ELECTRICAL MACHINES - II
(ELEC 3101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Salient pole type alternators are generally used on
(a) low speed primemovers (b) high speed primemovers
(c) low voltage alternator (d) high voltage alternator.

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

(iii) A 4-pole turbo alternator supplies a 50 Hz network. What should be the speed of generator?
(a) 6000 rpm (b) 3000 rpm (c) 1500 rpm (d) 1000 rpm.

(iv) The power developed by synchronous motor is maximum when the load angle is
(a) 0^0 (b) 45^0 (c) 90^0 (d) 120^0

(v) A synchronous motor can be made self starting by providing
(a) damper winding on rotor pole (b) damper winding on stator
(c) damper winding on stator and rotor (d) damper winding on stator or rotor.

(vi) The synchronous condenser is an
(a) over excited synchronous motor running at no load
(b) under excited synchronous motor running at full load
(c) normal excited synchronous motor running at no load
(d) over or under excited synchronous motor running at full load.

(vii) A 3-phase 440 V, 50 Hz induction motor has 4% slip. The frequency of rotor e.m.f. will be
(a) 200 Hz (b) 50 Hz (c) 2 Hz (d) 0.2 Hz.

(viii) The main and auxiliary windings in a single phase induction motor are connected
(a) in parallel (b) in series
(c) either series or parallel (d) through inductive coupling.

(ix) If the capacitor of a single phase induction motor is short circuited
(a) the motor will not start (b) the motor will run in reverse direction
(c) the motor will burn (d) the motor will run at low speed.

(x) If N_S represents synchronous speed, the actual speed of rotation of rotor of a 3-phase induction motor is given as
(a) N_S (b) (1-s) N_S (c) sN_S (d) $0.96N_S$.

Group- B

2. (a) A 400 V, 50 kVA, 50 Hz, 3-phase, star-connected alternator has the armature effective resistance of 0.1Ω per phase. An excitation of 2.5 A produces an open circuit emf of 130 V (line). The same excitation produces a current of 90A on short-circuit. Calculate the full load regulation at (i) 0.8 lagging power factor (ii) 0.8 power factor leading. [(CO2)(Understand/LOCQ)]

(b) An alternator has direct axis synchronous reactance of 0.8 per unit and a quadrature axis synchronous reactance of 0.4 per unit. Calculate the per unit open circuit voltage for full load at a lagging power factor of 0.8. [(CO2)(Understand/IOCQ)]

(c) A turbo generator synchronized with infinite bus-bar operates at unity power factor. If its field current reduced to 80% of previous value, will it be absorbing or delivering reactive power? Explain with phasor diagram. [(CO2)(Evaluate/HOCQ)]

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

3. (a) For a 3-phase, star connected winding with 3 slots per pole per phase and coil span of 8 slots. Compute the distribution and pitch factor. If the flux density wave in the air gap of this machine is found to have 25% third harmonic, find the ratio of line voltage to the phase voltage. [(CO1)(Apply/IOCQ)]

(b) At the time of synchronizing, the frequency of the incoming machine should be slightly higher than that of the infinite bus. Justify this statement. [(CO2)(Evaluate/HOCQ)]

(c) A turbo alternator is delivering power to an infinite bus at lagging power factor. If steam supply to the turbine of the generator stops accidently, explain what happened to the machine and the power factor. [(CO2)(Evaluate/HOCQ)]

(1.5 + 1.5 + 2) + 4 + 3 = 12

Group – C

4. (a) Derive the expression of reactive power input to the synchronous motor in terms of load angle. [(CO3)(Remember/LOCQ)]

(b) 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)(Evaluate/HOCQ)]

(c) Explain from physical considerations, how a synchronous motor can be made to operate at leading or lagging power factor. [(CO3)(Analyze/IOCQ)]

4 + 4 + 4 = 12

5. (a) Explain the hunting phenomena in synchronous machine. [(CO3)(Understand/LOCQ)]
   (b) A 3-phase synchronous motor of 6000 W at 1100 V has synchronous reactance of 6Ω per phase. Find the minimum load current and the corresponding induced emf for full load condition. The efficiency of the machine if 0.8. Neglect armature resistance. [(CO3) (Apply/IOCQ)]
   (c) A 3-phase, star-connected synchronous motor takes 20 kW at 400 V from the mains. The synchronous reactance is 4Ω and the effective resistance is negligible. If the exciting current is so adjusted that the back emf is 550 V, calculate the line current and the power factor of the motor. [(CO3) (Evaluate /HOCQ)]

5 + 4 + 3 = 12

Group – D

6. (a) Explain why the rotor of 3-phase induction motor can never attain synchronous speed. [(CO4)(Understand/LOCQ)]
   (b) How can the starting torque of 3-phase induction motor be increased? [(CO4)(Understand/LOCQ)]
   (c) The output of a 3-phase, 50 Hz, 4-pole induction motor is 10 HP at 1450 rpm. Calculate the starting torque if the maximum torque developed at 1250 rpm. Neglect stator resistance and rotational loss. [(CO4)(Apply/IOCQ)]
   (d) 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)]

2 + 2 + 4 + 4 = 12

7. A 15 kW, 415 V, 50 Hz, 4-pole, Y-connected SCIM gave the following test results

No-Load Test	415 V	10 A	250 W
Blocked Rotor Test	100 V	40 A	1400 W

The DC resistance of the stator winding per phase measured immediately after the blocked rotor test if 0.5 Ω. Calculate the

(i) equivalent circuit parameters (no-load resistance, no-load reactance, no-load impedance, equivalent resistance, equivalent reactance, equivalent impedance) of this SCIM per phase,
(ii) rotational losses,
(iii) draw the equivalent circuit refer to stator side. [(CO4)(Understand/LOCQ)

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

Group – E

8. (a) Classify single phase induction motor in accordance with the method of starting. [(CO5)(Remember/LOCQ)]
   (b) Explain how the shaded pole induction motor operates. [(CO6)(Understand/LOCQ)]
   (c) Explain why the starting torque of a capacitor-start single phase induction motor is better than that of a resistance-start single phase induction motor. [(CO5)(Evaluate /HOCQ)]

3 + 5 + 4 = 12

9. (a) What are the problems encountered when a dc series motor is operated on ac? [(CO6)(Remember/LOCQ)]

   (b) Explain the operation of capacitor split phase type of motor with circuit diagram and torque speed characteristic. [(CO5)(Understand/LOCQ)]

   (c) A 250 W, 230 V, 50hz single phase capacitor start induction motor has the following constants for the main and auxiliary windings. Main winding $Z_m = (4 + j3)\Omega$, auxiliary winding $Z_a = (9 + j3)\Omega$. Determine the value of starting capacitor that will make the main and auxiliary winding currents in quadrature at starting. [(CO6)(Analyze/IOCQ)]

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	46.87	26.04	27.09

Course Outcome (CO):

After the completion of the course students will be able to

1. Have an idea about the general terms of rotating machines.
2. Accrue the knowledge about the construction, operating principle, characteristic and commissioning of Alternators.
3. Accrue the knowledge about the construction, operating principle and characteristic of Synchronous Motor.
4. Understand operating principle and analyze the performance of Three Phase Induction Motors.
5. Able to analyze the performance and starting of Single Phase Induction Motor with their uses depending on their torque speedcharacteristics.
6. Apply the knowledge of special motors for solving engineering problems related to various applications.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question