VIVEKANANDA COLLEGE THAKURPUKUR KOLKATA-700063

NAAC ACCREDITED ‘A’ GRADE

Topic: HALF WAVE RECTIFIER

Course Title: Analog Systems and Applications

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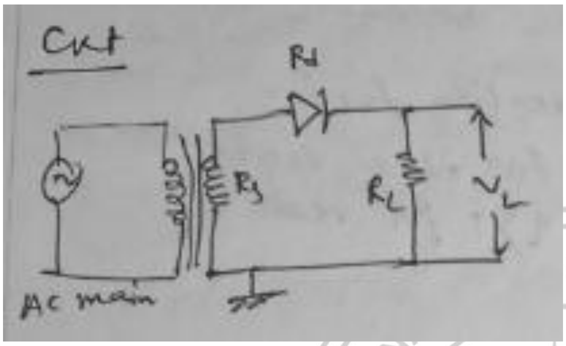
2. TWO TERMINAL DEVIECES AND THEIR APPLICATION

a. Rectifier Diode:-

Half Wave Rectifier

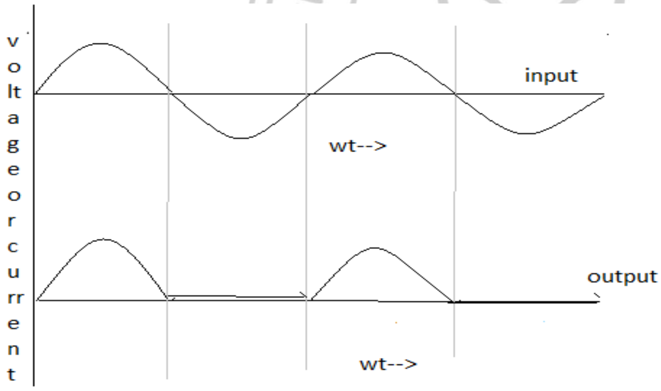
Definition- It is a device of ordinary pn-junction diode and able to convert half cycle of an alternative current/voltage signal into unidirectional current or voltage signal.

Circuit diagram:



Ckt operation: - when p side of the diode is +ve current will flow through it and we have current through R_L. If the p side of diode is –ve then the diode is in reverse bias and no current will flow through it. So +ve cycle will present in output but not the –ve cycle.

Input output diagram:-



The input current is $i=i_0\sin(wt)$ and output current is $i= i_0\sin(wt)$ for $0<wt<\pi$

$i=0$ for $\pi<wt<2\pi$

The output d.c value of the current is the average value of output signal. So $i_{d.c}$ can be calculated as –

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

$$= \frac{1}{T}\cdot\left[\int_0^{T/2} I_0 \sin(\omega t)\,dt + \int_{T/2}^{T} 0\,dt\right]$$

$$= \frac{1}{T}\cdot I_0 \left(\frac{-\cos(\omega t)}{\omega}\right)\Bigg|_0^{T/2}$$

$$= \frac{I_0}{\omega T}\left(-\cos\left(\frac{\omega T}{2}\right) + \cos 0\right)$$

$$= \frac{I_0}{2\pi}\left(-(-1)+1\right) = \frac{I_0}{\pi}$$

a d.c ammeter will read the current through R_L.

RMS Current($i_{a.c}$)

A.c equivalent of output current is $I_{r.m.s}$ can be calculated as

$$I_{rms} = \left[\frac{1}{2\pi}\int_0^{\pi} i^2\,d(\omega t)\right]^{\frac{1}{2}} = \left[\frac{I_0^2}{2\pi}\int_0^{\pi} \sin^2(\omega t)\,d(\omega t)\right]^{1/2}$$

$$= \left[\frac{I_0^2}{2\pi}\int_0^{\pi}\left(\frac{1-\cos(2\omega t)}{2}\right)d(\omega t)\right]^{\frac{1}{2}} = \left[\frac{I_0^2}{2\pi}\cdot\left(\frac{1}{2}\cdot\pi\right)\right]^{\frac{1}{2}}$$

$$= \frac{I_0}{2}$$

Total input power $P_{in} = I_{rms}^2 (R_f + R_L)$

Total output power $P_{out} = I_{dc}^2 \cdot R_L$

Efficiency of rectification(η):

It measures the fraction of total input power which is converted to d.c .

Thus, the efficiency of rectification,

$$\eta = \frac{P_{dc}}{P_{in}} \times 100\% = \frac{I_{dc}^2 R_L}{I_{rms}^2 (R_L + R_f)} \times 100\%$$

For half wave rectifier the efficiency is

$$\eta = \frac{(I_0/\pi)^2 R_L}{\left(\frac{I_0}{2}\right)^2 (R_f + R_L)} \times 100\%$$

$$= \frac{4}{\pi^2}\left(\frac{1}{1 + R_f/R_L}\right) \times 100\% = \left(\frac{40.6}{1 + R_f/R_L}\right)\%$$

if $R_L >> R_f$ then $\eta = 40.6\%$ which is the theoretical maximum efficiency of a half-wave rectifier. ~~is 40~~.

