W'08 : 5 AN : EL 405 (1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

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Group A

1. (*a*) Explain, drawing the necessary experimental circuit diagram, the Swineburne's test of finding the efficiency of a d.c. shunt motor. 7

(*b*) Two 220 V, separately excited d.c. generators operate in parallel. One machine has a terminal voltage of 270 V on no load and 220 V at a load current of 35 A. The other has a voltage of 280 V at no load and 220 V at 50 A. The external characteristics are rectilinear. Find the output current of each machine and the bus-bar voltage when the total load is 60 A. 5

(*c*) Explain *any two* methods of speed control of a d.c. series motor. 8

2. (a) Explain why a star-delta connection of three-phase transformers is a commonly used connection. 5

(b) Draw the circuit diagram and explain the working of Scott connection of transformers for three-phase to two-phase transformation. 10

(c) Three single-phase 1 kVA, 200/100 V transformers are to be connected to operate as step up three-phase transformer. For various three-phase connections, find the possible three-phase kVA rating, input current rating, and the output current rating. 5

3. (a) Explain the 'preventive reactor' method of on load tap changing of transformers. 5

(b) Discuss why the short-circuit characteristic of a synchronous machine is a linear characteristic. 5

(c) Derive the expression for power output of a salient pole synchronous generator in terms of its terminal voltage, excitation voltage, reactances and the load angle. Sketch the same as a function of load angle. Neglect armature resistance. 10

4. (a) List the essential conditions to be satisfied before a synchronous generator can be connected to the network bus bars. 4

(b) Drawing the circuit diagram and the phasor diagram of a synchronous motor, with resistance neglected, explain how do we get 'V' curve for constant power output. 8

(c) A synchronous generator has a direct-axis synchronous reactance of 0·8 p.u. and a quadrature-axis synchronous reactance of 0·5 p.u. It is supplying full load at rated voltage at 0·8 lagging power factor. Find the open circuit voltage of the machine. Neglect armature resistance. 8

Group B

5. (a) Explain how a rotating field is produced when a balanced three-phase induction machine is connected to a balanced three-phase supply. 7

(b) Stating the assumptions made, find a suitable expression for the torque developed by an induction motor in terms of applied voltage, rotor constants, slip, etc. Thereafter, find the condition for the starting torque to be maximum. 13

6. (a) A three-phase, 50 Hz, four-pole induction motor has a slip of 0·04 per unit when the output is 20 kW. The friction loss is 400 W. What is the relative speed between the rotating mmf and the rotor? What is the rotor circuit copper loss? 6

(b) Explain the auto transformer method of starting of three-phase induction motors. 7

(c) Calculate the relative values of (i) the starting torque, and (ii) the starting current of a three-phase cage-rotor induction motor when started with (A) direct switching; (B) a star-delta starter; and (C) an auto transformer having 40% tappings. 7

7. A 20 hp, 400 V, 50 c/s, 3-phase star-connected induction motor gave the following test data (line values):

No load test: 400 V, 9 A, $\cos\varphi = 0{\cdot}2$.

Short-circuit test: 200 V, 50 A, $\cos\varphi = 0{\cdot}4$.

Stator voltage (d.c.) drop test (between any two lines):

1·1 V, 5A.

From the stator, find the line current and power factor at full load, and the maximum horse power. Also, draw its equivalent circuit with values of the elements labelled. 20

8. (*a*) Draw the equivalent circuit of a pure single-phase induction motor, explaining various symbols used. 5

(*b*) Describe the construction, working and torque-speed characteristics of a stated pole induction motor. Can we reverse its direction of rotation? 8

(*c*) Draw the torque-speed characteristics of an a.c. two-phase servo motor. How is linear characteristic achieved? How is it used in control applications? Give a suitable example. 7

Group C

9. Answer the following: 2×10

(*i*) In a d.c. shunt motor, if the motor shaft load is increased, how does back emf change?

(*ii*) A differentially compounded d.c. motor is rarely used. Why?

(*iii*) Give an application of d.c. series generator.

(*iv*) If the core loss in a transformer at voltage V is P_c, what approximately shall it be at half the voltage, i.e., at $V/2$?

(*v*) If the eddy current loss at voltage V and frequency f be P_e, what shall it be at voltage V and frequency $2f$?

(*vi*) What is the meaning of the transformer connection Yd1?

(*vii*) The change in the rotor circuit resistance of a three-phase induction motor does not effect the value of maximum torque of the motor, though the starting torque is affected. Explain briefly.

(*viii*) When the slip of the induction machine is negative, then in which of the modes is the machine operating i.e., whether the machine motoring, generating or plugging?

(*ix*) The magnetizing current of an induction motor is relatively larger than that in a transformer of nearly the same kVA and voltage rating. Explain briefly.

(*x*) In a synchronous generator, the armature reaction is mainly demagnetizing under lagging power factor condition. Explain briefly.

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Group A

1. (*a*) Three d.c. shunt dynamos, driven by a prime mover, each having a field resistance of 120 ohms and an armature resistance of 0·1 ohm, are connected to a 120 V bus. These three generators have generated voltages of 125 V, 120 V and 114 V, respectively. For each of the generators, calculate the (*i*) line current drawn from or delivered to the bus and the armature current, and (*ii*) power drawn from or delivered to the bus and the power generated. 10

(*b*) Discuss factors determining the load distribution between a number of d.c. shunt dynamos running in parallel. 6

(*Turn Over*)

(c) For d.c. compound generators operating in parallel, explain why a diverter for given compound generator cannot be connected in parallel with the series field of that particular machine. 4

2. (a) Derive expressions for the current shared by two transformers operating in parallel, with unequal no-load voltages. 5

(b) Explain the method of estimating the load sharing when n number of transformers are operating in parallel. 5

(c) Two transformers T_1 and T_2 of different kVA ratings but equal voltage ratings operate in parallel and supply a common load of 700 kVA at 0·8 p.f. lag. Transformer T_1 has a rating of 500 kVA, resistive drop of 1% and reactance drop of 5%. Transformer T_2 has a rating of 250 kVA, resistive drop of 1·25% and reactance drop of 4%. Calculate the load shared by each transformer and the p.f. at which these are working. 10

3. (a) A 750 MVA, 13·8 kV, 50 Hz star-connected, three-phase, salient-pole, synchronous generator has direct axis synchronous reactance (X_d) 1·83 ohm and quadrature axis synchronous reactance (X_q) 1·21 ohm. It delivers the rated load at 0·8 p.f. lagging. Neglect the armature resistance. Determine the (i) voltage regulation, and (ii) power developed by the generator. 10

(b) Why is the direct axis synchronous reactance larger than the quadrature axis synchronous reactance in a salient-pole alternator ?. 4

(c) Explain the nature of external characteristics of a synchronous generator for unity, leading, and lagging power factors. 6

4. (a) A 120 V, 50 Hz, three-phase, star-connected, round-rotor synchronous motor has an armature-winding resistance of $(0·5 + j3)$ ohm/phase. The motor takes a current of 10 A at 0·8 p.f. leading when operating at a certain field current. The load is gradually increased until the motor develops the maximum torque while the field current is held constant. Determine the new line current, the power factor, and the torque developed by the motor. 10

(b) The armature current increases with an increase in the field current of a synchronous motor. What is the initial power-factor angle ? What is the effect on the torque-angle ? 6

(c) Why is it necessary to improve the overall power factor of a manufacturing plant ? 4

Group B

5. (a) A 230 V, 50 Hz, 4-pole, delta-connected three-phase induction motor operates at a full-load speed of 1440 rpm. The power developed at this speed is 2 H.P. and the rotor current is 4·5 amp. If the supply voltage fluctuates ±10%, determine (i) torque range, and (ii) current range. 10

(b) Explain the method of speed control of 3-phase induction motor by varying the supply frequency. 5

(c) What is the purpose of using deep-bar cage rotors ? Explain the construction and working of a deep-bar cage motor. 5

