Model Question Paper-I/II with effect from 2021 (CBCS Scheme)

USN

First Semester BE Degree Examination

Subject Title – Basic Electrical Engineering

TIME: 03 Hours **Max. Marks: 100**

Note: Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE.**

		Module -1	**Marks**
Q.01	a	Illustrate with examples, Kirchhoff's laws as applied to an electric circuit.	8
	b	Prove that, the circuit efficiency during maximum power transfer from source to load is only 50%.	6
	c	The equation for an AC voltage is given as V= 0.04sin $(2000t+60^{0})$ volts. Determine the frequency, angular frequency and instantaneous voltage when t=160μs.	6
		OR	
Q.02	a	Define R.M.S value of alternating current. Show that its value is proportional to maximum value.	8
	b	A circuit consisting of 12Ω, 18 Ω and 36 Ω respectively, joined in parallel, is connected in series with a fourth resistance. The whole is supplied at 60V and it is found that the power dissipated in 12 Ω resistance is 36 W. determine the value of fourth resistance and the total power dissipated in the group.	6
	c	Justify, why pure inductor does not consume any power when connected across single phase A.C. supply?	6
		Module-2	
Q. 03	a	Demonstrate that, two wattmeters are sufficient to measure power in a three phase balanced star connected circuit with the help of neat circuit diagram and phasor diagram.	8
	b	A circuit consists of a resistance of 20Ω, an inductance of 0.05H connected in series. A supply of 230V at 50 Hz is applied across the circuit. Determine the current, power factor and power consumed by the circuit.	6
	c	Deduce the relationship between the phase and the line voltages of a three phase star connected system.	6
		OR	
Q.04	a	Develop an equation for the power consumed by an R-L series circuit. Draw the waveforms of voltage, current and power.	8
	b	When a three phase balanced impedances are connected in star, across a three phase, 415V, 50Hz supply, the line current drawn is 20A, at a lagging p.f of 0.4. Determine the parameters of the impedance in each phase.	6
	c	A balanced 3 phase star connected system draws power from 440V supply. The two wattmeters connected indicate 5KW and 1.2 KW. Determine power, power factor and current in the circuit.	6
		Module-3	
Q. 05	a	Explain the principle of operation and construction of a dc generator.	8
	b	How back emf regulates the armature current in a D.C. Motor? Explain with relevant equations.	6
	c	A 4 pole, 1500 r.p.m. D.C. generator has a lap wound armature, having 32 slots and 8 conductors per slot. If the flux per pole is 0.04Wb, datermine the E.M.F. induced in the armature. What would be the E.M.F induced, if the winding is wave connected.	6

OR			
Q. 06	a	Discuss various types of losses in a transformer.	8
	b	With usual notations, develop the torque equation of D.C. motor.	6
	c	A 250 KVA, 11000/415 volts, 50 Hz single phase transformer has 80 turns on the secondary. Calculate i) Rated primary and secondary currents ii) Number of primary turns iii) Maximum value of flux in the core iv) Voltage induced/turn on secondary.	6
Module-4			
Q. 07	a	How rotating magnetic field is set up in case of three phase induction motor? Illustrate with neat figures.	8
	b	What is slip of an induction motor and derive expression for frequency of rotor current in terms of supply frequency.	6
	c	A 12 pole 3 phase alternator is coupled to an engine running at 500 rpm. It supplies an induction motor which has a full load speed of 1440 rpm. Determine the percentage slip and the number of poles of the motor.	6
OR			
Q. 08	a	With neat sketches, explain the construction of two types of synchronous generator.	8
	b	Develop the E.M.F. equation of synchronous generator.	6
	c	A 12 pole, 500 rpm star connected alternator has 48 slots with 15 conductors per slot. The flux per pole is 0.02 Wb and is distributed sinusoidally. The winding factor is 0.97. Calculate the line e.m.f.	6
Module-5			
Q. 09	a	What is electric power supply system? Draw a single line diagram of a typical a.c. power supply scheme.	8
	b	What are the desirable characteristics of a tariff and explain two part tariff.	6
	c	A consumer has a maximum demand of 200 kW at 40% load factor. If the tariff is Rs. 100 per kW of maximum demand plus 10aise per kWh, Find the overall cost per kWh.	6
OR			
Q. 10	a	Explain the working principle of fuse and MCB.	6
	b	What is earthing? Why earthing is required? With the help of neat sketch, explain plate earthing.	8
	c	Write a short note on precautions against an electric shock.	6

Table showing the Bloom's Taxonomy Level, Course Outcome and Program Outcome

Question		Bloom's Taxonomy Level attached	Course Outcome	Program Outcome
Q.1	(a)	L2	CO1	PO1, PO2,P12
	(b)	L3	CO1	PO1, PO2,PO3,PO8,P12
	(c)	L3	CO1	PO1,PO2,PO3
Q.2	(a)	L4	CO1	PO1,PO2,PO3
	(b)	L3	CO1	PO1,PO2,PO3,P12
	(c)	L4	CO1	PO1,PO2,PO3,P12
Q.3	(a)	L3	CO1	PO1,PO2,PO3,PO8,P12
	(b)	L3	CO1	PO1,PO2,PO3,P12
	(c)	L3	CO1	PO1,PO2,PO3,P12
Q.4	(a)	L3	CO1	PO1,PO2,PO3,P12

Module - 1

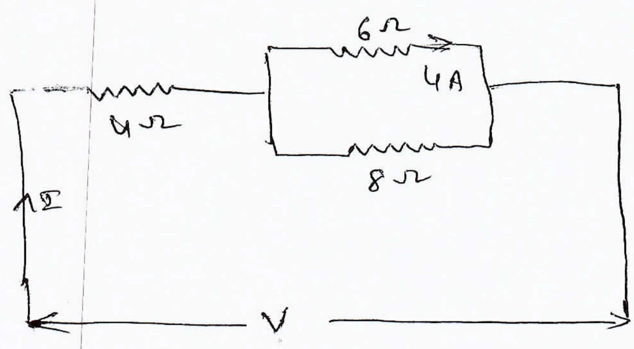
Q.1

a) Illustrate with Example Kirchoff's law as applied to an Electric Circuit

Current law :- The algebraic sum of the all the currents meeting at a any junction of an Electrical circuit is zero i.e $\Sigma I = 0$

Voltage law :- in any closed Electrical circuit the algebraic sum of all the emf and the resistive drop is Equal to zero.

$$\Sigma E + \Sigma IR = 0$$



I through 8 A is given by

$I = I_1 + I_2$

$7 = 4 + I_2$

$I_2 = 7 - 4 = 3\text{ A}$

$7 = 4 + 3$ KCL

$$4 = \frac{I \times 8}{6+8}$$

$$I = \frac{4 \times 14}{8} = 7\text{ A}$$

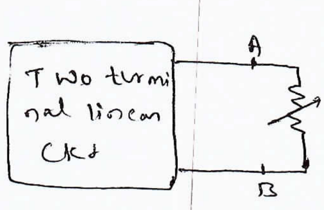
KVL

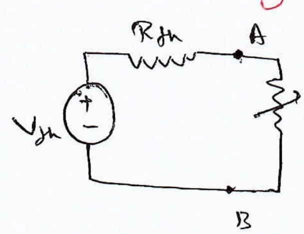
$$= 4 \times 7 + \left(\frac{6 \times 8}{6+8}\right) 7$$

$$52V = 28 + \frac{48}{14} \times 7 = 28 + 24 = 52V$$

$$52V = 28V + 24V$$

(ii) Prove that the circuit y/n during max Power transfer from source to load is only 50%.





