Unit-2
PN Diode-Applications

- A diode has unidirectional property that it conducts only in FB and in reverse bias it is cutoff.

Few-Applications of diode :-

1. Diode is used in rectifiers which are used in d.c power supplies.
2. Diode is used as switch in logic circuits in computers.
3. Diode is used in waveshaping circuits such as clippers & clampers
4. Zener diode used as voltage regulator ckts.
5. Varactor diodes are used in radio and T.V. receivers.

Rectifiers :- A rectifier is a circuit which is used to convert A.c voltage in to the pulsating d.c. voltage.

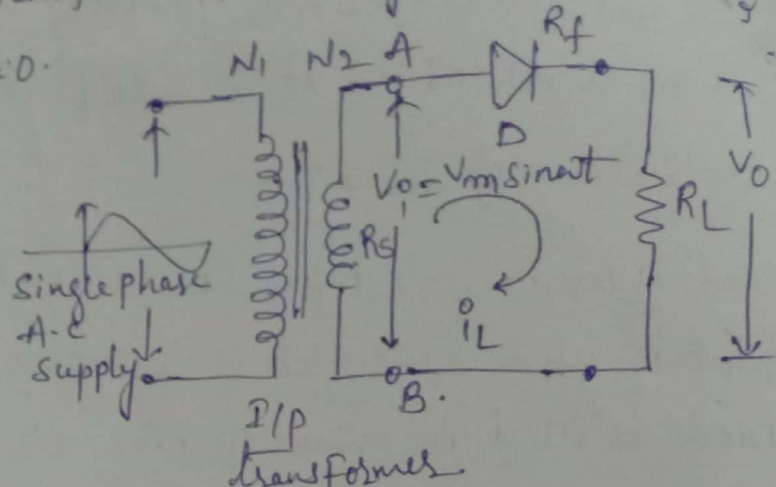
- A rectifier ckt uses one or more diodes. Broadly there are 3 types of rectifier ckts.

a) Half-wave rectifier
b) Full-wave rectifier
c) Bridge rectifier.

① Half Wave Rectifier :-

In half wave rectifier, rectifying element conducts only during positive halfcycle of input a.c supply. The negative halfcycles of a.c supply are eliminated from the output.

This rectifier ckt consists of resistive load, rectifying element i.e p-n junction diode, and source of A.C voltage all connected in series. Usually rectifier ckts are operated from a.c mains supply. To obtain the desired d.c voltage across load, The A.C Voltage is applied to rectifier ckt Using suit. step-up or stepdown transformer, mostly stepdown trans with necessary turns ratio.



Halfwave Rectifier.

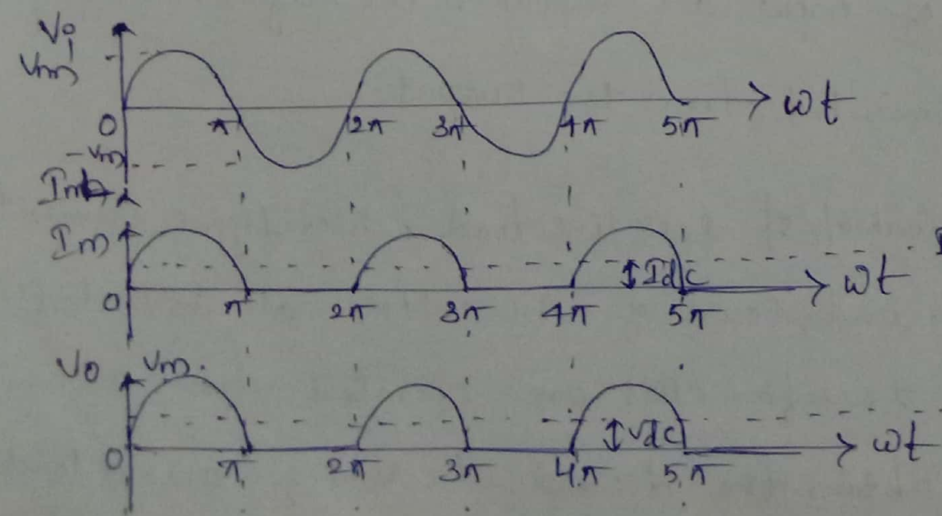
The i/p voltage to a half wave rectifier ckt, is a Sinusoidal a.c Voltage, having a frequency which is the Supply freq 50 HZ.

Operation of the ckt :-

During the halfcycle of Secondary a.c Voltage, terminal 'A' becomes positive with respect to terminal B. The diode F.B and the Curren flows in the ckt in the clockwise direction. Current will flow for almost full positive half cycle. This current also flows through load resistance R_L, Hence denoted as I_L. The load Current.

During the negative halfcycle, A is -ve with respect to B, diode becomes R.B. Hence No Current flows in the diode ckt. $V_0 = 0$.

The load Voltage being product of load current and load resistance. Will also be in the form of half sinusoidal pulses.



$I_{avg} = I_{dc}$

V_{dc} (or) E_{dc} Avg value.

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① Average D.C load current (I_{DC}) :-

The Avg or D.C value of A.C current is obtained by integration. For finding out Avg value of A.C wave, we have to determine the area under the curve over one complete cycle i.e from 0 to 2π. Then dividing it by the base i.e 2π.