6. (*a*) A 208 V, three-phase, six-pole, 50 Hz, 7·5 H.P. wound rotor induction motor has both its stator and rotor connected in star. The rotor has half the number of turns the stator has. Full-load (rated) speed is 1125
2 rpm. The rotor resistance is 0·08 ohms/phase, and the locked rotor reactance is 0·4 ohm/phase. Calculate (*i*) locked-rotor voltage per phase, (*ii*) rotor current per phase at rated speed, (*iii*) rated rotor power input per phase, (*iv*) rated rotor copper loss per phase, (*v*) rotor power developed per phase in h.p., (*vi*) rated torque developed per phase, (*vii*) total rotor torque developed, (*viii*) total output rotor torque. 12

(*b*) Draw and explain the power flow diagram of a 3-phase induction motor. Show that rotor-copper loss is slip times the power input to rotor. 4

(*c*) Cite possible reasons why a three-phase induction motor fails to start. 4

7. (*a*) A 230 V, 50 Hz, 4-pole single-phase induction motor has the following equivalent circuit impedances:

3. R_{1m} (resistance of the main stator winding) = 2·2 ohm

X_{1m} (leakage reactance of the main stator winding) = 3·1 ohm

R'_2 (standstill rotor resistance referred to the main stator winding) = 4·5 ohm

X'_2 (standstill rotor leakage reactance referred to the main stator winding) = 2·6 ohm

X_M (magnetizing reactance) = 80 ohm.

Friction, windage and core loss = 40 W, for a slip of 0·03 p.u.

Calculate (*i*) input current, (*ii*) power factor, (*iii*) developed power, (*iv*) output power, and (*v*) efficiency. 14

(*b*) Explain why a universal motor can operate from d.c. as well as a.c. supply. What are the main differences in construction between a.c. series motor and d.c. series motor? 3+3

8. (*a*) A 0·5 h.p., 230 V, single-phase induction motor (split-phase) takes a current of 4·2 amp lagging the voltage by 10° for the auxiliary winding and a current of 6·2 amp lagging the voltage by 40° for its main winding. Find (*i*) total current and p.f. at the time of starting, (*ii*) total p.f. and current during running, and (*iii*) phase angle between the main winding current and auxiliary winding current, (*v*) power drawn by main winding, (*vi*) total power drawn during starting, (*vii*) total power drawn during running, (*viii*) efficiency of the motor if the motor output is 0·5 h.p. (metric) and curents are as above. 12

(*b*) Name three types of d.c. stepping motors. What constructional differences are found to distinguish one type from another? For the same number of poles (rotor), which d.c. stepper produces the largest and smallest stepping angles, respectively. 8

Group C

9. Answer the following in *two* or *three* sentences: 10 × 2

(*i*) Why cannot an induction motor run at synchronous speed?

(*ii*) Distinguish between harmonic induction torque and harmonic synchronous torque developed in a 3-phase induction motor.

(*iii*) Is it possible for an induction motor to operate as an induction generator ? If yes, how can it be done ?

(*iv*) Is a universal motor also an induction motor ? Give reasons to justify the answer.

(*v*) Can the direction of rotation of a shaded-pole motor be reversed ?

(*vi*) Why is a capacitor motor better than a split-phase motor ?

(*vii*) What happens to power factor of a universal motor when the load is increased ?

(*viii*) State the precautions to be taken when two transformers are connected in parallel.

(*ix*) What are the special precautions required for the successful parallel operation of two d.c. compound generators ?

(*x*) What is the reason for a transient state in an electric machine ?

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Group A

1. (*a*) A d.c. generator has the following field windings :

(*i*) A separately-excited winding of 1000 turns per pole and a resistance of 80 Ω supplied from a constant voltage source of 110 V; and

(*ii*) A shunt winding of 500 turns per pole and a resistance of 200 Ω.

The open circuit magnetisation curve at 500 r.p.m. is

Armature voltage, V	154	302	396	458	505	538
Field at per pole	500	1000	1500	2000	2500	3000

Determine the no load voltages at 500 r.p.m. and 600 r.p.m., both windings being connected to their respective sources at respective speeds. 10

(*b*) A 4-pole d.c. series motor runs at a speed of N r.p.m. on a fixed d.c. supply with all field coils in series. Estimate the speed at which the motor would run if fed from the same supply with all field coils reconnected in two parallel groups of two coils each. Assume that the load torque varies as square of the speed, all losses are negligible, and the magnetization characteristic is linear. 10

2. (*a*) A 1000 kVA, 11/33 kV, 50 Hz, delta/star connected tap changing transformer has LV and HV impedances of (0.5 + j 6.67) Ω and (1.5 + j 20) Ω, respectively. What must be the tap settings on the LV side to maintain rated voltage at the secondary at full load 0.8 p.f. (lag) ? 10

(*b*) Under what value of p.f.s does a transformer give maximum and zero voltage regulations ? 4

(*c*) Why are transformer tappings usually provided on the HV side ? 6

3. (*a*) Two transformers, having the following particular supply in parallel, a 600 kVA 0.8 p.f. lagging load. Find the loading of transformers and the terminal voltage. Load is connected at the LV side. 10

	Transformer A	Transformer B
Ratings	3300/400 V, 400 kVA	3300/400 V, 200 kVA
Percentage Impedance	2 + j 2 Ω	1 + j 4 Ω

(*b*) A 3-phase, star-connected alternator has synchronous impedance of (0.4 + j 6) Ω per phase. It delivers 400 A at unity p.f. to 11 kV bus-bars. If the steam supply is unchanged, determine the percentage change in excitation to make the p.f. 0.8 lagging. Assume stray power loss to be constant. 10

4. (*a*) Why are cylindrical rotor alternators used with steam turbines and salient pole alternators with hydroelectric plant ? 8

(*b*) A synchronous generator, with a synchronous reactance of 1.3 p.u., is connected to an infinite bus whose voltage is 1.0 p.u. through an equivalent reactance 0.2 p.u. The maximum permissible output is 1.2 p.u.

(*i*) Compute the excitation voltage ; and 6

(*ii*) Power output is gradually reduced to 0.7 p.u. with fixed field excitation as in part (*i*). Find the new current, power angle, and the p.f. 6

Group B

5. (*a*) Explain why an induction motor cannot run at synchronous speed ? 5

(*b*) What are two types of rotor constructions used in induction motors ? Compare them. 5

(*c*) A three-phase, 4-pole, 50 Hz induction motor at standstill has 120 V induced e.m.f. across its star connected rotor terminals. The rotor resistance and reactance per phase are 0.2 Ω and 1.0 Ω, respectively. Calculate the (*i*) speed when the rotor is drawing a current of 16 A at a particular load, and (*ii*) speed at which the torque is maximum and the corresponding value of rotor input. 10

6. (*a*) Explain how the speed of slip-ring induction motor can be varied by varying its rotor circuit resistance. What are the limitations of this method ? 10

(*b*) An 8-pole, 50 Hz, three-phase induction motor is loaded deliberately to a point where pull-out torque will occur. The rotor resistance per phase is 0.3 Ω and motor stalls at 650 r.p.m. Calculate the (*i*) breakdown slip, (*ii*) locked rotor reactance, (*iii*) rotor frequency at the maximum torque point, and (*iv*) suppose this motor develops twice the full-load torque when started with rotor short-circuited and it runs at a full-load speed of 675 r.p.m. If resistance of 0.7 Ω is added in series with rotor per phase, calculate the new full-load with added resistance. 10

7. (*a*) A 2-pole, 50 Hz, single-phase induction motor has the effective rotor resistance and leakage reactance of 0.5 Ω and 5.0 Ω, respectively. If the motor runs at 2600 r.p.m., determine frequencies of the rotor current components and relative magnitudes of forward and backward fluxes. Neglect magnetising current and stator impedance. 6

(*b*) Develop the torque-speed/slip curve of a three-phase induction motor and indicate stable and unstable regions. 10

(*c*) Show that when the stator impedance is neglected, the torque of a balanced three-phase induction motor, T_e, at slip S can be expressed as

$$T_e = \frac{2\,T_{max}}{(S/S_{max}) + (S_{max}/S)}$$

with symbols have their usual meanings. 4

8. (*a*) 'The ceiling fans are invariably permanent-split-capacitor type'–Explain. 4

(*b*) Why is drag-cup rotor construction used in servomotor ? 4

(*c*) A 185 kW, 110 V, 50 Hz, 4-pole, single-phase induction motor has a rotational loss of 15 W at normal speeds. The equivalent circuit parameters are : $r_1 = 1.3\ \Omega$, $r'_2 = 3.2\ \Omega$, $x_1 = 2.5\ \Omega$, $x'_2 = 2.2\ \Omega$, $x_m = 48\ \Omega$. Determine the line current, line p.f., power output, and efficiency of this motor, when it operates at a slip of 4%. 12

Group C

9. Answer the following in a single word/sentence : 20 × 1

(*i*) A dummy coil is used in the armature windings of a d.c. machine. Is the machine lap or wave wound ?

