Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1 A Attempt any six of the following : 12

1 A a) Define crest factor for sine wave. State its value.

Ans-

Crest factor is defined as the ratio of peak value to rms value of an alternating wave: The crest factor for a sine wave, such as that which a pure resistive load would draw, is **1.414** since the peak of a true sinusoid is **1.414 times** the rms value.

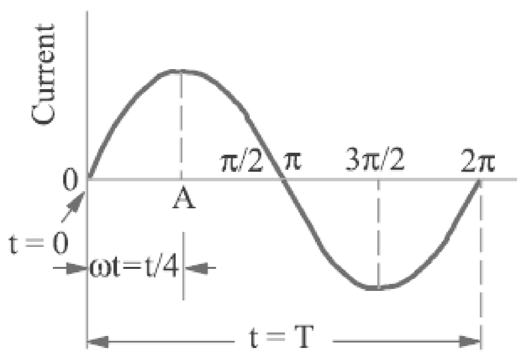
1 mark for definition & 1mark for value

1 A b) State the meaning of phase of an alternating quantity.

Ans:

Phase of alternating quantity is meant the fraction of the time period of that alternating quantity which has elapsed since the current last passed through the zero position of reference.

Meaning 1mark & diagram 1mark



1 A c) State the concept of phase sequence.

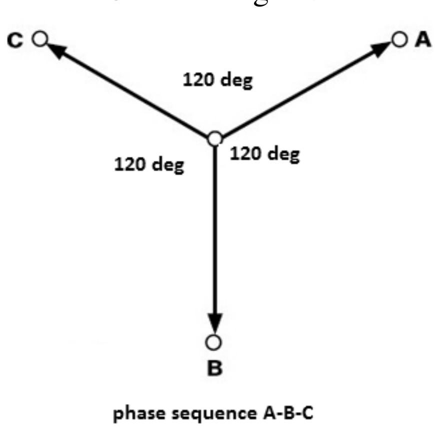
The phase sequence of the quantities is determined by the order in which they occur in the anti clockwise direction (wrt time).

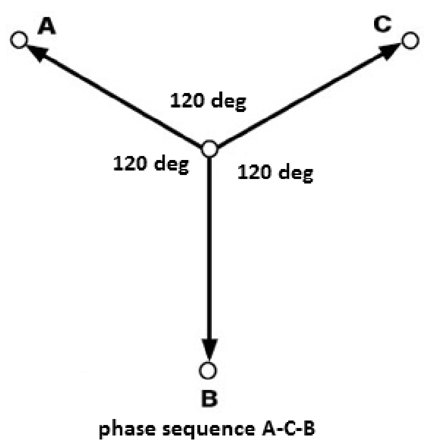
OR

Eg. The phase sequence is said to be A-B-C if A is followed by B phase120° later and B phase 240° later than the A phase.

Also A-C-B as in figure.

Statement 1mark & diagram 1mark





1 A d) State the Flemings right hand rule.

	Ans:- Fleming`s right hand rule state that, outstretch the first three fingers of right hand perpendicular to each other such that first finger points in the direction of magnetic field, thumb in direction of the motion of the conductor relative to field, then second finger indicates the direction of induced e. m. f.(or current)	Statement 2 marks
1 A e)	State the faradays law of electromagnetic induction. Ans:- Faraday's first law of electromagnetic induction: When a conductor cuts or is cut by the magnetic flux, an EMF is generated in the conductor. Faraday's second law of electromagnetic induction: The magnitude of EMF induced in the coil depends on rate of change of flux linking with coil.	1mark each statement = 2 marks
1 A f)	Define Synchronous speed and slip in case of induction motor. Ans:- Synchronous speed: it is speed of the rotating magnetic field in the air gap. $N_s = \frac{120\,f}{P}$	1 mark
	Slip: The difference between synchronous speed (Ns) and actual speed (N) of the rotor is known as slip speed, $S = N_s - N$ Or Slip: The ratio of the difference between synchronous speed (Ns) and actual speed (N) of the rotor to the synchronous speed (Ns) is known as slip (s). i.e. slip, $s = (N_s - N)/ N_s$	1 mark
1 A g)	State the types of three-phase induction motor. Ans- Squirrel cage rotor induction motor Slip ring rotor or wound rotor induction motor.	1mark for each type
1 A h)	State the types of earthing. Ans- Types of earthing: • Plate earthing. • Pipe earthing. • Earth mat (mesh of metal strips) for huge power installations as generating stations etc.	1 mark each Any two types = 2 marks
1 B	Attempt any two of the following.	8
1 B a)	What are the advantages of A.C. over D.C. quantity? Ans- Advantages of AC over DC quantity: • AC can be generated at high voltages, but DC cannot be generated at high	

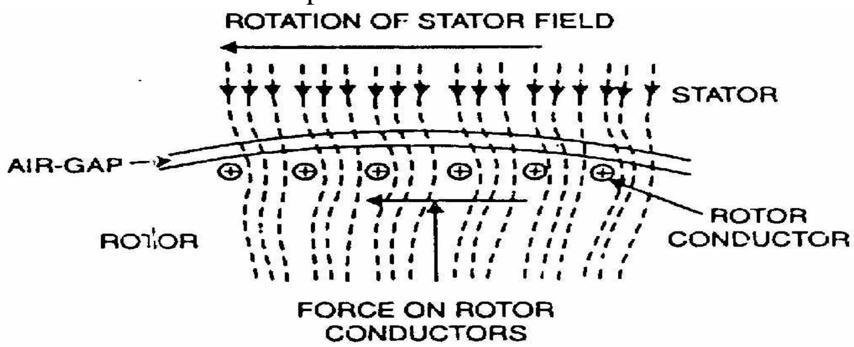
voltages because sparking starts at the commutator at high voltage, due to which commutator gets damaged. 1 mark each Any four advantages 4 marks

- High voltages AC generators are much simpler and cheaper than DC generators of the same range. It is because in AC generators there is no commutator which is costly part and is damaged.
- Alternating current can be stepped up or stepped down with a static device called transformer. When voltages is stepped up current decreases to a small value. Small current produces less heat and can be transmitted through a thin conductor.
- HV transmission reduces the size of conductor, transmission losses and increases transmission efficiency.
- At the receiving station, voltages can be stepped down to the required value by using step down transformer. This is most important reason for generating and using electrical energy as AC.
- A.C. induction motors are simplest in construction, cheaper in cot and require less maintenance whereas D.C. motors are complicated.

1 B b) Explain working of 3-phase induction motor.

Ans-

Consider a portion of 3-phase induction motor as shown in Fig. (8.13). The operation of the motor can be explained as under:



Working 4marks

(i) When 3-phase stator winding is energized from a 3-phase supply, a rotating magnetic field is set up which rotates round the stator at synchronous speed Ns (= 120 f/P).

(ii) The rotating field passes through the air gap and cuts the rotor conductors, which as yet, are stationary. Due to the relative speed between the rotating flux and the stationary rotor, e.m.f.s are induced in the rotor conductors. Since the rotor circuit is short-circuited, currents start flowing in the rotor conductors.