Mathematically, current waveform can be described, as

$$i_L = I_m \sin\omega t \quad , \text{ for } 0 \le \omega t \le \pi$$
$$= 0 \quad , \text{ for } \pi \le \omega t \le 2\pi$$

where I_m = peak value of load current

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

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

As no current flows during -ve half cycle of A.C i/p. b/w π to 2π

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

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

$$I_{dc} = \frac{-I_m}{2\pi}[-1-1] = \frac{2 I_m}{2\pi} = \frac{I_m}{\pi}$$

$$\boxed{I_{dc} = \frac{I_m}{\pi} = \text{Average value.}}$$

By Applying KVL

$$\Rightarrow \quad I_m = \frac{V_m}{R_S + R_L + R_f}$$

② Average D.C load voltage (V_{DC}):-

It is a product of I_{dc} & R_L

$$V_{dc} = I_{dc} \cdot R_L .$$

$$= \frac{I_m}{\pi} \cdot R_L$$

$$= \frac{V_m \cdot R_L}{\pi (R_S + R_L + R_f)} \cdot\cdot \frac{V_m \cdot \cancel{R_L}}{\cancel{R_L} \cdot \pi \left(1 + \frac{R_S + R_f}{R_L}\right)}$$

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$\therefore$ R_s, R_f values are small compared to R_L.
Since there are negligible.

$$\therefore \boxed{V_{dc} = \frac{V_m}{\pi}}$$

(3) R.M.S Value of load current (I_{rms}) :-

The R.m.s means squaring, finding mean then finding square root. Hence R.m.s value of load current

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

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

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

$$= I_m \sqrt{\frac{1}{2\pi}\left\{\frac{\omega t}{2} - \frac{\sin 2(\omega t)}{4}\right\}_0^{\pi}}$$

$$= I_m \sqrt{\frac{1}{2\pi}\left\{\frac{\pi}{2} - 0 - 0 - 0\right\}}$$

$$= I_m \sqrt{\frac{\pi}{4\pi}}$$

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

(4) D.C output power (P_{dc}) :-

D.c o/p power can be obtained as.

$$P_{dc} = V_{dc} \cdot I_{dc} = I_{dc}^2 \cdot R_L \qquad (\because V_{dc} = I_{dc} \cdot R_L)$$

$$= \left(\frac{I_m}{\pi}\right)^2 \cdot R_L$$

$$\boxed{P_{dc} = \frac{I_m^2}{\pi^2} \cdot R_L} \qquad I_m = \frac{V_m}{R_f + R_L + R_s}$$

$$\therefore P_{dc} = \frac{V_m^2 \cdot R_L}{\pi^2 (R_f + R_s + R_L)^2} \quad //.$$

(5) A.C power Input (P_{AC}):—

A.C power input taken from the secondary of transformer is the power supplied to three resistances namely R_L, R_s, R_f

$\therefore$ R_s = Winding Resistance.

$$P_{A.C} = I_{Rms}^2 \cdot (R_L + R_s + R_f)$$

$$\because I_{Rms} = \frac{I_m}{2} \quad (\text{for halfwave})$$

$$P_{A.C} = \frac{I_m^2}{4}(R_L + R_s + R_f)$$

(6) Rectifier Efficiency (η)

defined as the ratio of output d.c power to input a.c power.

$$\eta = \frac{\text{D.C O/p power}}{\text{A.C I/p power}} = \frac{P_{dc}}{P_{ac}}$$

$$\eta = \frac{\frac{\cancel{I_m^2}}{\pi^2} \cdot R_L}{\frac{\cancel{I_m^2}}{4}(R_f + R_s + R_L)} = \frac{(4/\pi^2) R_L}{(R_f + R_L + R_s)}$$

$$\eta = \frac{0.406}{1 + \left(\frac{R_f + R_s}{R_L}\right)} \quad [\because (R_f + R_s) << R_L]$$

$$\boxed{\% \eta = 0.406 \times 100 = 40.6\%}$$

Thus half wave rectifier, maximum 40.6% A.C power gets converted to d.c power in the load. If the efficiency of rectifier is 40% then what happens to the remaining 60% power. It is present in the form of ripples in the o/p. which is fluctuating component present in the o/p.

$\because$ Thus more the efficiency, less are the ripples content in the o/p.

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5 **Ripple factor :-** It is seen that the o/p of half wave rectifier is not pure d.c. But a pulsating d.c. The o/p contains pulsating components called ripples. Ideally there should not be any ripples in the rectifier o/p. The measure of such ripples present in the o/p is with the help of a factor called ripple factor. denoted by 'γ'. It tells how smooth is the output. (4)

Note :- Smaller the ripple factor closer is the o/p to a pure d.c. Ripple factor expresses how much successful the ckt is, in obtaining pure d.c from a.c i/p.

Defination :- Ratio of R.m.s value of the a.c component in the o/p to the average or d.c component present in the o/p.

Ripple factor γ :- $\dfrac{\text{Rms value of a.c component of o/p}}{\text{Average or d.c component of o/p.}}$

Now the o/p current composed of a.c component as well as d.c component.

I_{ac} = r.m.s value of a.c component present in o/p

I_{dc} = d.c value present in o/p.

I_{rms} = R.m.s value of total o/p current

$$I_{Rms} = \sqrt{I_{ac}^2 + I_{dc}^2}$$

$$I_{a.c} = \sqrt{I_{R.ms}^2 - I_{dc}^2}$$

Now $\boxed{\text{Ripple factor} = \dfrac{I_{ac}}{I_{DC}}}$ As per defination.

$$\gamma = \frac{\sqrt{I_{Rms}^2 - I_{dc}^2}}{I_{DC}}$$

$$\boxed{\gamma = \sqrt{\left(\frac{I_{Rms}}{I_{DC}}\right)^2 - 1}}$$ // General Expression.

∵ Now for a half wave ckt

$I_{Rms} = \frac{I_m}{2}$; $I_{DC} = \frac{I_m}{\pi}$

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

$\gamma = \sqrt{1.4674}$

$\boxed{\gamma = 1.211}$ //.

