RECTIFIER

Rectifiers

- Rectifier: Rectifier is that circuit, that converts ac to dc.

- The following two types of rectifier circuit can be used:

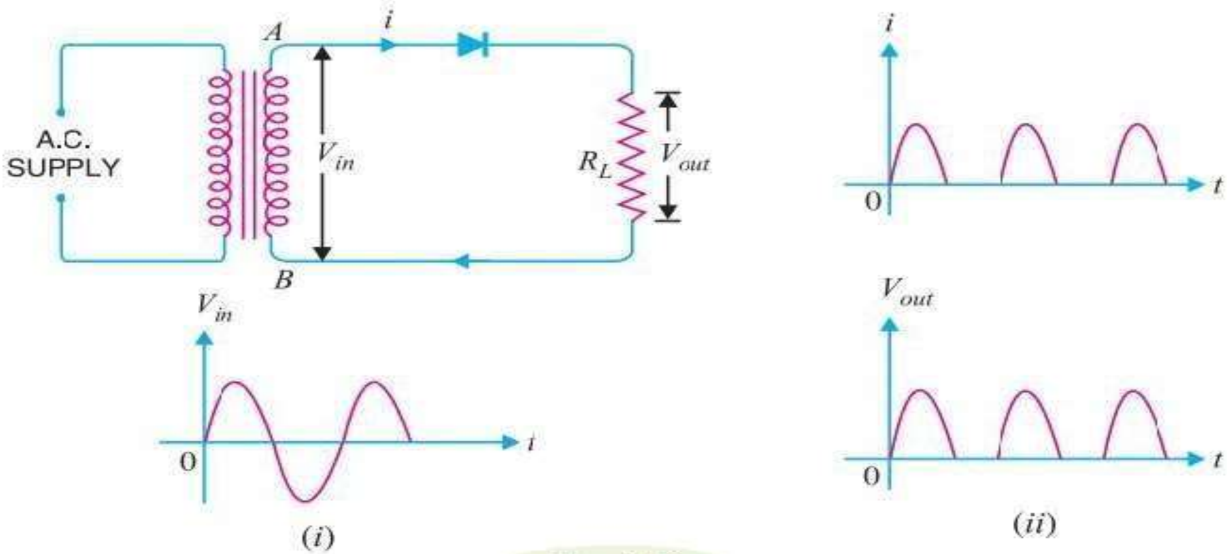
I. Half wave rectifier
II. Full wave rectifier

Half wave Rectifier

- The process of removing one-half the input signal to establish a dc level is called *half-wave rectification*.

- In Half wave rectification, the rectifier conducts current during positive half cycle of input ac signal only.

- Negative half cycle is suppressed or clipped.



Half wave Rectifier

- AC voltage across secondary terminals AB changes its polarity after each half cycle.

- During negative half cycle terminal A is negative so diode reversed biased and conduct no current.so current flows through diode during positive half cycle only.

- In this way current flows through load RL in one direction

Half wave Rectifier

Disadvantage of Half wave rectifier:

- Since, power is delivered only during one half of the cycle of the input alternating voltage, therefore, its power output and rectification frequency is low.
- Transformer utilization factor is also low.
- The DC output power produced from the half wave rectifier is not satisfactory to make a general power supply.

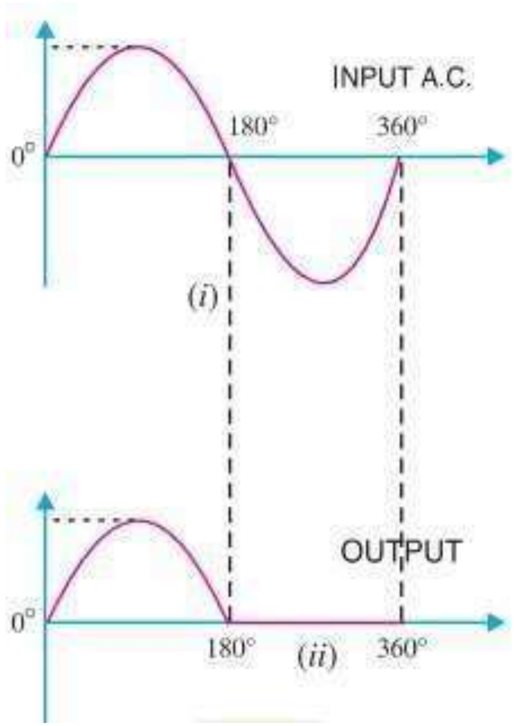
Half wave Rectifier

- Output frequency of HWR:

➢Output frequency of HWR is equal to input frequency.

