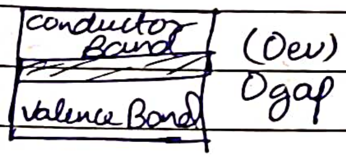
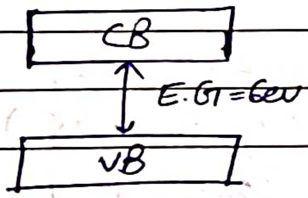
CL WADHWA
BL THAREJA
(EKeeda)
(Gate Academy plus)
(Neso Academy)

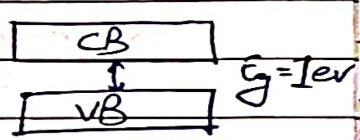
21/12/2020

FCEC003(EEE)

Conductor | Insulator | Semi-conductor







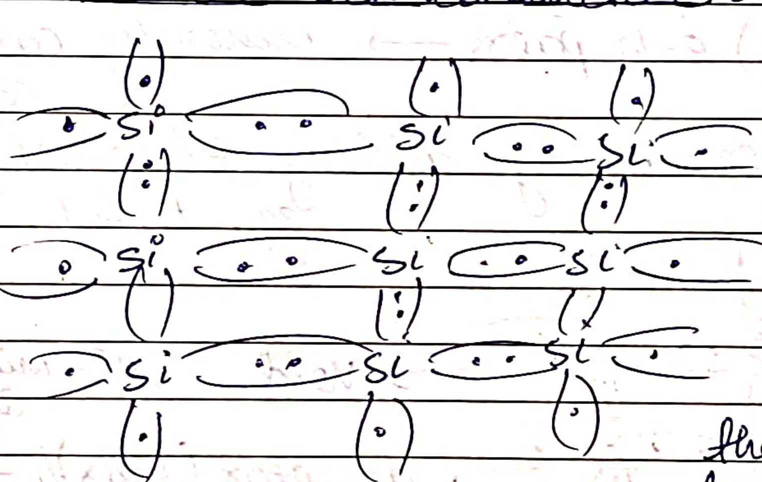
- At 0K, semiconductor behaves as insulator.
- At T>0K, some e's move to the CB and thus it allows the flow of current.

Advantages of Si over Ge → (High speed & Bandwith)

1) Si is less temp sensitive (temp stability)
2) Si is less expensive & available in large amounts
3) less I_s (saturation current).

→ Si, Ge → 4 valence electrons

→ Intrinsic semiconductors: (Pure semiconductors)



At '0K' – insulator (No charge carrier)

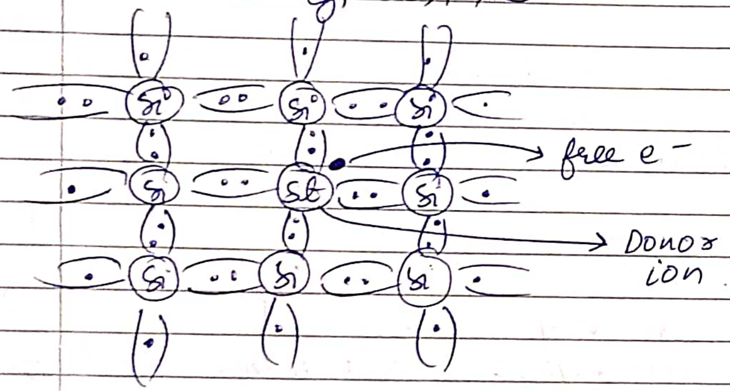
At T>'0K' – valence e's gain energy to break the covalent bond & become free charge carriers.

★ Si & Ge – As T ↑, resistivity ↓es

→ Extrinsic semiconductor:

n-type ← → p-type

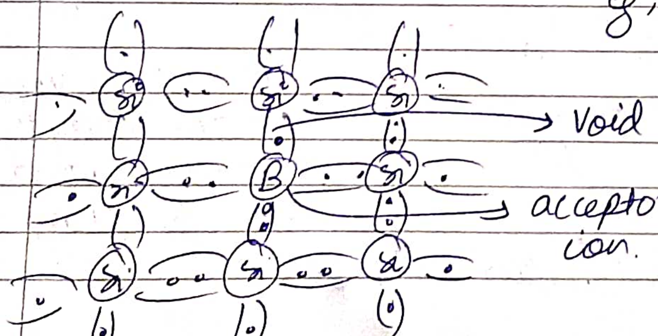
1) n-type: creating by adding pentavalent atoms (Group 15)
eg; Sb, P, As



→ e^- due to donor atoms
→ e-h pairs due to thermal energy

e's → majority carriers
(e-hole pairs) e-h pairs → minority carriers

2) p-type: created by adding trivalent atoms (Group-13)
eg, B, Ga, In



e^- - minority carriers.
(holes) h → majority carriers.

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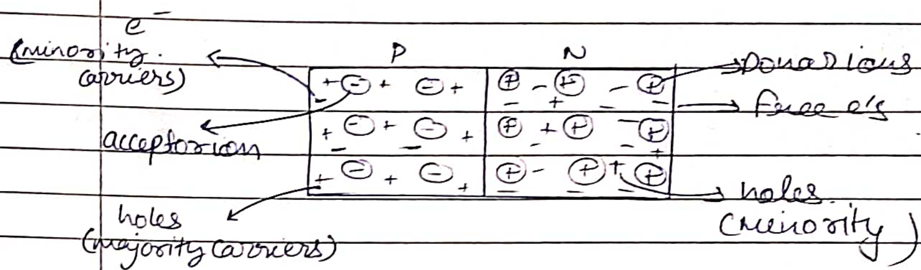
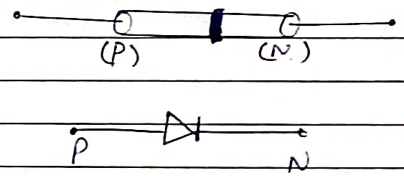
Semi-Conductor Diodes :

→ Diode : 1st solid state devices



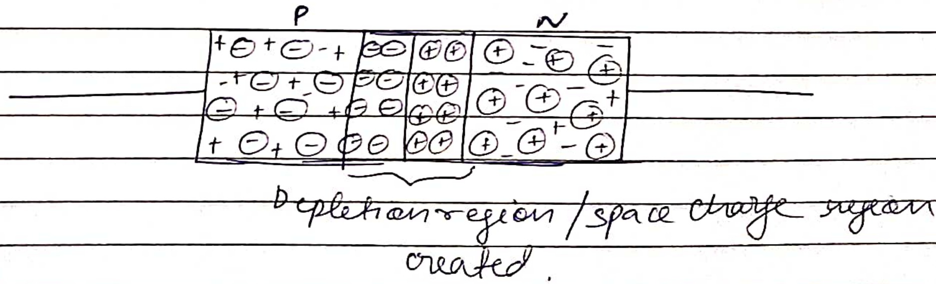


→ Diffusion of holes & e's takes place due to diff in concentration.

→ Carriers move from high conc to low conc.

holes → move from p to n
e's → move from n to p

→ Recombination will take place leaving behind ⊕ ions on n-side & ⊖ ions on p-side.



→ Now holes would be repelled by ⊕
& e's would be repelled by ⊖

→ There will be a barrier potential set up which results in an $\vec{E}$ that prevents further movement of carriers takes place due to $\vec{E}$.
(called drift current)

PN

Majority (diffusion current) (mA)

$h \longrightarrow \quad \longleftarrow e^-$

$I_h \longrightarrow \quad I_e \longrightarrow$

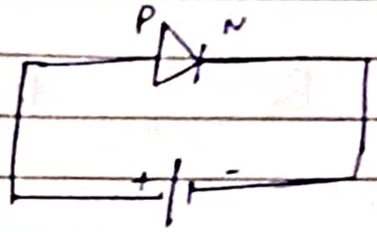
Minority (Drift current) (Thermal generated pair effect) (μA/nA/pA)

$e^- \longrightarrow \quad \longleftarrow h$

$\longleftarrow I_{d(e)} \quad \longleftarrow I_{d(h)}$

Forward & Reverse bias

Forward Bias

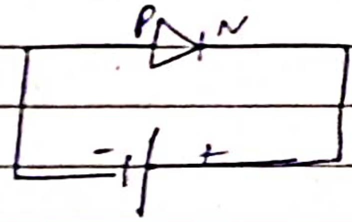


- Majority carriers are pushed towards junction
- when they collide, recombination takes place
- Depletion region becomes thinner.
- (mA)

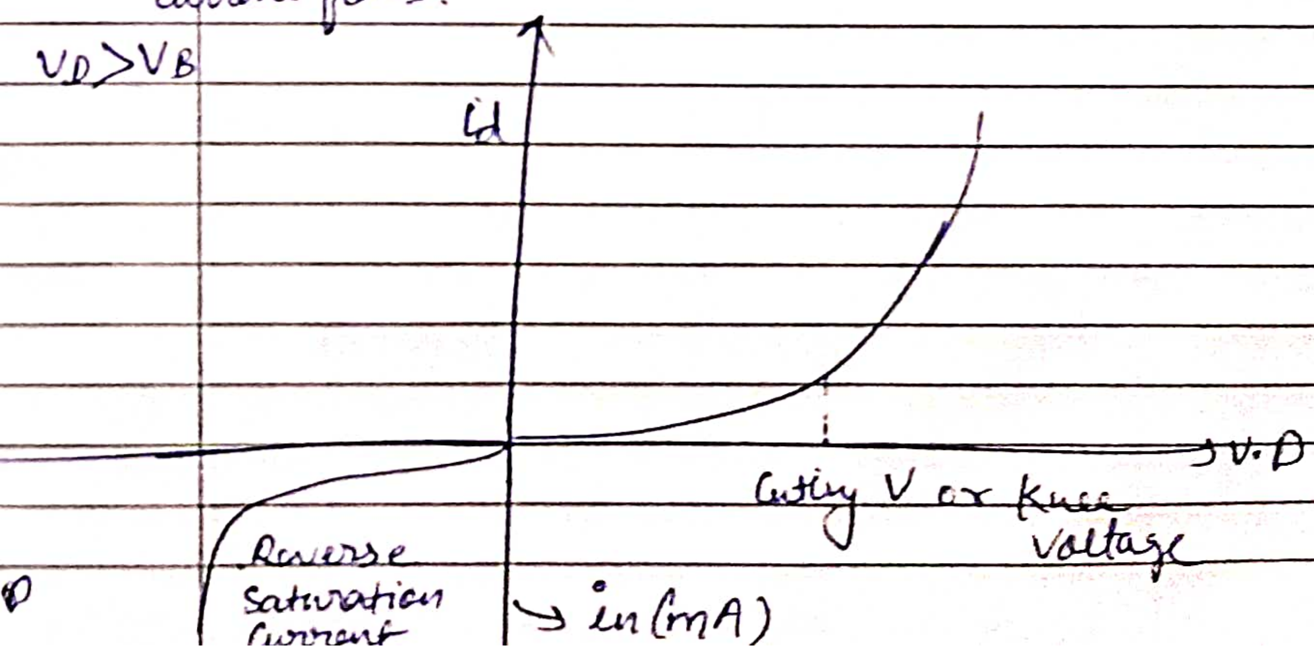
E:
Holes repelled by → +ve plate
e's " " → -ve plate

W↓ → Barrier gets↓
Current flows.

Reverse bias.



majority carriers are pushed away from the junction (NO flow of I due to majority carriers)
- The E Barrier strength is increased due to the external voltage
- Depletion region widens.
- Current flow would be due to minority carriers.
- This current is very small, (in µA/mA/pA) called reverse saturation current.



$$\boxed{I_d = I_s\left(e^{\eta \frac{V_D}{V_T}} - 1\right)}$$

I_s = Reverse saturation current
I_D = Diode current

V_T = Thermal voltage $= KT$ (K = Boltzaman Const $= 1.38 \times 10^{-23}$ J/K)
↳ 26mV at R.T (27°C) ($e = 1.6 \times 10^{-19}$ C)
(25.8 mV)

$V_D \longrightarrow$ applied voltage
η = physical contraction parameter

F.B

$$\boxed{I_D = I_{maj} - I_{s}}$$

R.B

$$\boxed{I_D = I_s}$$

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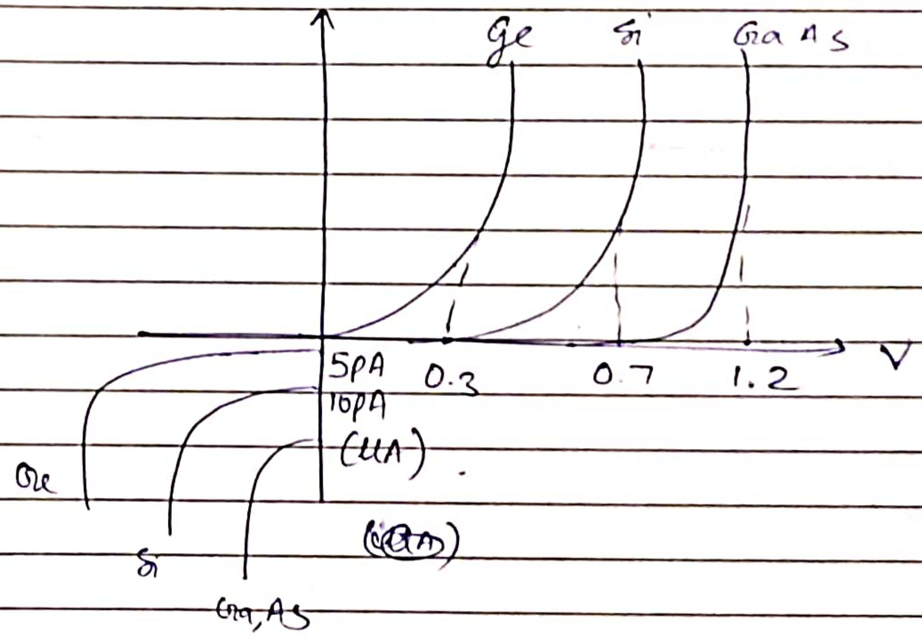
Junction Diode

$I_{diffusion}$: it is due to the majority carriers (in mA)

I_{drift}: It is due to the minority carriers. (in μA/pA)

Types of reverse breakdown → zener, → avalanche.



