GaP (Gallium Phosphide) the energy is emitted in the form of light. This is the basic principle of ~~light~~ LED

(2) **Photo Diodes**

It is a device to detect and convert light energy in the electrical energy. It operates in reverse bias below breakdown voltage



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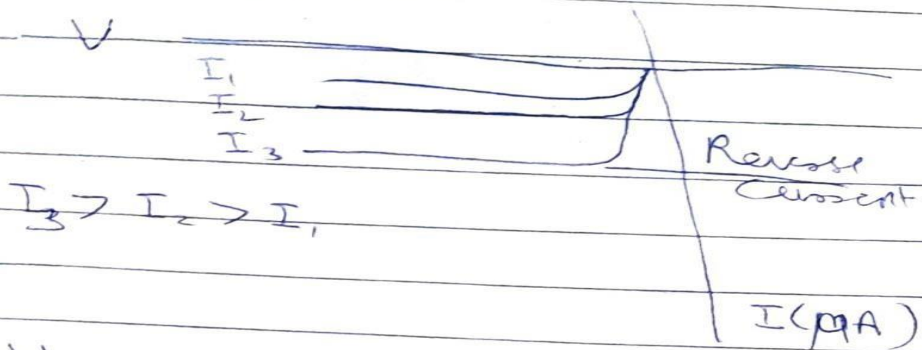
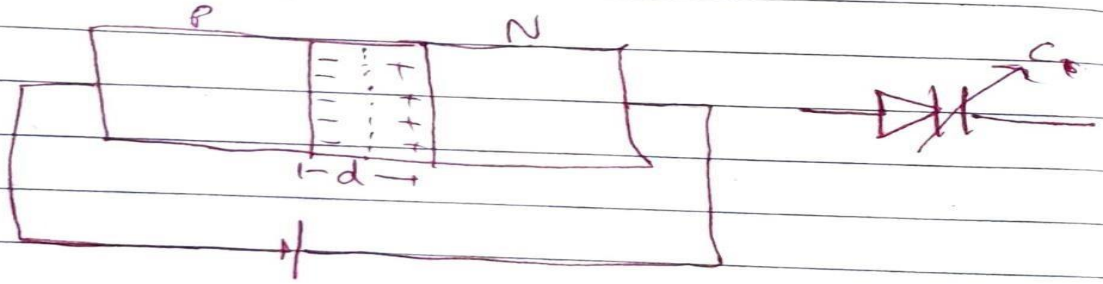
When the photodiode is illuminated with light with Energy greater than E_g than e^- hole pair are genrated to the absorption of photons these charge carrier contribute to the reverse current



$I_3 > I_2 > I_1$

(3) <u>Varactor Diode</u> :-



→ As voltage changes, its capacitance also changes ~~which~~
→ As width of deplation layer changes, its capacitance chang
→ It is always operated in reverse bias condition Here P and N type s/c behave like two charged plate of a capacitor and deplation layer act as a dielectric

we know $C = \frac{\varepsilon_0 A}{d}$

where ε_0 = permitivity of s/c ~~a~~ material
d = distance b/w to charged plates

So $V_R\uparrow \rightarrow d\uparrow$ so $C\downarrow$
$V_R\downarrow \rightarrow d\downarrow$ so $C\uparrow$

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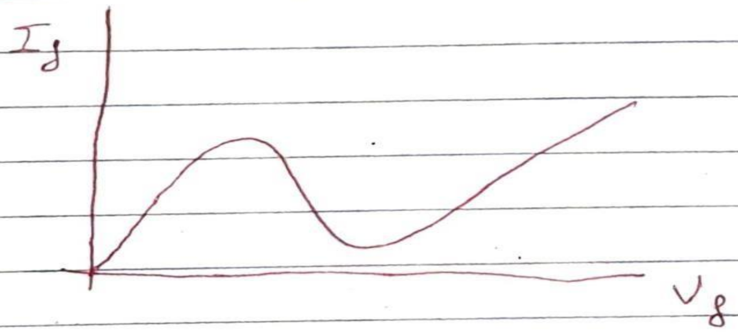
(4) Tunnel diode :

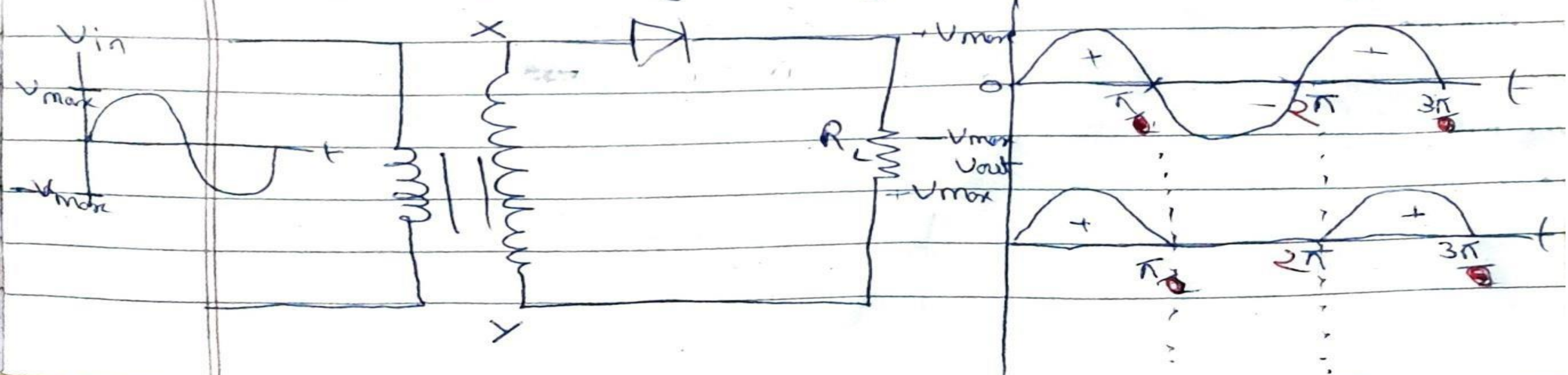
10^3 more doping
100 times less width

P and N type s/c are highly doped so that depletion layer becomes narrow. That narrow passage is called Tunnel. When forward biasing is done then by applying a very less voltage current can start to flow as depletion layer is small so that potential barrier is less. But after a certain value they show -ve resistance between two values of forward voltage then work as a normal diode



Rectifier

(A) Rectifier is a ckt which convert AC to pulsated DC. There are three types of Rectifier
(1) Half wave rectifier (2) Center-tape rectifier
(3) Bridge rectifier



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During the +ve half cycle the end X of the secondary is +ve and end Y is -ve thus, forward biasing the diode (so diode act as a short ckt). As the diode is forward biased, the current flows through the load R_L and voltage is developed across it.

During the -ve half cycle the end Y is +ve and end X is -ve thus reverse biasing the diode (So diode act as a open ckt). As the diode is reverse biased there is no flow of current through the R_L therefor the o/p voltage is 0

I_{rms} of Half wave rectifier

$$I_{rms} = \sqrt{\frac{(\text{Area of one cycle of curve})^2}{\text{Base}}}$$

$$= \sqrt{\int_0^{2\pi} \frac{i^2}{2\pi} d\theta}$$

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

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

$$= \sqrt{\frac{I_m^2}{2\pi} \int_0^{\pi} \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{2\pi} \int_0^{\pi} \frac{1-\cos 2\theta}{2} \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{4\pi} \int_0^{\pi} (1-\cos 2\theta) \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{4\pi} \left\{ [\theta]_0^{\pi} - \frac{1}{2} [\sin 2\theta]_0^{\pi} \right.}$$

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$$= \sqrt{\frac{I_m^2}{4\pi}\left\{(\pi - 0) - \frac{1}{2}\left[\sin 2\pi - \sin 0\right]\right.}$$

$$I_{RMS} = \frac{I_m}{2}$$

Average voltage in HWR

$$V_{average} = \frac{\text{Area under the curve}}{\text{Base}}$$

$$= \int_0^{2\pi} \frac{V_0}{2\pi} d\theta$$

$$= \frac{1}{2\pi} \int_0^{2\pi} V_m \sin\theta \, d\theta$$

$$= \frac{1}{2\pi} \int_0^{\pi} V_m \sin\theta \, d\theta + \int_{\pi}^{2\pi} 0 \, d\theta$$

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

$$= \frac{V_m}{2\pi}\left[(-\cos\pi) - (-\cos 0)\right]$$

$$= \frac{V_m}{2\pi}\left[1 + 1\right] = \frac{V_m}{\pi}$$

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

Ripple factor

- It measures of Purity of dc o/p of a rectifier
- The o/p voltage contains both ac and dc components so ripple factor means the % age of ac component in the rectifier

$$r = \frac{\text{RMS value of AC}}{\text{Average value of DC}} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

for full wave - 0.48
for HWR $r = 1.21$

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Efficiency of HWR

$\eta = \dfrac{P_{dc}}{P_{ac}} \Rightarrow P = I^2 R$

$P_{dc} = I_{dc}^2 R_L \qquad P_{ac} = I_{rms}^2 R_L$

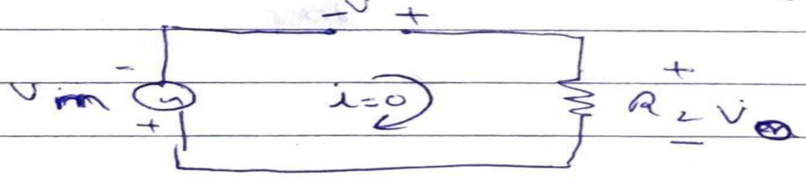
$$\eta = \frac{I_{dc}^2 R_L}{(I_{rms})^2 R_L} = \frac{\left(\frac{I_m}{\pi}\right)^2 R_L}{\left(\frac{I_m}{2}\right)^2 R_L}$$

$$\eta = \frac{4}{\pi^2}$$

$$\eta\% = \frac{4}{\pi^2} \times 100 = 40.6\%$$

Peak inverse voltage of HWR

Maximum Reverse bias voltage that can be applied across the diode before the zener breakdown



$-V + V_m = 0 \qquad V_m = V$

$-V_m + V - V_o = 0$

$-V_m + V - iR_L = 0$

$-V_m + V = 0$

$$PIV = \boxed{V = V_m}$$

Full wave Rectifier

(1) Center tapped Rectifier :

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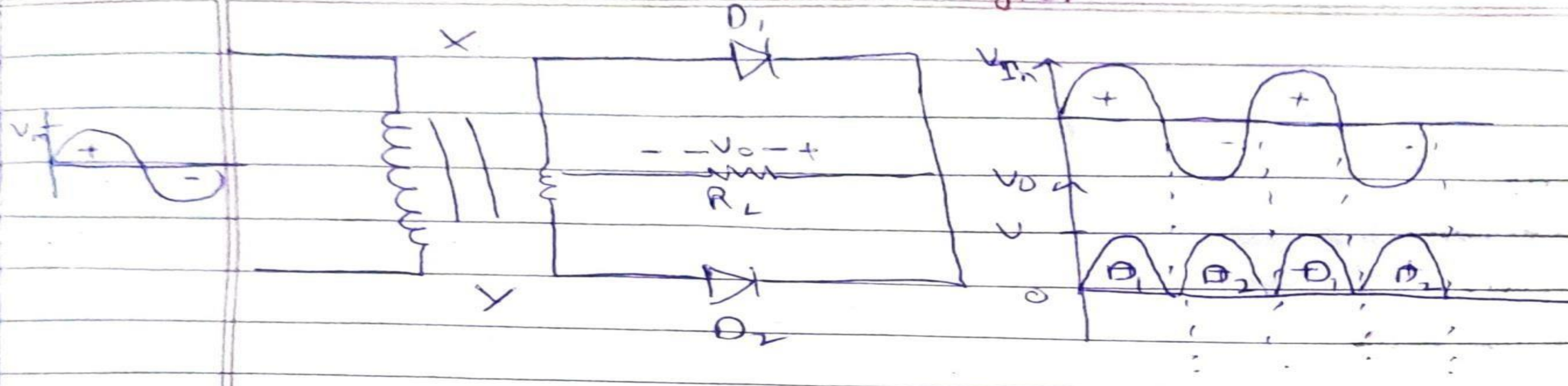
Center tapped rectifier



For +ve half cycle the end X of the secondary is +ve and end Y is −ve thus diode D_1 become forward baise and diode D_2 become Reverse baised. As the diode D_1 is forward biased the current flow through the load R_L and voltage is developed across it.

