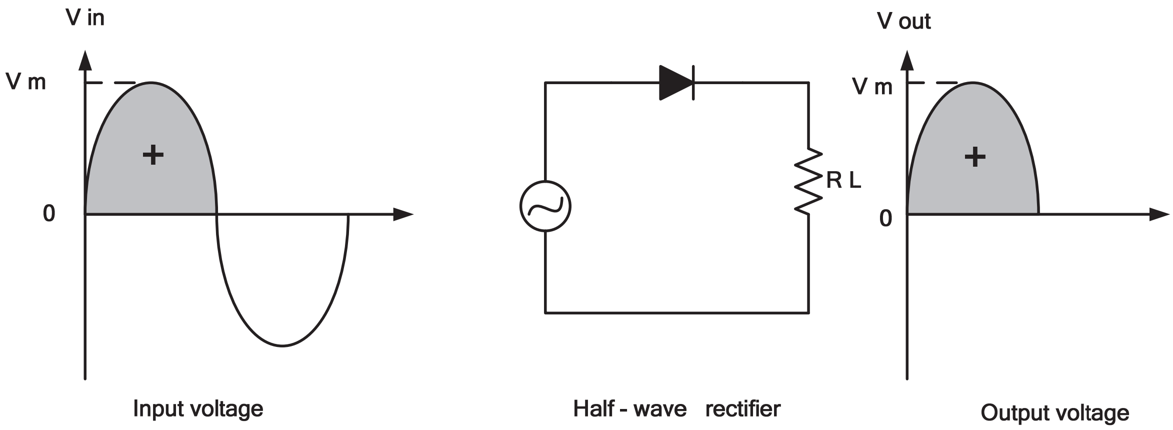
Lecture No. 29-30

“Rectifiers”

Rectifier

<u>Half – wave rectifier</u> :

A diode is connected to A.C source and load resistance as shown in figure below.



When the sinusoidal input voltage goes positive , the diode is forward biased and conducts current through the load resistor . The current produces an output voltage across R_L , which has the same shape as the positive half – cycle of the input voltage .
When the input voltage goes negative during the second half of its cycle the diode is reversed biased . There is no current , so the voltage across R_L is zero . The net result is that only the positive half – cycle of A.C input voltage appears across the load .

We can calculate the output voltage and output current as below :

$$V_{av} = \frac{V_m}{\pi} \quad \text{(if barrier potential is neglected)}$$

$$V_{av} = \frac{V_m - 0.7}{\pi} \quad \text{(if the barrier potential is not neglected)}$$

$$V_{r.m.s} = \frac{V_m}{2}$$

$$I_{r.m.s} = \frac{I_m}{2}$$

Input maximum voltage (V_m) = input r.m.s voltage x √2

Efficiency of half – wave rectifier :

The ratio of D.C output power to the applied input A.C power is known as rectifier efficiency .

$$\eta = \frac{\text{D.C output power}}{\text{A.C input power}}$$

The output current is pulsating direct current , therefore in order to find D.C power , average current ($I_{d.c}$) has to be find out .

$$I_{av} = I_{d.c} = \frac{I_m}{\pi}$$

$$P_{d.c} = (I_{d.c})^2 \times R_L$$

$$P_{d.c} = (I_m / \pi)^2 \times R_L$$

The A.C input power has to be find out as :

$P_{a.c} = I^2_{r.m.s}$ x $(R_f + R_L)$ where R_f is is the forward resistance of the diode .

$$I_{r.m.s} = \frac{I_m}{2}$$

$$P_{a.c} = (I_m / 2)^2 \text{ x } (R_f + R_L)$$

$$\eta = \frac{(I_m / \pi)^2 \text{ x } R_L}{(I_m / 2)^2 \text{ x } (R_f + R_L)}$$

$$\eta = \frac{0.406 \ R_L}{R_f + R_L}$$

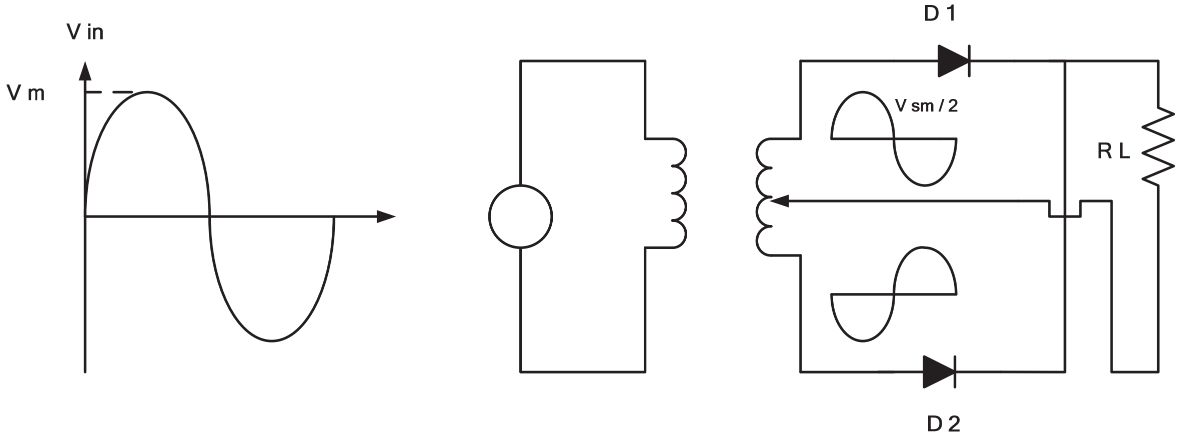
$$\eta = \frac{0.406}{1 + (R_f / R_L)}$$