amount of power dissipated across the load resistor is $P_L = I^2 R_L$

substitute $I = \dfrac{V_{th}}{R_{th} + R_L}$ in the above Equation

$$P_L = \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 R_L$$

for maximum first derivative will be zero

differentiate above Eqn w.r.t R_L and make it Equal to zero

$$\frac{\partial P_L}{\partial R_L} = V_{th}^2 \left\{ \frac{(R_{th}+R_L)^2 \times 1 - R_L \times 2(R_{th}+R_L)}{(R_{th}+R_L)^4} \right\} = 0$$

$$(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L) = 0$$

$$(R_{th}+R_L)(R_{th}+R_L-2R_L) = 0$$

$$(R_{th}-R_L) = 0 \qquad R_{th} = R_L$$

Condition for max power dissipation across the load is

$$R_L = R_{th}$$

<u>The value of max Power transfer</u>

substitute $R_L = R_{th}$ & $P_L = P_{Lmax}$

$$P_{Lmax} = V_{th}^2 \left\{ \frac{R_{th}}{(R_{th}+R_{th})^2} \right\}$$

$$P_{Lmax} = V_{th}^2 \left\{ \frac{R_{th}}{4R_{th}} \right\}$$

$$P_{Lmax} = \frac{V_{th}^2}{4R_{th}}$$

$$P_{Lmax} = \frac{V_{th}^2}{4R_L} \quad \text{since } R_L = R_{th}$$

the max amount of Power transfered to the load is

$$P_L = \frac{V_{th}^2}{4R_L} = \frac{V_{th}^2}{4R_{th}}$$

<u>η of maximum Power transfer</u>

$$\eta_{max} = \frac{P_{Lmax}}{P_s}$$

P_{Lmax} = is the max Power transfered to load

P_s = amount of power generated by the source

amount of Power generated by the source :

$$P_s = I^2 R_{th} + I^2 R_L \qquad P_s = 2I^2 R_{th} \quad \text{since } R_L = R_{th}$$

substitute $I = \frac{V_{th}}{2R_{th}}$ in the above Equation

$$P_s = 2\left(\frac{V_{th}}{2R_{th}}\right)^2 R_{th} = 2\left(\frac{V_{th}^2}{4R_{th}^2}\right) R_{th} = \frac{V_{th}^2}{2R_{th}}$$

Substitute the values of P_{Lmax} and P_s in Equation

$$\eta_{max} = \frac{\frac{V_{th}^2}{4R_{th}}}{\frac{V_{th}^2}{2R_{th}}} = \frac{1}{2} = 50\%$$

we can represent the % η of max power transfer in terms of %.

$$\%\eta_{max} = \eta_{max} \times 100\% = \frac{1}{2} \times 100\% = 50\%$$

c) The Equation of an A.C voltage is given as $V = 0.04 \sin (2000t + 60°)$ volts. Determine the frequency, angular frequency and instantaneous voltage when $t = 160\mu s$.

given : $V = 0.04 \sin (2000t + 60°)$ and $t = 160\mu s$

frequency is given by $\omega = 2000$

$$f = \frac{2000}{2\pi} = \frac{1000}{\pi} = 318.26 Hz$$

angular frequency is given by $\omega = 2000$ rad/sec

when $t = 160\mu s$

$$V = 0.04 \sin (2000 \times 160 \times 10^{-6} + 60°)$$

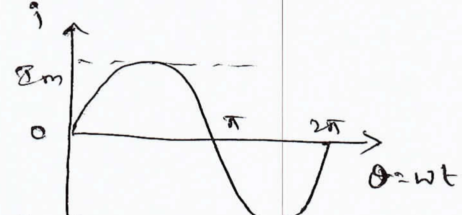
$$= 0.04 \sin (0.32 + 60°)$$

$$V = 0.0347 V$$

Q.2

a) Define R.M.S value of alternating current show that it's value is proportional to max value.

The term "RMS" stands for Root mean square is defined as the amount of AC power that produces the same heating effect as an equivalent D.C power. It is square root of the mean value of the squared function of instantaneous value.



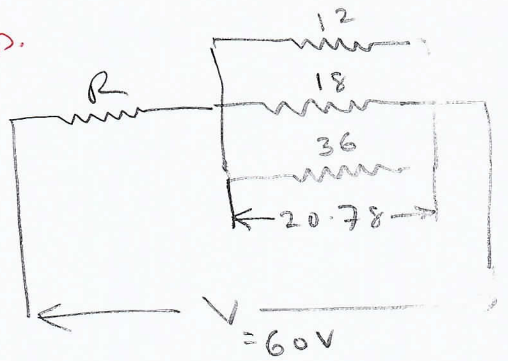
$$i = I_m \sin \theta$$

The effective value of this current is given by

$$I^2 = \frac{1}{2\pi} \int_0^{2\pi} i^2 d\theta = \frac{1}{2\pi} \int I_m^2 \sin^2 \theta \, d\theta$$

$$= \frac{I_m^2}{2\pi}\int_0^{2\pi}\frac{1-\cos 2\theta}{2}\,\partial\theta = \frac{I_m^2}{4\pi}\left[2\pi - 0\right] = \frac{I_m^2}{2} = 0.707\, I_m$$

b) A circuit consisting of 12Ω, 18Ω and 36Ω respectively joined in ||el. is connected in series with a fourth resistance. The whole is supplied at 60V and it is found that the power dissipated in 12Ω resistance is 36W. Determine the value of fourth resistance and the total power dissipated in the group.



$$P = I^2R = \frac{V^2}{R}$$

$$V^2 = P \times R = 12 \times 36$$

$$V = \sqrt{36 \times 12} = 20.78\,V$$

$$I = I_1 + I_2 + I_3$$

$$= \frac{20.78}{12} + \frac{20.78}{18} + \frac{20.78}{36}$$

$$= 1.73 + 1.15 + 0.576$$

$$I = 3.456\,A$$

$$V = I R_T$$

$$60 = 3.456\, R_T$$

$$R_T = \frac{60}{3.456} = 17.36$$

$$R + 6 = 17.36$$

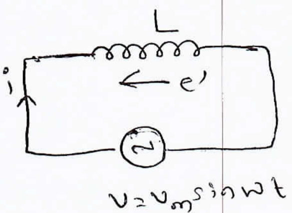
$$R = 17.36 - 6 = 11.36\,\Omega$$

Total Power dissipated in the group

$$P = VI$$

$$P = 60 \times 3.456 = 207\,W$$

Q) Justify why pure inductor does not consume any power when connected across a single phase A.C supply.



Consider a coil of pure inductance L across which an alternating voltage $e = E_m \sin \omega t$ is applied as alternating current i flows through it

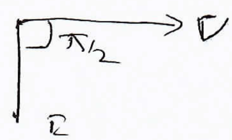
$$e = E_m \sin \omega t \qquad di = \frac{e}{L} dt = \frac{1}{L} E_m \sin \omega t \, dt$$

$$e' = -L\frac{di}{dt} = -e \qquad i = \frac{E_m}{L}\int \sin \omega t \, dt = \frac{E_m}{\omega L}(-\cos \omega t)$$

$$e = L\frac{di}{dt}$$

$$= I_m \sin(\omega t - \pi/2)$$

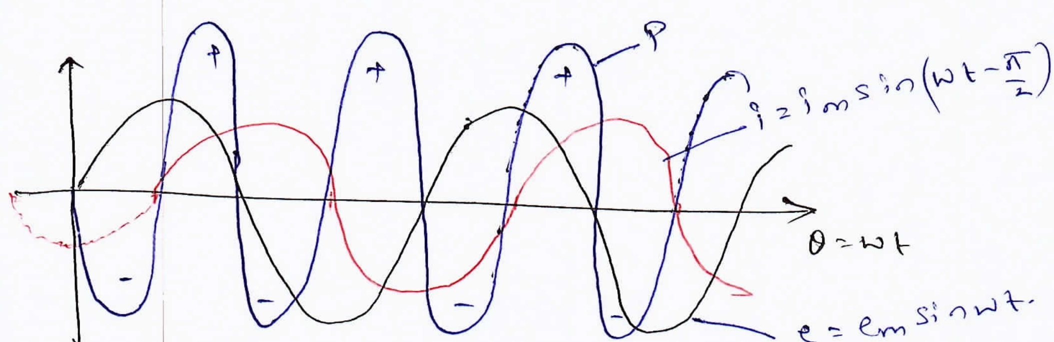
By observing Equation



Instantaneous power is given by

$$P = ei = E_m \sin \omega t \; I_m \sin(\omega t - \pi/2) = -\frac{1}{2} E_m I_m \sin 2\omega t$$

