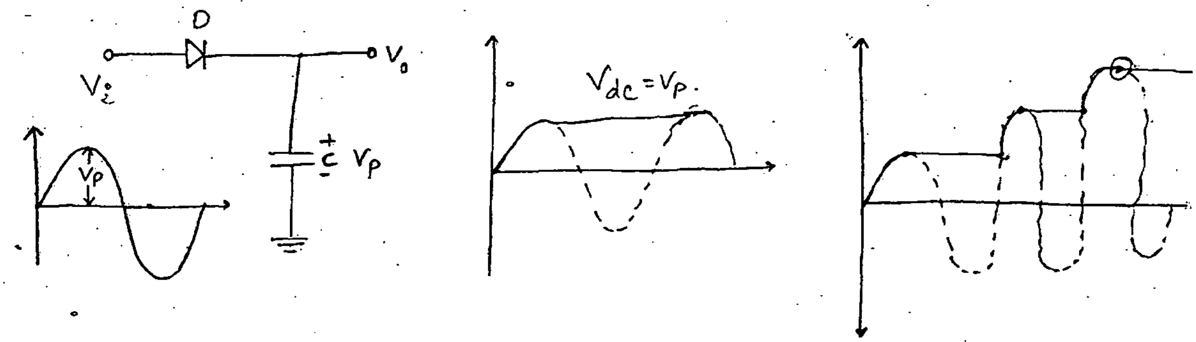
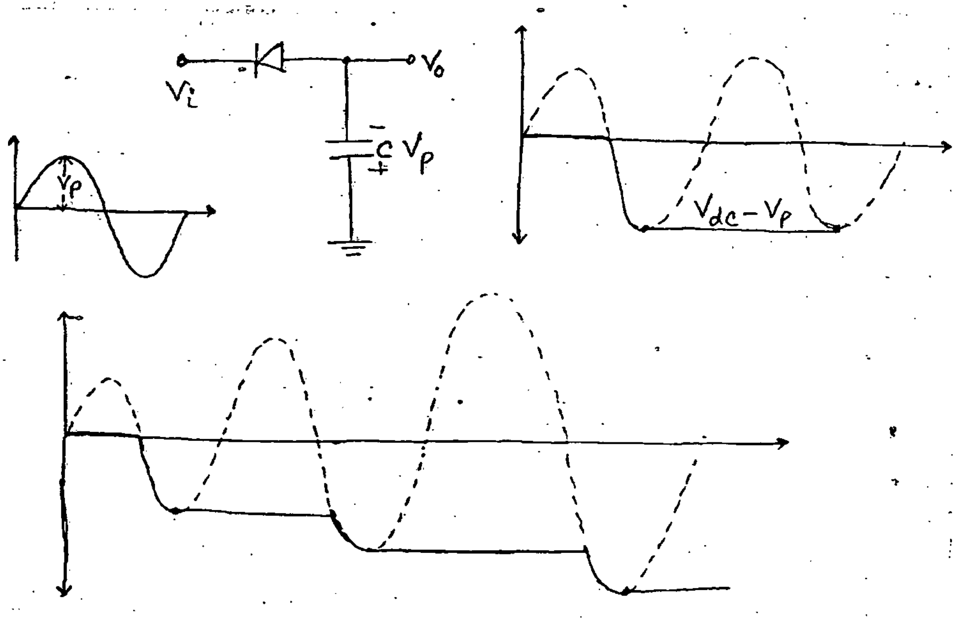
# PEAK DETECTOR, CLAMPER AND VOLTAGE MULTIPLIER

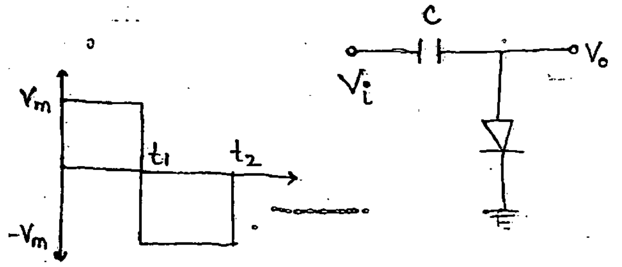
POSITIVE PEAK DETECTOR.



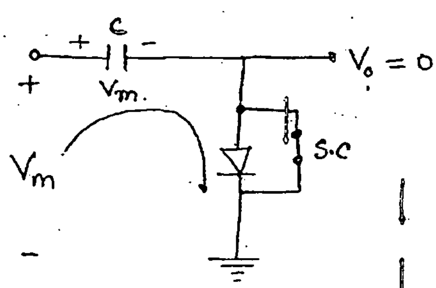

NEGATIVE PEAK DETECTOR.



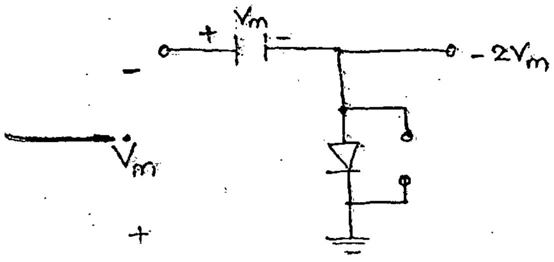

CLAMPLER NEGATIVE

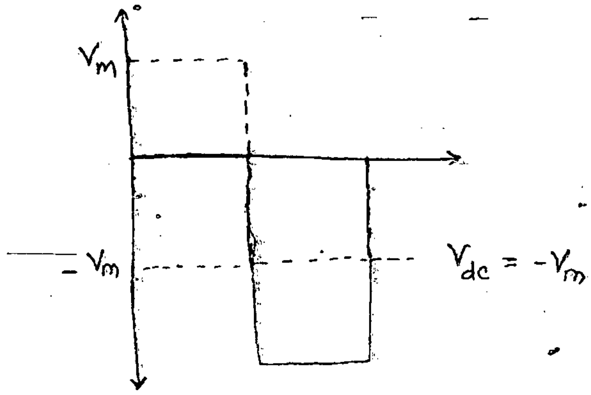



caseI: 0 to $t_1$.

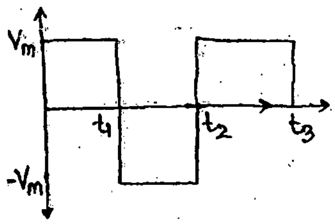


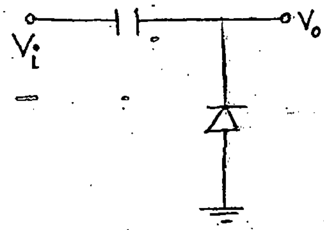
case II :- $t_1$ to $t_2$



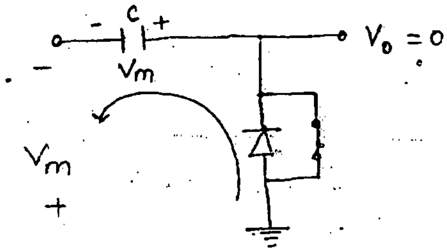




POSITIVE CLAMPER.

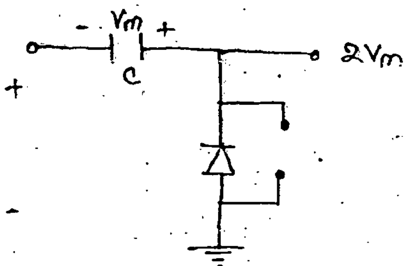


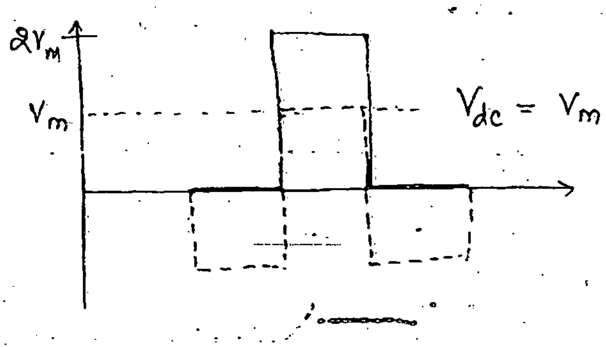




case I :- $t_1$ to $t_2$.




case II :- $t_2$ to $t_3$.



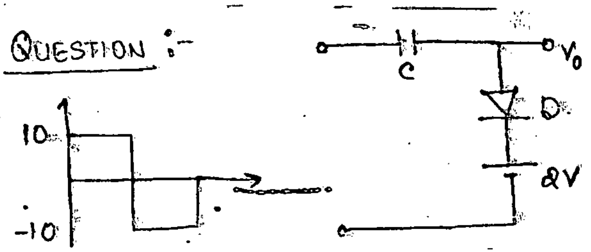




NOTE :→ During 0 to $t_1$ capacitor will charge $V_m$ only ∴ 0 to $t_1$ it is neglected.

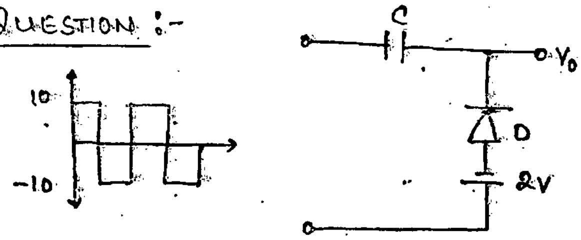
TECHNIQUE'S IN CLAMPERS

* When the diode is in downward direction the total s/g will be clamped below the reference voltage.
* When the diode is in upward direction the total s/g will be clamped above the reference voltage.

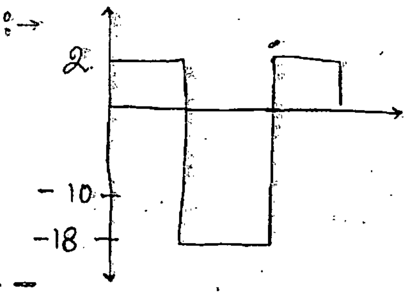
QUESTION :-



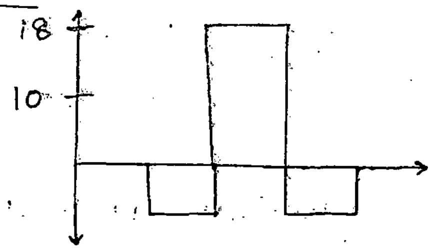

QUESTION :-




SOLUTION :→

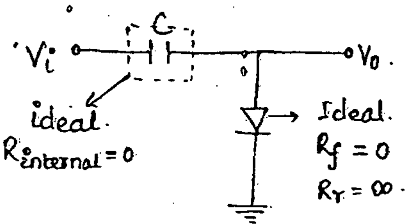


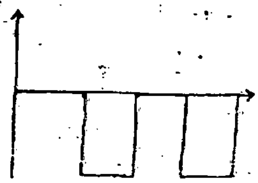

SOLUTION :→



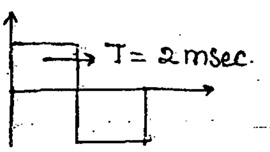

## ☐ PRACTICAL CLAMPER DESIGN.

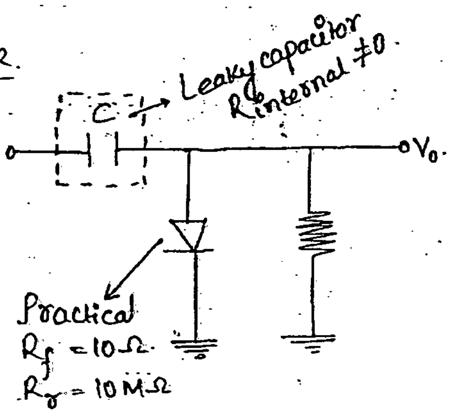
IDEAL CLAMPER.