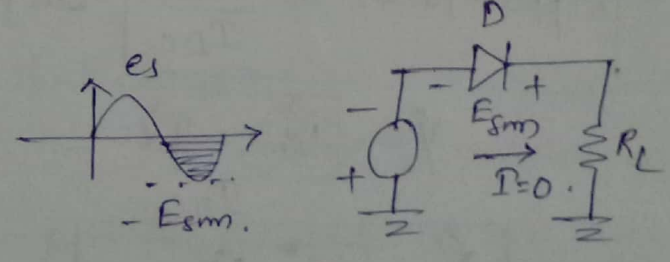
This indicates that the ripple contents in the o/p are 1.211 times the d.c. Component i.e 121.1 % of d.c Component.

Therefore the ripple factor for half wave is very high which indicates The half wave ckt is a poor Converter of a.c to d.c.

(8) Peak inverse voltage (PIV):-

The peak inverse Voltage is the peak Voltage ~~Volta~~ across the diode in The reverse direction. i.e when the diode is reverse biased. In half wave rectifier, the load current is ideally zero. when the diode is reverse biased & ~~has~~ hence maximum value of the voltage that can exist across the diode is nothing but E_{sm}.

PIV represents maximum Voltage which a diode used in reverse biased. Hence for half wave rectifier $\boxed{PIV = V_m.}$



Transformer Utilization Factor :- (TUF)

The factor which indicates how much is the utilization of the transformer in the ckt is called Transformer utilization factor (TUF)

Def: TUF defined as the ratio of d.c power delivered to the load to the a.c power rating of the transformer.

While calculating A.C power rating, it is necessary to consider r.m.s values of A.C voltage & current.

$$\text{A.c power rating of transformer} = V_{Rms} \cdot I_{Rms}$$

$$= \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{2} \qquad \left(\because V_{rms} = \frac{V_m}{\sqrt{2}}\right.$$

For pure Sinusoidal i/p)

$$= \frac{V_m \cdot I_m}{2\sqrt{2}}$$

$$\text{D.C power Delivered to load} = I_{DC}^2 \cdot R_L$$

$$= \left(\frac{I_m}{\pi}\right)^2 \cdot R_L$$

$$TUF = \frac{\text{D.C power Delivered to load}}{\text{A.C power rating of the transformer}} = \frac{\left(\frac{I_m}{\pi}\right)^2 \cdot R_L}{\left(\frac{V_{rms} \cdot I_m}{2\sqrt{2}}\right)}$$

By neglecting the drop across R_s, R_f

$$\because V_m = I_m \cdot R_L.$$

$$TUF = \frac{\cancel{I_m^2} \cdot \cancel{R_L}}{\pi^2} \times \frac{2\sqrt{2}}{\cancel{I_m} \cdot \cancel{R_L} \cdot \cancel{I_m}} = \frac{2\sqrt{2}}{\pi^2} = 0.287$$

Note:- The value of T.U.F is low which shows that in half wave ckt the transformer is not fully utilized.

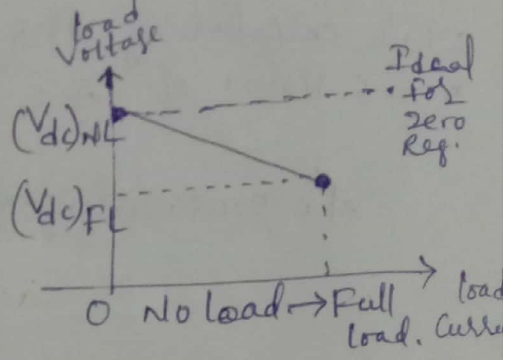
(10) **Voltage Regulation :-** The voltage regulation is the factor which tells us about the change in the d.c o/p voltage as load changes from No load to full load condition.

If $(V_{dc})_{NL}$ = D.C Voltage on no load

$(V_{dc})_{FL}$ = D.C Voltage on full load.

$\therefore$ Voltage Regulation $= \dfrac{(V_{dc})_{NL} - (V_{dc})_{FL}}{(V_{dc})_{FL}}$

Note:- less the Value of voltage Regulation, better is the performance of rectifier ckt.



$\because$ for halfwave $(V_{dc})_{NL} = \dfrac{V_m}{\pi}$

$$(V_{dc})_{FL} = I_{dc} \cdot R_L = \frac{I_m}{\pi} \cdot R_L$$

$$(V_{dc})_{FL} = \frac{V_m}{(R_s+R_f+R_L)\pi} \times R_L$$

$$\% R = \frac{\dfrac{V_m}{\pi} - \dfrac{V_m \cdot R_L}{\pi(R_s+R_f+R_L)}}{\dfrac{V_m \cdot R_L}{\pi(R_s+R_f+R_L)}} \times 100 \Rightarrow \frac{\cancel{\dfrac{V_m}{\pi}}\left[1 - \dfrac{R_L}{(R_s+R_f+R_L)}\right]}{\cancel{\dfrac{V_m}{\pi}}\left[\dfrac{R_L}{R_s+R_f+R_L}\right]} \times 100$$

$$\% R = \frac{\dfrac{\cancel{R_L}+R_f+R_s-\cancel{R_L}}{\cancel{(R_s+R_f+R_L)}}}{\dfrac{R_L}{\cancel{(R_s+R_f+R_L)}}} \times 100 = \frac{R_s+R_f}{R_L} \times 100.$$

By Neglecting winding resistance 'R_s' $\Rightarrow \boxed{\% R = \dfrac{R_f}{R_L} \times 100}$ //.

