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Topic:- Rectification (Half Wave)
U.G. III

Rectification is the process by which an alternating current or voltage is converted into a direct current or voltage. Any electrical device offering a low resistance to the current in one direction and a high resistance to the current in the opposite direction is called a "rectifier".

The vacuum diod and p-n junction diodes are commonly used as rectifiers. Here we will discuss the p-n junction diode rectifier. There are two types of rectification; half wave rectification and full wave rectification, depending upon the period of conduction.

Half Wave Rectifier

A rectifier in which current conducts only during positive half cycle of input a.c. signal but not for negative half cycle, is called "half wave rectifier".

A half wave rectifier circuit is shown in fig (1). A transformer is used at the input to step up or step down the ac mains voltage connected to the primary. Here an a.c. signal $e = E_m \sin \omega t$ is applied across a circuit consisting of a p-n junction diod with load resistance R_L. Since diode has an unidirectional properties, it conducts only during positive half cycle of input a.c. signal but not during ~~half cycle~~ negative half cyclic

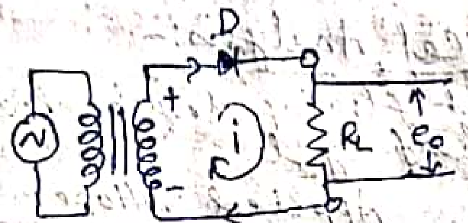

Fig (1)

The shape of the current through R_L consists of half sinusoidal wave is shown in fig (2).

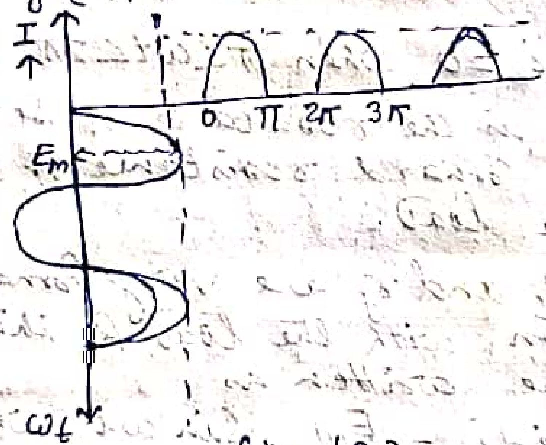

fig (2)

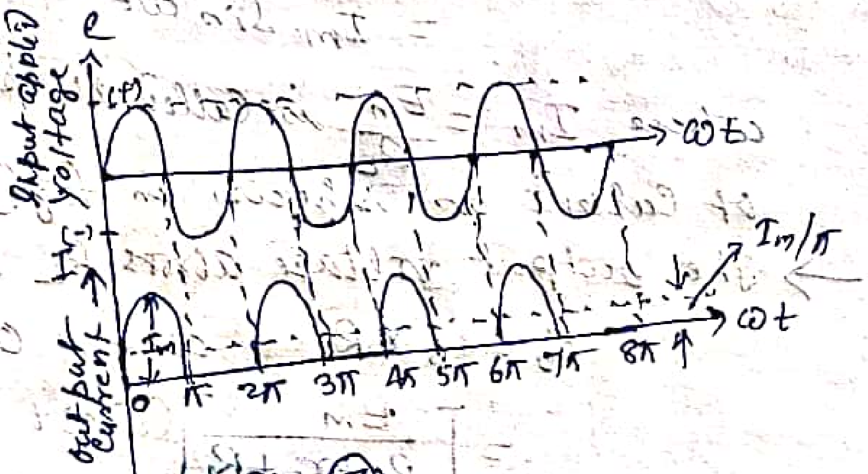

Fig (3)

Mathematical Analysis:-

* The current flowing through diode during positive half cycle,

$$i = i_b = \frac{\text{Applied voltage}}{\text{Total resistance of the circuit}}$$

$$= \frac{E_m \sin \omega t}{R_s + r_f + R_L} \quad \text{when } 0 < \omega t < \pi \quad \longrightarrow (1)$$

and $i_b = 0$ when $\pi < \omega t < 2\pi$ $\longrightarrow$ (2)

Here R_s is the resistance of secondary coil; r_f the forward resistance of diode and R_L the load.

If R_s and r_f are very small in comparison with the load R_L then eqn (1) can be written as

$$i = i_b = \frac{E_m}{R_L} \sin \omega t \quad \text{when } 0 < \omega t < \pi \quad \longrightarrow (3)$$

$$= I_m \sin \omega t$$

where $I_m = \frac{E_m}{R_L}$ is called the peak value of current as shown in fig (3)

→ The output voltage across R_L is given:

$$e_0 = i_b \times R_L \quad \text{when } 0 < \omega t < \pi$$

$$= \left[\frac{E_m}{R_s + r_f + R_L}\right] \sin \omega t \quad \longrightarrow (4)$$

$$= (I_m R_L) \sin \omega t \quad \longrightarrow (5)$$

→ The d.c. or average Current I_{dc} is given by

$$I_{dc} = \frac{1}{2\pi}\left[\int_0^{\pi} i\,d(\omega t) + \int_{\pi}^{2\pi} i\,d(\omega t)\right] \longrightarrow (5)$$

The second term in the bracket is zero since there is no conduction during negative half or π to 2π interval of input.

So,

$$I_{dc} = \frac{1}{2\pi}\int_0^{\pi} i\,d(\omega t) \quad \text{--- (6)}$$

Substituting for i from eqn (3), we have

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

$$= \frac{(-)E_m}{2\pi R_L}\left[\cos\omega t\right]_0^{\pi}$$

$$= \frac{E_m}{\pi R_L} = \frac{I_m}{\pi} \longrightarrow (7)$$

This current has been shown as a dashed straight line in fig (3).

→ The effective value of the current in the load (output) is the R.M.S. value of current and is given by

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

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

Substituting for i and noting that there is no conduction for the interval π to 2π i.e second term is zero, we have

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

$$= \frac{I_m}{2} \longrightarrow (8)$$

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→ Efficiency of Rectifier:—

The efficiency of rectifier is defined as the ratio of the d.c. output power to the a.c. input power.

i.e. $\eta = \frac{P_{dc}}{P_{ac}} = \frac{I_{dc}^2 R_L}{(I_{rms})^2(r_f+R_L)}$

$= \frac{(I_m/\pi)^2 R_L}{(I_m/2)^2(r_f+R_L)} = \frac{4}{\pi^2}\left[\frac{1}{\frac{r_f}{R_L}+1}\right]$

$\approx \frac{4}{\pi^2} = 0.406$ as $r_f << R_L$

Thus the maximum efficiency of a half wave rectifier is 40.6% i.e under this condition only 40.6% of ~~input~~ a.c input power is converted into d.c. power in load.

→ Ripple factor

The output of the rectifier is comprised of both a.c & d.c. power so the ratio of effective or r.m.s value of a.c component to d.c. component is called ripple factor r.

i.e $r = \frac{\text{effective or r.m.s value of a.c. component}}{\text{d.c. component}}$

$= \frac{(I_r)_{rms}}{I_{dc}}$

Also, $I_{rms}^2 = I_{dc}^2 + (I_r)_{rms}^2 \therefore (I_r)_{rms}^2 = I_{rms}^2 - I_{dc}^2$

$\therefore r = \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}} = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1} = \sqrt{\eta - 1}$

$= \sqrt{\frac{\pi^2}{4} - 1} = 1.12$

This indicates that the amount of a.c voltage present in the output is 121% of the d.c. voltage.