TED(15)3043 ELECTRICAL TECHNOLOGY REVISION 2015

ANSWER KEY

PART - A

I

1) The root mean square value of an alternating quantity is expressed by that direct current which when applied to a circuit for a given time produce same amount of heat energy as when the alternating current is applied to the same circuit for the same time

$I_{rms} = I_{max} \times 0.707$

$E_{rms} = E_{max} \times 0.707$.

2 Marks

2) To save human life from danger or shock or death by blowing fuse

b) To Protect Large building from atmospheric lightning.

c) To maintain the line voltage constant

d) To maintain the potential of any part of a system at a definite value with respect to earth

e) To make sure that, in the event of a fault, the apparatus should normally be dead and cannot reach a dangerous potential with respect to earth.

Any two 2 Marks

3) Any linear circuit consisting of voltage sources and resistances, if viewed from any two terminals in the network can be replaced by an equivalent voltage source V_{TH} in series with an equivalent resistance R_{TH}. 2 Marks

4) $\frac{\phi Z N}{60} \times \frac{P}{A}$ OR $E_b = V - I_a R_a$ 2 Marks

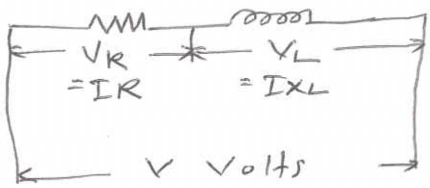
5) The two types of rotors are Salient pole type & Smooth cylindrical type. 2 Marks

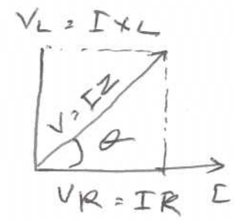
II

PART - B

①

A resistance and a pure ~~resistance~~ inductance are connected across an alternating voltage as shown in figure.





From the vector diagram

V_R = Voltage drop across resistance = IR

V_L = Voltage drop across Inductance = IX_L

where $X_L = 2\pi f L$.

Then V = Vector sum of V_R and V_L

ie $V^2 = V_R^2 + V_L^2$

$V = \sqrt{V_R^2 + V_L^2}$

OR $V = \sqrt{IR^2 + IX_L^2}$

$\therefore V = I\sqrt{R^2 + X_L^2}$

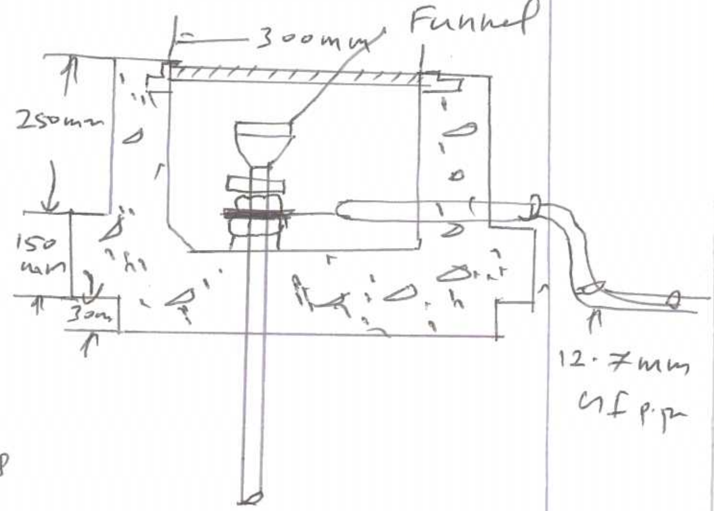
OR

$\frac{V}{I} = \sqrt{R^2 + X_L^2}$ OR $Z = \sqrt{R^2 + X_L^2}$

where Z is known as impedance of the circuit ie $\frac{V}{I} = Z$.

6 Marks

(2) The figure shows pipe earthing. A One end tapered GI Pipe is driven in to the general mass of earth as shown.



12.7mm GI pipe

The pipe has holes help in keeping the surrounding wet when water is pouring through funnel provided at the top. An alternate layer of charcoal and salt are provided in the surrounding of the pipe. The earth wire is soldered and connected to pipe is covered through 12.7 mm GI pipe. The pipe earthing is cheaper than plate earthing hence preferred for domestic and other low power installation.

