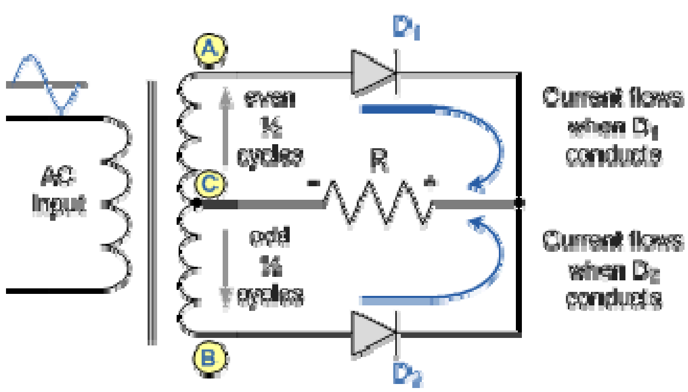
FULL WAVE RECTIFIER

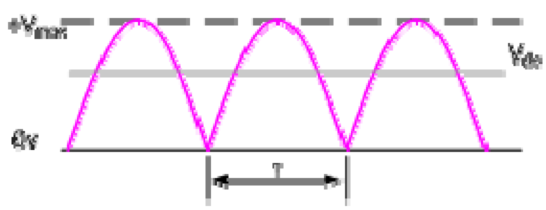
It converts AC voltage into pulsating DC voltage using both half-cycles of applied AC voltage.

There are two types of full wave rectifier (FWR)

1. Centre tapped full wave rectifier (FWR)
2. Full wave bridge rectifier (bridge rectifier)

Centre tapped full wave rectifier (FWR) :





Resultant Output Waveform

During –ve half-cycles the anode of D_1 is positive and anode of diode D_2 is negative. Therefore D_1 is forward biased and D_2 is reverse biased. Current flow through D_1 is I, will flow through RL i.e., $I_L = i$, but then is no current through D_2.

During –ve half-cycles the anode D_1 is –ve and anode of D_2 is +ve. So current is only in D_2.

Average Current $\left(I_{dc}\ \ or\ \ I_{av}\right)$:

$$I_{dc}\ \ or\ \ I_{av} = \frac{1}{\pi}\int_0^{\pi} \text{Im}\sin\omega t\ \ d(\omega t)$$

$$= \frac{1}{\pi} I_m [-\cos\omega t]_0^{\pi}$$

$$= \frac{1}{\pi} I_m [2]$$

$$\boxed{I_{dc} = \frac{2I_m}{\pi} = 0.636 I_m}$$

$$V_{dc}\ \ or\ V_{ac} = \frac{1}{\pi}\int_0^{\pi} V_m \sin\omega t\ \ d\alpha$$

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

$$= \frac{V_m}{\pi}[2]$$

$$= \frac{2V_m}{\pi}$$

$$= 0.636 V_m$$

Rms current :

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^t i^2 d\alpha}$$

$$= \sqrt{\frac{1}{\pi}\int_0^t i^2 m \sin^2\ \omega t d\alpha}$$

$$= \sqrt{\frac{i_m{}^2}{\pi}\int_0^t (1-\cos\omega t) d\alpha}$$

$$= \sqrt{\frac{i_m{}^2}{2\pi}[\omega t - \sin\omega t]_0^{\pi}}$$

$$= \sqrt{\frac{i_m{}^2}{2\pi}[\pi]}$$

$$= \frac{i_m}{\sqrt{2}}$$

$$\boxed{I_{rms} = 0.707 i_m}$$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V^2 d\alpha}$$
$$= \frac{V_m}{\sqrt{2}}$$
$$= 0.707 V_m$$

Ripple factor :

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

$$= \sqrt{\left(\frac{\frac{i_m}{\sqrt{2}}}{\frac{2i_m}{\pi}}\right)^2 - 1}$$
$$= \sqrt{\frac{\pi^2}{8} - 1}$$
$$= 0.483$$

Rectification efficiency :

$$
\begin{aligned}
\%\eta &= \frac{P_{dc}}{P_{ac}} \times 100 \\
&= \frac{I^2{}_{dc} R_L}{I^2{}_{rms}\left(R_L + R_f + R_S\right)} \times 100 \\
&= \frac{\left(\frac{2I_m}{\pi}\right)^2 R_L}{\frac{I_m}{\sqrt{2}} R_L \left(1 + \frac{R_f + R_S}{R_L}\right)} \times 100 \\
&= \frac{4}{\pi^2} \cdot 2 \times 100 \\
&= \frac{8}{\pi^2} \times 100 \qquad\qquad R_f + R_S << R_L \\
&= 0.81 \times 100 \\
&= 81.2\%
\end{aligned}
$$

Only 81.2% of ac power is converted to dc power efficiency of FWR is double to HWR.

