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 should 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 the figure. 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 constant values 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 judgment 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		Attempt any TEN of the following.	2 X 10 = 20
1	a	Write definition & formula of power factor. Ans- Power factor:- It is the cosine of the angle between voltage and current, i.e.,p.f.= cosØ OR It is the ratio of resistance to impedance, i.e., p.f. = R/Z OR It is the ratio of active power to the Apparent power. i.e., Power factor, cos Ø = (Watts/VA) = (VIcos Ø)/VI.	01 mark Any one formula 01 mark
1	b	State any two disadvantages of low power factor in supply system. Ans- 1) Load current increase. 2) Large copper loss. 3) Poor voltage regulation. 4) Greater conductor size. 5) Large KVA rating. 6) Reduced power handling capacity.	Any two each 1 mark
1	c	Write formula of 3-phase power and relation between line voltage and phase voltage in 3-phase star connected system. Ans- 3-phase power is given by P= $\sqrt{3}\ V_L I_L \cos Ø = 3V_P I_P \cos Ø$. Relation between line voltage and phase voltage in 3-ph star connected system is given as $V_L = \sqrt{3} V_P$.	01 mark 01 mark
1	d	Define resonance in series R-L-C circuit and write the formula of resonance frequency. Ans- Resonance is the phenomenon in AC circuit in which circuit exhibits unity power factor or applied voltage and resulting current are in phase with each other. Resonance frequency $f_r = 1/[2\pi\sqrt{(LC)}]$	01 mark 01 mark
1	e	Define and write formula of **I)** Slip **II)** Synchronous speed Ans- I)Slip - The difference between synchronous speed Ns and actual speed N of rotor is known as slip. %Slip $S = [(NS - N)/N_S] \times 100$ II)Synchronous speed -Speed of rotating magnetic field in air gap is known as synchronous speed(Ns). Ns = (120f/P) RPM. Where, f = Supply frequency & P = No. of poles on stator.	½ marks for definition & ½ for formula Of each

1 f State the E.M.F equation of transformer and write meaning of each term in the formula.

Ans-

Induced emf in primary winding- $E_1 = 4.44\ f\ \emptyset_m\ N_1$ Volts — Equation 1mark &

Induced emf in secondary winding $E_2 = 4.44\ f\ \emptyset_m\ N_2$ Volts — 1mark for terms

Where, f = Supply frequency

$\emptyset_m$ = Maximum flux

N_1 & N_2 = No. of Turns on primary & Secondary

1 g State the Faraday's 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. — 01 mark

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. — 01 mark

$|e| \alpha$ (change in flux)/(time in which it occurs),

$= -N(d\emptyset/dt)$ Volts.(where e = emf induced, N = no. of turns, $d\emptyset/dt$ = rate of change of flux w.r.t time)

1 h List any two applications of

I) Stepper motor

II) Servo motor

Ans-

APPLICATIONS OF STEPPER MOTOR

1) Wall clocks
2) CD drive
3) Robotics
4) Printer
5) Scanners
6) CNC machine

Each application ½ mark, any 2 = 1 mark for each motor

APPLICATIONS OF SERVO MOTOR

1) CNC machine
2) Precision control
3) Process controller
4) Robotics
5) Sewing machine
6) Aeronautical Application
7) Conveying
8) Tachogenerator

1 i Define:

I) Minimum fusing current

II) Fusing factor

Ans-

I)Minimum fusing current:- It is the minimum current at which the fuse element melts and thus disconnects the circuit protected by it. 1 mark

II) Fusing factor:- it is the ratio of minimum fusing current to the current rating of the fuse element i.e. 01 mark

Fusing factor = (minimum fusing current)/(rated current).

1 j Write the full form of following
I)ELCB II) MCB III) MCCB IV) HRC (Fuse)

Ans-
I) ELCB – Earth Leakage Circuit Breaker ½ each = 02 marks
II) MCB – Miniature Circuit Breaker
III) MCCB – Molded Case Circuit Breaker
IV) HRC – High Rupturing Cartridge Fuse

1 k Define:
I)%regulation
II)%Efficiency of transformer and write formula for it.

Ans-

I) Regulation - The difference between No load voltage V_o and Full load voltage $V_{FL}$is known as regulation. 01 mark
%Regulation = $[(V_O - V_{FL})/ V_O] \times 100$.

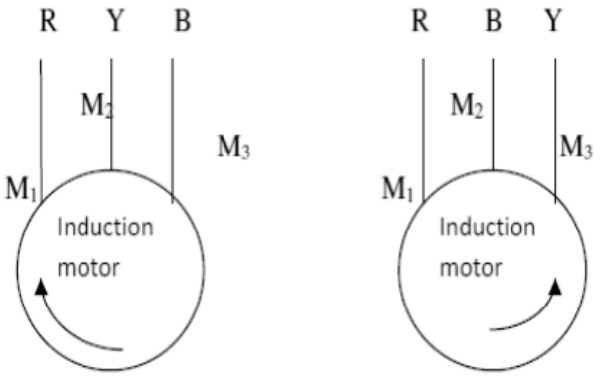
II) Efficiency- It is defined as the ratio of output power to the input power of the transformer.

%Efficiency = (output power/input power) x100

Or %Efficiency = [output power/(output power + losses)] x100 01 mark

1 l What will happen if transformer is connected to DC supply?
Ans-
When dc current is supplied to the transformer, the primary side will draw a steady current due to which a constant flux is generated. Hence no back emf is produced. 2 marks
Thus the primary side of the transformer which is a low resistance and zero reactance (X_L=0 due to f=0 Hz) primary side draws excessive current ultimately resulting in burning out of primary winding as the primary winding acts as a short circuit.

1 m How the direction of 3 phase induction motor can be changed?
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.

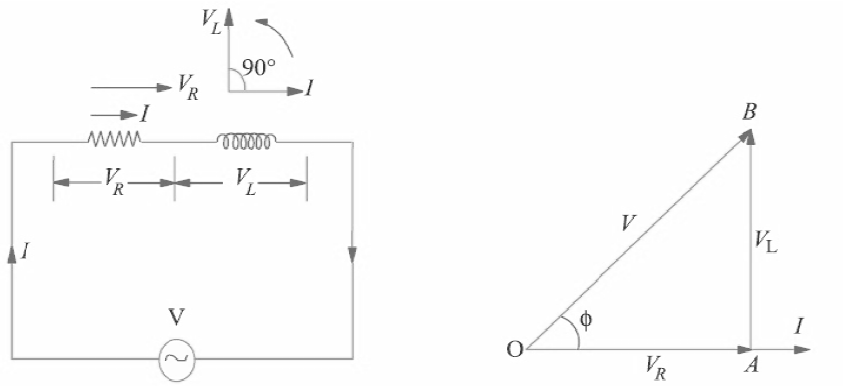


2 marks

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

1 n Draw only a Circuit diagram and phasor diagram of an ac R-L Series circuit.

Ans-



1 mark each = 2 marks

Circuit diagram & phasor diagram of R-L series circuit

2 Attempt any FOUR of the following. 4 X 4 = 16

2 a What are the effects of change in frequency on inductive and capacitive reactance? Also write the formula for X_L and X_C.

