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 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: 12

1 a) i) Define RMS value of alternating current:

Ans:

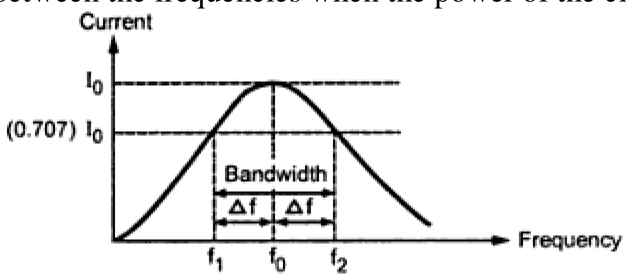
The RMS value of an AC is equal to the steady state or DC that is required to produce the same amount of heat as produced by AC provided that the resistance and time for which these currents flow are identical. 1 mark

$I_{rms} = 0.707\ I_{max.}$ 1 mark

1 a) ii) Define bandwidth of series resonant circuit and state expression for it.

Ans:

It is defined as the width of the resonance curve referred to frequency axis between the frequencies when the power of the circuit is half of the maximum. 1 mark



f_1 and f_2 are half power frequencies. Resonant frequency $f_0 = \sqrt{(f_1 f_2)}$.

Bandwidth = $(f_2 - f_1)$ Hz = $R/(2\pi L)$ 1 mark

1 a) iii) Explain the purpose of four wires in three phase four wire option.

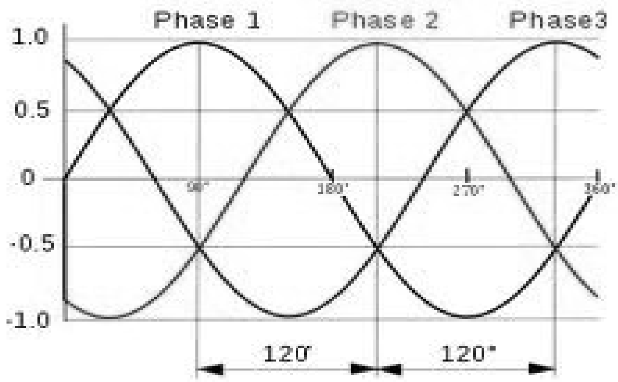
Ans:

The fourth wire is the neutral wire and three are phase wires. 1 mark

- To provide supply connections to single phase loads (phase & neutral)
- To provide supply connections to three phase star connected loads which require neutral connection. 1 mark

1 a) iv) Draw voltage waveform of three phase ac supply w.r.t time.

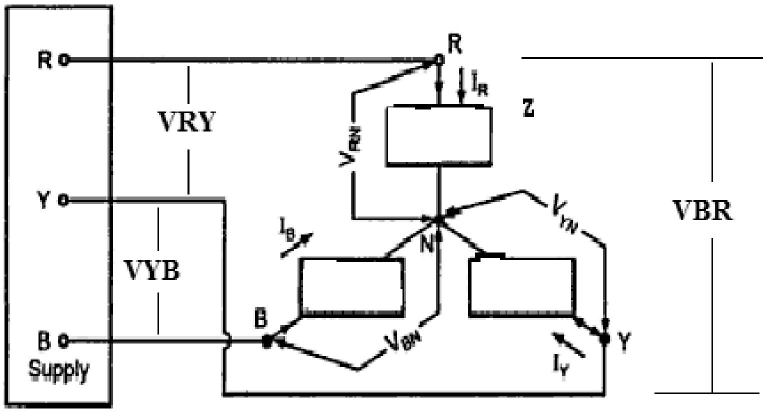
Ans:



Labeled 2 marks
Partially labeled 1 mark.

1 a) v) Draw star connected three phase load and show line and phase voltage.

Ans:



Labeled 2 marks, partially labeled 1 mark

PHASE VOLTAGES: V_{RN}, V_{YN} & V_{BN}; LINE VOLTAGES: V_{RY}, V_{YB} & V_{BR}.

1 a) vi) State any two methods for reducing starting current of induction motor.

Ans:

Any two 1 mark each = 2 marks.

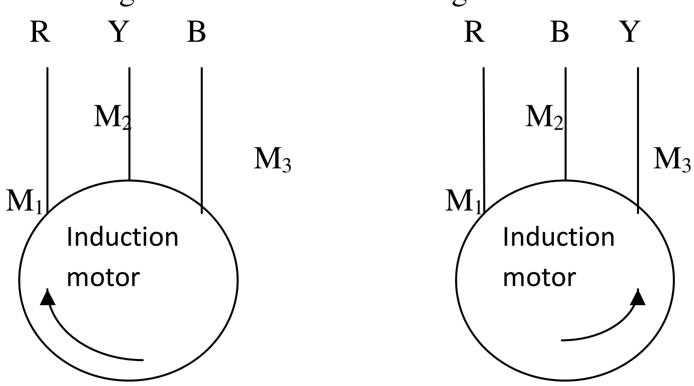
- Reduced voltage starting:
  1) Stator resistance starting (series resistance in stator circuit supply).
  2) Autotransformer starter (stator supplied through autotransformer).
  3) Star delta starting (stator winding connected in star first and then in delta).

- Rotor circuit control:
  1) Rotor circuit resistance varied from max to minimum during starting period to limit starting current. (rotor resistance starter).

1 a) vii) For reversing direction of rotation of rotor of induction motor, what changes has to be done in supply system?

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. 1 mark



1 mark

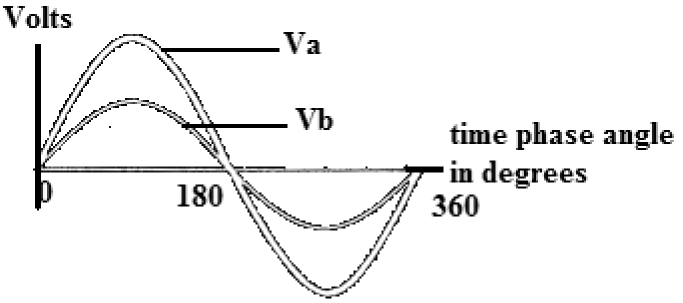
M_1, M_2, M_3 are the stator three winding terminals of the motor to be connected to the supply lines.

