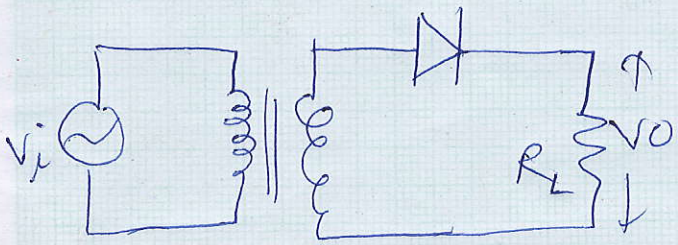
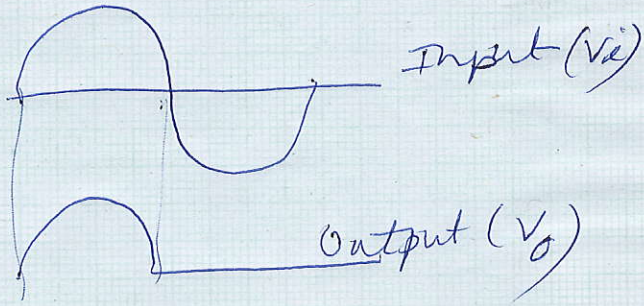
LECTURE 5TH OCT 2020

RECTIFIERS

A rectifier is a circuit which uses one or more diodes to convert a.c. voltage into pulsating d.c. voltage.

(1) HALF WAVE RECTIFIER.





CONSTRUCTION

It consists of a single diode in series with load resistor. The input is transformer coupled so that the source voltage can be stepped up or down and a.c. power is isolated from the rectifier circuit to reduce chances of getting shock.

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

where V_1 = rms of primary voltage
V_2 = rms of secondary voltage
N_1 = No. of turns in primary winding
N_2 = No. of turns in secondary winding.

Working:

(i) +ve half cycle

The diode is forward biased and acts as a short circuit. Voltage is produced across load resistor. The voltage produced across R_L

has the same shape as that of +ve input half cycle of a.c. input voltage.

(ii) -ve half cycle:

The diode is revarse biased and does not conduct. There is no current flow or voltage drop across R_L i.e. $i_d = 0$, $V_o = 0$

The circuit uses only half cycle of the ac input voltage ∴ known as half wave rectifier

PARAMETERS

(1) AVERAGE OR D.C. VALUE OF LOAD VOLTAGE (V_{dc})

$$V_{dc} = \frac{\text{Area under the curve over full cycle}}{\text{Base}}$$

$$= \int_0^{\pi} \frac{v\, d\theta}{2\pi} = \frac{1}{2\pi}\int_0^{\pi} V_m \sin\theta\, d\theta = \frac{V_m}{2\pi}\left(-\cos\theta\right)_0^{\pi}$$

$$= \frac{V_m}{2\pi}\left[+1-(-1)\right] = \frac{V_m}{2\pi} \times 2 = \frac{V_m}{\pi}$$

$$= 0.318\, V_m.$$

(2) AVERAGE OR DC VALUE OF LOAD CURRENT.

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

$$I_m = \frac{V_m}{R_L} \quad \therefore I_{dc} = \frac{I_m}{\pi} = 0.318\, I_m$$

(3) RMS CURRENT

$$I_{rms} = \sqrt{\frac{\int_0^{\pi} i^2 \, d\theta}{2\pi}} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} I_m^2 \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\int_0^{\pi}\left(\frac{1-\cos 2\theta}{2}\right) d\theta}$$

$$= \sqrt{\frac{I_m^2}{4\pi}\left[(\theta)_0^{\pi} - \left(\frac{\sin 2\theta}{2}\right)_0^{\pi}\right]}$$

$$= \sqrt{\frac{I_m^2}{4\pi}[\pi - 0]} = \sqrt{\frac{I_m^2}{4}} = \frac{I_m}{2}$$

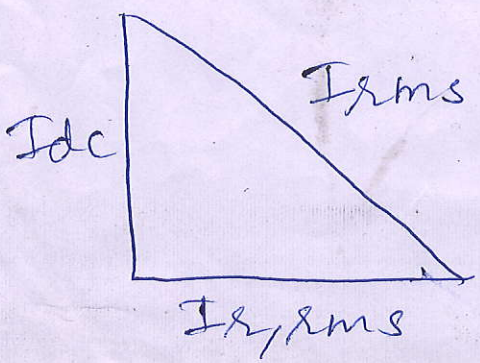
(4) RIPPLE FACTOR

The output voltage (or load current) of a rectifier consists of 2 components namely d.c. component and a.c. component. The a.c. component present in the output is called ripple.

Smaller the ripple, more effective will be the rectifier

$$\gamma = \frac{\text{The rms value of a.c. component of output voltage}}{\text{The d.c. component of O/p voltage}}$$

$$= \frac{V_{r(rms)}}{V_{dc}} = \frac{I_{r(rms)}}{I_{dc}}$$



$$I_{rms} = \sqrt{I_{dc}^2 + I_{r,rms}^2}$$

$$\frac{I_{rms}}{I_{dc}} = \frac{\sqrt{I_{dc}^2 + I_{r,rms}^2}}{I_{dc}}$$

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

Squaring both sides

$$\frac{I^2_{rms}}{I^2_{dc}} = 1+\left(\frac{I_{r,rms}}{I_{dc}}\right)^2$$

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

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

$$= \sqrt{\left(\frac{I_m/2}{I_m/\pi}\right)^2 - 1} = \sqrt{\frac{I_m^2}{4} \times \frac{\pi^2}{I_m^2} - 1}$$

$$= \sqrt{\frac{\pi^2}{4} - 1} = 1.21$$

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

(5) Efficiency or ratio of rectification

$$\eta = \frac{\text{d.c. power delivered to load}}{\text{a.c. input power from transformer secondary}}$$

$$= \frac{P_{dc}}{P_{AC}} = \frac{I^2_{dc} R_L}{2 I^2_{rms} (R_f + R_L)}$$

$$= \frac{\left(\frac{I_m}{\pi}\right)^2 R_L}{\left(\frac{I_m}{2}\right)^2 (R_f + R_L)} = \frac{4}{\pi^2}\left(\frac{R_f}{R_L + R_L}\right)$$

$\therefore \frac{4}{\pi^2}\left(\frac{1}{\frac{R_f}{R_L}+1}\right) = \frac{4}{\pi^2}$ as $\frac{R_f}{R_L} \ll 1$ as $R_f << R_L$

$= 0.406$

(6) Peak Inverse voltage

The maximum reverse voltage is called Peak Inverse voltage (PIV)

During -ve half cycle when the diode is reverse biased, the maximum value of voltage comming across the diode is called Peak Inverse voltage.

$PIV = V_m$.

(7) Form factor

$= \frac{\text{rms value}}{\text{average value}} = \frac{I_m/2}{I_m/\pi} = \pi/2$

$= 1.57$.

Advantages of Half Wave rectifier

1. Uses only one diode
2. circuit is very easy to design
3. No centre tap on transformer.

Disadvantages

(1) High ripple factor (1.21)

(2) Very low efficiency (40.16%)