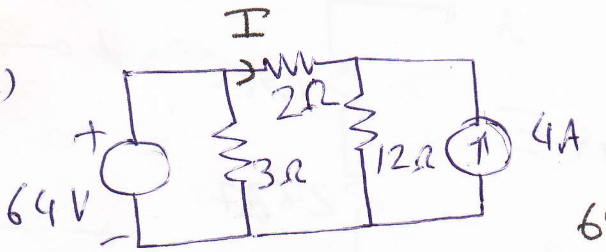
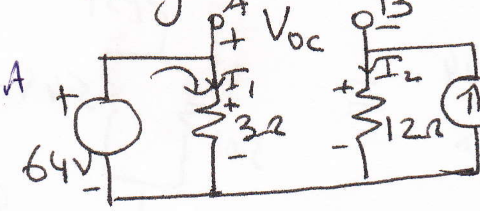
Section-B

Q3(a)



Using Thevenin's theorem—

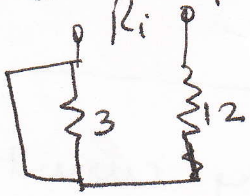


$I_1 = \frac{64}{3}$

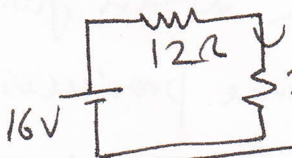
$V_{oc} - 3\times\frac{64}{3} + 12\times 4 = 0$

$V_{oc} = 64 - 48 = 16\,V$

Circuit for R_i :-

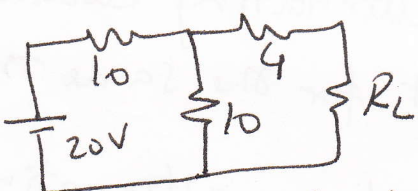


$R_i = 12\Omega$

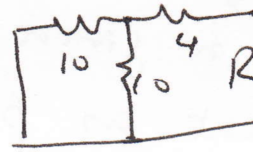


$I_L = \frac{16}{14} = 1.14\,A = \underline{\underline{1.14\,A}}$

(b)

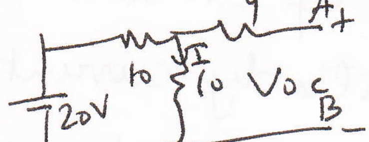


Value of $R_L \Rightarrow$



$R_L = R_i = \underline{\underline{9\Omega}}$

$V_{th} \rightarrow$



$P_{max} = \frac{V^2}{4R_L} = \frac{100}{4\times 9} = \underline{\underline{2.78\,W}}$

$I = \frac{20}{20} = 1\,A$

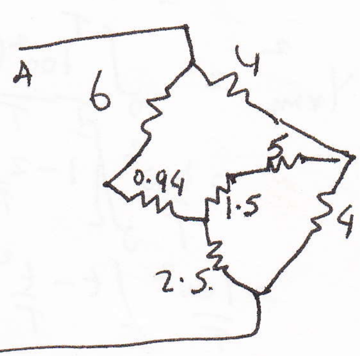
$V_{oc} = 10\,V$

(C)