➢This means when input ac completes one cycle, rectified wave also completes one cycle.

$$f_{out} = f_{in}$$

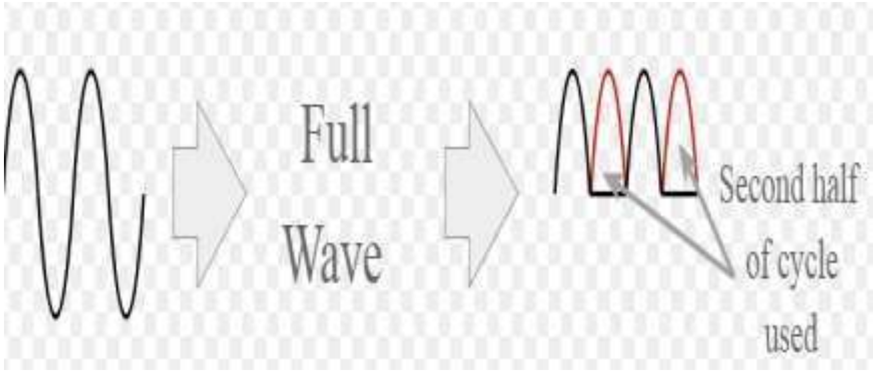


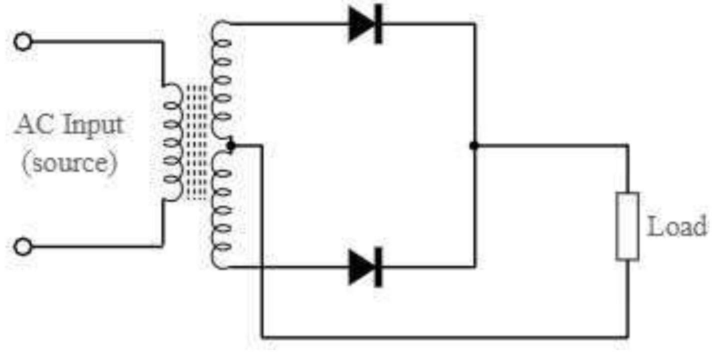
Full-Wave Rectifier

In Full wave rectification current flow through the load in same direction for both half cycle of input ac.

This can be achieved with two diodes working alternatively.

For one half cycle one diode supplies current to load and for next half cycle another diode works.





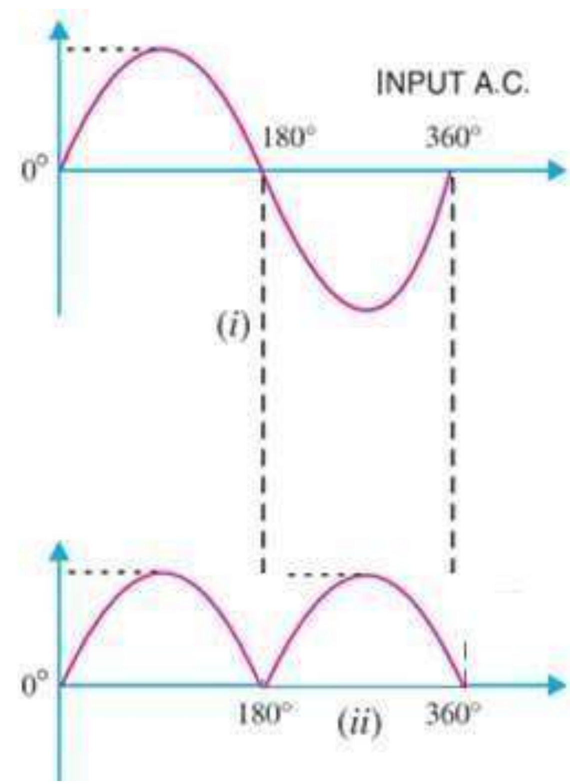
Full wave Rectifier

- Output frequency of FWR:

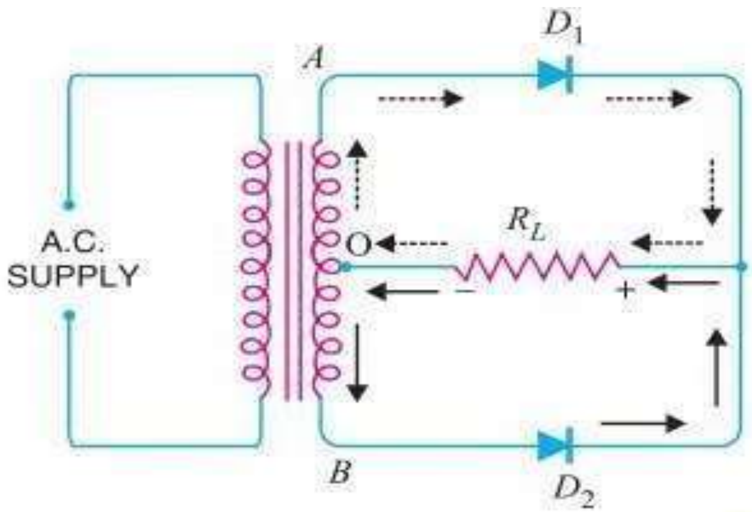
➢Output frequency of FWR is equal to double of input frequency.

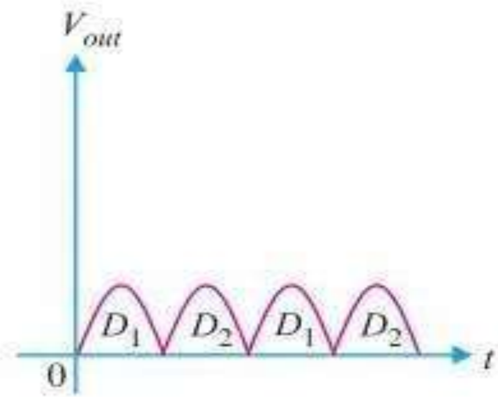
➢This means when input ac completes one cycle, rectified wave completes two cycles