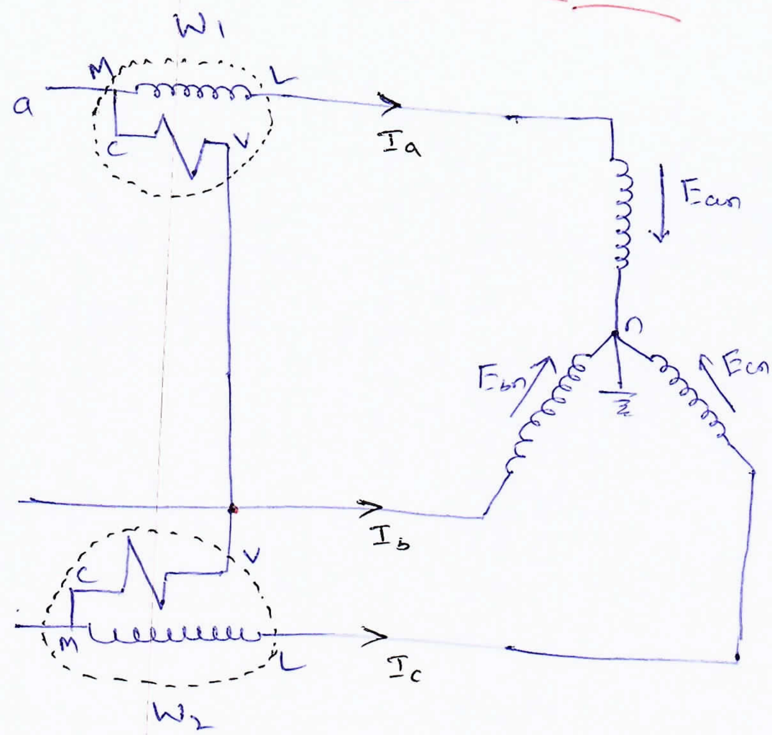
The Equation for P consists a quality which is periodically varying and having a frequency two times the frequency of applied voltage whose avg value is zero



MODULE - 2

Q.3

a)



The wattmeter reading W_1 is given by

$W_1 = E_{ab} I_a \cos \lfloor E_{ab} \& \lfloor I_a$

IIIly

$W_2 = E_{cb} I_c \cos \lfloor E_{cb} \& \lfloor I_c$

The angle between E_{ab} & I_a and E_{cb} & I_c are found by the vector diagram as shown

$E_{ab} = E_{an} + E_{nb} = E_{an} - E_{bn}$

Assuming the load is inductive I_a lags behind E_{an} by an angle ϕ. Hence the angle between E_{ab} & I_a is $(30-\phi)$

$$W_1 = E_{ab} I_a \cos(30-\phi) = E_l I_l \cos(30-\phi) \quad \text{— (i)}$$

$E_{cb} = E_{cn} + E_{nb} = E_{cn} - E_{bn}$

I_c lags behind E_{cn} by angle ϕ

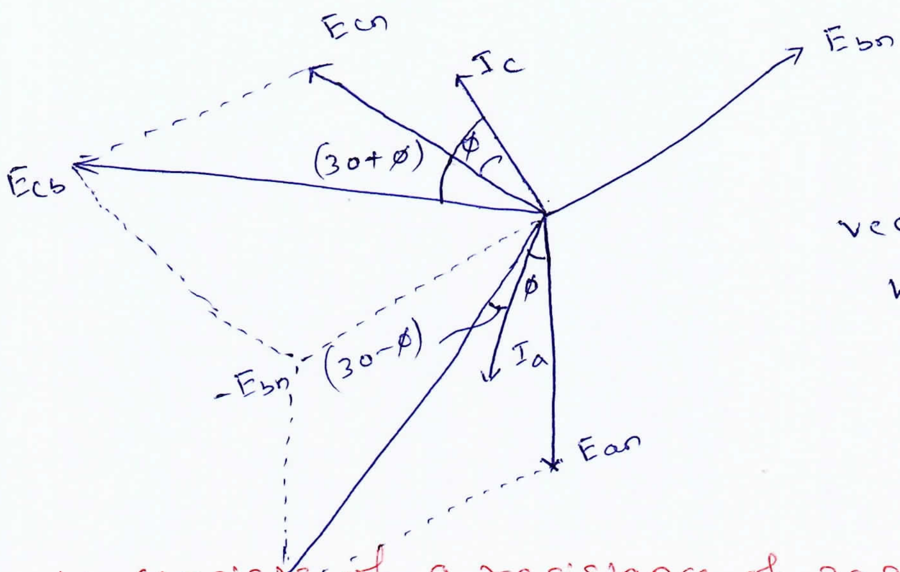
Hence the angle between E_{cb} & I_c is $(30+\phi)$ — (ii)

Adding Equation (i) & (ii) we get

$$W_1 + W_2 = E_l I_l \left[\cos(30+\phi) + \cos(30+\phi)\right]$$

$$= E_l I_l \left[2 \cos 30 \cos \phi\right]$$

$$= \sqrt{3}\, E_l I_l \cos\phi$$ three phase power



vector diagram of two watt meter method

A circuit consists of a resistance of 20Ω and inductance of 0.05H connected in series A supply of 230V, 50Hz is applied find Ckt Parameters.

b) given data

$R = 20\Omega$ $L = 0.05H$ $V = 230$ $f = 50Hz$

We know that

$X_L = 2\pi f L = 2 \times \pi \times 50 \times 0.05 = 15.71\Omega$

$Z = R + jX_L = (20 + j15.71)\Omega$ $I = \frac{V}{Z} = \frac{230\angle 0^\circ}{(20+j15.71)} = 9.04\angle -38.14^\circ$

Power factor of Ckt is $\cos\phi = \cos 38.14 = 0.786$

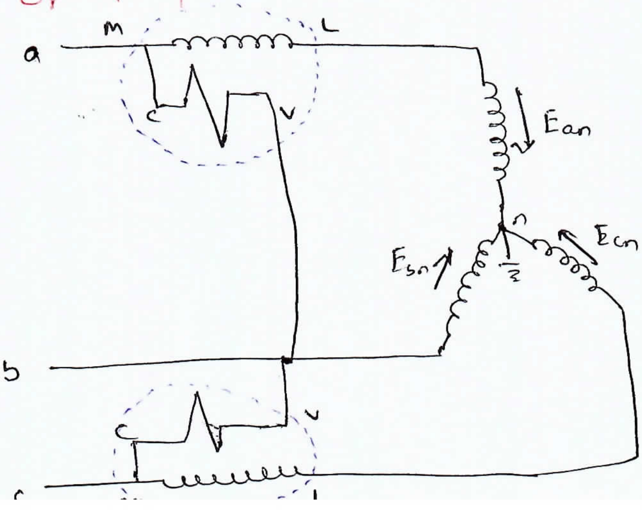
Power consumed by the Ckt is $P = VI\cos\phi$

$= 230 \times 9.04 \times \cos(38.14)$

$= 1635.29W$

Deduce the relation b/w the phase and line voltage of a 3ϕ star connected system.