The efficiency will be maximum if R_f is negligible as compared to R_L

Maximum efficiency $\eta_{max.} = 40.6 \%$

2. Center – tapped full wave rectifier :

A center – tapped full wave rectifier uses two diodes connected to the secondary of a center – tapped transformer as shown in figure below .



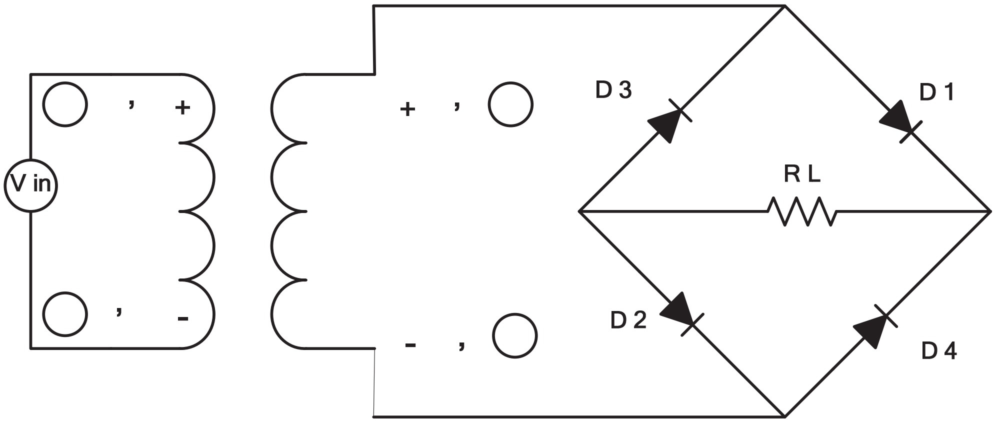
Half of the total secondary voltage appears between the center tap and each diode . For positive half – cycle of the input voltage , the positive of the secondary voltage will make diode D1 forward biased and diode D2 reverse biased (D1 ON , D2 OFF).
For negative half – cycle an opposite condition occurs (D1 OFF , D2 ON).
Because the output current during both the positive and negative portion of the input cycle is in the same direction through the load resistor , we shall obtain full wave rectified D.C voltage .

$$V_{out} = \frac{V_{m(sec)}}{2} - 0.7 \quad \text{volt}$$

$$V_{d.c} = V_{av} = \frac{2\,V_{out}}{\pi}$$

3. Bridge full wave rectifier :

The bridge rectifier uses four diodes connected as shown in figure below . When the input voltage is positive , diodes D1 and D2 are forward biased and conduct current and voltage developed across the load . During this time D3 and D4 are reverse biased .When the input voltage is negative D3 and D4 are forward biased and conduct current , while D1 and D2 are reversed biased .



+ , - (D1 , D2) Forward biased

(+) (-) (D3 , D4) Reversed biasd

$V_{out} = V_{m(sec)} - 1.4$ **(because two diodes conduct at the same time)**

$$V_{av} = \frac{2V_{out}}{\pi}$$

Efficiency of full wave rectifier :

$$\eta = \frac{\text{D.C output power}}{\text{A.C input power}}$$

Find out D.C output power:

$$P_{d.c} = I^2_{d.c} \times R_L$$

$$I_{av} = I_{d.c} = \frac{2\, I_m}{\pi}$$

$$P_{d.c} = (2\, I_m / \pi)^2 \times R_L$$

Find out A.C input power:

$$P_{a.c} = I^2_{r.m.s} \times (R_f + R_L)$$

$$I_{r.m.s} = \frac{I_m}{\sqrt{2}}$$

$$P_{a.c} = (I_m / \sqrt{2})^2 \times (R_f + R_L)$$

$$\eta = \frac{(2\, I_m / \pi)^2 \times R_L}{(I_m / \sqrt{2})^2 \times (R_f + R_L)}$$

$$\eta = \frac{4\, I^2_m \times R_L}{\pi^2} \times \frac{2}{I^2_m\, (R_f + R_L)}$$

$$\eta = \frac{8 R_L}{\pi^2 \left(R_f + R_L \right)}$$

$$\eta = \frac{0.812}{1 + \left(R_f / R_L \right)}$$

Therefore maximum efficiency = 81.2 %