(*ii*) Why is pole face of a d.c. machine chamfered ?

(*iii*) Why are brushes staggered on commutator ?

(*iv*) What is the name of the winding embedded in the pole shoes of large d.c. machines ?

(*v*) What is the frequency of the generated voltage in a 6-pole, 1000 rpm d.c. shunt generator ?

(*vi*) What is the use of Potier's triangle ?

(*vii*) How is the p.f. of a synchronous motor changed keeping the shaft load undisturbed ?

(*viii*) In alternator, the coils are short-pitched and also conductors of individual phases are distributed within their phase spread. What is the reason ?

(*ix*) A synchronous motor develops some mechanical power even if the field is unexcited. Is it cylindrical or salient-pole machine ?

(*x*) What will be the number of slip rings in a three-phase synchronous motor ?

(*xi*) In a star-star connected transformer, if a delta tertiary is provided, what is the major reason ?

(*xii*) In performing the short-circuit test of a transformer, HV side is usually short-circuited. Is the statement true or false ?

(*xiii*) The high frequency hum in a transformer is due to magnetostriction. Is the statement true or false ?

(*xiv*) Why is the yoke cross-section of a transformer made large ?

(*xv*) What is the most dominant harmonic component present in the magnetising current of a single phase transformer ?

(*xvi*) What is the purpose of skewing of rotor slots in induction motors ?

(*xvii*) An induction motor can be represented by equivalent transformer. Are their p.u. magnetising currents of the same order ?

(*xviii*) Which is the cheapest method of starting of a three-phase induction motor and why ?

(*xix*) Which is the most suited three-phase induction motor for high starting torque ?

(*xx*) Why is it that the V/F ratio kept constant while controlling the speed of a three-phase induction motor by varying the supply frequency ?

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Group A

1. (*a*) Draw the speed torque characteristics of a d.c. shunt motor whose speed is controlled through field current. 5

(*b*) A 250 V d.c. shunt motor has a field resistance of 125 ohms and an armature resistance of 1 ohm. It takes an armature current of 25A at a speed of 900 r.p.m. It is required to increase the speed to 1100 r.p.m. keeping the torque constant. Find the value of additional resistance to be added in the field circuit to get this speed. Assume unsaturated magnetic circuit. 15

2. (*a*) What are the distinguishing features of star-star, star-delta, delta-star and delta-delta connections in 3-phase transformers ? Compare their advantages and disadvantages. 12

(*b*) Explain the Scott connection giving a suitable diagram. Show the currents in windings in the diagram. 8

3. (*a*) What do you understand by direct and quadrature axis reactances of synchronous generators ? Discuss them in detail. 8

(*b*) How can direct and quadrature axes reactances be measured ? Explain. 6

(*c*) Explain briefly *any one* method for synchronisation of 3-phase synchronous generators. 6

4. (*a*) Draw V curves for a synchronous motor. Justify the shape of these curves. 8

(*b*) What is the application of a synchronous condenser ? Explain. 6

(*c*) What is the significance of torque-angle characteristics of a synchronous machine ? Explain. 6

Group B

5. (*a*) Draw and explain the torque-slip curve of a 3-phase induction motor. 8

(*b*) A slip ring induction motor has a full load speed of 288 r.p.m. and frequency is 50 Hz. Find the (*i*) number of poles and slip, and (*ii*) slip for full load, if rotor resistance is doubled. If initial rotor copper loss is 275 W, find new value of rotor copper loss. 2×4

(*c*) List the methods for speed control of 3-phase induction motor. 4

6. The results of no-load and blocked rotor tests on a 400 V, 50 h.p., 50 Hz, 3-phase, 4-pole induction motor are as under : No-load test, V_0 = 400 V, I_0 = 30 A, W_0 = 1800 W, blocked rotor test, V_{sc} = 110 V, I_{sc} = 80 A, W_{sc} = 4000 W.

The stator is star-connected having a resistance of 0.1 ohm per phase. Draw the circle diagram and find (*a*) full load current, power factor, slip, torque, and efficiency, (*b*) starting torque, maximum torque and maximum output. 10 + 10

7. (*a*) Briefly discuss the principle of split phase, shaded pole and capacitor single-phase induction motor. 3×3

(*b*) Discuss the principle of a.c. series motor. Draw its performance characteristics. 3 + 3

(*c*) What are the applications of a.c. series motor ? 5

8. Write short notes on the following : 7 + 6 + 7

(*a*) Repulsion motor
(*b*) d.c. servomotor
(*c*) Pull-out torque of induction motor.

Group C

9. Select the best alternative for the following : 20 × 1

(*i*) Two d.c. shunt generators are operating in parallel. It is desired to shutdown one of the generators. The proper method is to

(*a*) open its switch suddenly.
(*b*) open its switch slowly.
(*c*) reduce its excitation to zero.
(*d*) Any one of the above.

(*ii*) The torque developed by a d.c. motor is proportional to

(*a*) flux.
(*b*) armature current.
(*c*) flux and armature current.
(*d*) None of the above.

(*iii*) The resistance of shunt field is about

(*a*) 100 ohm
(*b*) 10 ohm
(*c*) 2 ohm
(*d*) 0.2 ohm

(*iv*) Suriburne test can be used only for

(*a*) series motor.
(*b*) shunt motor.
(*c*) shunt and series motor.
(*d*) shunt and compound motor.

(*v*) When the secondary winding of a transfomer is short-circuited, the power factor at primary terminals is about

(*a*) 0.2 lagging
(*b*) 0.2 leading
(*c*) 0.8 lagging
(*d*) 0.8 leading

(*vi*) The secondary winding of a transformer is open-circuited. The primary is connected to a d.c. voltage equal to rated primary voltage. The primary current would be about

(*a*) 50 p.u.
(*b*) 10 p.u.
(*c*) 1 p.u.
(*d*) 0.1 p.u.

(*vii*) During short-circuit test on transformer, iron losses are negligible because

(*a*) current is high.
(*b*) mutual flux is small.
(*c*) frequency is low.
(*d*) power factor is low.

(*viii*) Under short-circuit conditions, the power factor of a synchronous machine is

(*a*) 1
(*b*) about 0.8
(*c*) almost zero lagging
(*d*) about 0.5

(*ix*) In modern large size synchronous generators, synchronous impedance is about

(*a*) 0.2 p.u.
(*b*) 0.5 p.u.
(*c*) 1.0 p.u.
(*d*) 0.05 p.u.

(*x*) In two reaction theory, the armature current is decomposed into I_d and I_q. If E and V are generated e.m.f. and terminal voltage, then

(*a*) I_d is perpendicular to V and I_q is in phase with V.

(*b*) I_d is in phase with E and I_q is perpendicular to E.

(*c*) I_d is perpendicular to E and I_q is in phase with E.

(*d*) I_d is in phase with V and I_q is perpendicular to V.

(*xi*) When the real power output of a cylindrical rotor alternator is maximum, the reactive power output is

(*a*) $3\,V^2/X_s$
(*b*) $-3\,V^2/X_s$
(*c*) $3\,EV/X_s$
(*d*) $3\,E^2/X_s$

(*xii*) An under-excited synchronous motor operates at

(*a*) lagging p.f.
(*b*) unity p.f.
(*c*) leading p.f.
(*d*) Any one of the above.