Disadvantages:- 1. Ripple factor of halfwave rectifier is 1.21. which is high the o/p contains lot of varying components.

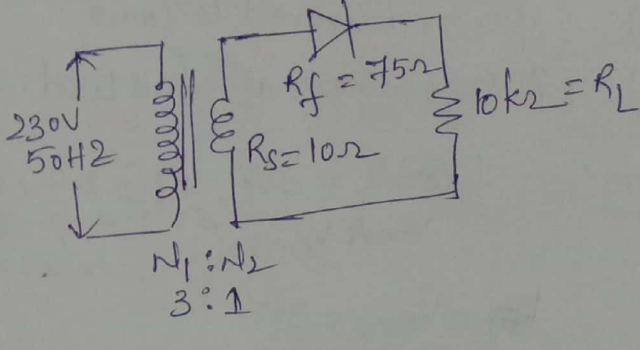
2. The max theoretical rectification efficiency is found to be 40%. The practical value to be less. This Indicates H.W.R is inefficient.

3. The ckt has low TUF, showing that the transformer is not fully utilized.

Becoz of all these reasons, the H.W.R is normally not used as a power rectifier ckt.

Problem - (1) HWR

A HWR circuit is supplied from a 230V, 50 HZ supply with a stepdown ratio of 3:1 to a resistive load of 10kΩ. The diode forward resistance is 75Ω while transformer secondary resistance is 10Ω. Calculate maximum, average, Rms values of current, D.C. o/p voltage, efficiency of rectification and ripple factor.



(i) Given data

$R_f = 75\Omega$

$R_s = 10\Omega$

$R_L = 10k\Omega$

The Given Supply Voltages are always Rms Values.

$E_p(Rms) = 230V$

$\frac{N_2}{N_1} = \frac{1}{3}$

$\therefore \frac{N_2}{N_1} = \frac{E_s(Rms)}{E_p(Rms)}$

$\frac{1}{3} = \frac{E_s(Rms)}{230}$

$E_s(Rms) = 76.667$

This is R.m.s Value of the transformer secondary voltage.

$V_m = E_{sm} = \sqrt{2} E_s \Rightarrow \sqrt{2} \times 76.667 = 108.423V$.

$V_m = \sqrt{2} \times V_{rms}$

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$I_m = \frac{V_m}{R_s + R_L + R_f} = \frac{108.423}{75 + 10 + 10 \times 10^3} = 10.75mA$

$I_{DC} = I_{avg} = \frac{I_m}{\pi} = \frac{10.75m}{\pi} = 3.422 mA$

$I_{Rms} = \frac{I_m}{2} = \frac{10.75m}{2} = 5.375mA$

$V_{dc} = I_{dc} \cdot R_L = 3.422m \times 10 \times K = 34.22V$

$P_{dc} = V_{DC} \times I_{DC} = 34.22 \times 3.422m$

$= 0.1171W$

$\% \eta = \frac{P_{dc}}{P_{ac}} \times 100$

$\% \eta = \frac{0.1171}{0.2913} \times 100$

$\% \eta = 40.19\%$

ripple factor $\gamma = 1.21$ const

$P_{ac} = I_{Rms}^2 (R_s + R_L + R_f)$

$= (5.375)^2 (10 + 75 + 10 \times 10^3)$

$P_{ac} = 0.2913W$

Problem – (2) F.W.R.

– A full wave rectifier ckt is fed from a transformer having a center tapped secondary winding. The r.m.s voltage from either end of secondary to center tap is 30V. If the diode forward resistance is 2Ω and that of the half secondary is 8Ω, for a load of 1kΩ, Calculate:

a) power delivered to load
b) % Regulation at full load.
c) Efficiency of rectification
d) TUF of secondary.

Given:– E_S (or) $V_2 = 30V$, $R_f = 2\Omega$, $R_S = 8\Omega$, $R_L = 1k\Omega$

V_{Rms}

$V = V_{Rms} = 30V$

$V_{Rms} = \frac{V_m}{\sqrt{2}}$

$V_m = \sqrt{2} \times 30 = 42.426V.$

$I_m = \frac{V_m}{R_S + R_f + R_L}$

$I_m = \frac{42.426}{8+2+1\times10^3} = 42mA$

$I_{dc} = \frac{2I_m}{\pi} = \frac{2\times42m}{\pi} = 26.74mA$

a) power delivered to load.

$P_{dc} = I_{DC}^2 \cdot R_L \Rightarrow (26.74mA)^2 \times 1\times10^3 = 0.715W$

b) $\% \text{ Regulation} = \frac{(V_{dc})_{NL} - (V_{dc})_{FL}}{(V_{dc})_{FL}}$

$V_{dc,\text{noload}} = \frac{2V_m}{\pi} = \frac{2\times42.42}{\pi} = 27V$

$V_{dc,\text{Fullload}} = I_{dc} \cdot R_L = 26.74mA \times 1\times10^3 = 26.74V$

$\% \text{ Regulation} = \frac{27-26.74}{26.74} \times 100 = 0.97\%$

c) $\text{Efficiency of Rectification} = \frac{8}{\pi^2}\left(\frac{1}{1+\frac{R_S+R_f}{R_L}}\right) = \frac{8}{\pi^2}\left(\frac{1}{1+\frac{2+8}{1000}}\right)$