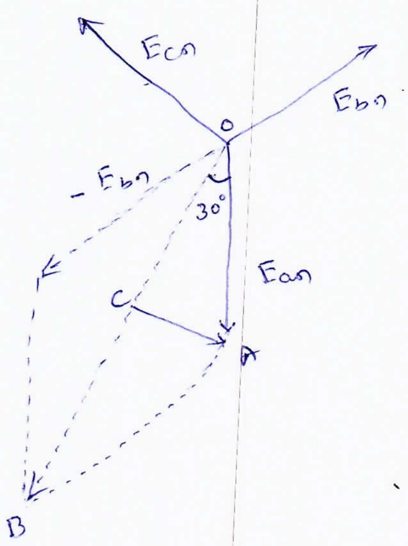
c)



Star connected system

The point n is known as neutral point. E_{an}, E_{bn}, and E_{cn} are the phase voltages which is Equal to E_{ph}. E_{ab}, E_{bc} and E_{ca} are the line voltages and each of them are Equal to E_L

From the above diagram we can observe that currents flowing through the line are same as currents flowing through phases.



The line voltages E_{ab} is given by $E_{ab} = E_{an} + E_{nb} = E_{an} - E_{bn}$

Draw a $\perp^{ar}$ AC on OB, $\angle AOC = 30°$ from the Δ^{le} AOC

$$\cos 30° = \frac{OC}{OA} = \frac{OB/2}{OA} = \frac{E_{ab}/2}{E_{an}}$$

$$\therefore \quad E_{ab} = 2 E_{an} \cos 30° = 2 E_{an} \frac{\sqrt{3}}{2} = \sqrt{3} E_{an}$$

$E_l = \sqrt{3} E_{ph}$ line voltage $= \sqrt{3}$ phase voltage

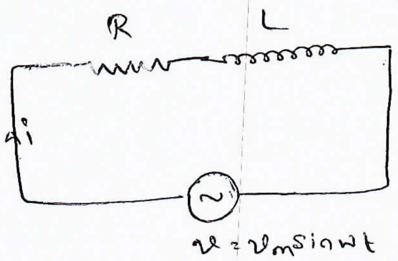
Power consumed is given by

$P = 3 \times$ Power consumed in each phase $= 3 \times E_{ph} I_{ph} \cos\phi$

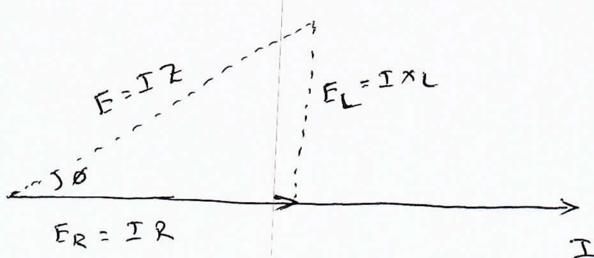
$$= 3 \times \frac{E_l}{\sqrt{3}} \times I_l \cos\phi = \sqrt{3} V_l I_l \cos\phi$$

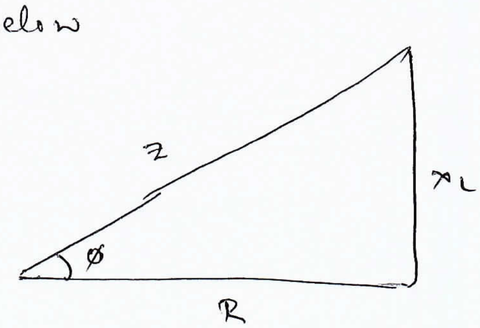
Q.4.

a] Develop an Equation for the power consumed by an R-L series Ckt Draw the waveform of the voltage current and power.



Consider an R-L circuit as shown in the fig to which an alternating voltage of r.m.s value V is applied due to which current I flows through the circuit. The vector diagram taking I as reference is as shown below





$$I = \frac{E}{Z} \quad \text{where } Z = \sqrt{R^2 + X_L^2}$$

where ϕ is power factor angle given by $\phi = \tan^{-1}\frac{X_L}{R}$

Hence $v = V_m \sin\omega t$ $I = I_m \sin(\omega t - \phi)$

Instantaneous Power is given by

$P = vi = V_m \sin\omega t \, I_m \sin(\omega t - \phi)$

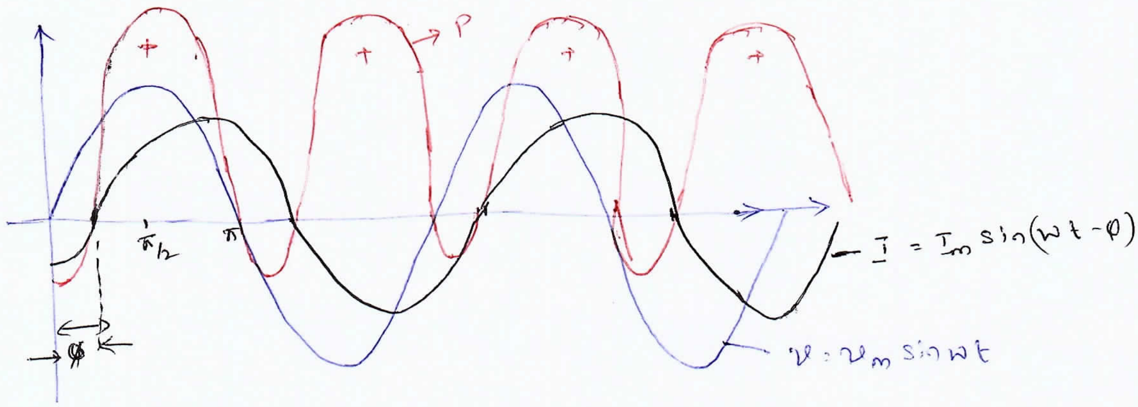
$= V_m I_m \frac{1}{2}\left[\cos\phi - \cos(2\omega t - \phi)\right]$

$= \frac{1}{2} V_m I_m \cos\phi - \frac{1}{2} V_m I_m \cos(2\omega t - \phi)$

The second term in the Equation is periodically varying quantity whose frequency is twice the frequency of applied voltage it's avg value is zero, Hence

$P = \frac{1}{2} V_m I_m \cos\phi = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\phi = VI\cos\phi$

"$\cos\phi$" is known as power factor of the circuit.



$P = VI\cos\phi$ Real Power in watts

$Q = VI\sin\phi$ Reactive Power in watts

$S = VI$ = apparant Power in watts

b) when a 3ϕ Balanced impedance are connected in Y across a 3ϕ 415V, 50Hz supply the line currents drawn is 20A at a lag P.f of 0.4 Determine the parameters of impedance in each phase

given Y connection, $V_L = 415V$ $f = 50Hz$ $I_L = 20A$

$\cos\phi = 0.4$ lag Parameters of impedence i.e R = L = ?

$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.60V$

since Y connected system $I_L = I_{ph} = 20A$

$Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{239.6}{20}\ \Omega$ $\cos\phi = \frac{R_{ph}}{Z_{ph}}$ $R_{ph} = 0.4 \times 11.98$

$= 11.98 \simeq 12\ \Omega$ $R_{ph} = 4.79\ \Omega$

$R^2 + X_L^2 = Z^2$ $X_L = \sqrt{Z^2 - R^2} = \sqrt{11.98^2 - 4.79^2}$

$= \sqrt{120.57} = 10.98\ \Omega$

$2\pi f L = 10.98$ $L = 34.94\,mH \simeq 35\,mH.$

c) A balanced 3ϕ Y connected system draws a power from 440V. The two wattmeters connected indicate 5kW and 1.2kW. Determine power, power factor and current in the ckt.