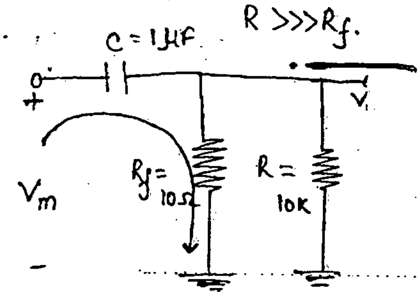



PRACTICAL CLAMPER.



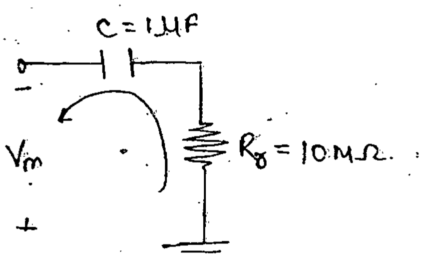



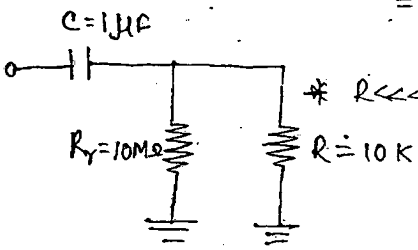

0 to $t_1$




Time constant $= C \times R_f \| R$.
$= C \times R_f = 1\mu F \times 10\Omega$
$= 10\mu sec.$

$t_1$ to $t_2$




* $R <<< R_r$

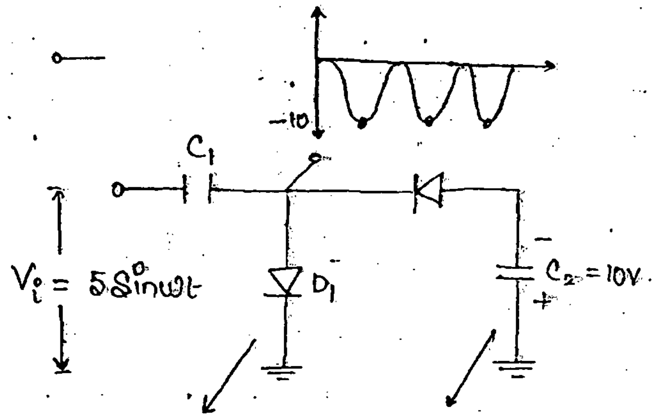
$T_R = C \times R_r \| R$
$= C \times R$
$= 1\mu F \times 10 \times 10^3$
$= 10 msec$

$T_{R_r} = C \times R_r$
$= 1\mu F \times 10 \times 10^6 = 10 Sec.$

*. Geometric Mean, $C = \sqrt{ab}$

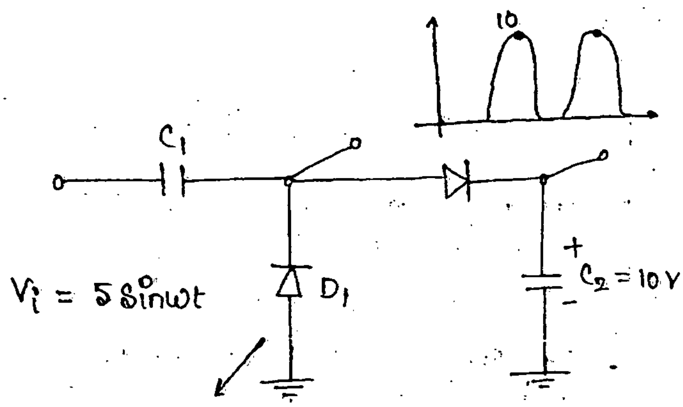
$R = \sqrt{R_f R_r} = \sqrt{10 \times 10 \times 10^6} = 10K\Omega.$

## (-)VE VOLTAGE MULTIPLIER.




Negative clamper + Negative peak detector = Negative Voltage multiplier

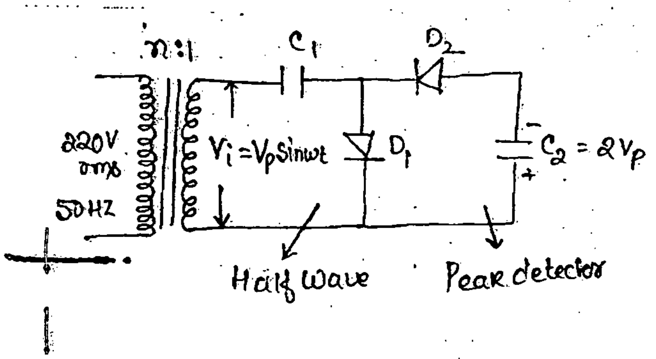
## POSITIVE VOLTAGE MULTIPLIER.



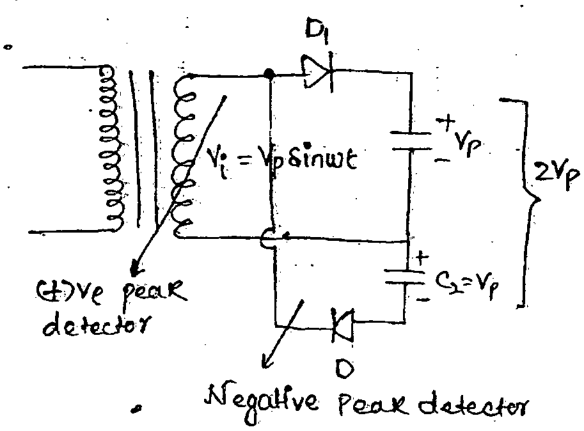

Positive Clamper + Positive peak detector = Positive Voltage Multiplier

## ☐ RECTIFIER.

### HALF WAVE VOLTAGE DOUBLER

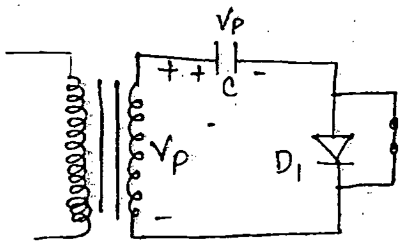



### FULL WAVE VOLTAGE DOUBLER

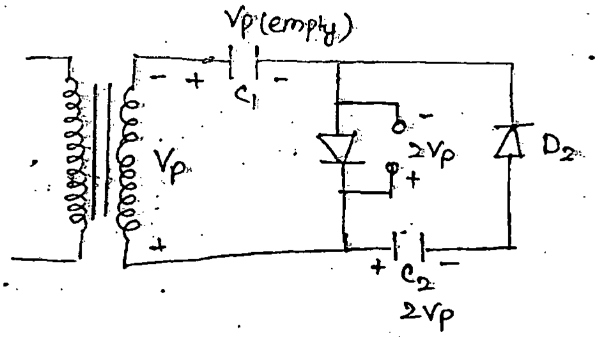


Ques:→ Design a voltage multiplier ckt which genrates $n$ multiples of DC.

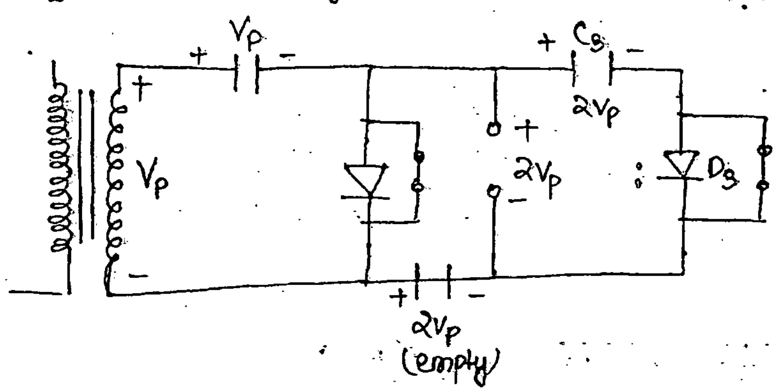
Sol$^n$ :→ Step 1 :- 1$^{st}$ cycle (+)ve half.




Step 2 :- 1$^{st}$ cycle (-)ve half

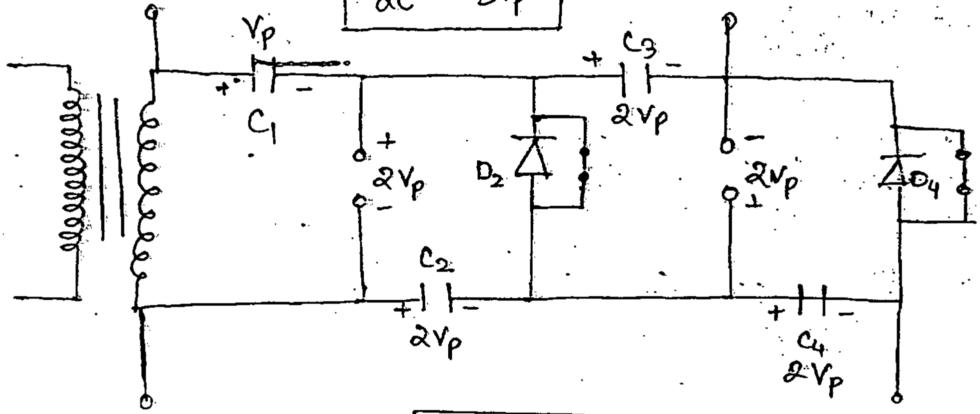



Step 3 :- 2$^{nd}$ cycle (+)ve half.