Ans-

When frequency increases inductive reactance increasesbecause $X_L \alpha f$ & capacitive reactance decreases as $X_C \alpha (1/f)$ and vice-versa. 2 mark

Formula :

$X_L = 2\pi fL\ \Omega$ 1 mark

$X_C = 1/(2\pi fC)\ \Omega$. 1 mark

2 b Why single phase motor is not self starting? How it is made self starting?

Ans-

It is necessary to produce RMF to make motor self starting, thus there should be at least two magnetic fields & they are shifted by 90^o w.r.t. each other in space. 2 marks

OR

The single-phase ac supply produces alternating flux but which is not revolving in nature. According to double field revolving theory, the flux has two components each equal to half of the alternating flux and each rotating synchronously in opposite direction to each other. These two oppositely revolving fluxes produces equal and opposite torques. Hence they produce no resulting torque at the starting.

Self starting methods -

The single-phase induction motor is not self- starting and it is necessary to mechanical spinning of the shaft or pulling a belt to start it. To make a single-phase induction motor self-starting, we should somehow produce a revolving stator magnetic field. This may be achieved by converting a single-phase supply into two-phase supply through the use of an additional winding. When the motor attains sufficient speed, the starting means (i.e., additional winding) may be removed depending upon the type of the motor. 2 marks

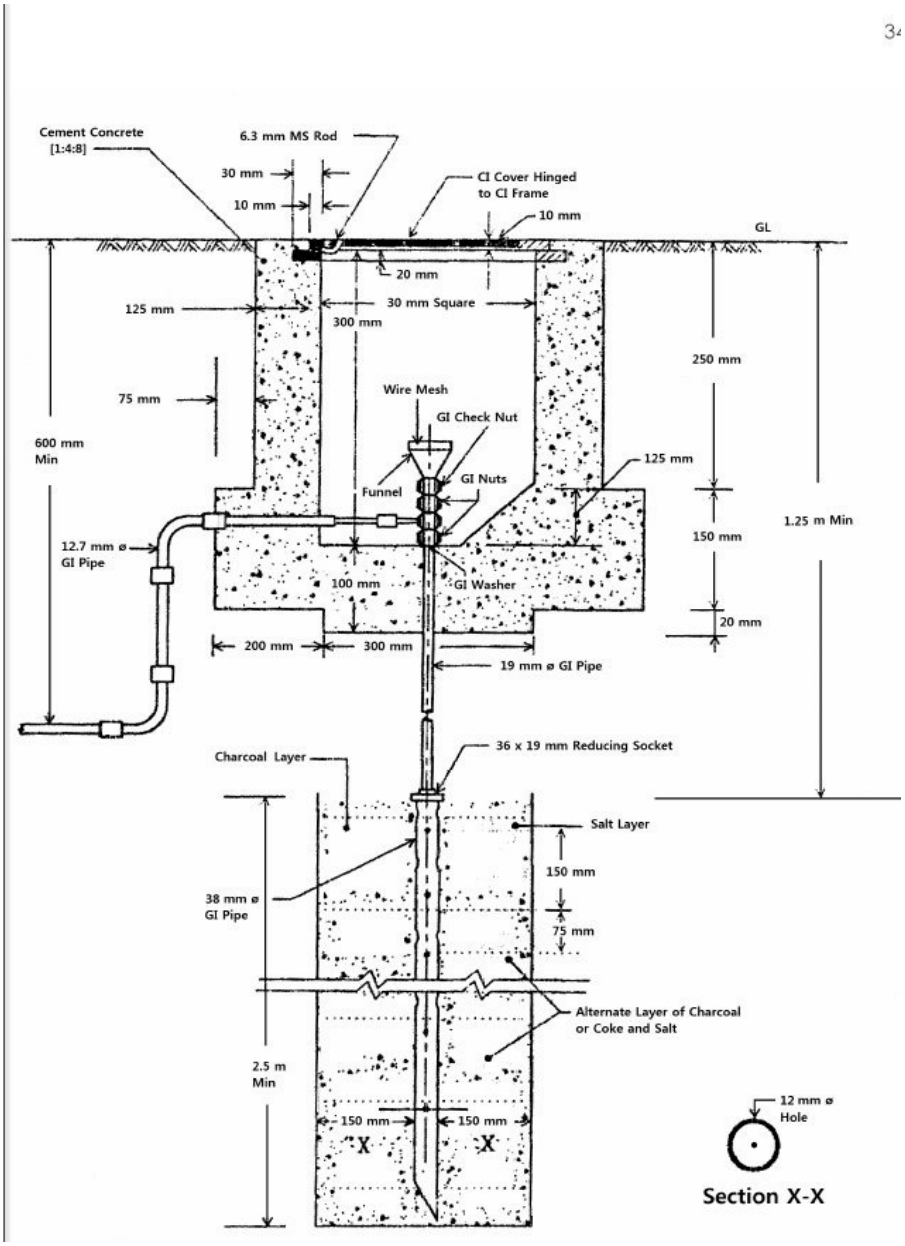
1. Split – phase Induction Motor
2. Capacitor – Start Mot
3. Permanent – Split Capacitor Motor
4. Capacitor - Start Capacitor – Run
5. Shaded Pole Induction Motor

2 c What is earthing? Draw only schematic diagram of pipe earthing.

Ans-

Earthing or grounding is circuitry which connects parts of the electric circuit with the ground. 1 marks

Schematic diagram of pipe earthing:-



Labeled diagram 3 marks

2 d Define:

i) Cycle
ii) Frequency
iii) Time period
iv) Amplitude of AC Voltage

Ans-

Cycle :One complete set of positive & negative values of alternating quantity is known as Cycle.

Frequency: The number cycles completed in one Second is called frequency of alternating quantity.

Time period: Time taken by an alternating quantity to complete one cycle is called its time period.

Amplitude: The maximum value, positive or negative of an alternating quantities known as Amplitude.

Each definition 01 mark

2 e Three Impedance each of 3-ohm resistance and 5-ohm reactance in series are connected in star across 50 Hz, 440 volt line voltage. Find
I)Impedance II)Phase current III)Power factor & IV)Total Power

Ans-

I)Impedance $Z_{ph} = \sqrt{(R^2 + X^2)} = \sqrt{(3^2 + 5^2)} = 5.83$ ohm — 01 mark

$V_{ph} = V_L / \sqrt{3} = 254$ V.

phase current = $V_{ph}/Z_{ph} = 254/5.83 = 43.57$ A — 01 mark

III) Power factor — 01 mark
cos Ø = R/Z = 3/5.83 = 0.514.

IV)Total Power $= \sqrt{3}\, V_L I_L \cos Ø = \sqrt{3} \times 440 \times 43.57 \times 0.514 = 17067.26$ watt — 01 mark

2 f Compare 3-phase Slip ring motor and squirrel cage motor based on following point
I) Construction and cost
II) Starting torque
III) Power factor and efficiency
IV) Methods of starting.