Given 3ϕ Y connected system $V = 440V$ $W_1 = 5kW$

$W_2 = 1.2kW$ $P = ?$ $\cos\phi = ?$ $I = ?$

Total Power $P = W_1 + W_2 = 5 + 1.2 = 6.2\ kW$

$$\cos\phi = \cos\left(\tan^{-1}\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right) = \cos\left(\tan^{-1}\frac{\sqrt{3}(5 - 1.2)}{6.2}\right) = \cos\left(\tan^{-1} 1.06\right)$$

$\cos\phi = \cos(46.71) = 0.685$

$P = \sqrt{3} V_L I_L \cos\phi$ $I_L = \frac{P}{\sqrt{3} V_L \cos\phi} = \frac{6.2 \times 10^3}{\sqrt{3} \times 440 \times 0.685} = \frac{6.2 \times 10^3}{522.04}$

$= 11.87\ A$

MODULE-3

Q.5
a) Explain the principle of operation & construction of D.C generator

D.C Generator mainly consists of two parts (i) stationary part (ii) Rotating part. Stationary part produces a magnetic flux and the rotating part convert the mechanical Energy in to Electrical Energy. Stationary part and Rotating part are separated by small air gap

Stationary Part consists of (i) Yoke (ii) main poles along with pole shoe & pole coils (iii) Base plate (iv) lifting eye (v) Brush box with brushes (vi) terminal box.

Rotating Part consists of (i) armature (ii) Armature winding (iii) commutator (iv) shaft. The construction of the various part and the purpose they serve in the D.C generator

Yoke:- Yoke forms the outer cover for the D.C Generator and is cylindrical in shape for smaller generator yoke is made up of cast iron, where as for large generators it is made up of cast steels. Cast iron get saturated at about 0.8 wb/m² where as cast steel gets saturated at 1.5 wb/m² Disadvantage of cast iron is that it's mechanical and magnetic properties are uncertain

main poles, Pole shoe, Pole coils

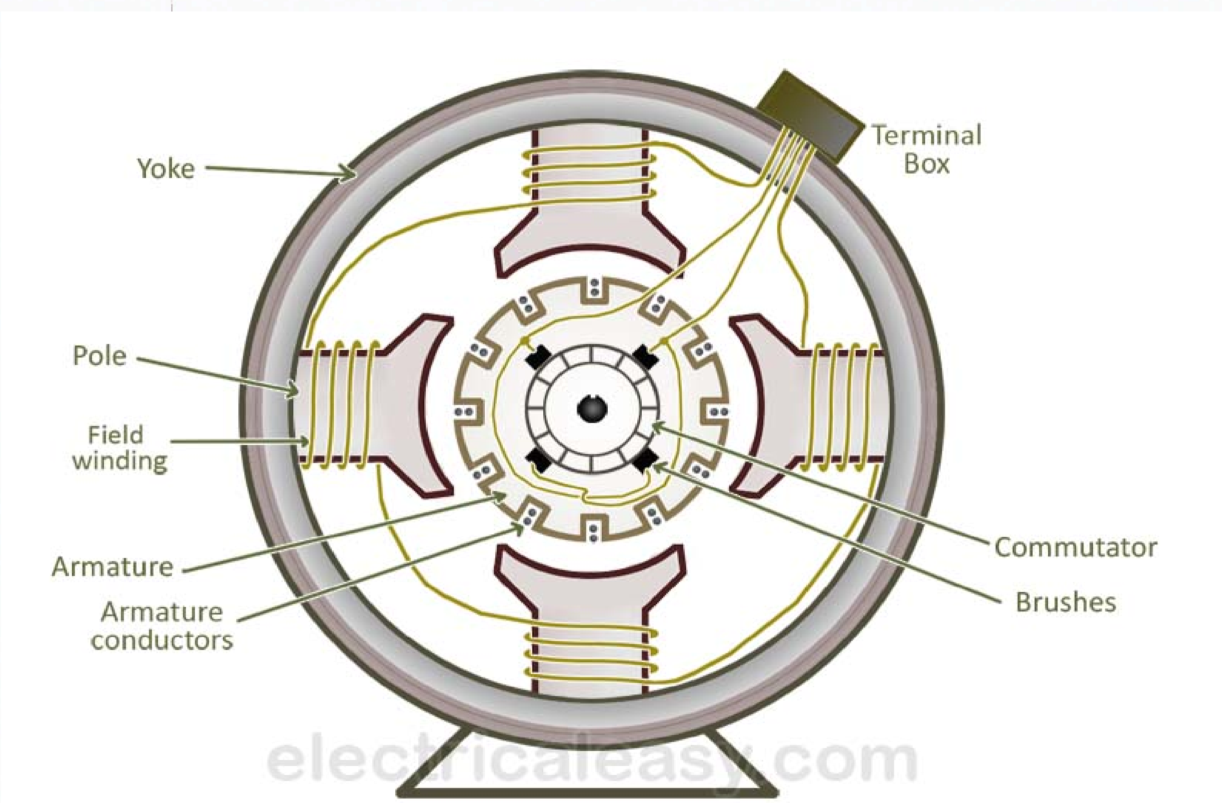
main poles are made up of an alloy steel of high relative permeability. The pole core is laminated to reduce eddy current loss. Thin sheet of alloy steel is insulated from one another and pressed together to form the core The laminations are held tightly with help of end plates. which are revitted together

For small machine the lamination of pole core and pole shoe are cast together as single piece For larger machine the lamination of pole core and pole shoe are cast as different pieces The base plate, the lifting eye the terminal box and brush box are cast integral with the yoke

Armature:- The armature consists of armature core and armature winding The armature core is made up of high Permeability and low loss Silicon steel lamination which are usually 0.4mm to 0.5mm thick and are insulated from one another by varnish. The conductors Placed in the slots are not only insulated from one another but also from the Slots of the armature core.

Armature windings:- Armature conductors are placed in the slots of the armature The conductors are not only insulated from one another but also from the armature slots. The armature conductors are connected together Either as a lap winding or wave winding

Commutator:- Commutator Converts the alternating emf generator in the armature windings in to the Direct current Voltage in the External Circuit



5
6

The armature current drawn by the DC motor is given by

$$I_a = \frac{V - E_b}{R_a}$$

The back emf makes the D.C motor self regulating machine, makes the motor to draw as much armature current as is needed to develop the torque required by the load

* when the motor is running at no-load, a small torque is required to overcome the mechanical loss. Hence I_a is small back emf is nearly Equal to the applied voltage.

* If the load is connected to the motor it causes the armature to slow down and hence the back emf decreases the decreased back emf causes the large current to flow through the armature and the large armature current means increased developed torque by motor.

* when the motor load is decreased then the torque is momentarily more than the requirement so that the armature is accelerated At the speed of the armature increased the back emf also increases and causes the armature current is decrease the motor will stop accelerating when the armature current is sufficient to develope the torque required by the load.

c) A 4 pole 1500rpm D.C generator has a lap wound armature having 32 slots and 8 conductor/slot. If the flux/pole is 40mwb determine the EMF induced in the armature. Repeate the same for wave connected.

To keep the Eddy current losses as small as possible the core is made up of lamination of high permeability magnetic material such as silicon steel

<u>Hysterisis loss</u>:- Core of the transformer is subjected to cycles of magnetisation steinmetz emporical formula for calculating the hysteresis loss in the core of the transformer is given by

$$W_h = \eta B_m^{1.6} f V \text{ watts}$$

W_h = hysteresis loss in watts

B_m = max value of flux density in the core

η = is a constant depends on quality of magnetic material used

Iron loss = Eddy current loss + Hysteris loss

<u>Copper loss</u>:- this loss is due to resistance R_1 and R_2 of the primary and secondary winding

Total copper loss: Cu loss in primary + Cu loss in sec

$$= I_1^2 R_1 + I_2^2 R_2$$

$$= I_1^2 (R_1 + R_2') = I_1^2 R_{01}$$

$$= I_2^2 (R_{02}) = I_2^2 (R_2 + R_2')$$

We find that the copper loss in the transformer vary as the square of the currents I_1 and I_2 which vary with load Hence Cu loss in the transformer is variable loss.