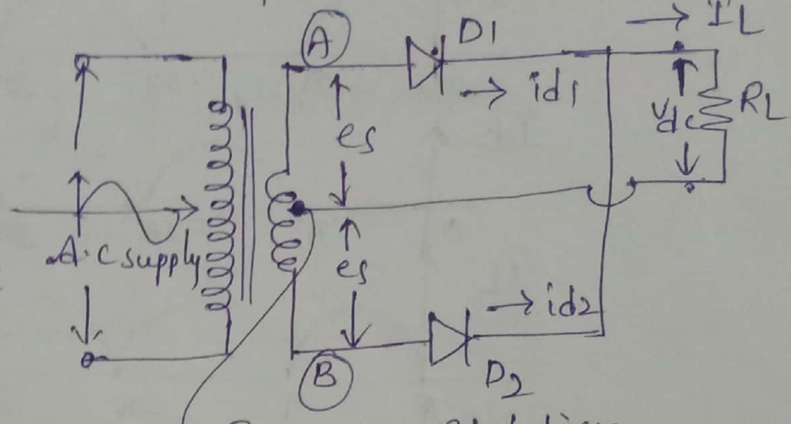
$= 0.802 = 80.2\%$

D) $\text{Transformer Secondary Rating} = \frac{\text{D.C power to load}}{\text{A.C Rating}} = \frac{0.715}{0.89} = 0.802$

$\text{A.C Rating} = V_{Rms} \cdot I_{Rms} = 30 \times \frac{42m}{\sqrt{2}} = 0.89W$

(2) Full Wave Rectifier :- (FWR)

The FWR Conducts during both positive and Negative half cycles of i/p a.c supply. In order to rectify both the half cycles of a.c i/p, two diodes are used in this ckt. The diodes feed a common load R_L with the help of centre-tapped transformer. The a.c Voltage is applied through a suitable power transformer with proper turns ratio.



Full Wave Rectifier.
Centertap.

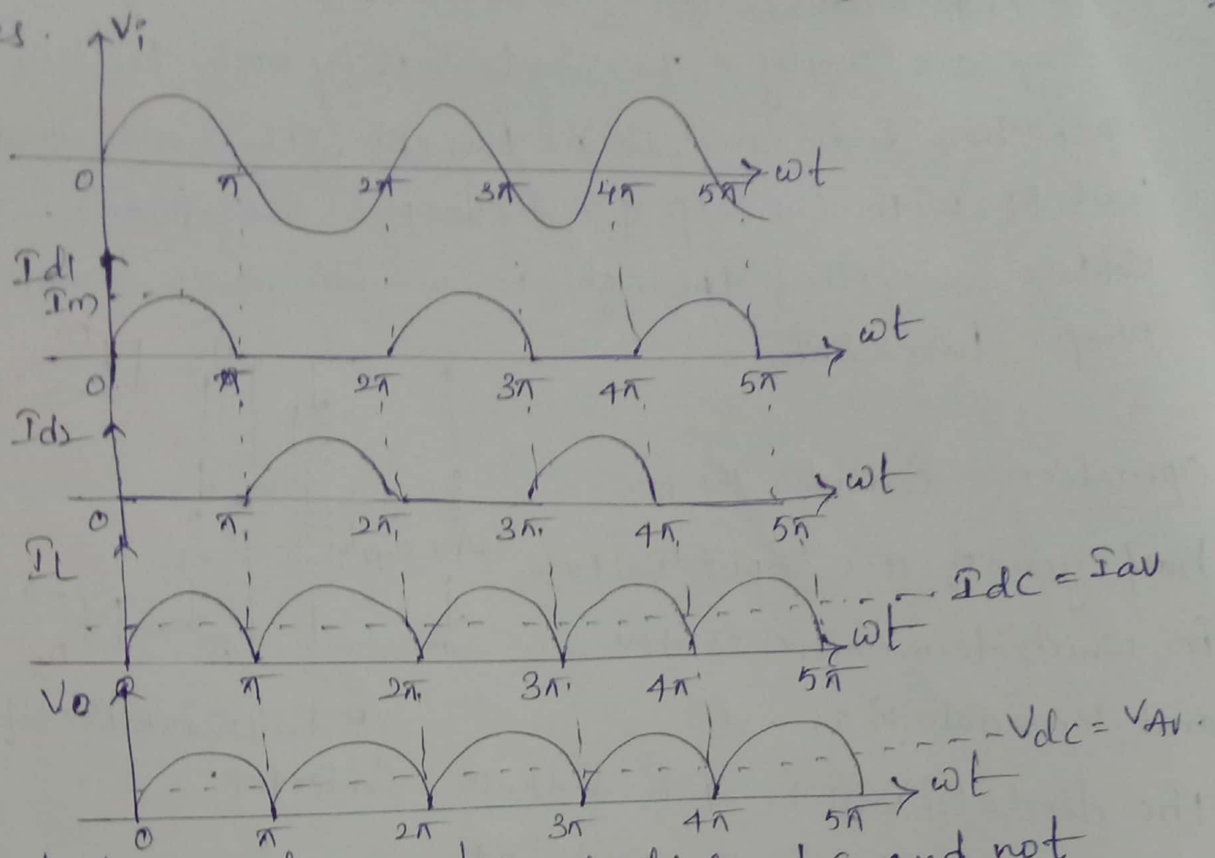
Operation:- Consider the +ve half cycles of a.c input Voltage in which terminal (A) is +ve and terminal (B) is -ve.

The diode D_1 will be F.B & Hence will Conduct, while D_2 will be R.B and does not Conduct & act as open ckt. The diode D_1 Supplies the load Current $i_L = id_1$. This Current is flowing through upper half ~~cycle~~ of Secondary winding, while the lower half of Secondary winding Carries no Current. Since D_2 is R.B & acts as open ckt.