$$f_{out} = 2 f_{in}$$



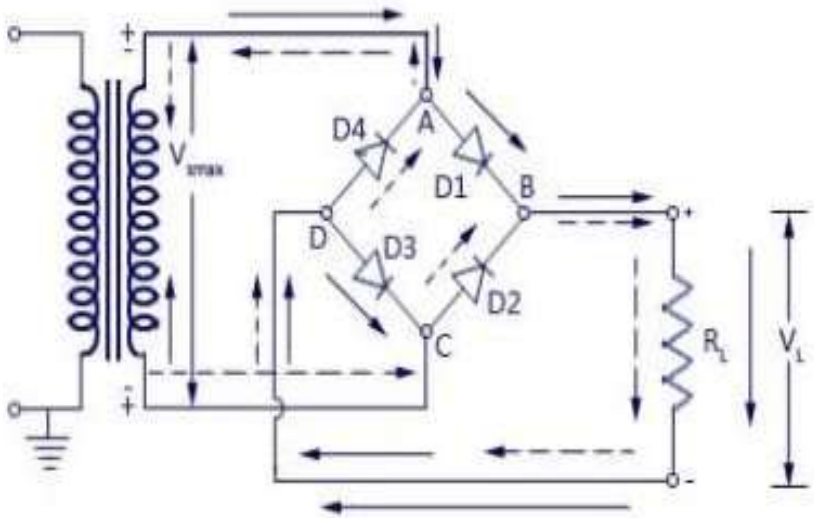
Centre Tap Full Wave Rectifier

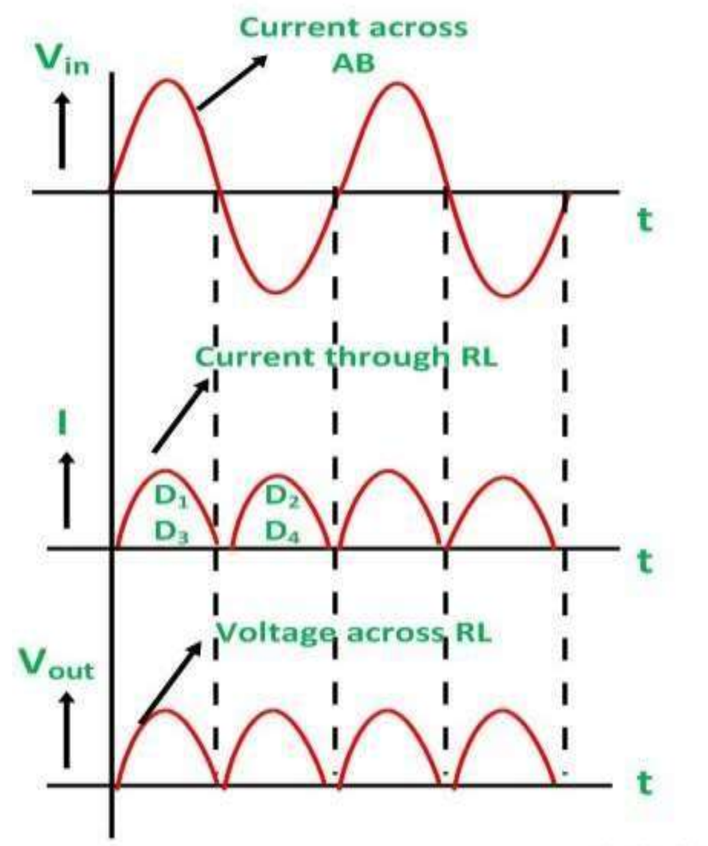




- ➢Circuit has two diodes D1 , D2 and a centre tap transformer.
- ➢During positive half cycle Diode D1conducts and during negative half cycle Diode D2 conducts.
- ➢It can be seen that current through load RL is in the same direction for both cycle.

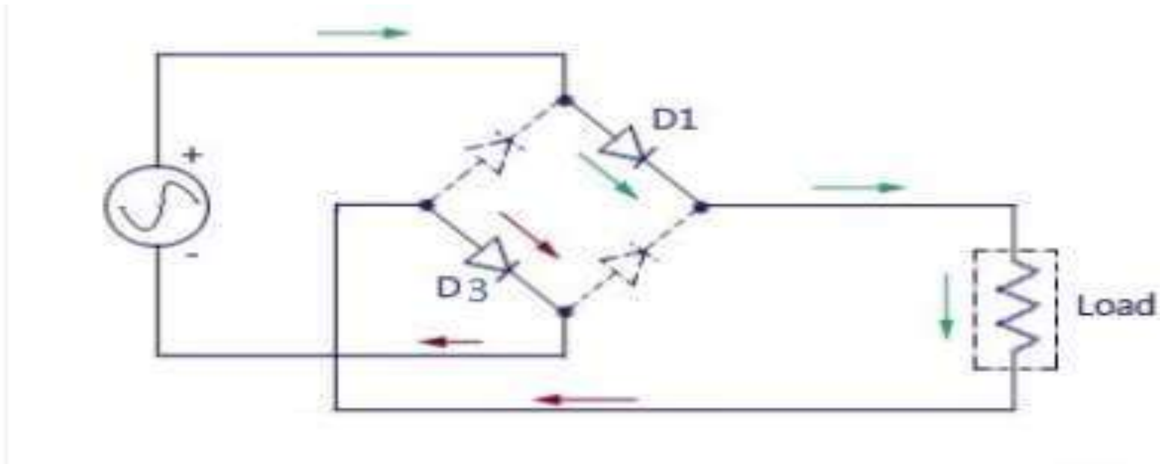
Full Wave Bridge Rectifier

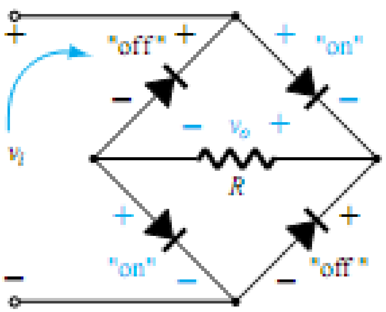




- Consists of 4 diodes instead of 2.