1 a) viii) State four types of wires used for wiring of an electrical installation. ½ mark each

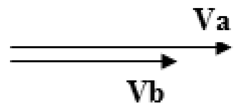
Ans: — any four = 2 marks.
VIR, CTS or TRS, PVC, Flexible, lead alloy sheathed wires, weather proof wires.

1 b) Attempt any two: — 8 marks

1 b) i) Explain meaning of in phase voltages and out of phase voltages with the help of waveform and phasor diagrams.
Ans:
In phase voltages: two alternating voltages are said to be in phase if the phase difference between them is zero as shown in figure.

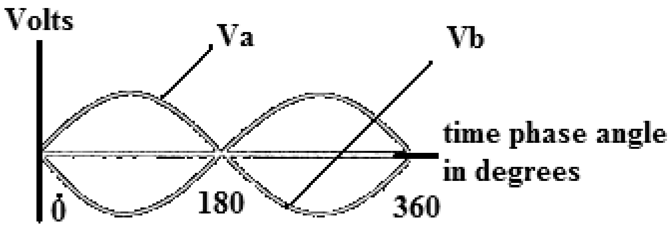


1 mark



1 mark

Out of phase voltages: two alternating voltages are said to be out of phase if the phase difference between them is 180^0 or π radians as shown in figure.



1 mark

1 mark

1 b) ii) State the Faraday's laws of electromagnetic induction and give the expressions for induced EMF with the meaning of each term.
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. — 1 mark

Faraday's second law of electromagnetic induction:

The magnitude of EMF induced in the coil depends on rate of change of flux — 1 mark linking with coil.

|e| α (change in flux)/(time in which it occurs),

‘e’ = -NdØ/dt. (V) 1 mark

(where e = emf induced, N = no. of turns, dØ/dt = rate of change of flux w.r.t time) 1 mark

1 b) iii) State the types of single phase induction motor. Explain working of any one with neat sketch.
Ans:

Types of single phase induction motors:- Types = 2 marks

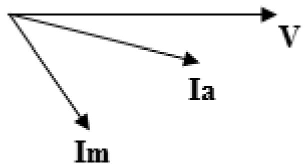
(1) Resistance Split-Phase motors:

(2) Capacitor Split-Phase motors - (i) Capacitor start motors, (ii) Permanent split or Single value capacitor motors and (iii) Capacitor start and run or Two value capacitor motors

(3) Shaded pole motors

Split phasing in motors (common to all motors):

Split phasing arrangement is done by making the currents in the main (running) winding and auxiliary (starting) winding differ in phase by some angle (sometimes as near as possible as near as possible to 90^o) which create fluxes accordingly in the air gap to get the required torque for rotation. 2 marks for working of any one type.



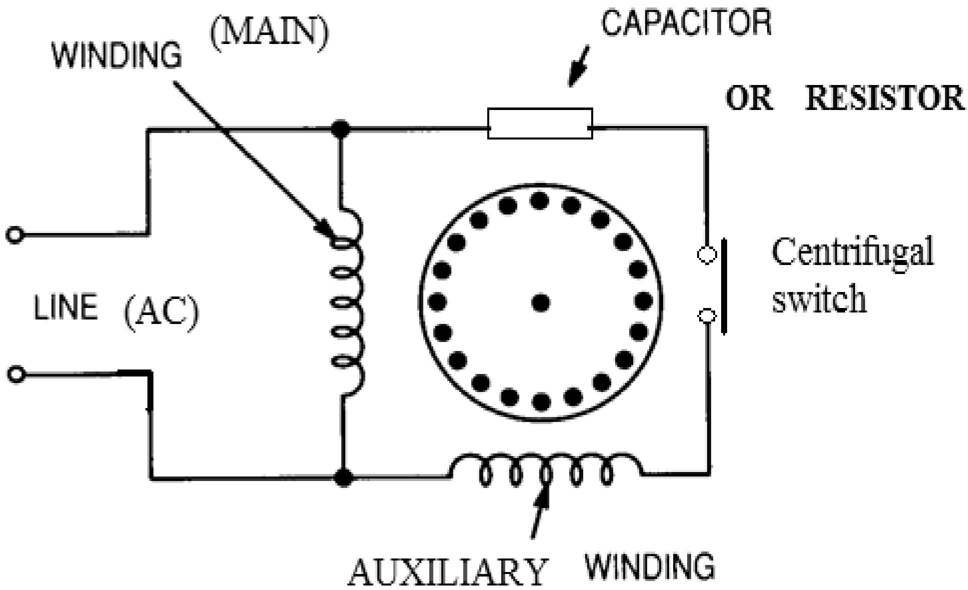
V = applied voltage, Ia = current in auxiliary and Im = current in main winding. The fluxes are produced by these currents.