Form Factor :

$$\text{Form factor } = \frac{I_m}{I_{avg}} = \frac{\frac{I_m}{\sqrt{2}}}{\frac{2I_m}{\pi}} = \frac{\pi}{2\sqrt{2}} = 1.11$$

Peak factor :

$$\text{Peak factor } = \frac{I_m}{I_{rms}} = \frac{I_m}{\frac{I_m}{\sqrt{2}}} = \sqrt{2} = 1.414$$

Transformer utilization factor :

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

$$= \frac{I^2{}_{dc} R_L}{V_{ac}(rms) I_{ac}(rms)}$$

$$= \frac{\frac{4I_m{}^2}{\pi^2} \times R_L}{2\left(\frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}\right)}$$

$$= \frac{4V_m}{2(\pi^2 V_m)}(2\sqrt{2})$$

$$= \frac{8\sqrt{2}}{2\pi^2} = \frac{1.146}{2} = 0.573$$

PIV : Peak inverse voltage

PIV of fullwave rectifier $= 2V_m$

Because entire transformer secondary voltge is appeared across non-conducting diode (reverse biased diode) because voltage drop across forward biased diode is zero. Therefore that voltage $'V_m'$ is added to the voltage applied to non-conducting diiode.

Transformer utilization factor (TUF) :

In FWR (centre-tapped) the secondary current flows through each half separately fjasdkj every half cycle. In each half of secondary winding current flows through 180^0, while primary of transformer carries current continuously (current flows through 360). Here, the average TUF is obtained by considering primary and secondary windings respectively.

$$Average\ TUF = \frac{TUF(primary) + TUF(\sec ondary)}{2}$$

$$\text{Secondary TUF} = \frac{dc\ \ power\ \ delivered\ \ to\ \ load}{ac\ \ power\ \ rating\ \ of\ \ transformer\ \ \sec ondary}$$

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

P_{ac} (rated) secondary = P_{ac} rated first half + P_{ac} (rated second half)

$$= \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{2} + \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{2}$$

$$= 2\left(\frac{V_m I_m}{2\sqrt{2}}\right)$$

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

$$\text{Secondary TUF } = \frac{\frac{4I_m{}^2}{\pi^2} R_L}{\frac{V_m I_m}{\sqrt{2}}}$$

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

$$= 0.573$$

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

$$P_{ac}(rated)\ primary = V_{ac}(rms) I_{ac}(rms)$$

Since the primary winding carries a full sinusoidal

$$P_{ac}(rated)\ primary = \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}$$

$$\frac{V_m . I_m}{2} =$$

$$\text{Primary TUF } = \frac{\frac{4I_m{}^2}{\pi^2} \cdot R_L}{\frac{V_m I_m}{2}}$$

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

$$= 0.812$$

$$TUF\ \ avergae = \frac{0.574 + 0.812}{2}$$
$$= \frac{1.386}{2}$$
$$= 0.693$$

DC power delivered to load $= 0.693 \times$ ac power rating of secondary transformer.

TUF of full wave rectifier (0.693) is better than

TUF of half wave rectifier (0.2870).

Merits :

1. It conducts for both half cycles of A.C input
2. High efficiency
3. low ripple factor (0.482)
4. High TUF (0.693)

problems

1. A half-wave rectifier having $R_L = 1000\Omega$ rectifies an a.c. voltage of 325V peak value and a diode has $R_f = 100\Omega$ Calculate

i. Peak, avg and rms value of current

ii. dc power output

iii. ac input power

iv. Rectification efficiency

Sol. $R_L = 1000\Omega \quad R_f = 100\Omega$

$$I_m = \frac{V_m}{R_L + R_f} = \frac{325}{1100} = 0.295A$$

$$I_{rms} = \frac{I_m}{2} = 0.1067A$$

$$I_{avg} = \frac{I_m}{\pi} = \frac{0.272}{\pi} = 0.094A$$

Dc Output power $= I^2{}_{dc} R_L$

$$= (0.094)^2 1000$$
$$= 8.836W$$

AC input power $= I^2{}_{rms}\left(R_f + R_L\right)$

$$= (0.147)^2 (1100)$$
$$= 23.7W$$

$$\%\eta = \frac{P_{dc}}{P_{ac}} \times 100$$
$$= \frac{8.836}{23.7} \times 100$$
$$= 37.28\%$$