(*xiii*) For fixed load on shaft, the armature current of a synchronous motor is minimum when p.f. is

(*a*) less than 1 and leading.
(*b*) unity.
(*c*) lagging.
(*d*) leading or lagging.

(*xiv*) In a synchronous motor,

(*a*) E is always less than V.
(*b*) $E = V$.
(*c*) E is always more than V.
(*d*) E may be more or less than V.

(*xv*) At $s = 0$, torque of a 3-phase induction motor is

(*a*) 0
(*b*) maximum.
(*c*) very high.
(*d*) nearly zero.

(*xvi*) The speed change of a 3-phase induction motor from no-load to full-load is about

(*a*) 40%
(*b*) 20%
(*c*) 10%
(*d*) 3%

(*xvii*) A single-phase induction motor has

(*a*) two windings on stator.
(*b*) one winding on stator and one on rotor.
(*c*) may have one or two windings on stator.
(*d*) two windings on rotor.

(*xviii*) As per double revolving field theory, a single-phase induction motor is considered equivalent to two hypothetical motors. If slip of one of these motors is s, the slip of the second motor is

(*a*) s
(*b*) $2s$
(*c*) $2 - s$
(*d*) $1 - s$

(*xix*) An a.c. series motor is switched on to d.c. supply of rated voltage. The speed of the motor will be

(*a*) higher than that under a.c. operation.
(*b*) lower than that under a.c. operation.
(*c*) equal or less than that under a.c. operation.
(*d*) equal to that under a.c. operation.

(*xx*) A two-phase servomotor has

(*a*) wound rotor.
(*b*) cage rotor.
(*c*) wound or cage rotor
(*d*) rotor similar to that in d.c. motor.

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Group A

1. (*a*) What are necessary conditions for parallel operation of d.c. generators? 4

(*b*) The full-load regulation of two d.c. shunt generators are 5.5% and 4.5%. The rating of both the machines are 250 kW and 450 V. How will they share a load current of 900 A? Determine the terminal voltage and currents shared by machines, if the load resistance is 0.55 Ω. 8

(*c*) A d.c. shunt motor has the following data:

Rated voltage = 220 V

Speed = 1050 r.p.m.

Armature resistance = 0.4 Ω

Calculate the value of resistance required to be inserted in the armature circuit to reduce the speed to 850 r.p.m. at an armature current of 22 A. 8

2. (*a*) Explain the difference between Yd 1 and Dy 11 of a three-phase transformer. 4

(*b*) Draw the electrical connections and vector diagrams of (*i*) delta/zig-zag of three-phase transformer, and (*ii*) double delta of three-phase transformer. 4+4

(*c*) Two electric furnaces are connected with the help of two scott-connected transformers. The three-phase supply was made to this transformer with the help of a 15 kV source. The load on one transformer is 650 kW at 120 V and the load on the other transformer is 1050 kW at 120 V. If the power factor is unity, determine the current flow in all three-phase lines. 8

3. (*a*) How do you determine the regulation of synchronous generator by the Potier method? 5

(*b*) A three-phase star-connected synchronous generator has effective resistance and synchronous reactance of 1.6 Ω and 35 Ω, respectively per phase. Determine the percentage regulation for a load of 1320 kW at power factors of (*i*) 0.8 lagging, and (*ii*) 0.8 leading when the rating of the machine is 1650 kVA and 13.8 kV. 7

(*c*) A synchronous generator has the following data:

Direct axis synchronous reactance = 0.85 p.u.

Quadrature axis synchronous reactance = 0.55 p.u.

Load is full-load at lagging power factor = 0.8

Determine per unit value of the open-circuit voltage with full-load excitation. Assume that the resistance and the effect of saturation are neglected. 8

4. (*a*) Explain the V-curves of synchronous machine. 5

(*b*) A three-phase star-connected synchronous generator is of salient pole-type. It is being run at synchronous speed with field circuit open. The stator is supplied from a three-phase balanced supply. A voltmeter, which is connected across the line, provides the maximum and minimum readings as 2825 V and 2805 V, respectively. The line current varies from 360 A to 280 A. Determine the direct and quadrature axis synchronous reactance per phase. The armature resistance may be neglected. 8

(*c*) Determine the rating of the synchronous condenser, which will raise the power factor of the substation from 0.7 lagging to 0.85 lagging. The substation is operating at full load of 1050 kVA and at a power factor of 0.7 lagging. 7

Group B

5. (*a*) Explain the circle diagram of a three-phase induction motor. 5

(*b*) The test results of 400 V, 3.7 kW, delta-connected induction motor are the following:

No load test: 400 W, 2.8 a power factor = 0.25

Blocked rotor test: 200 V, 11.8 a power factor = 0.45

Draw the circle diagram and determine the (*i*) full load current; (*ii*) full load power factor; (*iii*) starting torque in terms of the full load torque at the rated normal condition. Consider that the copper losses will be both for the stator and the rotor. 8

(*c*) Determine the tapping on an auto transformer to start the three-phase induction motor at 40% of full-load torque. The short-circuit current is four times the full load current of the motor. Consider the rated slip of the motor 5%. Also, determine the current to be drawn from the supply as a percentage of the full-load current. 7

6. (*a*) Describe a closed loop feedback system of speed control of three-phase slip ring induction motor. 4

(*b*) Two three-phase 50 Hz induction motors have 8 poles and 6 poles, respectively. They are connected in cascade. The machine having 8 no. of poles is slip ring induction motor. Determine the frequency of the rotor currents and the slips being referred to each stator rotating field when the combined set has a slip of 2.5% from the cascaded speed. 8

(*c*) A three-phase slip ring induction motor is provided with the following data:

(*i*) Maximum and minimum currents at the time of starting are kept at certain fixed values.

(*ii*) Full-load rated slip = 0.017

(*iii*) Rotor resistance per phase = 0.014 Ω.

There are five branches of external resistances being connected to the rotor. Determine the resistance in each branch. 8

7. (*a*) What is capacitor split phase motor? Explain clearly its principle of operation. 6

(*b*) The inductive reactance and resistance of each winding of a split phase induction motor are 240 Ω and 82 Ω, respectively. In series with one winding, there exist an additional resistor and a condenser. Determine the value of the additional resistance and capacitance of condenser to provide the same current in each winding with a phase difference of 90°. Assume the frequency of supply to be 50 Hz. 8

(*c*) What is the difference between repulsion induction motor and repulsion start induction motor? Explain clearly. 6

8. (*a*) How many types of d.c. servomotors are there? Describe them. What is drug cup induction motor? Explain clearly. 10

(*b*) A 115 V, 260 W, 5000 r.p.m., 50 Hz a.c. series motor is provided with the following data:

Total resistance = 1.6 Ω

Total reactance = 16 Ω

Stray power loss = 22 W

Determine the (*i*) current and the power factor at the normal rated condition, (*ii*) efficiency, speed and power factor when the load current is reduced to three-eighth of the rated condition. 10

Group C

9. Answer the following in brief: 10 × 2

(*i*) What is the main problem of parallel operation of compound d.c. generators?

(*ii*) What are the advantages of speed control of d.c. motor by semiconductor converter?

(*iii*) What is the main advantage of Hopkinson's test of d.c. machine?

(*iv*) What are diverter switch and selector switch for on load tap changing of transformer?

(*v*) Why are we getting the higher value of synchronous impedance by synchronous impedance method in case of calculation of voltage regulation of synchronous machine?

(*vi*) What is Blondel's two reaction theory in case of synchronous machine?

(*vii*) Why does the maximum torque of 3 φ induction motor remain independent of frequency?

(*viii*) Why is it said that, in case of star-delta starting of 3 φ induction motor, it behaves equivalent to a specific case of auto-transformer starting where the value of tap of auto-transformer is $1/\sqrt{3}$?

(*ix*) Why are main and auxiliary windings essential at the time of starting of single-phase induction motor?

