First | second Semester BE Examination.

June / July 2019

Basic Electrical Engineering.

18ELE13|23 Max. Marks: 100.

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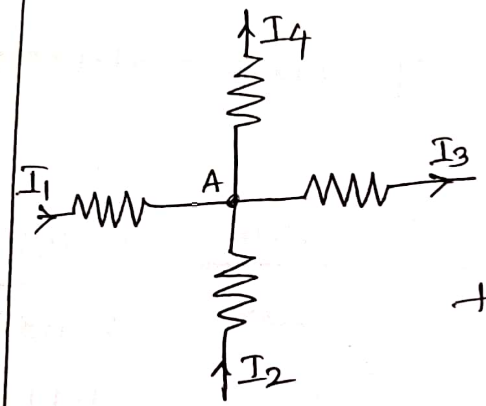
1a State & Explain Kirchoff's Laws? (08M).

i) Current law:-

The algebraic sum of all currents meeting at any junction of an electrical ckt is zero.

ie, $\Sigma I = 0$



By KCL

$I_1 + I_2 - I_3 - I_4 = 0.$

or $I_1 + I_2 = I_3 + I_4.$

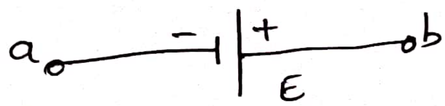
"At any junction of electric ckt, the sum of currents entering the node is equal to sum of currents leaving the node".

ii) Voltage Law:-

"In any closed electric ckt, the algebraic sum of all emf's & resistive drops is equal to zero.

ie, $\Sigma E + \Sigma IR = 0.$

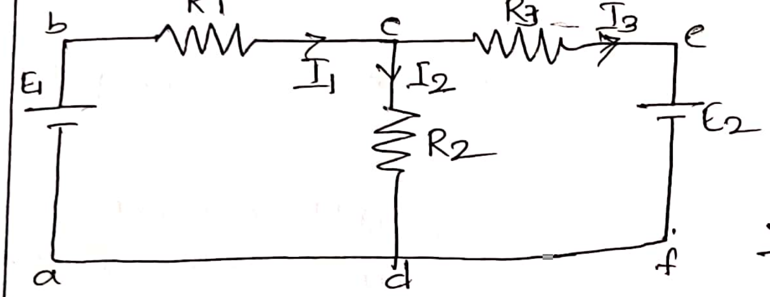
All voltage rise are taken as +ve & all vltg drops are taken as -ve.



An EMF 'E' is connected b/w a & b points. When it is traced from a to b, battery is traced from -ve terminal to +ve terminal. It is a vltg rise, hence EMF is +ve ∴ E(ab) is positive.

When traced from b to a. ie, traced from +ve terminal to -ve terminal its Voltage fall. Hence EMF is -ve. ∴ E(ba) is -ve.

Consider a ckt as in fig.



for loop abcda.

$$E_1 - I_1R_1 - I_2R_2 = 0.$$

for loop dcefd

$$I_2R_2 - I_3R_3 - E = 0.$$

1b. Define form factor & peak factor. Obtain their value for sinusoidal wave. (06) M.

→ i) Form factor (Kf) :-

It is the ratio of rms value to its average value.

$$K_f = \text{form factor} = \frac{\text{rms Value}}{\text{avg value}} = \frac{I_{rms}}{I_{av}} = \frac{0.707 I_m}{0.637 I_m} = 1.11$$

ii) Peak factor (Kp):-

It is the ratio of max. value to rms value.

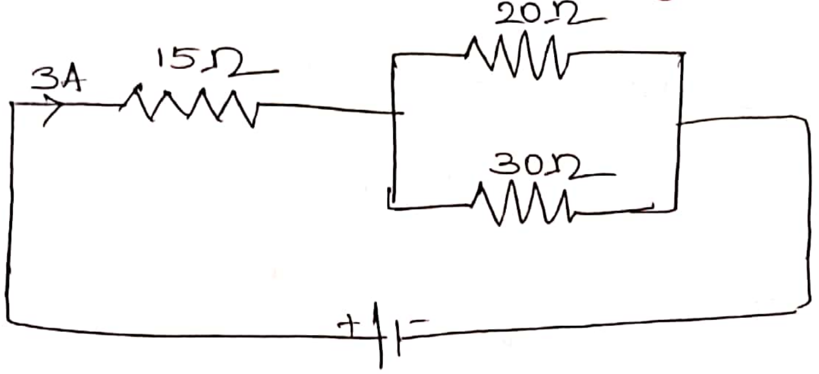
$$K_p = \frac{\text{max value}}{\text{rms Value}} = \frac{I_m}{I_{rms}} = \frac{I_m}{0.707 I_m} = 1.414$$

1c. A circuit consists of two parallel resistors having resistance of 20Ω & 30Ω respectively connected in series with a 15Ω resistor. If current through 15Ω is 3A find.