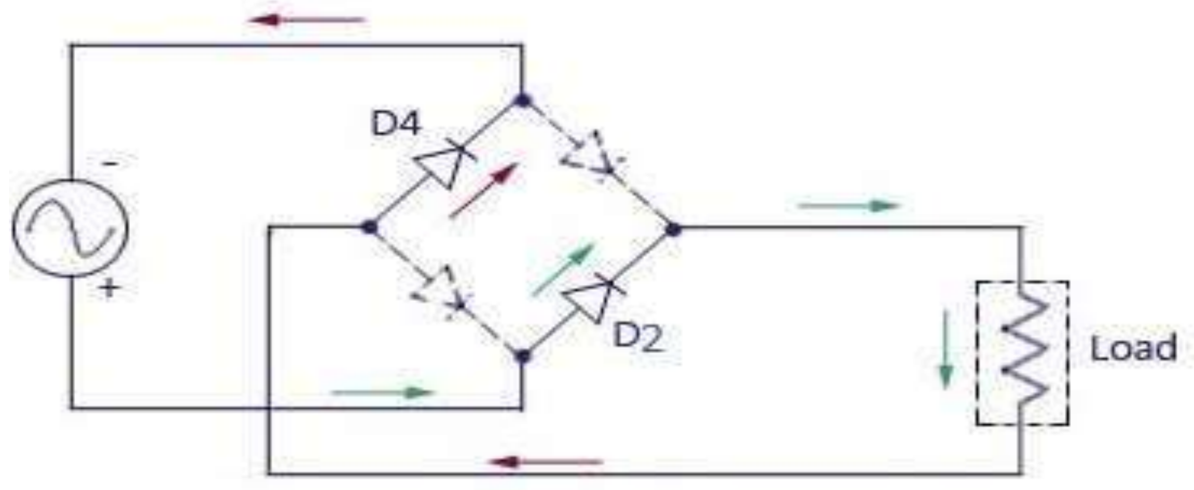
Full Wave Bridge Rectifier





➤During first half cycle D1 and D3 are conducting while D2 and D4 are in the "off" state.

Full Wave Bridge Rectifier



- During 2nd half cycle D2 and D4 are conducting while D1 and D3 are in the “off” state.

Full Wave Bridge Rectifier

Advantage:

I. Need for centre tap trnsformer is eliminated.
II. Output is twice than that of centre tap circuit.

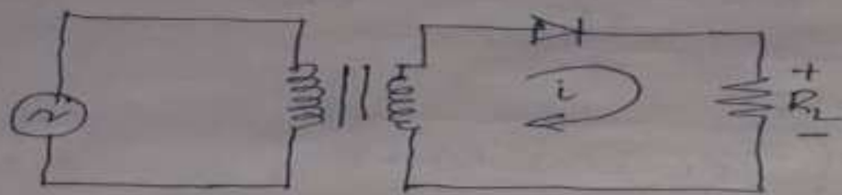
Disadvantage

I. Requires 4 diodes.
II. Internal resistance voltage drop is twice than that of Centre Tap Circuit.

Rectifier Performance

1. Conduction Status
2. Peak Inverse Voltage.
3. DC Current
4. DC Voltage
5. Rms Value of Current
6. Rms Value of Voltage
7. Ripple Factor
8. Efficiency
9. Transformer Utilization Factor
10. Regulation

Half wave Rectifier



$i = I_m \sin\omega t$ when $0 \le \omega t \le \pi$

$i = 0$ when $\pi \le \omega t \le 2\pi$

I_m = Peak value = $\dfrac{V_m}{R_f + R_L}$

① PIV (Peak Inverse Voltage)

The max^m. Voltage appears across the diode when diode is nonconducting (i.e Reverse biased) For $\frac{1}{2}$ wave Rectifier. PIV = V_m

② $I_{dc} = \frac{1}{2\pi}\int_0^{2\pi} I_m \sin\omega t \, d(\omega t) = \frac{I_m}{\pi}$