(*x*) What are the basic requirements of servomotors?

S'11 : 5 AN : EL 405 (1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Which method will you adopt to control the speed of a d.c. shunt motor below the base speed ? This method of speed control is called a constant torque drive method. Explain. 10

(*b*) The speed of a 500 V d.c. shunt motor is raised from 700 rpm to 1000 rpm by field weakening, the total torque remaining unchanged. The armature and field resistances are 0.8 Ω and 750 Ω, respectively, and the current at the lower speed is 12 A. Calculate the additional shunt field resistance required, assuming the magnetic circuit to be unsaturated. Neglect all losses. 10

2. (*a*) The Hopkinson test on two shunt machines gave the following results for full load:
Line voltage = 250 V; Line current = excluding field currents, 50 A; Motor armature current = 380 A; Field currents = 5 A and 4.2 A.
Draw the circuit diagram and mark the values. Assuming resistance of each machine as 0.02 Ω, determine the efficiency of each machine. 8

(*b*) A 200 V, 2000 rpm, 10 A, separately excited d.c. motor has an armature resistance is of 2 Ω. Rated d.c. voltage is applied to both the armature and field winding of the motor. If the armature draws 5 A from the source. find the torque developed by the motor. 6

(*c*) A 250 kW and 750 kW, 550 V generators operate in parallel, delivering a total load of 1500 A. The voltage regulation of the smaller machine is 0.058 in per unit and for larger one is 0.035 in per unit. Assume that the external characteristics are straight lines. Effect of armature reaction is negligible. Determine the (*i*) current delivered by each machine, and (*ii*) terminal voltage. 6

3. (*a*) What are the requirements for a satisfactory parallel operation of two 3-phase transformers? 4

(*b*) A 100 kVA transformer, having 1% resistance and 4% leakage reactance, is operated in parallel with a 200 kVA transformer having 1% resistance and 6% leakage reactance. If the total load delivered is 300 kVA at unity p.f., calculate the kVA load on each transformer as well as the operating p.f. of each transformer. Also, determine the largest value of load that can be delivered by the parallel combination of two transformers without overloading any of them. Derive the formula used. 16

4. (*a*) Derive an expression for the power developed by a salient pole synchronous machine. 4

(*b*) What are the V-curves of a synchronous motor? 4

(*c*) A 3-phase, 5 kVA, 220 V, 50 Hz star-connected alternator has negligible armature resistance and a synchronous reactance of 10Ω per phase and is operated in parallel with a 3-phase 220 V, 50 Hz supply. The machine is delivering rated kVA at 0.8 lagging p.f. If the field excitation is increased by 20%, without changing the prime mover power, find the new value of armature current and p.f. At what power output, would the alternator break from synchronism with this new value of excitation? What are the corresponding values of armature current and p.f.? 12

Group B

5. (*a*) Name the various methods of speed control slip-ring and cage rotor induction motor. 4

(*b*) Two induction motors, with 4-poles and 6-poles, respectively, are connected in cumulative cascade. The frequency in the secondary circuit of 6-pole motor is observed to be 2.0 Hz. Determine the combined speed of the set and the slip in each machine. Assume supply frequency as 50 Hz. 8

(*c*) An 8-pole, 50 Hz, 3-phase induction motor has an equivalent rotor resistance of 0.071 Ω per phase. If its stalling speed is 630 rpm, how much resistance must be included per phase to obtain maximum torque at starting. Ignore magnetizing current. 8

6. (*a*) Give two applications of servo motors. 2

(*b*) A 400 V, 3-phase, 50 Hz, star-connected, induction motor has the following test results:

No-load test: 400 V, 8.5 A, 1100 W

Blocked rotor test: 180 V, 45 A, 5700 W

Calculate the line current and power factor when operating at 4% slip. The stator resistance per phase is 0.5 Ω. Give a proof of the slip scale method. 18

7. (*a*) A 3-phase, 50 Hz, 400 V wound rotor induction motor runs at 960 rpm at full load. The rotor resistance and stand-still reactance per phase are 0.2 Ω and 1.0 Ω, respectively. If a resistance of 1.8 Ω is added to each phase of the rotor at standstill, what would be the ratio of starting torque with full voltage and the added resistance to the full load torque under normal running conditions? State assumptions made in your calculations. Can the same starting torque be obtained with another value of additional resistance? Explain. If the answer is yes, find its value. 10

(*b*) A cage induction motor takes 175% of full-load current and develops 35% of full-load torque at starting, when operated with a star/delta starter. What will be the starting torque and current, if an auto-transformer starter with 80% tapping is employed. 10

8. (*a*) Why does a single-phase induction motor not possess any starting torque? 5

(*b*) What is a servo motor? Why and where is a drag-cup rotor servo motor used? 5

(*c*) A 4-pole, 230 V, 50 Hz, single phase induction motor runs at 1425 rpm. The power absorbed by the forward and backward fields are 245 W and 35 W, respectively. The no load rotational losses is 45 W. Determine the developed torque and shaft torque. 10

Group C

9. Answer the following in brief: 10 × 2

(*i*) Why is in a normal synchronous machine x_q smaller than x_d?

(*ii*) Resistance of dampers for synchronous generators is lower than that of dampers for synchronous motors. Why?

(*iii*) What is meant by an infinite bus?

(*iv*) Distribution transformers are designed for lower iron losses. Why?

(*v*) What are the functions of transformer oil?

(*vi*) Do we use laminations for all iron parts of an electrical machine. If not, why?

(*vii*) Explain why in an induction motor a high value of rotor resistance is preferred at starting?

(*viii*) Why is an ordinary induction motor not started at normal voltage?

(*ix*) Why is the rotor core loss almost absent in normal operating condition of an induction motor ?

(*x*) Why is star-delta starter not suitable for high voltage induction motor ?

W'11:5 AN:EL 405(1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What is armature reaction ? Describe demagnetizing and cross-magnetizing effects of armature reaction in a d.c. machine. 6

(*b*) A d.c. generator has an armature emf of 100 V when the useful flux per pole is 20 mWb and speed is 800 rpm. Calculate the generated emf (*i*) with the same flux and a speed of 1000 rpm, and (*ii*) which flux per pole of 24 mWb and a speed of 900 rpm. 8

(*b*) Explain the process of building up of voltage in d.c. generators and give the conditions to be satisfied for voltage build-up. 6

2. (*a*) Explain the speed-current and speed-torque characteristics of a d.c. series motor. Account for the shape of these characteristics curves. 6

(*b*) A shunt generator delivers 50 kW at 250 V when running at 400 rpm. The armature and field resistance are 0.02 Ω and 50 Ω, respectively. Calculate speed of the machine when running as a shunt motor and taking 50 kW input at 250 V. Allow 1 V per brush for contact drop. 10

(*c*) Explain why a d.c. series motor should never run unloaded. 4

3. (*a*) State the conditions for proper operation of two transformers in parallel giving reasons for imposition of these conditions. 6

(*b*) Two single phase transformers, having the same voltage ratio on no-load, operate in parallel to supply a load of 1000 kVA at 0.8 power factor lagging. One of the transformers is rated at 400 kVA and has a per unit equivalent impedance of $(0.01 + j\,0.06)$; and the other one is rated at 600 kVA and has a per unit equivalent impedance of $(0.01 + j\,0.05)$. Determine the load on each of the transformer (in kVA) and the operating power factor. 10

(*c*) What is an open-delta (V-V) system ? What are the applications of this system ? 4

4. (*a*) A three-phase, 16-pole synchronous generator has a resultant air-gap flux of 0.06 Wb/pole. The flux is distributed simultaneously over the pole. The stator has two slots per pole per phase and four conductors per slot are accommodated in two layers. The coil span is 150° electrical. Calculate this phase and line-induced voltages when the machine runs at 375 rpm. 10

(*b*) Discuss the phenomenon of sudden three-phase short circuit at the armature terminals of an alternator. Draw a typical wave shape of current and mark the different regions. Write an expression of the current. 6

(*c*) What is a short-circuit ratio ? Why are modern alternators designed with high value of short-circuit ratio (SCR) ? 4