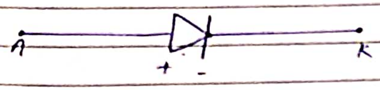
(8) Reverse saturation current is the leakage current. (undesirable).

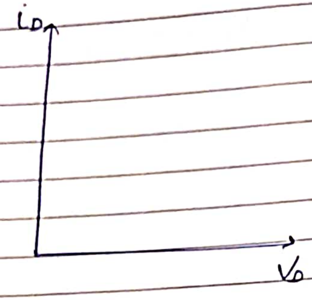
Ga, As → higher speed & bandwith

→ Diode is a non-linear element used in circuits.

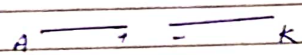
I_s → Reverse saturation current. (leakage Current).

→ Ideal Diode ($V_\gamma = 0$)





= Reverse bias - open circuit



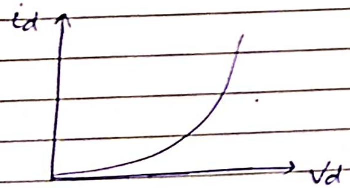
Resistance = ∞

= Forward bias - closed circuit

Resistance = $0\,\Omega$

→ Modelling of Diode

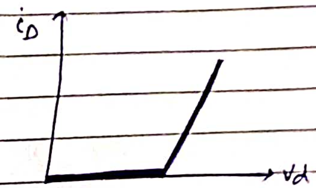
1) Exponential

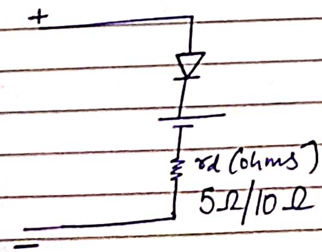


$$i_d = I_s e^{\frac{V_D}{\eta V_T}}$$

$$\Rightarrow V_D = \eta V_T \ln\left(\frac{i_D}{I_s}\right)$$

2) piece-wise linear approximation

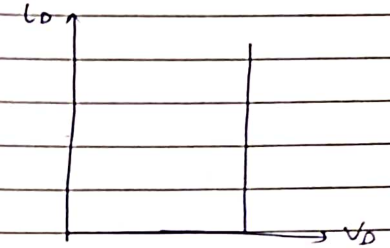


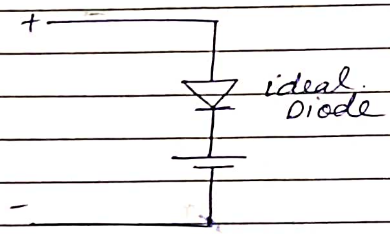


_/_/_

3) Constant Voltage drop model^{3}):

No Resistance Applied



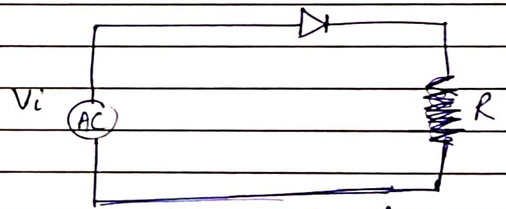


CLIPPER CIRCUITS:

(LIMITER CIRCUITS), used to change the appearance of signal

→ ~~Clip~~ Clip away a portion of input signal without disturbing the remaining part of the input signal

1)



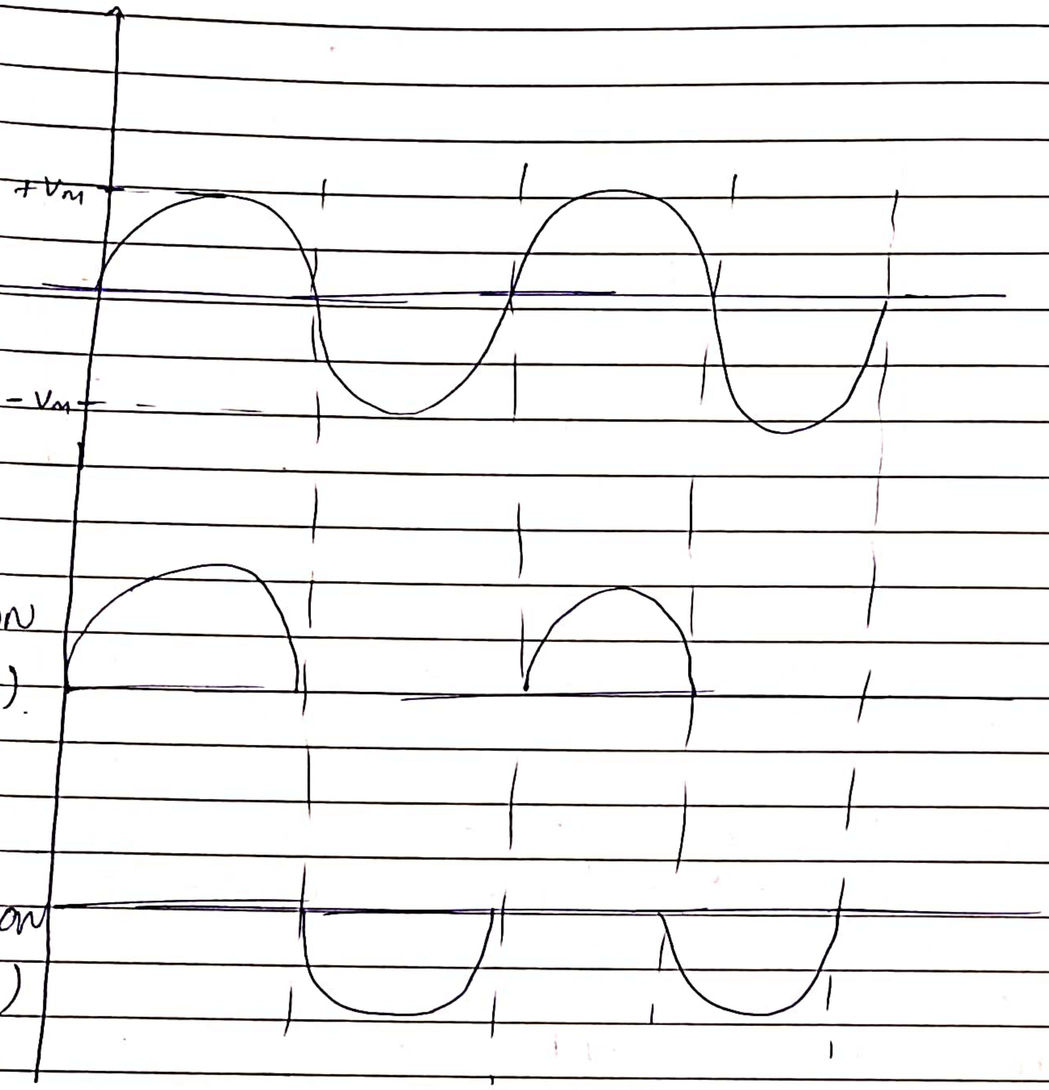
Half wave Rectifier

+ve half cycle → Diode in F.B

$V_D = V_{imax}$

-ve half cycle → Diode in R.B → OFF

$V_D = 0$



AFTER RECTIFICATION (-ve clipper)

AFTER RECTIFICATION (+ve clipper)

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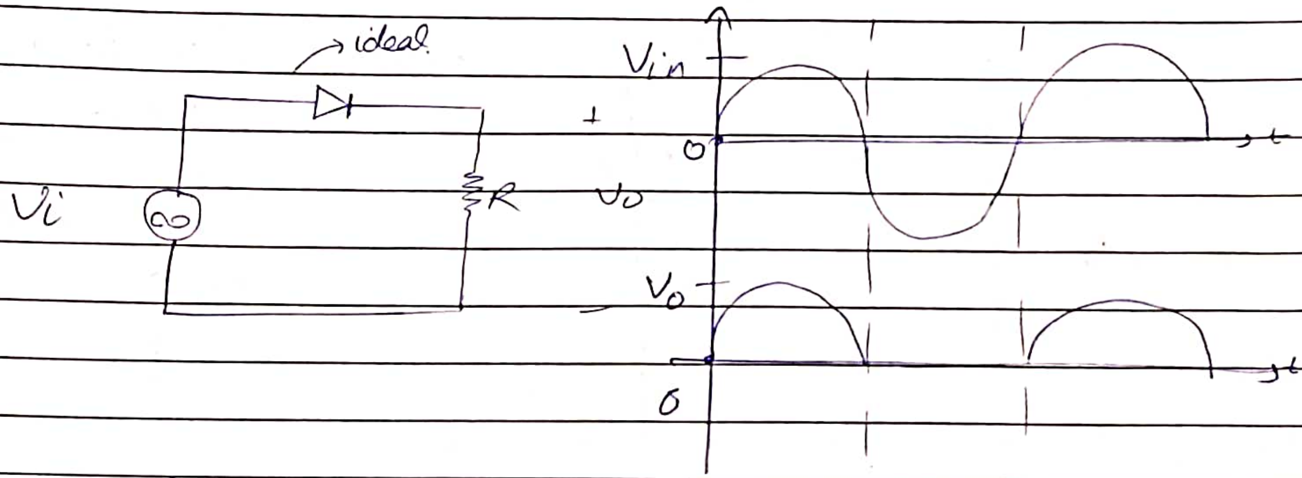
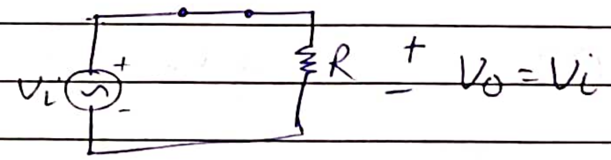
Clippers.

1. Negative Clipper : → Clip −ve

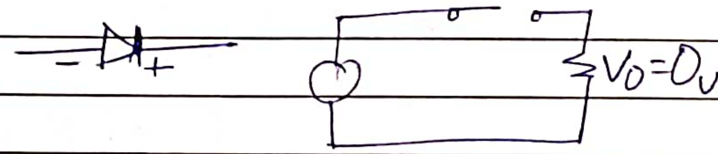
→ ideal



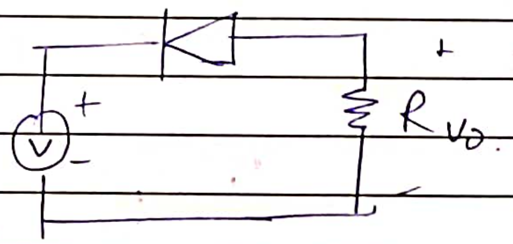
→ +ve half → Vin > 0
D → F.B → S.C ON
short cir.

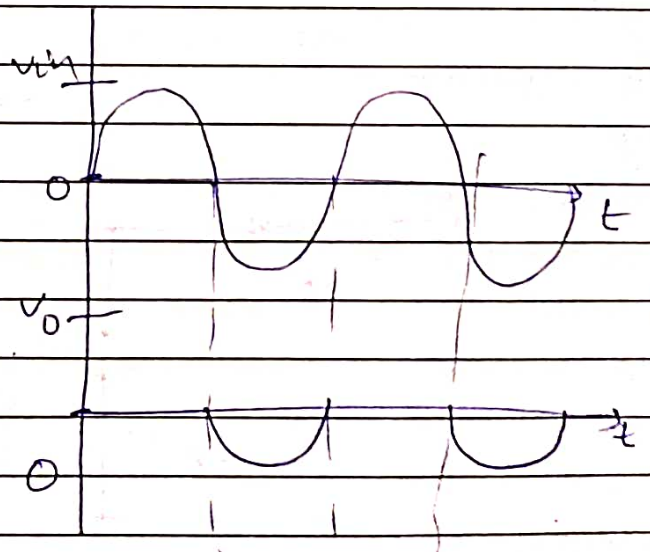


→ −ve half → Vin < 0 → D
D → RB − off → O.C
open circuit

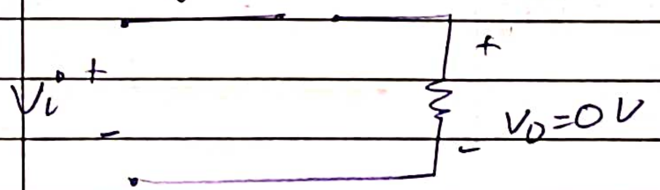


②



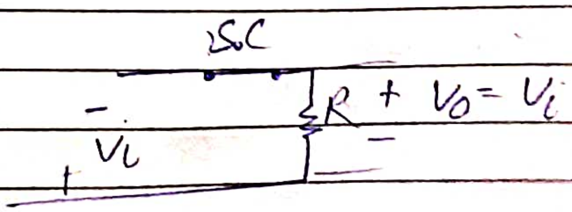


+ve cycle, D−RB−Off−OC.

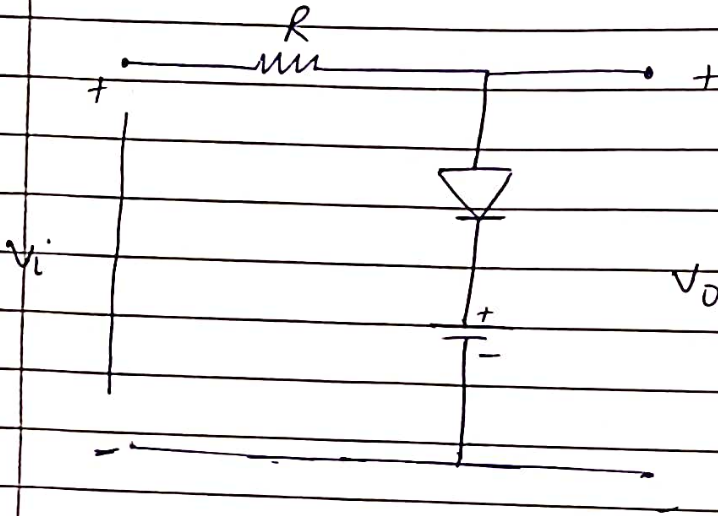


SELF

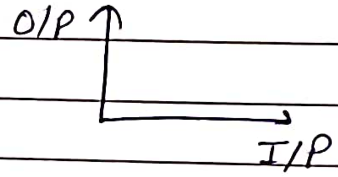
−ve cycle; D → FB, ⇒ ON ⇒ S.C



③ Biased clipper : use of DC battery voltage.