Ans-

Sr. No.	Parameters	Slip ring motor	Squirrel cage motor
1	Construction	Rotor made of windings of copper wires (Coils)	Rotor conductors are not wires they are made by bars of copper, Aluminum or Alloys.
	cost	More	Less
2	Starting torque	More	Less
3	Power factor	Poor	Better
	efficiency	Low	High
4	Methods of starting	Rotor resistance Starter	Stator Resistance starter, Autotransformer starter, Stare delta, DOL.

Each point carries 01 mark

3 Attempt any FOUR of the following. — 4 X 4 = 16

3 a Why the core of the transformer is laminated? Write only the names of losses in transformer and methods to reduce the losses.

Ans - — 01 mark

The core of transformer is laminated to reduce the eddy current loss.
There are two types of losses occurs in a transformer;
1) Core loss / Iron loss (Hysteresis and eddy current loss). — 01 mark
2) Copper loss.

Core losses can be reduce by using high permeability& low reluctance

magnetic material with laminated core and providing insulation between each lamination. 01 mark

Copper loss can be reducing by using high permittivity& low resistive conductor i.e. by reducing the values of primary and secondary winding resistance. 01 mark

3 b Write any two applications of

I) Pulse Transformer

II) Auto Transformer

III) Audio Transformer

IV) Intermediate frequency transformer

Ans-

I) Pulse Transformer- any two of each ½ mark for each application
a) For triggering circuit,
b) In radar
c) Particle accelerators
d) high energy pulse applications.

II) Auto Transformer-
a) As a dimmerstat
b) In electrical lab to get variable supply
c) interconnect systems operating at different voltage classes
d) voltage regulators
e) used to provide grounding on three-phase systems

III) Audio Transformer-
a) Tape recorder
b) Public Addressing (P.A) system,
c) Power Amplifier
d) impedance matching
e) audio amplifier circuits
f) isolated external connection for the loudspeakers

IV) Intermediate frequency transformer-
a) F.M.Circuit,
b) A.M. Circuit &
c) Communication Circuit
d) valve amplifiers

3 c List out the speed control methods for 3 phase Induction Motor. Explain any one with neat sketches.

Ans:
1) Pole changing method
2) Frequency Control method 02 mark
3) Stator voltage control Method
4) Rotor resistance method

5) Injected e.m.f. method

Pole changing method:

a) 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.

Explaination of any one method with diagram 02 marks

b) 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-

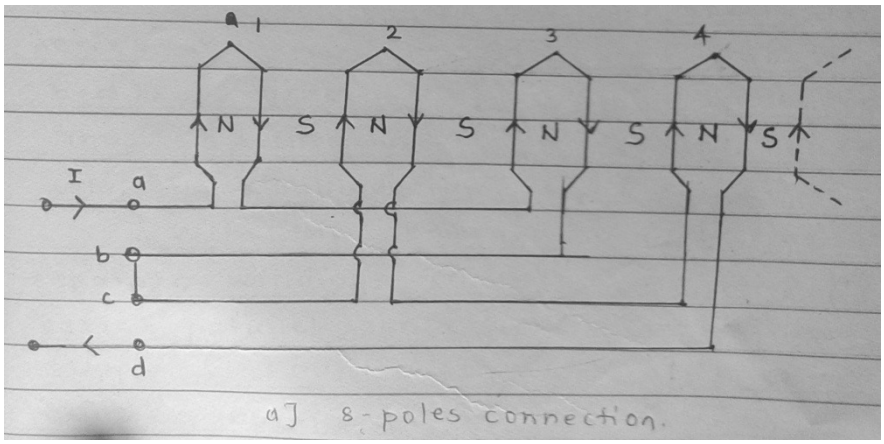


Fig (a)

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.

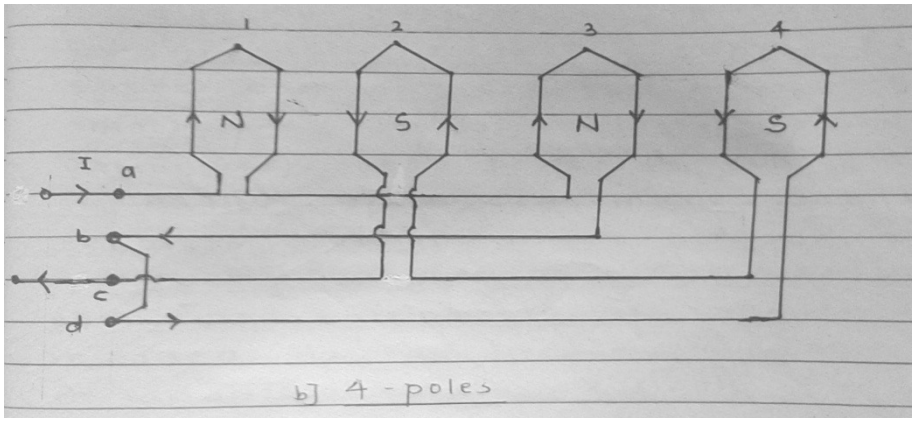
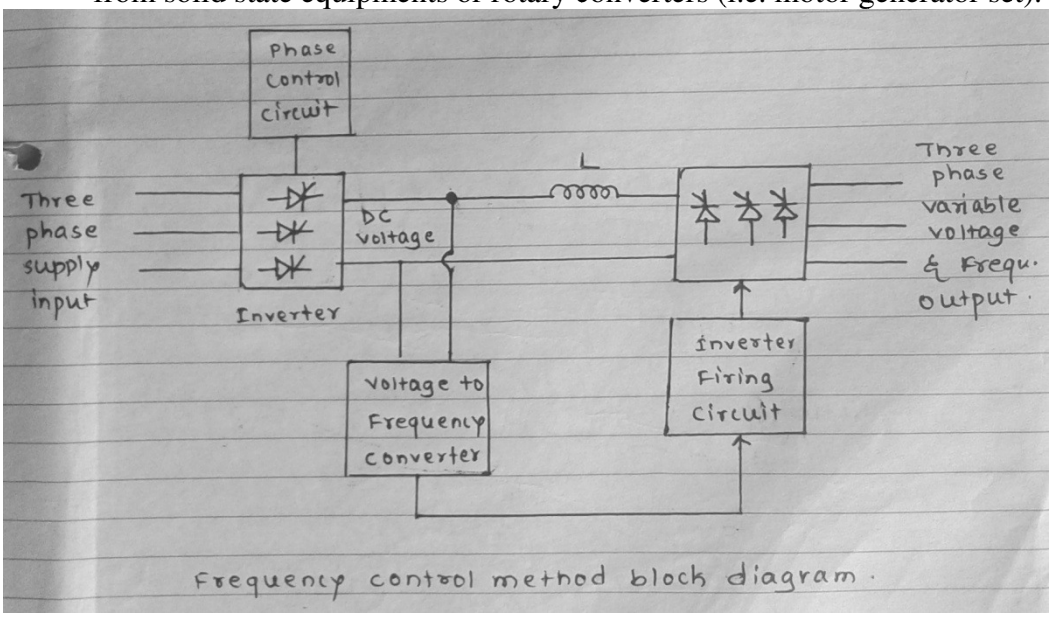


Fig.(b)

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).