(iii) The current-carrying rotor conductors are placed in the magnetic field produced by the stator. Consequently, mechanical force acts on the rotor conductors. The sum of the mechanical forces on all the rotor conductors produces a torque which tends to move the rotor in the same direction as the rotating field.

(iv) The fact that rotor is urged to follow the stator field (i.e., rotor moves inthe direction of stator field) can be explained by Lenz's law. According to this law, the direction of rotor currents will be such that they tend to oppose the cause producing them. Now, the cause producing the rotor currents is the relative speed between the rotating field and the stationary rotor conductors. Hence to reduce this relative speed, the rotor starts running in the same direction as that of stator field and tries to catch it.

1 B c) What is Stepper Motor? State it's any two applications.

Ans-

A stepper motor is electromechanical device which converts electric pulses into proportionate mechanical step movement. In these motors, each step input causes the shaft to rotate through a certain number of degrees i.e. one step movement. A step is defined as the angular rotation in degrees produced by the output shaft when the motor receives a step input pulse.

Applications-Wall clock, CD drive, robotics, printers, scanners and CNC machines.

Explanation 2 marks & Any two application 2marks

2 Attempt any FOUR of the following. 16

2 a) Define each of the following terms of A.C. voltage.

i) Frequency
ii) Time period
iii) Amplitude
iv) RMS value

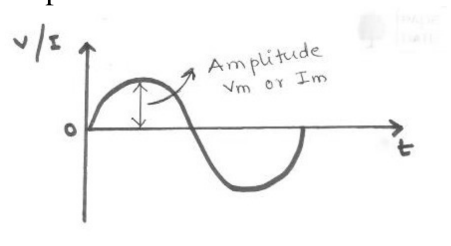
Ans:-

i) Frequency- number of cycles completed in one seconds is called as frequency. i.e. f=1/t Hz.

ii) Time period- Time taken by an alternating quantity to complete one cycle is called its Time period.

Each definition 1marks

iii) Amplitude:-The maximum value of an alternating quantity is called as Amplitude.



iv) RMS value:-

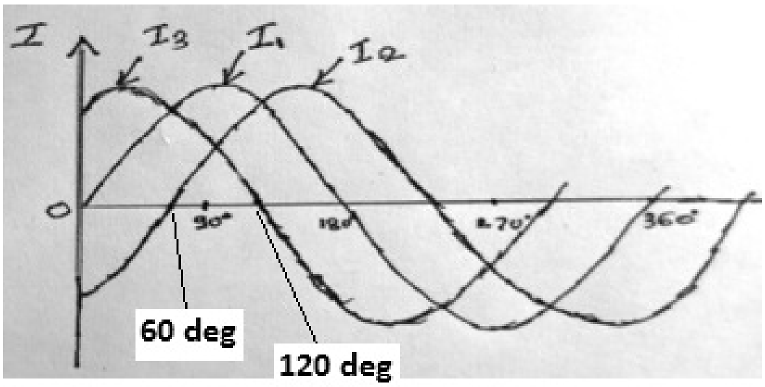
The RMS value of an AC is equal to the steady state or DC that is required to produce the same amount of heat as produced by AC provided that the resistance and time for which these currents flow are identical.

2 b) Represent the following circuit current graphically.

$I_1=I_m\sin\omega t$, $I_2=I_m\sin(\omega t-60)$ and $I_3=I_m\sin(\omega t+60)$

Ans;-

Correctly labeled



4 marks,

Partially correct 1 to 3 marks proportionally.

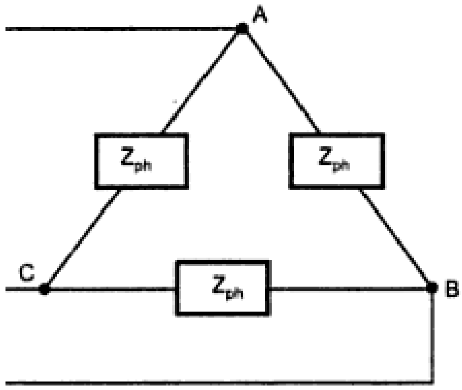
2 c) What are the advantages of 3 phase system over 1 phase system?
Ans;-

Advantages:
- Balanced three phase systems are most efficient ones for transmission & distribution.
- For equal power to be transmitted three phase systems require less copper.
- For equal power to be transformed three phase transformers are less in weight i.e save materials.
- The problem of heavy neutral currents (due to single phase loads) can be overcome only in three phase systems by load balancing.
- Three phase induction motors are self-starting, whereas single phase induction motors are not self-starting machines unless provided with an extra starting winding.
- Three phase motors have higher efficiency as compared to single phase motors.
- Three phase motors have better power factor.
- Three phase machines are very suitable for huge power applications whereas single phase ones are unsuitable.
- The size of three phase motors is small as compared to single phase motors of same rating.

1 mark each any four points = 4marks

2 d) Define balanced load and unbalanced load. Show the same diagrammatically.
Ans:
Balanced load:
If all phase impedances of three phase load are exactly identical (Same) in respect of magnitude and their nature, it is said to be a balanced three phase load. i.e. magnitude of voltages and resulting currents are same & they have same phase angles (they are displaced each other by 120^0)

1mark for definition & 1mark for diagram



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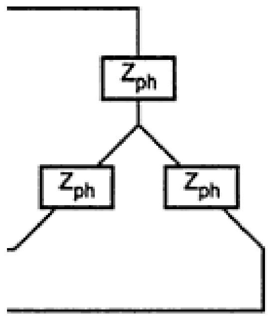
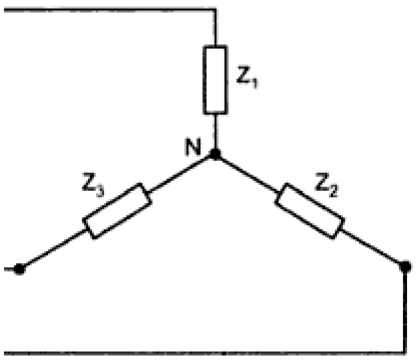
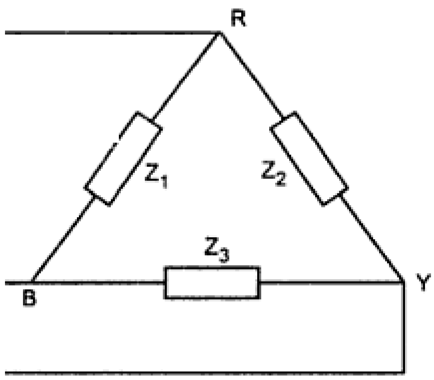


1mark for definition & 1mark for diagram

Unbalanced load:
In unbalanced load impedances of one or more phases are different from other phases. (Z_1, Z_2, & Z_3 are not identical simultaneously) The respective currents are not identical.





