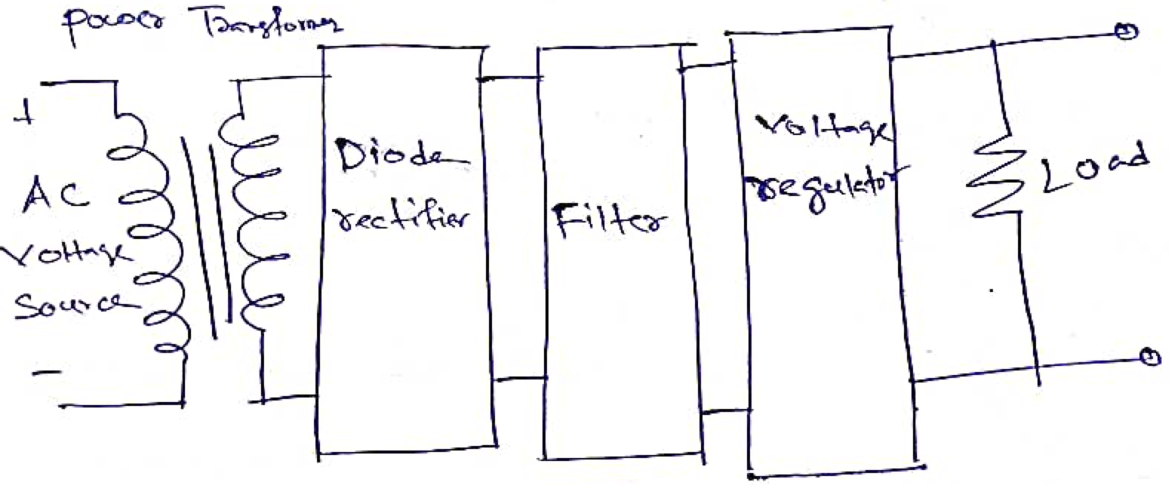
Rectifier Circuits :-

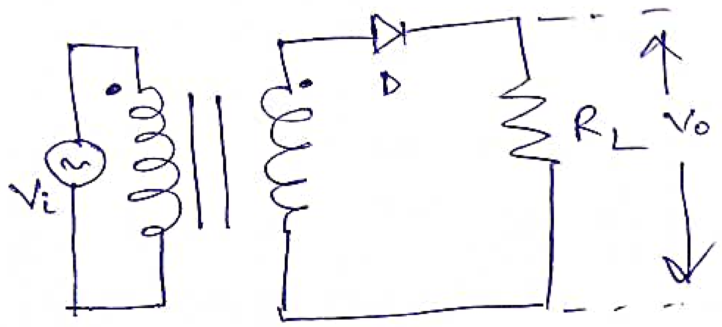
→ Rectification is the process of converting an alternating (ac) voltage into one that is limited to one polarity. The diode is useful for this function because of its nonlinear characteristics, that is current exists for one voltage polarity, but is essentially zero for the opposite polarity.

→ Rectification is classified as half-wave or full wave, with half-wave being the simpler and full wave being more efficient.