Plot the Vo vs transfer curve → Vo vs Vin
O/P vs I/P.



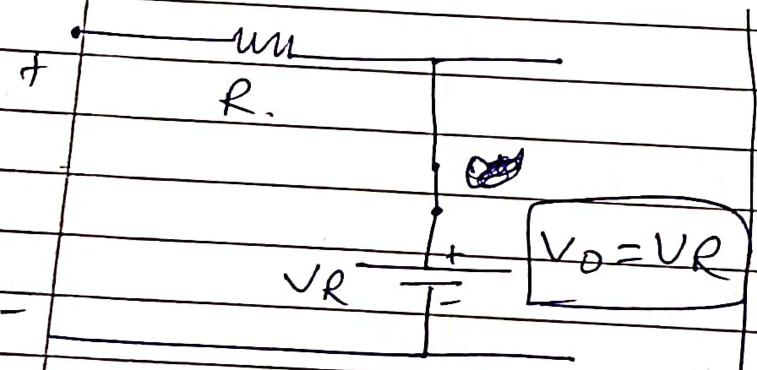
DRB ⟶ V_R

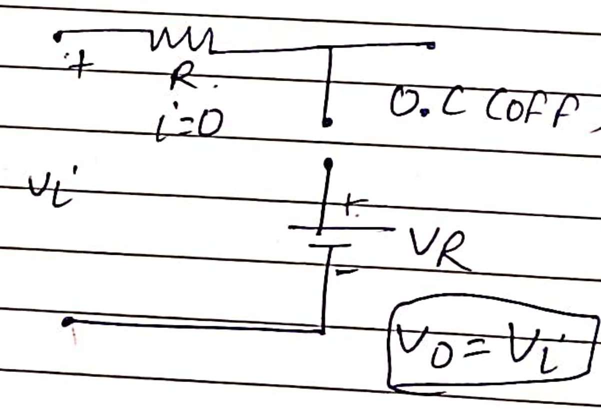
Diode Rev Bias.

+ve cycle :-

D → FB by V_i & RB

when $V_i > V_R \Rightarrow$ D FB (S.C) (short circuit)
$V_i < V_R \Rightarrow$ DRB (O.C) (open circuit)

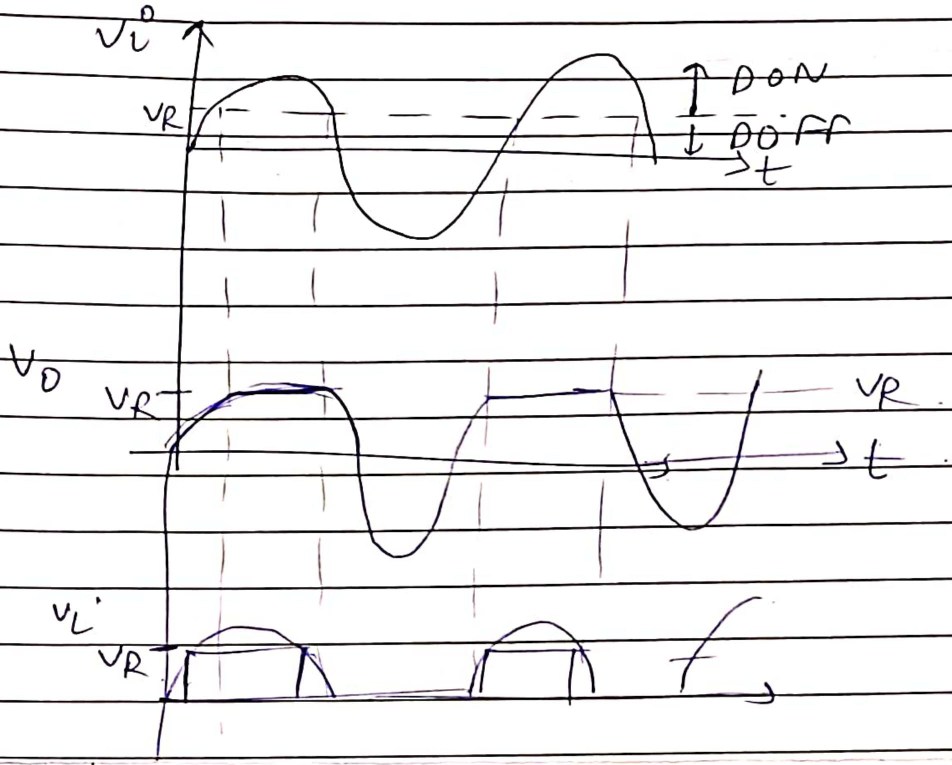




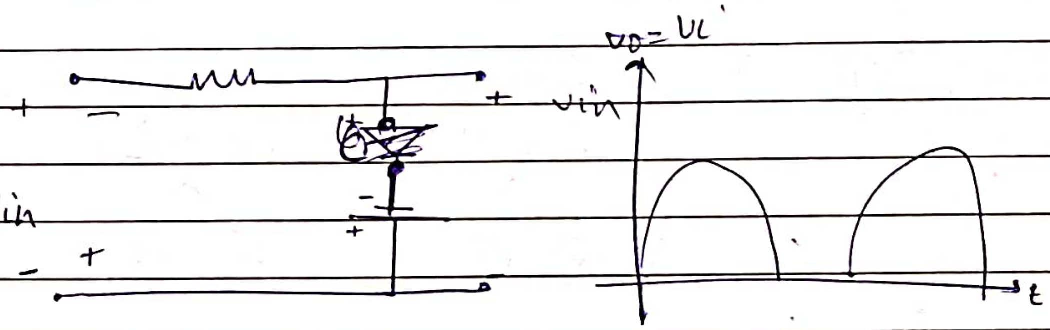
-ve half cycle D → RB by Vi & VR.

$D_{ON} \rightarrow V_o = V_R \quad V_i \geq V_R$

$D_{off} \rightarrow V_o = V_i \quad V_i < V_R$



-ve cycle

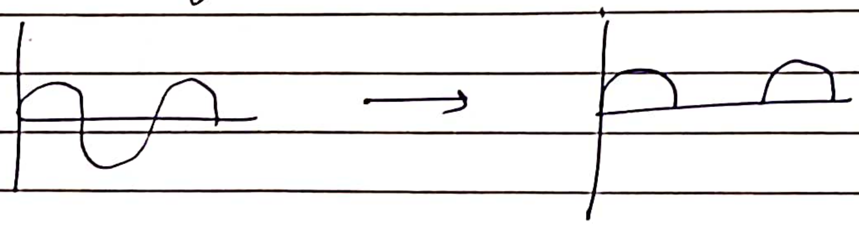


CLIPPERS

Clippers: are networks that use diodes to clip a portion of input signal without distorting the remaining part of the waveform.

eg

-ve clipper.

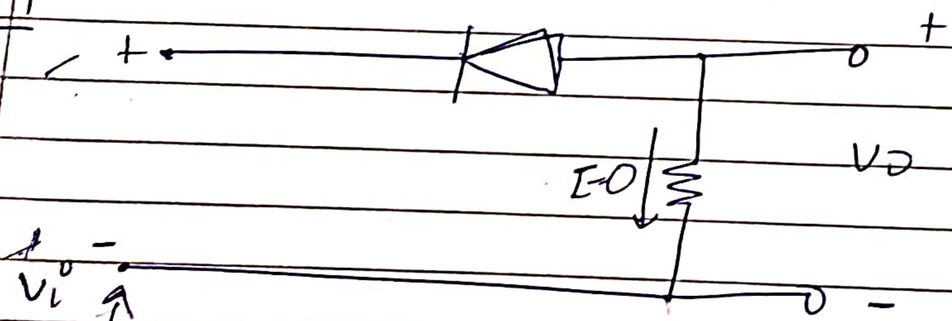


Clippers

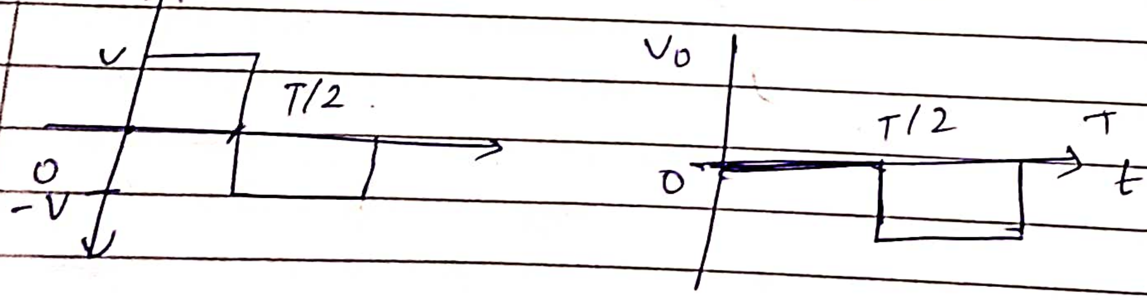
- Series
  - Unbiased (Basic) series: (+) (−)
  - Biased series: (+) (−)
- Parallel
  - Unbiased (Basic) Parallel: (+) (−)
  - Biased Parallel: (+) (−)

Unbiased series Clipper

Ex-1



$\boxed{V_o = 0}$



For +ve half cycle

Diode → R.B (O.C)

$V_0 = 0$

$I = 0$

for -ve half cycle

Diode → F.B (S.C)

$-V_i + V_0 = 0$

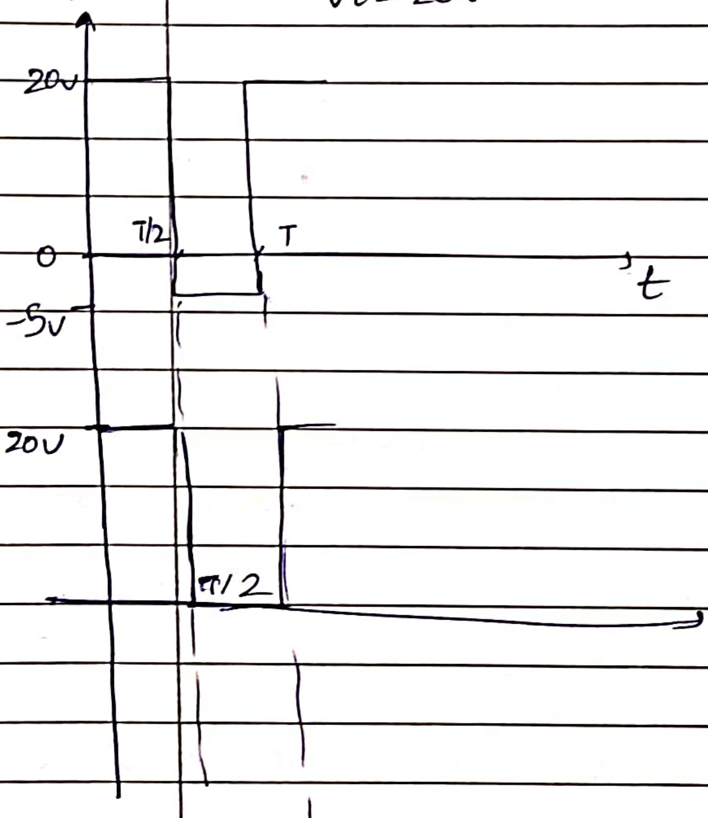
$V_0 = V_i$

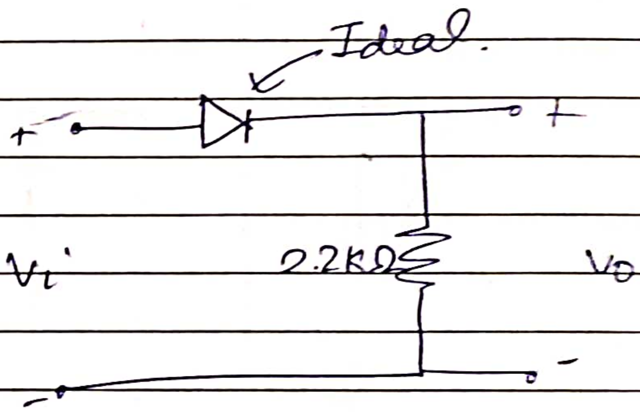
$\boxed{V_0 = -V}$

So its series Clipper
Unbiased Clipper.
+ve Clipper

Unbiased series Clippers:

$V_i = 20V$



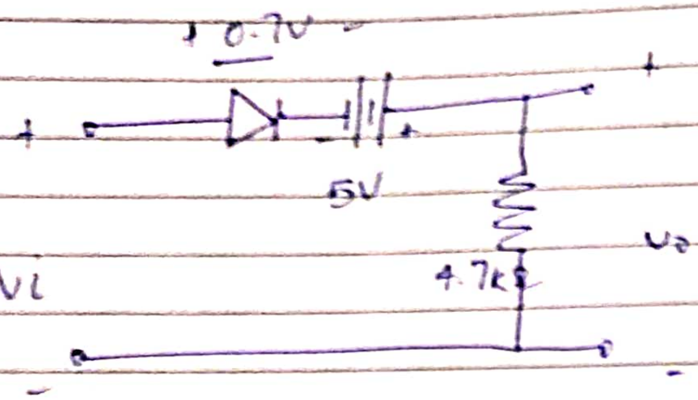


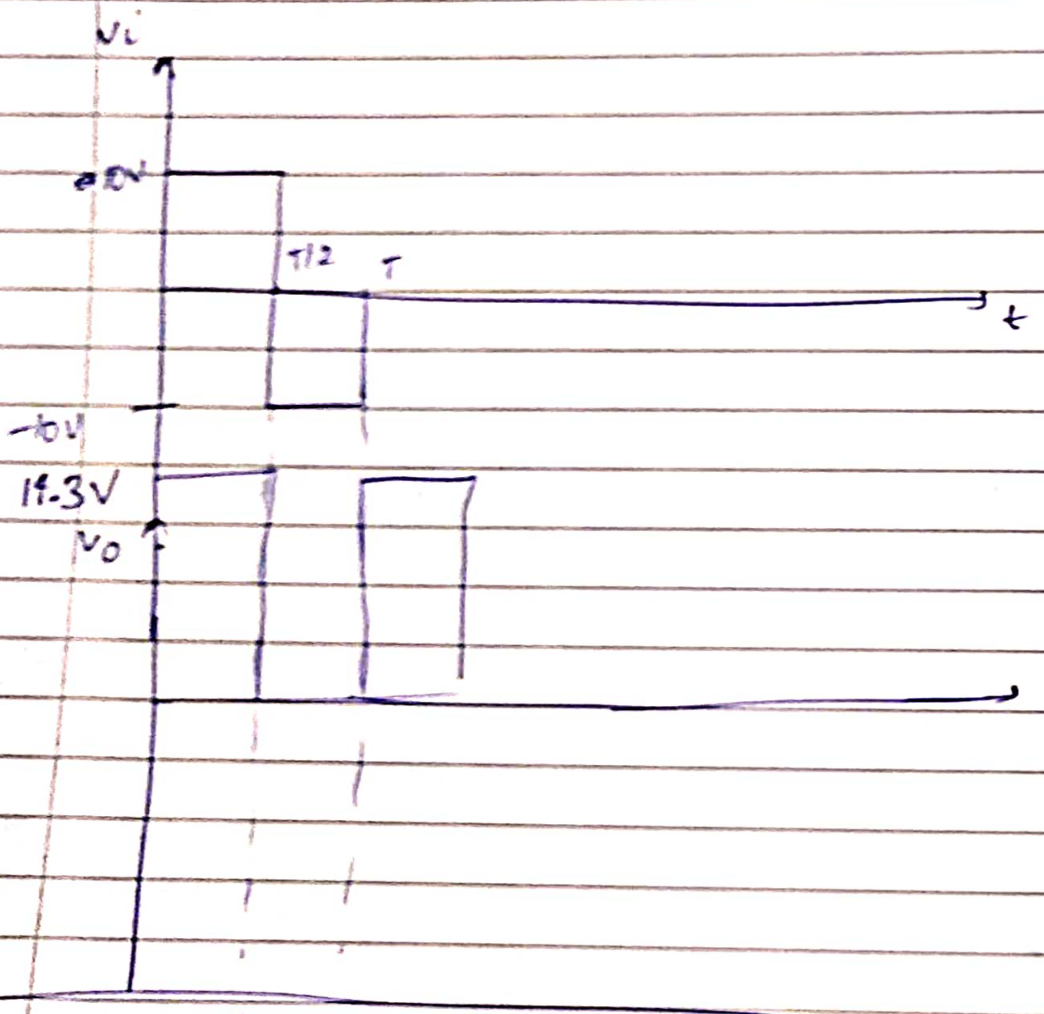
+ve half cycle	-ve half cycle
S.C, F.B	O.C, R.B
$V_0 = V_i$	$V_0 = 0$

-ve ~~Unbiased Clipper circuit~~

Biased series Clipper

Q)





So 5V battery is FB.

For +ve cycle

$V_i \geq 5V$ is FB

$V_o = V_i - 0.7 + 5V$

$= 10 - 0.7 + 5$

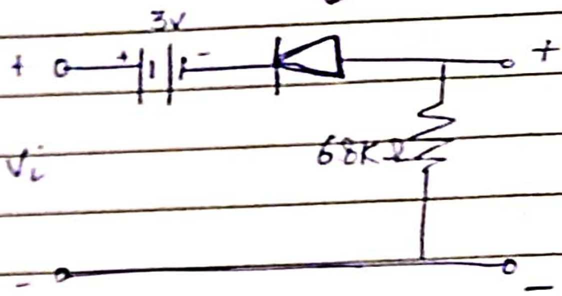
$V_o = 14.3V$

For -ve cycle

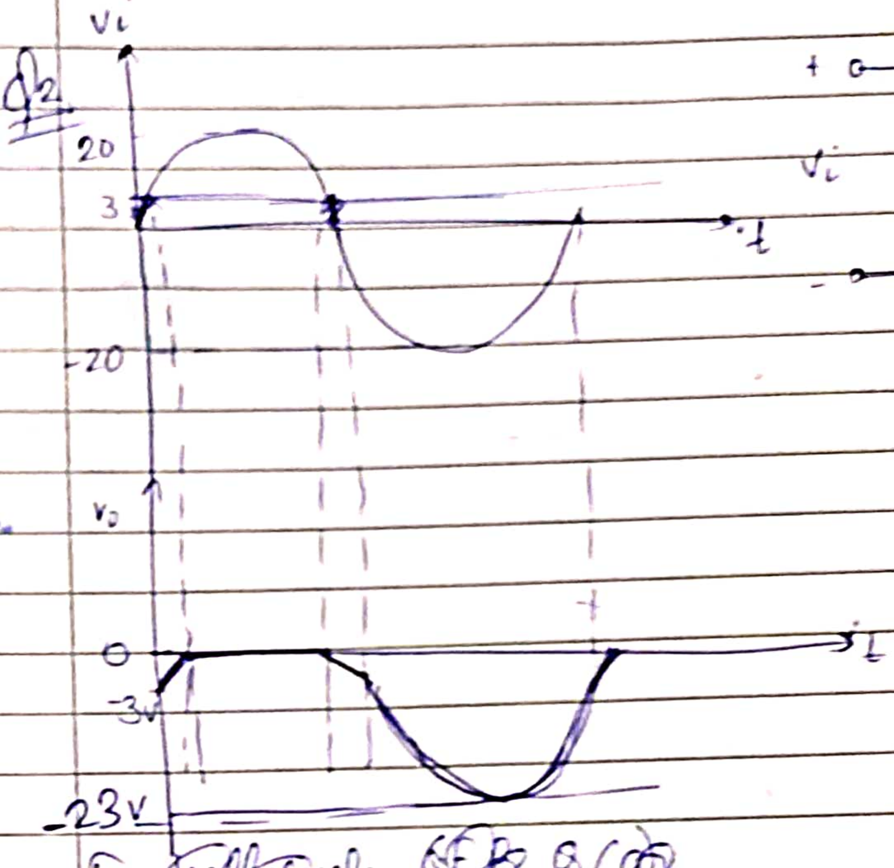
$V_o = 0V$ As $5V \leq V_i$

-ve clipper biased.

Ideal



Q2



~~+ve half cycle (F.B & O.C)~~

+ve half

~~$V_i - 3 - V_o = 0$~~

For $V_i (0,3)$ F.B $\rightarrow$ if $V_i < 3v$. (S.C) $V_o = V_i - 3v$

R.B $\rightarrow$ if $V_i > 3v$ (O.C) $V_o = 0V$

-ve half F.B $\rightarrow$ for all values of V_i
(S.C).

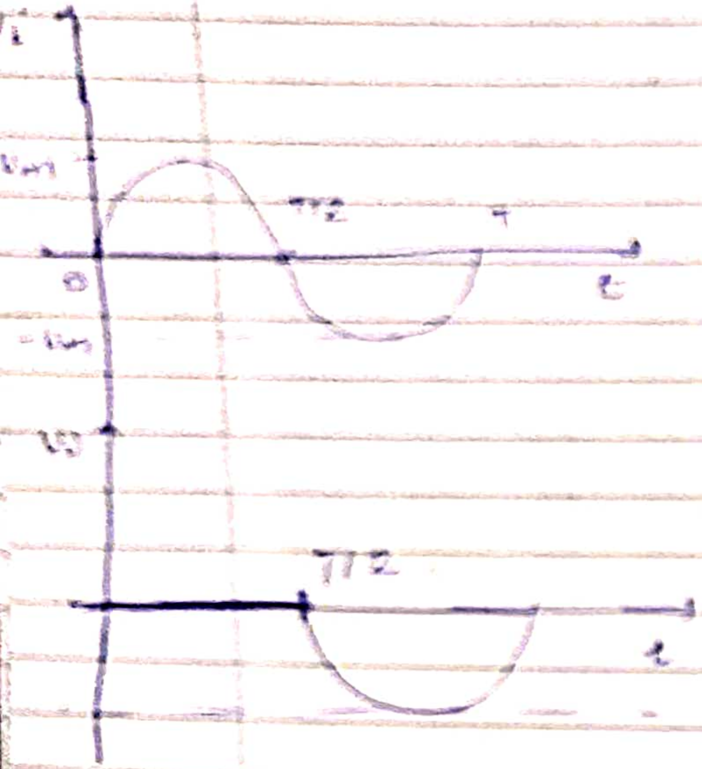
$$V_o + 3 + V_i = 0$$

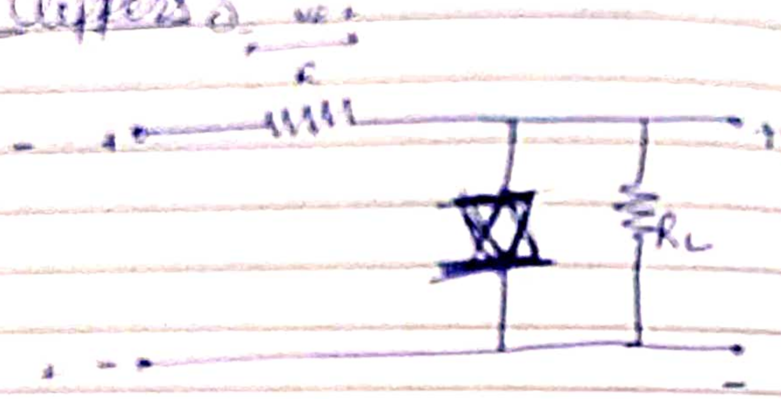
$$\boxed{V_o = -V_i - 3}$$

$V_i = 0$ $V_o = -3$ volts

$V_i = 20$ $V_o = -23$ volts

Unbiased parallel clippers:





for two half cycle (RBSC)
0 to T/2

$V_0 = 0$ (as no curr on R_L)

for negative cycle (T/2 to T)

$+V_i + V_D - V_R = 0$

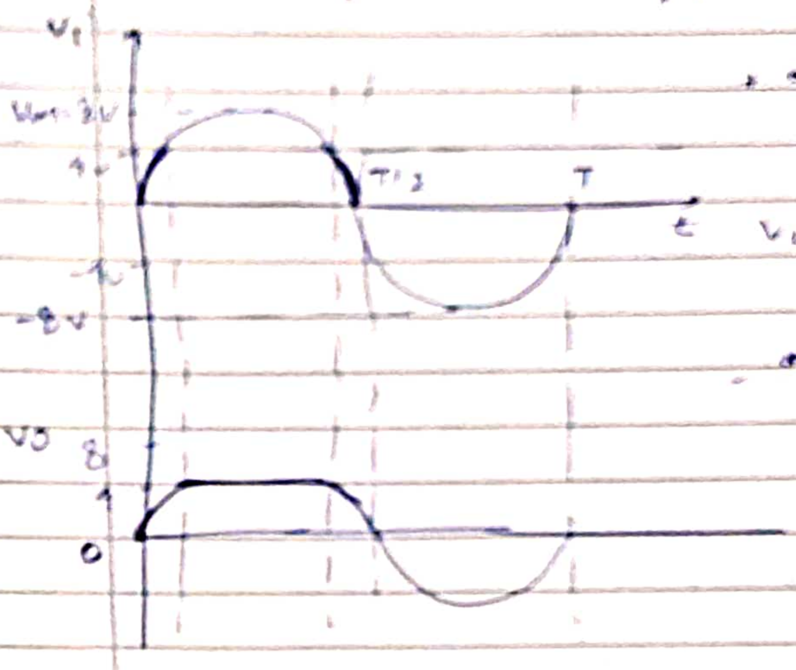
$$\boxed{V_0 = -V_i + V_R}$$

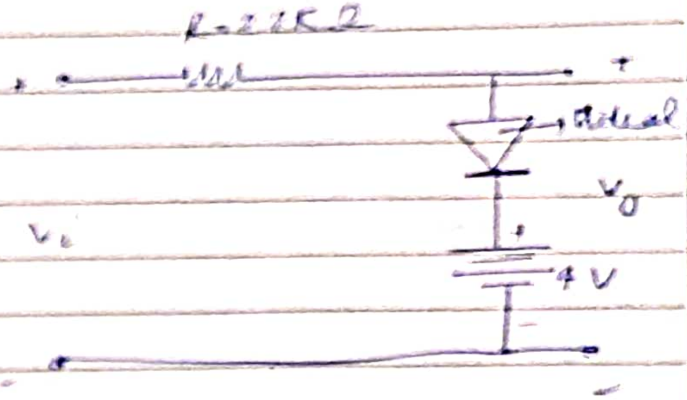
$V_R \approx 0$

$$\boxed{V_0 = -V_i}$$

Positive Clipper circuit.