2 e) Draw a delta connection of three phase power supply and show line current, line voltage, phase current and phase voltage on it and state the relation between currents and voltages. (phase value and line values).
Ans-

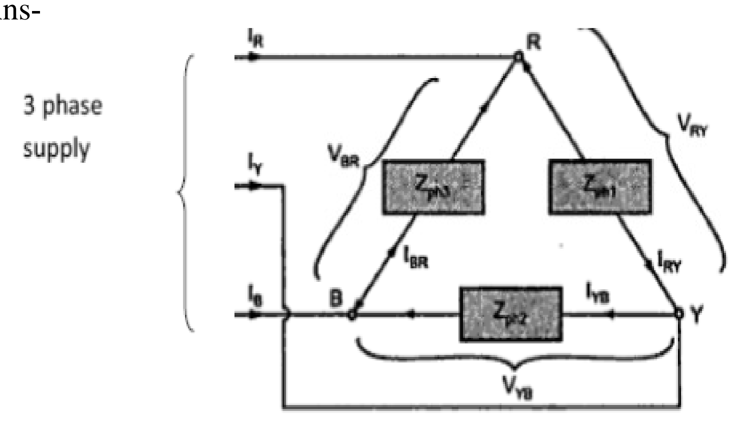


Diagram 2 mark

Line voltages = Phase voltages: are V_{RY}, V_{YB}, and V_{BR}.
Line currents = I_R, I_Y, and I_B.
Phase currents = I_{RY}, I_{YB}, and I_{BR}.

For balanced supply and loads: Relations 2 mark
$V_{Line} = V_{Phase}$, and
$I_{Line} = \sqrt{3}\ I_{Phase}$.

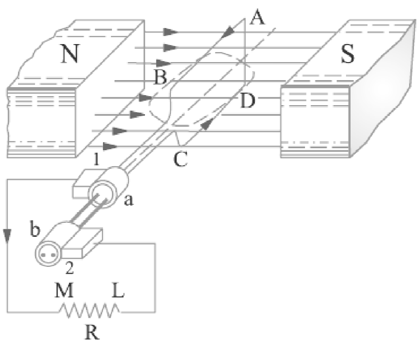
2 f) Compare two winding transformer with auto-transformer (any four points)
Ans-

Sr. No.	Two winding transformer	Auto transformer
1	Different primary & secondary winding	primary & secondary on common winding
2	No electrical connection between primary and secondary	Electrical connection between primary and secondary
3	Amount of copper required and weight is more	Amount of copper required and weight is less
4	Size is larger as compared to auto transformer for similar capacity	Size is small as compared to two winding transformer for similar capacity
5	Cost is more	Cost is less
6	More losses hence lower efficiency as compared to auto.	Less losses hence higher efficiency

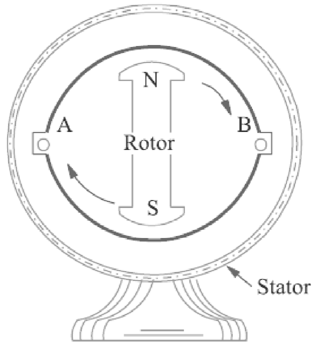
1mark each Any four points = 4marks

3 Attempt any four of the following : 16

3 a) Explain the generation of alternating voltages and alternating currents with the heif of sutable diagram.
Ans:- Generation of alternating voltages and alternating currents
Alternating voltages generated by rotating a coil in magnatic field, or rotating a magnatic field within a stationary coil, as shown in fig(b). 1 mark



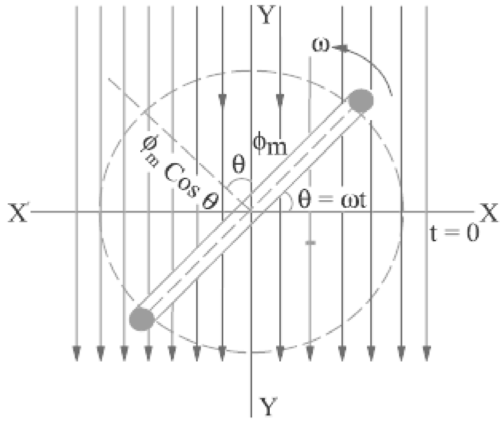
(a)



(b)

Fig 1 mark

The value of voltage generated depends, in each case, upon the number of turns on the coil, strength of the field and the speed at which the coil or magnetic field rotates. Alternating voltages may be generated in either of the two ways shown above, but rotating field metheod is one of which is mostly used in practice.
Equation of the alternating voltages and currents



Consider a rectangular coil, having N turns and rotating in a uniform magnetic field, with an angular velocity of ω radian/second, as shown in figure. Let time be measured from X-axis. Maximum flux ϕ_m is linked with the coil, when its plane coincides with the X-axis. In time t seconds, this coil rotates through an angle θ = ωt. In this deflected position, the component of flux which is perpendicular to the plane of the coil, is $\phi = \phi_m \cos \omega t$. Hence, flux linkages of the coil at any time are N ϕ =N ϕ_m cos ωt.

According to Faraday's law of electromagnetic induction, the emf induced is given by — Explanation 2 marks

$e = -\dfrac{d}{dt}(N\phi) volt = -N.\dfrac{d}{dt}(\phi_m \cos \omega t) volt$

$= -N\phi_m \omega\,(-\sin \omega t)$volt

$= \omega\ N\ \phi_m \sin\theta$--(1)

When coil is turned through 90^0i.ewhen $\theta = 90^0$, then sin θ = 1, hence e has maximum value, say E_m.

$E_m = \omega N\phi_m = \omega NB_m A = 2\pi f N B_m A\ volt$ ------------------------(2)

E_m = maximum flux density in Wb/m^2

A = Area of coil in m^2

f = frequency of rotation of coil

substituting this valve in equation (1) we get

$e = E_m \sin \omega t$

Similarly, the equation of induced alternating current is

$i=I_m \sin\ \omega t$ ------------------------(3)

3 b) Three resistances of 25Ω each are connected in delta across 3-phase, 400 V, 50 Hz AC supply. Find Phase current, Line current, Phase voltage, Total active power

Ans:-

For Delta Connection $V_L = V_{ph} = 400$ V, $I_L = \sqrt{3}I_{ph}$

i) Phase current:

$I_{ph} = V_{ph}/R = 400/25 = 16$ A. 1mark

ii) Line current = $\sqrt{3}I_{ph} = \sqrt{3} \times 16 = 27.71$ A, 1mark

iii) Phase = Line voltage = 400 V, 1mark

iv) Total active power: = $\sqrt{3}V_LI_L = 3\ V_{ph}I_{ph} = 3 \times 400 \times 16 = 19200$ W. 1mark

3 c) State Lenz's law. Write the equation of energy stored in magnetic field and meaning of each term.

Ans:

Lenz's Law:

Statement:

The direction of induced emf produced due to the process of electromagnetic induction is always such that, it will set up a current to oppose the basic cause responsible for inducing the emf. Law statement 1 mark

The mathematical representation is, $e = - N (d\Phi/dt)$ Equation 1 mark

Where 'e' = Induced emf , N = No. of turns in coil, $d\Phi/dt$ = rate of change of flux where -ve sign indicates opposition to induced emf.

Energy stored: = $\frac{1}{2} (LI^2) = \frac{1}{2} (NI\Phi) = \frac{1}{2} (N^2\Phi)/L = \frac{1}{2} (BHAl)$ (J) 1 mark

L = inductance of coil (H), I = flux producing current (A), Φ= flux set up Webers N = no. of turns in coil, A = cross section area of core (m^2), l= length of magnetic circuit (m). 1 mark

3 d) Define the following terms:

i) Induced emf

ii) Dynamically induced emf

iii) Statically induced emf.