$R_1 = \frac{15}{16} = 0.9375\,\Omega = 0.94$

$R_2 = \frac{24}{16} = 1.5\Omega$

$R_3 = \frac{40}{16} = 2.5\Omega$

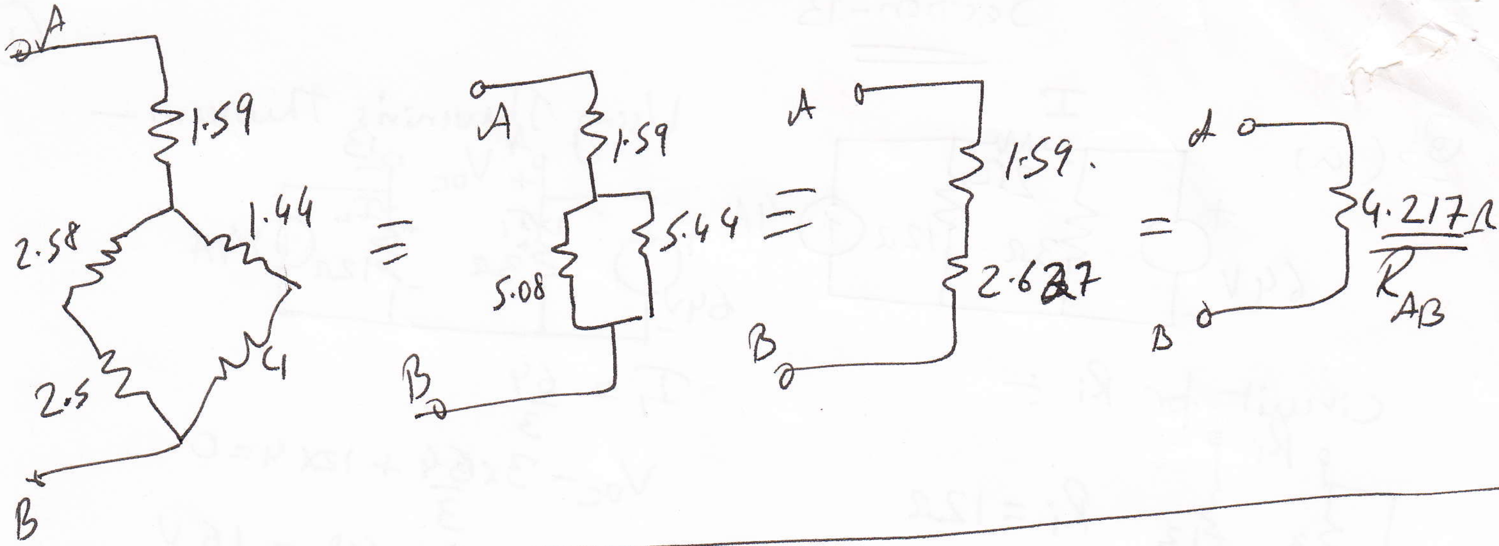


$\equiv$

$R_1 = \frac{4\times 6.44}{17.44} = 1.59\Omega$

$R_2 = \frac{6.44\times 6.5}{17.44} = 2.58\Omega$

$R_3 = \frac{4\times 6.5}{17.44} = 1.49\Omega$



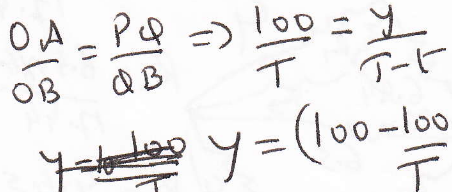
Q4(a) Rms value: Rms value of an Alternating current is given by that steady (D.C.) current which when flowing through a given circuit for a given time produces the same heat as produced by the alternating current when flowing through the same circuit for the same time.

Average value:- Average value of an alternating current is expressed by that steady current which transfers across any circuit the same charge as is transferred by that alternating current during the same time.

$$y_{ave.} = \frac{\int_0^T 100\left(1-\frac{t}{T}\right) dt}{T}$$

$$= \frac{100}{T}\left[t - \frac{t^2}{2T}\right]_0^T = \frac{100}{T}\left[T - \frac{T^2}{2T}\right]$$

$$= 100 - \frac{100}{2} = 50$$



$$y_{rms}^2 = \frac{\int_0^T 100^2\left(1-\frac{t}{T}\right)^2 dt}{T}$$

$$\frac{OA}{OB} = \frac{PQ}{QB} \Rightarrow \frac{100}{T} = \frac{y}{T-t}$$

$$= \frac{100^2}{T}\int_0^T \left[1 - \frac{2t}{T} + \frac{t^2}{T^2}\right] dt$$

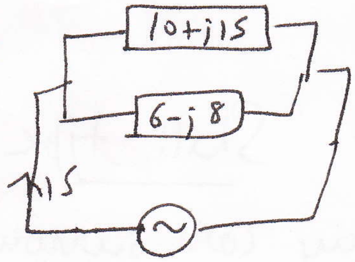
$$y = \left(100 - \frac{100t}{T}\right)$$

$$= \frac{100^2}{T}\left[t - \frac{t^2}{T} + \frac{t^3}{3T^2}\right]_0^T = \frac{100^2}{T}\left[T - \frac{T^2}{T} + \frac{T^3}{3T^2}\right]$$

$$= 100\left[1 - \frac{t}{T}\right]$$

$$= 100^2\left[T - T + \frac{T}{3}\right] = \frac{100^2}{3}$$

Q4(b)