For −ve half cycle the end X of the secondary is −ve and end Y is +ve thus diode D_1 become Reverse baised and diode D_2 become forward baised. As the diode D_2 is forward biased the current flow through the load R_L and voltage is developed across it

Irms of FWR

$$I_{rms} = \sqrt{\frac{(\text{Area of one cycle of curve})^2}{\text{Base}}}$$

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

$$= \sqrt{\frac{I_m^2}{\pi}\int_0^{\pi} \frac{1-\cos 2\theta}{2} \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\left([\theta]_0^{\pi} - \frac{1}{2}[\sin 2\theta]_0^{\pi}\right)}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\left\{[\pi] - \frac{1}{2}[\sin 2\pi - \sin 0]\right\}}$$

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

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Average voltage of FWR

$$V_{avg} = \frac{\text{Area under the curve}}{\text{Base}}$$

$$= \int_0^{\pi} \frac{V_m \sin\theta}{\pi}\, d\theta$$

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

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

Ripple factor of FWR

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

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

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

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

$$= 0.48$$

Efficiency of FWR

$$\eta = \frac{P_{dc}}{P_{ac}} \qquad P_{dc} = I_{dc}^2 R_L \qquad P_{ac} = I_{rms}^2 R_L$$

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

$$= \left(\frac{2\sqrt{2}}{\pi}\right)^2 = 0.81$$

$$\eta\% = 81\%$$

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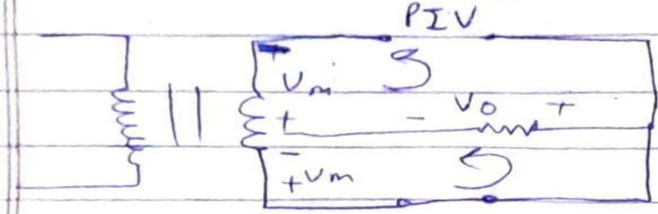
Peak Inverse Voltage (CT FWR)



$$V_m - V_o = 0$$

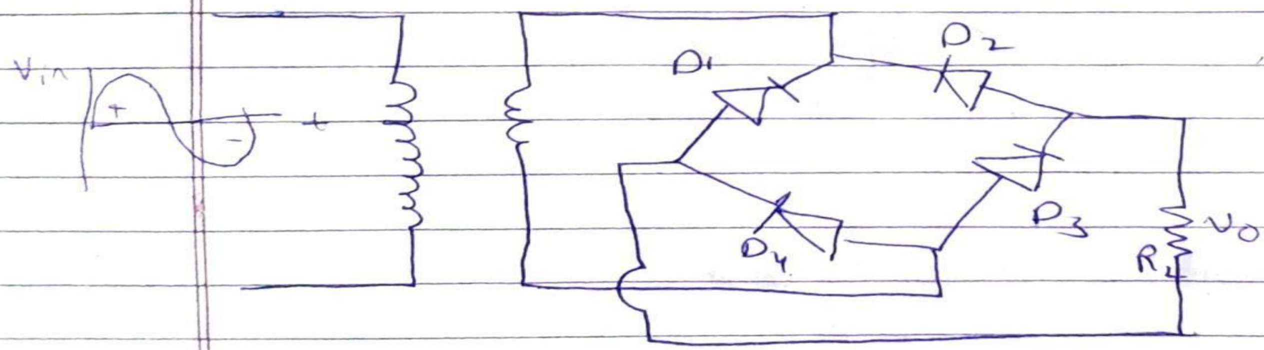
$$V_o = V_m$$

Now

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

$$\boxed{PIV = 2V_m}$$

(2) Bridge Rectifier



For +ve half cycle Diode D_1 and D_3 are reverse biased and diodes D_2 and D_4 are forward biased. Therefore D_2 and D_4 will conduct current across them but diodes D_1 and D_3 will not conduct. The direction of current shown. Due to current through R_L an o/p voltage Vo is obtained across it.

For -ve half cycle Diode D_1 and D_3 are forward biased and diodes D_2 and D_4 are ~~forward~~ reverse biased. Therefore D_1 and D_3 will conduct current across them

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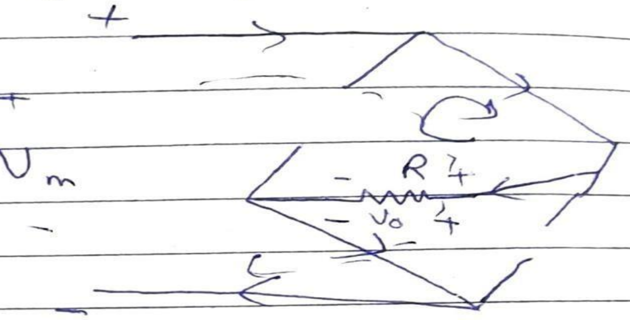
But diodes D_2 and D_4 will not conduct. The direction of current shows. Due to current through R_L an o/p voltage V_o is obtained across it.

PIV of Bridge Rectifier

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



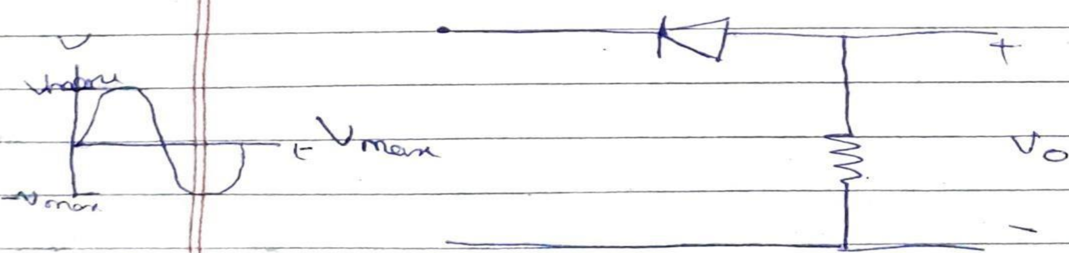
Now $-V_o + PIV = 0$

$$PIV = V_o$$
$$\boxed{PIV = V_m}$$

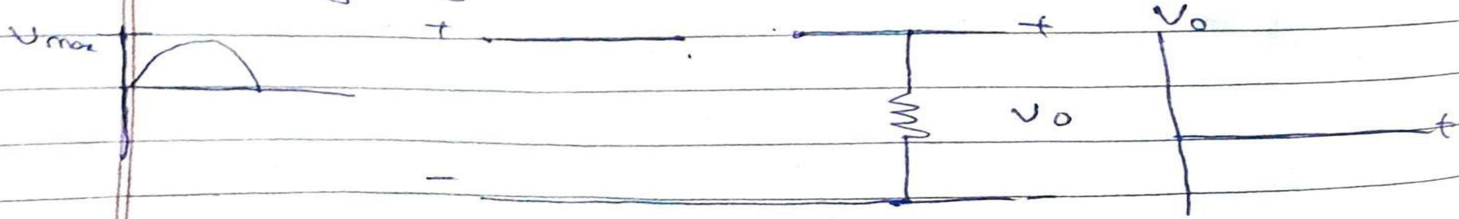
Clipper ckt

→ Clipper is a ckt which cut some specific amount of wave form.

① Positive Series Clipper:



For +ve half cycles



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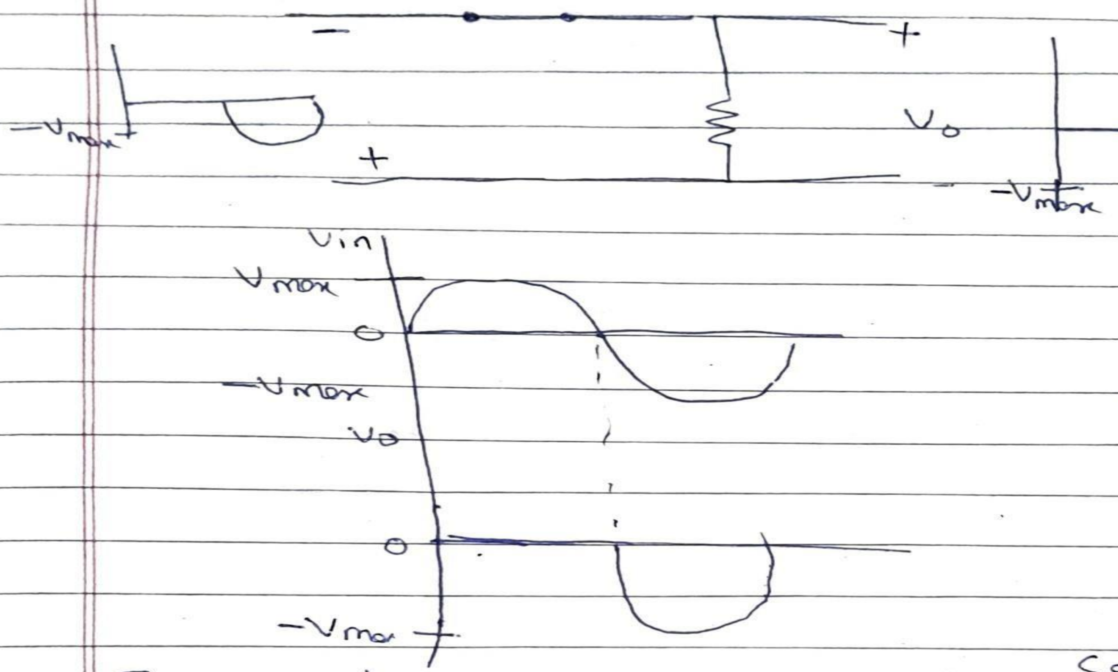
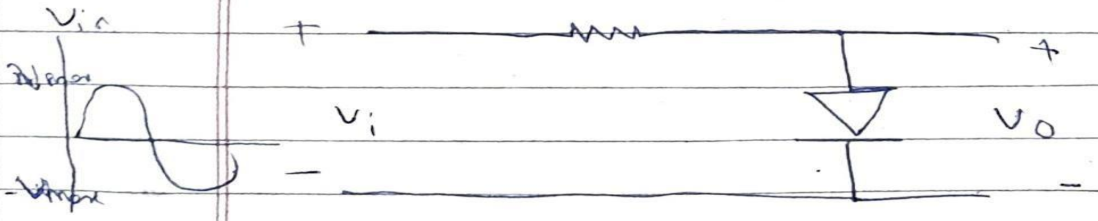
For -ve half cycle



For +ve half cycle n side of diode ~~become~~ connet to +ve so diode become revise baised (open ckt). So there is 0 voltage at o/p.

For -ve half cycle n side of diode connect to -ve so diode become forward baised (short ckt) so there is -Vmax voltage at o/p.

(2) Positive Shunt Clipper:-



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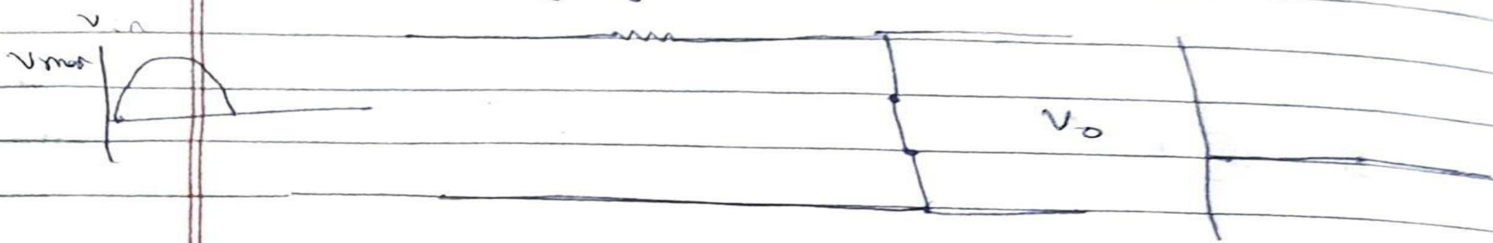
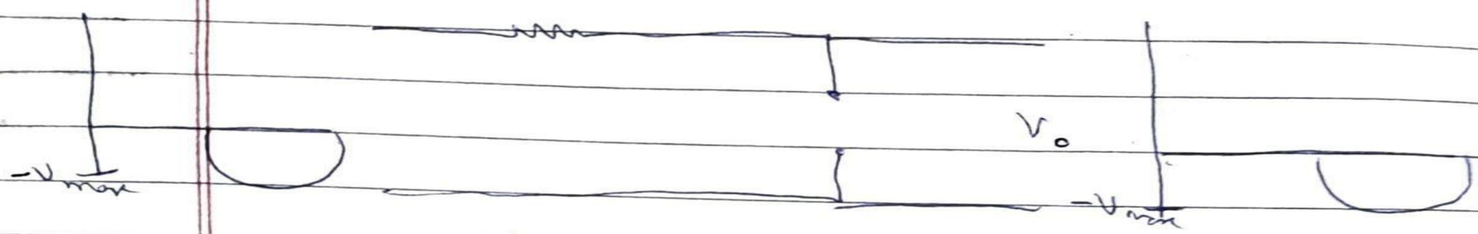
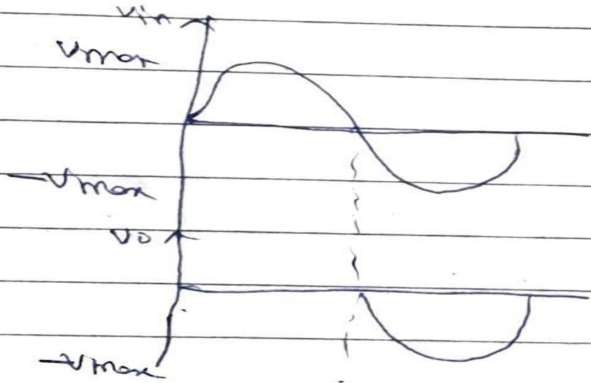
For +ve half cycle



For −ve half cycle





For +ve half cycle p side of diode connect to the +ve so diode work as a short-ckt and there is no voltage at o/p

For −ve half cycle p side of diode connect to −ve so diode works as a open ckt and there is −Vmax voltage at o/p

