VIVEKANANDA COLLEGE THAKURPUKUR KOLKATA-700063

NAAC ACCREDITED ‘A’ GRADE

Topic: FULL WAVE RECTIFIER(CENTRE-TAPPED)

Course Title: Analog Systems and Applications

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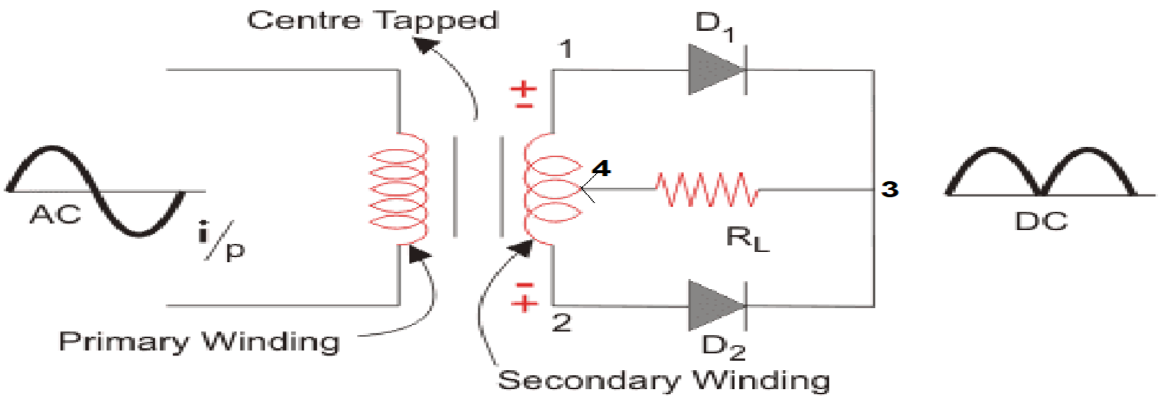
2. TWO TERMINAL DEVIECES AND THEIR APPLICATION

a. **Rectifier Diode:-**

Full Wave Rectifier

Definition- It is a device of ordinary pn-junction diode and able to convert full cycle of an alternative current/voltage signal into unidirectional current or voltage signal. It is better than the half wave rectifier where we use minimum two diode to get full rectified signal.

Circuit diagram:



Centre Tapped Full Wave Rectifier

Figure - 1

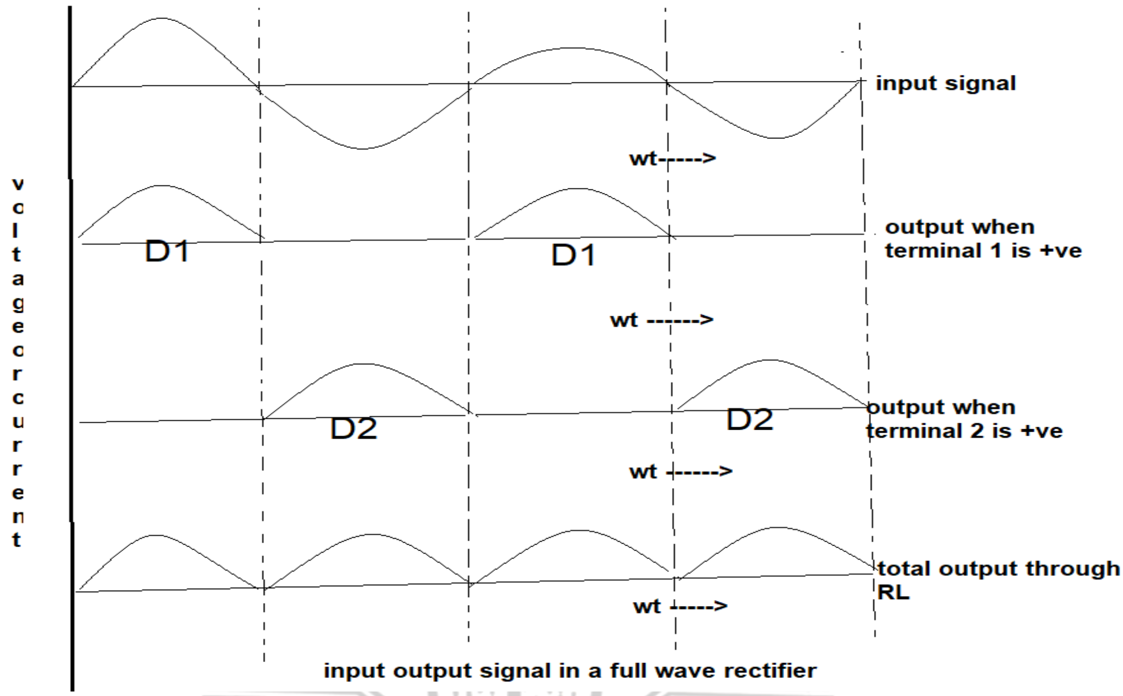
Circuit operation: - When terminal 1 is +ve current will flow through D1 diode as it is in forward bias. The current will go from 1 to 3 but as D2 is in reverse bias it will go through R_L from 3 to 4 to the center tapped transformer and we have current through R_L in a particular direction. If the terminal 2 is +ve then the diode D2 is in forward bias and current will flow through it from 2 to 3 but as D1 is in reverse bias the current will go from 3 to 4 to the center tapped transformer and we have current through R_L in the same particular direction. So through R_L we have unidirectional current for full cycle of the signal.