Capacitor motors:

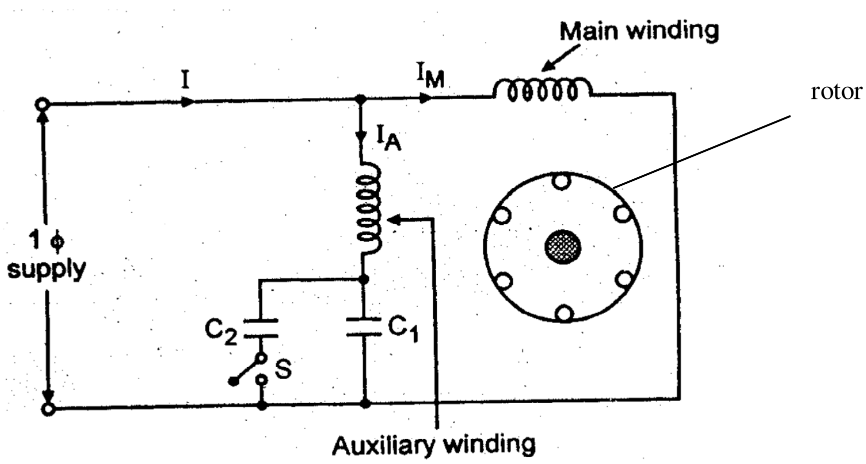
- Have arrangement in the form of two windings placed with axes 90^0 apart in the stator.
- Single phase supply given to these windings results in phase diff. in the currents in these two windings due to the different impedances of the winding circuits. (split phasing arrangement)
- Resistance or capacitance is added in series to one of the coils (called as starting or auxiliary coil) to create the two currents that result in proportional

magnetic fluxes with time phase difference (space phase is already created due to the winding/coil axes relative position) in the air gap resulting in the required starting torque in the required direction. The other coil is called as the main winding.

- The centrifugal switch is used to disconnect the starting winding once the motor picks up speed after which the motor continues to run.
- Example as given below.



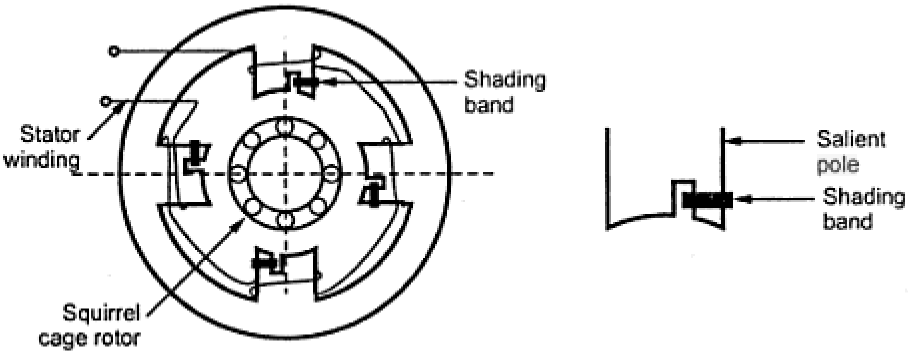
Working of capacitor start capacitor run induction motor:



The fluxes produced by the main and auxiliary (starting) windings create the torque in the air gap on the rotor by their interaction (with the switch S in closed condition); when the total capacitance is (C_1+C_2) at start. Due to the high capacitance in the auxiliary winding branch the current I_A has large phase difference (near about 75^o to 85^o with respect to main winding current I_M which produces a larger starting torque and hence the motor is used where higher starting torque is needed.

Once the motor picks up speed near about 70% to 85% of rated the switch (normally centrifugal type) opens to reduce the capacitance in the auxiliary circuit to C_1. The motor continues to run with a better running power factor due to C_1.

Shaded pole motors:
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.

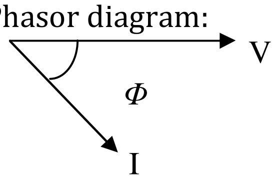


2 Attempt any four. 16 marks

2 a) Consider RL series circuit connected across an alternating voltage $v = V_m \sin\omega t$, write expression for instantaneous current, phasor diagram, voltage triangle and power consumed.

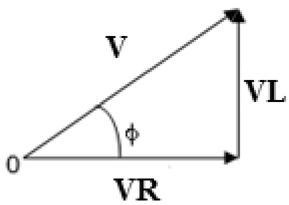
Ans:

1) Instantaneous current $i = I_m \sin(\omega t\text{-}\Phi)$, where $I_m = V_m/R$, $\Phi = \tan^{-1}(\omega L/R)$. 1 mark
2)
3) Phasor diagram:



1 mark

4) Voltage triangle:

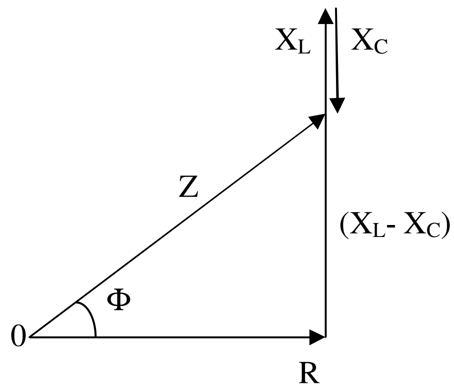


1 mark

5) Power consumed = VI cosΦ = $[(V_m I_m)/2]$ cosΦ. 1 mark

2 b) Explain the concept of impedance and impedance triangle:
Ans:

Impedance:
It is the combined effect of resistance R and reactance X ($= X_L - X_C$) in ac circuits. 2 marks
$Z = \sqrt{[(R^2 + (X_L - X_C)^2)]}$ ohms.

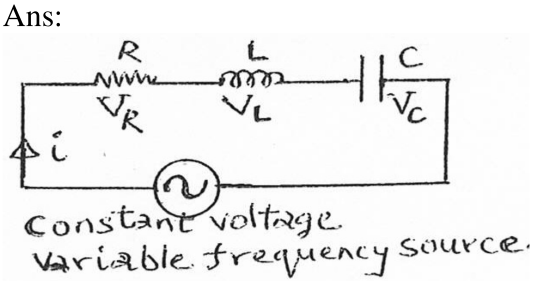


2 marks

2 c) State different types of power in ac circuits. Write the expressions and units for the same.
Ans:
1) Active power: $P = VI \cos\phi$. (W) 1 mark
2) Reactive power: $Q = VI \sin \phi$. (VAR) 1 mark
3) Apparent power: $S = V I$. (VA) 1 mark

(where V and I are RMS values of voltage and current respectively, ϕ = phase angle between them. 1 mark

2 d) Explain meaning of resonance in series RLC circuit; derive expression of resonant frequency in RLC series circuit.
Ans:



As the frequency is increased from zero towards higher values at a certain frequency f_O, $X_L = X_C$ and the net reactance of the circuit becomes zero. This is resonance condition. At resonance the voltages across the inductive reactance and capacitive reactance (X_L and X_C) are equal and opposite in phase. 1 mark

V_L = - V_C and hence $V_L + V_C = 0$, (phasor addition).