(3) Negative Series Clipper :-

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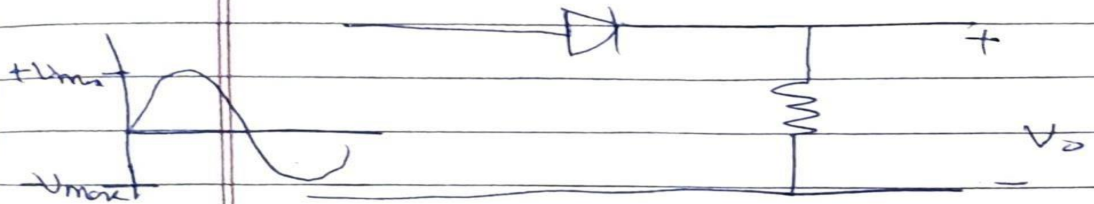
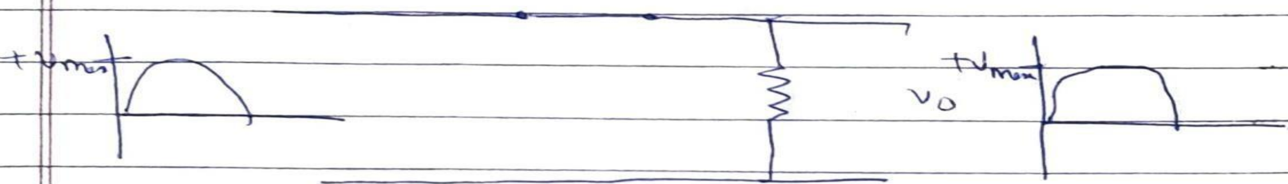
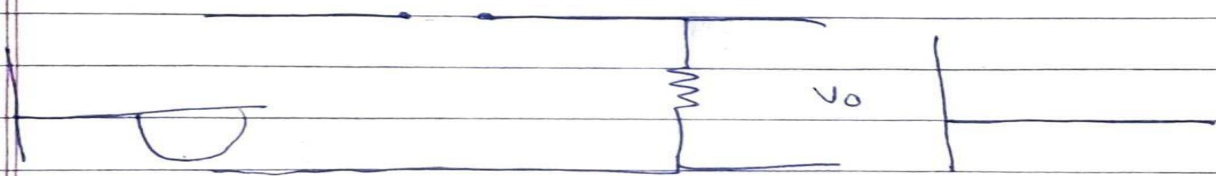
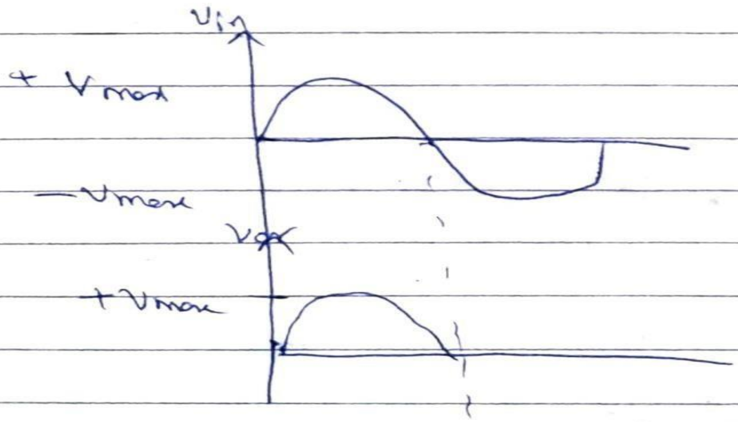


For +ve half cycle



For -ve half cycle





For +ve half cycle p side of diode connect to +ve terminal so diode act as a short ckt and there is +Vmax voltage at o/p

For -ve half cycle p side of diode connect to -ve terminal so diode act as a O.C. and there is 0 voltage at o/p.

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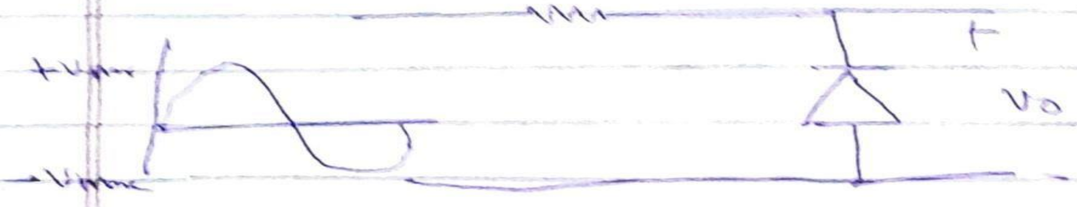
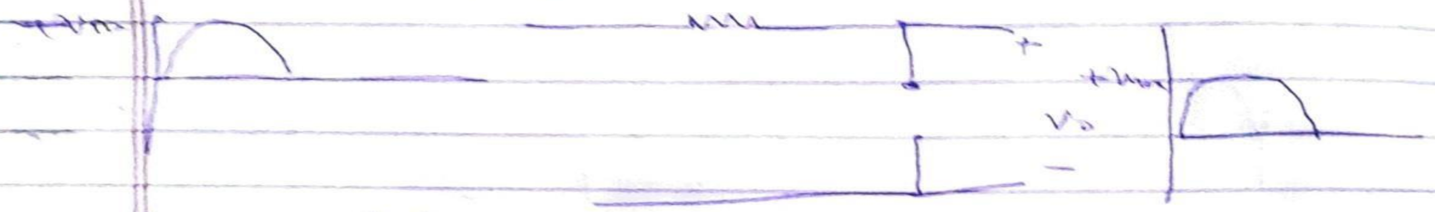
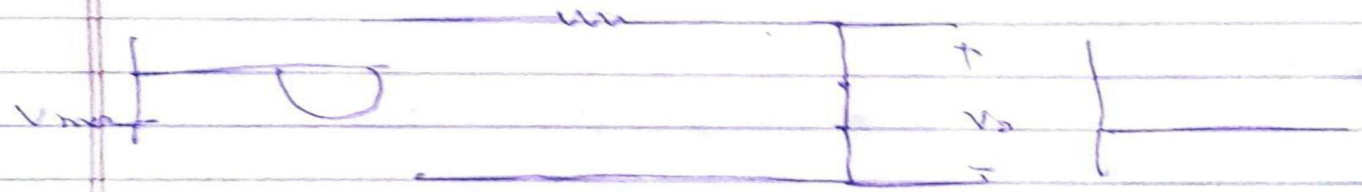
(4) Negative shunt clipper:

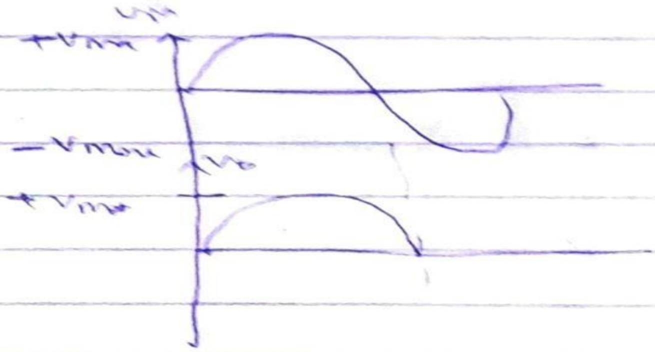


For the half cycle



For the half cycle





For the half cycle n side of diode connect to the
so diode act as a o.c. and +Vmax voltage get
across it
For the half cycle n side of diode connect to -ve
so diode act as a s.c. and 0 voltage get across

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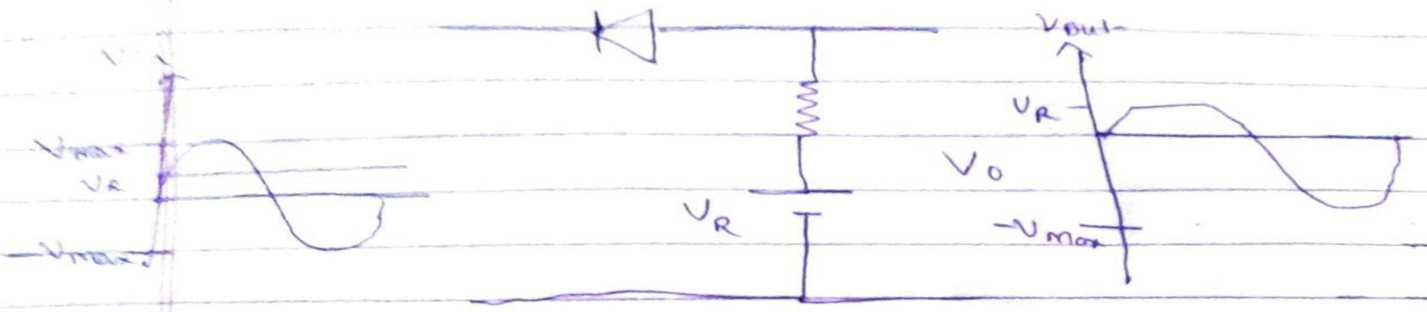
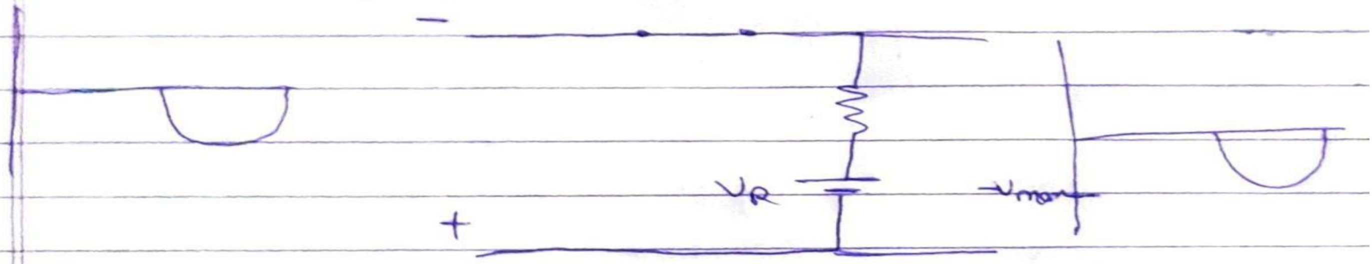
(5) Positive Series Clipper with Positive Bias :



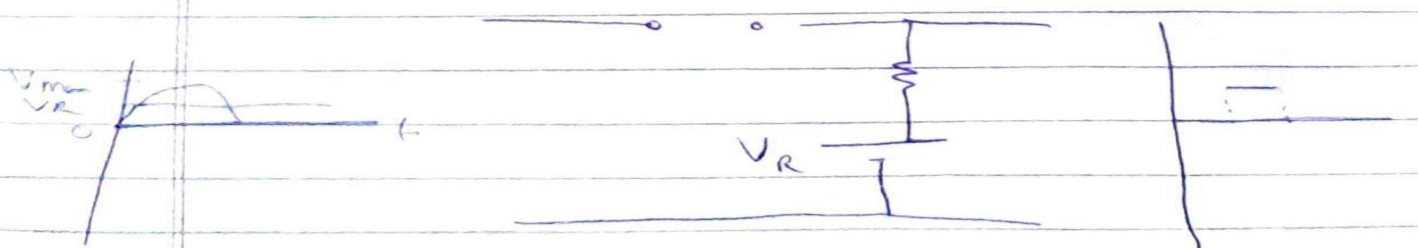
For +ve half cycle



For + half cycle

Case Ist $V_R > V_{in}$

Case IInd $V_R < V_{in}$



For -ve half cycle n side of diode connect to -ve terminal so diode act as a ~~Short~~ open circuit and there is ~~total~~ total input voltage get across it

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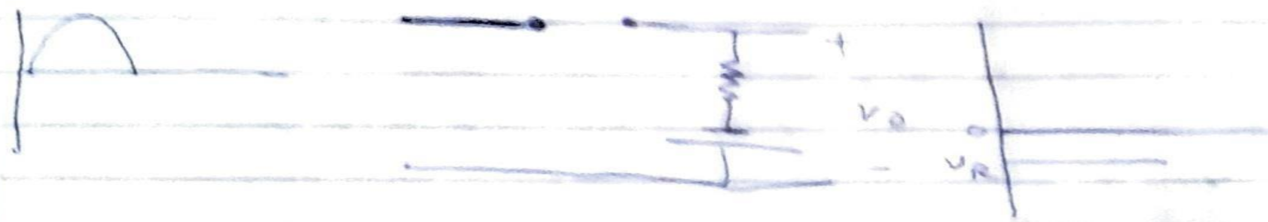
For +ve half cycle when $V_R < V_{in}$ the diode work as a short circuit and input voltage upto V_R get at the o/p
When $V_R > V_{in}$ then diode work as a o.c. and V_R voltage get at the o/p