The input voltage say V1 = V_m sin (wt) for D1 and V2= V_m sin (wt+π) for D2.

The current in D1 is $i_1 = i_m$ sin (wt) for 0<=wt<=π and i_1 = 0 for π<=wt<=2π.

The current in D2 is i_2 =0 for 0<=wt<=π and $i_2 = i_m$ sin (wt) for π<=wt<=2π.

Input output diagram:-



input output signal in a full wave rectifier

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

Average Current I_{dc} :-

$$I_{dc} = \frac{\int_0^T i\,dt}{\int_0^T dt} = \frac{\int_0^{2\pi} i\,d(\omega t)}{\int_0^{2\pi} d(\omega t)}$$

$$= \frac{\int_0^{\pi} I_m \sin(\omega t)\,d(\omega t) - \int_{\pi}^{2\pi} I_m \sin(\omega t)\,d(\omega t)}{2\pi}$$

$$= \frac{I_m}{2\pi}\left[-\cos(\omega t)\Big|_0^{\pi} + \cos(\omega t)\Big|_{\pi}^{2\pi}\right]$$

$$= \frac{I_m}{2\pi}(2+2) = \frac{2I_m}{\pi}$$

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

Input A.C component (I_{rms})

$$I_{rms}^2 = \left[\frac{1}{2\pi}\int_0^{\pi} i_1^2\, d(\omega t) + \frac{1}{2\pi}\int_{\pi}^{2\pi} i_2^2\, d(\omega t)\right]$$

$$= \frac{I_m^2}{2\pi}\left[\int_0^{\pi} \sin^2(\omega t)\, d(\omega t) + \int_{\pi}^{2\pi} \sin^2(\omega t)\, d(\omega t)\right]$$

$$= \frac{I_m^2}{4\pi}\left[\int_0^{\pi} [1-\cos(2\omega t)]\, d(\omega t) + \int_{\pi}^{2\pi} [1-\cos(2\omega t)]\, d(\omega t)\right]$$

$$= \frac{I_m^2}{4\pi}\left[\int_0^{\pi} d(\omega t) + \int_{\pi}^{2\pi} d(\omega t) - \int_0^{2\pi} \cos(2\omega t)\, d(\omega t)\right]$$

$$= \frac{I_m^2}{4\pi}\left[\pi + (2\pi - \pi) - \frac{\sin(2\omega t)}{2}\Big|_0^{2\pi}\right]$$

$$I_{rms}^2 = \frac{I_m^2}{2}$$

$$\therefore I_{rms} = \frac{I_m}{\sqrt{2}}$$

Efficiency of rectification (η):