$V_{dc} = \frac{I_m}{\pi} \cdot R_L$

③ RMS Value of current (I_{rms})

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

$$= \frac{I_m^2}{4}$$

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

$$V_{rms} = \frac{I_m}{2} \cdot R_L$$

(4) Ripple factor $= \gamma = \dfrac{I'_{rms}}{I_{dc}} = \dfrac{V'_{rms}}{V_{dc}}$

$$i' = i - I_{dc}.$$

$$I'_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi}(i - I_{dc})^2\,d(\omega t)}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi}(i^2 - 2iI_{dc} + I_{dc}^2)\,d(\omega t)}$$

$$= \sqrt{(I_{rms}^2 - I_{dc}^2)}$$

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

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

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

$$= \sqrt{(\pi/2)^2 - 1} \quad = 1.21.$$

(5) $\eta =$ Efficiency $= \dfrac{P_{dc}}{P_{ac}} \times 100\%$

$$= \frac{I_{dc}^2 \cdot R_L}{(R_f + R_L)\,I_{rms}^2}$$

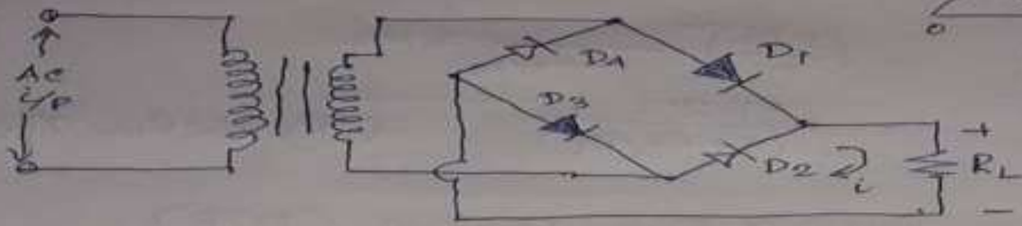
$$= \left(\frac{I_{dc}}{I_{rms}}\right)^2 \cdot \frac{R_L}{R_f + R_L} \times 100$$

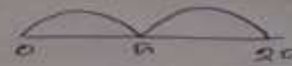
$$= \left(\frac{2}{\pi}\right)^2 \cdot \frac{1}{1 + R_f/R_L} \times 100$$

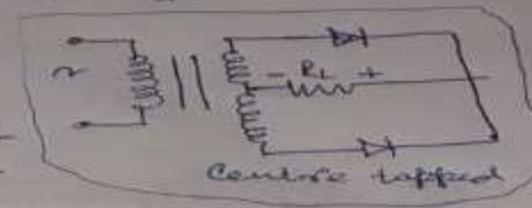
$$= \frac{40.6}{1 + R_f/R_L} \times 100$$

Full wave Rectifier

Bridge







$i = I_m \sin\omega t$ for $0 \leq \omega t \leq \pi$

$i = I_m \sin\omega t$ for $\pi \leq \omega t \leq 2\pi$

$I_m = \dfrac{V_m}{R_f + R_L}$ for Centre-tap rectifier

$I_m = \dfrac{V_m}{2R_f + R_L}$ for bridge rectifier

① Peak Inverse Voltage (PIV)

The maxm voltage that appears across the diode when the diode is non conducting (i.e reverse biased)

② $I_{dc} = \frac{1}{\pi}\int_0^{\pi} i \, d(\omega t) = \frac{1}{\pi}\int_0^{\pi} I_m \sin\omega t \, d(\omega t) = \frac{2 I_m}{\pi}$

③ $V_{dc} = I_{dc} \cdot R_L = \frac{2}{\pi} I_m R_L$

④ $I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} I_m^2 \sin^2 \omega t \, d(\omega t)} = \frac{I_m}{\sqrt{2}}$

⑤ $V_{rms} = \frac{I_m}{\sqrt{2}} \cdot R_L$

⑥ Ripple factor $= \gamma = \frac{I'_{rms}}{I_{dc}}$

Formfactor $= \dfrac{I_m/\sqrt{2}}{2I_m/\pi} = \dfrac{I_{rms}}{I_{dc}} = \dfrac{\pi}{2\sqrt{2}} = 1.11$