$Z_1 = 10+j15 = 18\angle 56.3\ \Omega$

$Z_2 = 6-j8 = 10\angle -53.13\ \Omega$

$Z = \dfrac{Z_1 Z_2}{Z_1+Z_2} = \dfrac{18\angle 56.3 \times 10\angle -53.13}{16+j7} = \dfrac{180\angle 3.17}{17.46\angle 23.63}$

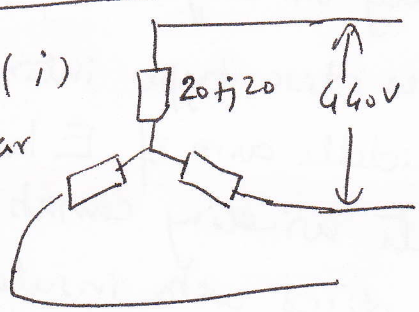
or, $Z = 10.31\angle -20.46\ \Omega$

$V = IZ = 15 \times 10.31\angle -20.46 = 154.65\angle -20.46\ V$

$I_1 = \dfrac{154.65\angle -20.46}{18\angle 56.3} = 8.59\angle -76.76\ A$

$I_2 = \dfrac{154.65\angle -20.46}{10\angle -53.13} = 15.465\angle 33.13\ A$

(c) (i) Star



$Z = 20+j20 = 28.28\angle 45°\ \Omega$

$V_{ph} = \dfrac{440}{\sqrt{3}} = 254\ V$

$I_{ph} = \dfrac{254}{28.28} = 8.98\ A = I_L$

~~$I_L = \sqrt{3} \times 8.98 = 15.56\ A$~~

(ii)

$I_{ph} = \dfrac{440}{28.28} = 15.56\ A$

$I_L = \sqrt{3} \times 15.56 = 26.95\ A$

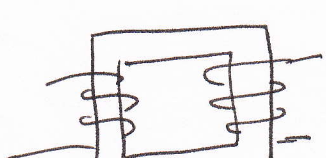
(i) $W_1 = V_L I_L \cos(30-\phi) = 440 \times 8.98 \times \cos(30-45°) = 3816.566\ W$

$W_2 = V_L I_L \cos(30+\phi) = 440 \times 8.98 \times \cos(30+45) = 1022.64\ W$

(ii) $W_1 = 440 \times 26.95 \times \cos 15 = 11453.95\ W$

$W_2 = 440 \times 26.95 \times \cos 75 = 3069\ W$

Q5 (a)



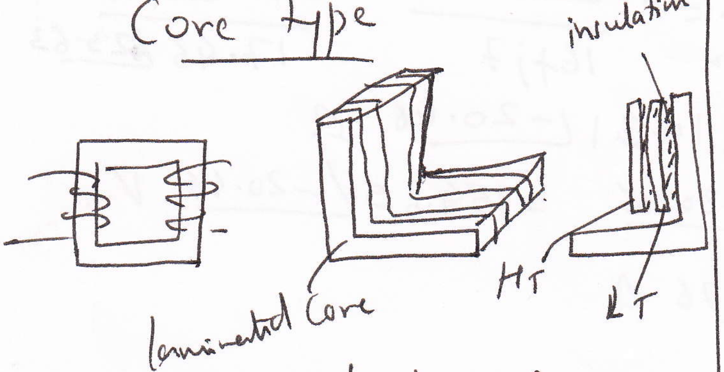
Transformers basically consist of 2 parts: Core, Winding