Also $Z = \surd[R^2+(X_L - X_C)^2]$ and $V = \surd[V_R^2+(V_L - V_C)^2]$, give $V = V_R$. 1 mark

Hence the supply voltage applied is across the resistance R, $V = V_R$.
The impedance is minimum at resonance.
Current is max. = $I_O = V/R$. And is in phase with applied voltage. 1 mark

As $X_L = X_C$, we have $2\pi f_O L = 1/(2\pi f_O C)$ which gives us
$f_O = 1/[2\pi\surd(LC)]$. (Where L = coefficient of inductance in henry, and C = Capacitance in farads). 1 mark

2 e) Explain three phase balanced load and unbalanced load.

Ans:

Three phase balanced load: All the three impedances in the phases are equal in magnitude and have identical phase angles. 2 marks

Three phase un-balanced load: All the three impedances in the phases are not identical in all respects. 2 marks.

2 f) Compare two winding transformer with auto transformer:

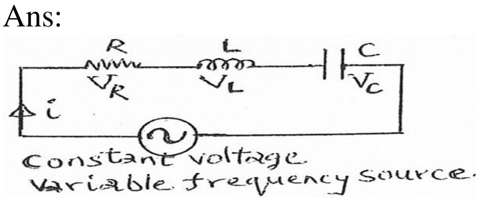
Sr. No	Two winding transformer	Auto transformer
1	Different primary & secondary winding	primary & secondary on common winding
2	No electrical connection between primary and secondary	Electrical connection between primary and secondary
3	Amount of copper required and weight is more	Amount of copper required 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

1 mark each any four points = 4 marks

3 Attempt any four: 16 marks

3 a) Define and explain the meaning of Q factor and give mathematical expression for Q factor in RLC series circuit.

Ans:



Q factor: referred as quality factor; it is the voltage magnification in the circuit at resonance; (at resonance $V_L = V_C$). the Q factor signifies the selectivity or sharpness of tuning circuit — 2 marks

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

$= (\omega L)/R = (1/R)\sqrt{(L/C)}$ [as $\omega = 1/(\sqrt{(LC)})$]. — 2 marks

3 b) $v = 140 \sin 314t$,
$i = 3 \sin(314t-\pi/2)$.

$V_{RMS} = V_M/\sqrt{2} = 140/\sqrt{2} = 99$ V.
$I_{RMS} = I_M/\sqrt{2} = 3/\sqrt{2} = 2.12$ A. — 1 mark

$V_{AVG} = 0.637 \times V_M = 0.637 \times 140 = 89.18$ V.
$I_{AVG} = 0.637 \times I_M = 0.637 \times 3 = 1.91$ A. — 1 mark

PF = $\cos(\pi/2) = 0$. — 1 mark

PF = 0 lag — 1 mark

3 c) $X_L = 2\pi fL = 2 \times \pi \times 50 \times 0.4 = 125.68$ ohms.

$X_C = 1/(2\pi fC) = 1/(2 \times \pi \times 50 \times 125 \times 10^{-6}) = 25.46$ ohms.

$Z = \sqrt{[R^2 + (X_L - X_C)^2]} = \sqrt{[25^2 + (125.68 - 25.46)^2]} = 103.29$ ohms. — 1 mark

PF = R/Z = 25/(103.29) = 0.242 lag. — 1 mark

I = V/Z = 230/103.29 = 2.226 A.

$P_{active} = VI\cos\Phi = 230 \times 2.226 \times 0.242 = 123.89$ W. — 1 mark

$P_{apparent} = VI = 230 \times 2.226 = 511.98 = 512$ VA. — 1 mark

3 d) Explain statically induced emf and dynamically induced emf.
Ans:

i) Statically induced emf: Emf produced in conductors where in the magnetic field around them changes with the conductors being stationary.
For coils 'e' = -NdØ/dt. (V) where N is number of turns in coil, Ø is the changing flux wrt time t. (unit volts) — 2 marks

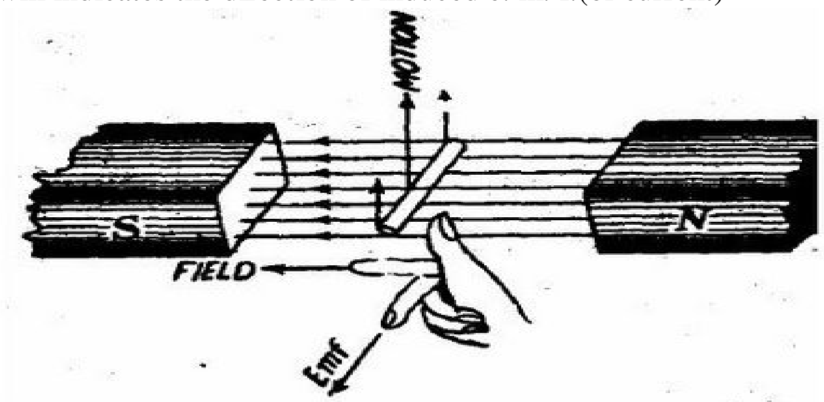
Two types: a) self induced emf: b) Mutually induced emf.

ii) Dynamically induced emf: Emf produced in conductors due to relative motion of conductors with respect to magnetic fields (Volts) = e = B l v sinθ (Volts) where B = flux density (T), l = effective length of conductor in the magnetic field, v sinθ = relative velocity of conductor wrt the magnetic field. θ = angle between velocity and flux lines. — 2 marks

3 e) State and explain the Fleming's right hand rule and Lenz law for deciding the direction of induced emf.