i) Current through the branches.

ii) Voltage across whole ckt.

iii) Power consumed by 20Ω & 15Ω resistors. [06 Marks]



$R_T = 15 + \left(\frac{20 \times 30}{20+30}\right)$

$= 27\Omega.$

$I = V/R.$

ii) $V = I.R = 3 \times 27 = 81V.$

i) $I_1 = 3 \times \frac{30}{50} = 1.8A.$

$I_2 = 3 \times \frac{20}{50} = 1.2A.$

iii) $P_{20\Omega} = (1.8)^2 \times 20 = 64.8W$

$P_{15} = (3)^2 \times 15 = 135W.$

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OR

2a Define average & rms value of a sinusoid. Also derive the respective expressions. (08)

→ * Average value of Sine Wave :-

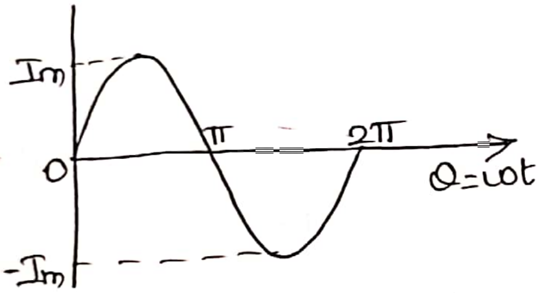
$$I_{av} = \frac{1}{\pi}\int_0^{\pi} i\,d\theta = \frac{1}{\pi}\int_0^{\pi} I_m \sin\theta\,d\theta.$$

$$= \frac{I_m}{\pi}\left[-\cos\theta\right]_0^{\pi}$$

$$I_{av} = \frac{2 I_m}{\pi} = 0.637 I_m.$$

$$\therefore I_{av} = 0.637 I_m.$$

* Effective value of sine wave :-



$$i = I_m \sin\theta.$$

$$i^2 = I_m^2 \sin^2\theta$$

$$\overline{}$$
$$\pi$$

$$Avg = \int_0^{\pi} \frac{I_m^2 \sin^2\theta}{\pi}$$

$$Avg = \frac{I_m^2}{\pi}\int_0^{\pi} \sin^2\theta.$$

$$= \frac{I_m^2}{\pi}\int_0^{\pi} 1 - \cos 2\theta.$$

$$= \frac{I_m^2}{2\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^{\pi}$$

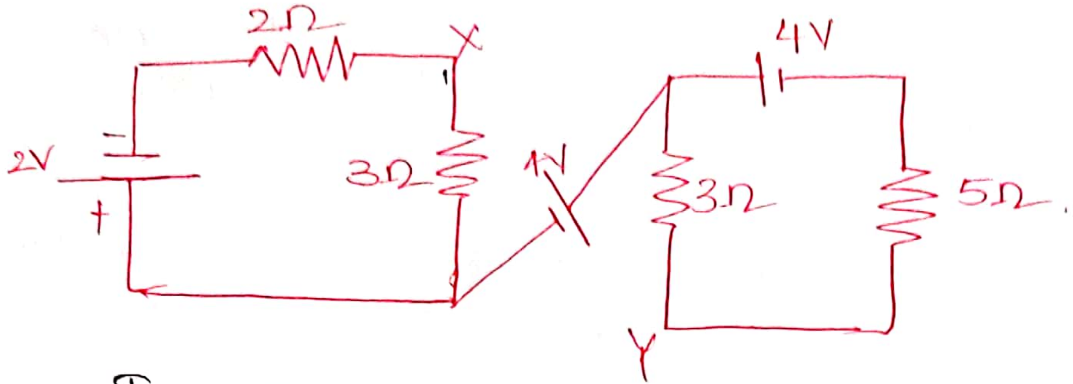
$$I = \frac{I_m^2}{2\pi} \times \pi$$

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

$$= I_m/\sqrt{2}$$

$$\boxed{I_{rms} = 0.707 I_m.}$$

2b Find the potential difference b/w XY for the n/w shown in below fig. (06)



$I_1 = \frac{2}{2+3} = 0.4\,A$ & $I_2 = \frac{4}{3+5} = 0.5\,A$.

$\therefore V_{xy} = 3I_2 - 4 - 3I_1$

$= 3(0.5) - 4 - 3(0.4)$

$= -3.7$ Volts.

(Y is at higher potential than X).

Q(c) State Ohm's law & Mention its limitations (06)

→ The current flowing through any conductor is directly proportional to p.d b/w two ends of the conductor provided its temperature & other physical conditions remain constant.

$I \propto V$ when temp is constant.

ie, $\boxed{I = \frac{V}{R}}$ R→ Resistance.

Thus, CGPA= 24x7 + 24x8.5 + 27x9.2 +

* Limitations of Ohm's law?

1) Ohm's law does not hold good for non-metallic Conductors such as silicon carbide.