Core – supports windings

Terminals are brought out with the

Transformers are of two types:-

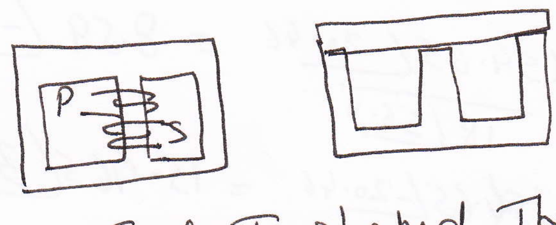
Core type



In core type ~~[illegible]~~ winding surrounds the core. To reduce core losses, Si steel material is used for core to minimise hysteresis loss. Core is laminated to reduce eddy current loss. The laminates are varnished for insulation purpose. The thickness of lamination is between 0.35 mm - to 0.5mm. The laminations are in the form of 'L' shape. The Cu windings are former wound & LT winding are first put next to core to minimise insulation. Then HT winding is put after insulating the LT winding. This way alternate LT & HT windings are put. Small size transformers has

Shell type

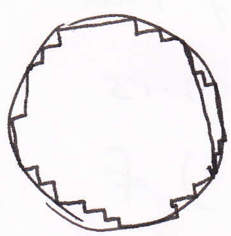
Here we say core surrounds the winding. The core laminations



are E & I shaped. The primary & secondary winding are put as multilayer disc type interleaved on the middle arm of E laminations. The complete winding consists of stacked discs with insulation space between the coils - the spaces forming horizontal cooling & insulating discs.

Core type

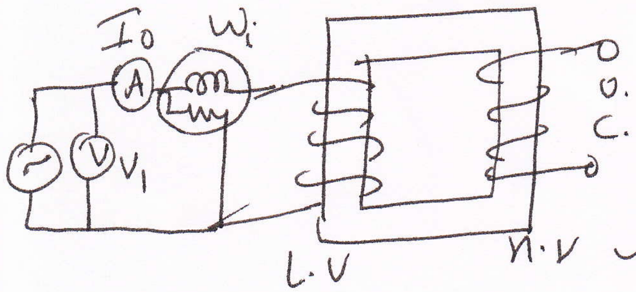
So primary & secondary windings are interleaved in both the legs to reduce leakage flux. The laminations are butted against each other. Small transformers have circular cores but large transformers have circular or rectangular cores. Rectangular cores are stepped cores to reduce the reluctance of magnetic path.



All the transformers leads are brought out of their cases through suitable bushings made of porcelain.

Cooling:- Transformers are air-cooled or oil cooled. Oil is used for two purposes:- Cooling & insulation. For oil cooling, transformer unit is put in a container & oil is filled. The tank is sealed air-tight. To avoid moisture, breathers are ~~put~~ used. There is conservator on top of the tank to take away the oil which expands when oil gets hot. For voltages above 25 kV, transformers are cooled by means of air-blast. The transformer is housed in a thin sheet-metal box open at both ends through which air is blown from the bottom to the top by means of a fan or blower.

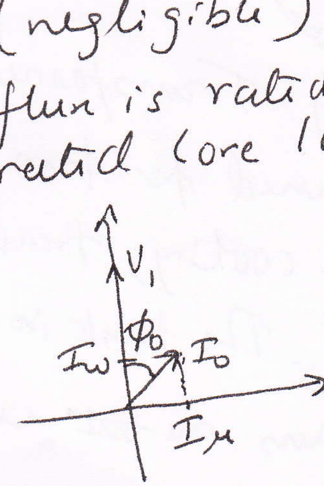
Q5 (b) O.C test — O.C test is done on transformer to find core loss & no load components / parameters. Generally



this test is done on L.V side which HV side open.

The circuit is as shown in figure. The supply V is increased to rated voltage V_1 & reading of ammeter (I_0) & wattmeter (W_i) is noted down. As secondary is O.C., the primary current carries only no-load current I_0 which is just 4–5% of full load current of the transformer. ∴ Cu loss is primary winding is very less (negligible) & as voltage is rated voltage, flux is rated & core loss measured ~~by~~ is rated core loss.