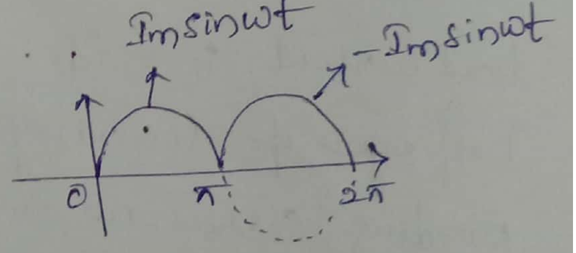
In the next half cycle A.C Voltage polarities reverses, and terminal (A) becomes -ve & (B) +ve. The diode D_2 Conducts being F.B, while D_1 Does not, being reverse biased. The D_2 Supplies load current $i_L = id_2$. Now the lower half of the Secondary winding Carries Current but the upper half does not.

Note:- It is noted that, the load Current flows in both the half cycles of a.c voltage and in the same direction to the load resistance.

Hence we get rectified output across the load. The load current is equal to sum of diode currents flowing in corresp half cycles.



∴ The o/p load current is still pulsating d.c and not pure a.c.



① Average DC load Current (I_{dc}) :-

Consider one ~~half~~ cycle of load current i_L from 0 to 2π to obtain the avg value which is d.c value of load current.

$$i_L = i_m \sin(\omega t) \quad ; \quad 0 \le \omega t \le \pi.$$

But for π to 2π, i_L again +ve, while $\sin\omega t$ is -ve. Hence from π to 2π i_L can be represented during π to 2π as negative.

$$i_L = -I_m \sin\omega t \quad ; \quad \pi \le \omega t \le 2\pi.$$

$$I_{avg} = I_{DC} = \frac{1}{2\pi}\int_0^{2\pi} i_L \, d(\omega t)$$

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

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

$$= \frac{I_m}{2\pi}\left[(-\cos\omega t)_0^{\pi} - (-\cos\omega t)_{\pi}^{2\pi}\right] \qquad (\cos\pi = -1)$$

$$= \frac{I_m}{2\pi}\left[\cancel{-(-1-1)} \cancel{+(+1+1)}\right] \quad \frac{I_m}{\pi}\left[\cancel{-(-1)+(1)+(-1)}\right]$$

$$= \frac{I_m}{2\pi}[2] \qquad \frac{I_m}{\pi}\left[-\cos\pi + \cos 0 + \cos 2\pi - \cos\pi\right]$$

$$\frac{I_m}{\pi}\left[+1+1+1+1\right] = \frac{4 I_m}{2\pi} = \frac{2 I_m}{\pi}$$

$$\boxed{I_{dc} = \frac{2 I_m}{\pi}}$$ // for full wave rectifier.

(2) Average DC load Voltage (V_{dc}):-

The d.c voltage is $V_{dc} = I_{DC} \cdot R_L = \frac{2 I_m}{\pi} \cdot R_L$

$$V_{dc} = \frac{2 V_m}{\pi(R_f + R_s + R_L)} \cdot R_L = \frac{2 V_m}{\pi\left(1 + \frac{R_s + R_f}{R_L}\right)}$$

$\therefore R_f \,\&\, R_s << R_L$

Hence $\frac{R_s + R_f}{R_L} << 1$

$$\boxed{V_{dc} = \frac{2 V_m}{\pi}}$$ //.

(3) R.m.s load Current:-

$$I_{R.m.s} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (I_m \sin\omega t)^2 \, d(\omega t)}$$

Since two half wave rectifiers are similar in operation Can be written as

$$I_{Rms} = \sqrt{\frac{2}{2\pi}\int^{\pi} (I_m \sin\omega t)^2 \, d(\omega t)}$$

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

$$= I_m \sqrt{\frac{1}{\pi}\left[\frac{\omega t}{2} - \frac{\sin 2\omega t}{4}\right]_0^{\pi}}$$

$$= I_m \sqrt{\frac{1}{\pi}\left[\frac{\pi}{2} - 0 - 0 - 0\right]} = I_m \sqrt{\frac{1}{\cancel{\pi}} \times \frac{\cancel{\pi}}{2}} = \frac{I_m}{\sqrt{2}}$$

$$\boxed{I_{Rms} = \frac{I_m}{\sqrt{2}}}$$ //

④ D.C power output (P_{dc}) :-

$$\text{D.C power o/p } P_{dc} = V_{dc} \cdot I_{dc}$$

$$= I_{dc}^2 \cdot R_L$$

$$= \left(\frac{2I_m}{\pi}\right)^2 \cdot R_L$$

$$\boxed{P_{dc} = \frac{4 I_m^2}{\pi^2} \cdot R_L}$$ //

$$\boxed{P_{dc} = \frac{4}{\pi^2}\left[\frac{V_{dc}^2}{(R_s + R_f + R_L)^2} \times R_L\right]}$$ //.

⑤ A.C power input ($P_{A.C}$) :-

$$P_{A.C} = I_{Rms}^2 \cdot (R_f + R_s + R_L)$$

$$= \left(\frac{I_m}{\sqrt{2}}\right)^2 \cdot (R_f + R_s + R_L)$$

$$P_{a.c} = \frac{I_m^2 (R_f + R_s + R_L)}{2}$$

Substituting Value of I_m

$$P_{a.c} = \frac{V_m^2}{(R_f + R_s + R_L)^{\cancel{2}}} \times \frac{1}{2} \times (R_f + R_s + \cancel{R_L})$$

$$\boxed{P_{a.c} = \frac{V_m^2}{2(R_s + R_f + R_L)}}$$ //.