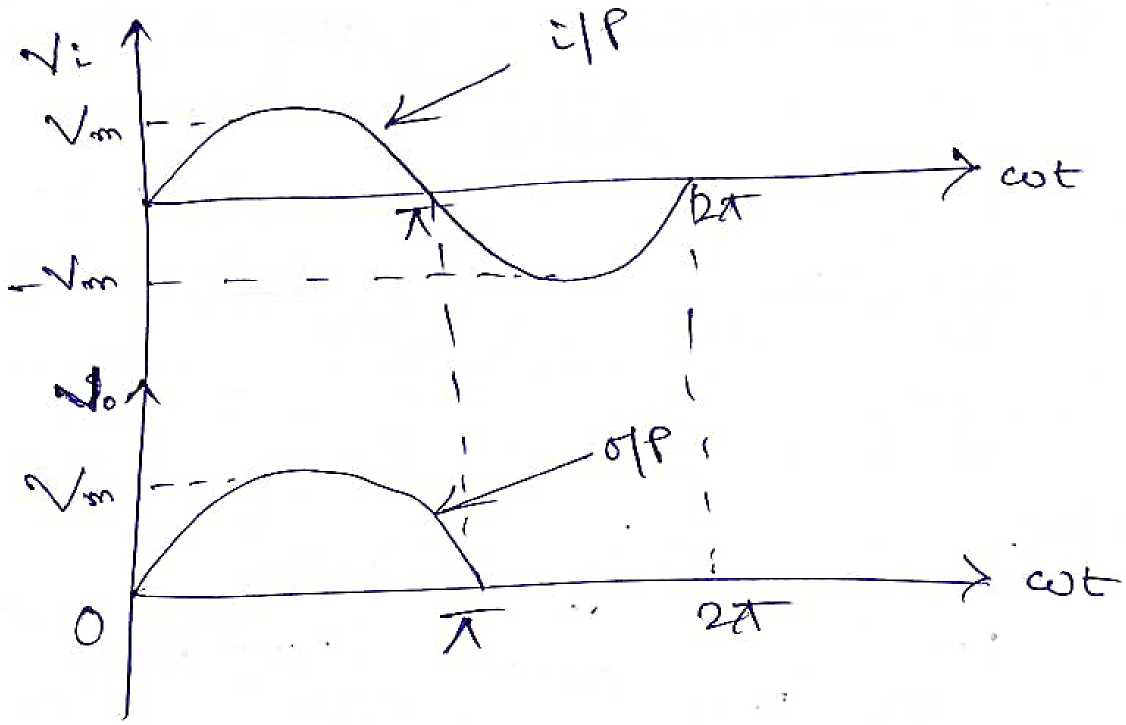


Half wave Rectifier :-

It converts an ac voltage into a pulsating dc voltage using only one half of the ~~appl~~ ac cycle. Fig shows the basic ~~cir~~ circuit and waveforms of a half wave rectifier (HWR).



V_o = pulsating dc o/p voltage



Ripple factor (γ) :- The ratio of rms value of ac component to the dc component in the output is known as ripple factor.

$$\gamma = \frac{\text{rms value of ac component}}{\text{dc value of component}} = \frac{V_{rms}}{V_{dc}}$$

where $V_{rms} = \sqrt{V_{rms}^2 - V_{dc}^2}$

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

The rms value of continuous time period waveform is the square root of the ratio of the square of the waveform function to the time period T, as given by

$$V_{rms} = \sqrt{\frac{\text{square of the area under the curve for one cycle}}{\text{Time period}}}$$

$$= \sqrt{\frac{1}{T}\int_0^T [x(t)]^2 dt}$$

The average or dc content of the voltage across the load is given by

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

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

Therefore $I_{dc} = \dfrac{V_{dc}}{R_L} = \dfrac{V_m}{\pi R_L} = \dfrac{I_m}{\pi}$

If the values of diode forward resistance (r_f) and the transformer secondary winding resistance (r_s) are also ~~and~~ taken into account then

$$V_{dc} = \frac{V_m}{\pi} - I_{dc}(r_s + r_f)$$

$$I_{dc} = \frac{V_{dc}}{(r_s + r_f) + R_L} = \frac{V_m}{\pi(r_s + r_f + R_L)}$$

The rms voltage at the load resistance can be calculated as

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

$$= V_m\left[\frac{1}{4\pi}\int_0^{\pi}(1-\cos 2\omega t)\,d\omega t\right]^{1/2} = \frac{V_m}{2}$$

$$\Gamma = \sqrt{\frac{V_m/2}{V_m/\pi} - 1} = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1} = 1.21$$

Efficiency (η) :- The ratio of dc o/p power to ac i/p power is known as rectifier efficiency (η).