2) Ohm's law does not hold good for non-linear devices such as zener diodes, Voltage regulators etc.

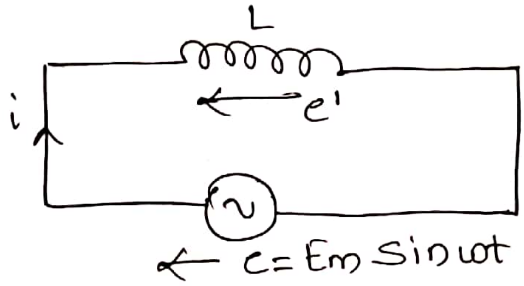
3) Ohm's law doesn't hold good for arc lamps.

4) Temperature & other physical conditions are constant.

Module 2

3a. Obtain the behaviour of voltage, current & power in a pure inductor, connected to 1ϕ supply. (08)

→



WKT $e = E_m \sin \omega t$.

$$e' = -L\frac{di}{dt} = -e.$$

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

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

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

$$i = \frac{E_m}{L} \int \sin \omega t \, dt.$$

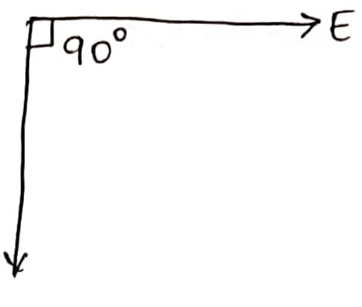
$$i = \frac{E_m}{\omega L} (-\cos \omega t)$$

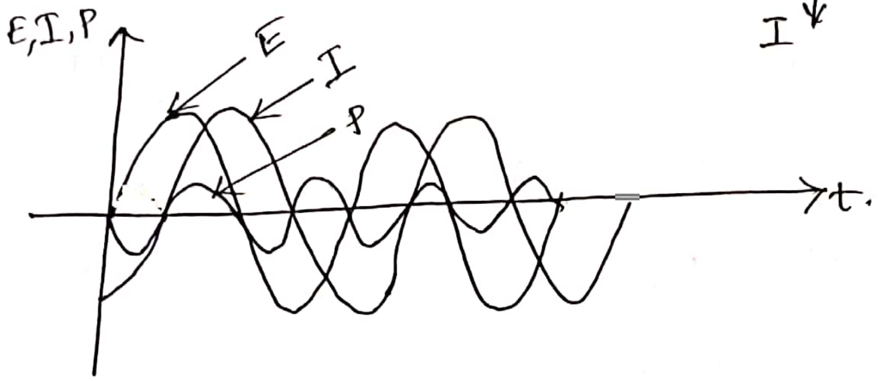
$$i = \frac{E_m}{X_L} \sin(\omega t - \pi/2).$$

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

Phasor diagram :-

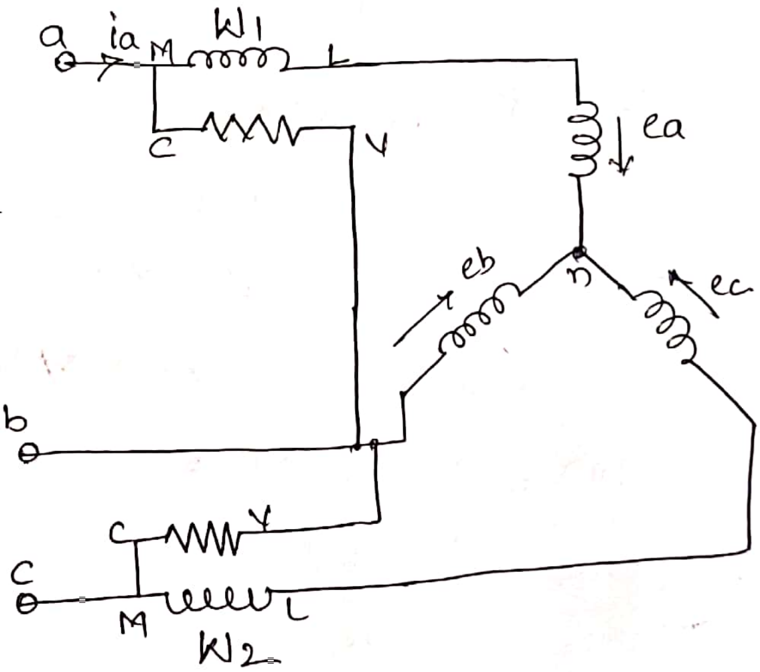
Current lags voltage by 90°





3(b) Show that 3ϕ power can be measured using only 2 wattmeters for a balanced star connected load. (06)

→ The way in which, two wattmeters are connected to measure power is shown in fig.



WKT, $W_1 = i_a \cdot e_{ab}$

But $e_{ab} = e_a - e_b$.