Hence total loss in the transformer is the sum of iron loss and copper loss.

given:- $P = 4$, $Z = 32 \times 8$ $N = 1500$ $\phi = 40 mwb$

for lap winding

$$E = \frac{\phi Z N}{60}\left(\frac{P}{A}\right) = \frac{40 \times 10^{-3} \times 32 \times 8 \times 1500}{60} \times (1)$$

for lap winding $\frac{P}{A} = 1$

$$= \frac{4 \times 32 \times 8 \times 15}{60} = 256V$$

for wave winding

$$E = \frac{\phi Z N}{60}\left(\frac{P}{A}\right) = \frac{40 \times 10^{-3} \times 32 \times 8 \times 1500}{60} \times \left(\frac{4}{2}\right)$$

Q.6

$$= 512V$$

a) Discuss various types of losses in the transformer.

As the transformer is a static appartus and does not contain any rotating parts there are no mech losses like friction and windage loss the losses that occur in transformer are (i) iron loss (ii) copper loss.

Iron loss:- This loss is also called core loss this loss occurs in the iron portion the iron loss is of two types (i) Eddy current loss and hysteresis loss.

Eddy current loss:- occurs due to the flow of eddy currents in the lamination of the core Eddy currents are induced in the laminations. the Eddy current loss in the core of a transformer is given by an Empirical formula due to Steinmetz which is given by

$$W_e = \beta B_m^2 f^2 t^2 v \text{ watts.}$$

where W_e = Eddy current losses in watts; V = volume of the core in m^3

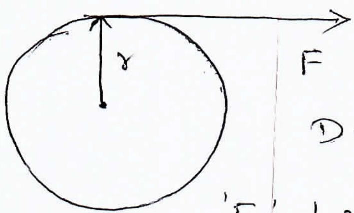
B_m - max value of flux density in the core

f - frequency of the supply in Hz; β = is a constant

t - thickness of the lamination in meter

b) With usual notation develop the torque Equation of D.C motor

Torque is the turning movement about an axis. It is Equal to the product of the force and the radius at which it acts.



Consider the armature of the D.C motor to have a radius 'r' and let 'F' be the force acting tangential to it's surface as shown in fig. The torque exerted by a force 'F' on the armature is given by

$$T_a = F \times r \ Nm$$

The work done by this force F in one revolution is given by

W = force × distance covered in one revolution

$= F \times 2\pi r$ W-s

The power developed by the armature = work done in one second

$= F \times 2\pi r \times$ no. of revolution / s

$$= F \times 2\pi r \times \frac{N}{60} = \frac{2\pi N}{60}(F \times r) = \frac{2\pi N}{60} T_a \text{ watts}$$

The Electrical Equivalent of the mechanical power developed by the armature of the D.C motor is Equal to $E_b I_a$

$$\frac{2\pi N T_a}{60} = E_b I_a = \frac{\phi Z N P}{60 A} I_a$$

$$T_a = 0.159\,\phi Z I_a \left(\frac{P}{A}\right) Nm$$

c) A 250 KVA, 11000/415 V, 50 HZ single phase transformer has 80 turns on the secondary calculate i) Rated primary and secondary currents (ii) no. of primary turns (iii) max value of flux in the core (iii) voltage induced/turn on secondary

given: 250 KVA, $V_1 = 11000$ $V_2 = 415\,V$ $N_2 = 80$

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} \qquad \frac{415}{11000} = \frac{80}{N_1} \qquad N_1 = \frac{80 \times 11000}{415} = 2120.48$$

$$\text{Primary current} = \frac{KVA}{V_1} = \frac{250 \times 10^3}{11000} = 22.72\,A$$

$$\text{secondary current} = \frac{250 \times 10^3}{415} = 602.40\,A$$

flux in the core = $4.44 f \phi N_1$

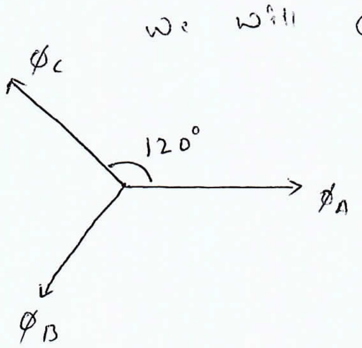
$$11000 = 4.44 \times 50 \times 2120.48 \times \phi \qquad \phi = 23.36\,mwb$$

$$\text{voltage induced/turn in the secondary} = \frac{415}{80} = 5.18\,V$$

MODULE-4

Q.7
a) How rotating magnetic field is set up in case of three phase induction motor illustrate with neat fig.

we will assume +ve direction



$$\phi_A = \phi_m \sin \omega t$$

$$\phi_B = \phi_m \sin(\omega t - 120°)$$

$$\phi_C = \phi_m \sin(\omega t - 240°)$$

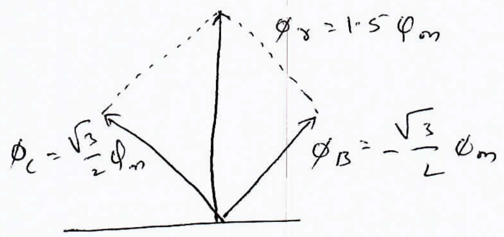
The resultant flux of these fluxes at any instant is given by the vector sum of the individual fluxes ϕ_A, ϕ_B and ϕ_C.

(i) when $\theta = 0$ we find from the wave diagram of fluxes,

$\phi_A = 0$ $\phi_B = -\frac{\sqrt{3}}{2}\phi_m$ $\phi_C = \frac{\sqrt{3}}{2}\phi_m$

These values of fluxes at this instant and their resultant the vector ϕ_B is written opposite to it's assumed +ve direction as it is -ve. the resultant flux ϕ_r lies along Y-axis and it's magnitude is given by

$$\phi_r = 2 \times \frac{\sqrt{3}}{2}\phi_m \cos 30° = \frac{3}{2}\phi_m = 1.5\phi_m$$

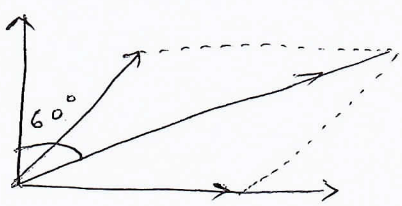


when $\theta = 60°$ the value of three fluxes are

$\phi_A = \frac{\sqrt{3}}{2}\phi_m$

$\phi_B = -\frac{\sqrt{3}}{2}\phi_m$

$\phi_C = 0$

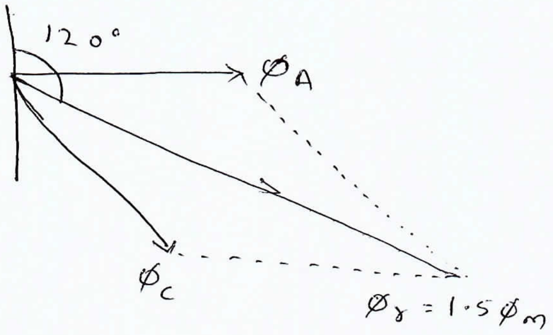


The three fluxes at this instant and their resultant are shown it is observed that the resultant flux has rotated by 60° in the clockwise direction and it's magnitude is $1.5\phi_m$

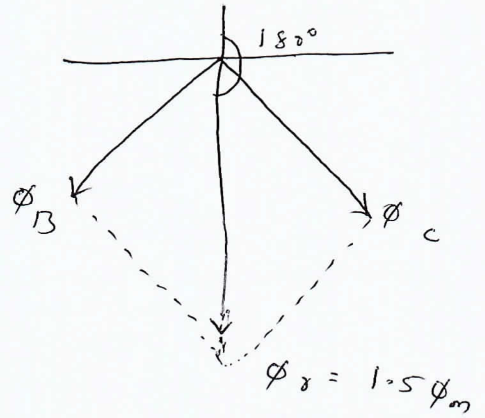
when $\theta = 120°$ the values of the three fluxes are

$\phi_A = \frac{\sqrt{3}}{2}\phi_m$ $\phi_B = 0$ $\phi_C = -\frac{\sqrt{3}}{2}\phi_m$