Group B

5. (*a*) Explain the principle of operation of a three-phase synchronous motor. Draw phasor diagrams of cylinderical rotor synchronous motor for lagging and leading power factors, and discuss these phasor diagrams. 8

(*b*) Why is synchronous motor not self-starting ? What are the methods generally used to start synchronous motors ? 2

(*c*) A three-phase, 3.3 kV, 2 pole, 3000 rpm, 934 kW synchronous motor has an efficiency of 0.95 p.u. and delivers full-load torque with its excitation adjusted so that input power factor is unity. The moment of inertia of the motor and its load is 30 kg-m^2 and synchronous impedance is $(0.0 + j\,11.1)$ Ω. Determine the period of undamped oscillation on full load for small changer in load angle. 10

6. (*a*) A 6-pole, 230 V, 50 Hz, star-connected, three-phase induction motor has the following parameters on a per-phase basis; R_1 = 0.5 Ω, R_2 = 0.25 Ω, X_1 = 0.75 Ω, X_2 = 0.5 Ω, X_0 = 100 Ω, and R_0 = 500 Ω. The friction and windage loss is 150 W. Find the efficiency of the motor at its rated slip of 2.5 percent. 10

(*b*) How does the increase in the rotor resistance affect the breakdown slip, the starting torque, and the breakdown torque with regard to an induction motor ? Show by sketching the torque-slip characteristics. 6

(*c*) What is the effect of increase in rotor reactance on the starting current and the maximum torque as regard to an induction motor ? 4

7. (*a*) Using double-revolving field theory, explain the operation of a single-phase induction motor. Also, describe the torque-slip characteristics of the motor based on constant forward and backward flux waves. 8

(*b*) A 220 V single-phase induction motor gave the following test results : Blocked-rotor test : 120 V, 9.6 A, 460 W. No-load-test : 220 V, 4.6 A, 125 W. The stator winding resistance is 1.5 Ω, and during the block rotor test, the starting winding is open. Determine the equivalent circuit parameters. Also, find core, friction, and windage loss of the motor. 12

8. (*a*) Explain the principle of operation of a linear induction motor. Draw its characteristics. Also, list its important applications. 10

(*b*) Describe the operation of a variable reluctance-type stepper-motor. What do you mean by micro-stepping ? 10

Group C

9. Answer the following in brief : 10 × 2

(*i*) Why do round rotor synchronous generators have small diameters and large axial length of core ?

(*ii*) Why does open-circuit characteristics of a synchronous machine have curved shape ?

(*iii*) Do slot harmonics affect the torque-speed curve of a three-phase induction motor ?

(*iv*) Why are brushes of a d.c. machine made of carbon ?

(*v*) Why are interpoles used in a d.c. machines ?

(*vi*) What is the all-day efficiency of a transformer ?

(*vii*) What is the use of oil in a transformer ?

(*viii*) Why are core-type transformer used in high-voltage circuits ?

(*ix*) How are iron losses in a transformer made very small ?

(*x*) In a short-circuit test performed on a transformer, iron losses are negligible — why ?

S'12:5 AN: EL 405 (1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) Which method will you adopt to control the speed of a d.c. shunt motor above the base speed ? This method of speed control is called a constant power drive method. Explain. 10

(*b*) The magnetisation characteristic of a 4-pole d.c. series motor may be taken as proportional to the current over a part of working range ; on this basis the flux per pole is 4.5 mWb/A. The load requires a gross torque proportional to the square of the speed equal to 30 N.m at 1000 rpm. The armature is wave wound and has 492 armature conductors. Determine the speed at which the motor will run and the current it will draw when connected to a 220 V supply, the total resistance of the motor being 2.0 Ω. 10

(*Turn Over*)

2. (*a*) The Hopkinson test on two shunt machines gave the following results for full load : Line voltage–250 V ; line current, excluding field currents , 50 A ;motor armature current, 380 A ; and field currents 5 A and 4.2 A. Draw the circuit diagram and mark the values. Assuming resistance of each machine as 0.02 Ω , determine the efficiency of each machine. 8

(*b*) A 200 V, 2000 rpm, 10 A, separately excited dc motor has an armature resistance of 2 Ω . Rated d.c. voltage is applied to both the armature and field winding of the motor. If the armature draws 5 A from the source, find the torque developed by the motor. 6

(*c*) A 250 kW and 750 kW, 550 V generators operate in parallel, delivering a total load of 1500 A. The voltage regulation of the smaller machine is 0.058 in per unit and for larger one is 0.035. Assume the external characteristic are straight lines. Effect of armature reaction is negligible. Determine the (*a*) current delivered by each machine, and (*b*) terminal voltage. 6

3. (*a*) What are the requirements for a satisfactory parallel operation of two 3-phase transformers ? 4

(*b*) A 100 kVA transformer having 1% resistance and 4% leakage reactance is operated in parallel with a 200 kVA transformer having 1% resistance and 6% leakge reactance. If the total load delivered is 300 kVA at unity p.f., calculate the kVA load on each transformer as well as the operating p.f. of each transformer. Also, determine the largest value of load that can be delivered by the parallel combination of two transformers without overloading any of them. Derive the formula used. 16

4. (*a*) Derive an expression for the power developed by a salient pole synchronous machine. 4

(*b*) What are the V-curves of a synchronous motor ? 4

(*c*) A 3-phase, 5 kVA, 220 V, 50 Hz star-connected alternator has negligible armature resistance and a synchronous reactance of 10 Ω per phase and is operated in parallel with a three-phase 220 V, 50 Hz supply. The machine is delivering rated kVA at 0.8 lagging p.f. If the field excitation is increased by 20%, without changing the prime mover power, find the new value of armature current and p.f. At what power output, would the alternator break from synchronism with this new value of excitation ? What are the corresponding values of armature current and p.f. ? 12

Group B

5. (*a*) Explain why the rotor of a squirrel cage induction motor is forced to rotate in the same direction as the rotating magnetic field. 5

(*b*) What are two types of rotor constructions used in induction motors ? Compare them. 5

(*c*) A balanced three-phase induction motor has an efficiency of 85% when its output is 45 kW. At this load, both the star copper loss and rotor copper loss are equal to the core loss. The mechanical losses are one-fourth of the no-load losses. Calculate the slip. 10

6. (*a*) Explain how the speed of slip-ring induction motor can be varied by varying its rotor circuit resistance. What are the limitations of this method ? 10

(*b*) A 8-pole 50 Hz, three-phase induction motor is loaded deliberately to a point where pull-out torque will occur. The rotor resistance per phase is 0.3 Ω and motor stall at 650 rpm. Calculate the (i) breakdown slip, (ii) locked rotor reactance, (iii) rotor frequency at the maximum torque point, and (iv) suppose this motor develops twice the full-load torque when started with rotor short-circuited and it runs at a full-load speed of 675 rpm. If resistance of 0.7 Ω is added in series with rotor per phase, calculate the new full-load with added resistance. 10

7. (a) A three-phase, 50 Hz, 400 V wound rotor induction motor runs at 960 rpm at full load. The rotor resistance and standstill reactance per phase are 0.2 Ω and 1.0 Ω, respectively. If a resistance of 1.8 Ω is added to each phase of the rotor at standstill, what would be the ratio of starting torque with full voltage and the added resistance to the full load torque under normal running conditions ? State assumptions made in your calculations. Can the same starting torque be obtained with another value of additional resistance ? Explain. If the answer is yes, find its value. 10

(b) A cage induction motor takes 175% of full-load current and develops 35% of full-load torque at starting, when operated with a star/delta starter. What will be the starting torque and current, if an auto-transformer starter with 80% tapping is employed ? 10

8. (a) Why does a single-phase induction motor not possess any starting torque ? 5

(b) What is a servomotor ? Why and where is a drag-cup rotor servomotor used ? 5

(c) A 4-pole, 230 V, 50 Hz, single phase induction motor runs at 1425 rpm. The power absorbed by the forward and backward fields are 245 W and 35 W, respectively. The no-load rotational losses is 45 W. Determine the developed torque and shaft torque. 10

Group C

9. Choose the *correct* answer for the following : 20 × 1

(i) If a 230 V d.c. series motor is connected to 230 V a.c. supply, the

(a) motor will vibrate violently.

