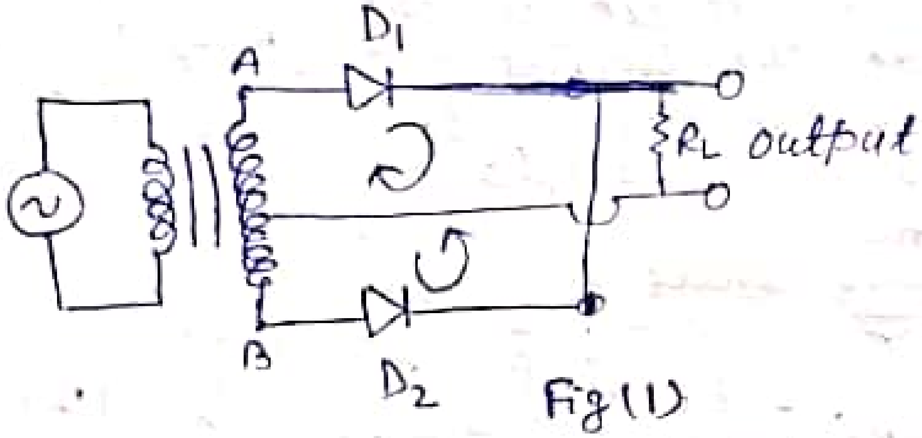
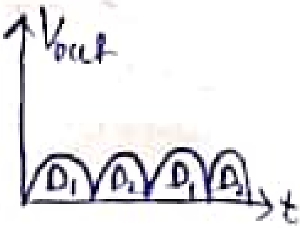
Topic:- FULL WAVE RECTIFIER
(UG-III)

A full wave rectifier circuit is shown in fig(1). It consists of two p-n junction diodes with a centre tapped transformer.





Fig(1)

The output is obtained across load resistance R_L between terminals as shown. The input a.c. signal is supplied by the transformer on the secondary coil AB.

Operation:- During the +ve half cycle of the input a.c. the end A of secondary winding is +ve and end B -ve. This makes D_1 forward biased and D_2 reverse biased. Thus, D_1 conducts current and D_2 does not conduct.

Similarly, during the -ve half cycle of input a.c. the end A and B of the secondary winding become -ve and +ve respectively. This makes D_1 reverse biased and D_2 forward biased. Thus, D_2 conducts and D_1 is cut off.

Thus the current in the load R_L is in the same direction for both half cycle of input a.c. voltage. Thus, continuous output is obtained across R_L in the form of pulsating d.c.

ANALYSIS OF FULL WAVE RECTIFIER

Let us consider an a.c. voltage ~~E=E₀~~ $V = V_0 \sin \omega t$ is to be rectified. If both the diodes D_1 and D_2 are supposed to be identical then the respective diode currents are given by

$$I_1 = \frac{V_0 \sin \omega t}{r + R_L} \quad \text{and } I_2 = 0 \text{ for first half cycle i.e from } t = 0 \text{ to } t = \frac{T}{2}$$

$$= I_0 \sin \omega t \longrightarrow (1a)$$

And $I_1 = 0$; $I_2 = \dfrac{V_0 \sin(\omega t + \pi)}{r + R_L}$

$$= -\frac{V_0 \sin \omega t}{r + R_L} \quad \text{for next half cycle}$$

$$= -I_0 \sin \omega t \quad \text{i.e from } t = T/2 \text{ to } t = T$$

$$\longrightarrow (1b)$$

Here, I_1 and I_2 = current of two diodes

r = a.c. resistance of each diode

R_L = Load resistance

π = phase difference between first and 2nd half cycle.