The fluxes at this instant and their result are shown It is observed that the resultant flux has rotated by another 60° i.e through 120° from it's original position i.e it's magnitude $1.5\phi_m$



when $\theta = 180°$ the flux are given by



$\phi_A = 0$

$\phi_B = \frac{\sqrt{3}}{2}\phi_m$

$\phi_C = -\frac{\sqrt{3}}{2}\phi_m$

The three fluxes at this instant and their result are shown. The resultant flux has rotated by an 60° through 180° from it's original position & it's magnitude is $1.5\phi_m$

b) what is slip of an induction motor and derive expression for frequency of rotor current in terms of supply frequency

The difference between the sych speed N_s of the magnetic field and the actual speed of the rotor N is called as the slip speed

slip seed $= N_s - N$

The slip of an induction motor is defined as the ratio of the slip speed to the sych speed

$$S = \frac{N_s - N}{N_s}$$

The slip of an induction motor is usually expressed as % and the % slip is given by

$$\% s = \frac{N_s - N}{N_s} \times 100$$

when the rotor is stationary frequency of rotor current is same as supply frequency

when the IM is rotating frequency of the current induced in the rotor conductor is proportional to the relative speed or slip speed. If f' is the frequency of the induced current in the rotor

$$N_s - N = \frac{120 f'}{P} \qquad N_s = \frac{120 f}{P}$$

$$\frac{N_s - N}{N_s} = \frac{f'}{f} = s \qquad f' = sf$$

The frequency of the rotor current is slip times the frequency of the supply

c) A 12 pole 3phase alternator is coupled to an engine running at 500 rpm. It supplies an IM which has a full load speed of 1440 rpm. Determine the % slip and the no. of poles of the motor.

$$f = \frac{PN}{120} = \frac{12 \times 500}{120} = 50 Hz$$

N_s for IM is assumed to be 1500 rpm as the actual speed is 1440 rpm

$$N_s = \frac{120 f}{P} \qquad 1500 = \frac{120 \times 50}{P} \qquad P = 4$$

$$\% \text{ slip} = \frac{N_s - N}{N_s} \times 100 = \frac{1500 - 1440}{1500} \times 100 = 4\%$$

Q.8
a) With neat sketch Explain the construction of two types of sych generator

Basically alternator consists of two parts viz
(i) Stator (ii) Rotor

Stator - It consists of stator frames made of mild steel plates welded together to form a cylindrical drum Inside this circular stator lamination made up of spacial steel alloy are fixed The stator core lamination are insulated from one another and pressed together to form a core. On the inner periphery of the stator core uniform slots are cut to house the stator conductors.

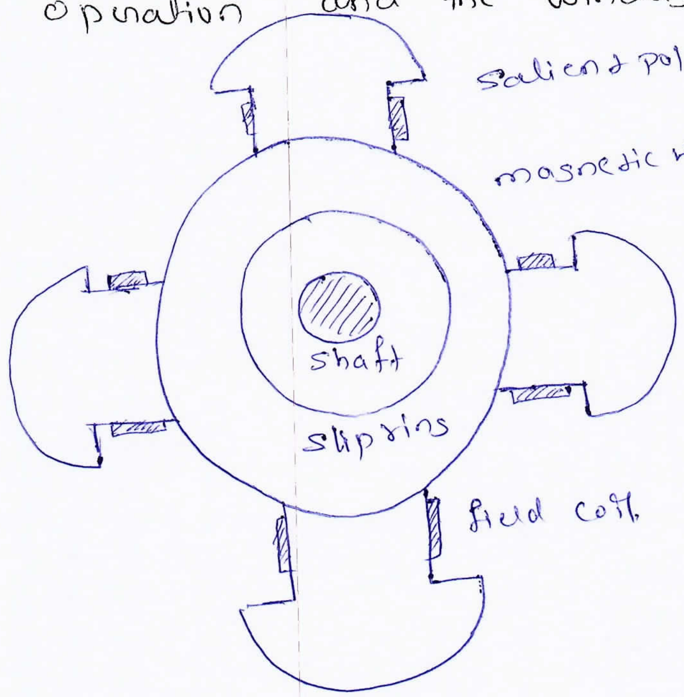
Rotor :- There are two types of Rotor a) Salient pole type (ii) smooth cylindrical type The alternator with salient pole type rotor is called as salient pole alternator alternator with smooth cylindrical type rotor is called non saliend pole alternator

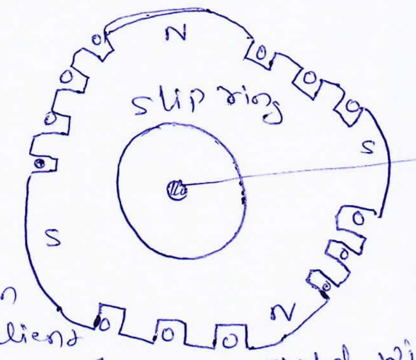
Salient Pole type of Rotor

This type of Rotor is used in low and medium speed alternator (300 to 600 rpm) This type of rotor has a large no. of projecting poles having their cores bolted to a heavy magnetic wheel of cast iron or steel. Such rotors have large diameters and shorter axial length the poles are laminated to reduce Eddy current loss Coils are wound on these poles and when D.C supply is given to coils poles becomes Electromagnet

Smooth cylindrical type rotor

This type of rotor is usually driven by a turbine and rotates at very high speed (1500 to 3000 rpm) the rotor consists of steel lamination which are insulated from each other and pressed together to form a cylindrical core having a no. of slots on it's outer periphery for accomodating field winding such a rotor designed to have two or four poles It usually rotates on the vertical axis and is characterised by small diameter and larger axial length This type of rotor construction gives better balance and quieter operation and the windage losses will be less.





5) Develop the E.M.F Equation of the sych generator

let Z = no. of stator Conductor/phase

P = no. of Poles f = freq of induced Emf in Hz

ϕ = flux/pole in wb

The flux cut by the conductor in one revolution $= P\phi$
$= d\phi$

The time taken for one revolution $= \frac{60}{N}$ sec $= dt$

The avg E.M.F induced in one conductor $= \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60}$

Avg emf induced per phase $= \frac{\phi P N}{60} \times Z = \frac{\phi P Z}{60} \times \frac{120 f}{P}$

$= 2 f \phi Z$ volts

for a sinusoidal wave $\frac{E_{rms}}{E_{av}} = 1.11$

r.m.s value of the induced EMF /phase

$= 1.11 \times 2 f \phi Z = 2.22 f \phi Z$

E.M.F Equation of an alternator is

$E_{ph} = 2.22 f \phi Z = 4.44 f \phi T$

T = no. of turns $= \frac{Z}{2}$

$E_{ph} = 2.22\, k_p\, k_d\, f\, \phi\, Z_{ph}$

where k_p - Pitch factor k_d - distribution factor

Q) A 12 pole, 500 rpm star connected alternator has 48 slots with 15 conductor/slot. The flux/pole is 20 mwb and distributed sinusoidally. The winding factor is 0.97 Calculate the line E.M.F.

Given $P = 12$, $N = 500$ rpm $Z = 48 \times 15 = 720$ $\phi = 20$ mwb

$k_d = 0.97$ $V_L = ?$

$N_s = \frac{120 f}{P}$ $f = \frac{N_s \times P}{120}$

$= \frac{500 \times 12}{120}$

$= 50$ Hz

w.k.T

$E_{ph} = 2.22 f \phi Z k_p k_d$

assuming coil is full pitched $k_p = 1$

$= 2.22 \times 50 \times 20 \times 10^{-3} \times 720 \times 1 \times 0.97$

$E_{ph} = 1550.45$ V

$E_l = \sqrt{3} \times E_{ph} = \sqrt{3} \times 1550.45 = 2685.45$ V

$E_l = 2685.45$ V

MODULE-5

10 a) Explain the working Principle of fuse and MCB

The Electric fuse is based on the Principle of the thermal effect of Electric current. It is made of thin metal wire of non combustible material. The fuse is always connected between the two ends of the terminal connected in series with circuit.