(b) motor will run with less efficiency and more sparking.

(c) motor will not run.

(d) fuse will be blown.

(ii) The direction of rotation of a single-phase induction motor can be reversed by reversing the

(a) leads of main winding.

(b) leads of auxiliary winding.

(c) supply leads.

(d) either (a) or (b) above.

(iii) For which one of the following applications is the universal motor most suitable ?

(a) Table fan

(b) Tape recorder

(c) Hand-operated drilling machine

(d) Recorder player

(iv) Direct axis synchronous reactance of a salient pole synchronous motor can be estimated fairly from short-circuit and open-circuit tests.

(*a*) True

(*b*) False

(*v*) In a three-phase round-rotor synchronous machine, the effect of armature reaction is taken care of by

(*a*) synchronous reactance.

(*b*) magnetizing reactance.

(*c*) self-reactance.

(*d*) leakage reactance.

(*vi*) The sum of armature mmfs in three-phases of the stator winding of a synchronous generator is zero.

(*a*) True

(*b*) False

(*vii*) A three-phase synchronous motor, having constant excitation, drives a load taking power from infinite bus at leading p.f., if the shaft load decreases,

(*a*) the power angle decreases while p.f. increases.

(*b*) the power angle increases while p.f. decreases.

(*c*) both power angle and p.f. decrease.

(*d*) both power angle and p.f. increase.

(*viii*) For the same power rating, an alternator operating at lower voltage will be

(*a*) less noisy.

(*b*) costlier.

(*c*) larger in size.

(*d*) more efficient.

(*ix*) In a synchronous generator, a divided winding rotor is preferable to a conventional winding rotor because of

(*a*) higher efficiency.

(*b*) increased steady-state stability limit.

(*c*) higher short circuit ratio.

(*d*) better damping.

(*x*) An induction motor and a synchronous motor are connected to a common feeder line. To operate the feeder line at unity p.f., the synchronous motor should operate

(*a*) under excited.

(*b*) over excited.

(*c*) normally excited.

(*d*) disconnected from common terminals.

(*xi*) It is desired to eliminate fifth harmonic voltage from the phase voltage of an alternator. The coils should be short-pitched by an electrical angle of

(*a*) 30°

(*b*) 36°

(*c*) 72°

(*d*) 18°

(*xii*) High frequency transformers use

(*a*) aluminium core.

(*b*) iron core.

(*c*) air core.

(*d*) copper core.

(*xiii*) The all day efficiency of a transformer is

(*a*) less than its power efficiency.

(*b*) equal to power efficiency.

(*c*) more than power efficiency.

(*d*) unrelated to power efficiency.

(*xiv*) Circular coil sections are used, because they

(*a*) have better mechanical strength.

(*b*) are easy to wind.

(*c*) reduce copper loss.

(*d*) reduce iron loss.

(*xv*) In an auto-transformer, power is transferred through the

(*a*) inductive process.

(*b*) conduction process.

(*c*) mutual coupling process.

(*d*) both (*a*) and (*b*) above.

(*xvi*) The magnetising current in a transformer is rich in

(*a*) third harmonic.

(*b*) fifth harmonic.

(*c*) seventh harmonic.

(*d*) thirteenth harmonic.

(*xvii*) Transformer transforms

(*a*) voltage.

(*b*) frequency.

(*c*) current.

(*d*) power.

(*xviii*) The efficiency of a well designed transformer may be expected in the range of

(*a*) 75% to 80%.

(*b*) 65% to 70%.

(*c*) 85% to 90%.

(*d*) 95% to 99%.

(*xix*) The leakage flux in a transformer depends upon

(*a*) supply frequency.

(*b*) load current.

(*c*) mutual flux.

(*d*) None of the three above.

(*xx*) The shunt motor has

(*a*) hard torque-speed characteristics.

(*b*) soft torque-speed characteristics.

(*c*) speed varies with load.

(*d*) speed varies greatly with load.

W'12: 5 AN: EL 405 (1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

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Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) Explain the procedure of bringing a d.c. shunt generator in parallel with a loaded d.c. generator and transferring part load to it. 6

(*b*) A shunt generator, which gives a terminal voltage of 400 V at no load and 360 V when delivering 100 A, is working in parallel with one which gives 400 V on no load and 350 V when delivering 100 A. If the voltage characteristics of the machines are approximately linear, find the common terminal voltage and the current in each when they are storing a total load of 100 A. 6

(*c*) Draw the circuit of 'diverter field control' method of speed control of a d.c. series motor. Deduce a suitable expression for motor speed in terms of various resistances and constants of the machine. 8

2. (*a*) What does Dy 1 connection of a three-phase transformer mean ? Draw the windings, show the connections labelling various terminals. Also, draw the phasor diagram of voltages on high voltage side and the low voltage side for this connection. 7

(*b*) Where are star/delta and star/zig-zag connections of three-phase transformers used ? Discuss. 7

(*c*) The open delta connection has 58% rating of the normal delta/delta connection rating. Explain. 6

3. (*a*) Explain the 'preventive reactor' on load tap changing arrangement of transformers. 6

(*b*) Considering that the resultant flux in the air gap of a synchronous generator is the phasor sum of the field flux phasor and the armature reaction flux phasor, draw the phasor diagram showing various fluxes and emf. 6

(*c*) If a field excitation of 10 A in a certain alternator gives a current of 150 A on short-circuit and a terminal voltage of 900 V on open-circuit, find the internal voltage drop with a load current of 60 A. 4

(*d*) What is understood by direct-axis reactance and quadrature-axis reactance of a synchronous machine ? Which one of the two is smaller and why ? 4

4. (*a*) Explain, with the help of phasor diagram(s), the V curves of a synchronous motor. 10

(*b*) A 1000 kW, 3-phase, star-connected, 3.3 kV, 24 pole, 50 Hz synchronous motor has a synchronous reactance of 3.24 Ω per phase; the resistance being negligible. The motor is fed from infinite bus at 3.3 kV. Its field excitation is adjusted to result in unity power factor operation at rated load. Find the maximum power and torque that the motor can deliver with its excitation remaining constant at this value. 10

Group B

5. (*a*) Explain the production of air-gap rotating field when the symmetrically wound armature of a three-phase machine is supplied from a balanced three-phase supply. 8

(*b*) If the emf in the stator of an 8-pole induction motor has a frequency of 50 c/s, and that in the rotor $1\frac{1}{2}$ c/s, at what speed is the motor running and what is the slip ? 4

(*c*) Draw the equivalent circuit of a three-phase induction machine and the torque slip characteristics for a slip range of −1.0 to 2.0. 8

6. (*a*) Explain the auto-transformer starter for starting a three-phase squirrel cage induction motor drawing a circuit diagram. Find the ratios of starting to normal torques and currents as a function of transformer tap. 10

(*b*) The power input to a three-phase induction motor is 60 kW. The stator losses total 1 kW. Find the total mechanical power developed, and the rotor copper loss per phase, if the motor is running at 3% slip. 4

(*c*) State the salient features of a d.c. servo motor. 6

7. (*a*) Describe the frequency control method of speed control of induction motors. Also, develop the torque-speed relation under constant v/f condition. 12

(*b*) In a short-circuit test, a 12-pole, 3-phase, 50 c/s induction motor took 100 kW. Find the starting torque developed in N-m. Assume equivalent stand-still rotor resistance equal to the stator resistance. 8

8. (*a*) Develop the equivalent circuit of a pure single-phase induction motor using double revolving field theory. 10

(*b*) Give the construction and working of an a.c. series motor. Draw its circuit model and the phasor diagram for a.c. operation. 10

Group C

9. Answer the following in brief: 10 × 2

(*i*) Why are the pole shoes of d.c. machines laminated ?

(*ii*) If the magnetization characteristic were a straight line passing through the origin, the shunt generator will not be able to build voltage. Discuss.