$\therefore W_1 = (e_a - e_b) i_a.$

lllY $W_2 = e_{cb} i_c$

$= (e_c - e_b) i_c.$

$W_1 + W_2 = (e_a - e_b) i_a + (e_c - e_b) i_c$

$= e_a i_a + e_c i_c - e_b (i_a + i_c)$

$\because i_a + i_b + i_c = 0$ $\therefore i_a + i_c = -i_b.$

$\therefore W_1 + W_2 = e_a i_a + e_b i_b + e_c i_c = 3\phi$ power.

Hence, we can prove that 2 wattmeters are sufficient to measure 3ϕ power.

3C. A 3ϕ load of 3 equal impedances are connected in delta, across a 400V, 50Hz, 3ϕ supply. which takes a line current of 10A at a pf of 0.7 lagging. Calculate i) Phase Current ii) Total power in W iii) P in VA iv) P in VAR. (06)

→ i) Phase current (I_{ph}).

$$I_{ph} = I_L/\sqrt{3}$$

$$= 10/\sqrt{3} = 5.77\ A.$$

ii) $P = EI\cos\phi$

$$= 400 \times 5.77 \times 0.7$$

$$= 1616.58\ W.$$

iii) P in VA.

$$S = EI$$

$$= 400 \times 5.77$$

$$= 2308\ VA.$$

iv) P in VAR.

$$Q = EI\sin\phi.$$

$$= 400 \times 5.77 \times 0.714$$

$$= 1648.24\ VAR$$

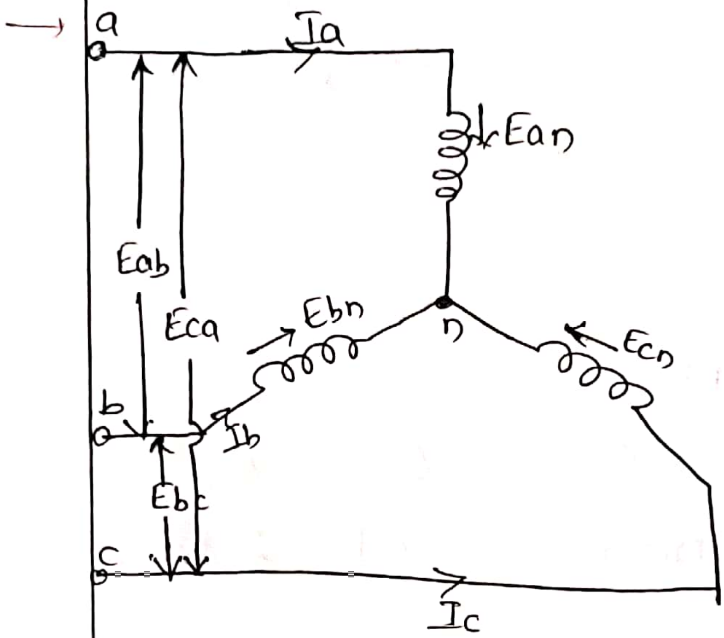
$\cos\phi = 0.7$

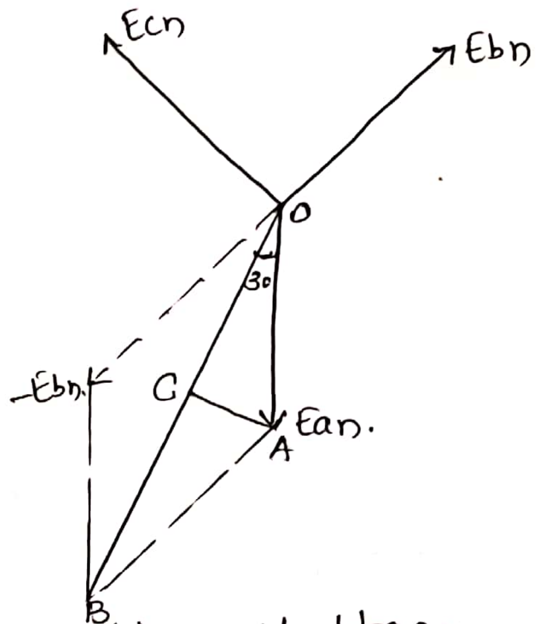
$\phi = \cos^{-1}(0.7)$

$= 45.57$

$\sin\phi = 0.714$

4a. Obtain expression for line & phase relationship of Voltage &, Current & power in a 3ϕ star connected s/m. (08).





Here Eab, Ebc & Eca are line voltages.

Ia, Ib & Ic are line currents

$\therefore I_L = I_{ph}$.

Ean, Ebn & Ecn are phase voltages.

$\therefore E_{ab} = E_{an} + E_{nb}$

$= E_{an} - E_{bn}$.

Draw a $\perp^r$ AC on OB.

$\therefore \angle AOC = 30^\circ$

from ΔOAC, $\cos 30^\circ = \frac{OC}{OA} = \frac{OB}{2OA} = \frac{E_{ab}}{2E_{an}}$

$$\frac{\sqrt{3}}{2} = \frac{E_{ab}}{2E_{an}}.$$

$E_{ab} = \sqrt{3} E_{an}$.