Biased parallel Clippers





for +ve half cycle

$v_i > 4$ (FB SC

$v_i < 4$ (RB O C)

~~v_i ...~~

* $v_i > 4$ (FB)

$\boxed{V_o = 4v}$

* $v_i < 4$ (R B) (O.C)

$\boxed{V_o = V_i}$

for -ve half cycle

for all v_i

(RB) (O.C)

$V_o = V_i$

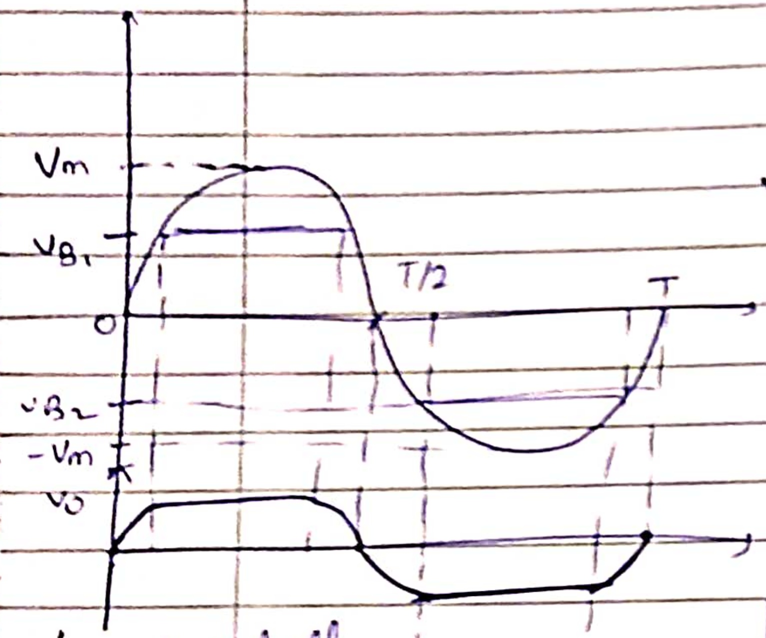
$= -V_2$

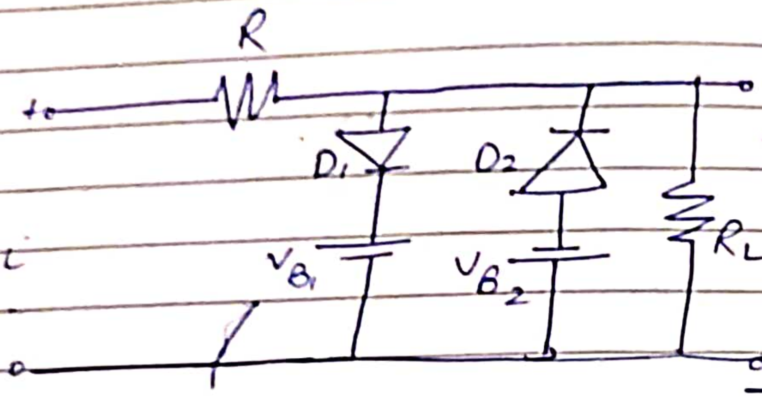
$V_i > V_1$

$v_i > -V_2$

Combination Clipper Circuit

Biased +ve Clipper
Biased -ve clipper





$V_R \simeq 0$
$R << R_L$

for +ve half	for -ve half
$D_2 \rightarrow$ r.b (O.C)	$D_1 \rightarrow$ r.b (O.C)
$D_1 \rightarrow$ r.b by V_{B_1}	$D_2 \rightarrow$ r.b by V_{B_2}
F.b by V_i	F.B by V_i

$V_i < V_{B_1}$	$V_i > V_{B_1}$	$V_i < V_{B_2}$	$V_i > V_{B_2}$
$D_1 \rightarrow$ r.b	$D_1 \rightarrow$ F.B	$D_1 \rightarrow$ R.B	$D_1 \rightarrow$ R.B.
$D_2 \rightarrow$ r.b	$D_2 \rightarrow$ r.b	$D_2 \rightarrow$ R.B	$D_2 \rightarrow$ F.B.
$\boxed{V_0 = V_i}$	$\boxed{V_0 = V_{B_1}}$	$\boxed{V_0 = V_i}$	$\boxed{V_0 = V_{B_2}}$

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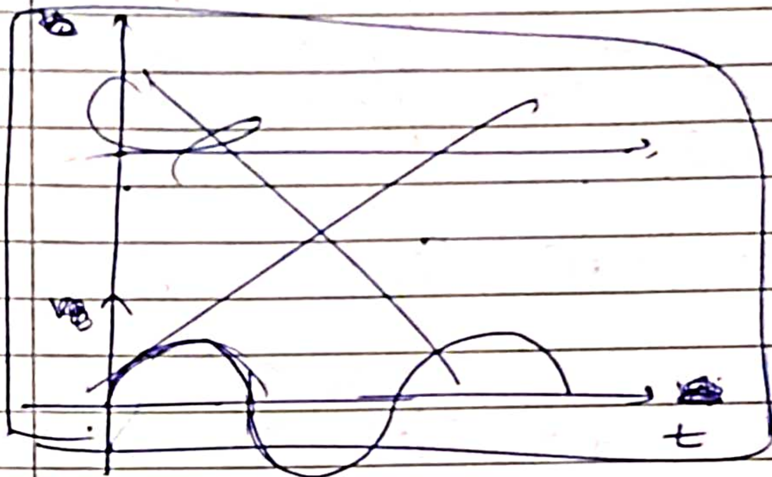
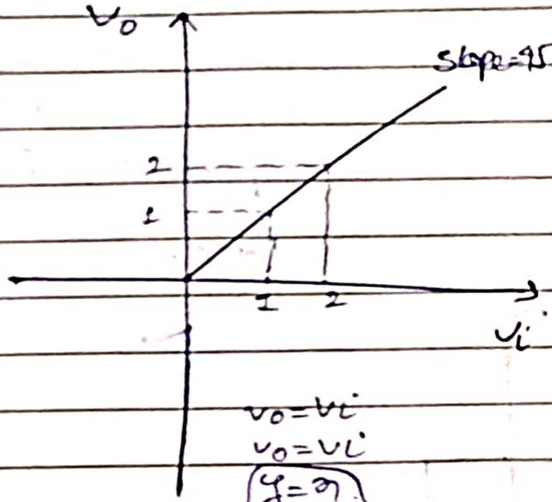
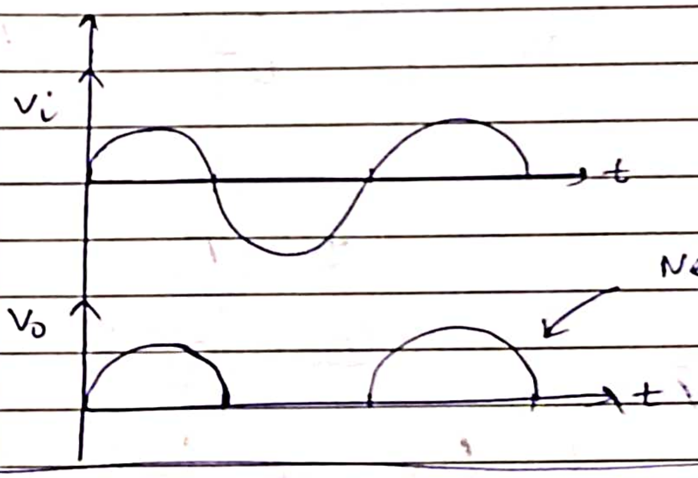
Transfer Characteristics of Clipper Circuits

T.C is graph b/w i/p voltage and o/p voltage.



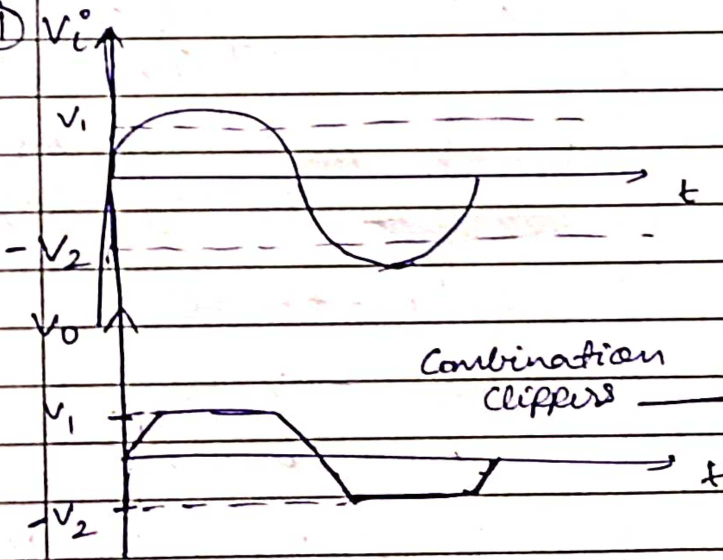


$V_0 = V_i$
$V_0 = V_i$
$\boxed{y = x}$

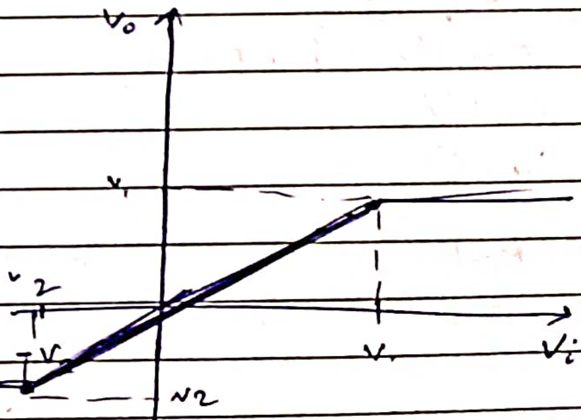


Negative Clipper

$$V_0 = \begin{cases} V_i & V_i \geq 0 \\ 0 & V_i < 0 \end{cases}$$

① 

Combination Clippers



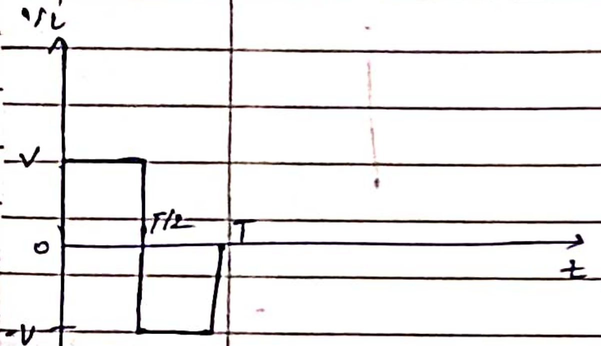
$$V_0 = \begin{cases} V_0 & V_1 \leq V_i \leq -V_2 \\ V_1 & V_i > V_1 \\ & V_i > -V_2 \end{cases}$$

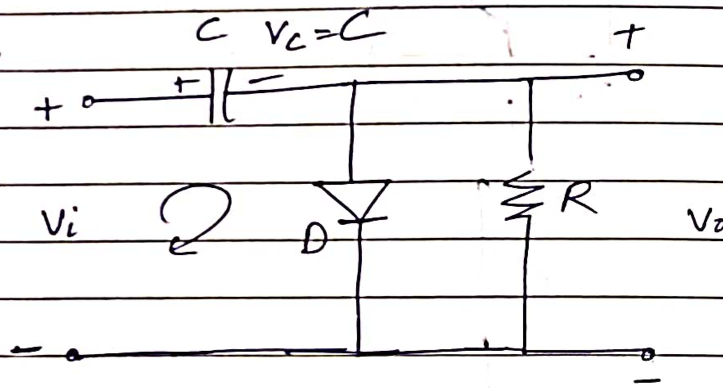
—/—/—

Introduction to Clampers:

Clampers: A clamper is a network constructed of a diode, a resistor and a capacitor that shifts the waveform to a different dc level without changing the appearance of the applied signal.

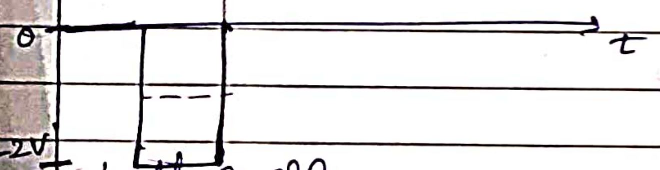
τ (time constant) $= RC$ (Capacitor charges in 5τ)





$\tau \gg \frac{T}{2}$

(Diode off.)



+ve half cycle.

0 to $T/2$ (D F.B)(S.C)

$V_i = +V$

$V_o = 0$

$R = 0$

$\tau = 0$ $\quad \tau = RC$.

$+V_i - V_c = 0$

$\boxed{V_c = V_i = +V}$

for −ve half cycle

$T/2 \rightarrow T$ (D R.B) (O.C)

$V_i = -V$ Now the capacitor is already charge.

$+V_i + V_o + V_c = 0$.

$V_o = -(V_i + V_c)$

$V_o = -(-V + V_c)$

$V_o = -V - V_c$ ($V_c = V$, also)

$V_o = -V - V$

$\boxed{V_o = -2V}$

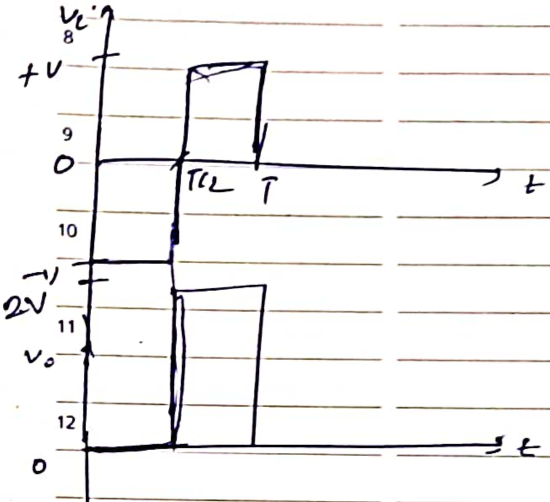
__/__/__

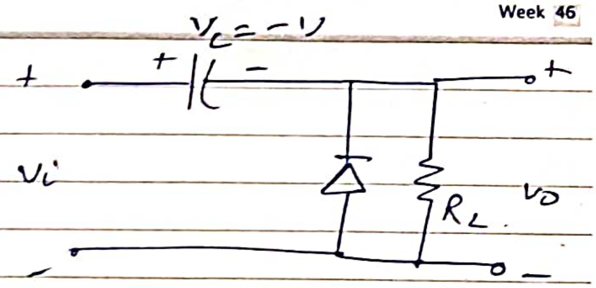
NOTE → 1) rms remains same
2) peak value changes.