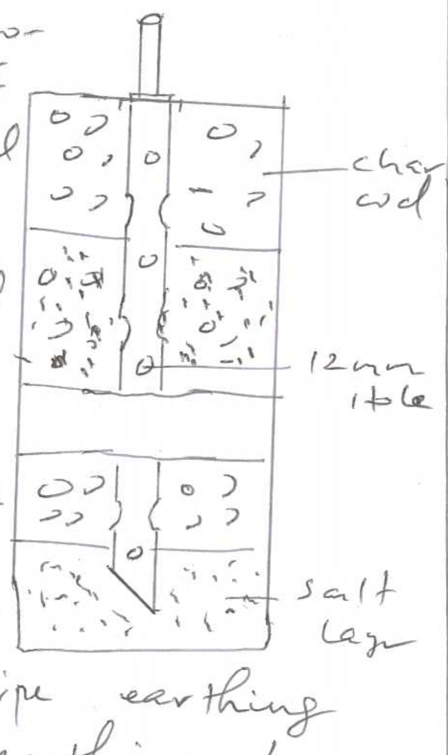


Figure 2 Mar
Expla- 4 Mar

4

Let

N_1 be the number of turns in the primary

N_2 - Number of turns in the secondary

Φ_m - Maximum flux in core in webers

f - Frequency of supply.

Then maximum flux occurs at $\frac{1}{4f}$ second

Average rate of change of flux

$$= \frac{\Phi_m}{\frac{1}{4f}} = 4f\Phi_m$$

= Average emf / turn

Since the flux is sinusoidal, then rms value of induced emf = Average value × Form factor

$$= 4f\Phi_m \times 1.11 = 4.44 f\Phi_m \text{ volts}$$

∴ Induced emf in the primary having N_1 turns = $4.44 f \Phi_m N_1$ - volts

$E_1 = 4.44 f B_m A N_1$ - volts ∵ $\Phi_m = B_m \times A$

Similarly induced emf in secondary having N_2 turns

$E_2 = 4.44 f \Phi_m N_2$ - volts

= ~~4.44 Φm f~~ $4.44 f B_m A N_2$ volts. 6 Marks

5 The effect of magnectic field set up by the armature current on the distribution of flux under the main poles of a generator.

(a) It demagnetise ~~and~~ or weakens the main flux and cross magnectise or distorts it.

(b) It reduces emf induced in the armature.

(c) sparking may occur at brush contact

(d) The efficieny of generator decreases. 6 Marks

6 To produce one cycle of emf the flux has to cut a pair of poles. If P represents the total poles the P/2 gives pair of poles. If N is the speed of the machine in RPM.

Then Revolutions / Second $= \frac{N}{60}$

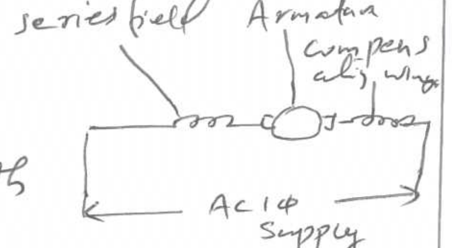
In one ~~revolutions~~ second rotor rotates $\frac{N}{60}$ rev.

For $\frac{N}{60}$ revolution the rotor produces

$\frac{P}{2} \times \frac{N}{60}$ cycles.

$\therefore$ Frequency $f = \frac{PN}{120}$ 6 Ma

7



Universal motors are designed to work on both AC and DC supply. It is similar to dc series motor except that the core and pole are laminated to reduce eddy current and hysteresis loss. The rotor is wound similar to armature of a d.c motor with commutator and brushes. Such motors develope unidirectional torque regardless of whether they are operated on AC or DC. The motors works on the same principle of dc motor. To avoid sparking at brushes while using AC supply sometimes compensating winding are provided in the winding. 6 Marks

PART-C

III (a)

1) Form factor - The ratio of the RMS value to average value is called Form factor.

For sinusoidal alternating current

$$\text{Form factor} = \frac{I_{max} \times 0.707}{I_{max} \times 0.637} = 1.11$$

2) Crest factor - It is the ratio between maximum value and rms value.

$$\text{crest factor} = \frac{I_{max}}{I_{max} \times 0.707} = 1.414$$

3) Power factor : ~~It is~~ The cosine o
the angle between voltage current.
a circuit.