(C) Positive Series clipper with negative baising

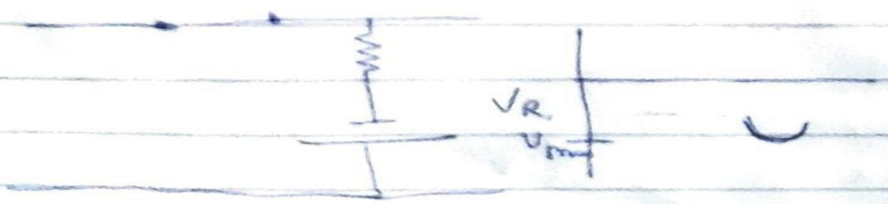
For +ve half cycle



For -ve half cycle

Case I $V_R < V_{in}$

Case II $V_R > V_{in}$



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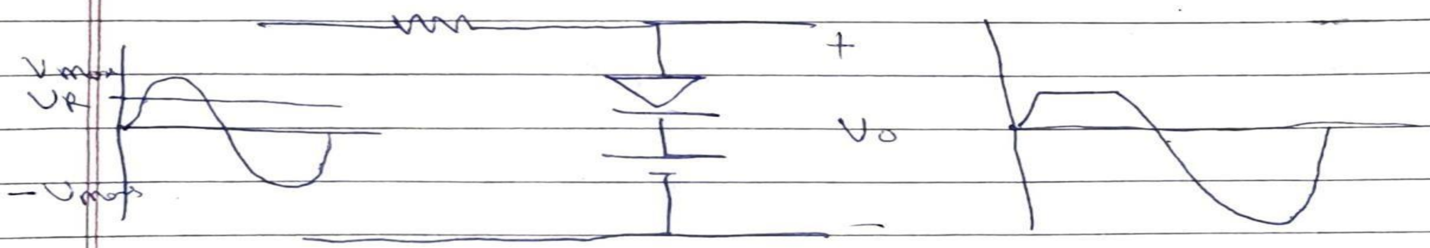
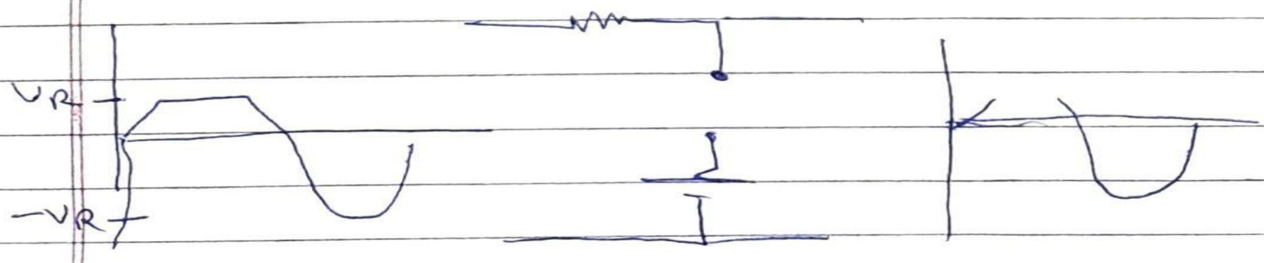
When $V_R < V_{in}$ then n side of diod at higher potential and p side of diode at lower potential than diode work as a o.c. and $-V_R$ voltage get at the o/p. For $V_R > V_{in}$ n side of diod at lower potencial and p side of diode at higher potential than diode work as a S.c. and $-V_{max}$ voltage get at the o/p.

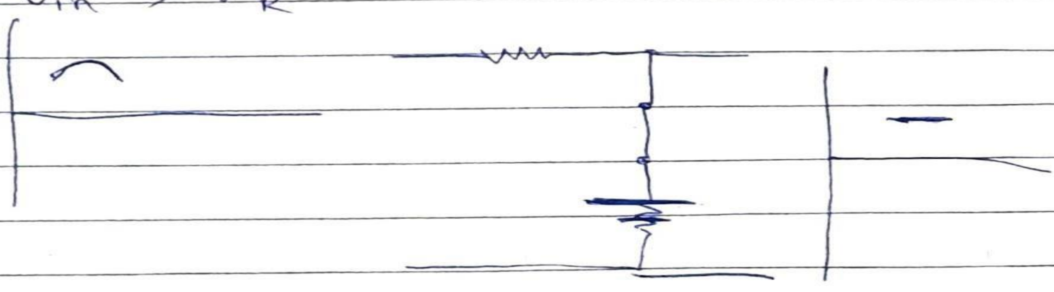
(7) Positive Shunt clipper with positive basing



$V_{in} < V_R$



$V_{in} > V_R$



When $V_{in} < V_R$ then n side of diode at higher potential and p side of diode at lower potential

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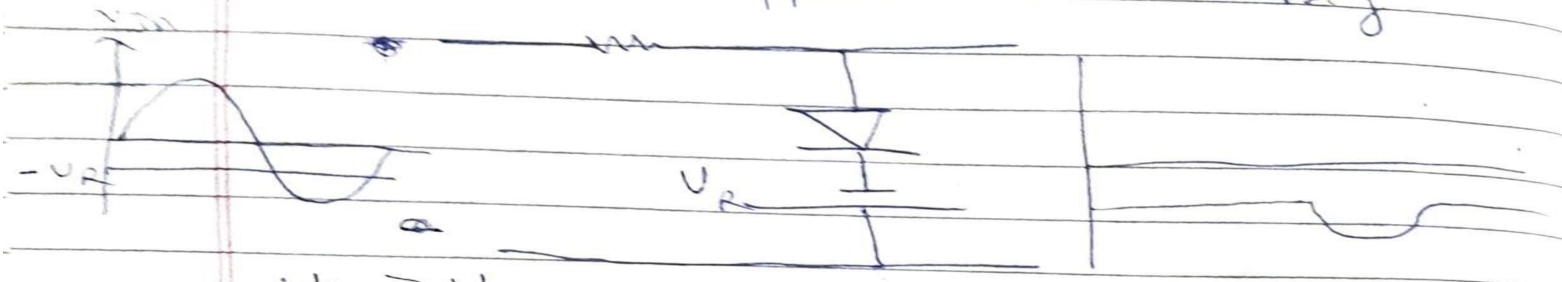
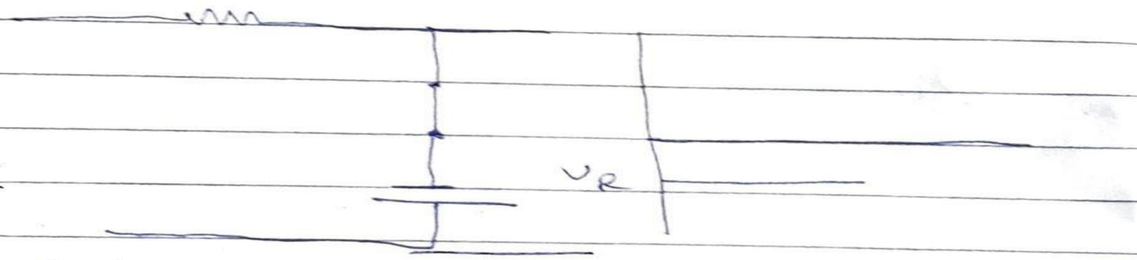
than diode work as a o.c. and total i/p voltage get at the o/p

For $V_{in} < V_R$ n side of diode at lower potential and p side of diode at higher potential then diode act as a S.C. and V_R voltage get at the o/p.

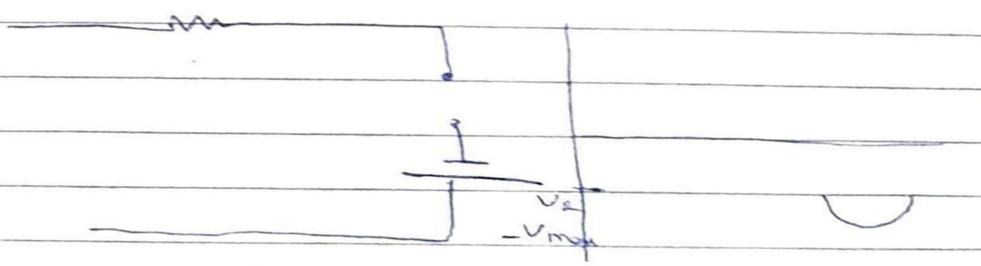
③ Positive Shunt clipper with +ve Battery



$V_{in} > V_R$



$V_{in} < V_R$



For $V_{in} > V_R$ ~~diode work as a S.C. than~~ p side of diode connect to higher potential than diode act as a S.C. so V_R voltage get at the o/p

For $V_{in} < V_R$ n side of diode connect to higher potential then diode act as a O.C so total

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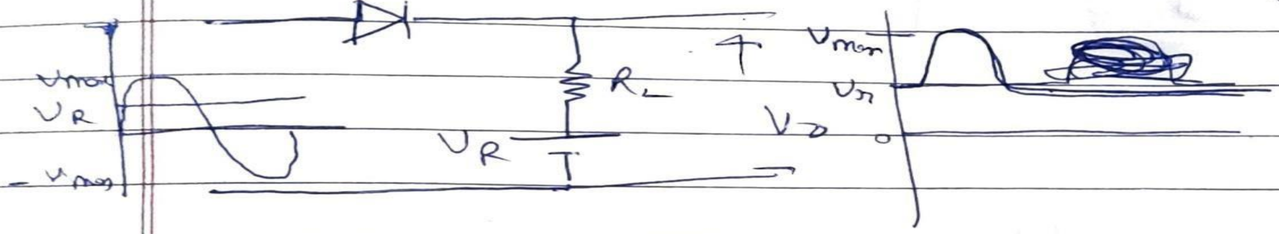
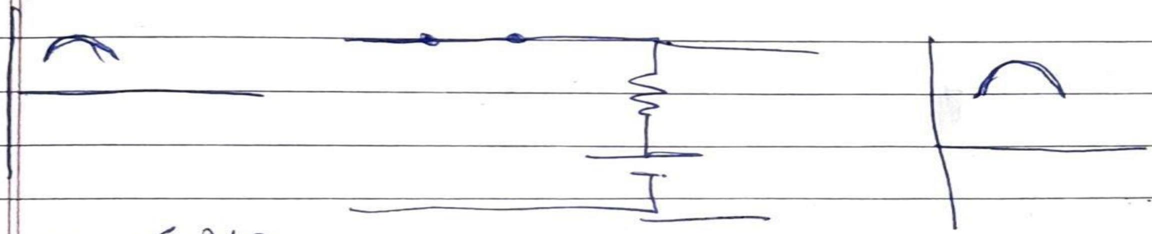
Vin voltage get at the o/p.

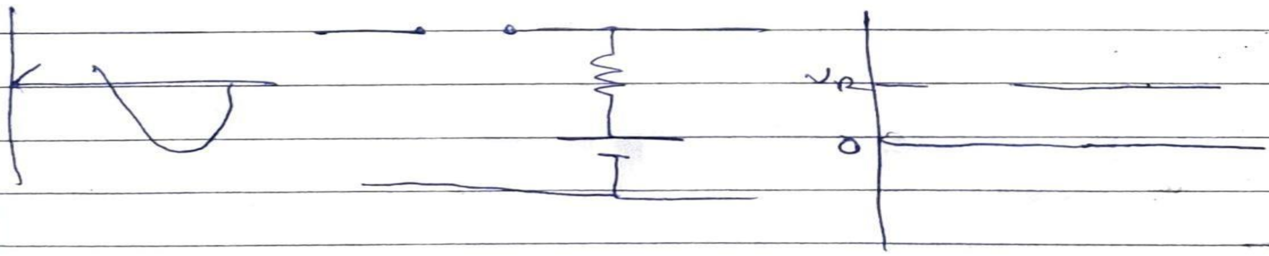
(9) Negative Series clipper with +ve Baising



$V_{in} > V_R$



$V_{in} < V_R$



For $V_{in} > V_R$ p side of diode at higher potential than diode act as a s.c. then total Vin voltage get at the o/p

For $V_{in} < V_R$ p side of diode at lower potential than diode act as a o.c. so V_R voltage get at the o/p.