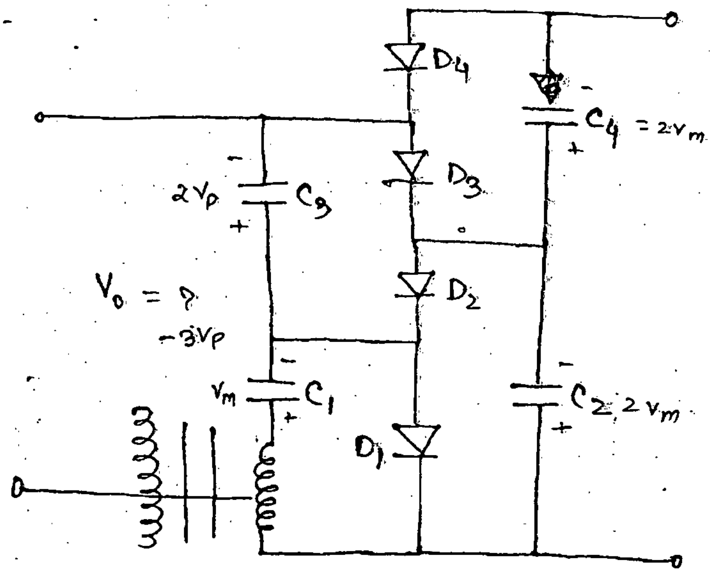

STEP 4 :- 2$^{nd}$ cycle (-)ve half

$\boxed{V_{dc} = 3V_p}$




$\boxed{V_{dc} = 4V_p}$

QUESTION :-




$V_0 = ?$

$= -4V_p$

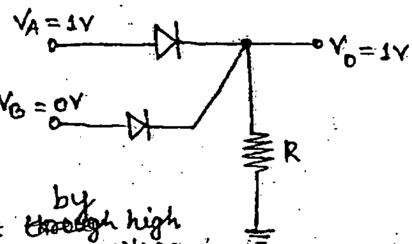
SOLUTION :->

## ☐ DIGITAL LOGIC GATE

OR LOGIC

$A + B = C$

| A | B | C |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

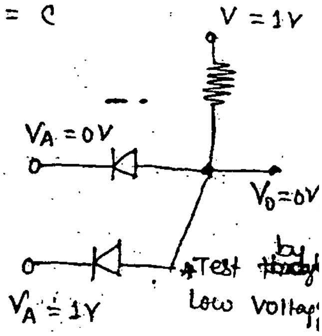



*Test ~~through~~ by high voltage

AND LOGIC

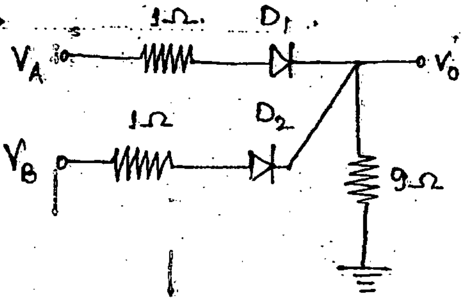
$A \cdot B = C$

| A | B | C |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |



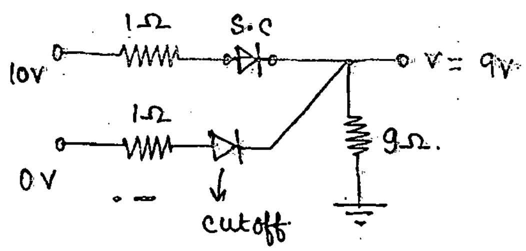

*Test ~~through~~ by Low Voltage

QUESTION :->

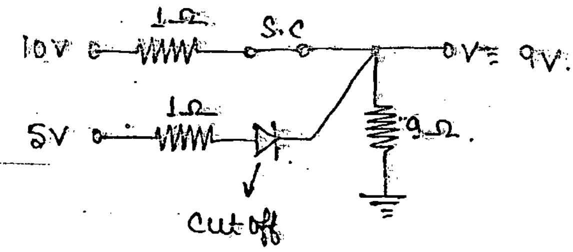



SOLUTION :->

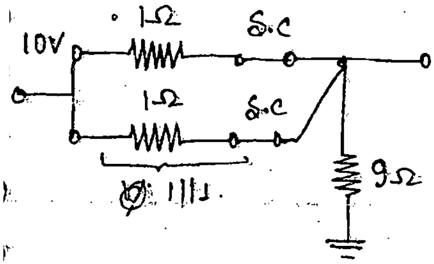
Case I :- $V_A = 10V$ , $V_B = 0V$.




Case II :- $V_A = 10V$, $V_B = 5V$.

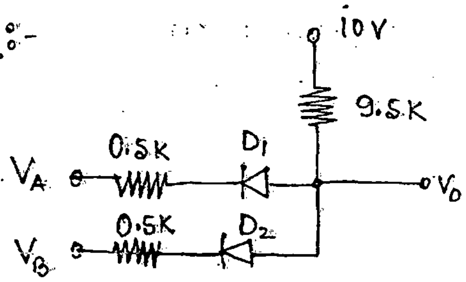



Case III :- $V_A = 10V, V_B = 10V$



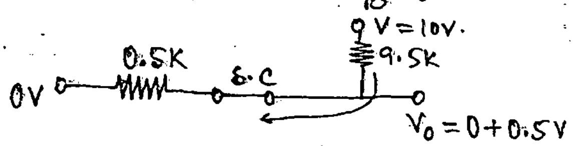

$$V_0 = 10 \times \frac{9}{9.5} = 9.47V$$

QUESTION :-




SOLUTION :-

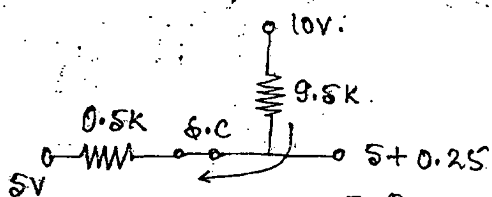
Case I :- $V_A = 10V$ , $V_B = 0V$.




$V_0 = 0 + 0.5V$

$= 0.5V$.

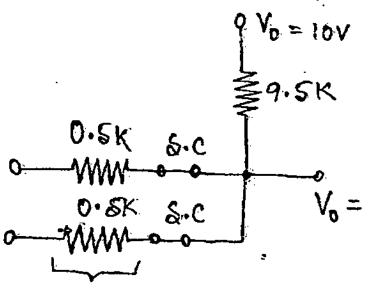
Case II :- $V_A = 10V$ , $V_B = 5V$




$5 + 0.25$

$= 5.25V$.

Case III :- $V_A = 0$ , $V_B = 0$.

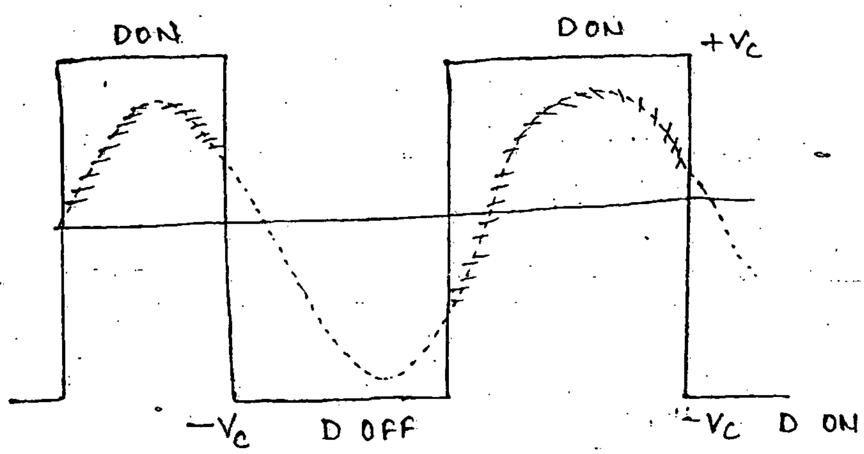


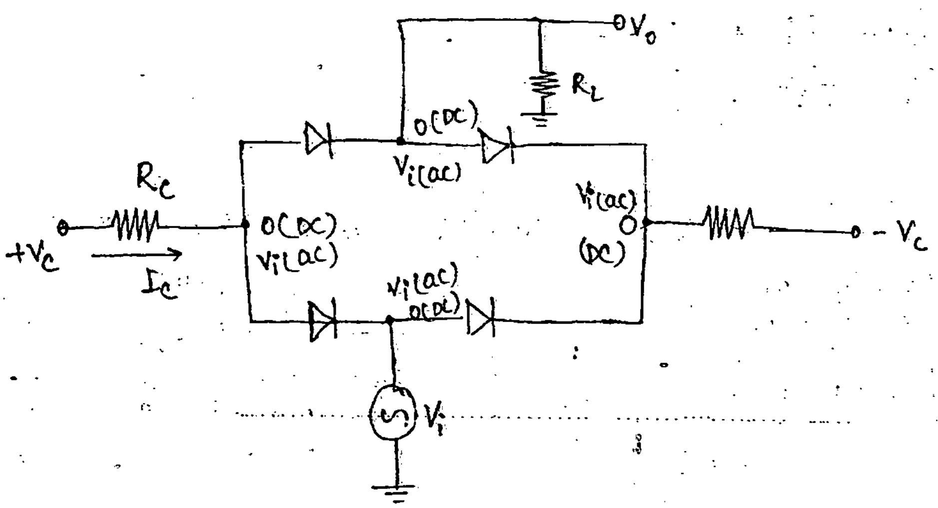

$V_0 = 0.256V$

TECHNIQUES IN DIGITAL LOGIC GATE.

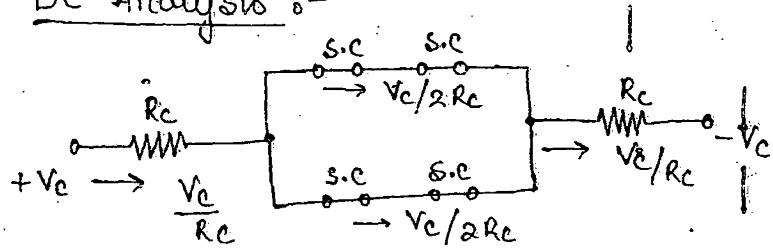
* For OR logic gate we have to test with high input.
* For AND logic gate we have to test with low input.

## ☐ ANALOG GATE / SAMPLING GATE

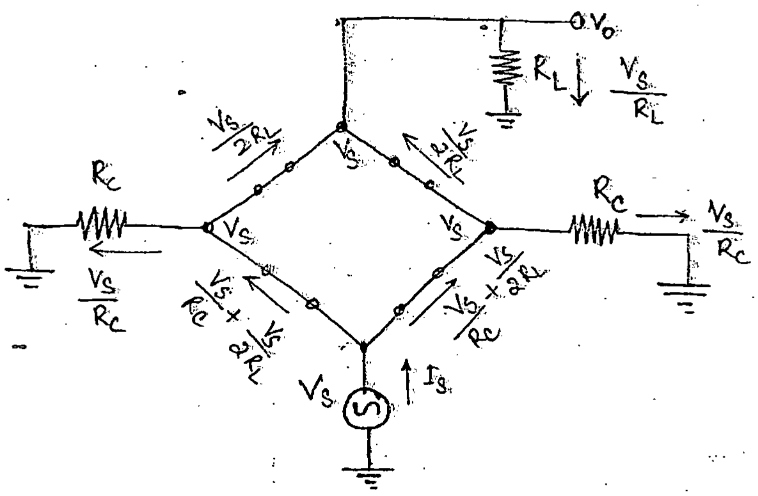


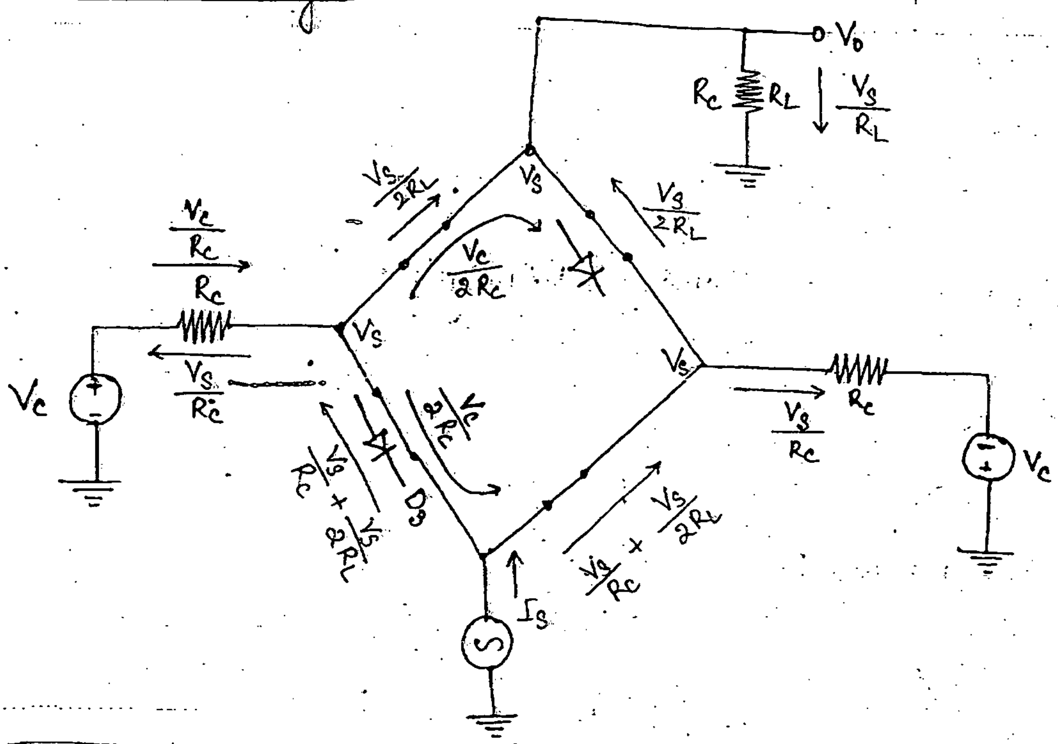

DC Analysis :-



## AC Analysis




## DC + AC Analysis




$\boxed{V_c > 2R_c\left[\frac{1}{R_c}+\frac{1}{2R_c}\right]V_s}$ * condition for $D_3$ switch to be "ON".