$E_L = \sqrt{3} E_{ph}$.

IIIY $P = \sqrt{3} E_L I_L \cos\phi$.

4b. An alternating voltage of (160+j120)V is applied to a ckt & current is given by (6+j8)A. find values of circuit elements by assuming f = 50Hz. Calculate the pf & power consumed by the circuit. (06)

→ $I = E/Z$ ∴ $Z = E/I$

$$= \frac{160 + j120}{6 + j8}$$

~~= 0 + j20~~ = $19.2 - j5.6\ \Omega$

∴ ~~Z = 20∠90° Ω~~ = $20\angle{-16.2}\ \Omega$.

Power $= I^2R$

$= 10^2 \times 19.2 = 1920\ W$

$Pf = \cos\phi = R/Z = \frac{19.2}{20} = 0.96$.

4C. A balanced 3ϕ star connected s/m draws power from 440V supply. Two wattmeters connected indicate $W_1 = 5KW$, $W_2 = 1.2KW$. Calculate I, p.f & P in the circuit. (06).

→ $W_1 = 5KW$ $W_2 = 1.2KW$

$W_1 - W_2 = 3.8KW$ $W_1 + W_2 = 6.2KW$

$\tan\phi = 1.0615$ $\phi = 46.71$

$\Rightarrow \cos\phi = 0.6857$.

$P = W_1 + W_2 = 6.2KW$.

$6.2 \times 10^3 = \sqrt{3}\, V_L I_L \cos\phi$.

$6.2 \times 10^3 = \sqrt{3} \times 440 \times I_L \times 0.685$

$I_L = 11.86A$.

Module 3.

5a. Explain Electric shock, its causes & precautions to prevent them. (08)

→ When person touches the live part of electric equipment, he recieves electric shock.

The Severity of electric shock depends on vltg of wire & human body resistance.

The max. current human body can withstand for a short time is 25msec is 30mA.

The current flowing through the body depends upon human body resistance.

The body resistance is 1kΩ when body is totally wet, if body is neighter weight nor dry its 3kΩ to 5kΩ.

Mild shock, nervousness, next stage is Unconsciousness & it may cause cardiac arrest.

* Precautions:-

1) Don't touch the Victim by bare hands if he is still in contact with electricity.
2) Immediately switch off the supply.
3) Once the Victim is free, check his breathing pulse, if it is not normal then provide artificial respiration.
4) Separate the Victim from supply using non conductive material like wood, plastic, rubber etc.

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5b. Discuss about various types of losses in a transformer. (06)

→ Transformer is a static device, so mechanical losses in a transformer is zero.

Electrical losses in a transformer are divided into two types Iron loss & Copper loss.

1) Iron loss (Wi):-

This loss occurs in a core, so it is also called as core loss. Core is made up from iron material, so losses occuring in core is called Iron loss.

Iron losses are further classified in 2 types

1) Eddy current loss
2) Hysteresis loss.

1) Eddy current loss:- flowing of eddy currents through laminations of core produces heat in the core. This is called Eddy current loss.

$$W_e = \beta B_m^2 f^2 t^2 V \quad \text{Watts}$$

2) Hysteresis loss (Wh):-

Magnetization & Demagnetization of core results in Hysteresis loss.

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

2) Copper loss (Wcu):-

It occurs in the tfr wdg's due to resistance R_1 & R_2 on respective side.

It is also called as I^2R loss.

Total copper loss = Pri. side Cu loss + Sec. side Cu loss

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

$$= I_1^2 R_{01}$$

5c. A 250 KVA ; 11KV/415V , 50Hz 1φ tfr has 80 turns on the secondary. Calculate
1) Rated pri & sec currents (06)
2) No of pri turns.
3) Max value of flux in core.
4) Voltage induced per turn on sec.

→ iv) $E_2 = 4.44 f \phi_m N_2$

$415 = 4.44 \times 50 \times \phi_m \times 80$

$\phi = 23.36\ mWb.$

i) $I_1 = \frac{KVA \times 1000}{E_1} = \frac{250 \times 1000}{11 \times 10^3} = 22.72\ A$

$I_2 = \frac{KVA \times 1000}{E_2} = \frac{250 \times 1000}{415} = 602.4\ A$

ii) $\frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{415}{11 \times 10^3} = \frac{80}{N_1}$

$\therefore N_1 = \frac{80 \times 11 \times 10^3}{415}$

$= 2120.48$ turns.

6a A 500 KVA, 1φ tfr has an efficiency of 92% at full load, upf & at half the full load 0.9 pf. Determine its η at 80% of F.L & 0.95 pf. (08)

→ $0.92 = \frac{500 \times 1000 \times 1}{500 \times 1000 \times 1 + W_i + W_{cu}}$

$W_i + W_{cu} = 43478.2\ W$ —— (1).