Rectif

Rectifier efficiency:- (η)

$$\eta = \frac{P_{DC}\ \text{output}}{P_{AC}\ \text{input}} = \frac{\frac{4}{\pi^2} \cdot I_m^2 \cdot R_L}{\frac{I_m^2 (R_f + R_s + R_L)}{2}}$$

$$\eta = \frac{8R_L}{\pi^2 (R_f + R_s + R_L)} \quad ; \quad R_f + R_s << R_L$$

$$\eta = \frac{8\cancel{R_L}}{\pi^2 (\cancel{R_L})} = \frac{8}{\pi^2}$$

$$\boxed{\%\eta = \frac{8}{\pi^2} \times 100 = 81.2\%}$$ //.

(7) **Ripple factor (γ):-** General Expression of ripple factor

$$\text{Ripple factor} = \sqrt{\left(\frac{I_{Rms}}{I_{DC}}\right)^2 - 1}$$

$\therefore$ For full wave $I_{Rms} = \frac{I_m}{\sqrt{2}}$, $I_{dc} = \frac{2I_m}{\pi}$

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

$$= \sqrt{\frac{\pi^2}{8} - 1}$$

$$\boxed{\gamma = 0.48}$$ //

This indicates that the ripple contents in the output are 48% of the d.c component which is much less than that for the half wave ckt.

(8) **peak Inverse voltage (PIV) :-** $2V_m$.

(9) TUF (Transformer Utilization factor):-

Here TUF is calculated for primary and secondary winding seperately. Coz In FWR, the secondary current flows through each half seperately in every half cycle. While the primary of transformer carries current continuously. And then average of T.U.F is determined.

$$\text{Secondary TUF} = \frac{\text{D.C power to the load}}{\text{A.C power rating of secondary}}$$

$$= \frac{I_{dc}^2 \cdot R_L}{V_{rms} \cdot I_{rms}} = \frac{I_{dc}^2 \cdot R_L}{\frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}} \qquad (\because V_m = I_m R_L)$$

$$= \frac{I_{dc}^2 \cdot R_L}{\frac{I_m \cdot R_L}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}} \Rightarrow \frac{\frac{4 \cancel{I_m^2}}{\pi^2} \cdot \cancel{R_L}}{\frac{\cancel{I_m^2}}{2} \cdot \cancel{R_L}} \qquad \left(I_{dc} = \frac{2I_m}{\pi}\right)$$

$$\text{Secondary TUF} = \frac{8}{\pi^2} \Rightarrow 0.812$$

The primary of Transformer is feeding two half wave rectifiers seperately. The 2 half wave rectifiers work indipendently of each other but feed a common load. We have already derived TUF for HWR is 0.287.

$$\text{TUF for primary winding} = 2 \times \text{T.U.F of HW ckt}$$
$$= 2 \times 0.287$$
$$= 0.574.$$

$$\text{The Avg TUF for FWR will be} = \frac{\text{TUF of primary} + \text{TUF of Secondary}}{2}$$

$$= \frac{0.574 + 0.812}{2}$$

$$\boxed{\text{Avg TUF for FWR} = 0.693}$$

Here transformer gets utilized more than HWR.

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Voltage Regulation: —

for FWR $(V_{dc})_{NL} = \frac{2V_m}{\pi}$

$(V_{dc})_{FL} = I_{dc} \cdot R_L$

$$\% R = \frac{(V_{dc})_{NL} - (V_{dc})_{FL}}{(V_{dc})_{FL}} \times 100 = \frac{\frac{2V_m}{\pi} - I_{dc} \cdot R_L}{I_{dc} \cdot R_L} \times 100$$

[Now $I_m = \frac{V_m}{R_s + R_f + R_L}$

$V_m = I_m (R_s + R_f + R_L)$

$I_{dc} = \frac{2I_m}{\pi}$]

$$\therefore \% R = \frac{\frac{2I_m (R_s + R_f + R_L)}{\pi} - \frac{2I_m \cdot R_L}{\pi}}{\frac{2I_m}{\pi} \times R_L} \times 100$$

$$\% R = \frac{\cancel{2I_m} [R_s + R_f + \cancel{R_L} - \cancel{R_L}]}{\cancel{\pi}} \times \frac{\cancel{\pi}}{\cancel{2I_m} \cdot R_L} \times 100$$

$$\% R = \frac{R_s + R_f}{R_L}$$

$$\boxed{\% R = \frac{R_f}{R_L} \times 100}$$

(By neglecting winding Resistance R_s)

* **Comparision of H.W.R and F.W.R: —**

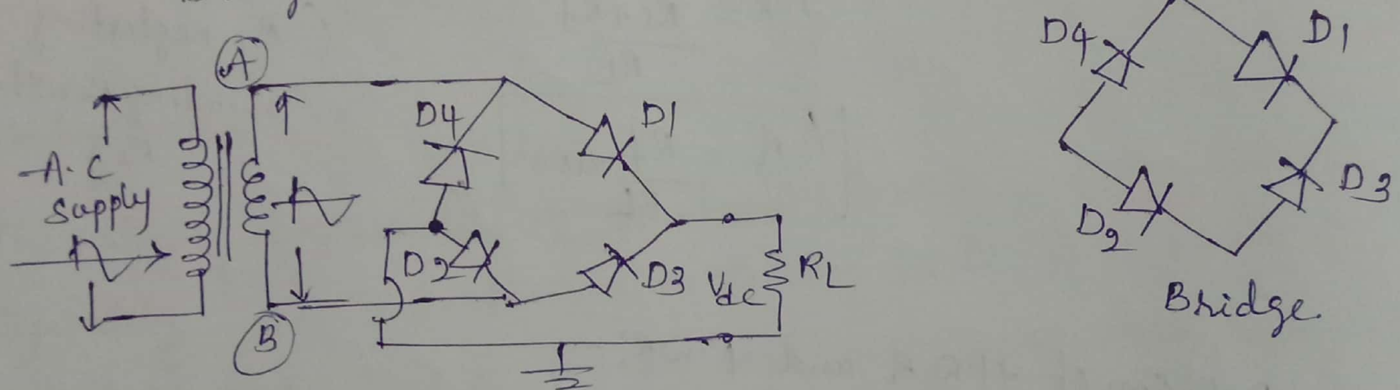
1. The d.c load current in case of full wave ckt is twice to that in H.W. ckt, Ily the D.C load voltage in full wave ckt is twice that in half wave ckt.
2. The lowest ripple frequency in full wave ckt is twice that in half wave ckt.
3. The full wave connection gives d.c power output four times as larger, when compared to half wave connection.
4. Efficiency of rectification in a full wave connection is twice that for half wave connection.