$\boxed{V_c > 3V_s.}$

$$\frac{V_c}{2R_c} > \frac{V_s}{R_c} + \frac{V_s}{2R_L}$$

$$V_c > 2R_c\left[\frac{1}{R_c}+\frac{1}{2R_L}\right]V_s$$

$R_L = R_c.$

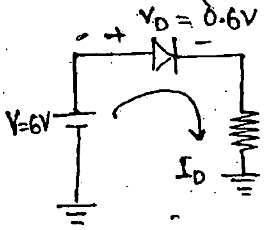
# SMALL SIGNAL ANALYSIS OF A DIODE.

DIODE RESISTANCE

→ STATIC RESISTANCE

→ DYNAMIC RESISTANCE

**STATIC RESISTANCE**




$I_D = \frac{V - V_D}{R_L}$

$= \frac{6 - 0.6}{1k\Omega}$

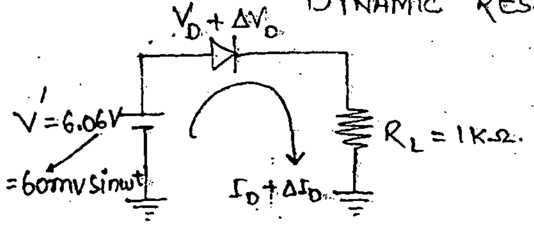
$= 5.4mA$

$\boxed{R_D = \frac{V_D}{I_D}}$ → DC Resistance

$R_D = \frac{0.6V}{5.4mA}$

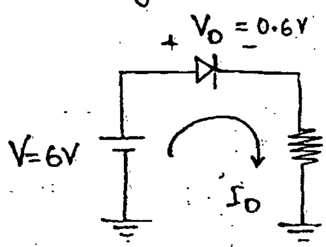
$R_D = 111\Omega$

**DYNAMIC RESISTANCE**




$\boxed{\gamma_D = \frac{\Delta V_D}{\Delta I_D}}$ → AC resistance.

## Analysis of Static Resistance :-




**Mathematical Analysis :-**

$I_D = \frac{V - V_D}{R_L} = \frac{6 - 0.6}{1k\Omega} = 5.4\,mA.$

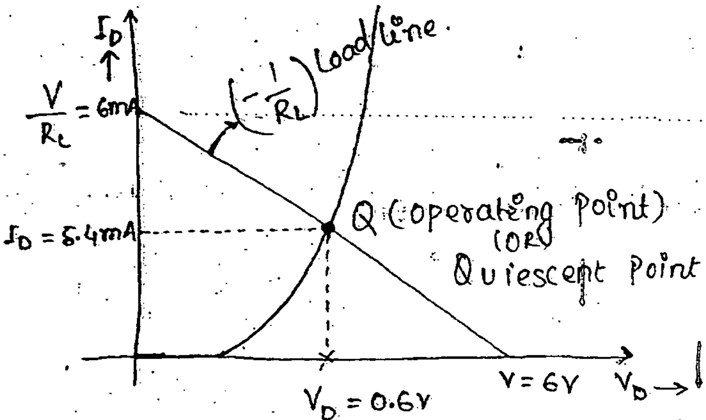
## GRAPHICAL METHOD :-

$I_D = \frac{V - V_D}{R_L}$

$I_D = \left(-\frac{1}{R_L}\right) V_D + \frac{V}{R_L}$

$\downarrow \quad\quad \downarrow \quad\quad \downarrow$

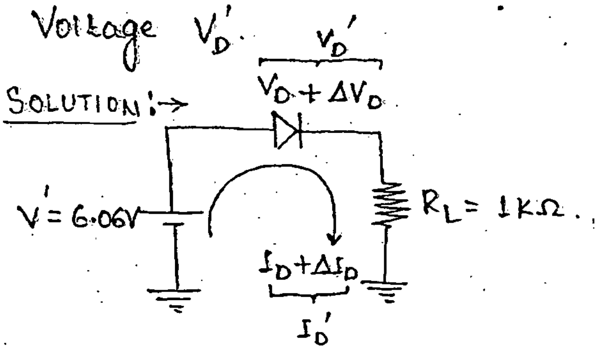
$y \quad = \quad m \quad x \quad + \quad c$




$R_D = \frac{V_D}{I_D} = \frac{0.6}{5.4mA} = 111\Omega.$

QUESTION :- Suppose there is a small variation in ac suppl ($V_i$ = 60 mV $\sin\omega t$). The DC voltage $V = 6V$ changed to $V' = 6.06\,V$. Calculate new diode current $I_D'$ and diode voltage $V_D'$.

SOLUTION :→

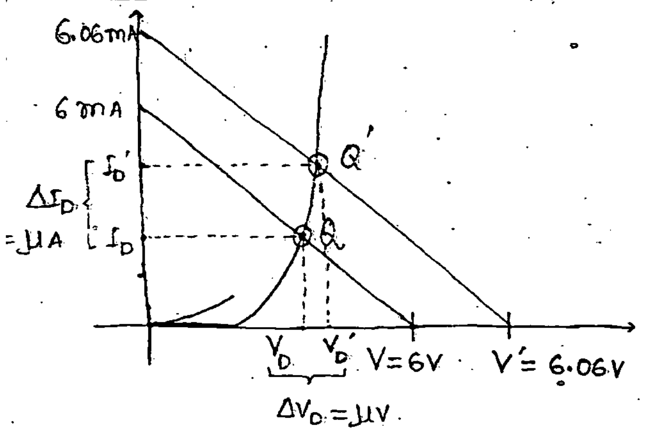



$$V' = V + \Delta V$$
$$6.06V \quad 6V \quad 0.06V$$

$$V_D' = V_D + \Delta V_D$$
$$? \quad 0.6V \quad ?$$

$$I_D' = I_D + \Delta I_D$$
$$? \quad 5.4mA \quad ?$$

GRAPHICAL ANALYSIS.




NOTE :→ for small signal analysis of a device (diode, BJT, FET, MOSFET) graphical analysis is not best method because the variation of the device will be in μA & μV. So mathematical analysis is best.

MATHEMATICAL ANALYSIS.

$$\underset{(DC)}{I_D} = I_0\, e^{V_D/V_T}$$

$$I_D + \Delta I_D = I_0 \cdot e^{(V_D + \Delta V_D)/V_T}$$

$$I_D + \Delta I_D = \underbrace{I_0 \cdot e^{V_D/V_T}}_{I_D\,(DC)} \cdot e^{\Delta V_D/V_T}$$

$$I_D + \Delta I_D = I_0 \cdot e^{\Delta V_D/V_T}.$$

$\Delta V_D = \mu V$.

$V_T = mV$

$$e^{\Delta V_D / V_T} = e^{x} = 1 + x.$$

$$= 1 + \frac{\Delta V_D}{V_T} \rightarrow \text{Linear.}$$

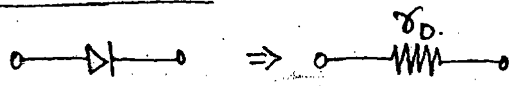
$$I_D + \Delta I_D = I_D\left[1 + \frac{\Delta V_D}{V_T}\right].$$

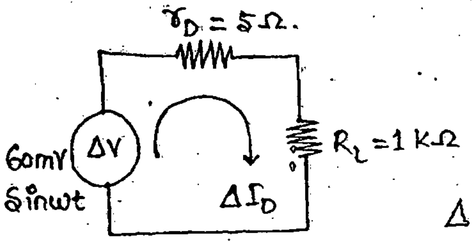
$$\cancel{I_D} + \Delta I_D = \cancel{I_D} + I_D \frac{\Delta V_D}{V_T}$$

$$\boxed{r_D = \frac{\Delta V_D}{\Delta I_D} = \frac{V_T}{I_{D(DC)}}} = \frac{26\,mV}{5.4\,mA}$$

$$= 5\,\Omega.$$

AC MODEL




$$\Delta I_D = \frac{\Delta V}{R_L + r_D} = \frac{60\,mV\,\sin\omega t}{1\,K\Omega}$$

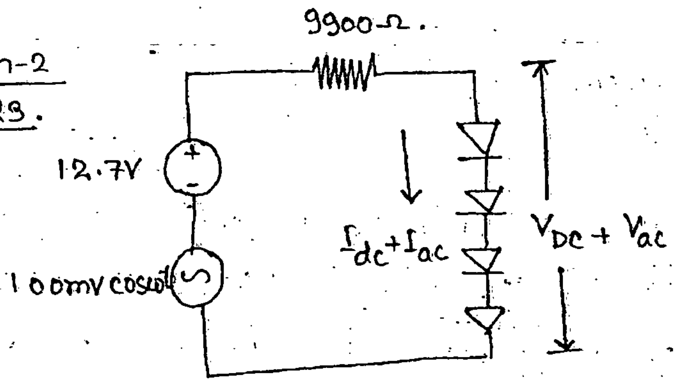
$$= 60\,\mu A\,\sin\omega t$$

$$\Delta V_D = \Delta I_D + r_D = 60\,\mu A\,\sin\omega t \times 5\,\Omega$$

$$\Delta V_D = 300\,\mu AV\,\sin\omega t.$$

Ch-2

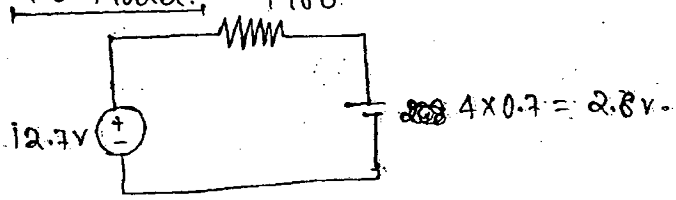
Q3.




$I_{dc} = ?$

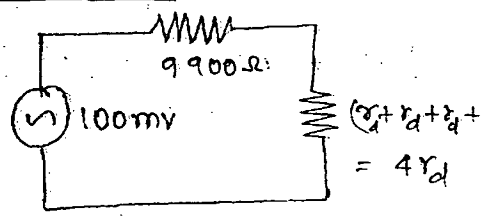
$V_{ac} = ?$

DC Model.




$$I_{dc} = \frac{12.7 - 2.8}{9900} = 1\,mA$$

AC Model.



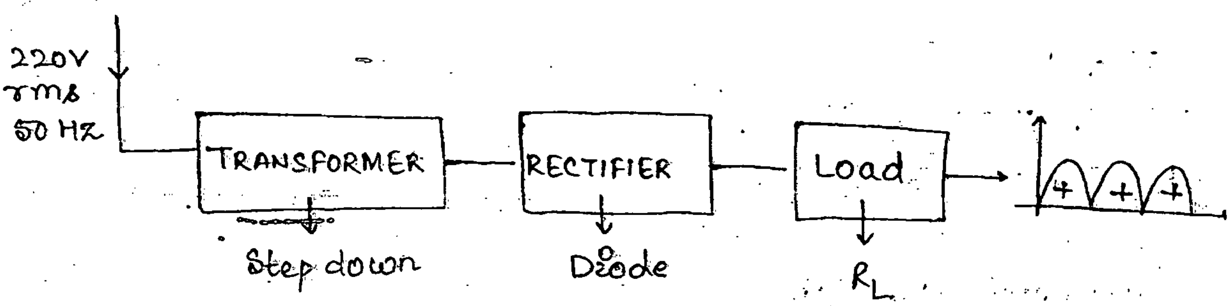

$$r_d = \frac{V_T}{I_{dc}} = \frac{25\,mV.}{1\,mA} = 25$$

$4r_d = 100\,\Omega$.

$$V_{ac} = \frac{100\,mv\,\cos\omega t \times 100}{10{,}000} = 1\,mv\,\cos\omega t.$$

## RECTIFIER

**Block Diagram.**




DEFINATION :- Rectifier is a circuit which convert ac to Pulsating DC.