Ans :-

i) Induced emf:

The emf produced in conductors (or coils) when linked with changing magnetic fields or having relative motion with respect to magnetic fields.(unit) 1mark

ii) Dynamically induced e.m.f:

If flux linking with a particular conductor is brought about by moving the coil in stationary field or by moving the magnetic field w.r.t to stationary conductor. Then the e.m.f. induced in coil or conductor is knownas "Dynamically 1mark induced e.m.f.

$E = B\ l.\ v.\ \sin\theta$ ½ mark

iii) Statically induced e.m.f.

The e.m.f. induced in coil by changing the current in coil itself or in the nearby coil such e.m.f. is known as "Statically induced e.m.f." 1mark

$$e = -L\frac{di}{dt}$$ ½ mark

3 e) Explain the working principle for single phase trasformer.

Ans:-

A transformer is a static piece of equipment by means of which electric power in one circuit is transformed into electric power of same frequency in another circuit. It can be used either for raising or lowering the voltage of an a.c. supply with a corresponding decrease or increase in current. The physical basis of a a transformer is mutual induction between two circuit linked by a common magnatic flux. Explanation 2 marks

It essentially consists of two windings, the primary and secondary, wound on a common laminated magnetic core as shown in Fig. The winding connected to the a.c. source is called primary winding (or primary) and the one connected to load is called secondary winding (or secondary). The alternating voltage V1 whose magnitude is to be changed is applied to the primary. Depending upon the number of turns of the primary (N1) and secondary (N2), an alternating e.m.f. E2 is induced in the secondary. This induced e.m.f. E2 in the secondary causes a secondary current I2. Consequently, terminal voltage V2 will appear across the load. If V2 > V1, it is called a step up-transformer. On the other hand, if V2 < V1, it is called a step-down transformer.

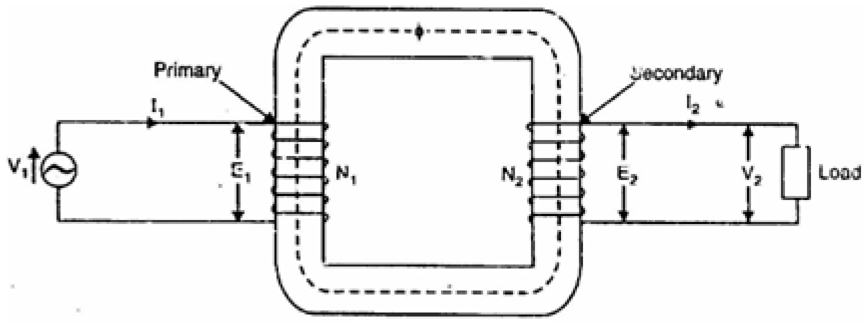


Diagram 2 marks

Working

When an alternating voltage V1 is applied to the primary, an alternating flux f is set up in the core. This alternating flux links both the windings and induces e.m.f.s E1 and E2 in them according to Faraday's laws of electromagnetic induction. The e.m.f. E1 is termed as primary e.m.f. and e.m.f. E2 is termed as secondary e.m.f.

3 f) Justify why the rating of transformer is given in KVA and not in KW.

Ans:-

Load power factor is not fixed quantity as secondary load may vary. Hence rating cannot be given in kW but it has to be in VA or kVA which will give the correct conductor capacity. 2 marks

An important factor in the design and operation of electrical machines is the relation between the life of the insulation and operating temperature of the machine. Therefore, temperature rise resulting from the losses is a determining factor in the rating of a machine. We know that copper loss in a transformer depends on current and iron loss depends on voltage. Therefore, the total loss in a transformer depends on the volt-ampere product only and not on the phase angle between voltage and current i.e., it is independent of load power factor. For this reason, the rating of a transformer is in kVA and not kW. 2 marks

4 Attempt any four of the following : 16

4 a) An alternating current is represented by i=70.7 sin 520 t determine
i)Frequency
ii) rms value of current
iii) Average value current and
iv) Find the current at 0.0015 seconds after passing through zero and increasing positively.

Ans:-

$i = i_m \sin \omega t = 70.7 \sin 520\, t$

Frequency

$\omega = 2\pi f$

$f = \frac{\omega}{2\pi} = \frac{520}{2\pi} = 82.76$ Hz 1 mark

ii) rms value of current

$$i_{rms} = \frac{i_m}{\sqrt{2}} = \frac{70.7}{\sqrt{2}} = \mathbf{49.99A}$$

1 mark

iii) Average value of current

$$i_{av} = \frac{2\, i_m}{\pi} = \frac{2 * 70.7}{\pi} = \mathbf{45A}$$

1 mark

iv) Current at 0.0015 seconds
i= 70.7 sin (520 * t) = 70.7 sin (520*0.0015)
= 70.7 * 0.703
= 49.72 A 1 mark

4 b) State the meaning of impedance and impedance triangle.

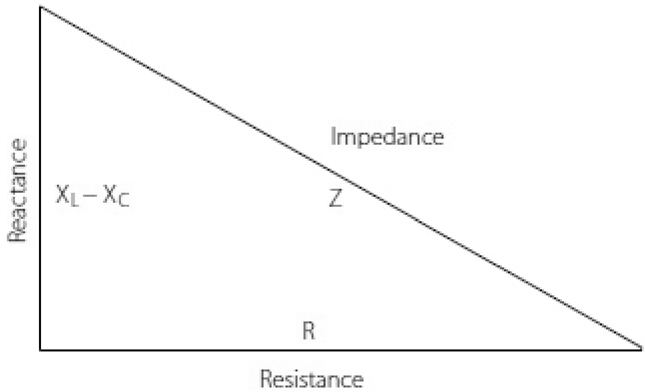
Ans:-

The combined effect of ohmic resistance and reactance is in an electric circuit is impedance. 1 mark

$Z = \sqrt{R^2 + (X_l - X_c)^2}\ \ \Omega$

1 mark

Impedance triangle.



Impedance triangle.

Impedance triangle 2 marks

4 c) Define voltage regulation of transformer. Two transformers A and B have a voltage regulation of 10% and 20% respectively. Which transformer is better and why?

Ans:-
The voltage regulation of a transformer is the arithmetic difference (not phasor difference) between the no-load secondary voltage (V_{02}) and the secondary voltage V_2 on load expressed as percentage of no-load voltage i.e.

Definition 2 marks

$$\% \, voltage \ regulaton = \frac{V_{02} - V_2}{V_2} X \, 100$$

V_{02} = no-load secondary voltage
V_2 = secondary voltage on load

Transformer A with 10% voltage regulation is better as it indicates there is less voltage drop in it and hence the load gets better voltage which is nearer to its rated value.

Reason 2 marks

4 d) Compare three phase squirrel cage induction motor and slip ring induction motor based on starting torque, starting current, power factor and maintenance cost.