OR

The ratio between resistance and impedence in a circuit ie $\cos\phi = \frac{R}{Z}$

OR

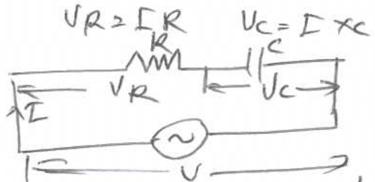
It is ratio between real or active power to the apparent power

ie $\frac{VI\cos\phi}{VI} = \cos\phi$.

4) Average Value

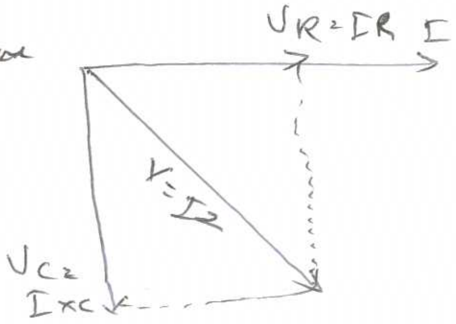
the average value of an ac quantity is given by that direct current which transfers across any circuit in a given time the same charge as transferred by the ac in the same circuit. 8 Marks

5) Consider the circuit having a resistance R and a capacitance C as shown in figure above. The applied voltage V is ~~of~~ the vector sum of V_R and V_c as per vector diagram.



The value of capacitance reactance of the capacitor is

$X_C = \frac{1}{2\pi f C}$



then

$$V^2 = V_R^2 + V_C^2$$

$$V = \sqrt{V_R^2 + V_C^2} = \sqrt{(IR)^2 + (IX_C)^2}$$

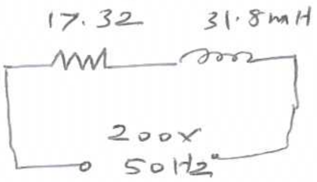
or $V = I\sqrt{(IR)^2 + (IX_C)^2}$ or $\frac{V}{I} = \sqrt{R^2 + X_C^2}$

$$Z = \sqrt{R^2 + X_C^2}$$

IV a) $R = 17.32$ $L = 31.8\ mH$

$= 31.8 \times 10^{-3}\ H$

$V = 200V$ $f = 50Hz$



$Z = \sqrt{R^2 + X_L^2}$, $X_L = 2\pi f L$

$= 2 \times 3.14 \times 50 \times 31.8 \times 10^{-3} = 9.985$

$Z = \sqrt{17.32^2 + 9.985^2} = \sqrt{399.68}$

$= \underline{19.99\ \Omega}$

$I = \frac{V}{Z} = \frac{200}{19.99} = \underline{10\ A}$

Active power $= VI\cos\varphi$ $\cos\varphi = \frac{R}{Z}$

$= \frac{17.32}{19.99} = 0.866$

Active power $= VI\cos\varphi = 200 \times 10 \times 0.866$

$= \underline{1732\ W}$

Voltage across resistor $= IR = 10 \times 17.32$

$= \underline{173.2\ V}$

8 Marks

b)