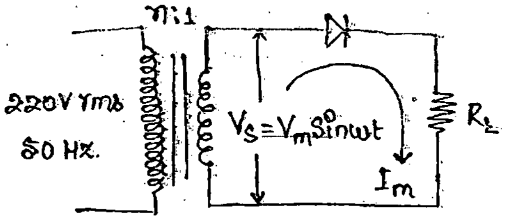
→ PRACTICAL RECTIFIER DESIGN.

1. HALF WAVE RECTIFIER. 2. FULL WAVE RECTIFIER WITH CENTRE TAPPED
3. FULL WAVE RECTIFIER WITHOUT CENTRE TAPPED (BRIDGE).

→ RECTIFIER PARAMETER.

1. Average current, $I_{dc}$
2. DC o/p voltage, $V_{dc}$
3. RMS load current, $I_{rms}$
4. Ripple Factor.
5. Voltage Regulation.
6. Rectification Efficiency, $\eta$.
7. Transformer utilization factor (TUF)
8. Peak Inverse Voltage (PIV)
9. Form factor.
10. Peak factor.

## HALF WAVE RECTIFIER.



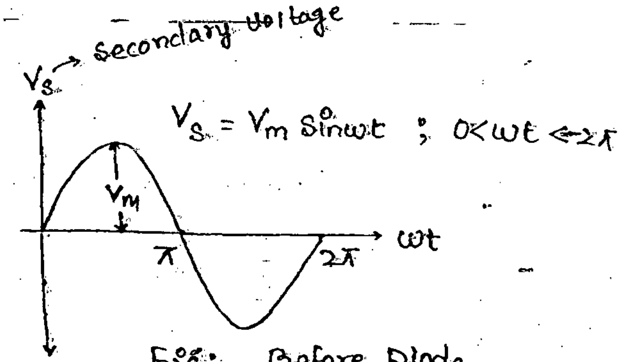
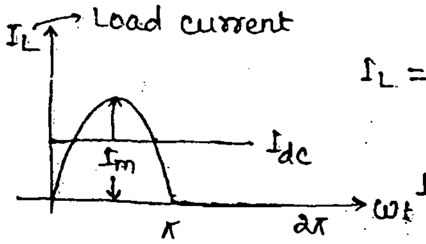




Fig:- Before Diode




$I_L = I_m \sin \omega t$

$0 < \omega t < \pi$

$I_L = 0 \quad (\pi < \omega t < 2\pi)$

Fig:- After diode.

### Parameter calculation :-

$$I_{dc} = \frac{\text{Area under the curve}}{2\pi}$$

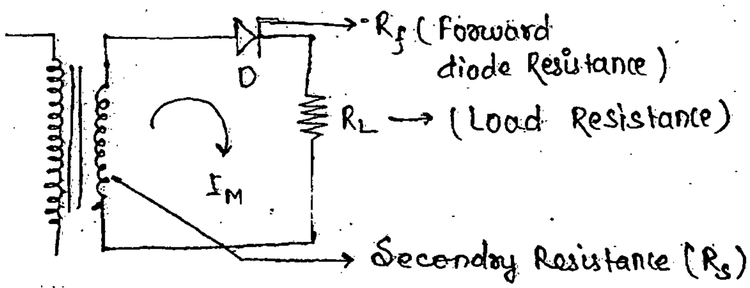
$$\boxed{I_{dc} = \frac{1}{2\pi}\int_0^{2\pi} I \, d\alpha} \rightarrow \text{where } \alpha = \omega t.$$

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

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

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

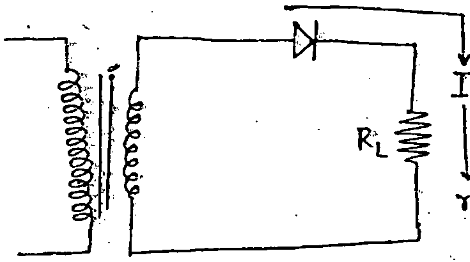
$$V_{dc} = \frac{I_m}{\pi} \times R_L \quad ; \quad V_{dc} = \frac{V_m}{\pi(R_f + R_s + R_L)} \cdot R_L$$



$$V_{dc} = \frac{V_m}{\pi} \cdot \frac{1}{\frac{R_f + R_S}{R_L} + 1}$$

when $R_L = \infty$ $\boxed{(V_{dc})_{NL} = \frac{V_M}{\pi}}$

3. $I_{RMS}$.




$$I = I_{ac} + I_{DC}$$
$\downarrow$ rms

$$\boxed{I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} I^2 d\alpha}}$$

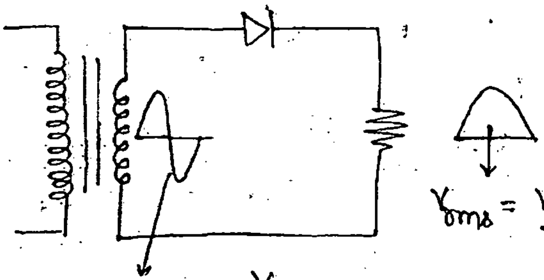
$$I_{rms} = \sqrt{\frac{I_m^2}{2\pi}\int_0^{\pi} \sin^2\alpha\, d\alpha}$$

$\boxed{I_{rms} = \frac{I_m}{2}}$ → For H.W.R.

4. $V_{rms}$.

$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$ → across Load ($R_L$)

$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$ → Transformer (Secondary)



$V_{rms} = \frac{V_M}{2}$

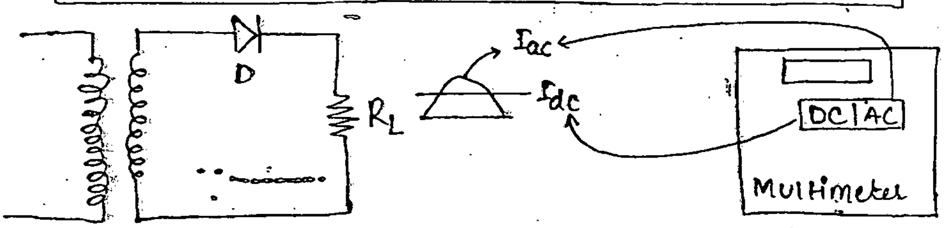
$V_{rms} = \frac{V_M}{\sqrt{2}}$.

I.V.I

5. RIPPLE FACTOR.

$$\boxed{R.F = \frac{\text{RMS value of alternating component}}{\text{Average value}}}$$

$$\boxed{R.F = \frac{I_{ac\,rms}}{I_{dc}}}$$



Assume.

- $I_{ac}$ = Ac current ; $I_{dc}$ = dc current.

  $I$ = Total current ; $I_{ac\,rms}$ = Rms value of ac current.

$$I_{ac\,rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} I_{ac}^2 \, d\alpha}.$$

$$\Rightarrow I_{dc} + I_{ac} = I.$$

$$\Rightarrow I_{ac} = I - I_{dc}$$

$$I_{ac\,rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (I - I_{dc})^2 \, d\alpha}.$$

$$I_{ac\,rms}^2 = \underbrace{\frac{1}{2\pi}\int_0^{2\pi} I^2 d\alpha}_{I_{rms}^2} - 2 I_{dc} \cdot \underbrace{\frac{1}{2\pi}\int_0^{2\pi} I \, d\alpha}_{I_{dc}} + I_{dc}^2 \underbrace{\frac{1}{2\pi}\int_0^{2\pi} d\alpha}_{=1}.$$

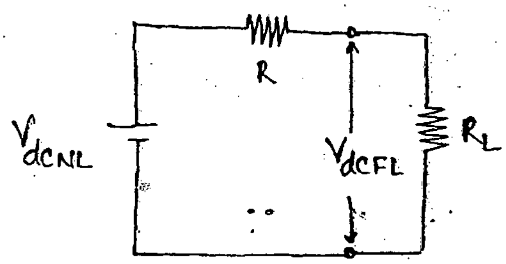
$$I_{ac\,rms} = \sqrt{I_{rms}^2 - I_{dc}^2}$$

$$\boxed{R.F = \frac{I_{ac\,rms}}{I_{dc}} = \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}}$$

For HWR:- $I_{rms} = \frac{I_m}{2}$ ; $I_{dc} = \frac{I_m}{\pi}$ ; $R.F = \sqrt{\left(\frac{I_m/2}{I_m/\pi}\right)^2 - 1}$

$\boxed{R.F = 1.21}$ → For HWR.

6. VOLTAGE REGULATION.




$$\% \, VR = \frac{V_{dcNL} - V_{dcFL}}{V_{dcFL}}.$$

$$I_{dc} = \frac{I_m}{\pi} \quad ; \quad I_{dc} = \frac{V_m}{\pi(R_f + R_s + R_L)}$$

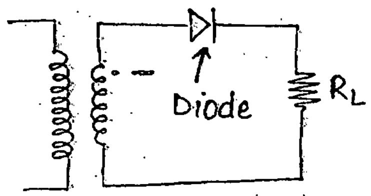
$$I_{dc}(R_f + R_s) + \underbrace{I_{dc} R_L}_{V_{dcFL}} = \underbrace{\frac{V_m}{\pi}}_{V_{dcNL}}$$

$$\left.\begin{aligned} R_f &= 0 \\ R_s &= 0 \\ R_L &= \infty \end{aligned}\right\} \rightarrow \text{Ideal}$$

$$\% VR = \frac{\cancel{I_{dc}}(R_f + R_s)}{\cancel{I_{dc}} R_L} \quad ; \quad \boxed{\% V.R = \frac{R_f + R_s}{R_L}}$$

7. RECTIFICATION EFFICIENCY ($\eta$)

$$\eta = \frac{P_{D.C}}{P_{a.c}} = \frac{I_{dc}^2 \cdot R_L}{V_{rms} \times I_{rms}}$$

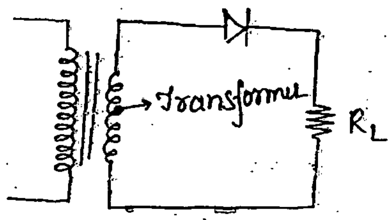



$$\eta = \frac{I_{dc}^2 \cdot R_L}{\frac{V_M}{2} \times \frac{I_m}{2}} = \frac{(I_m/\pi)^2 \cdot \cancel{R_L}}{\frac{I_m^2}{4}\cancel{(R_f + R_s + R_L)}}$$

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

8. T.U.F.

$$T.U.F = \frac{P_{DC}}{P_{a.c}} = \frac{I_{dc}^2 \cdot R_L}{V_{rms} \times I_{rms}}$$

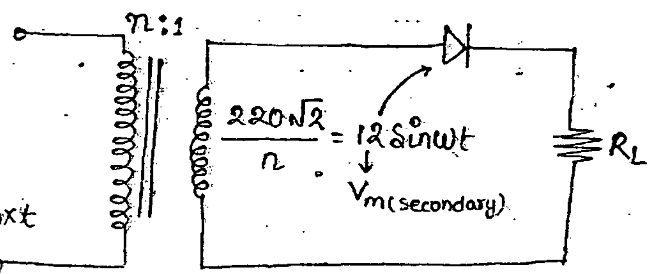


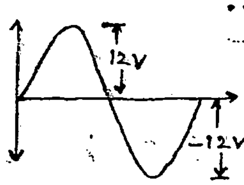

$$T.U.F = \frac{I_{dc}^2 \cdot R_L}{\frac{V_m}{\sqrt{2}} \times \frac{I_m}{2}}$$

$$\boxed{T.U.F = \frac{2\sqrt{2}}{\pi^2} = 28\%}$$

9. PEAK INVERSE VOLTAGE:

220 V rms
50 HZ
$\downarrow$
$220\sqrt{2}\sin 2\pi \times 50 \times t$




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

Where. $V_m$ = Secondary $V_m$.