(*iii*) In the field control method of speed control, the speed can only be increased above normal. Explain.

(*iv*) What is the effect of increasing the frequency on hysteresis loss with voltage magnitude remaining same ?

(*v*) How does a delta-connected tertiary winding of a transformer suppress harmonic voltages ?

(*vi*) What is the phase difference between fifth harmonic voltages present in the three-phase windings and their phase sequence ?

(*vii*) What is the design change made in an a.c. servo motor to obtain linear torque-speed characteristic ?

(*viii*) What ill effects occur, if a d.c. series motor is connected to a.c. mains ?

(*ix*) Why is a compensating winding provided in a.c. series motor ?

(*x*) Why is the short-circuit characteristic of a synchronous machine linear, whereas its open circuit characteristic is non-linear ?

S'13 : 5 AN : EL 405 (1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain the parallel operation of d.c. shunt generators. **6**

(*b*) Two d.c. shunt generators are operating in parallel. One has an external characteristic which may be considered a straight line rising from 450 V at no-load to 500 V at 100 A. The other has characteristic which may also be considered a straight line with 450 V at no-load to 480 V at 80 A. Determine the common busbar voltage and current supplied by each machine when the total current supplied is 160 A. **8**

(*c*) Describe in detail the speed control of d.c. shunt motors by flux control method. **6**

2. (*a*) What is meant by three-phase transformer vector groups ? What is the significance of the groups ? 5

(*b*) Explain in detail the conversion of three-phase to two-phase transformer. 10

(*c*) What are different transformer corrections ? 5

3. (*a*) What are the drawbacks of brake test on d.c. machines ? 5

(*b*) Explain in detail about Swinburne's test or No-load test of d.c. motor. 10

(*c*) Write a short note on 'load tap changing' ? 5

4. (*a*) What are V-curves with regard to synchronous motor ? Also, explain the same with practical significance. 10

(*b*) Explain how a synchronous motor may act as a synchronous condenser and draw the phasor diagram of the synchronous condenser. 10

Group B

5. (*a*) Draw the slip-torque characteristics of double-cage squirrel cage motor. 10

(*b*) Explain in detail various methods of speed control for induction motors. 10

6. Explain working of various starters used for induction motors with a neat sketch. 20

7. (*a*) What are various types of single-phase induction motors ? Discuss their respective applications. 6

(*b*) Explain in detail about the working principle and operation of split phase induction motor. 14

8. (*a*) Explain in detail the construction of the circle diagram for induction motor, and the parameters determined for the circle diagram. 10

(*b*) Explain the load test on three-phase induction motor to evaluate its performance with a neat sketch. 10

Group C

9. Answer the following in brief : 10 × 2

(*i*) Why is the transformer rating in kVA ?

(*ii*) What is meant by leakage flux in general ?

(*iii*) Write the necessity of damper winding in synchronous machine.

(*iv*) Which part of the d.c. machine is laminated and why ?

(*v*) What is the difference between lap winding and wave winding ?

(*vi*) What is the design change made in an a.c. servomotor to obtain linear torque-slip characteristics ?

(*vii*) Define slip of an induction motor.

(*viii*) Why is the compensating winding provided in a.c. series motor ?

(*ix*) Explain the use of slip ring and brushes.

(*x*) Derive the condition for maximum torque.

W'13 : 5 AN : EL 405 (1466)

ELECTRICAL MACHINES

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Write the conditions to be satisfied before two d.c. generators are connected in parallel. 6

(*b*) Why is it necessary to provide equaliser bar for parallel operation of series generators ? 6

(*c*) Two shunt generators, each with an armature resistance of 0.01 Ω and field resistance of 20 Ω, run in parallel and supply a total load of 4000 A. The emfs are 210 V and 220 V, respectively. Calculate the bus bar voltage and output of each machine. 8

2. (*a*) What are the advantages of a Transformer Bank of 3 single-phase transformers over a three-phase unit transformer ? 6

(*b*) Where are delta-star connection of a three-phase transformer used ? Show the winding connection for a DY_{11} connection (for 30° lead). 6

(*c*) How is a three-phase supply converted to a two-phase system ? Show the connection, mentioning in brief the winding arrangement and the power output. 8

3. (*a*) With the help of a phasor diagram, show how the regulation of an alternator is computed from the synchronous impedance of the machine for a given load current. 6

(*b*) A three-phase star connected 1000 kVA, 11 kV alternator has rated current 52.5 A. The a.c. resistance of the winding/phase is 0.45 Ω. The test result shows that a field current of 12.5 A gives an open-circuit voltage of 422 V between lines and 52.6 A of armature current on short-circuit. Determine the full load voltage regulation of 0.8 p.f. leading. 8

(*c*) Draw a simple circuit diagram for an alternator to be synchronised with the bus bar. Write the steps to be followed briefly. 6

4. (*a*) When do you get two different reactances X_d and X_q in a synchronous machine ? How do you determine these reactances experimentally ? Show the connection and write the steps to be followed. 8

(*b*) Draw the phasor diagram of a round rotor synchronous motor with the field winding excited to more than 100%. 4

(*c*) A star-connected synchronous with X_S = 1.2 Ω/phase is connected to a 400 V, three-phase supply and takes a current of 20 A at 0.8 power factor leading. Estimate the excitation current in terms of its nominal value. 8

Group B

5. (*a*) Starting from the equation for the rotor current, show how you can get the equivalent circuit of a three-phase induction motor. How is the mechanical power developed and calculated from the equivalent circuit ? 8

(*b*) How do you estimate the starting torque T_{st} and the maximum torque T_{max} from the parameters of the equivalent circuit ? 4

(*c*) A 6-pole, 50 Hz, three-phase induction motor develops a useful torque of 150 N-m when the rotor current makes 120 complete cycles/min.

(*i*) Calculate the slip, mechanical power developed and net shaft power developed, if the torque lost in friction is 8 N-m. 2 + 3

(*ii*) Determine the copper loss and the input, if total stator loss = 800 W. 2 + 1

6. (*a*) Why is star delta starting preferred to DoL (Direct on Line) starting in case of large induction motors ? Compare the relative values of starting torques in two cases. 4 + 4

(*b*) Show the circuit diagram for a star-delta starter. 6

(*c*) Name different methods of controlling the speed of an induction motor. Describe *any one* of the methods with the diagram of the control element. 2 + 4

7. (*a*) Describe how from a pulsating magnetic field in a single-phase motor, a rotating magnetic field is created with the help of an auxiliary winding. 8

(*b*) Show how an armature winding connected with a series field can develop a non-zero average torque, even if the supply is a.c. 4

(c) Sketch the torque-speed characteristic of a single-phase induction motor showing the forward, backward and net torque in the speed range of 8

$$-N_s \leq n \leq N_s.$$

8. (a) Explain, with a neat diagram, how a torque is produced in a shaded pole induction motor by the splitting of the flux. 8

(b) How can one use a two-phase motor for measuring the speed of a shaft ? Show the schematic diagram. 6

(c) Explain, with a neat diagram, the arrangement of windings in a two-phase a.c. servomotor. Show the torque-speed characteristics and mention its characteristic feature relating to the rotor impedances. 6

Group C

9. Answer *any five* of the following : 5 × 4

(i) Show the connection for two identical d.c. series motors for traction purposes at low speed and high speed.

(ii) Mention the advantages of a V-V (open delta) connection of a three-phase transformer, showing the connection.

(iii) Explain the need for interpole and compensating windings in a d.c. machine.

(iv) How can one control the speed of a d.c. shunt motor ? Show the simple connections.

(v) If a transformer 11kV/400V, 50 Hz is energised by a source of 11 kV, 60 Hz supply, will the no-load losses increase or decrease or remain unaltered ? Justify your answer.

(vi) Explain the principle of operation of a d.c. servomotor.

(vii) How are the direct axis and quadrature axis reactances, X_d and X_q determined experimentally ?

(viii) What are the advantages of a three winding transformer ? Show its connection and equivalent circuit.