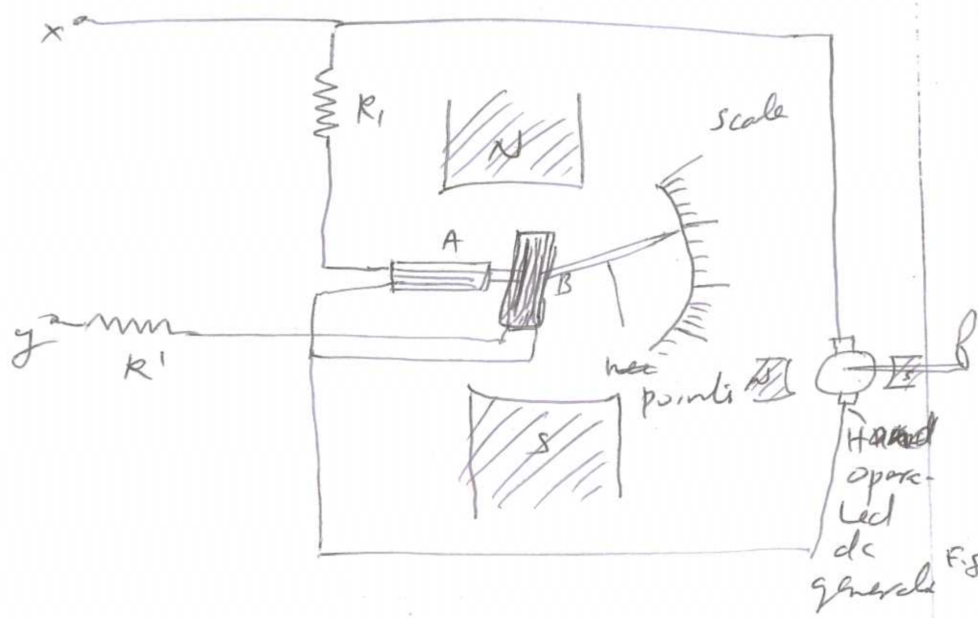


Figure 2 Marks

Megger is the trade name of a hand driven portable true ohm meter extensively used in electrical installations for measuring insulation resistance.

Construction. It has a hand operated dc generator. On hand operation (about 160 rpm) it generate 500V, 1000V, 1500V according to design. ohmmeter. It consists of two coils A & B both mounted on a common shaft. They are pivoted so as to move freely in the magnetic field of a permanent magnet. the voltage coil (A) connected across the generator through a fixed resistance R1 and across deflecting coil (B) through another resistance R' called current limiting resistance. The resistance whose value is to be determined is connected across x and y terminal.

operation. The two terminal of the resistor under test is connected to the terminals of the megger and rotate the handle of the megger. The value of the resistor is determined by the deflection of the pointer over the calibrated scale which is marked from 0 to ∞.

5 marks total 7 Marks

V(a) In a linear network containing more than one source of emf, the resultant current in any branch is the algebraic sum of current that would be produced by each emf acting alone, all other sources of emfs being replaced meanwhile by their respective internal resistance.

Explanation.

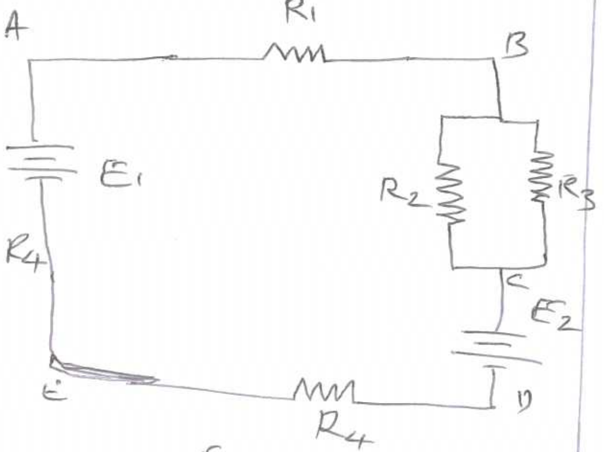


figure I

Consider figure I the total resistance R_T is given by $R_T = R_1 + R_p + R_4$

where $R_p = \frac{R_2 R_3}{R_2 + R_3}$

circuit current $I = \frac{\text{Net emf}}{R_T}$

$$= \frac{E_1 - E_2}{R_1 + R_p + R_4} = \frac{E_1}{R_1 + R_p + R_4} - \frac{E_2}{R_1 + R_p + R_4}$$

Now consider emf E_1 acting alone by replacing E_2 with a short circuit between points C & D. Then

current due to E_1 alone $I_1 = \frac{E_1}{R_1 + R_p + R_4}$

Now replace E_1 alone with ~~short circuit~~ circuit between points A & C:

current due to E_2 alone $= I_2 = \frac{-E_2}{R_1 + R_p + R_4}$

The minus sign with I_2 indicates current due to E_2 alone is in a direction opposite to that produced by E_1 alone.

current I = Algebraic Sum of I_1 & I_2

$$= \left[\frac{E1}{R_1+R_p+R_4}\right] + \left[\frac{-E_2}{R_1+R_p+R_4}\right]$$

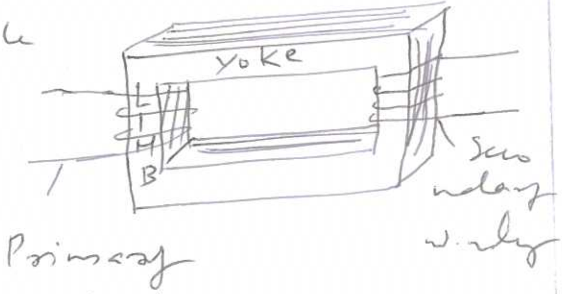
$$= \frac{E1}{R_1+R_p+R_4} - \frac{E_2}{R_1+R_p+R_4}$$ Thus The

therom proved.