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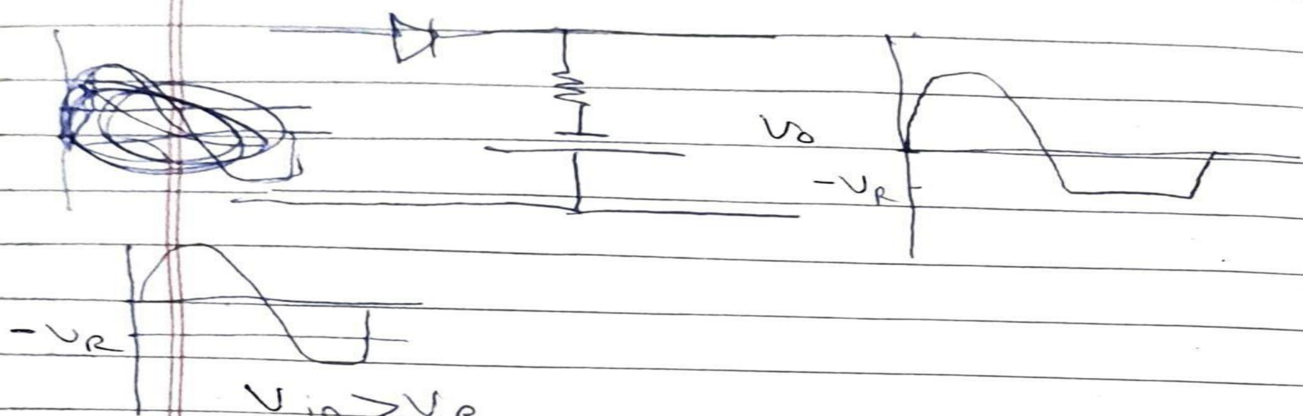
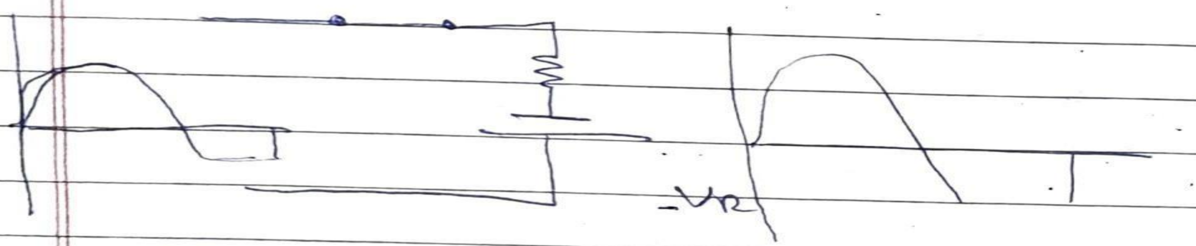
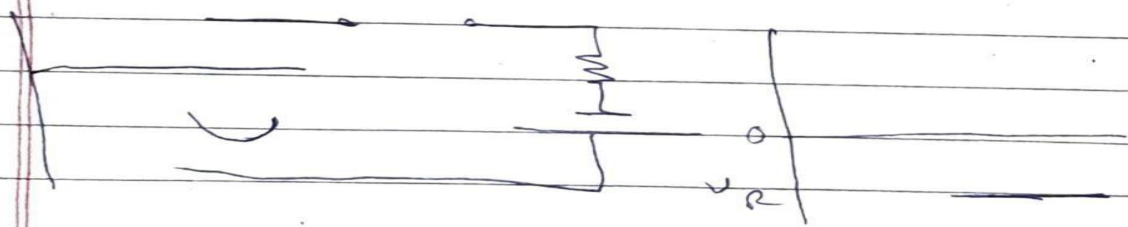
(10) Negative Series Clipper with -ve Bais :-



$V_{in} > V_R$



$V_{in} < V_R$



For $V_{in} > V_R$ p side of diode at higher potential so diode act as a s.c and total i/p voltage get at the O/P.

For $V_{in} < V_R$ p side of diode at lower potential so diode act as a o.c. and total V_R voltage get at the O/P.

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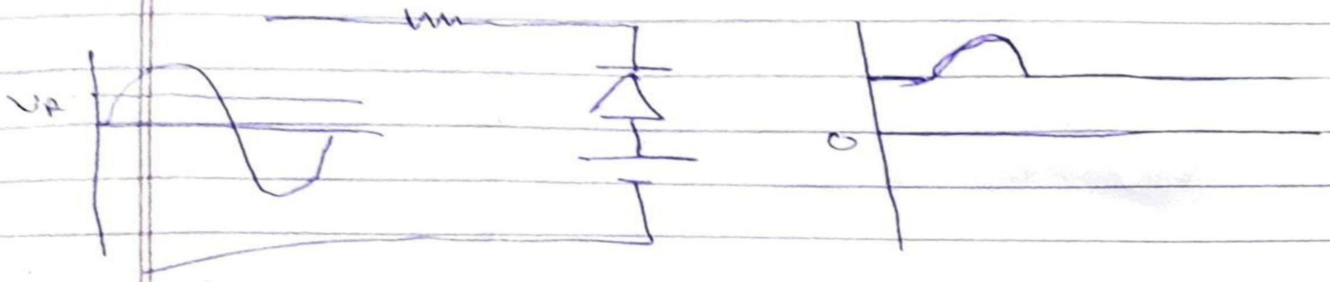
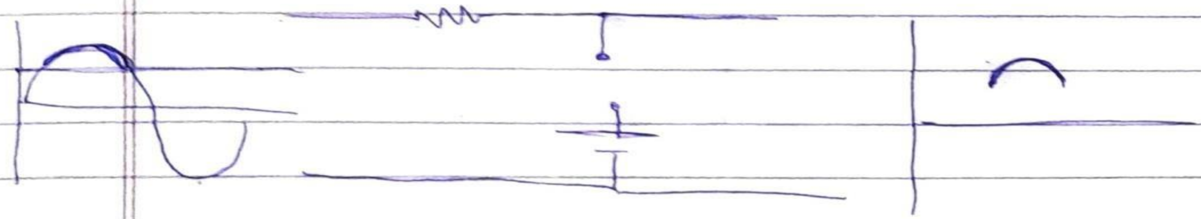
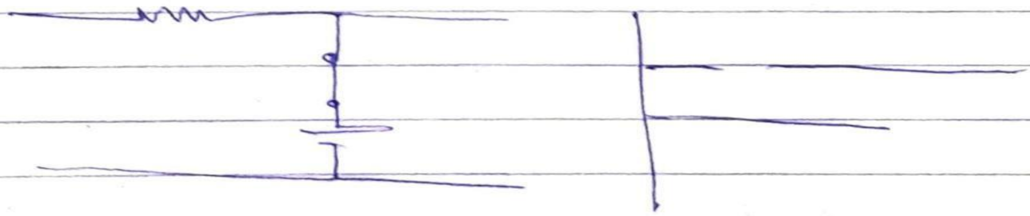
(11) +ve Shunt clipper with the Bias



$V_{in} > V_R$



$V_{in} < V_R$



For $V_{in} > V_R$ p side of diode at lower potential than diode act as as O.C and total i/p voltage get at the O/P.

For $V_{in} < V_R$ p side of diode at higher potential than diode act as a s.c. and V_R voltage get at the O/P

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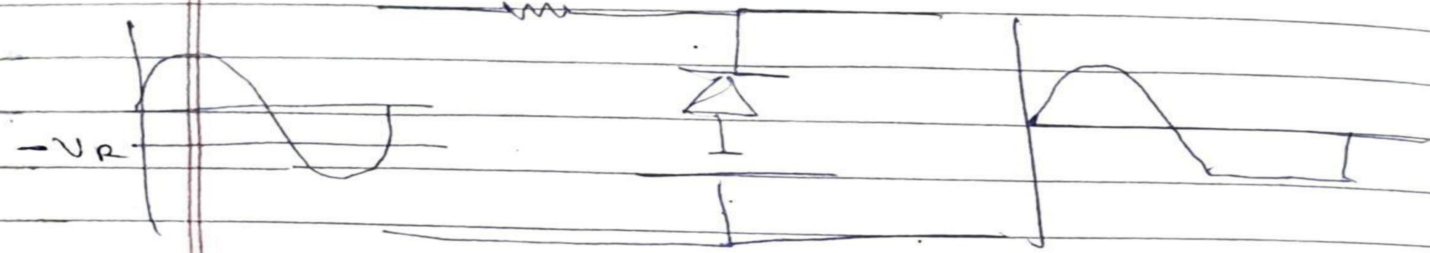
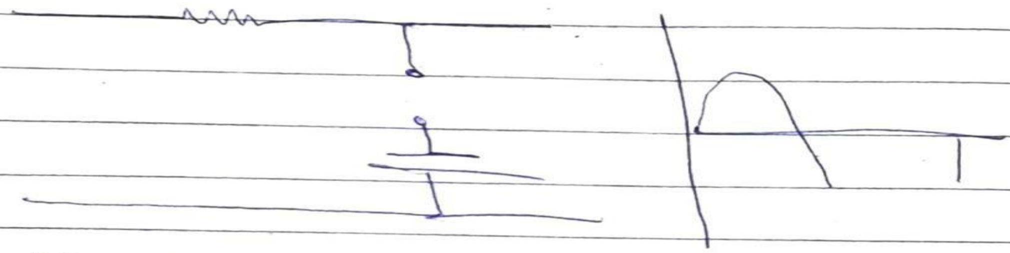
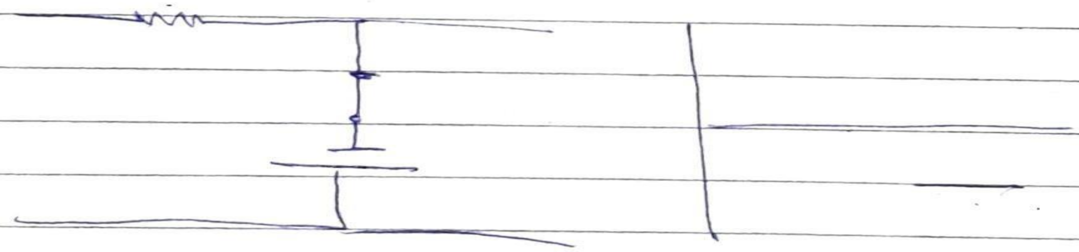
(12) -ve Shunt clipper with -ve bias



For $V_{in} > V_R$



For $V_{in} < V_R$



For $V_{in} > V_R$ p side of diode at lower potential than diode act as a o.c. and total i/p voltage get as the o/p.

For $V_{in} < V_R$ p side of diode at higher potential than diode act as a s.c. and V_R voltage get at the o/p.

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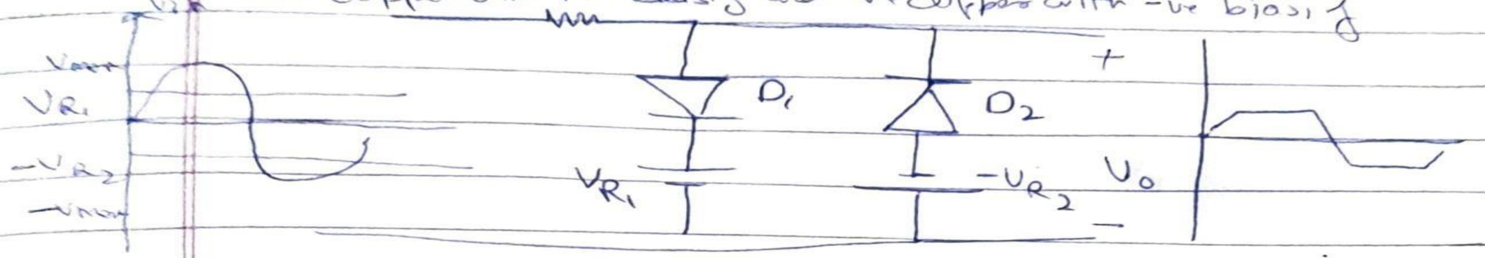
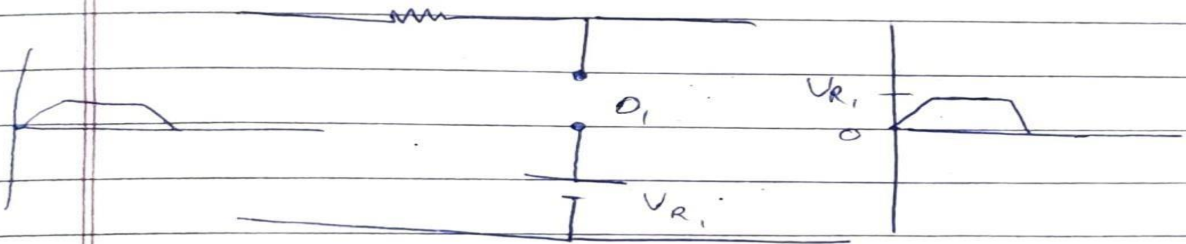
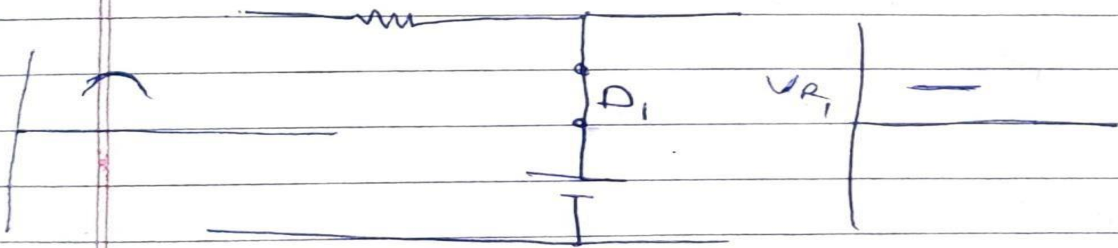
(13) Combination clipper ckt:- It is a combination of +ve clipper with +ve biasing and -ve clipper with -ve biasing



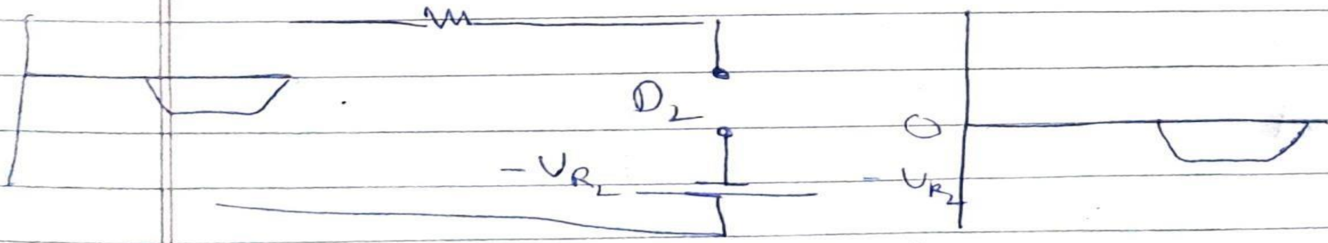
For +ve half cycle and $V_{R_1} > V_{in}$