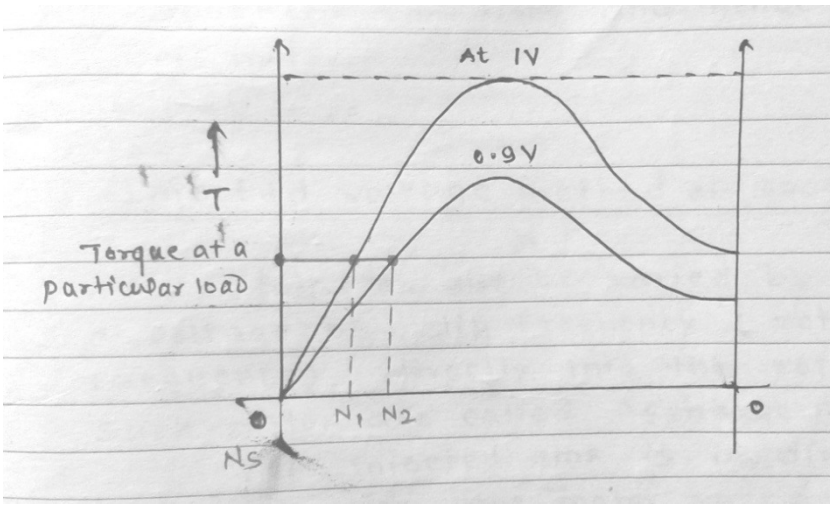


A basic block diagram of speed control of induction motor using variable frequency source is shown in above fig. Three phase supply at input is first converted into controlled DC. This DC voltage is applied to inverter circuit whose frequency is controlled by pulses from voltage to frequency controller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

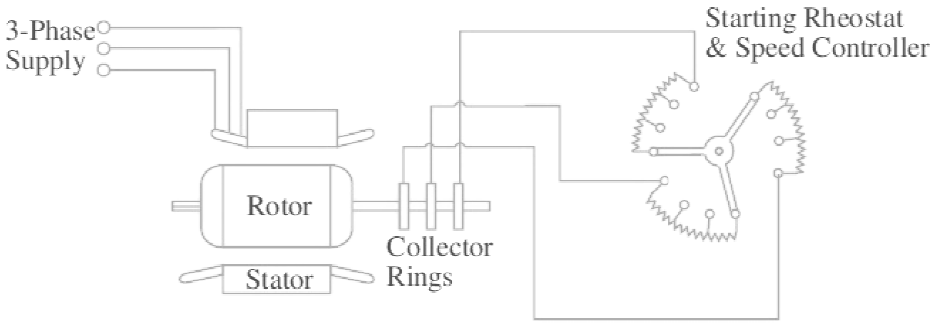


Since the torque is reduced to to 81%, the rotor starts rotating at speed N2, i.e. its speed will be reduced. This method of speed control is rarely used industrial three phase motors because of requirement of additional costly voltage changing equipment. A large change in voltage is required for a relatively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

3 d Draw neat sketch and write working principle of shaded pole single phase motor.

Ans:

Shaded pole motors:

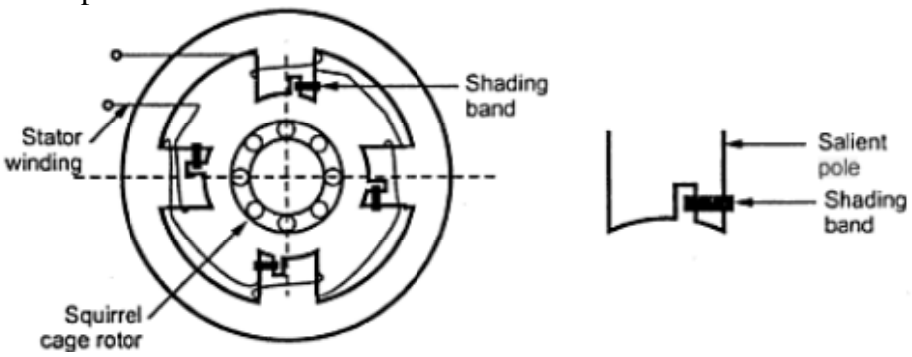


Diagram 02 mark

Shaded pole induction motor has squirrel cage rotor and salient pole stator. The stator poles are shaded partially by short circuited conductor band to create the phase difference between the fluxes emerging from shaded and un-shaded portion. These phase differing fluxes produce the required torque on the rotor for motion.

02 mark

3 e Compare Single phase and three phase system on the basis of following point ;

I) Output II) Efficiency

II) Cost IV) Power Factor

Ans :

Sr. No.	Parameter	Single Phase	Three Phase
1	Output	Less	more
2	Efficiency	Low	high
3	Cost	High cost	Low Cost (economical)
4	Power Factor	Lower	Greater

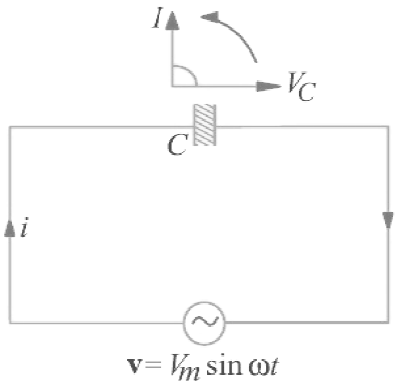
Each point carries 01 mark

3 f For a given equation of voltage and current in a circuit $v=V_m Sin\omega t$, $i= I_m Sin(\omega t + 90^0)$. State what type of circuit is it. Draw wave form of voltage, current and power in the circuit.

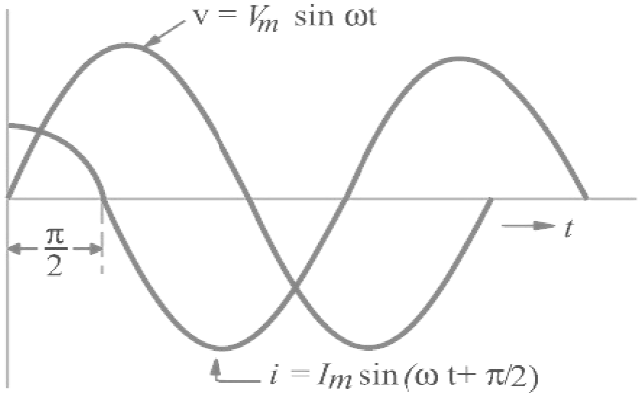
Solution:

For a given equation of voltage & current the type of circuit is Purely Capacitive circuit.