$\gamma = \sqrt{\dfrac{I_{rms}^2 - I_{dc}^2}{I_{dc}^2}} = \sqrt{(F.F)^2 - 1} = \sqrt{(1.11)^2 - 1} = 0.482$

(7) Efficiency $= \frac{P_{dc}}{P_{ac}} = \left(\frac{I_{dc}}{I_{rms}}\right)^2 \cdot \frac{R_L}{R_f + R_L} \times 100\%$

$$= \left(\frac{2\sqrt{2}}{\pi}\right)^2 \cdot \frac{1}{1 + R_f/R_L} \times 100$$

$$= \frac{81.2\%}{(1 + R_f/R_L)} \quad \text{if } R_f << R_L,\ \eta \approx 81.2\%$$

(8) <u>Transformer Utilization factor</u> (TUF)

$$TUF = \frac{P_{dc}}{P_{ac(rated)}}$$

$P_{dc} = I_{dc}^2 \cdot R_L$ & P_{ac} (rated) $= V_{rms} \cdot I_{rms}$

<u>For half wave.</u>

$$V_{rms} = \frac{V_m}{\sqrt{2}},\quad I_{rms} = \frac{I_m}{2},\quad I_{dc} = \frac{I_m}{\pi}$$

$$TUF = \frac{I_{dc}^2 \cdot R_L}{\left(\frac{V_m}{\sqrt{2}}\right)\left(\frac{I_m}{2}\right)} = \frac{2\sqrt{2}}{\pi^2} \cdot \frac{1}{1 + (R_f/R_L)}$$

$R_f << R_L$, $TUF = \frac{2\sqrt{2}}{\pi^2} = 0.287$

<u>For full wave.</u>

$$TUF\Big|_{primary} = \frac{I_{dc}^2 R_L}{V_{rms} \cdot I_{rms}} = \frac{\left(\frac{2I_m}{\pi}\right)^2 \cdot R_L}{\left(\frac{V_m}{\sqrt{2}}\right)\left(\frac{I_m}{\sqrt{2}}\right)}$$

$$= \frac{8}{\pi^2} \cdot \frac{R_L}{R_f + R_L}$$

$R_f << R_L$. $TUF\Big|_{primary} = 0.812$

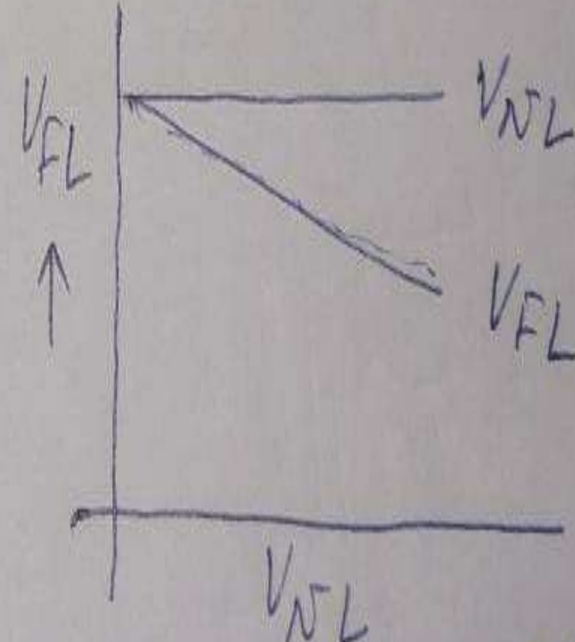
$TUF\Big|_{secondary} = 2 \times TUF\Big|_{secondary} = 2 \times 0.286$