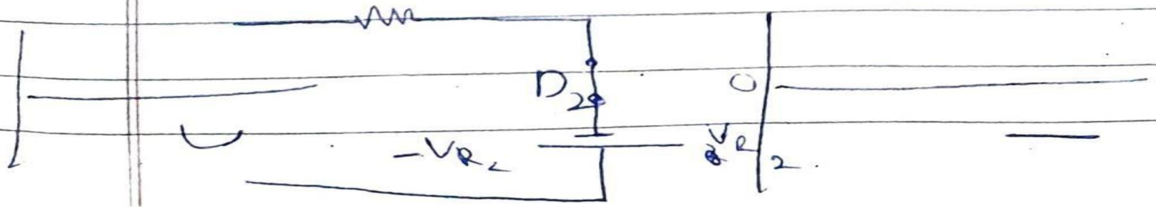
For +ve half cycle and $V_{R_1} < V_{in}$



For -ve half cycle and $V_{R_2} > V_{in}$



For -ve half cycle and $V_{R_2} < V_{in}$



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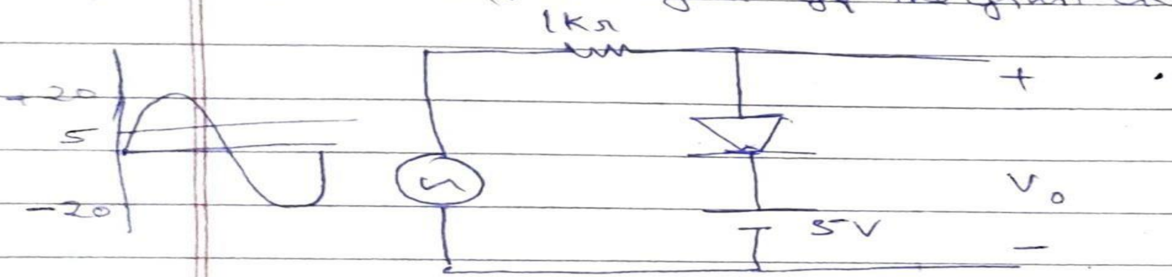
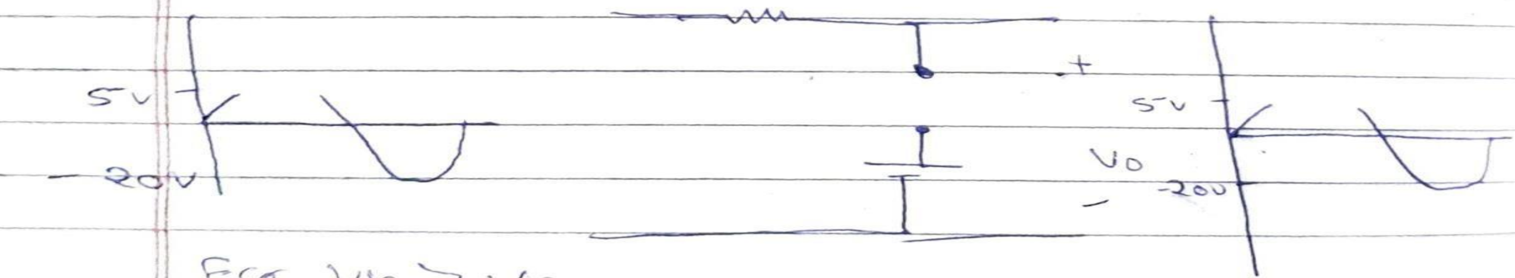
H.W.

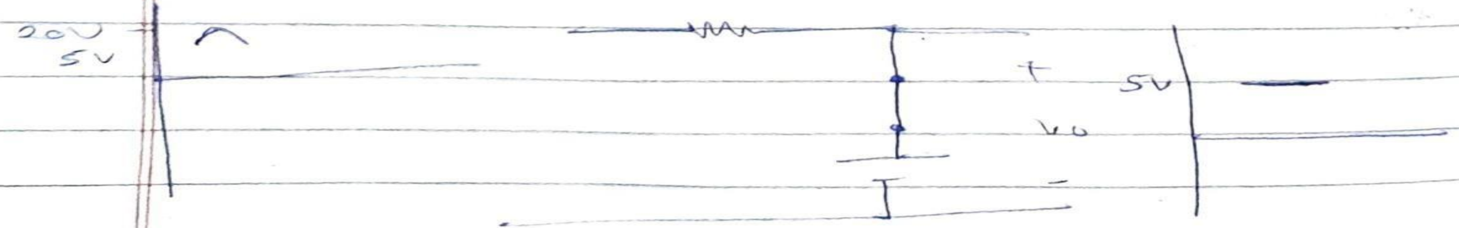
Q Draw O/P waveform of the given ckt:



Sol For $V_{in} < V_R$



For $V_{in} > V_R$



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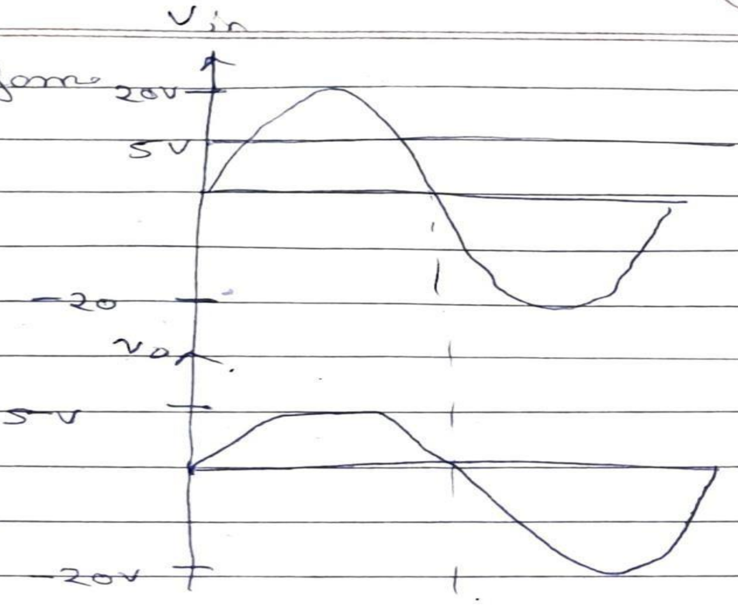
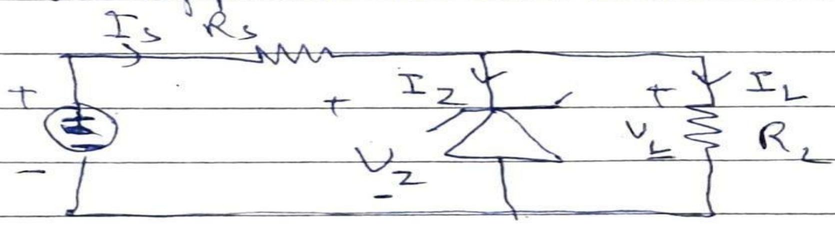
Wave form



Zener diode

It is a highly doped p-n junction diode which is always work in reverse baised after breakdown.
The most important application of zener diode is Zener diode as a voltage regulator. The ckt of this application are shown in the fig



According to the fig load Voltage V_L is always equal to V_Z

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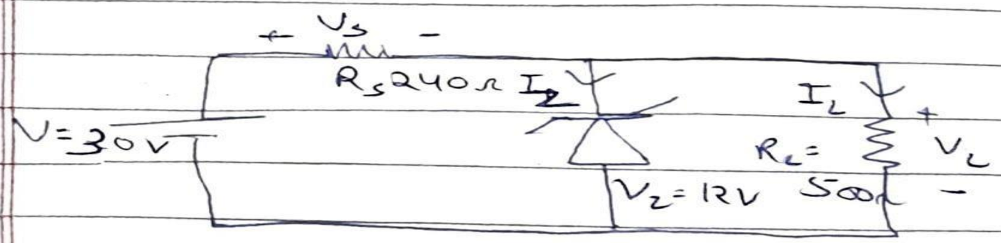
Q Find V_L, V_s, I_Z, I_s



Sol

$$V_Z = V_L = 12V$$

~~$V_s = I_s R_s +$~~

$$-30 + V_s + 12 = 0$$

$$V_s = 30 - 12 = 18 V$$

$$I_s = \frac{V_s}{R_s} = \frac{18}{240} = 0.075 A$$

Now

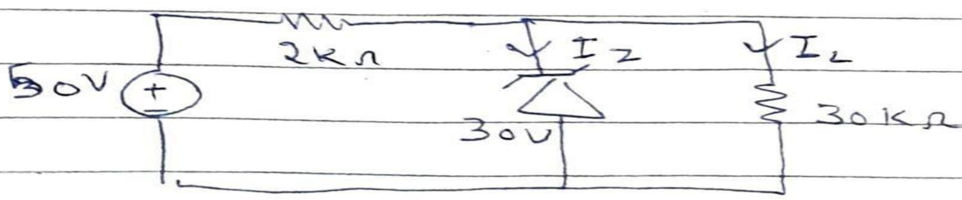
$$I_s = I_Z + I_L$$

$$0.075 = I_Z + \frac{12}{500}$$

$$0.075 = I_Z + 0.024$$

$$I_Z = 0.075 - 0.024 = 0.051 A$$

Q Find I_Z



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Sol

$V_L = 30V$

$I_L = \frac{30}{30000} = 0.001\ A$

$V_s = 20\ V$

$I_s = \frac{20}{2000} = 0.010\ A$

$I_s = I_Z + I_L$

~~$I_Z = 0$~~ $\quad I_Z = I_s - I_L$

$= 0.010 - 0.001$

$= 0.009\ A$

$I_Z = 9\ mA$

Voltage multiplier

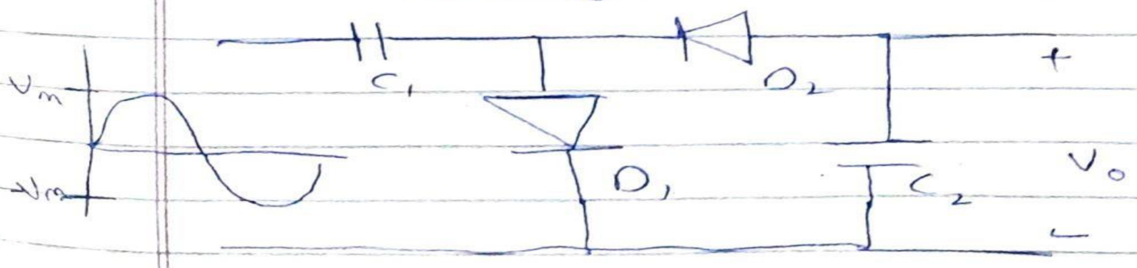
Voltage multiplier is a ckt which give n multiple of i/p voltage at o/p i.e.

if V_{in} is i/p then $V_o = nV_{in}$

where n is the natural number so

$V_o = 2V_{in}, 3V_{in}, 4V_{in} \ldots$

Voltage Doubler ckt



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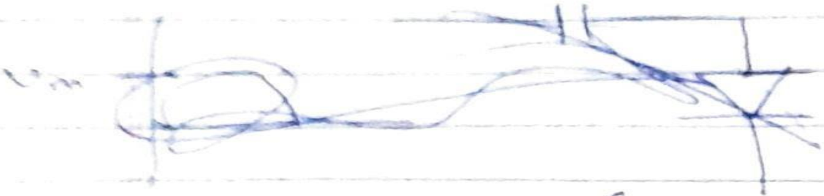
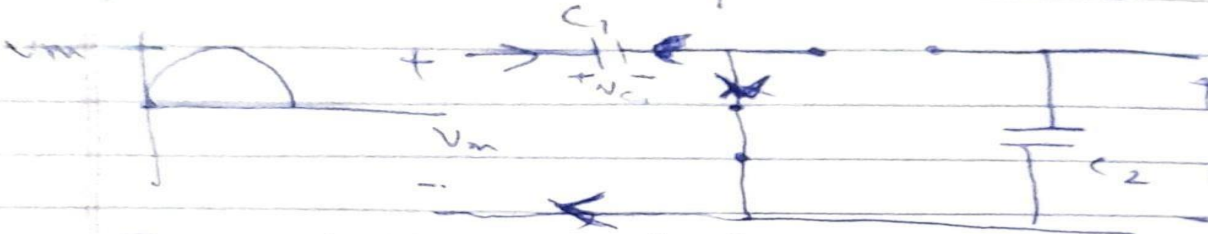
For the half cycle

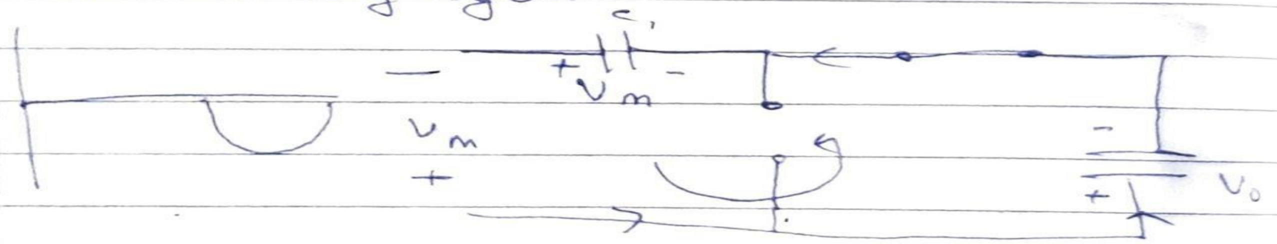




For the half cycle diode D_1 act as a S.C. and d_2 act as a O.C. so path of current shown in the fig and our capacitor C_1 get charge upto V_m

$$V_{C_1} = V_m$$

For -ve half cycle



For -ve half cycle diode D_1 act as a O.C. and d_2 act as a S.C. So path of current shown in the fig and now C_1 capacitor become discharge and C_2 capacitor become charge so the voltage in C_2 is