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

Efficiency of rectification (η):-

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

$$= \frac{\left(\frac{2I_m}{\pi}\right)^2}{\frac{I_m^2}{2}\left(\frac{R_f}{R_L}+1\right)} \, 100\%$$

for $R_L >> R_f$, $1 + \frac{R_f}{R_L} \simeq 1$ then $\eta = \frac{8}{\pi^2} \times 100\% = 81.05\%$

So efficiency of full wave rectifier is double of half wave rectifier ($\eta = 40.527\%$)

Ripple factor γ:

is defined as

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

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

Ripple factor is the measure of the fluctuation component in the output which can be defined as Now theinstantaneous load current $I = i_{d.c} + i_{a.c}$ $I - i_{d.c} = i_{a.c}$

$$I'_{rms} = \left(\overline{i_{ac}^2}\right)^{\frac{1}{2}} = \left[\overline{(i - I_{dc})^2}\right]^{\frac{1}{2}} \qquad \bar{i} = i_{dc}$$

$$= \left[\overline{i^2} - 2\bar{i}.I_{dc} + I_{dc}^2\right]^{\frac{1}{2}} = \left[i_{rms}^2 - I_{dc}^2\right]^{\frac{1}{2}}$$

$$= \left(\frac{I_m^2}{2} - \frac{4I_m^2}{\pi^2}\right)^{\frac{1}{2}} = \left[I_m^2\left(\frac{\pi^2-4}{2\pi^2}\right)\right]^{\frac{1}{2}}$$

$$= \left[0.297 I_m^2\right]^{\frac{1}{2}} = 0.545 I_m$$

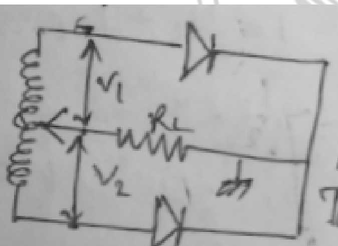
$$\gamma = \left[\frac{I_{rms}^2}{I_{dc}^2} - 1\right]^{\frac{1}{2}} = \left[\frac{\frac{I_m^2}{2}}{\frac{4I_m^2}{\pi^2}} - 1\right]^{\frac{1}{2}}$$

$$= \left[\frac{\pi^2}{8} - 1\right]^{\frac{1}{2}} = 0.483$$

So ac component in the output current is less than dc component which is better than half wave rectifier ($\gamma = 1.21$)

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.



For forward bias the voltage across D_1 is $v_1 = V_m$. Then due to reverse bias voltage across D_2 is $v_2 = -V_m$. So Total voltage across transformer secondary is $V_m - (-V_m) = 2V_m$ which is the peak inverse voltage.

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.

Regulation characteristic :-

Load regulation is the variation of d.c output voltage with d.c load current for a given input voltage.

$$I_{dc} = \frac{2I_0}{\pi} = \frac{2V_0}{\pi(R_f+R_L)}$$

$$\therefore I_{dc}\cdot R_L = V_{dc} = \frac{2V_0}{\pi} - I_{dc}\cdot R_f$$

w.r.t half wave rectifier the no load voltage $(R_L=\infty)$ $V_{NL} = \frac{2V_0}{\pi}$ and stability factor $S = \frac{V_{NL}-V_L}{V_L}\times 100\%$

but the variation with load current i_{dc} is as equal to half wave rectifier.

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)

(TUF) Here only half of the centre-tapped transformer secondary remains active when any one of the diodes is conducting. A full-wave rectifier can be approximated as two half-wave rectifiers acting one at a time. So TUF of the full wave transformer can be approximated as twice that of the half-wave rectifier.

$$TUF = \frac{I_{dc}^2 R_L}{V_{rms}\cdot I_{rms}} = \frac{\left(\frac{2I_m}{\pi}\right)^2 R_L}{\left(\frac{V_m}{\sqrt{2}}\cdot\frac{I_m}{\sqrt{2}}\right)} = \frac{8}{\pi^2} \rightarrow 0.81$$

$$TUF = 2\times 0.287 \approx 0.57$$