Now let us calculate the following things

Ⓐ Output D.C. current and power:→

Since each diode conducts alternately for only half cycles of the input a.c voltage, the d.c. current is given by

$$I_{dc} = \frac{1}{T}\int_0^T I\,dt$$

$$= \frac{1}{T}\left[\int_0^{T/2} I_1\,dt + \int_{T/2}^{T} I_2\,dt\right]$$

$$= \frac{1}{T}\left[\int_0^{T/2} I_0 \sin\omega t\,dt + \int_{T/2}^{T} -I_0 \sin\omega t\,dt\right]$$

$$= \frac{I_0}{T}\left[\int_0^{T/2} (\sin\omega t)\,dt - \int_{T/2}^{T} (\sin\omega t)\,dt\right]$$

$$= \frac{I_0}{T}\left[\left(-\frac{\cos\omega t}{\omega}\right)_0^{T/2} - \left(-\frac{\cos\omega t}{\omega}\right)_{T/2}^{T}\right]$$

$$= \frac{I_0}{T\omega}\left[(\cos\omega t)_{T/2}^{T} - (\cos\omega t)_0^{T/2}\right]$$

$$= \frac{I_0}{T\omega}\left[\left(\cos\frac{2\pi}{T}.T - \cos\frac{2\pi}{T}.\frac{T}{2}\right) - \left(\cos\frac{2\pi}{T}.\frac{T}{2} - \cos 0\right)\right]$$

$$= \frac{I_0}{T\omega}\left[1-(-1) - (-1-1)\right]$$

$$= \frac{I_0}{T\omega}\left[2+2\right] = \frac{4 I_0}{T \cdot \frac{2\pi}{T}} = \frac{2I_0}{\pi}$$

$$\therefore I_{dc} = \frac{2}{\pi}\cdot\frac{V_0}{r+R_L} \longrightarrow (2) \quad \left(\because I_0 = \frac{V_0}{r+R_L}\right)$$

The d.c. output voltage will be

$$V_{dc} = I_{dc} \times R_L = \frac{2I_0}{\pi}.R_L = \frac{2}{\pi}\frac{V_0}{(r+R_L)}R_L \longrightarrow (3)$$

The d.c. power output is given by

$$P_{dc} = I_{dc}^2 R_L = \frac{4I_0^2}{\pi}R_L = \frac{4}{\pi^2}\frac{V_0^2}{(r+R_L)^2}R_L \longrightarrow (4)$$

(B) A.C. input power:

The total a.c. power input into the circuit is

$$P_{ac} = I_{rms}^2 (r+R_L) \longrightarrow (5)$$

where, $I_{rms} = \sqrt{\frac{1}{T}\int_0^T I^2 dt} = \left[\frac{1}{T}\left\{\int_0^{T/2} I_1^2 dt + \int_{T/2}^{T} I_2^2 dt\right\}\right]^{1/2}$

$$= \left[\frac{1}{T}\left\{\int_0^{T/2} I_0^2 \sin^2\omega t\,dt + \int_{T/2}^{T} (-I_0)^2 \sin^2\omega t\,dt\right\}\right]^{1/2}$$

$$= \left[\frac{I_0^2}{T}\int_0^T \sin^2\omega t\,dt\right]^{1/2} = \left[\frac{I_0^2}{T}\cdot\frac{T}{2}\right]^{1/2}$$

$$= \frac{I_0}{\sqrt{2}} \qquad \left(\because \int_0^T \sin^2\omega t\,dt = \frac{T}{2}\right)$$

$\therefore$ from eqn (5) $P_{ac} = \left(\frac{I_0}{\sqrt{2}}\right)^2 (r+R_L) = \frac{I_0^2}{2}(r+R_L)$

$$= \frac{V_0^2}{2(r+R_L)} \longrightarrow (6)$$

© Rectifier efficiency:-

$$\eta_R = \left(\frac{P_{dc}}{P_{ac}} \times 100\right)\% = \frac{8R_L}{\pi^2(r+R_L)} \times 100\%$$

$$= \frac{81.2}{\left(1+\frac{r}{R_L}\right)}\,\%$$

Therefore, a full wave rectifier is twice as effective as half wave rectifier.

(D) Ripple Factor:- $r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{1.23-1} = 0.482$