Positive & Negative Clamper Circuits :

17 321-044
Friday

Week 46





$0 \to T/2$

$V_i = -V$

$V_o = 0$

$+V_i - V_c = 0$

$\boxed{V_c = V_i = -V}$

$T/2 \to T$

$V_i = +V$

$+V_o + V_c - V_i = 0$

$V_o = V_i - V_c$

$V_o = +V - (-V)$

$\boxed{V_o = 2V}$

~~0 → T/2~~

~~$V_i = -V$ (V_i is +ve)~~

~~$V_o = 0$~~

~~T/2 → T~~

~~$V_i = +V$~~

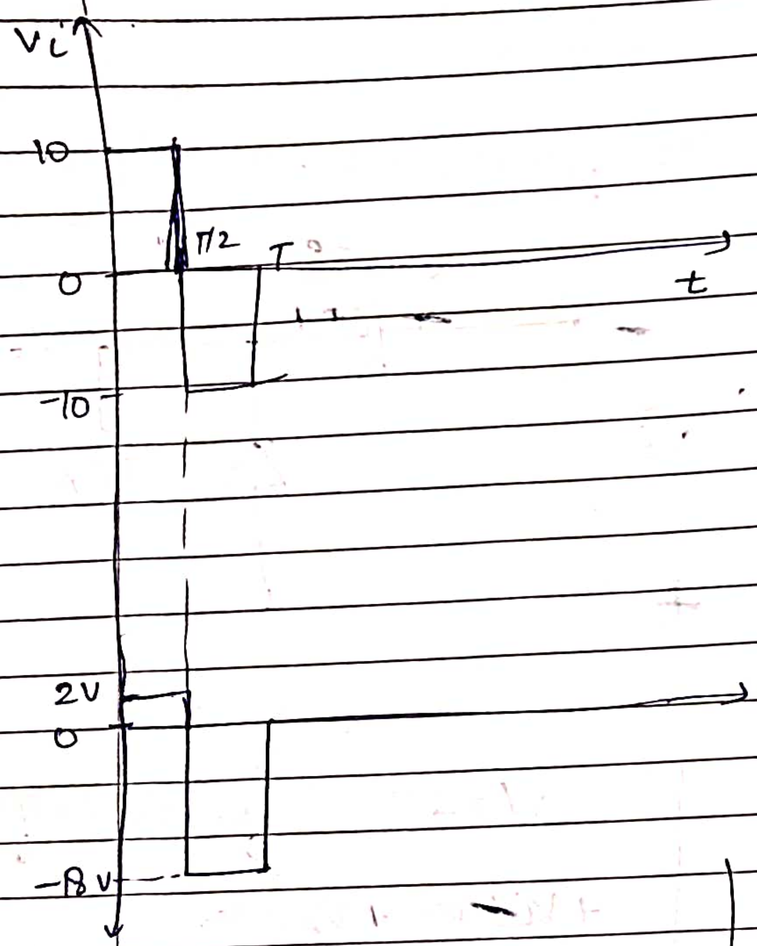
~~$V_o = V_c - V_i$~~

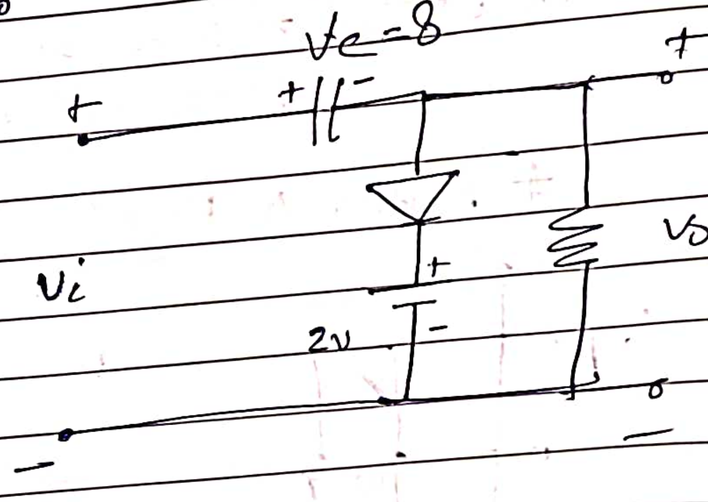
~~$V_o = V - (-V)$~~

~~$\boxed{V_o = 2V}$~~

(Additional Voltage swing)

Biased-Clamper Circuit:





for $0 \to T/2$

$V_i = +10\,V$ (F.B/SC)

$+V_i - V_c - 2 = 0$

$V_c = V_i - 2$

$V_c = 10 - 2$

$\boxed{V_c = 8V}$

$+V_i - V_c - V_o = 0$

$V_o = V_i - V_c$

$V_o = 10 - 8$

$\boxed{V_o = 2V}$

$T/2 \to T$

$V_i = -10V$ (OC)

$+V_i - V_c - V_o = 0$

$V_o = V_i - V_c$

$V_o = -10 - (8)$

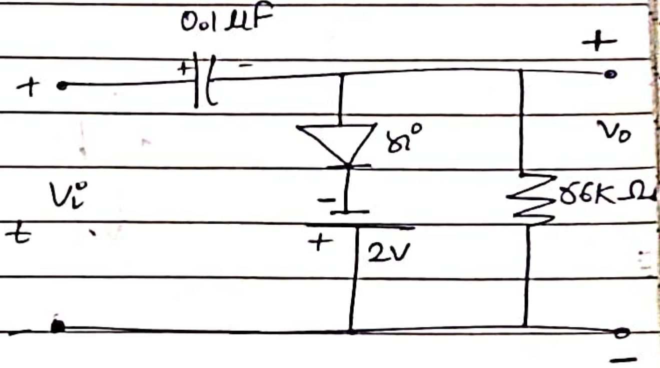
$\boxed{V_o = -18V}$

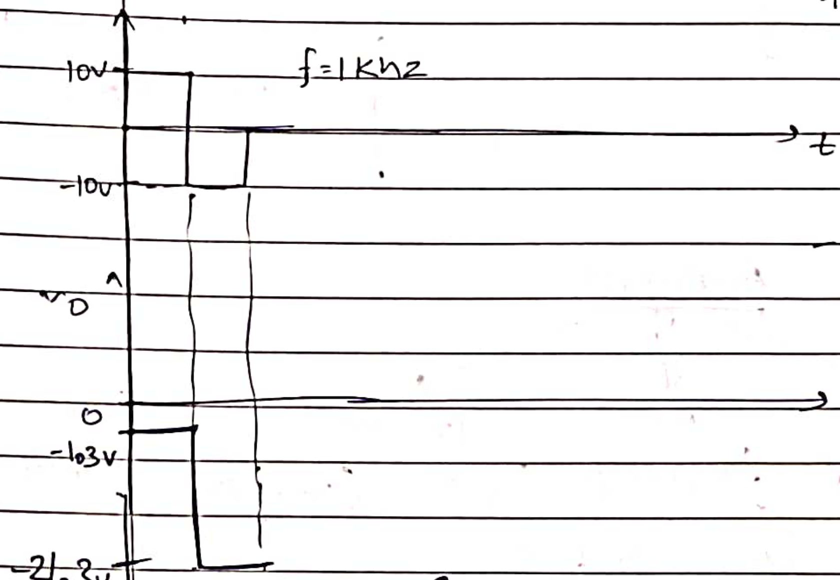
Q For the network in figure:

a) Calculate 5τ.

b) Compare 5τ to half the period of the applied signal

c) sketch V_o





a) $\tau = RC = 56\times10^{3} \times 0.1\times10^{-6} = 5.6\times10^{-3} \Rightarrow 5\tau = 5\times5.6\times10^{-3} = 28\times10^{-3}$

b) $T = \frac{1}{f}\,sec = \frac{1}{1\times10^{3}}\,sec = 10^{-3}\,sec = 1\,ms \quad \frac{T}{2} = 0.5\,msec$

$5\tau >> T/2$

c) +ve half cycle

F.B / S.C

~~$+V_i$~~ $V_i = 10$

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

$V_c - V_i + 2 \Rightarrow$ ~~12~~

$\boxed{V_c = 11.3\,V}$

$+V_i - V_c - V_o = 0$

$V_o = V_i - V_c$

$= 10 - 11.3$

~~$V_o = -20$~~

$\boxed{V_o = -1.3\,V}$

−ve half cycle

~~$V_i = -10$~~

$+V_i - V_c - V_o = 0$

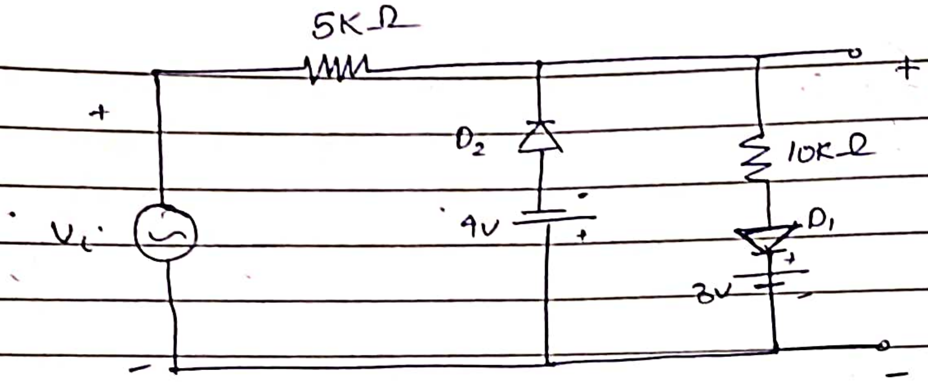
$V_o = V_i - V_c$

$V_o = -10 - 11.3$

~~$V_o = -20$~~

$\boxed{V_o = -21.3\,V}$

Q



(1) For ideal diode. (2) For practical diode (0.7)

(1) <u>For +ve half</u>

$D_2 \to R.B$

$D_1 \to F.B \quad V_i > 3$

$\quad\quad R.B \quad V_i < 3$

<u>$V_i > 3$</u>

D_1 (ON) D_2 (OFF)

~~$V_0 - i10 - 3 = 0$~~

~~$V_0 = i10 + 3$~~

$$V_0 = \frac{V_i - 3}{15K\Omega} \times 10K\Omega + 3$$

$$\boxed{V_0 = \frac{2}{3} V_i + 1}$$

<u>$V_i < 3$</u>

D_1, D_2 (OFF)

$V_0 + V_R - V_i = 0$

$V_0 = V_i - V_R \quad (V_R \simeq 0)$

$V_0 = V_i$

$\boxed{V_0 = V_i}$

<u>For −ve half</u>

$D_1 \to R.B$

$D_2 \to R.B \quad V_i < 4$

$\quad\quad F.B \quad V_i > 4$

<u>$V_i > 4$</u>

D_2 (ON) D_1 (OFF)

$+V_0 + 4 = 0$

$\boxed{V_0 = -4}$

<u>$V_i < 4$</u>

D_1(R.B) D_2(R.B)

$\boxed{V_0 = V_i}$

For practical diode

For +ve half

$D_2 \rightarrow R.B.$

$D_1 \rightarrow$ F.B $V_i > 3$

R.B $V_i < 3$

For −ve half

$D_1 \rightarrow R.B.$

$D_2 \rightarrow$ R.B $V_i < 4$

F.B $V_i > 4$

$\underline{V_i > 3}$

$D_1(F.B)\ D_2(R.B)$

~~$+V_i = i(5) - i(10) - 0.7 - 3 = 0$~~

~~$V_i = 15i + 3.7$~~

$V_0 - i(10) - 3 - 0.7 = 0$

$V_0 = i(10) + 3.7$

$V_0 = \frac{V_i - 3 - 0.7}{15} \times 10 + 3.7$

$V_0 = \frac{2}{3}(V_i - 3.7) + 3.7$

$$\boxed{V_0 = \frac{2}{3}V_i + \frac{3.7}{3}}$$

$\underline{V_i < 3}$

$D_1(RB)\ D_2(R.B)$

$$\boxed{V_0 = V_i}$$

$V_i > 4$

$D_1 \rightarrow R.B\ (OFF)$

$D_2 \rightarrow F.B\ (ON)$

$+V_0 + 0.7 + 4 = 0$

$$\boxed{V_0 = -4.7}$$

$V_i < 4$

$D_1(OFF)\ D_2(OFF)$

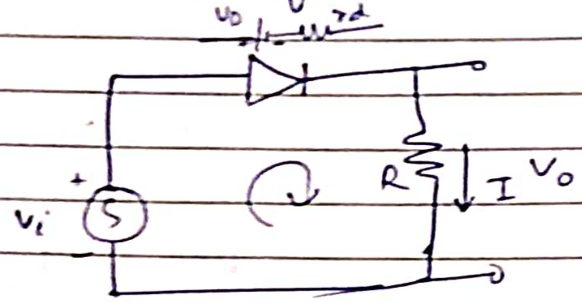
$$\boxed{V_0 = V_i}$$

30/12/2010

Rectifier circuit.