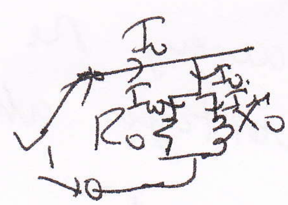
∴ Core loss



∴ $W_i = V_1 I_0 \cos\phi_0$

$\cos\phi_0 = \dfrac{W_i}{V_1 I_0}$

Core loss comp. of current I_w ~~cos φ~~ $= I_0 \cos\phi_0$



magnetising current $I_\mu = I_0 \sin\phi_0$

$R_0 = \dfrac{V_1}{I_w}$ & $X_0 = \dfrac{V_1}{I_\mu}$.

5(c) O.C. Test : 200V, 0.7A, 70W

S.C. Test : 15V, 10A, 80W

From O.C. test : $70 = 200 \times 0.7 \times \cos\phi_0$

$\cos\phi_0 = 0.5$

$\sin\phi_0 = 0.866$

$K = \frac{400}{200} = 2$

$\therefore R_0 = \frac{V_1}{I_W} = \frac{200}{0.7 \times 0.5} = 571.43\,\Omega$

$X_0 = \frac{V_1}{I_\mu} = \frac{200}{0.7 \times 0.866} = 329.92\,\Omega$

From S.C test :-

$80W = I_2^2 R_{02} = 10^2 R_{02}$

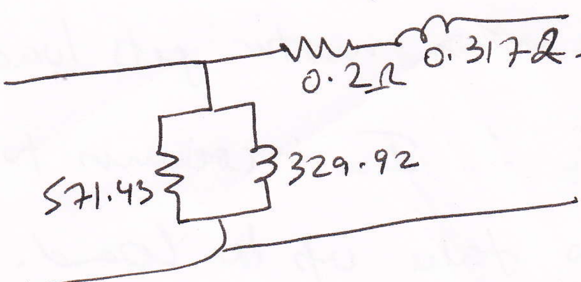
$R_{02} = 0.8\,\Omega$

$Z_{02} = \frac{15}{10} = 1.5\,\Omega$

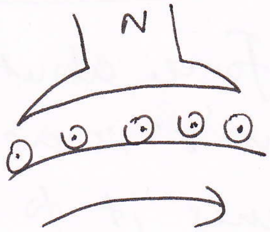
$\therefore X_{02} = \sqrt{1.5^2 - 0.8^2} = 1.269\,\Omega$

$\therefore R_{01} = \frac{0.8}{2^2} = 0.2\,\Omega$

$X_{01} = \frac{1.269}{4} = 0.3172\,\Omega$



6(a)



When electrical supply is given to the motor, with the interaction of armature current with main flux, a torque is produced & motor starts rotating in clockwise by Fleming's left hand rule

When motor starts rotating, there is generator action in motor & due to this, emf will be induced in armature windings ~~the~~ which will try to oppose the current flow in armature winding. This induced emf is called back emf E_b which is in direct opposition with applied voltage. As it is due to generator action,

$$E_b = \phi \frac{N}{60} Z \times \frac{N}{A} \; V$$

The electric work done to overcome this opposition results in converting electrical energy into mechanical energy.

Significance:- Back emf E_b depends upon speed.

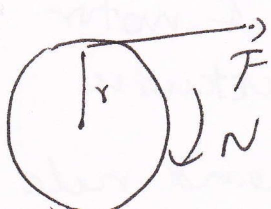
$$E_b = \phi \frac{N}{60} Z \left(\frac{P}{A}\right)$$

If speed is high, E_b high & $\therefore$ I_a low & T low

IIIly when speed is low, E_b low & $\therefore$ I_a high T high

$\therefore$ E_b acts as a governor i.e. it makes the motor self-regulating so that it draws as much current as is just necessary. So when motor gets loaded, its speed drops & also E_b $\therefore$ I_a increases to build up more torque to take up the load.