Ans:

Fleming`s right hand rule state that, outstretch the first three fingers of right hand perpendicular to each other such that first finger pointing the direction of magnetic field, thumb directing the motion of the conductor, then second finger will indicates the direction of induced e. m. f.(or current) 2 marks



Lenz law: this states that the direction of induced emf in coil or conductors is such that its effect is to oppose the cause producing it.
e = - N(dΦ/dt), the negative sign signifies Lenz law. 2 marks

3 f) What is kVA rating of transformer? Why transformer is rated in kVA?

Ans:

VA rating of transformer is the product of rated voltage (of primary or secondary side) and current rating (of corresponding side). It is normally expressed in kiloVA or kVA. 2 marks

The voltage rating being fixed the variable currents due to power factor variations of loads on secondary side are taken care of by stating in kVA so that the rated values of currents are known and utilized for proper operation of transformers without overloading unknowingly. 2 marks

4 Attempt any four. 16 marks

4 a) f = 50 Hz. V_{RMS} = 130 V, R = 80 Ohms, L 0.4 H.

$V_M = \sqrt{2} \times 130 = 183.84$ V.

$v = V_M \sin\omega t = 183.84 \sin(2\pi ft) = 183.84 \sin(2\pi \times 50 \times t) = 183.84 \sin 100\pi t$. 1 mark

$X_L = 2\pi fL = 2 \times \pi \times 50 \times 0.4 = 125.68$ ohms.

$Z = \sqrt{[R^2 + X_L^2]} = \sqrt{[80^2 + 125.68^2]} = 148.98$ ohms = 149 ohms.

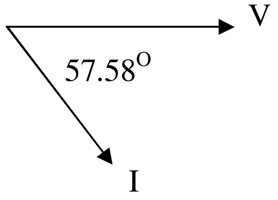
$I_{RMS} = V_{RMS}/Z = 130/149 = 0.8724$ A.

$I_{MAX} = \sqrt{2} \times 0.8724 = 1.233$ A.

$\cos\Phi = R/Z = 80/149 = 0.536$ lag.

Therefore $\Phi = 57.58^o = 9.82$ rad. 1 mark

Hence 'i' = $1.233\sin(100\pi - 9.82)$ A. 1 mark



1 mark

4 b) $N_1 = 375$, $N_2 = 1050$, $V_1 = 400$ V, f = 50 Hz, a = 40 cm^2 = 40 x 10^{-4} m^2.
$E_1 = 4.44\ \Phi_m f\ N_1 = 400$.
Hence $\Phi_m = 400/(4.44 \times 50 \times 375) = 0.0048$ Wb.
$\Phi_m = B_m\ a$,
Hence $B_m = \Phi_m/a = 0.0048/(40 \times 10^{-4}) = 1.2$ Wb/m^2 (tesla). 2 marks

$E_1 = 4.44\ \Phi_m f\ N_1 = 4.44 \times 0.0048 \times 50 \times 375 = 400$ V.
$E_2 = 4.44\ \Phi_m f\ N_2 = 4.44 \times 0.0048 \times 50 \times 1050 = 1118.88 = 1119$ V. 2 marks

4 c) "The actual speed of an induction motor can never be equal to synchronous speed of the motor". Explain.
Ans:
Torque produced for rotation is proportional to the rotor current which will be zero if the rotor speed becomes equal to the synchronous speed (because rotor current is proportional to the induced emf in rotor circuit; this emf is proportional to the slip speed which will be zero if rotor speed is equal to synchronous speed) and motion cannot be produced. 2 marks

The power input to rotor is at synchronous speed. Power lost in the rotor (copper & iron losses) is reflected as drop in the speed and the remaining power is available as output power at a speed less than synchronous. 2 marks

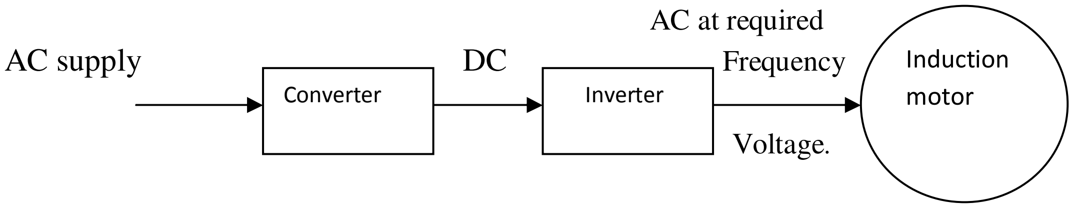
4 d) Explain the principle of operation of the induction motor.
Ans:
Principle of operation of the induction motor

- An induction motor basically consists of a stator and a rotor separated by a uniform air gap.
- Stator carries winding. When a supply is fed to the winding, moving magnetic field produced by virtue of the placement of the winding. 1 mark
- The lines of force of the stator field cut the rotor conductors and an alternating emf is induced in these conductors. 1 mark
- The rotor winding is equivalent to a short circuited winding, the emf generated in the rotor conductor circulates a current. 1 mark
- Thus a force will act upon the current carrying rotor conductor as it is in the magnetic field and the rotor will move in the direction of the moving magnetic field. 1 mark

4 e) Explain stator frequency speed control method of induction motors.

Ans:

Stator frequency control:



2 marks

Synchronous speed = 120f/P,

By changing frequency synchronous speed is changed hence rotor speed changes.