8 Marks

b) constructionally a simple transformer has

① core. ② winding.



① Core. The core the is made up of magnetic sheet steel laminations. The core is laminated to reduce eddy current losses. The horizontal part is known as yoke and the vertical part is known as limb. Usually the windings are placed in the limbs.

Winding.

The windings are placed one over another on the limb after insulation. Thee windings to which supply is connected is known as primary winding and the winding to which load is connected is known as secondary winding. According to the no: of turns employed in the primary and secondary winding. these are step up and step down transformers.

7 Marks

V1(a) Power transformers and distribution transformers are used in electrical transmission and distribution system. so they are used to step down or step ~~up~~ voltage or current to the circuit condition at the same frequency of supply.

Audio frequency transformers are designed to respond to audio frequencies and mostly used for matching impedance such as loud speaker mike etc.

Radio frequency transformers are designed to respond to radio frequencies which are higher value than that of audio frequencies. For tuned transformer capacitor are connected across the winding wide band transformers are also called Pulse transformers and can handle Pulses without distortion. 8 Marks

b) <u>Flux losses</u>: Some of the magnetic flux leaks out in the air causes losses

<u>Copper Losses</u>

In the primary and the secondary winding the energy is lost in the form of heat. It is due to the resistance of the winding

The total copper losses = $I_1^2 R_1 + I_2^2 R_2$

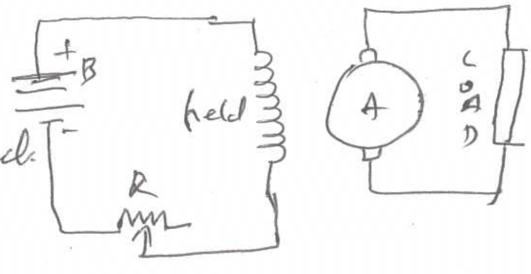
Iron loss or Core loss

It occurr in the core of ~~thee~~ the transformers and can be minimized by laminating the core. The two types of Iron losses ~~are~~ are hysteresis loss and eddy current losses.

7 Mark

VII (a) Seperatily excited d.c generator

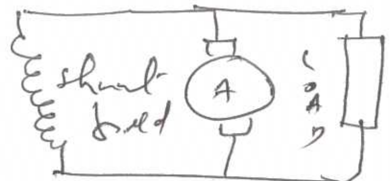
It is one which an independent d.c source energies the field magnet.



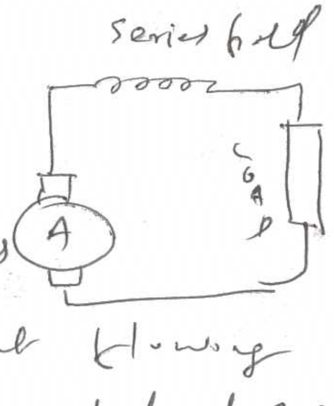
Self excited

(1) Shunt generator.

In this the field coils are connected in ||el with thee armature coils. The field coils is wound with many turns of fine wire



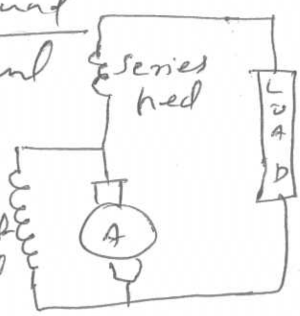
Series field wound



In this type the field winding are connected in series with the armature. The current flowing through Armature, Series field, and load are same. So The field coils are wound with ~~a~~ fewer turns of thick wire compound wound generators

