ELECTRICAL MACHINES – II
(ELEC 3101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The pole pitch in electrical machine is
(a) $= 180^0$ electrical (b) $> 180^0$ electrical
(c) $< 180^0$ electrical (d) $= 180^0$ mechanical

(ii) In an alternator when the load increases then the terminal voltage for constant field
(a) drop (b) rises
(c) either drop or rises (d) does not have any change

(iii) The synchronous condenser is an
(a) over excited synchronous motor
(b) under excited synchronous motor
(c) normal excited synchronous motor
(d) over or under excited synchronous motor

(iv) A synchronous motor is operating on no load at unity power factor. If the field current is increased, the pf will become
(a) leading and current will decrease (b) lagging and current will increase
(c) lagging and current will decrease (d) leading and current will increase

(v) Synchronous motor runs at
(a) leading power factor (b) lagging power factor
(c) unity power factor (d) any one of the above

(vi) Torque developed by a 3-phase, 400 V, induction motor is 100 N-m. if the applied voltage is reduced to 200 V, the developed torque will be
(a) 50 N-m (b) 25 N-m
(c) 200 N-m (d) 1000N-m

(vii) A 3-phase 440 V, 50 Hz induction motor has 4% slip. The frequency of rotor current will be
(a) 50 Hz (b) 25 Hz (c) 5 Hz (d) 2 Hz

(viii) The starting torque of an induction motor can be increased by
(a) increasing the rotor reactance
(b) increasing the rotor resistance
(c) increasing the supply frequency
(d) giving supply through star-delta starter

(ix) The type of single-phase induction motor having the highest power factor at full load is
(a) shaded pole type
(b) split phase type
(c) capacitor-start type
(d) capacitor-run type

(x) A universal motor operates on
(a) constant speed and varying load
(b) constant load and varying speed
(c) approximately constant speed and load
(d) synchronous speed with varying load

Fill in the blanks with the correct word

(xi) For inductive load the effect of armature reaction of an alternator on main field flux is _____.

(xii) A 400V, 60hz synchronous machine has 6 poles. The synchronous speed in rpm is _____.

(xiii) A cylindrical rotor synchronous machine has maximum power output when power angle δ is _____.

(xiv) The ratio of starting torque to maximum torque of a 3-phase, 50Hz, 4 pole induction motor for a maximum torque at 1200 rpm is _____.

(xv) In a double squirrel cage induction motor, the resistance of upper cage is _____ than that of inner cage.

Group - B

2. (a) Why the short pitch winding is used? *[(CO1)(Understand/LOCQ)]*
(b) Calculate the distribution factor for a 3-phase 4 pole, 48 slots distributed single layer winding of an alternator. *[(CO1)(Remember/LOCQ)]*
(c) A 3-phase star connected turbo alternator having a synchronous reactance of 10 ohm per phase and negligible armature resistance has an armature current of 20 A at unity pf. The supply voltage is constant at 11 kV at constant frequency. If the steam admission is unchanged and the emf is raised by 25%, determine the new current and power factor. *[(CO3)(Analyse/HOCQ)]*

2 + 3 + 7 = 12

3. (a) Explain how the rotating magnetic field is being created within the stator of an 3-phase alternator connected across 3-phase supply. *[(CO1)(Understand/LOCQ)]*
(b) Explain why the rating of the alternator is in kVA? *[(CO2)(Understand/LOCQ)]*

(c) An alternator has an efficiency of 90% when operating at 0.8 p.f. leading power factor at rated kVA. Explain what happened to its efficiency at rated kVA but 0.8 p.f. lagging. *[(CO1)(Analyse/HOCQ)]*

6 + 3 + 3 = 12

Group - C

4. (a) A synchronous motor is operating at a certain load. Examine how you will find out in the laboratory whether it is operating at leading power factor or lagging power factor. *[(CO3)(Analyse/HOCQ)]*

(b) Describe the methods of starting of synchronous motor with light load. *[(CO3)(Remember/LOCQ)]*

(c) A synchronous motor is operating at 0.2 p.f lagging at half full load. With Ef, Vt, Xs remain constant. Analyze whether its p.f is worsened or improved when it made to operate at full load. *[(CO3)(Apply/IOCQ)]*

4 + 4 + 4 = 12

5. (a) A synchronous motor is supplying a certain load. In order to stop the motor, it is essential to switch off first the a.c. supply and then the field current. Explain the reason. *[(CO3)(Apply/IOCQ)]*

(b) A 25MVA, 3-phase, 11kV, 50Hz, 8-pole, star connected synchronous motor has $X_d = 5\Omega$ and $X_q = 2\Omega$. At full load unity power factor and rated voltage, find (i) excitation voltage, (ii) active power, (iii) synchronizing power per electrical degree (iv) synchronizing power per mechanical degree. *[(CO3)(Remember/LOCQ)]*

4 + 8 = 12

Group - D

6. (a) A 100 kW , 440 V, 3-phase, 6-pole, 50 Hz, wound-rotor induction motor has a full-lad slip of 0.03 and the slip at maximum torque of 0.2 when operating at rated voltage and frequency with rotor winding short-circuited at the slip-rings. Assume the stator resistance and rotational losses to be neglected. Find:
   (i) Maximum torque,
   (ii) Starting torque, and
   (iii) Full-load rotor copper-loss. *[(CO4)(Apply/IOCQ)]*

(b) Derive the expression for developed torque for a 3-phase induction motor and obtain the condition for maximum torque. Also draw torque-slip curves and discuss the effect of rotor resistance. *[(CO4)(Understand/LOCQ)]*

(2 + 2 + 2) + (2 + 2 + 1 + 1) = 12

7. (a) Why is the rotor resistance starting preferred to reduced voltage starting in case of wound rotor induction motor? *[(CO4)(Remember/LOCQ)]*

(b) Develop the equivalent circuit of a 3 phase Induction Motor and show that a pure resistance in the rotor circuit can represent the mechanical power developed. *[(CO4)(Apply/IOCQ)]*

(c) The rotor of a 4-pole, 50 Hz, slip-ring induction motor has a resistance of 0.25 ohm per phase and runs at 1440 rpm at full load. Determine the external

resistance per phase which must be added to lower the speed to 1200 rpm, the torque being the same as before. *[(CO4)(Evaluate/HOCQ)]*

3 + 5 + 4 = 12

Group - E

8. (a) Explain the double revolving field theory for operation of single-phase induction motor. Draw torque-speed characteristics of a single-phase induction motor based on this theory. *[(CO5)(Understand/LOCQ)]*

   (b) A 230 V, 4-pole, 50 Hz, 1-phase induction motor has an effective rotor resistance and leakage reactance of 0.5 ohm and 5 ohm respectively. It is running at a speed of 1350 rpm. Determine:

   (i) Frequencies of forward and backward rotor current components.

   (ii) Relative magnitudes of forward and backward fluxes. Neglect magnetizing current and stator impedance. *[(CO5)(Evaluate/HOCQ)]*

(4 + 2) + (2 + 4) = 12

9. (a) A 75 W , 2-pole ,50 Hz, 230V single phase series motor having salient poles has the following data:
   Total resistance: 25 ohm, total reactance: 261 ohm, mutual reactance: 121 ohm on the direct axis and stray power loss: 15 W.
   Calculate current, pf and output when running at 6000 rpm. *[(CO5)(Analyse/IOCQ)]*

   (b) Explain, the construction, working principle and torque-speed characteristics of shaded pole induction motor. *[(CO6)(Understand/LOCQ)]*

(2 + 2 + 2) + (2 + 2 + 2) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	48.9	26	25