5. The ripple factor is less for full wave i.e rectification more nearly complete for full wave as compared to half wave.

③ Bridge Rectifier :-

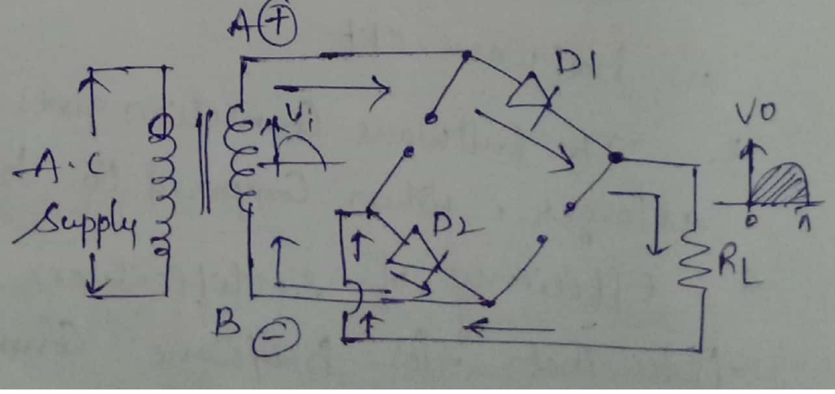
The bridge rectifier ckt is essentially a full wave rectifier ckt, using four diodes forming the four arms of an electrical bridge. To one diagonal of the bridge, the A.C voltage is applied through a transformer if necessary, and rectified d.c voltage is taken from the other diagnal of the bridge.

The main advantage of this ckt is, that it does not require a center-tap on the secondary winding of the transformer. Hence whenever possible, ac voltage can be directly applied to the bridge.



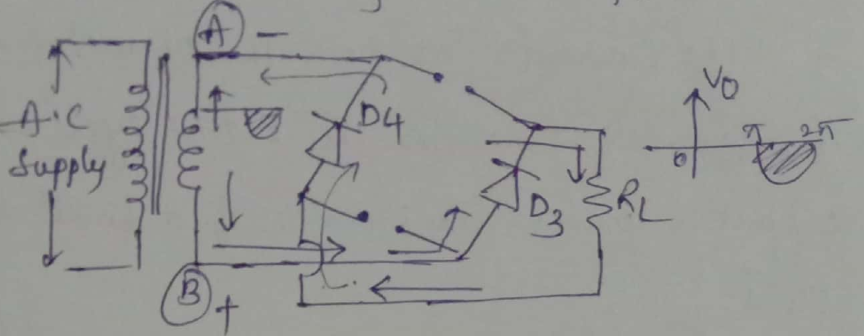
Operation of the ckt :-

Consider the positive half of a.c input voltage. point A of secondary becomes positive. The diode D_1 and D_2 will be F.B. while D_3 and D_4 are R.B. The two diodes D_1 & D_2 conducts in series with the load and current flows.



next half cycle, when the polarity of a.c voltage changes (reverses) hence point B become positive diodes D_3 and D_4 are f.B, while D_1 and D_2 reverse biased. Now the diodes D_3 and D_4 conduct in series with the load & current flows.

Note:- It is seen that in both cycles of ac, the load current is flowing in the same direction hence, we get a fullwave rectified output.



The waveforms of load current and voltage remains exactly same as fullwave rectifier.

Expressions for various parameters :-

~~The relation b/w~~ The bridge rectifier ckt, being a full wave rectifier ckt, All the characteristics for a F.W.R using two diodes are characteristic of a bridge rectifier ckt.

$I_{dc} = \frac{2I_m}{\pi}$, $V_{dc} = \frac{2V_m}{\pi}$

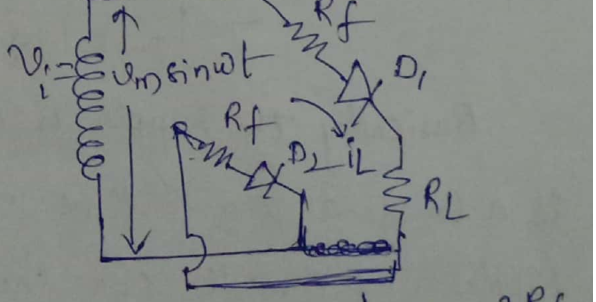
$I_{Rm} = \frac{I_m}{\sqrt{2}}$, $P_{dc} = I_{DC}^2 \cdot R_L = \frac{4}{\pi^2} I_m^2 R_L$

The Expression 'I_m' will change slightly.

$\left(\because I_m = \frac{E_m}{R_s + 2R_f + R_L} \right)$

$PIV = V_m$, $P_{AC} = I_{Rms}^2 (R_s + 2R_f + R_L)$

$= \frac{I_m^2 (2R_f + R_s + R_L)}{2}$



Total Resistance $= 2R_f$

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

$\% \eta_{max} = 81.2\%$

$\gamma = 0.48$

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