To maintain air gap flux to normal value under varying frequency the ratio V/f is to be maintained constant. 2 marks

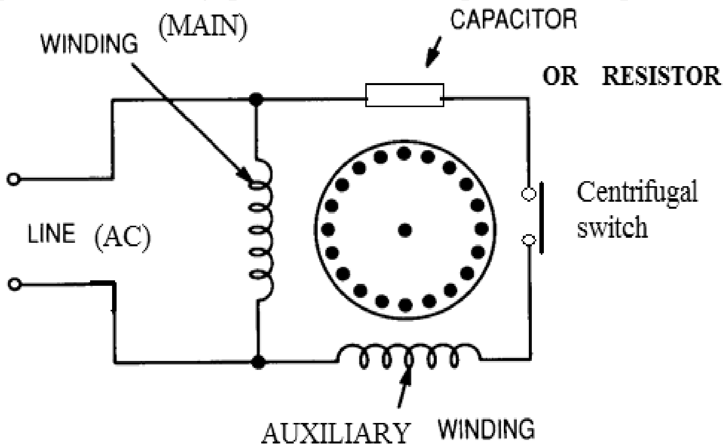
The frequency changing is now done electronically using SCRs etc.

4 f) Explain the method of making single phase motors self starting.

Ans:

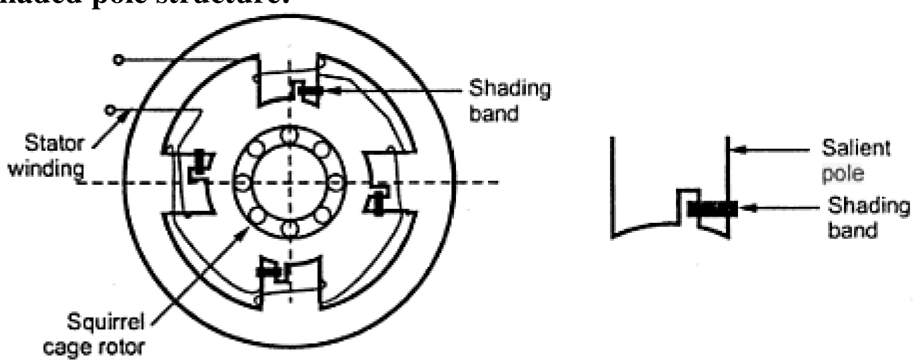
The starting torque is proportional to the product of fluxes of the 2 windings and the sine of angle between them. 1 mark

Split phasing arrangement is used to create fluxes separated in space and time phase in the air gap to create the torque in the required direction.



1 mark

Shaded pole structure:



1 mark

The shaded pole and un-shaded portion create fluxes differing in time and space phase that create the required torque to start the motors. 1 mark

5 Attempt any four — 16 marks

5 a) Z = 14.28 ohm, V = 200 V, f = 50 Hz, R = 10 ohms, L = 0.1 H.

I = V/Z = 200/14.28 = 14 A. — 2 marks

$Z = \sqrt{[R^2 + X^2]}$,

$X = \sqrt{[Z^2 - R^2]} = \sqrt{[14.28^2 - 10^2]} =$ 10.19 ohms.

$X_L = 2\pi fL = 2\pi \times 50 \times 0.1 = 31.42$ ohms.

$X = (X_L - X_C)$, hence $X_C = (X - X_L) = 10.19 - 31.42 = 21.23$ ohms.

$X_C = 1/(2\pi fC)$, hence $C = 1/(2\pi fX_C)$

$= 1/(2\pi \times 50 \times 21.23) = 0.000150$ F = 150 μF. — 2 marks

5 b) $V_{ph} = 231$ V,

$Z_{ph} = (4+j4) = \sqrt{[R^2 + X^2]} = \sqrt{[4^2 + 4^2]}\angle\tan^{-1}(4/4) = 5.65\angle 45^o$ohms — 1 mark

$I_{ph} = V_{ph}/Z_{ph} = 231/5.65 = 40.88$ A. — 1 mark

PF = cosΦ = cos 45 = 0.707 lag. — 1 mark

$P = 3\, V_{ph}\, I_{ph} \cos\Phi = 3 \times 231 \times 40.88 \times 0.707 = 20029.19$ W = 20.029 kW — 1 mark

5 c) Explain in brief the constructional features and working of isolating transformer and state its applications.

Ans:

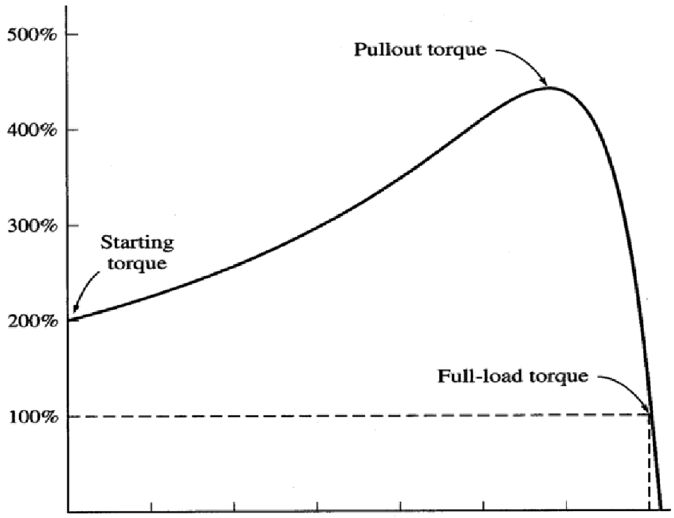
- Transformers designed & constructed to provide electrical isolation between the primary and secondary sides without change in voltage and current. — 1 mark
- Primary and secondary voltages are equal.
- Hence the turns are equal on both sides. (turns ratio 1:1).
- Construction is same as two winding transformer (laminated electromagnetic core with insulated copper windings) — 1 mark

Applications:

- Areas where common mode noise is generated.
- Protect sensitive equipment from unwanted voltage spikes on primary side.
- Used in electronic circuits for isolation.
- Used in circuits to avoid audio and video distortions.