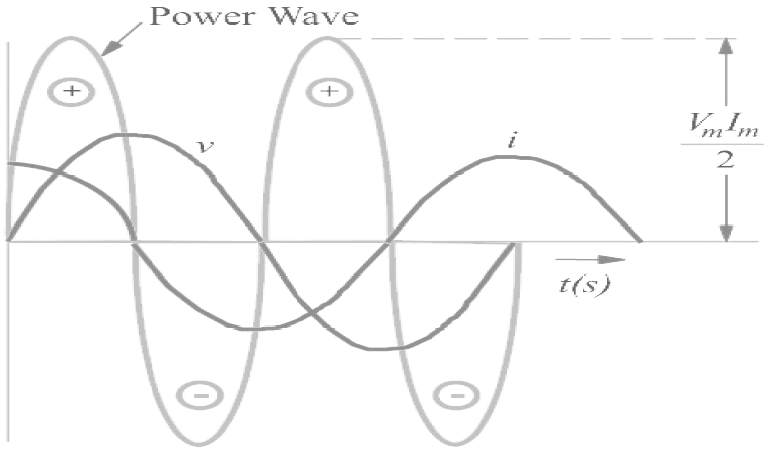
01 mark



Wave form for Voltage&Current - 01 mark



Power waveform -

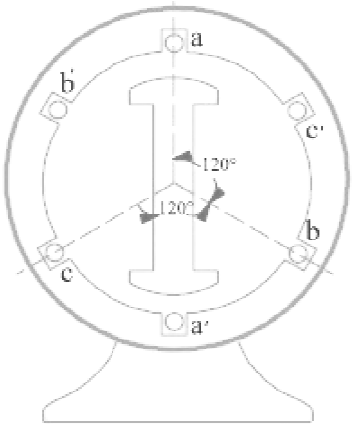


02 mark

4 Attempt any FOUR of the following. 4 X 4 = 16

4 a What is the principle of 3 phase E.M.F. generation? Draw its waveform.

Ans:

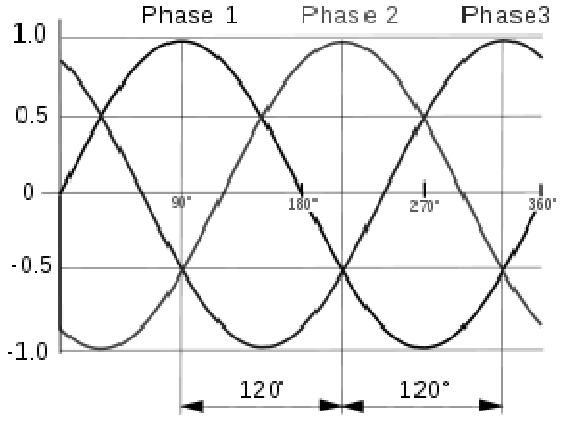


Two pole alternator

Principle of three phase EMF generation –

Above fig shows two pole stationary armature, rotating field type three phase alternator. It has three armature coils aa', bb' and cc' displaced 120^0 apart from one other. With the position and clockwise rotation of the poles as indicated in above fig it is found that the emf induced in conductor-a for coil aa' is maximum. The emf in conductor 'b' of coil bb' would be maximum when N-pole has turned through 120^0 i.e. N-S axis lies along bb'. It is clear that induced emf in conductor 'b' reaches its maximum value 120^0 later than that the maximum value in conductor 'a'. Similarly, the maximum emf induced in conductor 'c' would accurs 120^0 later than that in 'b' or 240^0 later than that in 'a'. 02 mark

Three phase waveforms-



02 mark

Three phase waveforms

4 b An alternating voltage is given as e =250sin314.16t then find ;

I) R.M.S. Value II) Maximum Value

II) Frequency IV)value of voltage at t=05ms

Solution:

I) R.M.S.=$E_m/\sqrt{2}$ =$250/\sqrt{2}$ =176.78V. 01 mark

II) Maximum value=Em = 250 V 01 mark

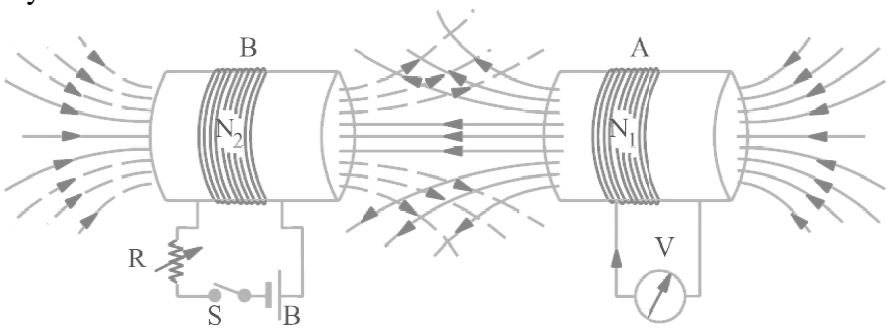
III) Frequency- $\omega = 2\pi f$
Therefore, $f = \omega/(2\pi) = 314.16/(2\pi) = 50Hz$ 01 mark

IV) value of voltage at t=05ms
$e = 250 \sin 314.06 \times 5 \times 10^{-3} V = 6.85$ Volts 01 mark

4 c Define dynamically induced EMF and explain principle of mutual induced EMF.

Ans-
Dynamically induced EMF:-
When a moving conductor placed in a uniform magnetic field, an e.m.f. is induced in a conductor which is called as dynamically induced e.m.f. 01 mark

Mutually induced emf:-



01 mark

Consider two coils A and B lying close to each other. Coil A joined to a battery, a switch and a variable resistance are whereas coil B is connected to a sensitive voltmeter V. When current through A is established by closing the switch, its magnetic field is set up which partially links with coil B. As current through A is changed, the flux linked with B is also changed. Hence, mutually induced emf is produced in coil B, whose magnitude is given by Faradays Law and direction by Lenz Law. 02 mark

4 d Define alternating current and write any three advantages of AC over DC voltage.

Ans-
Alternating current-
The wave form of current which changes its magnitude as well as its direction with respect to time is called as alternating current. 01 mark

Advantages of AC over DC voltage-

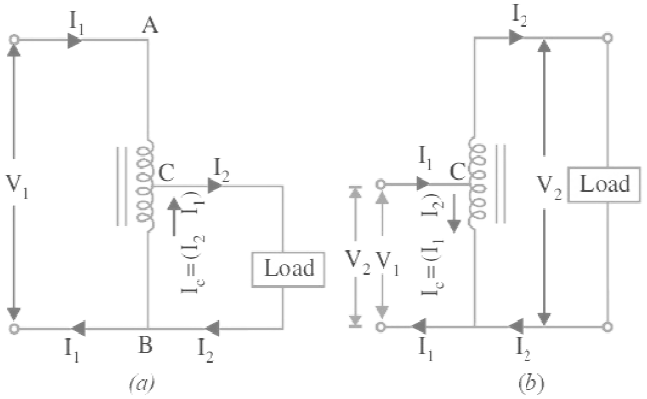
1) AC voltage can be step up or step down easily but DC Voltage cant step up or step down.
2) Generation of high voltage AC is easier than generation of DC.
3) Long Distance transmission is possible for AC system.
4) AC Power transmission is economical.
5) AC machines are simple in construction as compared to DC machines.
6) Maintenance of AC switchgear & protection system is less and easy.

Any three points each 01 mark = 03 mark

4 e What is auto transformer? Write any three applications of auto transformer.

Ans-

Auto transformer: It is a transformer with one winding only, part of this being common to both primary and secondary.