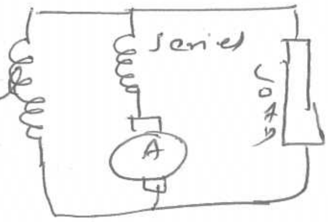
short shunt compound wound

A Long shunt compound wound It is a combination of series as well as shunt field. If the



shunt field are connected across the armature only, the generator is known as short shunt as shown in figure above

and if the shunt field are connected across the series field as well as the armature as shown in figure the



generator is termed as Long shunt compound wound. 8 Marks

(b) $P = 4$, $A = 2$, $Z = 600$, $\phi = 0.015\,wb$, $N = 1200$

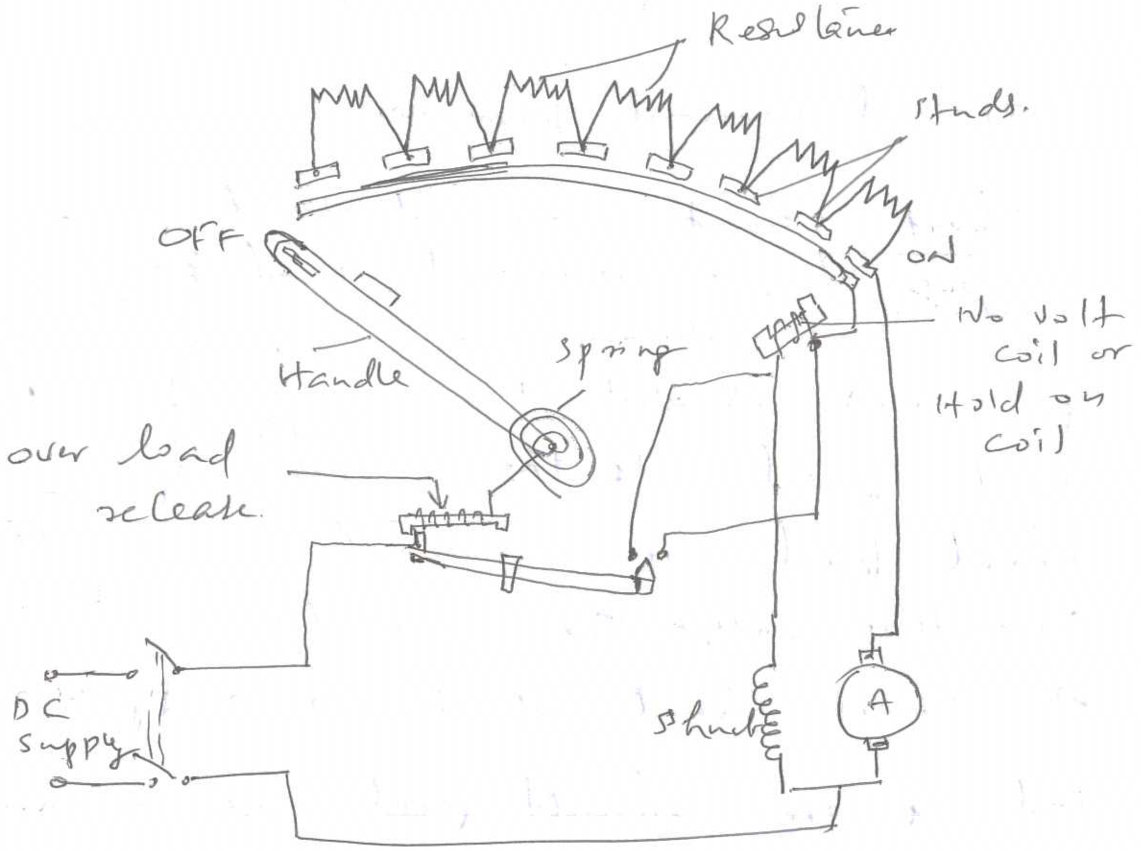
$$E_g = \frac{\phi Z N}{60} \times \frac{P}{A}$$

$$= \frac{0.015 \times 600 \times 1200}{60} \times \frac{4}{2}$$

$$= 360\,V$$

7 Marks

VIII
9



It consists of a rheostatic series resistance divided in to several sections through studs. After switching on the dc supply, the handle of the starter is swiftly moved from OFF position to ON position through studs so that the resistance is minimum at the early stage, and cut each resistance, the motor picks up speed and generates back emf thus current is limited. when the handle is at ON position the it is maintained there by the action of electro magnet of no volt coil. thus the motor gets full voltage. Due to any reason supply is gone; thee electro magnet of No volt coil is demagnetised and due to the action of spring connected the handle will come back to OFF position.