Also $0.92 = \frac{\frac{1}{2} \times 500 \times 1000 \times 0.9}{\frac{1}{2} \times 500 \times 1000 \times 0.9 + W_i + (\frac{1}{2})^2 W_{cu}}$

$\therefore W_i + 0.25 W_{cu} = 19565.2\, W \rightarrow (2)$

Solving (1) & (2).

$W_i = 11594.2\, W$ & $W_{cu} = 31884\, W$.

$$\therefore \eta_{80\%/0.9\,pf} = \frac{0.8 \times 500 \times 1000 \times 0.9}{0.8 \times 500 \times 1000 \times 0.9 + 11594.2 + (0.8)^2 \times 31884}$$

$= 0.918$

$= 91.8\%$

6a. Discuss necessity of Earthing? With neat fig. explain plate earthing. (06)

→ Connect the body of electrical equipment to the general mass of earth by atleast resistance wire is called Earthing.

Earthing avoids electrical shock by maintaining body of electrical equipment at zero potential.

To maintain neutral at zero potential it is solidly earthed.

→ The fig of Plate Earthing & explaination is already given in previous solved QP sol^n. (Refer 6b)

6b. Write a short note on Fuse & MCB? (06)

→ MCB → Miniature Circuit Breaker.

It is already written in previous solved QP. (Refer 6.c).

* Fuse :- fuse is the weakest protective link in the circuit. A fuse is essentially a small piece of metal connected b/w two terminals mounted on an insulating base in series with the circuit.

When current exceeds more than the rated value, fuse wire heats, then melts & breaks the circuit. Heat produced is given by $H = I^2Rt$. fuse wire must have high resistivity & low melting point. Tin, lead, zinc, Al, Cu etc & their alloys are used as fuse material.

$$\text{fusing factor} = \frac{\text{Min. fusing current}}{\text{Current rating of the fusing element}}$$

Module 4.

7a With neat sketch explain, construction of DC Machine. (08)

→ The answer to this Question is already given in 7a (Question) of previous paper.

7b A 4 pole, 230V DC series wave connected armature with 1254 conductors with flux per pole 22mWb takes 50A for motoring. The armature & series field coil resistances are 0.3Ω & 0.2Ω respectively. Calculate speed & torque developed in watts. (06)

→ $E_b = V - I_a(R_a + R_{se})$

$= 250 - 50(0.2 + 0.3)$

$= 225V$.

$$E_b = \frac{P\phi NZ}{60A}$$

ie, $$225 = \frac{22\times10^{-3}\times1254\times N\times4}{60\times2}$$

$\therefore N = 244.67$ rpm.

$P_a = E_b . I_a$

$= 225 \times 50$

$= 11,250$ W.

$$P_a = \frac{2\pi N T_a}{60}$$

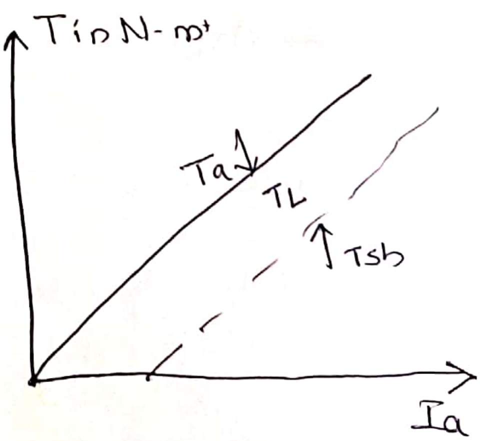
ie, $$11,250 = \frac{2\pi\times244.67\times T_a}{60}$$

$\therefore T_a = 439.08$ N-mt

7c Brief on characteristics of DC shunt Motors with neat diagrams. (06)

→ i) T_a / I_a :→

* According to arm torque equ^n. $T_a \propto I_a$.
When load increases, I_a increases,
to drive load T_a increases.
Due to T_L, T_{sh} is less than T_a



ii) N/Ia :→

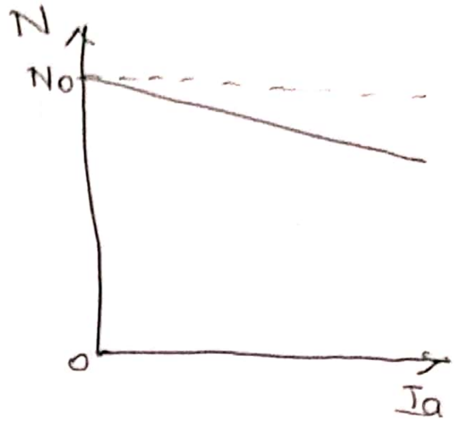
→ $N \propto 1/\phi$ according to Back EMF eq^n.

$$E_b = \frac{P\phi NZ}{60A}$$

$N \propto E_b$

ϕ is constant in shunt Motor.