01 mark

Application of auto transformer:

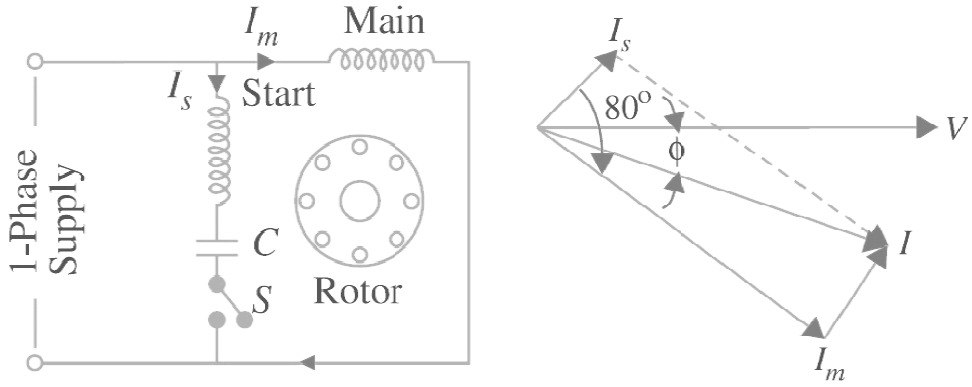
1) Large three-phase autotransformers are used in electric power distribution systems.
2) Auto transformers are used to get variable output.
3) Auto transformers are used as a dimmer stat.
4) Auto transformers are used as starters for motors.

1 mark each any 3 = 03 marks

4 f Draw only circuit diagram of a single phase capacitor start induction run motor. What is the use of centrifugal switch? And write any one application of it.

Ans-

Diagram of capacitor start induction run motor-



02 mark

Use of centrifugal switch –

Centrifugal switch is used to disconnect the series combination of staring winding (Auxiliary winding) and capacitor from the main winding and supply as soon as the motor achieves 75% of its rated speed.

01 mark

Applications-

1) Fans and blowers
2) Centrifugal pumps

3) Separators
4) Washing machines
5) Small machine tools
6) Duplicating machines
7) Refrigerators
8)

Any one 01 mark

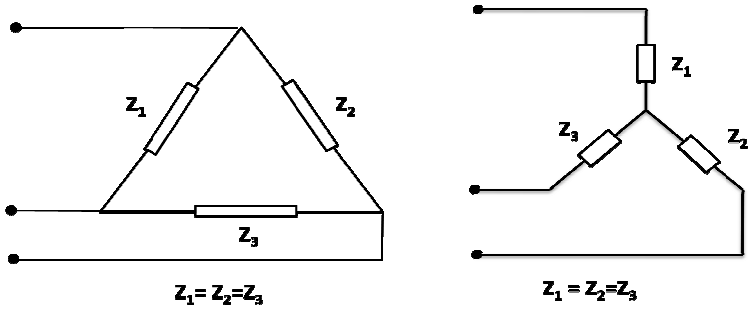
5 Attempt any FOUR of the following. 4 X 4 = 16

5 a What is meant by a three phase balanced load and unbalanced load.

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)

01 mark for definition



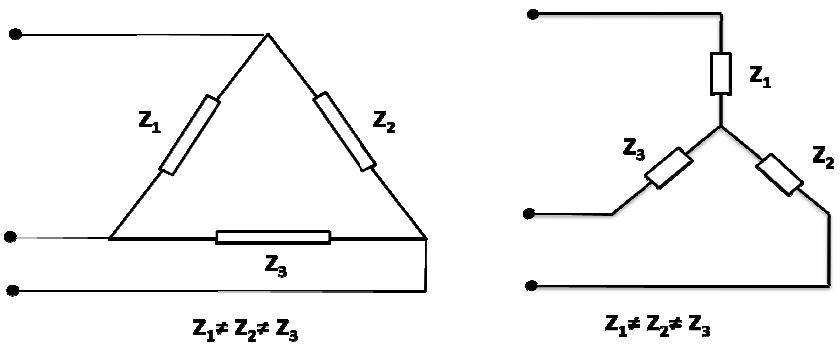
01 mark for diagram

Star or delta connected balanced loads
(or equivalent diagram)

Unbalanced load:

If any one or more than one phase impedances of three phase load are different in respect of Magnitude and their nature, it is said to be a unbalanced three phase load. i.e. magnitude of voltages and resulting currents are also different & do not posses same phase angles (they are not displaced with each other by 120^0)

01 mark for definition



01 mark for diagram

Star or delta connected unbalanced loads
(or equivalent diagram)

5 b Define following terms as related to AC supplies

i) Form factor
ii) Peak factor
iii) Q-factor
iv) Impedance

Solution:

i) Form factor : It is defined as the ratio of RMS value to the Average value of an alternating quantity.

ii) Peak Factor: It is defined as the ratio of Maximum value to the RMS value of an alternating quantity.

iii) Q-factor : It is defined as the ratio of maximum energy stored to the energy dissipated per cycle.

In mathematical form,

Q – factor = 2π(max. energy stored per cycle)/(energy dissipated per cycle)

or

Voltage magnification in series resonant circuit is also known as Quality factor.

= (voltage across L or C)/(supply voltage)

iv) Impedance: It is defined as the combined effect offered by resistance, inductance & capacitance to current in an AC circuit. It is denoted by Z and is measured in Ohm (Ω).

Each definition 1 mark

5 c Write any four factors upon which an inductance of a coil depends.

We have,

$L = N\Phi/I = (N^2 A\mu) / l$ henry

Thus Inductance depends on-

i) N= no. of turns of coil
ii) Φ = flux produced in web.
iii) I= Current flowing through coil in ampere.
iv) μr= relative permeability of core material
v) l= length of the coil
vi) A= cross-sectional area of conductor.

Each parameter caries 1 mark

equations not compulsory

5 d Write the property of ideal transformer and also write the formula for transformation ratio.

Properties of ideal transformer:

i) Ideal transformer has no copper losses i.e. its windings have no ohmic resistance.
ii) There is no magnetic leakage.
iii) It has no core losses.
iv) Ideal transformer consists two purely inductive coils wound on a loss

Students should write any 4 properties

free core. each carries
v) Ideal transformer has 100% efficiency. ½ mark
vi) Ideal transformer has 0 % regulation.

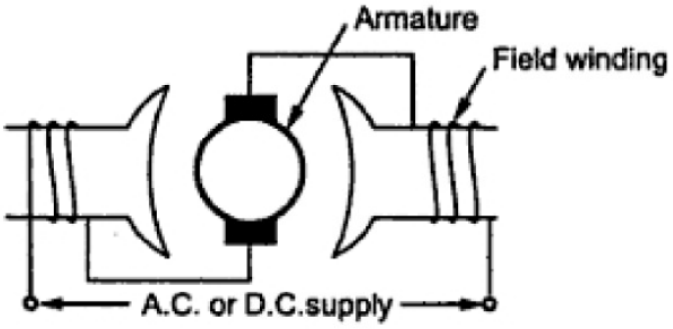
Transformation ratio (K)-
$= E_1/E_2 = N_1/N_2$ Equation 1 mark

Where,
E1 = rms value of induced emf in primary winding.
E2 = rms value of induced emf in primary winding. Terms 1 mark
N1=No. of turns in primary.
N2 = No. of turns in secondary.