Transform → Rectifier → Filter → Voltage Regulator → Load

Half wave rectifier



for the half

$$+v_i - V_D - I r_d - IR = 0$$

$$I = \left(\frac{V_i - V_D}{r_D + R}\right)$$

$$V_0 = V_R$$

$$V_0 = IR = \left(\frac{V_i - V_D}{r_D + R}\right) R$$

$$\Rightarrow \quad V_0 = \left(\frac{R}{r_D + R}\right) v_i - \left(\frac{R}{r_D + R}\right) V_D$$

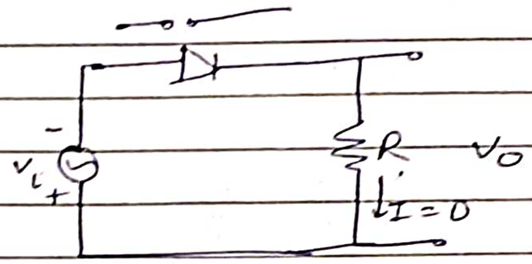
$$r_D << R$$

$$\Rightarrow \quad \boxed{V_0 = V_i - V_D}$$

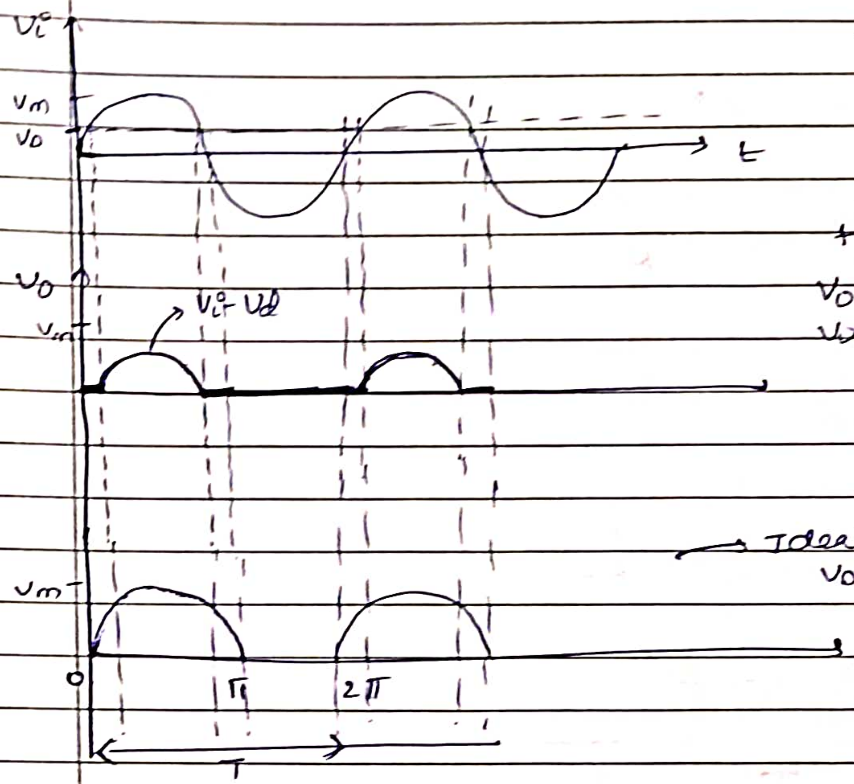
$V_D = 0.7V \rightarrow Si$
$= 0.3V - Ge$

_/_/_

for -ve half



$\boxed{V_0 = 0}$



$V_0 = V_i - V_D$

$V_i < V_D$ (OFF)

+ve

$V_0 = 0$ ~~$V_i < V_D$~~

~~$V_0 = V_i - V_D$ $V_i > V_D$~~

-ve

$V_0 = 0$

→ Ideal model.

$V_0 = 0$.

$V_0 = V_i$ — +ve half

$V_0 = 0$ → -ve half.

* Avg. O/P voltage $\quad \omega t - (0 \to \pi) \quad V_0 = V_m \sin\omega t$

$\omega t - (\pi \to 2\pi) \quad V_0 = 0$

$$V_{av} = \frac{\int_0^{2\pi} V_0 \, d(\omega t)}{2\pi - 0} \Rightarrow \frac{1}{2\pi}\left[\int_0^{\pi} V_m \sin\omega t \, d\omega t + \int_{\pi}^{2\pi} 0 \, d(\omega t)\right]$$

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

$$\Rightarrow \frac{V_m}{2\pi}\left[-\cos\omega t\right]_0^{\pi} \Rightarrow \frac{V_m}{2\pi}\left[-\cos\pi - (-\cos 0)\right]$$

$$\Rightarrow \frac{V_m}{2\pi} \times 2$$

$$V_{avg} = \frac{V_m}{\pi} = 0.318\ V_m$$

$$\boxed{V_{avg} = 0.318\,V_m}$$

* Av. Load Current:

$$I_{av} = \frac{V_{av}}{R} = \frac{V_m/\pi}{R}$$

$$I_{av} = \frac{V_m}{\pi R} = \frac{I_m}{\pi}$$

$$\boxed{I_{avg} = 0.318\ \pi}$$

* RMS Load Current

$$I_{rms} = \sqrt{\frac{\int_0^{2\pi} I^2\, d(\omega t)}{\int_0^{2\pi} d(\omega t)}}$$

$$\Rightarrow \sqrt{\frac{1}{2\pi}\int_0^{2\pi} I^2\, d(\omega t)}$$

$$\Rightarrow \left[\frac{1}{2\pi}\left(\int_0^{\pi} I_m^2 \sin^2\omega t\, d(\omega t) + \cancel{\int_{\pi}^{2\pi} 0\, d\omega t}^{\,0}\right)\right]^{1/2}$$

$I = I_m \sin\omega t \quad 0 < \omega t < \pi$

$I_0 = 0 \quad \pi < \omega t < 2\pi$

RMS value is equivalent to DC current.
lamp connected to 5 V rms & 5 V DC shines same brightness

$$\Rightarrow \left[\frac{1}{2\pi}\int_0^{\pi} I_m^2 \sin^2\omega t\, d(\omega t)\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[\frac{I_m^2}{2\pi}\int_0^{\pi} \frac{1-\cos(2\omega t)}{2} d(\omega t)\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[\frac{I_m^2}{4\pi}\left(\omega t - \frac{\sin 2\omega t}{2}\right)_0^{\pi}\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[\frac{I_m^2}{4\pi}((\pi - 0) - 0)\right]^{\frac{1}{2}}$$

$$\Rightarrow \left(\frac{I_m^2}{4}\right)^{\frac{1}{2}} = \frac{I_m}{2}$$

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

$$V_{rms} = I_{rms} R$$

$$V_{rms} = \frac{I_m}{2} R$$

$$V_{rms} = \frac{(I_m R)}{2}$$

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

$$\gamma = \frac{\text{rms value of AC component of output}}{\text{avg value of output}}$$

$I = I_{AC} + I_{DC} \Rightarrow I_{AC} = I - I_{DC}$

$$I_{AC\,rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} I_{ac}^2 \, d(\omega t)}$$

$$= \left[\frac{1}{2\pi}\int_0^{2\pi} (I - I_{dc})^2 \, d(\omega t)\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[\frac{1}{2\pi}\int_0^{2\pi} (I^2 + I_{dc}^2 - 2 I I_{dc}) \, d\omega t\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[\underbrace{\frac{1}{2\pi}\int_0^{2\pi} I^2 \, d\omega t}_{(I_{rms})^2} + \frac{1}{2\pi}\int_0^{2\pi} I_{dc}^2 \, d(\omega t) - \frac{1}{2\pi} \times 2\int_0^{2\pi} I I_{dc} \, d\omega t\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[I_{rms}^2 + \frac{I_{dc}^2 (2\pi - 0)}{2\pi} - 2I_{dc}^2\right]^{\frac{1}{2}}.$$

$$\Rightarrow \left[I_{rms}^2 - I_{dc}^2\right]^{\frac{1}{2}}$$

$$\gamma = \frac{\left(I_{rms}^2 - I_{dc}^2\right)^{\frac{1}{2}}}{I_{dc}} \Rightarrow \left[\frac{I_{rms}^2 - I_{dc}^2}{I_{dc}^2}\right]^{\frac{1}{2}}.$$

$$\gamma = \left[\frac{I_{rms}^2}{I_{dc}^2} - 1\right]^{\frac{1}{2}}$$

$$\boxed{\gamma = \sqrt{(F.F)^2 - 1}} \qquad \gamma\% = \sqrt{(F.F)^2 - 1} \times 100$$

for $f.f = 1.57$ $\boxed{\gamma\% = 121\%}$

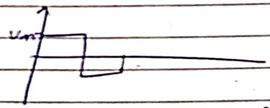
Form factor: defined as the ratio of rms load voltage and average load voltage.

$\left(\begin{matrix} F.F \geq 1 \\ V_{rms} \geq V_{av} \end{matrix}\right)$

$$F.F = \frac{V_{rms}}{V_{avg}}$$

For half wave rectifier:

$$F.F = \frac{V_m/2}{V_m/\pi} = \frac{\pi}{2} = 1.57 > 1$$



$V_{rms} = V_m$ $\quad f.f = \frac{V_m}{V_{av}} = 1.$

$V_{av} = V_m$

$$\boxed{V_{rms} = 1.57\, V_{avg}}$$

Ripple factor: The output current contain both AC & DC components. The ripple factor measures the percentage of ac component in the rectified output.

$\gamma = 0.$ (ideally)

ac comp $= 0 \Rightarrow \gamma = 0$

OR $I_{rms}^2 = I_{AC}^2 + I_{DC}^2$.

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

$$= \sqrt{f.F^2 - 1}.$$

$$= 1.21$$

(Diff b/w styles of rectifier)

Efficiency: ratio of dc power available at the load to the input ac power.

$$\eta\% = \frac{P_{LOAD}}{P_{in}} \times 100\%$$

$P = VI$

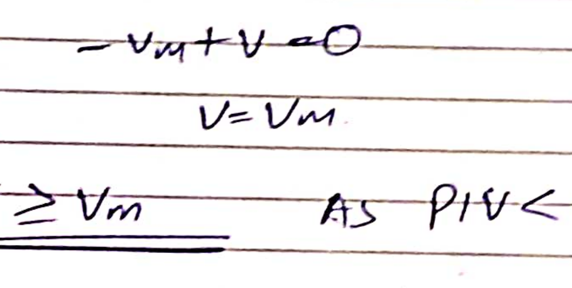
$P = I^2 R$

$$= \frac{I_{dc}^2 \times R}{I_{rms}^2 \times R} \times 100\%$$

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

$$\boxed{\eta\% = 40.56\%}$$

Peak Inverse Voltage: (PIV) Maximum reverse bias voltage that can be applied across the diode before entering to the zener or breakdown region.



$V_o = 0$

$$-V_m + V = 0$$

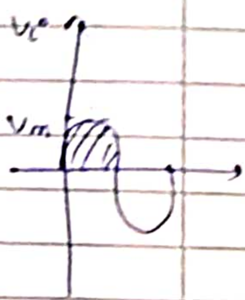
$$V = V_m$$

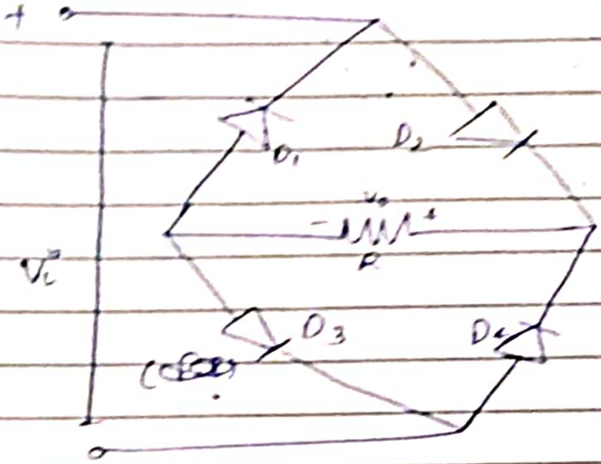
$PIV \geq V_m$ As $PIV < V_m$ (damage occur)

To protect from damage.

01/12/2020

Full wave - Bridge rectifier





for +ve half

$D_2, D_3 \rightarrow$ ON
$D_1, D_4 \rightarrow$ OFF

$+V_i - V_o = 0$

$\boxed{V_0 = V_i}$ → ideal

$\boxed{V_0 = V_i - 2V_f}$ for (UD)

$\boxed{V_0 = V_i - 2V_f - 2Ir_d}$ → real

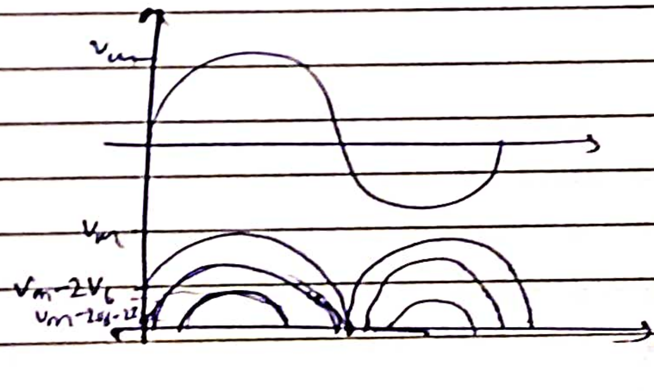
for -ve half

$D_2, D_3 \rightarrow$ OFF
$D_1, D_4 \rightarrow$ ON

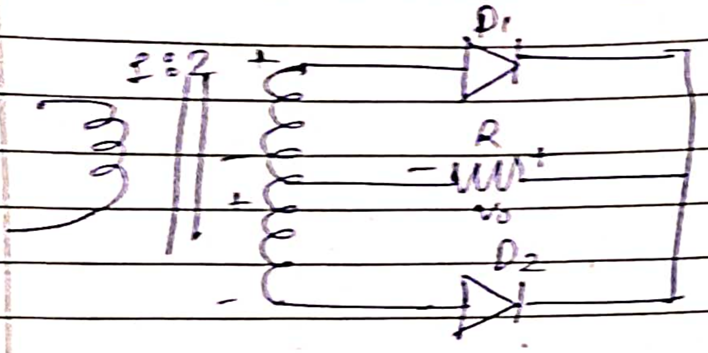
$\boxed{V_0 = V_i}$

$\boxed{V_0 = V_i - 2V_f - 2Ir_d}$

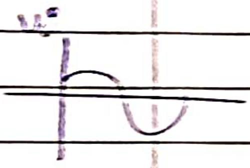
Current flowing in same direction
No polarity change at load



Full wave - Center taped rectifier



$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$



for +ve half cycle

$D_1 \to ON$ $D_2 \to OFF$

$+V_i - V_0 = 0$

$\boxed{V_0 = V_i}$

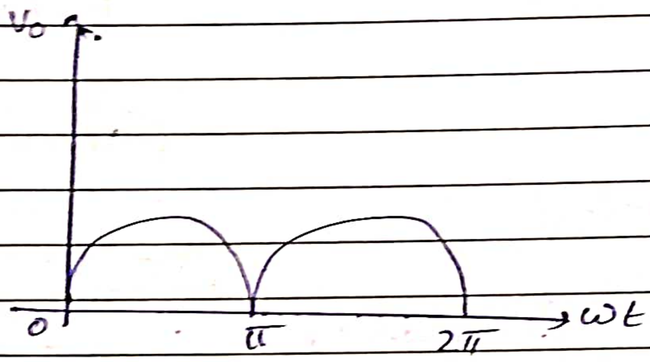
for -ve half cycle

$D_1 \to OFF$ $D_2 \to ON$

$+V_i - V_0 = 0$

$\boxed{V_0 = V_i}$

Current in same sense



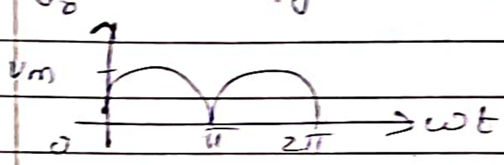
Full wave rectifier

Av. load current & Av load ~~current~~ Voltage.