$= 0.572$

$$(TUF)_{av} = \frac{0.812 + 0.572}{2} = 0.692$$

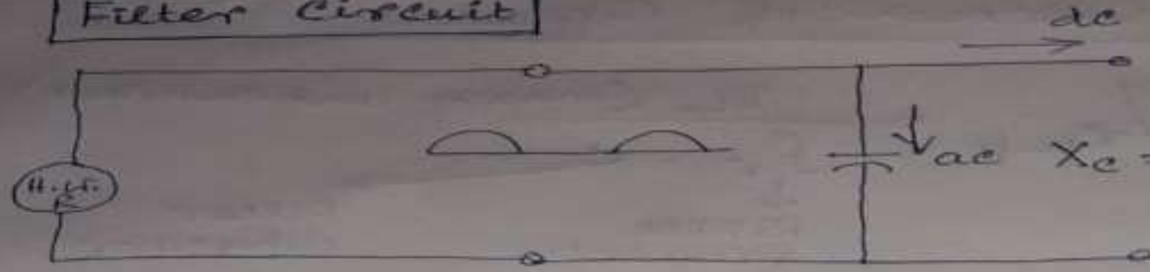
Regulation

$$= \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

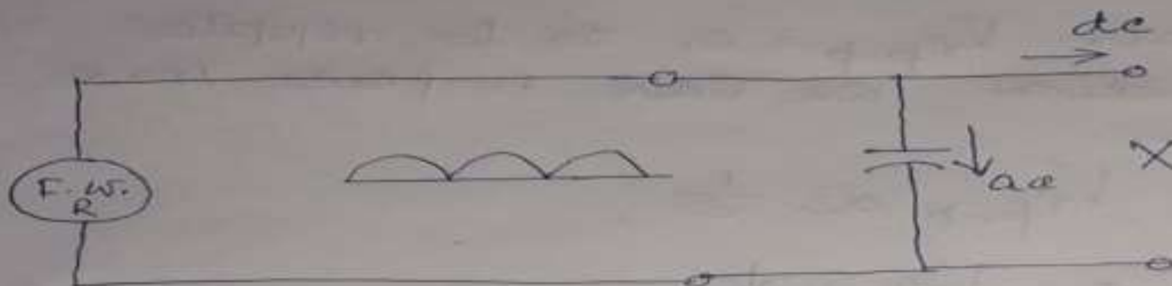


Slope?

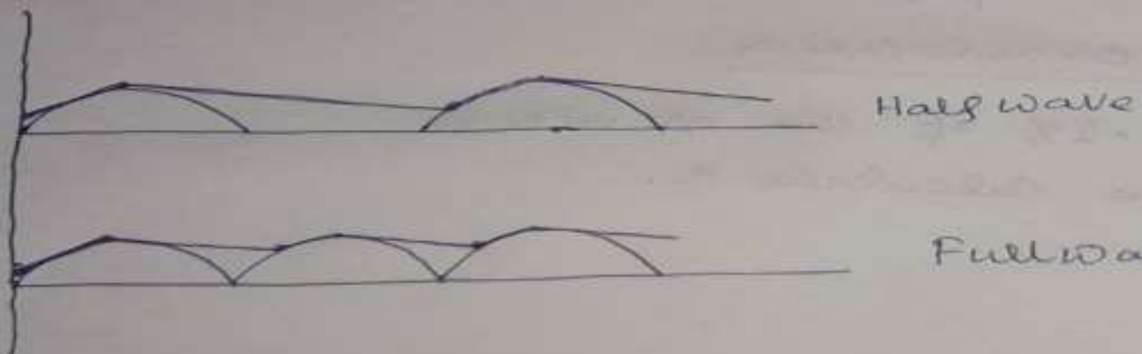
Filter Circuit



$X_c = \frac{1}{2\pi f c}$



$X_c = \frac{1}{2\pi f c}$



In order to bypass all ac components, we require to make $X_c = 0$. for that we have to set $C = \infty$. [Practically impossible]
So we cannot make it fully ripple free.

Selection of Capacitor

$$V_{r_{p-p}} = \frac{I_L \text{ (maxm. load Current)}}{\underset{\substack{\downarrow \\ \text{Ripple frequency}}}{f_r} \cdot \underset{\substack{\downarrow \\ \text{Filter Capacitor}}}{C}}$$

If $I_L = 0$. $V_{r_{p-p}} = 0$, so for ripple estimation we have to place load surely.

$$V_{r_{p-p}} \propto \frac{1}{C}$$

$$C \uparrow, \quad V_{r_{p-p}} \downarrow$$

Practical Consideration.

$V_{r_{pp}} = \cdot 1\%$ of the o/p voltage.

then we calculate C.