5 e Explain with neat sketch working principle of universal motor.

Universal Motor-

Neat labeled diagram 2 marks



Working-
A universal motor is defined as the motor which may be operated either DC or single phase AC supply at approximately same speed and output.Such motors develop unidirectional torque, regardless whether they operate on AC or DC supply. Its action is based on the principle that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force whose magnitude is given by, Working principle 2 marks

F= BIL Newtons.

i.e. force is exerted between main pole flux and the current carrying armature conductors.

5 f Compare series and parallel resonance circuits (any four points)

ameter	Series resonant circuit	Parallel resonant circuit
Resonating frequency	$f_O = 1/(2\pi\sqrt{LC})$ Hz	$f_O = 1/(2\pi)\{\sqrt{[1/(LC)) - R^2/L^2]}\}$ Hz
Impedance	Minimum Z=R ohms	Maximum $Z_D = L/(RC)$ ohms
Current	Maximum $I_O = V/R$ amp	Minimum $I_O = V/(L/CR)$

Any four correct points expected

Magnification	voltage magnification	Current magnification
Power factor	Unity	Unity
Q-factor	(1/R) √(L/C)	(1/R) √(L/C)
Nature of circuit	Resistive circuit	Resistive circuit
Type of circuit	Accepter Circuit	Rejecter Circuit

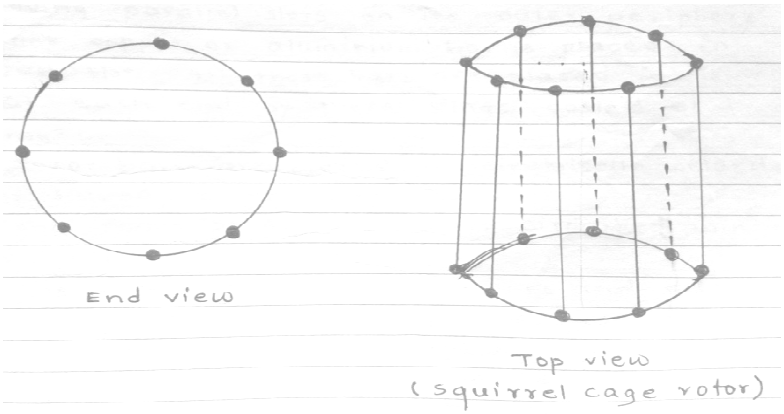
each carries 1 mark

6 Attempt any FOUR of the following. 4 X 4 = 16

6 a Explain in brief the construction and working principle of 3-phase induction motor.

construction-

1) Squirrel cage Induction motor-



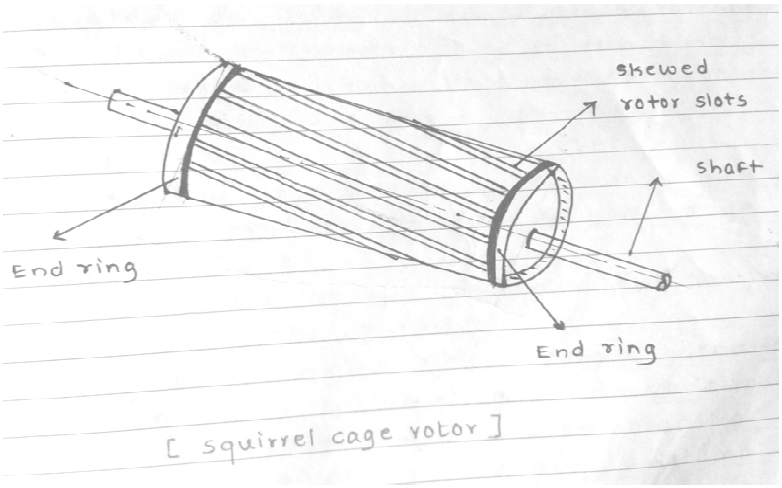


Diagram 1 mark

- It consist laminated cylindrical core having parallel slots on its outer periphery.
- One copper or aluminum bar is placed in each slot. All the bars are joined at each end by metal rings called end rings.
- Rotor bars are brazed or electrically welded or bolted to the end rings.
- This forms permanently short circuited winding which is non-breakable.

Explanation 1 mark

- The rotor slots are not parallel to the shaft but they are skewed at certain angle with the shaft.

Or

2) Slip ring Induction motor-

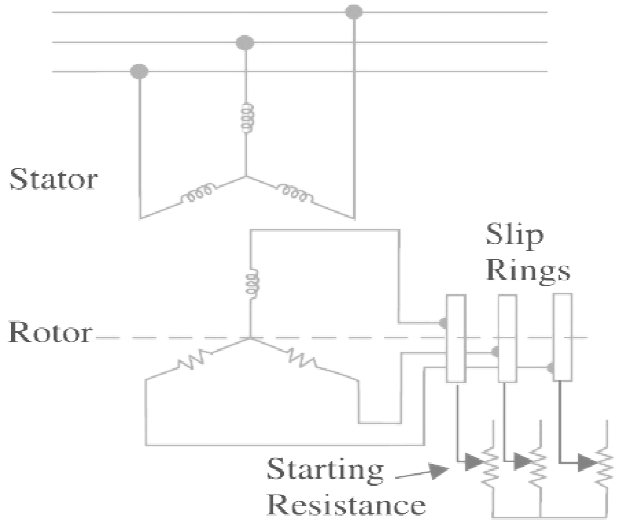


Diagram 1 mark

- It consist laminated cylindrical core and it carries three phase windings.
- The rotor winding may be single layer or double layer.
- The rotor winding is uniformly distributed in slots and it is always star connected.
- Rotor is wound for same number of poles as that of the stator winding.
- Three phases of rotor winding is are shorted internally to form star point and other three winding terminals are brought out and joined to three insulated slip rings mounted on the rotor shaft.
- One brush is resting on each slip ring. These three brushes are further externally connected to three phase star connected rheostat.

Explanation 1 mark

Working-

When 3-Ph AC supply is given to stator, rotating magnetic flux is produced in air gap. It has constant magnitude & constant speed called as 'synchronous speed, (Ns=120 f/P). When the flux rotates over rotor conductors changing flux (*dØ/dt)* is created & emf is induced in rotor conductor according to faradays laws of electromagnetic induction. As rotor is short circuited, current flows through it. Interaction of rotor current and rotating magnetic field produces torque on rotor and it starts rotating.

According to 'Lenz Law' the rotor current should oppose the cause which produces it. Here the cause is relative speed between flux & rotor therefore to minimize the relative speed rotor starts rotating in the direction of flux.

02 marks

6 b Write the symbol and unit of following.

i) Magnetic flux density
ii) Magnetic field strength
iii) Reluctance
iv) Coefficient of self inductance

Each correct symbol and unit carries 1 mark

Sr.No.	Term	Symbol	Unit
i	Magnetic flux density	B	Tesla or Web/m^2
ii	Magnetic field strength	H	AT/m
iii	Reluctance	S	AT/Wb
iv	Coefficient of self inductance	L	Web-Turns/Amp

6 c Draw neat sketch and write working principle of direct on-line starter for small squirrel cage induction motor.