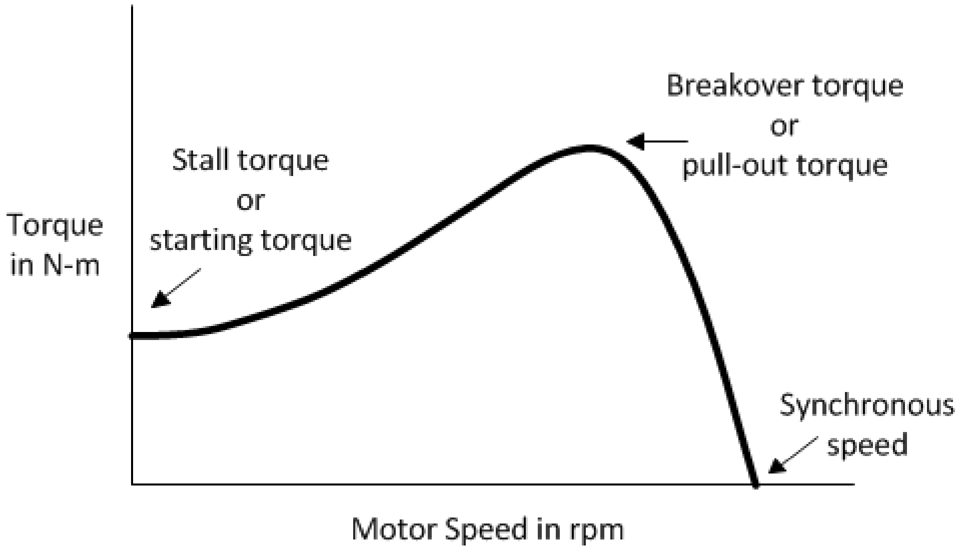
Ans:-

Parameters	Squirrel cage I.M.	Slip ring Slip ring I.M.
starting torque	Low	High with rotor resistance starter.
starting current	More	Less
power factor	Better running	Better starting
maintenance cost	Less	More

Each point 1marks

4 e) Explain the torque-speed characteristics of three-phase induction motor.

Ans-



Speed-Torque Curve for a Three-Phase Induction Motor

Characteristics 2marks

In this diagram, T represents the nominal full load torque of the motor.
In this case, the starting torque (at $N = 0$) is 2T.
The maximum torque (pullout torque) is nearly equal to 4.5T.
At full load, the motor runs at speed N.
When mechanical load increases, motor speed decreases till the motor torque again becomes equal to the load torque.
However, if the load torque exceeds the pullout torque, the motor will suddenly stop.

Explanation 2marks

4 f) State the principle of operation of an universal motor. Give any two applications.

Ans:-

Operating principle is the interaction of the main field and field due to current in the armature conductors to produce force/torque for motion. The force is directly proportional to the product of main flux and armature current.

principle of operation 2 mark

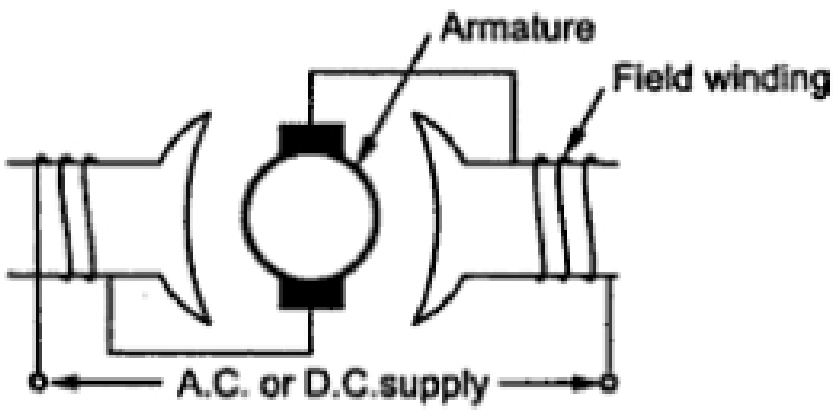


Diagram or equivalent 1 mark

Applications ½ mark each app any 2 = 1 mark
vacuum cleaners
drill machine
food mixers
blenders
domestic sewing machine
hair dryers etc.

5 Attempt any four of the following. 16

5 a) Draw the schematic diagram of ac flowing through pure inductance. Write the expression for voltage and current. Also draw the waveform and write the expression of power.
Ans :
AC flowing through pure inductance-

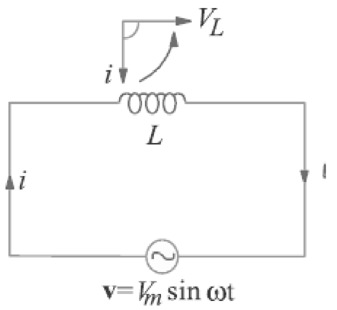


Diagram 1mark

Expression for voltage and current

$v = L\dfrac{di}{dt}$

$v = V_m \sin \omega t$

$V_m \sin \omega t = L\dfrac{di}{dt}$

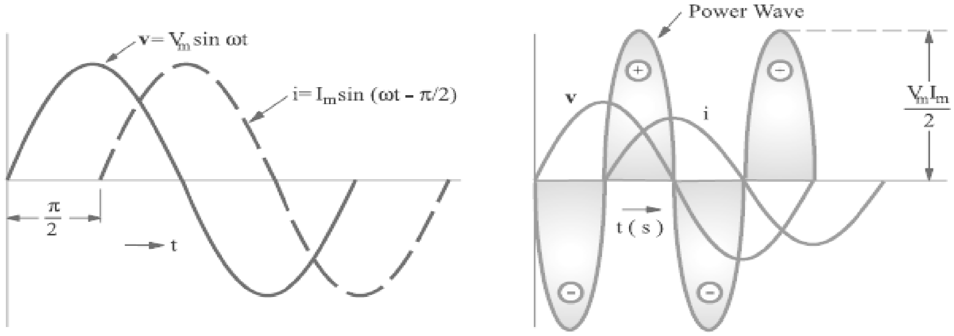
$di = \dfrac{V_m}{L}\sin \omega t\, dt$

Integrating both side

$i = \dfrac{V_m}{L}\int \sin \omega t\, dt$

Expressions (v, i) ½ mark each = 1 mark

waveform



(a) (b)

Waveform 1mark

Power Equation

$$\text{power for whole cycleis P} = -\frac{\text{Vm Im}}{2}\int_0^{2\pi} \sin \omega t \; dt$$

Power equation 1mark

5 b) A Coil Consist of 0.08 H inductance with resistance 40 ohm connected to 230 V, 50 Hz supply. Find impedance, reactance, current and power factor.

Solution: given L= 0.08 H, R= 40 Ω, V=230 V, f=50 Hz

$X_L = 2\pi fL = 2\pi * 50 * 0.08 = 25.13\ \Omega$ — Reactance 1marks

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{40^2 + 25.13^2} = 47.23\ \Omega$$

Impedance 1mark

$I = \frac{V}{Z} = \frac{230}{47.23} = 4.86\ Amp$ — Current 1mark

$\cos\varphi = \frac{R}{Z} = \frac{40}{47.23} = 0.84\ lag$ — Power factor 1mark

5 c) A single phase transformer has 350 primary and 1050 secondary turns. The net cross-sectional area of core is $55cm^2$. If the primary winding is connected to a 400V, 50Hz supply. Calculate –
i) Maximum value of flux density in the core
ii) Voltage induced in the secondary

Solution:
Sol-
Given data, N_1=350, N_2=1050, a= 55 cm^2=$55*10^{-4}m^2$.
B_m=? and V_1=?