$$\eta = \frac{\text{dc o/p power}}{\text{ac i/p power}} = \frac{P_{dc}}{P_{ac}}$$

$$= \frac{\left(\frac{V_{dc}}{R_L}\right)^2}{\left(\frac{V_{rms}}{R_L}\right)^2} = \frac{\left(\frac{V_m}{\pi}\right)^2}{\left(\frac{V_m}{2}\right)^2} = \frac{4}{\pi^2}$$

$$= 0.406$$

$$= 40.6 \text{ (max)}.$$

Peak Inverse Voltage :- It is defined as the max reverse voltage that a diode can withstand without destroying the junction. The peak inverse voltage across a diode is the peak of the negative half cycle. For half wave rectifier PIV is V_m.

Transformer Utilization Factor (TUF):-

In the design of any power supply, the rating of the transformer should be determined. This can be done with a knowledge of the dc power delivered to the load and the type of rectifying circuit used.

$$TUF = \frac{\text{dc power delivered to the load}}{\text{ac rating of the transformer secondary}}$$

$$= \frac{P_{dc}}{P_{dc\ rated}}$$

In the half-wave rectifying circuit, the rated voltage of the transfer secondary is $V_m/\sqrt{2}$, but the actual rms current flowing through the winding is only $\frac{I_m}{2}$ not $\frac{I_m}{\sqrt{2}}$.

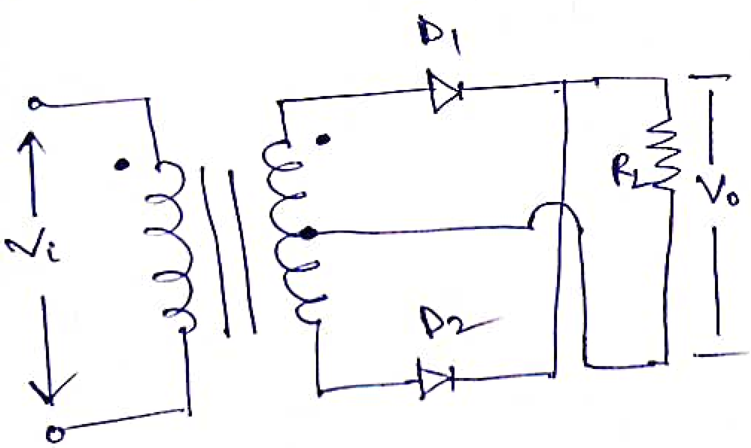
$$TUF = \frac{\frac{I_m^2}{\pi^2} R_L}{\frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}} = \frac{\frac{V_m^2}{\pi^2} \frac{1}{R_L}}{\frac{V_m}{\sqrt{2}} \frac{V_m}{2R_L}} = \frac{2\sqrt{2}}{\pi^2} = 0.$$

Form factor:- $\frac{\text{rms value}}{\text{avg value}} = \frac{V_m/2}{V_m/\pi} = \frac{\pi}{2}$
$= 1.57$

peak factor:- $\frac{\text{Peak value}}{\text{rms value}} = \frac{V_m}{V_m/2} = 2$

Full wave Rectifier:-

It converts an ac voltage into a pulsating dc voltages using both half cycles of the applied ac voltage. It uses two diodes of which one conducts during one half-cycle while the other diode conducts during the other half cycle of the applied ac voltage. There are two types of full-wave rectifiers, viz (i) full wave rectifier with centre tapped transformer and (ii) Full-wave rectifier without transformer (bridge rectifier)