When motor is loaded, Change in Speed is less as compared with no load speed (N_0).

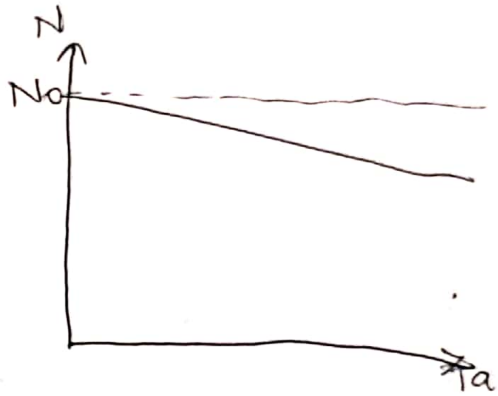


iii) N/Ta :→

$T_a \propto \phi$ & $\phi \propto 1/N$

ϕ is Constant in shunt motor.

So N/Ta is |||^r to N/Ia



8a Define Back EMF & derive torque equation for a dc motor. (08)

→ Motor will not be able to produce mechanical o/p without Back EMF.

WKT $I_L = I_a + I_{sh}$.

Due to I_{sh}, field s/m creates magnetic flux & due to I_a, armature rotates in mag. field. Armature cuts the magnetic flux & hence EMF is induced in armature. This induced emf is called Back EMF (E_b). The direction of back emf & applied voltages are opposite.

Note:- The torque equation derivation is derived in previous Q.P (Refer 8a).

8b. A Shunt Generator has 4 poles, lap wound armature having 24 slots with 10 conductors/slot. If flux per pole is 0.04 wb. & speed is 1500rpm. Calculate emf generated in armature. What would be generated emf if wdg is wave connected. (06)

→ For lap winding,

$$E = \frac{P \phi N Z}{60 A}$$

$$= \frac{4 \times (0.04) \times 1500 \times (24 \times 10)}{60 \times 4}$$

$$= 240 \text{ Volts}.$$

for Wave Winding.

$$A = 2.$$

$$\therefore E = 240 \times 2$$

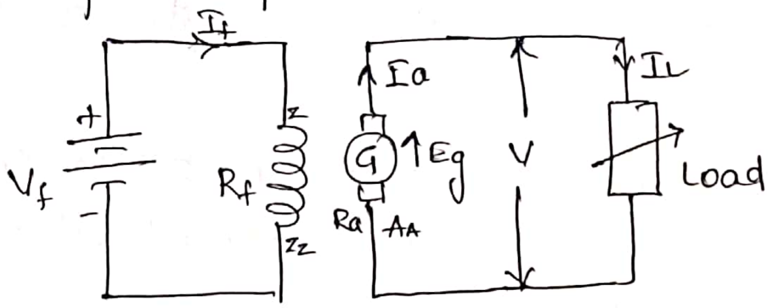
$$= 480V.$$

8c. Give the classification of DC Generators with their equivalent ckt diagram. (06)

→ DC Generators are classified as

1) Separately excited DC Generator.
2) Self Excited DC Generator.

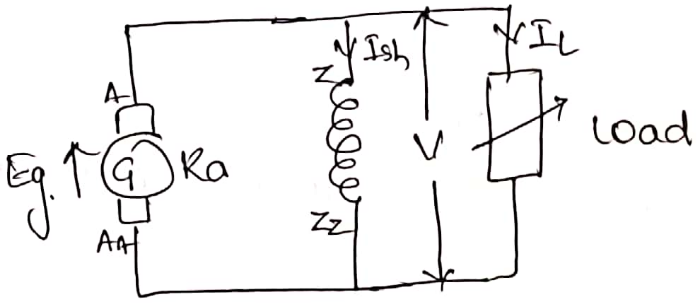
1) Separately Excited DC Generator:-



$E_g = V + I_a R_a + A.R.D + B.V.D.$

2) Self Excited

i) DC shunt Generator.

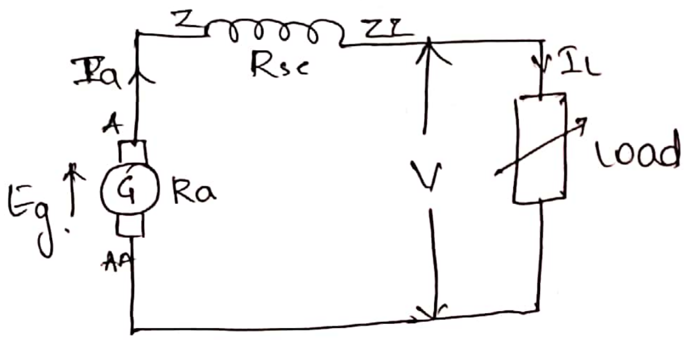


$E = V + I_a R_a + ARD + BVD.$

$I_a = I_L + I_{sh}$

$I_{sh} = V / R_{sh}.$

ii) Series Generator.