10. Form factor $= \dfrac{\text{RMS Value}}{\text{Average Value}}$

$$\boxed{F.F = \frac{I_{rms}}{I_{dc}}}$$

$$\boxed{F.F = \frac{I_m/2}{I_m/\pi} = \frac{\pi}{2} = 1.57}$$

→ FOR H.W.R.

$$\boxed{I_{rms} = F.F \times I_{dc}}$$

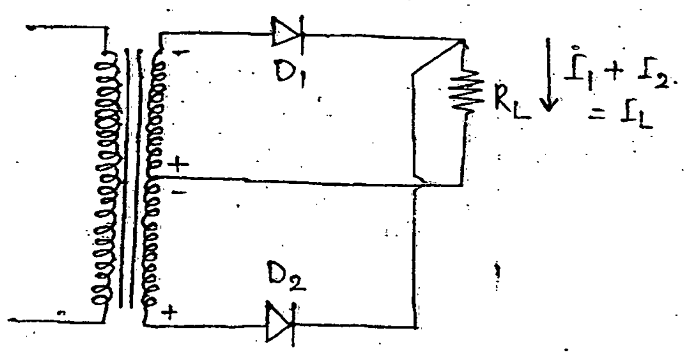
11. Peak Factor $= \dfrac{\text{Peak Value}}{\text{RMS Value}}$

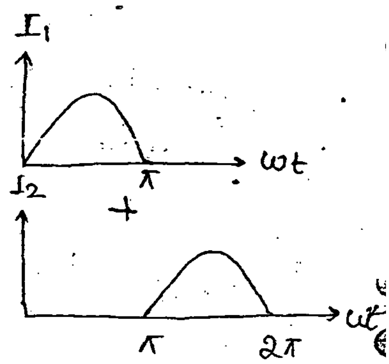
$$\boxed{P.F = \frac{I_m}{I_{rms}}}$$

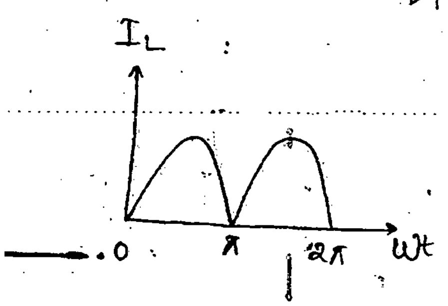
$$\boxed{I_m = I_{rms} \times \text{Peak Factor}}$$

☐ FULL WAVE RECTIFIER.

→ CENTRE TAPPED.



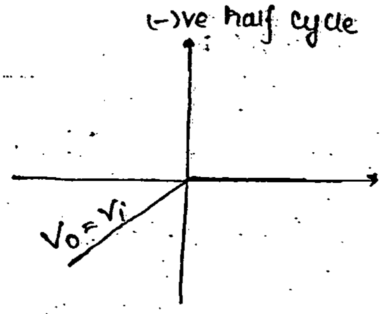




Fig :- CLIPPER

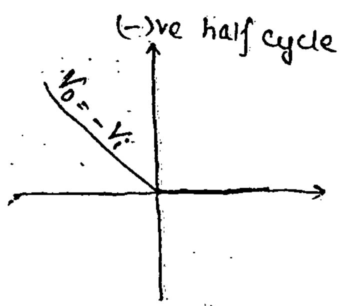



Fig :- RECTIFIER.

## RECTIFIER PARAMETER

1. $I_{dc} = \dfrac{2 \cdot I_m}{\pi}$

2. $V_{dc\,NL} = \dfrac{2 \cdot V_M}{\pi}$

3. $I_{rms} = \dfrac{I_m}{\sqrt{2}}$ ; $V_{rms} = \dfrac{V_m}{\sqrt{2}}$

4. $R.F = \sqrt{\dfrac{(I_{rms})^2}{(I_{dc})^2} - 1} = \sqrt{\left(\dfrac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1} = 0.48$

$R.F = 0.48$

5. Voltage Regulation.

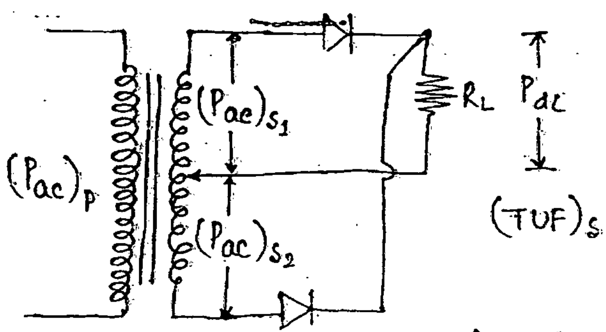
$$-\frac{2I_m}{\pi}\left(R_f + \frac{R_s}{2}\right) + \frac{2I_m}{\pi} \cdot R_L = \frac{2V_M}{\pi}$$

6. Rectification Efficiency

$$\eta = \frac{P_{DC}}{P_{ac}} = \frac{I_{dc}^2 \cdot R_L}{V_{rms} \cdot I_{rms}} = \frac{I_{dc}^2 \cdot R_L}{I_{rms}^2 (\cancel{R_f + R_s +} R_L)} = \frac{(2I_m/\pi)^2}{(I_m/\sqrt{2})^2}$$

$$\boxed{\eta = \frac{8}{\pi^2} = 81.2\%}$$

7. Transformer UTILIZATION FACTOR.




$$(T.U.F)_p = \frac{P_{DC}}{(P_{ac})_p} = \eta = 81.2\%.$$

$$(TUF)_s = \frac{P_{DC}}{P_{ac}\text{ sec one half} + P_{ac}\text{ sec other half}}$$

$$(TUF)_s = \frac{I_{dc}^2 \cdot R_L}{V_{rms} \times I_{rms} + V_{rms} \times I_{rms}}$$

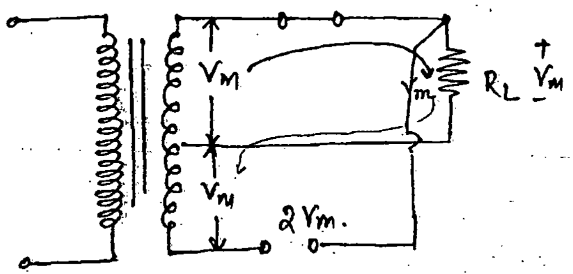
$$(TUF)_s = \frac{I_{dc}^2 \cdot R_L}{\frac{V_M}{\sqrt{2}} \times \frac{I_M}{2} + \frac{V_M}{\sqrt{2}} \times \frac{I_M}{2}} = 57.3\%.$$

$$\boxed{(TUF)_s = 57.3\%}$$

$$(TUF) = \frac{(TUF)_p + (TUF)_s}{2} = \frac{81.2 + 57.3}{2}$$

$$\boxed{TUF = 69.3\%}$$

8. Peak Inverse Voltage (PIV)

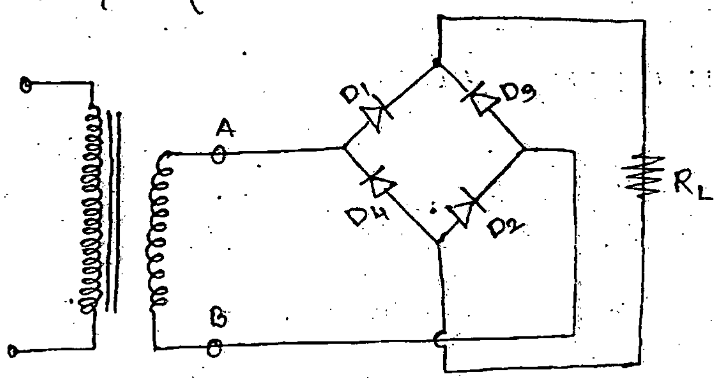



$$\boxed{PIV = 2V_m}$$

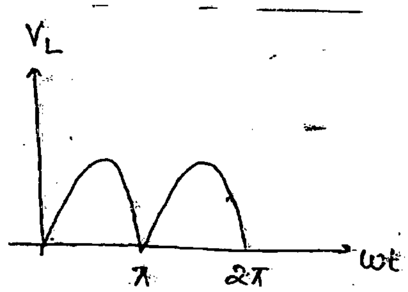
→ DRAWBACKS IN CENTRE TAPPED.

* The TUF is not equal to Rectification Efficiency because of Centre Tapped.
* The PIV rating is high.

☐ BRIDGE RECTIFIER.



| (+)ve Half cycle | (−)ve half cycle. |
| --- | --- |
| Conduction path | conduction path |
| $A D_1 R_L D_2 B$ | $B D_3 R_L D_4 A$ |
| $D_1$ and $D_2 \rightarrow$ ON | $D_3$ and $D_4 \rightarrow$ ON |
| $D_3$ and $D_4 \rightarrow$ OFF | $D_1$ and $D_2 \rightarrow$ OFF |




→ Common parameter as full wave Rectifier.

1. $I_{dc} = \frac{2 \cdot I_m}{\pi}$

2. $V_{dcNL} = \frac{2 \cdot V_M}{\pi}$

3. $I_{rms} = \frac{I_m}{\sqrt{2}}$ ; $V_{rms} = \frac{V_m}{\sqrt{2}}$

4. R.F = 0.48.

5. Rectification Efficiency, $\eta = 81.2\%$.

→ Different parameter in Bridge Rectifier.

6. % Voltage Regulation =

$$\frac{2 I_m}{\pi}\left(R_f + \frac{R_s}{2}\right) + \frac{2 I_m}{\pi} \cdot R_L = \frac{2 V_M}{\pi}$$

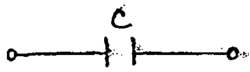
7. Transformer utilization factor (TUF)

$$TUF = \frac{(TUF)_p + (TUF)_s}{2} = \frac{81.2 + 81.2}{2} = 81.2\%.$$

8. $PIV = V_m$.