Ripple factor γ:

Althow the simple ckt of half wave rectifier convert input a.c signal into unidirectional , still the output have a.c component with it. Ripple factor is the measure of the fluctuation component in the output which can be defined as

s defined as

$$\gamma = \frac{\text{rms value a.c component of load current}}{\text{average value of output current } (i_{dc})}$$

$$\gamma = \frac{I'_{rms}}{I_{dc}} = \frac{V'_{rms}}{V_{dc}}$$

Now the instantaneous load current

$I = i_{d.c} + i_{a.c}$

$I - i_{d.c} = i_{a.c}$

where i_{ac} is the ac component in load current.

$$I'_{rms} = \sqrt{\overline{(i_{ac})^2}} = \sqrt{\text{average of } (i_{ac}^2)}$$

$$(I'_{rms})^2 = \overline{(i-i_{dc})^2} = \overline{i^2 - 2i_{dc}\cdot i + i_{dc}^2} = \overline{i^2} - 2i_{dc}\cdot i_{dc} + i_{dc}^2$$

as $[\bar{i} = i_{dc}]$

$$i'_{rms} = \sqrt{i_{rms}^2 - i_{dc}^2} \quad [\overline{i^2} = i_{rms}^2]$$

$$\therefore \gamma = \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}} = \sqrt{\frac{I_{rms}^2}{i_{dc}^2} - 1} = \sqrt{\frac{(\frac{I_0}{2})^2}{(I_0/\pi)^2} - 1}$$

$$\gamma = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1} \quad \text{or} \quad \gamma = 1.21$$

∴ i'_{rms} = ac component of Load current is 1.21 times of dc component.

Peak inverse voltage (PIV)

The peak inverse voltage is the maximum voltage appearing across the diode at the time of reverse bias. The diode must be so chosen that or the voltage at the transformer secondary so that the PIV become equal to the transformer voltage and the diode be able to operate without being damaged.

Load regulation:-

It is desirable to have a rectifier whose output voltage varies least with the load connected across it. The variation of d.c output voltage with d.c load current for a given input is called the 'load regulation' of the rectifier.

the rectifier.

We have $I_{dc} = \frac{I_0}{\pi} = \frac{V_0}{\pi(R_L+R_f)}$

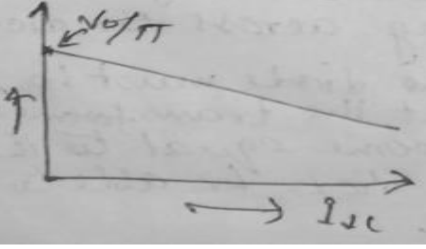
$\Rightarrow I_{dc}(R_L+R_f) = \frac{V_0}{\pi}$

or $I_{dc}\cdot R_L = \frac{V_0}{\pi} - I_{dc}\cdot R_f$

or $V_{dc} = \frac{V_0}{\pi} - I_{dc}\cdot R_f$

If we plot V_{dc} vs I_{dc} we have a straight line with negative slope of $(-R_f)$

~~If Idc incr~~



If load resistance is infinity then the output voltage (V_0/π) is called V_{NL} or no load voltage.

Stability factor:

the stebilized output may be achived if we are able to decrease the a.c component in the output part.

Stability factor can be defined as $S_L = ((V_{NL}-V_L)/V_L)*100\%$

Transformer Utilisation factor(TUF)

Thus $TUF = \frac{\text{d.c power supplied to the Load}}{\text{a.c rating of transformer secondary}}$

$$= \frac{I_{d.c}^2 R_L}{V_{rms} \cdot I_{rms}} = \frac{\left(\frac{I_0}{\pi}\right)^2 R_L}{\frac{V_0}{\sqrt{2}} \cdot \frac{I_0}{2}}$$

putting $V_0 = I_0(R_f + R_L)$ we get

$$TUF = \frac{I_0^2}{\pi^2} \cdot R_L \Big/ \frac{I_0(R_f+R_L) \cdot I_0}{2\sqrt{2}}$$

$$= \frac{2\sqrt{2}}{\pi^2} \Big/ \left(\frac{R_f}{R_L} + 1\right)$$

if $R_f >> R_L$ then $TUF = \frac{2\sqrt{2}}{\pi^2} = 0.287$

This shows that the d.c power that could be delivered to the load in a half-wave rectifier is much smaller than the a.c transformer rating.