$E_g = V + I_a R_a + ARD + BVD.$

$I_a = I_L = I_{se}.$

iii) Compound DC Generator :- is combination of shunt & series Generator.

Module 5

9a) Explain principle of working of Induction Motor. (08)

→ 3 φ Supply is applied to 3 φ I.M stator. Current flows through each wdg in stator, due to current it produces flux in each phase which is 120° electrically apart.

The produced flux from stator is rotating in nature, the magnitude of flux is $1.5\phi_m$ & its speed is $120f/P$.

The rotating flux sweeps over the rotor conductors hence rotor induces emf in it. Current also flows through the rotor.

Rotor starts to rotate & it achieves speed N.

There is a slight speed difference b/w N & Ns. this is called slip speed.

$$\text{slip speed} = N_s - N.$$

The ratio of slip speed to synchronous speed is called slip.

$$\text{Slip} = \frac{\text{slip Speed}}{N_s} = \frac{N_s - N}{N_s}.$$

$$\therefore \ \% \ \text{Slip} = \frac{N_s - N}{N_s} \times 100$$

$$N_s = 120f/P.$$

$$N = N_s(1-s).$$

9b. List advantage of rotating field over rotating armature. (08)

→1) Generated vltg can be directly connected to load, so that I_L need not pass through brush contacts.

2) It is easy to insulate stationary armature for high AC Generated voltages, which may be 11KV or 33KV.

3) Sliding contact ie, slip rings are transferred to low vltg low power dc field ckt which can be

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easily insulated. The excitation Voltage is of the Order of 110V to 220V dc.

4) Armature windings can be easily braced to prevent any deformation produced by large mechanical stresses setup due to S.C. currents & large centrifugal forces that might be setup.

9c A 3φ, 6 pole star connected Alternator revolves at 1000 rpm. The stator has 90 slots & 8 conductors/slot. The flux per pole is 0.05 Wb. Calculate vltg generated by machine if winding factor is 0.96. (06)

→ $Z = \frac{90 \times 8}{3} = 240$.

$N = \frac{120f}{P}$ $\therefore f = \frac{PN}{120}$

$= \frac{6 \times 1000}{120} = 50\,Hz$.

As coil is full pitched $K_p = 1$

$\therefore E_{ph} = 2.22 K_p K_d f \phi Z$

$= 2.22 \times 1 \times 0.96 \times 50 \times 0.05 \times 240$.

$= 1278.72\,V$.

$\therefore E_L = \sqrt{3} \cdot E_{ph}$

$= \sqrt{3} \times 1278.72$

$= 2214.80\,V$.

10a Explain Working principle of Alternator, Also derive its EMF equⁿ. (08)

→ Stator acts as armature & rotor as field s/m in an alternator.

An excitation Vltg of 110V or 220V DC is applied to ~~rotor~~ field coils, it initiates the magnetic flux.

To exchange the magnetic flux w.r.t ($d\phi/dt$) mechanical i/p is given to the rotor.

The excitation Vltg is applied with help of batteries or DC Generator through brushes & slip rings.

Bcoz of mech i/p, rotor rotates, flux also rotates, these flux sweeps over stator conductors. Hence EMF is induced in stator conductors.

Note: The EMF equⁿ is derived in previous QP. (Refer 9a).

10b Compare Squirrel Cage & Slip ring type of Induction Motors. (06)

→ Squirrel Cage:→ i) It consist of Cylindrical core with parallel slots.

ii) Heavy Copper or Aluminium bars are Used as rotor conductors & is placed in each slot

iii) All the bars are braced to two copper end rings & is short circuitted.

iv) No provision to add additional resistance to rotor.

v) Rotor bars are skewed, to reduce magnetic hum

ii) Slip Ring Induction Motor :-

1) Star connected rotor wdg is connected to slip ring.

2) Slip ring is attached to rotor shaft.

3) Brushes are connected to each slip ring to collect the current.

4) During starting period of motor, brushes have contact with slip ring to collect current & produce more torque.

5) Brushes supply the collected current to primary resistors, these resistors dessipate energy in it.

6) Once motor gets started & pickup its speed brushes are automatically removed from slip ring, which reduces friction loss.

10c) An 8 pole alternator runs at 750 rpm. Supplies power to a 4 pole IM. The frequency of rotor is 1.5Hz. What is the speed of motor? (06)

→ $$f = \frac{PN}{120}$$

$$= \frac{8 \times 750}{120}$$

$$= 50\,HZ$$

for I.M, $f' = S \cdot f$

$$\therefore S = \frac{f'}{f} = \frac{1.5}{50} = 0.03$$

$\therefore \quad S = \dfrac{N_s - N}{N_s}$

$0.03 = \dfrac{750 - N}{750}$

$22.5 = 750 - N.$

$\therefore N = 772.5$ rpm.