$E_1=4.44*f*\phi_m* N_1$
$400=4.44 *50* \phi_m*350$
ϕ_m=0.005148 Wb
Bm= ϕm/a
=$0.005148/55*10^{-4}$
Bm= 0.936 wb/m^2

Maximum value of flux density 2 marks

Transformation ratio (k)= $V_2/V_1=N_2/N_1$
$V_2=(N_2/N_1)* V_1$
V_2=1050/350 * 400
V_2=1200 VOLTS

Voltage induced in the secondary 2 marks

5 d) Explain any one method of speed control of 3-phase induction motor.

Ans:

Pole changing method
Frequency Control method
Stator voltage control Method
Rotor resistance method
Injected e.m.f. method

Pole changing method:

Speed control using two separate winding-

An induction motor stator is wound for fixed number of poles. The speed of the induction motor depends upon the number of poles for which stator is wound. If instead of one stator winding two independent windings are wound for a different number of poles then two definite speeds can be obtained. E.g. one winding for 4-pole and another winding for 8-poles them speeds can be achieved. Two windings are insulated from one another when any one of the winding is used, the other should be kept open circuited by the switch or kept star connected.

Speed control using consequent pole technique-

This method is used for obtaining multispeed in squirrel cage induction motor. In this method only one winding is used and it is provided with some simple switching means (device), so that connections of coils with supply are changed and different number of poles are formed. This is explained as below-

Any one method of speed control 2 marks diagram + 2 marks description

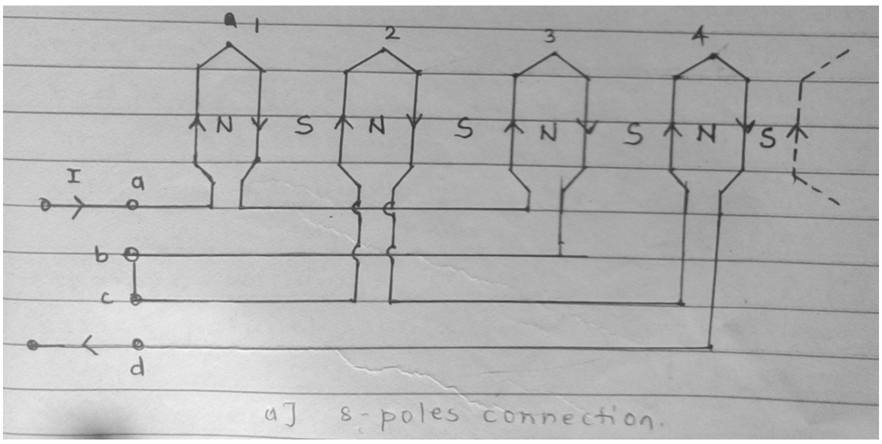


Fig (a)

Above fig (a) shows developed winding diagram for one phase of balanced three phase winding. Coil-1 & coil-3 are in series and they form one coil group while coil-2 & coil-4 connected in series to form another coil group. These two coil groups are connected in series such that all coils are magnetized in the same direction. Hence these coils forms
4-North poles and 4-South poles. Thus these arrangement gives total
8-poles.

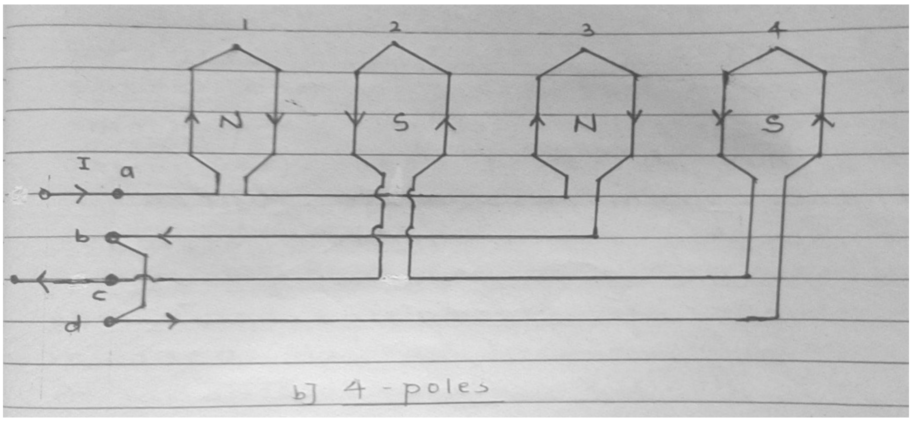
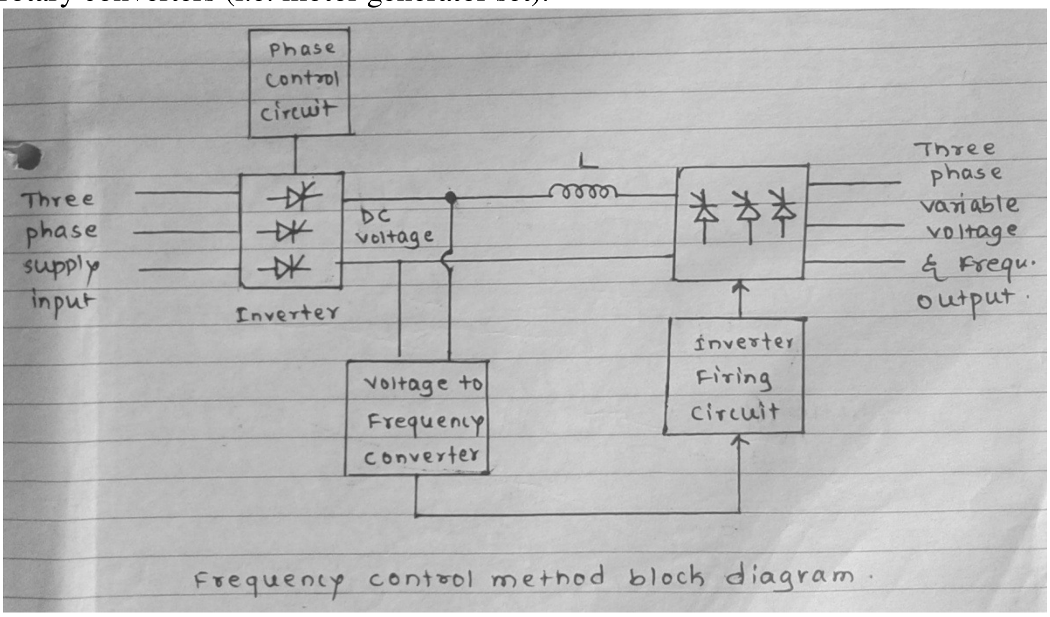


Fig.(b)
If two coil groups are connected in series as shown in fig (b), there will be only 4-poles formed. Thus synchronous speed in this case will be doubled than first case.