## FILTER.

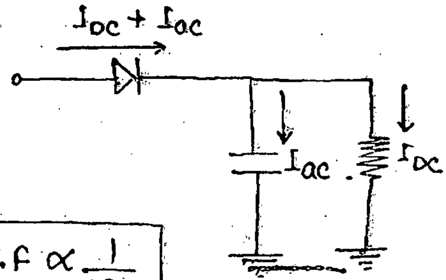
CAPACITOR :→




$X_C \propto \frac{1}{f}$

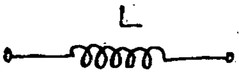
$f = 0$ (DC) ; $X_C \to \infty$ (o.c)

$f = \infty$ (ac) ; $X_C \to 0$ (s.c)




$\boxed{R.F \propto \frac{1}{R_L}}$

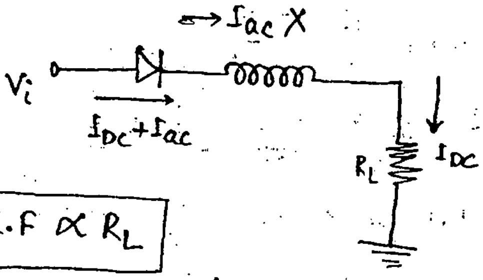
INDUCTOR :→




$X_L \propto f$

$f = 0$ (DC) ; $X_L \to 0$ (s.c)

$f = \infty$ (a.c) ; $X_L \to \infty$ (o.c)



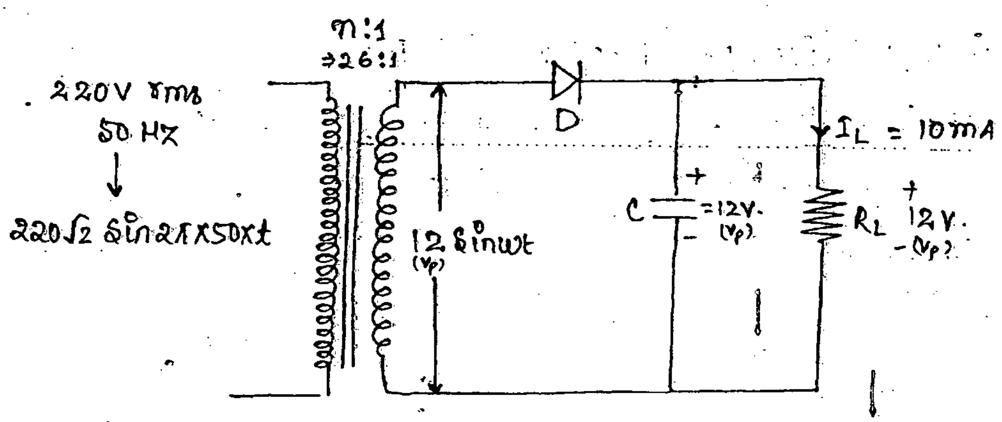

$\boxed{R.F \propto R_L}$

∴ Not used.

FOR ONLY.
IES→CONV.

## CAPACITANCE FILTER DESIGN (HWR).

Requirements :- $V_{dc}$ across the $R_L$ = 12 V.
Load current $I_L$ = 10mA




1. Turn Ratio :-

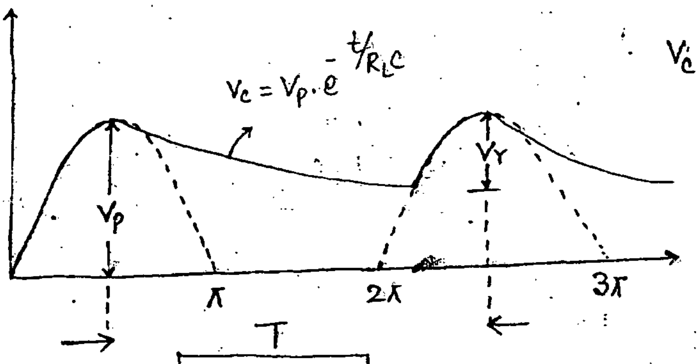
$$\frac{220\sqrt{2}}{n} = 12 \Rightarrow n = \frac{220\sqrt{2}}{12} \Rightarrow n = 26.$$

2. Voltage across the capacitor $= 12V$.

3. $R_L = \frac{V_{dc}}{I_L} = \frac{12}{10mA} = 1.2K\Omega$.

4. $T = \frac{1}{f} = \frac{1}{50Hz} = 20msec$.

5. Ripple Waveform.

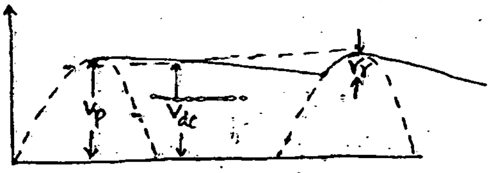



$\boxed{R_LC >> T}$

$V_c = V_p \cdot e^{-T/R_LC}$

$V_c = V_p\left(1 - \frac{T}{R_LC}\right)$

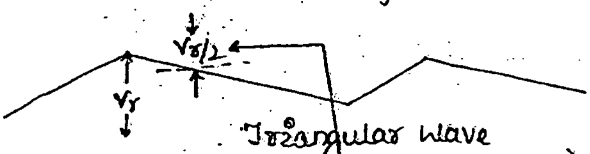
$$\boxed{V_c = \underbrace{V_p}_{V_{dc}} - \underbrace{\frac{V_p \cdot T}{R_L \cdot C}}_{V_r}}$$




$V_{dc} \approx V_p$

$\boxed{V_r = \frac{V_p \cdot T}{R_LC} = \frac{V_r}{2}}$ (Ripple to be eliminated)

## Expression for Ripple factor :-



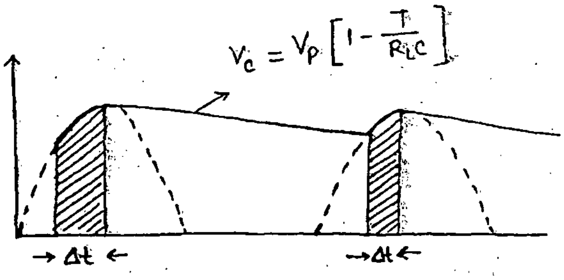

$\boxed{V_{rms} = \frac{V_m}{\sqrt{3}}}$

$R.F = \frac{V_{r\,rms}}{V_{dc}} = \frac{\frac{V_r}{2\sqrt{3}}}{V_p}$

$\Rightarrow R.F = \frac{\frac{V_p \cdot T}{2\sqrt{3} \cdot R_L \cdot C}}{V_p}$

$\Rightarrow \boxed{R.F = \frac{1}{2\sqrt{3}} \cdot \frac{1}{R_L \cdot f \cdot C}}$

## 6. Conduction Time (Δt)




$$V_p \cos \omega \Delta t = V_p\left[1 - \frac{T}{R_L C}\right]$$

Δt → is very small

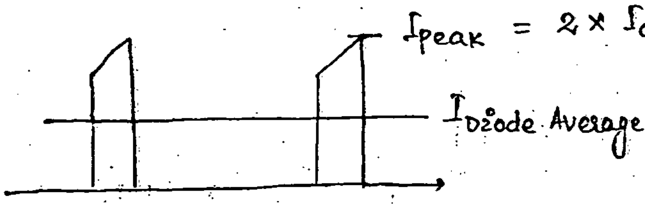
$$\boxed{\begin{aligned} \cos\theta &= 1 - \frac{\theta^2}{2!} \\ \sin\theta &= \theta - \frac{\theta^3}{3!} \end{aligned}}$$

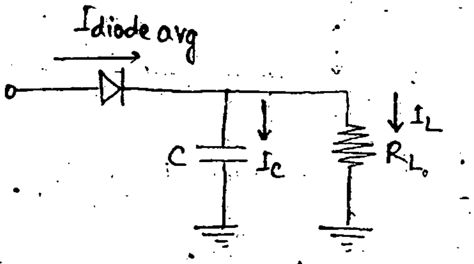
$$V_p\left[1 - \frac{(\omega \Delta t)^2}{2}\right] = V_p\left[1 - \frac{T}{R_L C}\right]$$

$$(\omega \Delta t)^2 = \frac{2T}{R_L C}$$

$$\boxed{\Delta t = \frac{1}{\omega}\sqrt{\frac{2T}{R_L C}}}$$

## 7. Peak current of Diode Rating.




$$I_{diode\ average} = I_{c\ average} + I_L$$

$$I_{diode\ avg} = C\frac{dV_c}{dt} + \frac{V_{dc}}{R_L}$$

$$I_{c\ avg} \times \Delta t = C \times V_r$$

$$I_{c\ avg} = \frac{C \times \frac{V_p}{R_L \cdot C}}{\Delta t}$$

$$I_{c\ avg} = I_{dc} \cdot \cancel{T} \cdot 2\pi \cancel{f} \sqrt{\frac{R_L \cdot C}{2T}} \Rightarrow \boxed{I_{c\ avg} = I_{dc} \times 2\pi\sqrt{\frac{R_L \cdot C}{2T}}}$$

$$\boxed{I_{diode\ avg} = I_{dc}\left[1 + 2\pi\sqrt{\frac{R_L \cdot C}{2T}}\right]}$$

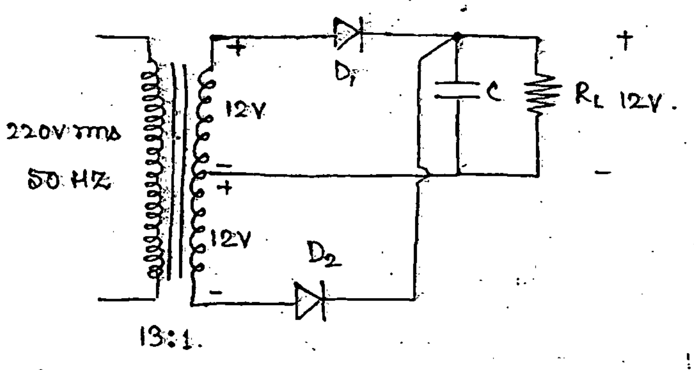
= 0.5

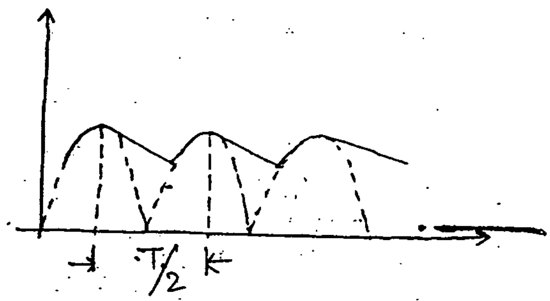
Peak current of diode = 2 $I_{diode\ avg}$

Peak current of diode $= 2I_{dc}\left[1 + 2\pi\sqrt{\frac{R_L \cdot C}{2T}}\right] = 14.$

8. Imp PIV Rating of diode $= 2V_m$.

## ☐ FILTER DESIGN (FWR)



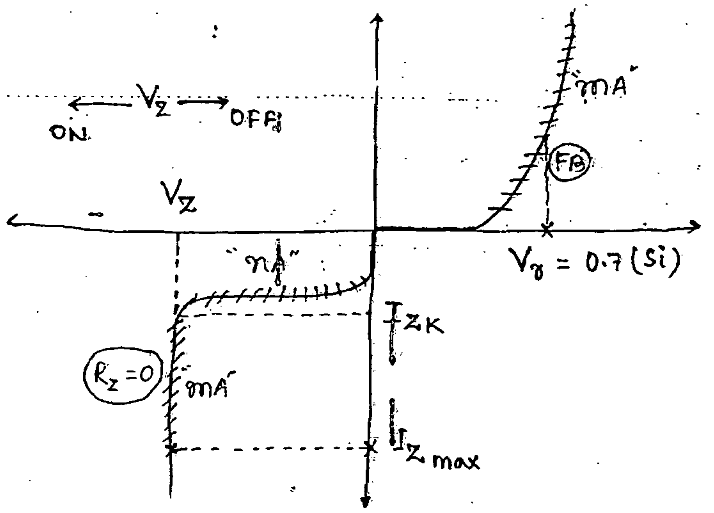

$$R.F = \frac{1}{2\sqrt{3} \cdot R_L f \cdot C} \longrightarrow H.W.R.$$

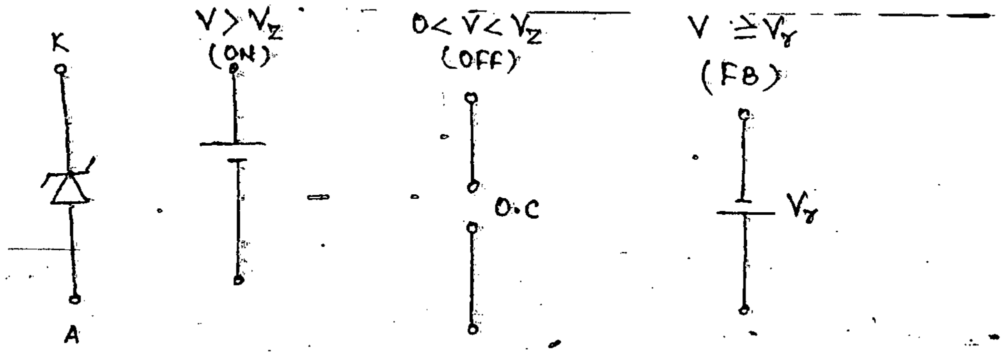
$$R.F = \frac{1}{4\sqrt{3} R_L f \cdot C} \longrightarrow F.W.R.$$

NOTE :- The ripple frequency of HWR $= f$.