As we studied earlier the output volt. & curr are same for both center tap & bridge full wave

So, the results for av I & V will be same for both

Av. (dc) voltage:



$V_0 = V_m \sin \omega t \quad 0 \le \omega t \le \pi$

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

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

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

Av load current:

$$I_{av} = \frac{V_{av}}{R} \Rightarrow \frac{2V_m}{\pi R}$$

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

$$\boxed{V_{full\,wave} = 2\,V_{half\,wave}}$$

In H.W.R

$$V_{av} = \frac{V_m}{\pi}$$

$$I_{av} = \frac{I_m}{\pi}$$

RMS LOAD Current.

I = load current

$I = I_m \sin\omega t \quad 0 \leq \omega t \leq \pi$

$$I_{rms} = \left[\frac{1}{\pi}\int_0^{\pi} I^2 d(\omega t)\right]^{\frac{1}{2}}$$

$$= \left[\frac{1}{\pi}\int_0^{\pi} I^2_{rms} \sin^2\omega t \, d(\omega t)\right]^{\frac{1}{2}}$$

$$= \left[\frac{I^2_{rms}}{\pi}\int_0^{\pi} \frac{1-\cos(2\omega t)}{2} d(\omega t)\right]^{\frac{1}{2}}$$

$$\Rightarrow \frac{I^2_{rms}}{2\pi}\left[(\pi-0) - 0\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[\frac{I^2_{rms}}{2}\right]^{\frac{1}{2}}$$

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

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

$$= \frac{I_m}{\sqrt{2}} \times R$$

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

__/__/__

Form factor :

$$F.f = \frac{V_{rms}}{V_{av}} \text{ or } \frac{I_{rms}}{I_{av}}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} \qquad V_{av} = \frac{2V_m}{\pi}.$$

$$\boxed{F.F = \frac{\pi}{2\sqrt{2}} = 1.11}$$

Ripple Factor :

ideally $\gamma = 0 \Rightarrow ac = 0$.

$$\gamma = \sqrt{F.f^2 - 1}$$

$$\gamma_\% = \sqrt{(1.11)^2 - 1} \times 100$$

$$\boxed{\gamma\% = 48.1\%}$$

ac-component

when in H.W.R it was 121%

Hence we have reduced A-C component.

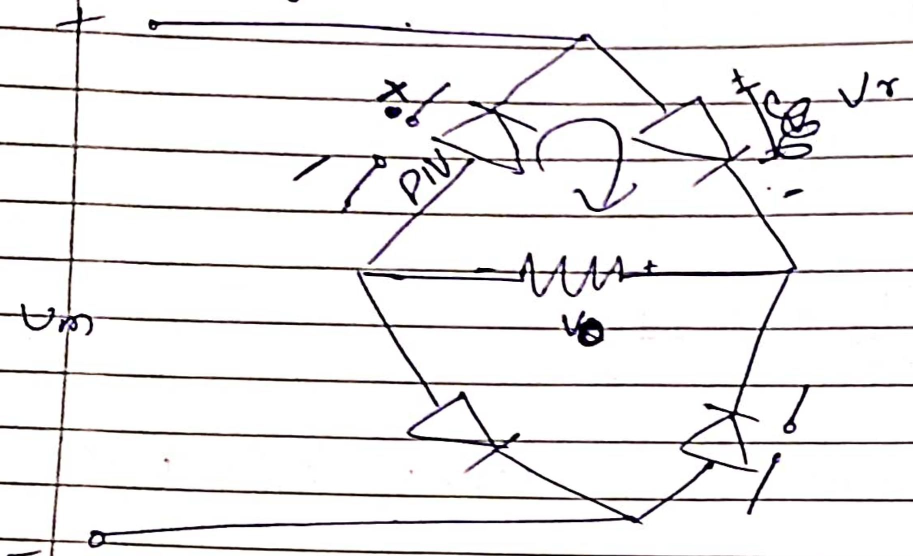
Efficiency

$$\eta\% = \frac{P_{dc}}{P_{rms}} \times 100\% \, , = \frac{I^2_{dc} \times R}{I^2_{rms} \times R} \times 100$$

$$\rightarrow \left(\frac{\frac{2I_m}{\pi}}{\frac{I_m}{\sqrt{2}}} \right)^2 \times 100 = \boxed{81.13\%} \rightarrow F.W.R.$$

PIV

① Bridge



$+V_m - V_0 = 0$ $\qquad$ $-V_0 + PIV = 0$

$\boxed{V_0 = V_m}$ $\qquad$ $\boxed{PIV = V_m}$

$\boxed{PIV \geq V_m}$

For Real diode

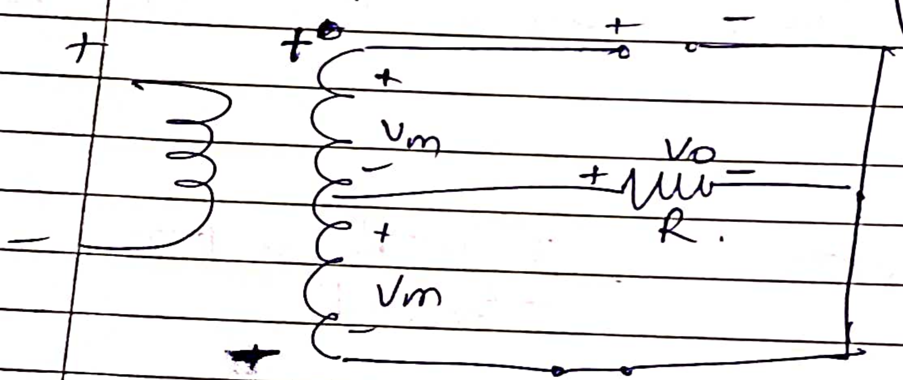
$-V_0 + PIV - V_\gamma = 0$

$\boxed{PIV \geq V_0 + V_\gamma}$

$PIV \geq (V_m - 2V_\gamma) + V_\gamma$

$\boxed{PIV \geq V_m - V_\gamma}$

② Center tap



$+V_m - V_0 = 0$

$\boxed{V_0 = V_m}$

$+V_m - PIV + V_0 = 0$

$PIV = 2V_m$

$\boxed{PIV \geq 2V_m}$

For real

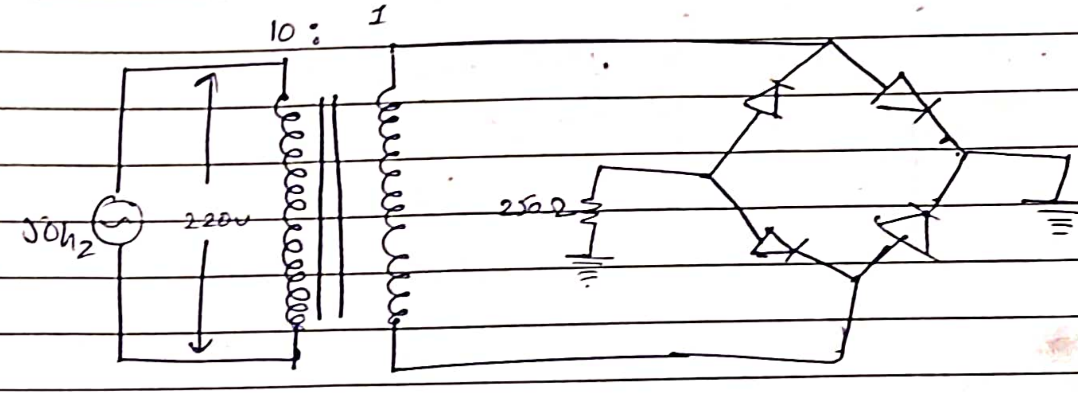
$\boxed{PIV = V_m + V_0}$

$PIV = V_m + V_m - V_\gamma$

$\boxed{PIV = 2V_m - V_\gamma}$

Hence we rarely use Center tap F.W.R

Q a) DC output voltage (V_{dc}/V_{av}) b) Rectification efficiency ($\eta\%$)
c) Peak inverse Voltage (PIV) d) Output frequency (f_o)



$f_{in} = 50Hz$

$\frac{N_P}{N_S} = \frac{10}{1} = \frac{V_P}{V_S}$ $\quad V_S = \frac{V_P}{10}$ $\Rightarrow \boxed{V_S = \frac{220}{10} = 22V} = V_i = V_{rms}$

(a) $V_{av} = \frac{2V_m}{\pi} \Rightarrow \frac{2 \times V_m}{\pi}$ $\quad$ (As, $V_{rms} = \frac{V_m}{\sqrt{2}}$, $V_m = \sqrt{2}V_{rms}$ $= \sqrt{2} \times V_{in}$)

$\Rightarrow \frac{2 \times \sqrt{2} \times V_{in}}{\pi}$

$\Rightarrow \frac{2\sqrt{2}}{\pi} \times V_{rms} = \frac{2\sqrt{2}}{\pi} \times 22 = 19.81V$.

(b) $= \frac{P_{out}}{P_{in}} = \frac{I_{dc}^2}{I_{rms}^2}$

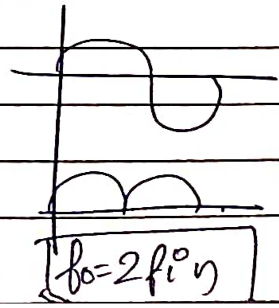
$\Rightarrow \left(\frac{\frac{2I_m}{\pi}}{\frac{I_m}{\sqrt{2}}}\right)^2 \Rightarrow \left(\frac{2\sqrt{2}}{\pi}\right)^2 = \frac{8}{\pi^2}$

(c) $PIV \geq V_m$

$\geq \sqrt{2} \times 22$

PIV $\Rightarrow$ 31.11 Volts.

d)



$f_1 = \frac{1}{T}$ $\quad T = \frac{1}{f}$

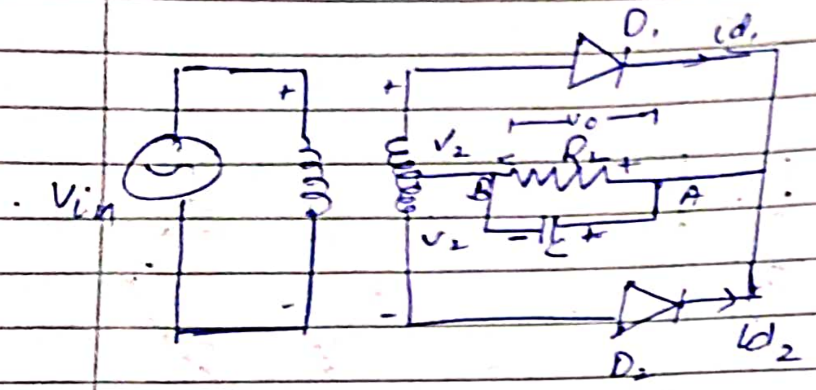
$T' = \frac{T}{2}$

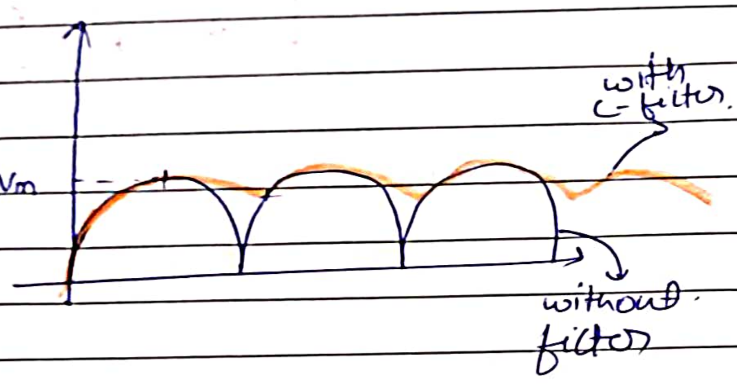
$T = 2T'$

$\frac{1}{f_{in}} = 2 \times \frac{1}{f_o}$

$\boxed{f_o = 2f_{in}}$

FULL WAVE RECTIFIER WITH CAPACITOR FILTER:





C → charge $V_i > V_C$

discharge $V_i < V_C$

Now we have to again pass the filter through voltage regulator to get dc-voltage.