Speed control by changing supply frequency-

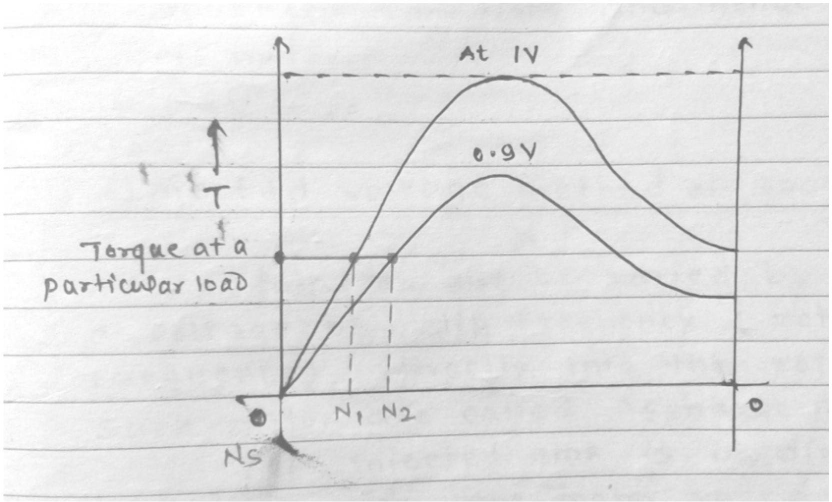
The synchronous speed of the induction motor is given by, Ns=120f/P. The synchronous speed of an induction motor can be changed by changing the supply frequency (f). Variable frequency can be obtained from solid state equipments or rotary converters (i.e. motor generator set).



A basic block diagram of speed control of induction motor using variable frequency source is shown in above fig. Three phase supply at input is first converted into controlled DC. This DC voltage is applied to inverter circuit whose frequency is controlled by pulses from voltage to frequency controller unit. A smoothing reactor, L is connected in the circuit to filter the controlled DC.

Stator voltage control Method-

We have relation that, torque is directly proportional to square of the voltage (i.e.Tα V^2) e.g. if the applied voltage is reduced from V to 0.9V, the torque will be reduced from T to 0.81T. The torque-speed characteristics at reduced stator voltage is shown in below fig.

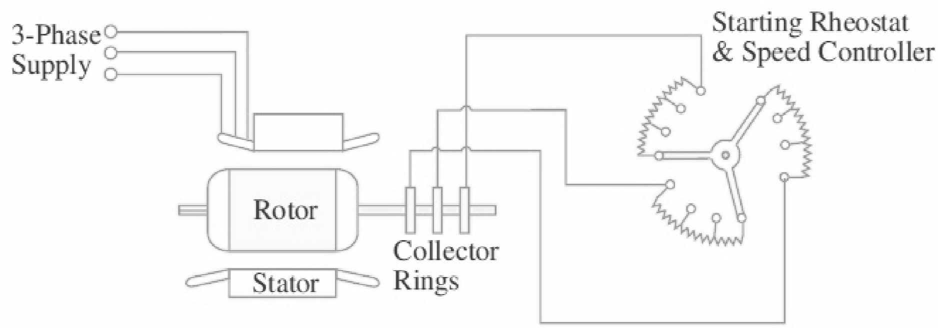


Since the torque is reduced to to 81%, the rotor starts rotating at speed N2, i.e. its speed will be reduced. This method of speed control is rarely used industrial three phase motors because of requirement of additional costly voltage changing equipment. A large change in voltage is required for a relatively small change in speed.

Control of speed by changing the rotor resistance-

This method of speed control is belongs to speed control by changing slip (s). As in slip ring induction motor slip at a particular load can be changed by changing the rotor circuit resistance. As we increase rotor resistance, the rotor slip increases, thus speed of the rotor decreases as $N = \frac{120f}{P}(1 - s)$, as we further increases the rotor circuit resistance, the speed of the motor further decreases.

Thus speed of the motor can be varied by changing rotor resistance. The arrangement for speed control using variable rotor resistance is shown below.



Injected e.m.f. method-

Slip can be varies by introducing a voltage of slip frequency (rotor current frequency) directly into rotor circuit. Such motors are called scharge motors.

If injected emf is in direct opposition to rotor emf, the motor speed will decrease. If the injected emf is inphase with the rotor emf, then the speed will be above synchronous speed.

These motors are rarely used because of bulky construction & high cost.

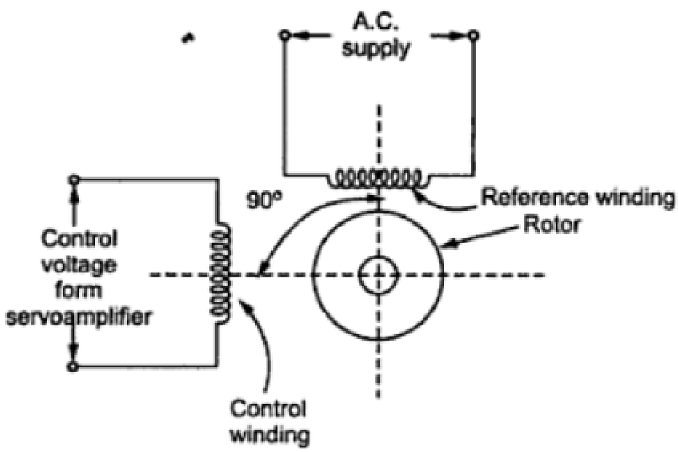
5 e) Explain operation of A.C. servo motor and state its application.

Ans-

There are some special types of application of electrical motor where rotation of the motor is required for just a certain angle not continuously for long period of time. For these applications some special types of motor are required with some special arrangement which makes the motor to rotate a certain angle for a given electrical input (signal). Such motors can be ac or dc motors. When controlled by servo mechanism are termed as servomotors.

These consist of main and control winding and squirrel cage / drag cup type rotors. Vr is the voltage applied to the main or reference winding while Vc is that applied to control winding which controls the torque- speed characteristics. The 90o space displacement of the two coils/windings and the 90o phase difference between the voltages applied to them result in production of rotating magnetic field in the air gap due to which the rotor is set in motion. The power signals can be fed from servo amplifiers either to the field or armature depending upon the required characteristics.

Operation with diagram 2 marks



APPLICATIONS OF SERVO MOTOR
CNC machine
Precision control
Process controller
Robotics
Sewing machine
Aeronautical Application
Conveyor, Tachogenerato

½ mark each Any four applications 2 marks

5 f) Compare resistance split phase induction motor with capacitor start motor.