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

So $$V_o = 2V_m$$

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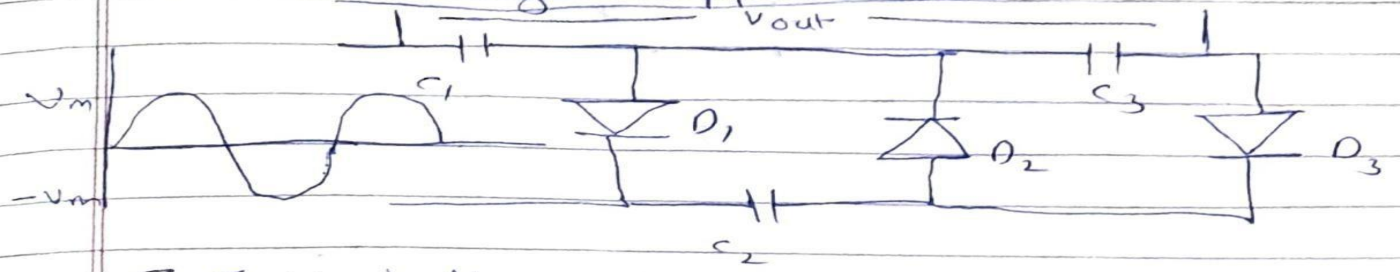
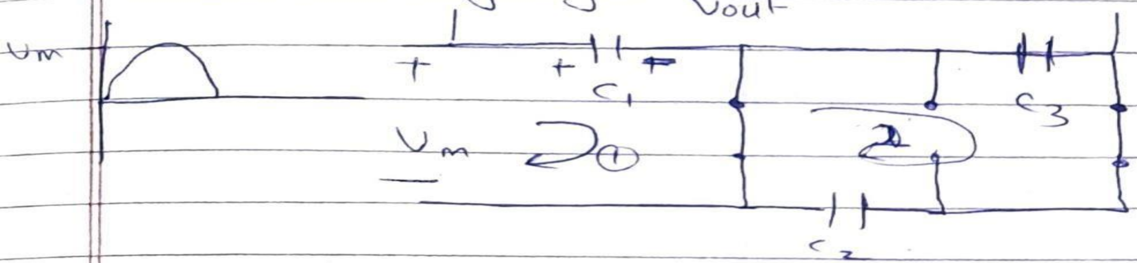
Voltage Trippler ckt



For Ist +ve half cycle



For +ve half cycle diode D_1 and D_3 are S.C and D_2 is O.C.

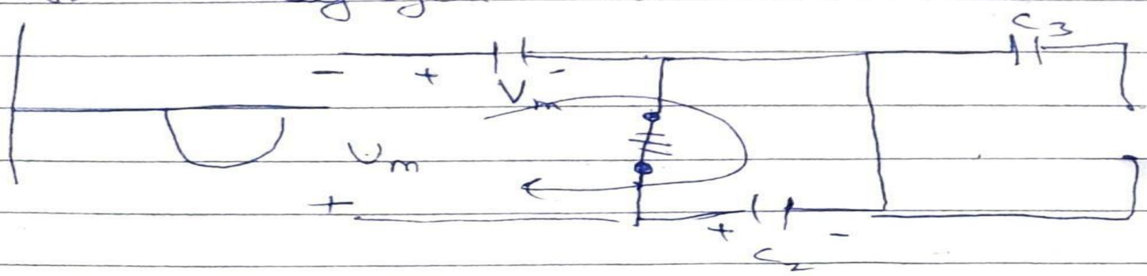
Now loop $+V_{C_1} - V_m = 0$

$$V_{C_1} = V_m$$

So capacitor C_1 charged upto V_m

Now loop2 C_2 and C_3 are discharged so no voltage at this loop

For −ve half cycle



Diode D_1 and D_3 are O.C. and D_2 is S.C.

Now loop $+V_m - V_{C_2} + V_m = 0$

$$V_{C_2} = 2V_m$$

So capacitor C_2 become charged upto $2V_m$ and C_1 become discharged upto 0 V

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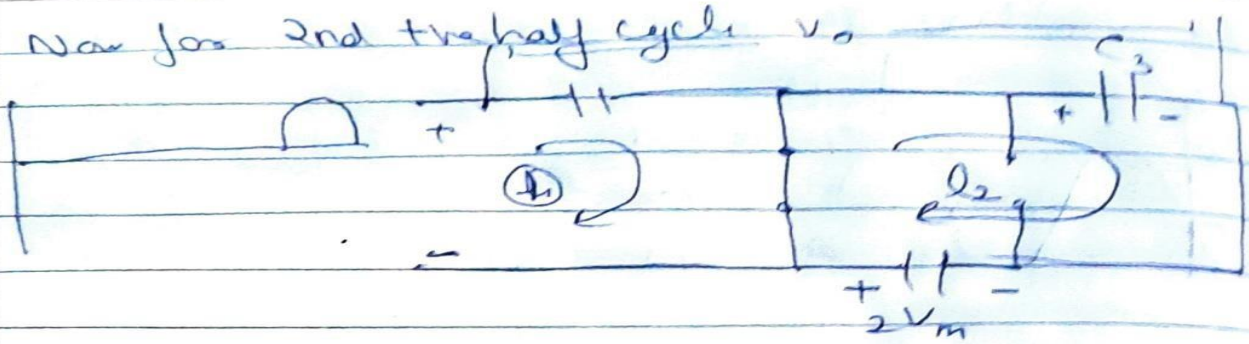
Now for 2nd +ve half cycle



D_1 and D_3 S.C. and D_2 O.C. So

loop 1

$$V_{C_1} = V_m$$

loop 2 = $V_{C_2} - V_{C_3} = 0$

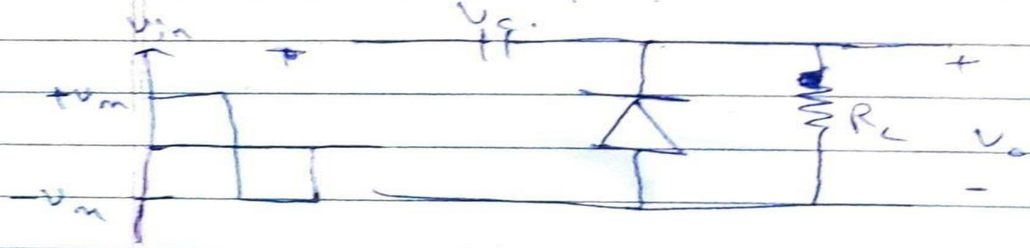
$$V_{C_3} = 2V_m$$

So total O/p voltage is

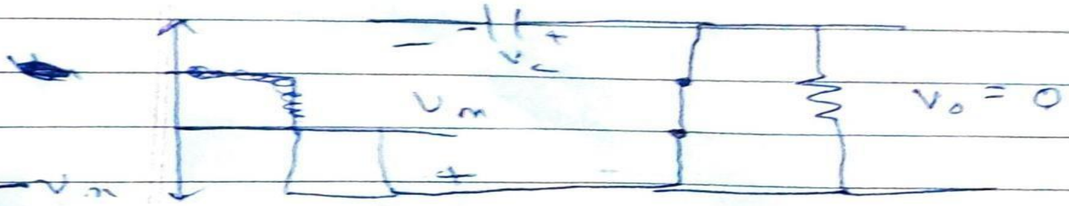
$$V_{C_1} + V_{C_3} = 3V_m$$

Clamper :-

① Positive clamper :-



For -ve half cycle



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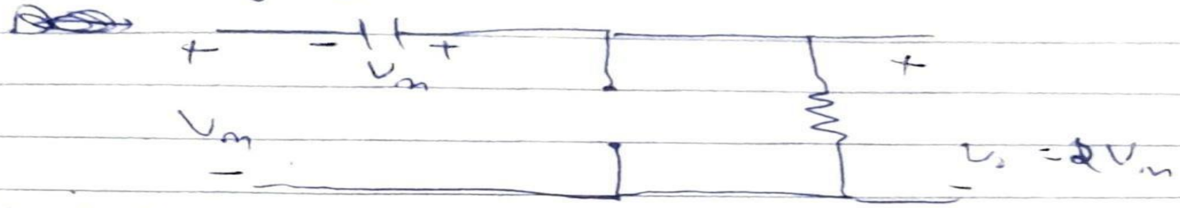
D → S.C.

$-V_m + V_c = 0$

$V_c = V_m$

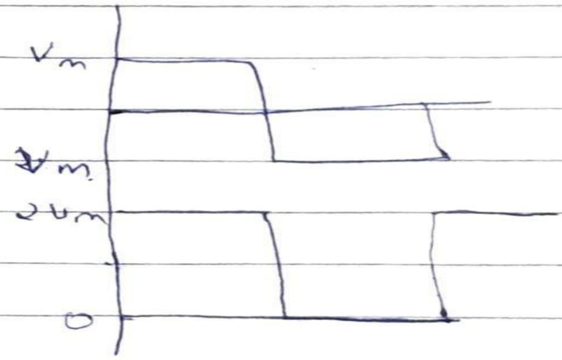
For the half cycle



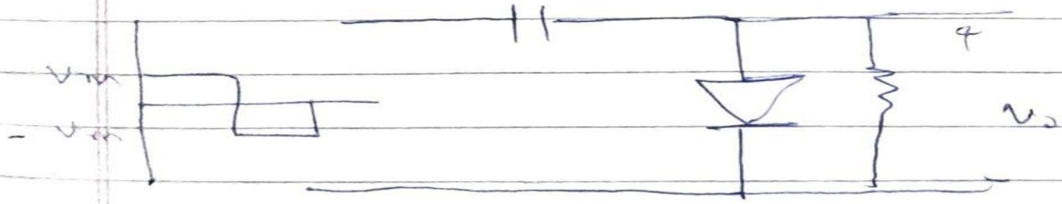
D → O.C.

$V_m + V_m - V_o = 0$

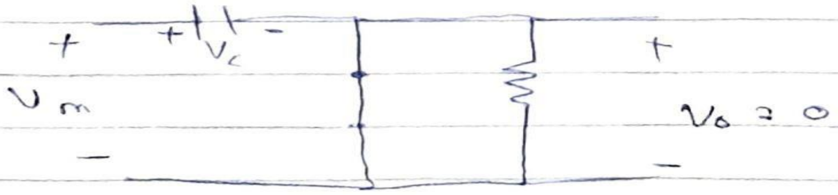
$V_o = 2V_m$



② −ve clamper :



For the half cycle D → S.C



$-V_m + V_c = 0$

$V_c = V_m$

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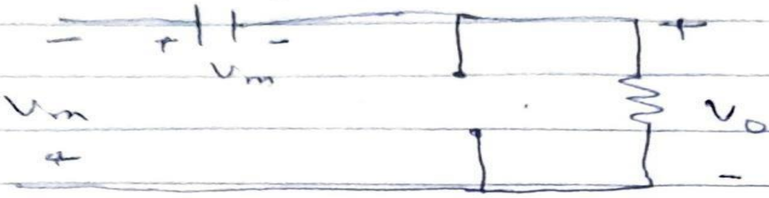
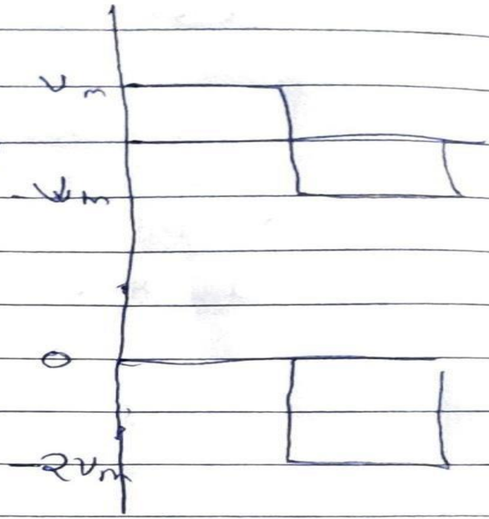
For -ve half cycle D → O.C

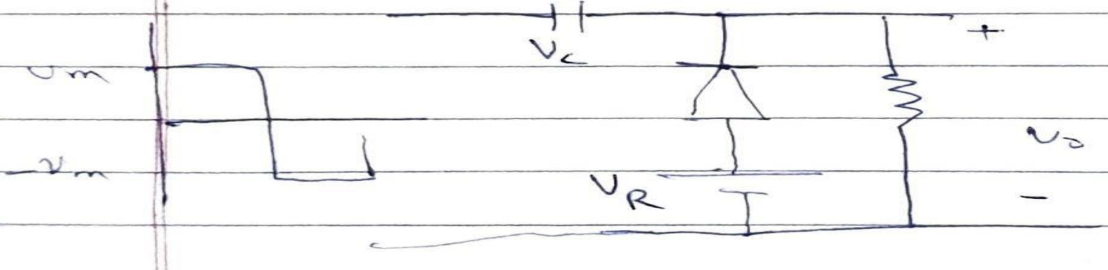


$+V_m + V_m + V_o$

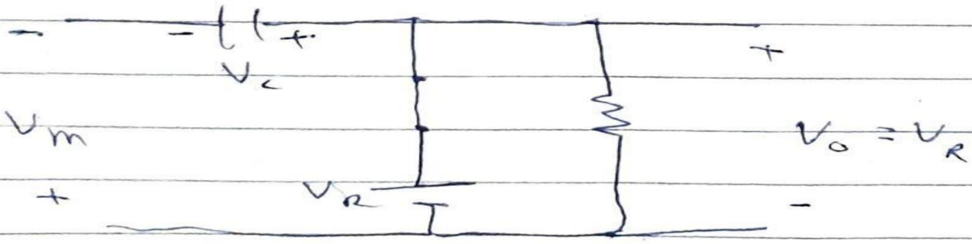
$V_o = -2V_m$



③ Positive clamper with +ve biasing:-



For -ve half cycle:- D → S.C.