Q6 (b) Torque is turning moment of force about an axis. If a pulley of radius 'r' is acted upon by force F which causes it to rotate at N rpm,



Work done/ $= F \times 2\pi r$ J

or, Power developed $= F \times r \times \omega$

$= T \times \omega$ where T — torque produced & $\omega \rightarrow$ angular velocity

Or, $P = \frac{2\pi N T}{60}$ if N is rpm

The gross torque produced by armature $= T_a$

$\therefore$ Total power developed $= T_a \times 2\pi \frac{N}{60}$ watts

In electrical terms, in motor

$$V = E_b + I_a R_a$$

$$\underbrace{V I_a}_{\text{i/p to armature}} = \underbrace{I_a E_b}_{\text{o/p electrical}} + \underbrace{I_a^2 R_a}_{\text{Cu loss}}$$

$\therefore E_b I_a$ is converted into mechanical power

$$\therefore \frac{2\pi N T_a}{60} = E_b I_a = \frac{\phi N Z}{60} I_a \left(\frac{P}{A}\right)$$

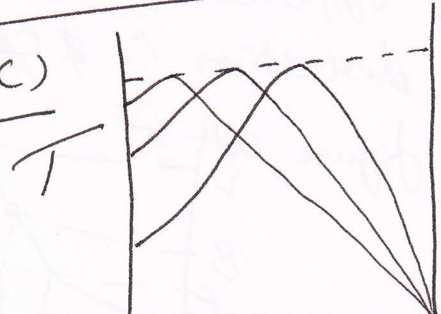
$$T_a = \frac{1}{2\pi} \phi Z I_a \left(\frac{P}{A}\right) \text{ N m.}$$

or, $T_a \propto \phi I_a$.

Shaft torque is given by: $P_{shaft} = \frac{2\pi N T_{SL}}{60}$

$\therefore T_a - T_{SL} =$ lost torque

Q6(C)



$$T = \frac{K \phi S E_2 R_2}{R_2^2 + (S X_2)^2}$$ expression of Torque

When $S \cong 0$, $N \cong N_s$

& $S X_2 << R_2$ $\therefore T \propto S$

as T inc. S also inc.

T is max. at $S = \frac{R_2}{X_2}$ this T is called "pull-out" or "breakdown" Torque

As slip inc. further, $S X_2 >> R_2$

$\therefore T \propto \frac{S}{(S X_2)^2} \propto \frac{1}{S}$ $\therefore$ as S inc., T dec.

$\therefore$ T/S Curve is rectangular hyperbola. So after max. T, further inc. in load, decr. the torque & $\therefore$ motor is unstable. $\therefore$ stable region is between $S=0$ & T_{max}.

At start $T_{st.} = \frac{K E_2 \phi R_2}{R_2^2 + X_2^2}$ $(S=1)$

& at T_{max} $S = \frac{R_2}{X_2}$, $T_{max} = \frac{K_1 \left(\frac{R_2}{X_2}\right) E_2^2 \cdot R_2}{R_2^2 + \left(\frac{R_2}{X_2}\right)^2 X_2^2}$

$\therefore$ max. T is ind. of rotor resistance but $= K_1 \frac{E_2^2}{2X_2}$.

Starting T is.

Q7(a) In practice, no diode is an ideal one i.e. it doesn't behave as perfect conductor on forward bias nor it acts as an insulator when it is reverse biased. Actually diode offers a small resistance when forward biased & high resistance when reverse biased.

(i) DC resistance — the resistance offered by diode to DC current flow in forward direction is called d.c forward resistance. From figure, at P

$R_F = \frac{OA}{..}$

(ii) AC resistance – The opposition to the changing current flow in forward dir. is called ac. forward ~~current~~. resistance. It is ratio of change in voltage across diode to the change in current through it.

Dynamic resistance – $r_f = \frac{CE}{DF} = \frac{\Delta V}{\Delta I}$

The value of r_f is very small varying from 1 to 25 Ω.

Reverse resistance – under reverse biasing, the opposition offered by the diode to the reverse current is called reverse resistance. The ratio of reverse to forward resistance is 100,000 : 1 for Si diode & 40,000 : 1 for Ge-diode.