The over load release gives protection to the motor during over load condition. If over load occurs; the coil of over load release is energised and the ~~ph~~ plunger connected moves upward and short circuit the electromagnetic coil. It is result in to thee demagnetising of No volt coil and due to the action of spring the handle moves back to OFF position. Thus the motor is protected. Figure 2 Mark Expln - 6 Marks 8 Marks

b) When the motors rotates the rotating armature conductors also cuts the magnetic line of force they be developing and induced EMF in that conductors. These emf produced will opposes the applied voltage. This induced emf is known as back emf. The magnitude of ~~induced~~ induced emf is same as the generated emf in generator and equal to

$$\frac{\phi Z N}{60} \times \frac{P}{A} \text{ volts}$$

. The back emf is abbrevated as Eb where

$E_b = V - I_a R_a$ where V = terminal voltage

I_a = armature current. and

R_a = armature resistance

7 Marks

1xa) Alternator works on the principle of Faraday's laws of electromagnetic induction. It states that whenever a conductor cuts the magnetic flux emf is induced in it, and the magnitude of induced emf is proportional to the rate of change of flux linkages.

An alternator consists of a stator made of magnetic material and support a laminated armature core having slots in to which a three phase winding is placed displaced by 120° electrical. The windings are connected in star and the neutral is earthed directly through a resistance. The rotor may be salient or cylindrical pole type which produce magnetic flux with help of an exciter fitted on the same shaft of the machine.

When rotor is rotated by prime mover, the stator windings are cut by the magnetic flux produced by the rotor thus produced an induced emf in the stator winding according to the law of Faraday. 8 Marks

b) It is a type of motor when an input signal is given to the motor it will rotate with a step angle

The operation of this motor works on the principle that unlike pole attract each other and like poles repel each other. When the stator windings are excited with a dc supply, it produces magnectic flux and establishe north and south pole

The stepper motor consists of a permanent magnetic rotating shaft called rotor and electromagnects on the stationary portion that surrounds the motor called the stator

The stepper motor are DC motors that moves in discrete steps. They have multiple coils that are organised to group called phases. By energising each phase in a sequence, the motor rotate one step at a time with a computer controlled stepping you can achive very ~~poof~~ precise positioning or speed control and can be controlled digitally

7 Marks

X

a) Let

Z = No conductors / phase = 2T.

P = No of poles

f = frequency of indeed emf = $\frac{PN}{120}$

Φ = flux / pole in wb.

Kd = the distribution factor

Kf = Form factor.

N = the speed of the rotor

In one revolution of the rotor the total flux the cutting is equal to ϕP wb

Time taken for one revolution $\frac{60}{N}$ second

Average emf induced per conductor $= \frac{d\phi}{dt}$

$$\frac{\phi P}{60/N} = \frac{\phi P N}{60}$$ But ~~frequency~~

Speed $N = \frac{120 f}{P}$

Average emf per conductor

$$= \frac{\phi P}{60} \times \frac{120 f}{P} = 2 f \phi \text{ volts}$$

If Z is the no: of conductors emf

$$= 2 f \phi Z \text{ volts} = 2 f \phi \times 2T = 4 f \phi T \text{ volt}$$

If the winding is short pitched and distributed

RMS value of emf / phase

$$= 4.44 f \phi T k_d k_p \text{ volts}$$

8 Marks

b)

When the 3ϕ winding of the stator is connected to a three phase supply, then 3ϕ phase current in the stator winding produces rotating magnetic field ~~rott ro~~ rotating at synchronous speed $N_s = \frac{120 f}{P}$. The rotating flux passes through air gap and cuts the rotor conductors. Due to the relative speed between the rotating flux and the stationary conductors emf is induced in the rotor conductors. Since the rotor circuit is closed, the ~~ind~~ induced emf produces rotor current. It is similar to the condition that a current carrying conductor placed in a magnetic field a torque is produced, is established. ~~Due~~ Due to the torque the ~~roto~~ rotor starts rotating continually..

7 Marks