$-V_m - V_R + V_c = 0$

$V_c = V_m + V_R$

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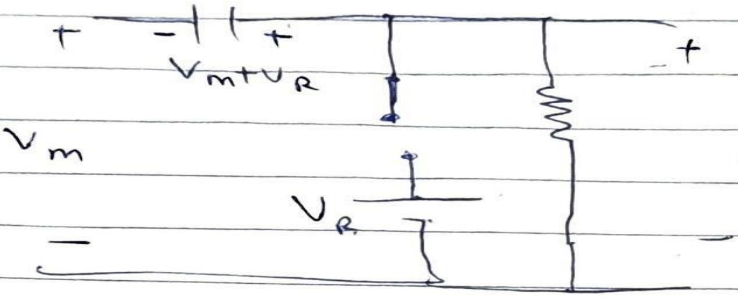
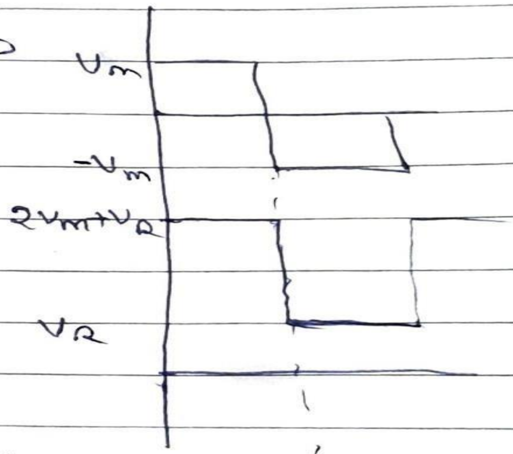
For the half cycle D → O.C.

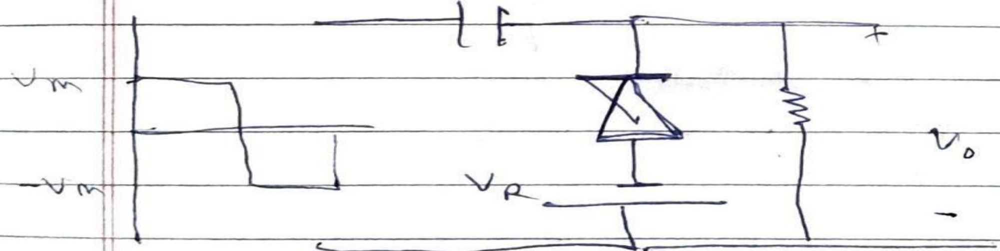


$+V_m + V_m + V_R - V_o = 0$

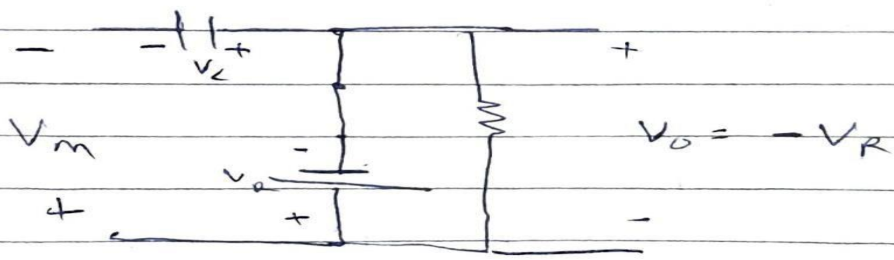
$$V_o = 2V_m + V_R$$



(4) Positive clamper with -ve biasing:-



For +ve half cycle D → S.C.



$V_m - V_c - V_R = 0$

$$V_c = V_m - V_R$$

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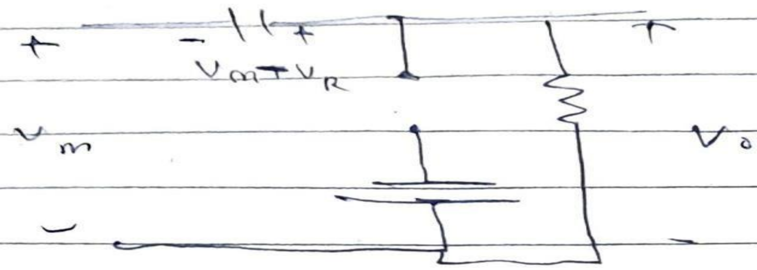
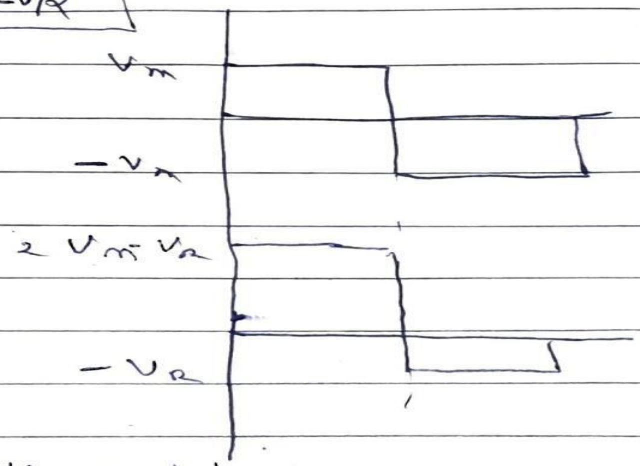
For the half cycle D → O.C.

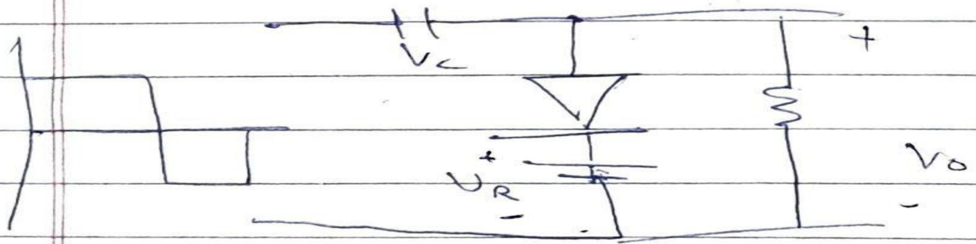


$V_m + V_m - V_R + V_o = 0$

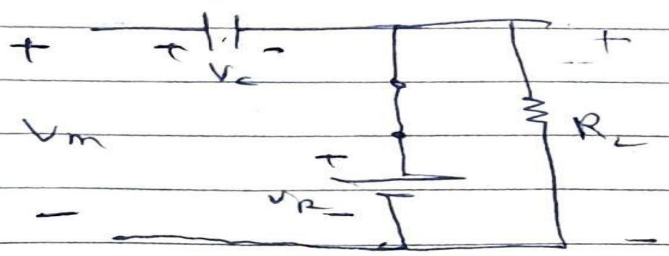
$$V_o = 2V_m - V_R$$



(5) −ve clamper with the biasing



For the half cycle D → S.C.



$V_m - V_c + V_R = 0$

$$V_c = V_m + V_R$$

$V_o = V_R$

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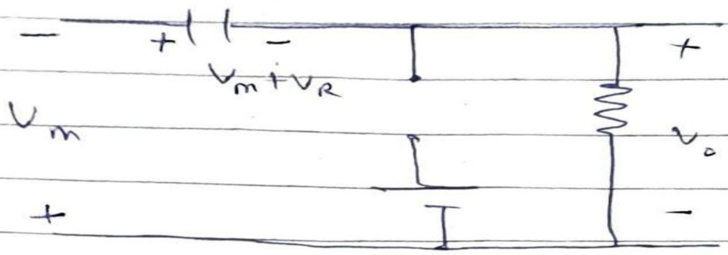
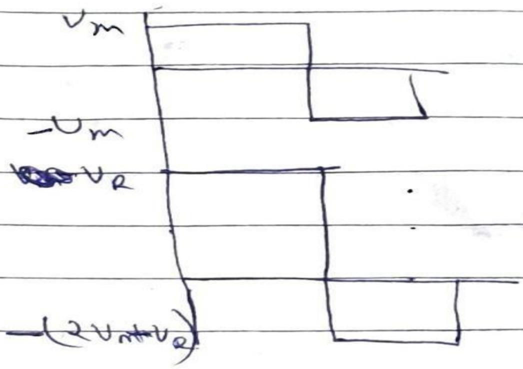
For -ve half cycle D · O · C

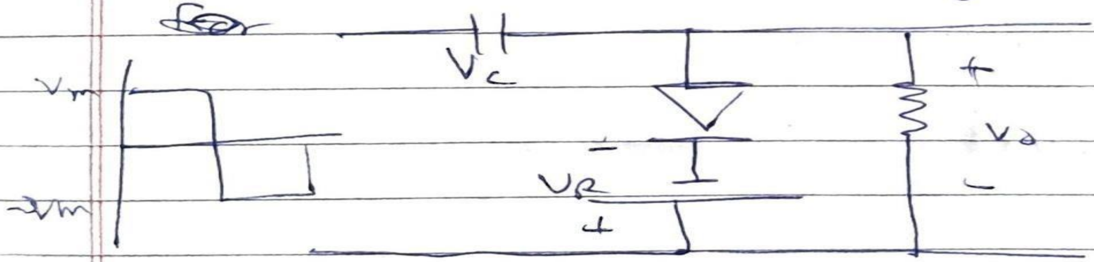


$V_m + V_m + V_R + V_o = 0$

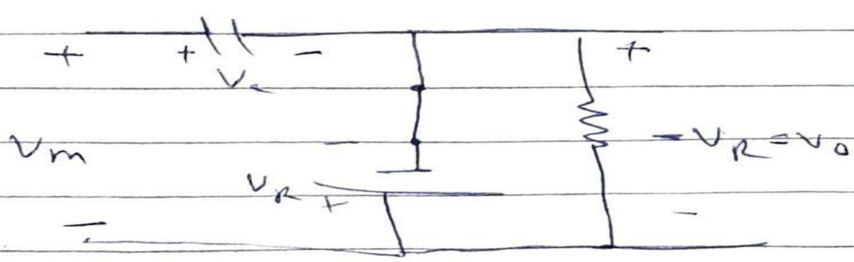
$V_o = -(2V_m + V_R)$



(6) -ve clamper with +ve biasing :-



For +ve half cycle D - S.C.



$V_m - V_c + V_R = 0$

$$\boxed{V_c = V_m + V_R}$$

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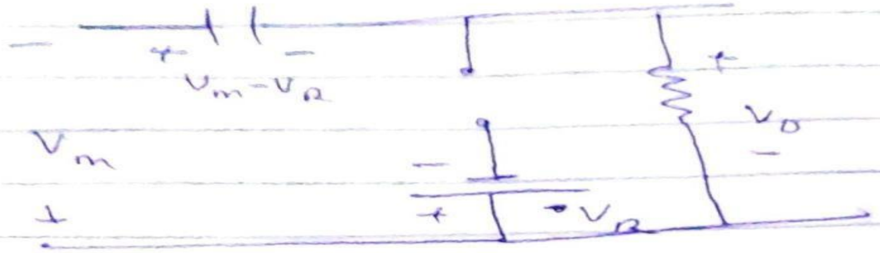
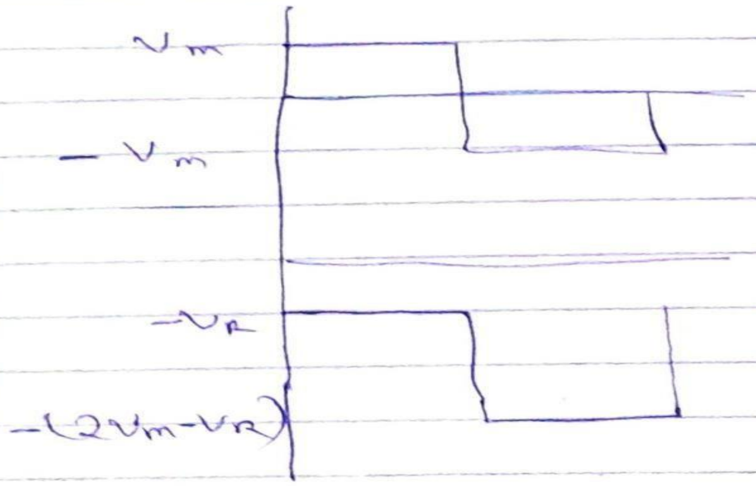
For -ve half cycle O.O.P



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

$$V_o = -(2V_m - V_R)$$



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