Fuses are usually composed of Elements such as Zinc, Copper, Al and silver.

The fuse acts as CB and opens the ckt in the event of any fault in the circuit. It not only protector of Electrical appliance but also safety measure for humans.

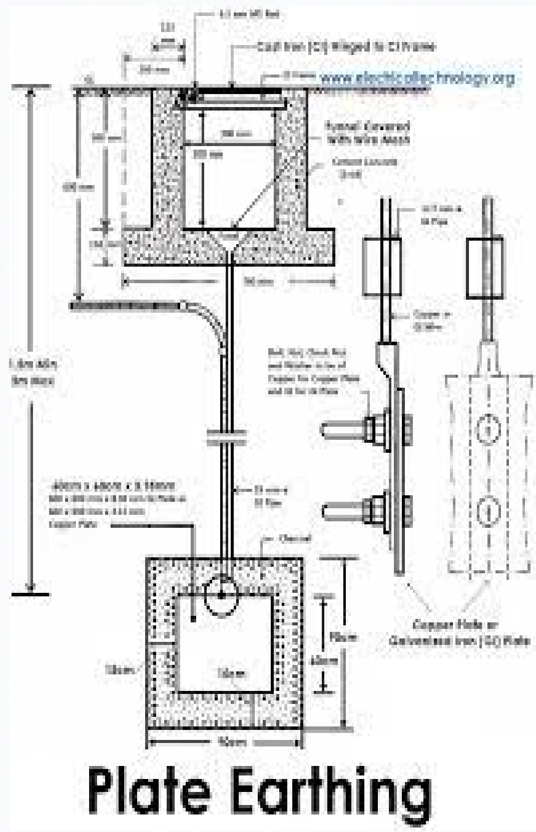
MCB which are mechanically operated switches and circuit protection devices. It is an Electro mechanical operated automatic circuit protection device. It is used to interrupt the circuit during overload and short circuit. It can be used for household fuses. They are more sensitive to failure than fuse.

b) What is Earthing? why earthing is required? with help of neat sketch Explain the plate Earthing.

Earthing or Grounding is to connect the body of the Electrical Equipment to the general mass of the earth by a wire of negligible resistance. Earthing brings the body of the Equipment to zero potential and thus avoids shocks to personnel, incase, the body of the Equipment comes in contact with live wire.

Pipe Earthing:- The method of pipe earthing in which a galvanised iron pipe of approved length & diameter are used. The size of pipe depends on the current to be carried and type of soil. The diameter of the galvanised pipe should not be less than 38.1 mm and length 2 ...

It should be placed to a depth of 4-75m The depth at which the pipe must be buried depends on the condition of the moisture in the ground The pipe at the bottom should be surrounded by broken pieces of coke and charcoal for a distance of about 15cm around the pipe. Charcoal with salt further reduces the resistance During the summer the moisture contend of the Earth will be very less and hence in order to have effective earthing the fuel should be filled on 3-4 buckets of water.



c) Write a short note on precaution against an Electric shock.

When a person comes in contact with live wire supplying Electricity he receives a shock. The severity of shock depends on the voltage of the wire and the body resistance of the person.

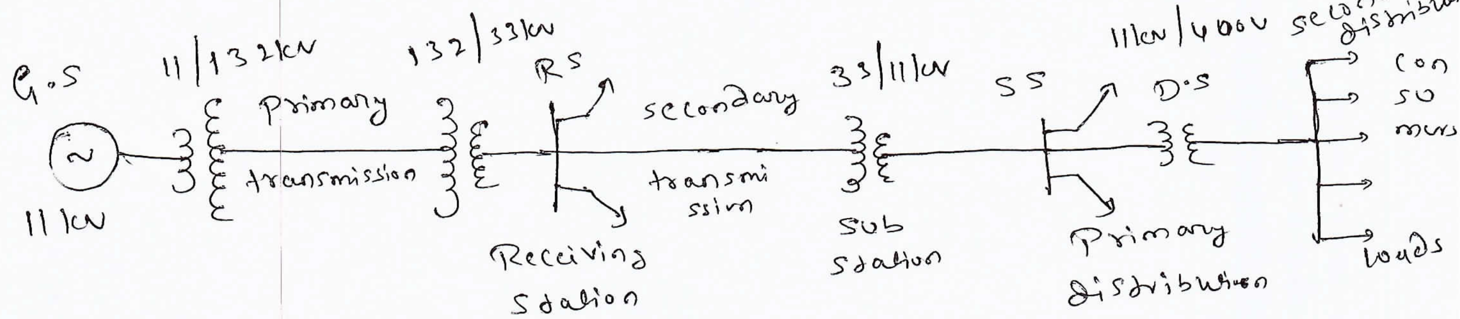
Following precaution must be taken against the shock

* Do not touch the victim with bare hand when he is still in contact with Electricity
* shut off the supply immediatly
* Use non-conducting object such as dry wooden rod, broom, chair, rug to push the victim away from the source of the current. Never use wet medal or conducting objects. If possible stand on something dry and non conducting surface

* once the victim is free check his breathing, pulse If they have stopped or dangerously slow Initiate artificial breathing. Treat third degree burns and get the Emergency health care

Q.9
a) what is Electrical power supply system Draw a single line diagram of a typical a.c power supply scheme.

Electrical power system is defined as a network of Electrical components used to supply transmit, and consume Electric power.



b) what are the desirable Characteristics of a tariff and Explain two part tariff.

Desirable Characteristics of a tariff

Proper return:- The tariff should be such that it ensure the proper return from each consumer in other words the total receipts from the consumers must be equal to the cost of producing and supplying Electrical Energy plus reasonable profit

Fairness:- Tariff must be fair so that different types of consumers are satisfied with the rate of charge of Electrical Energy. Thus a big consumer should be charged at a lower rate than a small consumer it is because increased Energy consumption spreads the F.C (fixed charges) over a great no. of units

Reasonable Profit :- The profit element in the tariff should be reasonable. The investment is relatively safe due to a non competition in the market. This calls for the profit to be restricted to 8% or so per annum.

Attractive :- A tariff should be attractive so that a large no. of consumers are encouraged to use a Electric Energy.

Two part Tariff

* when the rate of Electrical Energy is charged based on maximum demand of the consumer and the units consumed
* Total charges are divided in to two components i.e fixed charges and running charges
* fixed charges (F.C) depends on the no. of units consumed by the consumer
* The consumer is charged at a certain amount /kW of M.D plus a certain amount per kWh of Energy consumed

$$\text{Total Charges} = Rs\,(b \times kW + c \times kWh)$$

b = charge / kW of M.D

c = charge / kWh of Energy consumed

Advantages

* It is Easy to understand
* It recovers the F.C which depends on M.D of consumer but independ of units consumed

Disadvantages

* It is not suitable for small consumers a seperate M.D meter is required
* mostly applicable for big consumers

Q.9
c

A consumer has a maximum demand of 200kW at 40% load factor. If the tariff is Rs 100 per kW of max demand plus 10 paise per kWh find the overall cost per kWh.

Given that maximum demand = 200kW

Units consumed per year & tariff rate

Tariff rate = ₹ 200/kW of max demand + 10 paise/kWh.

Energy consumed per annum (kWh)

$= (200 \times 0.4 \times 8760) = 700.8 \times 10^3$ kWh

Annual fixed charge = Rs 100 per kWh of M.D

Annual fixed charge = 200×100 = 20,000 ₹

Running charge = 10 paise/kWh.

Running cost = $0.1 \times 700.8 \times 10^3$ = ₹ 700,800

Total tariff or charge = ₹ 20,000 + ₹ 70,800

= ₹ ~~90,800~~. 90,080.