Ans:

Parameter	Resistance split phase induction motor	Capacitor start motor
Winding design	Starting winding has high resistance and relatively small reactance while main winding has low resistance and large reactance.	Starting winding and running winding are nearly identical in nature.
Centrifugal switch	Present in series with starting winding.	Present in capacitor start capacitor run motor and its absent capacitor start induction run machine.
Phase difference between two winding currents	The currents flowing in the two windings have reasonable phase difference of about 25 to 30^o	The currents flowing in two windings have phase difference of about 80^o
Starting torque	As starting torque Ts is smaller. Or The starting torque is 1.5 to 2 times the full-load torque	Starting torque is much more than that of a split-phase motor. Or The starting torque is 3.5 to 4.5 times the full-load torque
current drawn by motor at starting	For same starting torque current drawn by the motor is double than that of capacitor start motor	For same starting torque the Current in the starting winding is only about half that in a split-phase motor
Power rating	The power rating of such motors generally lies between 60 W and 250 W.	The power rating of such motors lies between 120 W and 7-5 kW.
Cost	Low	High as compared to split phase motor.
Applications	(a) fans (b) washing machines (c) oil burners (d) small machine tools etc.	(a) compressors (b) large fans (c) pumps (d) high inertia loads

1 mark each any four points = 4 marks

6 Attempt any FOUR of the following. 16

6 a) An alternating voltage is expressed as e=200 sin 314.16t. find
i) RMS value
ii) Maximum value
iii) Frequency
iv) Value of voltage after 5 m sec.

Solution: Given- e= 200 sin 314.16t volts

i) RMS value-

Since, Em= 200 Volts

$$\therefore \text{Erms} = \frac{\text{Em}}{\sqrt{2}} = \frac{200}{\sqrt{2}} = 141.42 \text{ volts}$$ 1 mark

ii) Maximum value- Em = 200 volts 1mark

iii) Frequency –

$$\omega = 2\pi f = 314.16$$

$$\therefore \ f = \frac{314.16}{2\pi} = \frac{314.16}{2\pi} = 50 \text{ Hz}$$ 1mark

iv)Value of voltage after 5 m sec

At t= 5 msec

E=200 sin 314.16t = 200sin (314.16 x 5 x 10^{-3}) 1 mark
E= 5.48 volts

6 b) State specifications and two applications of isolation transformer and radio frequency transformer.

Ans:

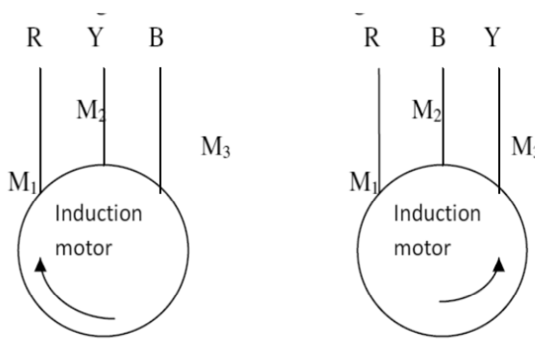
	Isolation transformer	Radio frequency transformer
Specifications	Power rating 0.125, 0.25, 0.5,…, __phase, frequency: 47 – 50 Hz.	Frequency in MHz, Power rating, voltage, current etc.
Applications	1. Areas where common mode noise is generated. 2. Protect sensitive equipment from unwanted voltage spikes on primary side. 3.Used in electronic circuits for isolation 4. Used in circuits to avoid audio and video distortions	1. To transfer rf signal from one circuit to another circuit 2. Impedance matching to achieve maximum power transfer and to suppress undesired signal reflection 3. Voltage, current step-up or step-down 4. DC isolation between circuits while affording efficient AC transmission

Specifications 2 marks

1 app of each together 1 mark, Total : applications 2 marks

6 c) Explain how direction of rotation is reversed in 3-phase induction motor.
Ans:
By interchanging any two of the supply phase lines to the motor the direction of stator rotating field is reversed resulting in reversal of the rotor direction. 2 marks

M1, M2, M3 are the stator three winding terminals of the motor to be connected to
the supply lines.



2 marks

6 d) Draw and explain capacitor start, capacitor run induction motor.

Ans:

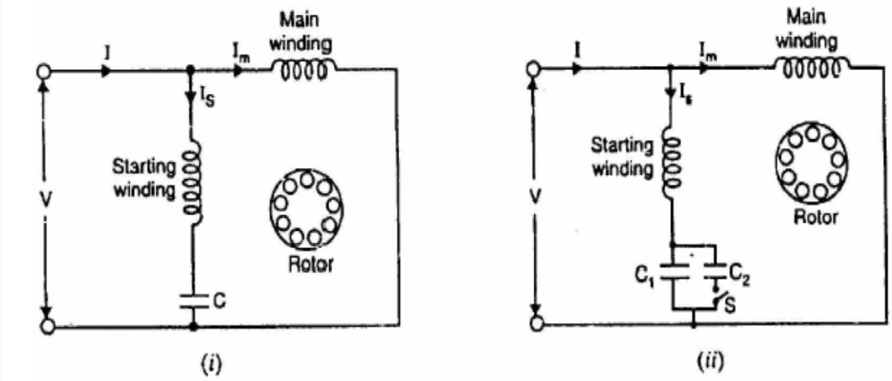


Diagram 2 marks

In this motor the starting winding is not opened after starting so that both starting winding and running winding are remain connected to the supply at the time of starting as well as in running condition. Two designs are generally used.

In one design, a single capacitor C is used for both starting and running as shown in Fig.(i). This design eliminates the need of a centrifugal switch and at the same time improves the power factor and efficiency of the motor.

In the other design, two capacitors C1 and C2 are used in the starting winding as shown in Fig. (ii). The smaller capacitor C1 required for optimum running conditions is permanently connected in series with the starting winding. The much larger capacitor C2 is connected in parallel with C1 for optimum starting and remains in the circuit during starting. The starting capacitor C1 is disconnected when the motor approaches about 75% of synchronous speed. The motor then runs as a single-phase induction motor.

Explanation 2 marks

Characteristics

The starting winding and the capacitor can be designed for perfect 2-phase operation at any load. The motor then produces a constant torque and not a pulsating torque as in other single-phase motors.

Because of constant torque, the motor is vibration free and gives noiseless operation it can be used in: (a) hospitals (6) studios and (c) other places where silence is important.

6 e) Define fuse. State the necessity of fuse. Write rating of fuses used in the labs and classification of fuses.

Ans:

Fuse: a fuse is a short piece of metal, inserted in the circuit, which melts when excessive current flows through it and thus breaks the circuit. Definition 1 mark

Necessity of fuse:
It provides short circuit protection.
It provides overload protection.
Necessity of fuse 1 mark

Rating of fuses: 2 A, 3 A, 5 A, 6A, 10 A, 16 A .etc Rating 1 mark

Classification of fuse:
Low voltage fuses-
Semi-enclosed rewirable fuse
High rupturing capacity (HRC) cartridge fuse.
HRC fuse with tripping device
High voltage fuse-
Cartridge type fuse
Liquid type fuse
Metal clad fuse
Classification 1 mark

6 f) Explain why electrical equipment is earthed.

Ans:

Earthing is carried out for the safety of personnel operating on the equipment - if a person comes in contact with the body (frame) of the machine, under this faulty condition, the fault current flows through two paths, one will be through earth connection and other in parallel with the body resistance of the person touching the faulty machine. As earth resistance is very low as compared to body resistance, most of the current flows through the earth electrode and a very small amount of current flows through the body of the person. Thus a person can be protected against getting severe shock hazards. 2 marks

Earthing also secure equipment itself- When the body of the equipment is connected to earth through earth electrode and if a line to body fault takes place, very large current flows through this connection, which will blow of the fuse in the phase line circuit or operate the earth fault relay and causing tripping of the circuit breaker. 2 marks