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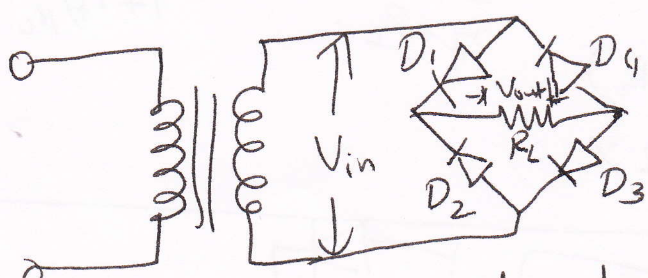
7 (b) Full wave Bridge Rectifier



(i) Ripple factor = $\frac{\text{rms. value of ac. comp.}}{\text{value of dc. comp.}}$

Rms. value of load current

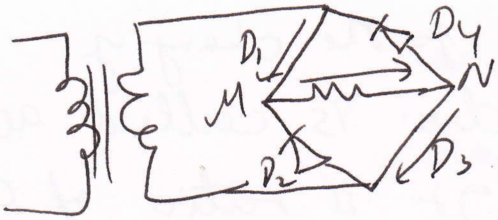
$I_{rms} = \sqrt{I_{dc}^2 + I_{ac}^2}$

or, $I_{ac} = \sqrt{I_{rms}^2 - I_{dc}^2}$

or, Ripple factor $= \frac{I_{ac}}{I_{dc}} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

For Full wave, Ripple factor $= \sqrt{\left(\frac{I_m/\sqrt{2}}{\ }\right)^2 - 1} = 0.482.$

(ii) PIV



when D_1 & D_3 are conducting the voltage across diode D_2 or D_4 is MN which is V_m

$\therefore PIV = V_m$.

(iii) Efficiency of rectification

$$\eta = \frac{\text{DC power o/p}}{\text{AC power i/p}}$$

$v = V_m \sin\theta$

r_f = forward resistance of diode

R_L = load resistance

$$i = \frac{v}{r_f + R_L} = \frac{V_m \sin\theta}{r_f + R_L}$$

$$I_{av} = \frac{\int_0^\pi i\,d\theta}{\pi} = \frac{2I_m}{\pi}$$

$$\& \quad I_m = \frac{V_m}{r_f + R_L}$$

$$P_{dc} = I_{dc}^2 R_L = I_{av}^2 R_L$$

$$\therefore P_{dc} = \left(\frac{2I_m}{\pi}\right)^2 R_L$$

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

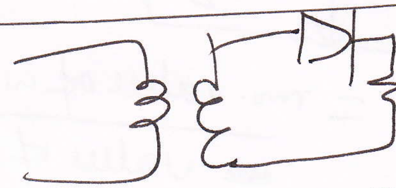
$$P_{ac} = I_{rms}^2 (r_f + R_L)$$

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

$$\therefore \eta = \frac{\left(\frac{2I_m}{\pi}\right)^2 R_L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L)} = \frac{0.812}{r_f + R_L} R_L = \frac{0.812}{1 + r_f/R_L}$$

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

7(c) $$\eta = \frac{P_{dc}}{P_{ac}}$$



$$i = \frac{V_m \sin\theta}{r_f + R_L}$$

$$I_{av} = \frac{\int_0^\pi i\,d\theta}{2\pi} = \frac{I_m}{\pi}$$

$$P_{dc} = I_{av}^2 R_L = \left(\frac{I_m}{\pi}\right)^2 R_L$$

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

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

$$P_{ac} = I_{rms}^2 (r_f + R_L)$$

$$= I_m^2 (r_f + R_L)$$

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{\left(\frac{I_m}{\pi}\right)^2 R_L}{\left(\frac{I_m}{2}\right)^2 (r_f + R_L)} = \frac{0.406}{1 + r_f/R_L}$$

$$\therefore \eta_{max} = 40.6\%$$

$$\text{Ripple factor} = \frac{I_{ac}}{I_{dc}} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

$$= \sqrt{\left(\frac{I_m/2}{I_m/\pi}\right)^2 - 1} = 1.21.$$

It shows that half wave rectifier has more ripples & ∴ it is a poor rectifier

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