Any two points (other valid also) = 2 marks

5 d) Draw the torque speed characteristics of the three phase induction motor and explain the same.
Ans:



2 marks

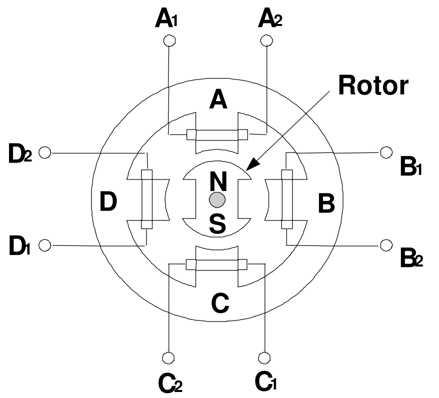
- In this diagram, T represents the nominal full load torque of the motor.
- In this case, the starting torque (at $N = 0$) is 2T.
- The maximum torque (pullout torque) is nearly equal to 4.5T.
- At full load, the motor runs at speed N. 2 marks
- When mechanical load increases, motor speed decreases 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.

5 e) Explain how stepper motor rotates in steps.
Ans:
Working of stepper motor:-
A stepper motor is electromechanical device which converts electronic 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. Construction and working of Permanent-Magnet (PM) type stator motor is given here.
The permanent-magnet stepper motor operates on the reaction between a permanent-magnet rotor and an electromagnetic field produced by the stator. Fig. (a) shows the schematic representation of four phase, two pole permanent magnet stepper motor and fig, (b) shows its basic drive circuit. The stator of this type of motor is multipolar. In this case, the stator has four poles. Exciting coils A, B, C 2 marks

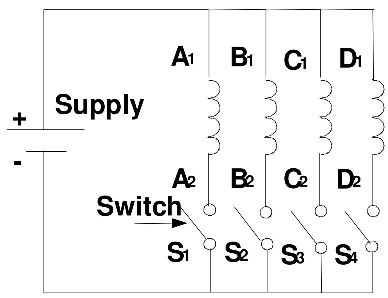
and D are wound around these poles. The rotor can be salient pole type or smooth cylindrical type and it has a permanent magnet mounted at each end. The rotor is made of ferrite material which is permanently magnetized.

When a steady DC signal is applied to one stator winding of PM stepper motor, the rotor makes a revolution of 90^0. This angle is called as step for each input voltage pulse. These steps are explained as below:

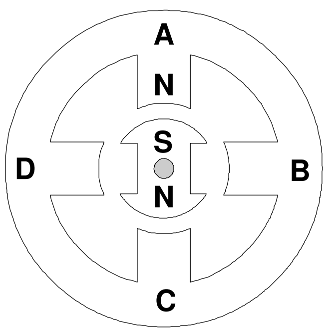
1) When the switch S_1 is closed, a pulse is applied to the phase A. Thus the torque is developed on the rotor and it rotates such that its magnetic axis gets aligned with the magnetic axis of the stator. The position of the rotor when phase A is excited is shown in fig. (c).
2) Now if phase A is disconnected and phase B is excited by closing the switch S_2. Then the rotor will further rotate through 90^0 in such a way that the magnetic axis of rotor again gets aligned with the magnetic axis of stator as shown in fig. (d). Here, if both the phases A and B are excited simultaneously, the rotor will rotate through 45^0 and will take a position between the stator poles A and B.
3) Similarly when phases C and D are excited sequentially, the rotor will every time rotate through 90^0 as shown in fig. (e) and (f).
4) Thus by giving pulses to the stator coils in a desired sequence, it is possible to control the speed and direction of the motor.



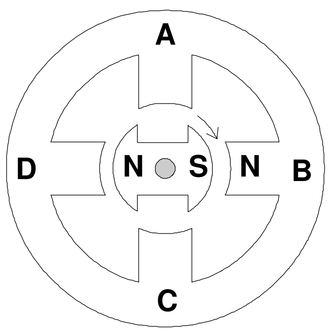
(a)



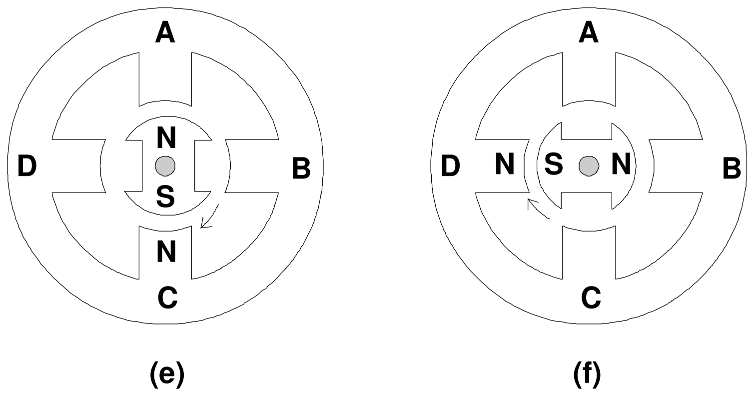
(b)



(c)



(d)



2 marks

6 Attempt any four. 16 marks

6 a) $I_{ph} = V_{ph}/Z_{ph} = V_L/Z_{ph} = 440 /30 = 14.66$ A. 1 mark

$I_L = \sqrt{3}\ I_{ph} = \sqrt{3} \times 14.66 = 25.39$ A. 1 mark

Power $P = \sqrt{3} V_L I_L \cos\Phi = \sqrt{3} \times 440 \times 25.39 \times 1 = 19349.77$ W = 19.35 kW. 2 marks

6 b) Q = 50 kVA, full load loss = 4 kW, iron loss = 2 kW, $\cos\Phi = 1$.

Full load copper loss = total full load loss – iron loss = 4 – 2 = 2 kW.