Centre-tapped transformer

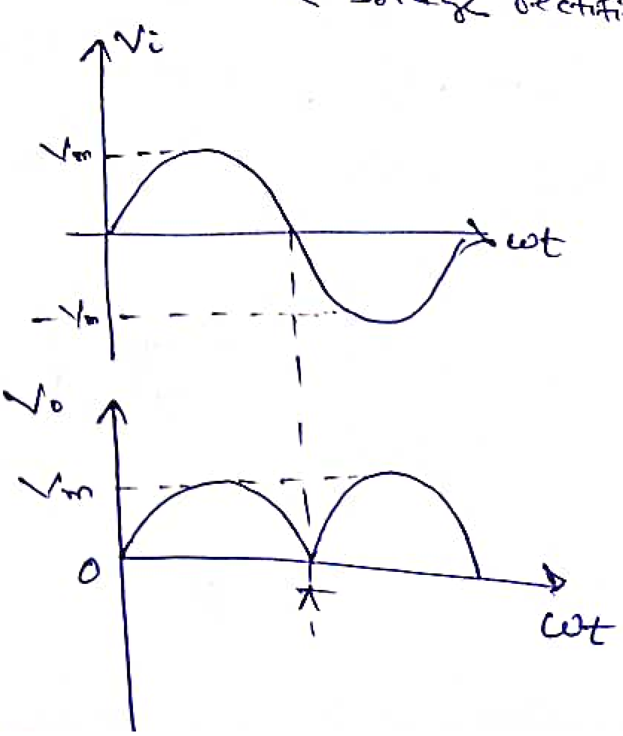


Figure shows the basic ckt and waveforms of full-wave rectifier with a center tap transformer. During positive half of the i/p signal, the anode of the diode D_1 become positive and at the same time, the anode of diode D_2 becomes negative. Hence, D_1 conducts and D_2 does not conduct. The load current flows through D_1 and the voltage drop across R_L will be equal to the i/p voltage.

During the (-ve) half cycle of the i/p, the anode of D_1 becomes negative and the anode of D_2 becomes positive. Hence D_1 does not conduct and D_2 conducts. The load current flows through D_2 and the voltage drop across R_L will be equal to the i/p voltage.

Ripple Factor (J) :-

$$J = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right) - 1}$$

The average voltage or dc voltage available across the load resistance is

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

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

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi} \text{ and } I_{rms} = \frac{I_m}{\sqrt{2}}$$

P.T.O

If the diode forward resistance (r_f) and the transformer Secondary winding resistance (r_s) are included in analysis then

$$V_{dc} = \frac{2V_m}{\pi} - I_{dc}\,(r_s + r_f)$$

$$I_{dc} = \frac{V_{dc}}{(r_s + r_f) + R_L} = \frac{2V_m}{\pi(r_s + r_f + R_L)}$$

The rms value of the voltage at the load resistance is

$$V_{rms} = \sqrt{\left[\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t \; d(\omega t)\right]} = \frac{V_m}{\sqrt{2}}$$

Therefore, $\Gamma = \sqrt{\left(\frac{V_m/\sqrt{2}}{2V_m/\pi}\right)^2 - 1} = \sqrt{\frac{\pi^2}{8} - 1} = 0.482$

<u>Efficiency :-</u>

$$\eta = \frac{\text{dc o/p Power}}{\text{ac i/p power}} = \frac{P_{dc}}{P_{ac}}$$

$$= \frac{(V_{dc})^2/R_L}{(V_{rms})^2/R_L} = \frac{\left[\frac{2V_m}{\pi}\right]^2}{\left[\frac{V_m}{\sqrt{2}}\right]^2} = 0.812$$

$$= 81.2\% \text{ (max)}$$

<u>Form Factor :-</u> $\frac{\text{rms value of the o/p voltage}}{\text{avg value of the o/p voltage}} = \frac{V_m/\sqrt{2}}{2V_m/\pi} = \frac{\pi}{2\sqrt{2}} = 1.11$

<u>Peak factor :-</u> $\frac{\text{Peak value of the o/p voltage}}{\text{rms value of the o/p voltage}}$

$$= \frac{V_m}{V_m/\sqrt{2}} = \sqrt{2}$$