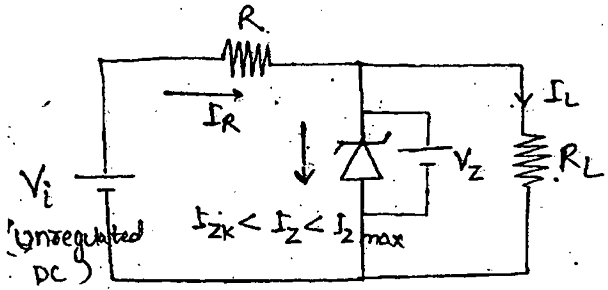
The ripple frequency of FWR and BR $= 2f$.

## ☐ ZENER DIODE AS A REGULATOR.






## ZENER REGULATOR DESIGN.




$$\boxed{I_R = I_Z + I_L}$$

* $I_L$ is due Zener:

$\therefore$ $I_L$ does n't depend on $I_R$.

Design:

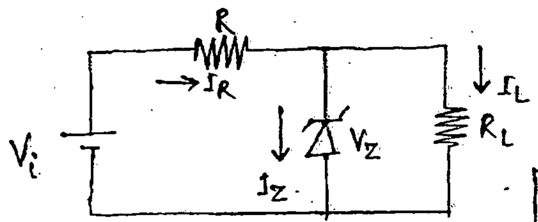
$V_i$ fixed & $R_L$ fixed

$V_i$ Variable & $R_L$ fixed

$V_i$ fixed & $R_L$ variable

$V_i$ and $R_L$ are variable.

Case I :- $V_i$ fixed and $R_L$ fixed.

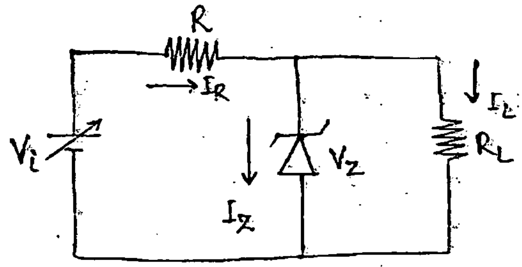



$$I_R = I_Z + I_L$$

$$I_Z = I_R - I_L$$

$$\boxed{I_Z = \frac{V_i - V_Z}{R} - \frac{V_Z}{R_L}}$$

Case II :- $V_i$ is variable and $R_L$ fixed.




$$\boxed{I_R = I_z + I_L}$$

$$I_{Rmin} = I_{zmin} + I_L$$

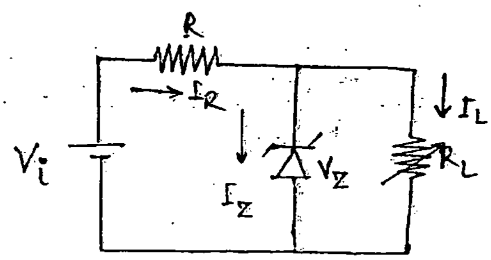
$$\boxed{I_{zmin} = \frac{V_{imin} - V_z}{R} - \frac{V_z}{R_L}}$$

$$I_{Rmax} = I_{zmax} + I_L$$

$$I_{zmax} = I_{Rmax} - I_L$$

$$\boxed{I_{zmax} = \frac{V_{imax} - V_z}{R} - \frac{V_z}{R_L}}$$

Case III :- $V_i$ is fixed and $R_L$ is Variable.




$$\boxed{I_R = I_z + I_L}$$

$$I_R = I_{zmin} + I_{Lmax}$$

$$I_{zmin} = I_R - I_{Lmax}$$

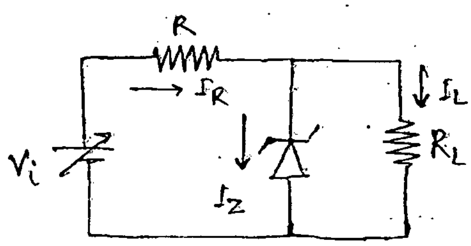
$$I_R = I_{zmax} + I_{Lmin}$$

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

$$\boxed{I_{zmin} = \frac{V_i - V_z}{R} - \frac{V_z}{R_{Lmin}}}$$

$$\boxed{I_{zmax} = \frac{V_i - V_z}{R} - \frac{V_z}{R_{Lmax}}}$$

Case IV :- $V_i$ and $R_L$ is Variable.




$$I_R = I_z + I_L$$

$$I_{Rmin} \neq I_{Rmax} \qquad I_{Rmin} = I_{zmin} + I_{Lmax}$$

$$I_{zmin} = I_{Rmin} - I_{Lmax}$$

$$I_{Rmax} = I_{zmax} + I_{Lmin}$$

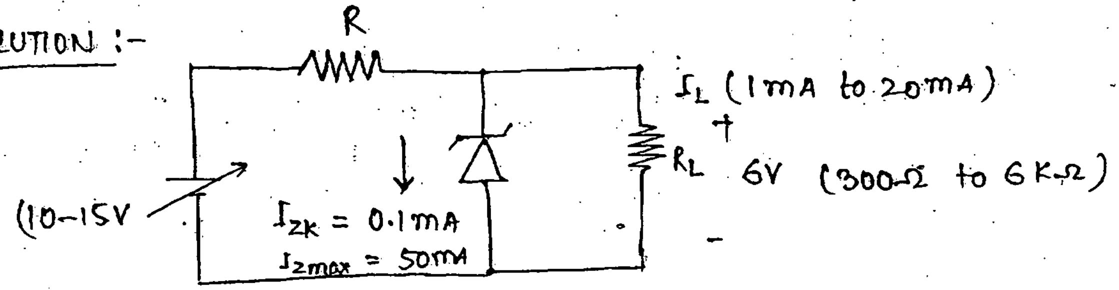
$$\boxed{I_{zmin} = \frac{V_{imin} - V_z}{R} - \frac{V_z}{R_{Lmin}}}$$

$$\boxed{I_{zmax} = \frac{V_{imax} - V_z}{R} - \frac{V_z}{R_{Lmax}}}$$

QUESTION :- Design a Zener ~~diode~~ voltage Regulator of regulated voltage 6V for a load current variation of 1mA to 20mA. The unregulated DC Voltage is 10V to 15V.

Zener Specification :- $I_{ZK} = 0.1mA$ ; $I_{Z_{max}} = 50mA$.

SOLUTION :-




$$\Rightarrow I_{R_{min}} - I_{L_{max}} > I_{Z_{min}}$$

$$\Rightarrow \frac{V_{i_{min}} - V_Z}{R_{max}} - I_{L_{max}} > 0.1mA \quad \Rightarrow \frac{10-6}{R_{max}} - 20mA > 0.1mA$$

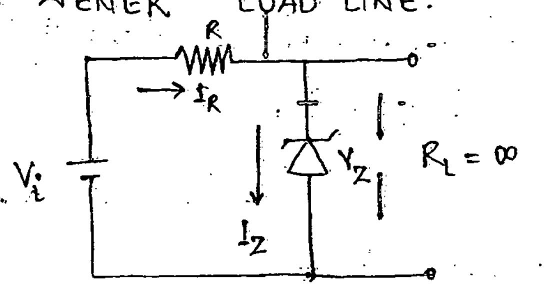
$$\boxed{R_{max} < 199\Omega.}$$

$$\Rightarrow I_{R_{max}} - I_{L_{min}} < I_{Z_{max}}$$

$$\Rightarrow \frac{V_{i_{max}} - V_Z}{R_{min}} - I_{L_{min}} < 50mA \quad \Rightarrow \frac{15-6}{R_{min}} - 1mA < 50mA$$

$$\Rightarrow \boxed{R_{min} > 176\Omega}$$

□ ZENER LOAD LINE.



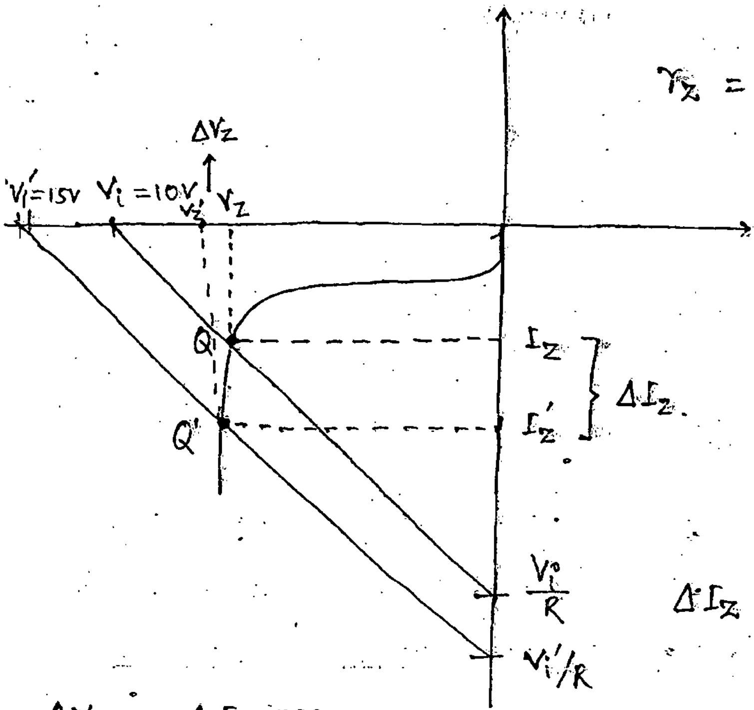

$$V_i = I_R R + V_Z$$

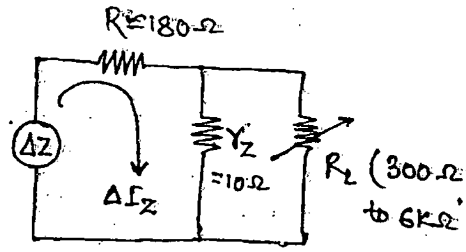
$$\boxed{I_R = I_Z}$$

$$V_i = I_Z R + V_Z$$

$$\boxed{I_Z = \left[-\frac{1}{R}\right] V_Z + \frac{V_i}{R}}$$

$$r_z = \frac{\Delta V_z}{\Delta I_z} = 10\,\Omega.$$




$$\Delta I_z = \frac{\Delta V}{R + r_z // R_L} = \frac{\Delta V}{R + r_z} = \frac{\Delta V}{R}.$$

$$\Delta V_z = \Delta I_z * r_z$$

$$= \frac{\Delta V}{R} \times r_z$$

$$\Delta V_z = \frac{5V}{180} \times 10 = 0.27\,V.$$

<u>17/10/14</u>.