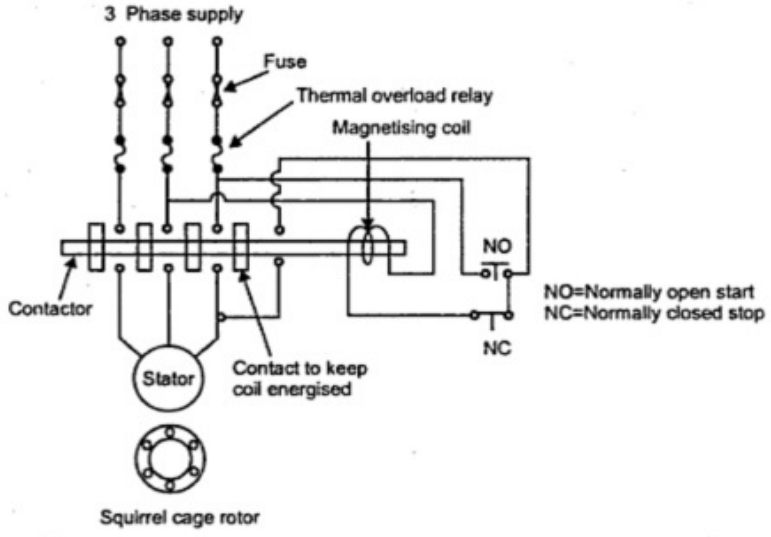


Diagram 02 marks

In case of small capacity motors having rating less than 5 h.p., the starting current is not very high and such motors can withstand such starting current without any starter. Thus there is no need to reduce applied voltage, to control the starting current. Such motors use a type of starter which is used to connect stator directly to the supply lines without any reduction in voltage. Hence the starter is known as direct on line starter.

Though this starter does not reduce the applied voltage, it is used because it protects the motor from various severe abnormal conditions like over loading, low voltage, single phasing etc.

Above Fig. shows the arrangement of various components in direct on line starter. The NO contact is normally open and NC is normally closed. At start, NO is pushed for fraction of second due to which coil gets energized and attracts the contactor. So stator directly gets supply. The additional contact provided, ensures that as long as supply is ON, the coil gets supply and keeps contactor in

Explanation 02 marks

ON position. When NC is pressed, the coil circuit gets opened due to which coil gets de-energized and motor gets switched OFF from the supply.

Under over load condition, current drawn by the motor increases due to which is an excessive heat produced, which increases temperature beyond limit. Thermal relays get opened due to high temperature, protecting the motor from overload conditions.

6 d Write any four applications of
i) 3-phase slip ring induction motor
ii) Squirrel cage induction motor

Any four applications each application carries ½ marks = 2 marks

i) 3-phase slip ring induction motor applications-
a) Lifts
b) Cranes
c) Hoists
d) Elevators
e) Centrifugal pumps
f) Rolling mills
g) Propulsion of ships
h) Winding machines

ii) Squirrel cage induction motor
a) Water Pumps
b) Tube well
c) Lathes Machine
d) Line shaft
e) Grinders
f) Polishers
g) Wood Planners / wood cutting equipments
h) Compressors
i) Laundry washing machines
j) Fans
k) Blowers
l) Various types of presses
m) Cement & textile mills
n)

6 e Define active, reactive and apparent power in AC circuit. Write the unit of each power and draw the power triangle for an inductive load.

Ans-
Active Power (P):
The average power drawn by the AC circuit is called as Active power.
Or
It is the power which is actually dissipated in the circuit resistance.
It is given by, $P = VI \cos \phi$ watts (or kilowatts).

01 mark

Reactive Power (Q):
Power drawn by the circuit due to reactive component (ISin Ø) is called as reactive power. 01 mark

Or

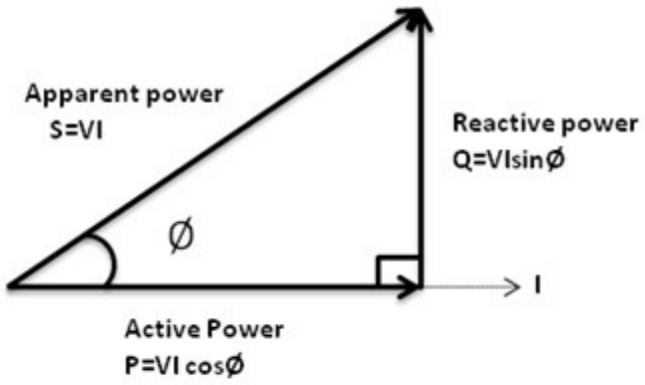
It is the power developed in the inductive reactance or capacitive reactance of the circuit.

It is given by, Q = VI Sin Ø VAR (or kVAR).

Apparent Power (S):
It is defined as the product of r.m.s. values of voltage and current, called apparent power. 01 mark

It is given by, S = V x I VA (or kVA).

Power triangle for inductive load:



Neat labeled power diagram 01 mark

6 f Write two general precautions while using electrical energy. Define lagging power factor and leading power factor.

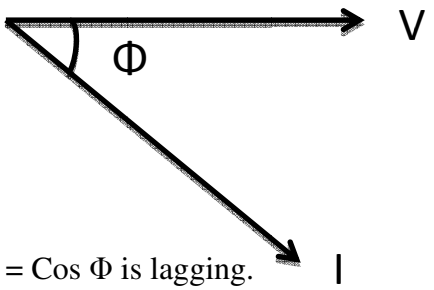
Precautions while using electrical energy-

1) Make all connections tight.
2) Do not leave loose wires.
3) Do not touch live terminals or any open wires in the circuit.
4) Use suitable wire types and sizes while wiring up of electrical circuit.
5) During maintenance work, switch off the supply mains and disconnect the fuse unit.
6) Use insulated hand glows while working with live terminals, electrical apparatus or machine.
7) Understand the equipment to be tested and apparatus to be used from the user point of view before working on it.
8) While working above the ground level, ladder should be hold firmly by subordinate.

Any two precautions or equivalent Each carries 1 marks

Lagging power factor:
If the load current lags the load voltage, which implies lagging power factor and 01 mark

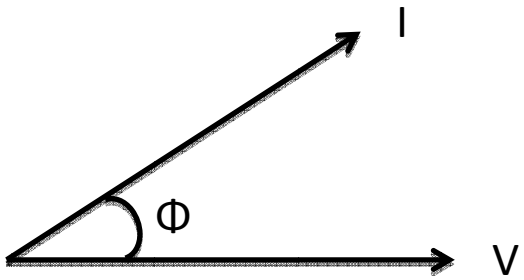
the load in this case is inductive in nature.



Power factor = Cos Φ is lagging.

Leading power factor:
If the load current leads the load voltage, which implies leading power factor and the load in this case is capacitive in nature.

01 mark



Power factor = Cos Φ is leading.