1) Full load η = [output/(output + P_I + P_{CU})] x 100
= [(50 x 1)/(50 x 1 + 2 + 2)] x 100 = 92.59 %. 2 marks

2) Half load η = [output/(output + P_I + P_{CU})] x 100
= [(25 x 1)/(25 x 1 + 2 + 0.5)] x 100 = 90.9 %. 2 marks

6 c) State two applications of each of the following type of transformers.

i) Power transformers.
ii) RF transformers.
iii) Pulse transformers.
iv) AF transformers.

Any two applications of each 1 mark = total 4 marks.

Ans:

i) Power transformer applications:
- Used at feeding end in primary and secondary transmission systems.
- Used at receiving end of primary & secondary transmission systems.

ii) RF transformers applications:
- To obtain maximum power transfer in radio frequency circuits.
- To obtain maximum voltage in electronic circuits.
- Radio frequency electronic circuits.

iii) Pulse transformers applications:
- Pulse generating circuits.
- SCR, switching transistor circuits.

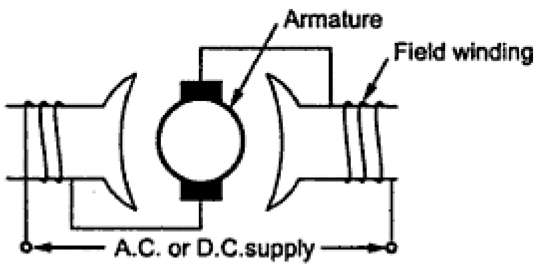
- Digital signal transmission systems.

iv) AF transformers applications:
- Audio frequency oscillator applications.
- AF sine wave generator.
- Used in RC feedback oscillators.
- Used in beat frequency oscillators.

6 d) Explain the working principle and operation of universal motors.

Ans:

Universal motor:
- 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. 1 mark
- Small motors designed and constructed to operate on either DC or single phase AC supply of same voltage.
- Have nearly similar operating characteristics on AC and DC. 1 mark
- The effect of inductance in AC adversely affects the operating characteristics which can be overcome by compensating winding.
- The armature is similar to that of the DC machine (winding, commutator, brushes). 1 mark



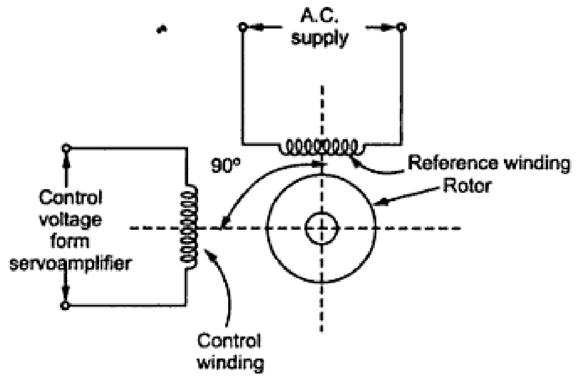
1 mark

6 e) Explain the working of servo motors.

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. 1 mark

A.C. Servomotors:

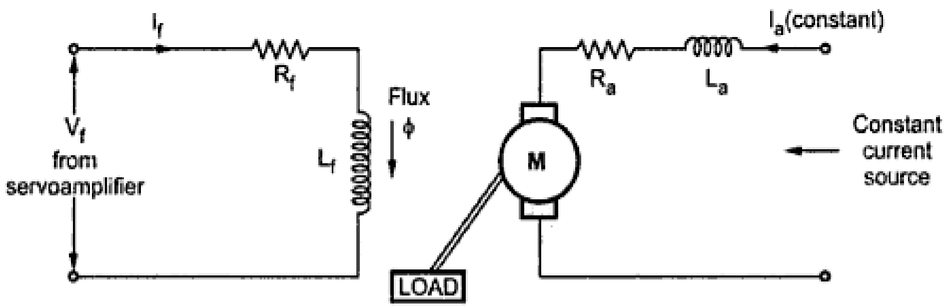


2 marks

These consist of main and control winding and squirrel cage / drag cup type rotors. V_r is the voltage applied to the main or reference winding while V_c is that applied to control winding which controls the torque- speed characteristics. The 90^o space displacement of the two coils/windings and the 90^o 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. 1 mark

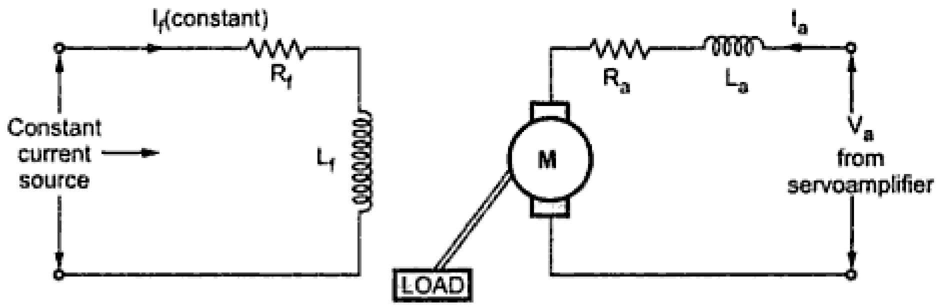
OR

D. C. servomotors:



2 marks

OR



2 marks

armature controlled dc servo motor

These consist of the usual dc motor windings. But the power /signals to these windings are fed from servo amplifiers to achieve the required torque and speed 1 mark characteristics. Here the field is controlled by servo amplifier feed.

6 f) Explain the necessity of earthing. State the types of earthing.

Need for earthing:

Equipment body earthing to protect the personnel from electrical shocks due faulty equipment by fuse getting blown under such circumstances. 1 mark

Neutral earthing to provide suitable voltage between line and neutral of supply system as per load/customer requirement, for installation of protective circuit gear, maintain rated system voltage at healthy lines under line – earth fault conditions. 1 mark

Types of earthing:

- Plate earthing.
- Pipe earthing.
- Earth mat (mesh of metal strips) for huge power installations as generating stations etc.

Any two 1 mark