ELECTRICAL MACHINE-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) Armature reaction in synchronous generator at rated voltage and zero power factor (lead) is
(a) magnetizing
(b) demagnetizing
(c) both magnetizing and cross-magnetizing
(d) cross-magnetizing.

(ii) The backward rotor slip in a single phase induction motor is equal to
(a) 1-s (b) 2-s (c) s (d) s/2.

(iii) Star-delta starting of a polyphase induction motor is equivalent to auto-transformer starting with
(a) 85% tapping (b) 58% tapping
(c) 52% tapping (d) 33.3% tapping.

(iv) In a capacitor-start single-phase induction motor, a capacitor is connected
(a) in series with main winding
(b) in parallel with main winding
(c) in series with auxiliary winding
(d) in parallel with auxiliary winding.

(v) 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.

(vi) In a salient pole synchronous machine where X_d = d-axis synchronous reactance, X_q = quadrature-axis synchronous reaction,
(a) $X_q = X_d$ (b) $X_q > X_d$ (c) $X_q < X_d$ (d) $X_q = 0$.

(vii) The speed regulation of a synchronous motor is
(a) unity (b) zero (c) infinity (d) always less than one.

(viii) The ratio among rotor input, rotor output, and rotor Cu-loss is
(a) 1:(1 - s):s (b) 1:s:(1 - s) (c) s:1:(1 - s) (d) (1 - s):s:1.

(ix) 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) none of the above.

(x) A synchronous capacitor is
(a) ordinary static capacitor bank
(b) an over excited synchronous motor
(c) an over excited synchronous motor without load
(d) none of the above.

Group - B

2. (a) Why are starters used for starting of 3-phase induction motors ?

(b) A 10 kW, 400 V, 4-pole, delta connected squirrel cage induction motor gave the following test results:
No-load test: 400 V, 8.1 A, 750 W
Block rotor test: 90 V , 34 A, 1350 W
The equivalent circuit parameters.

(c) An 8-pole, 50-Hz, 3-phase slip-ring induction motor has effective rotor resistance of 0.08Ω/phase. Speed at maximum torque is 650 rpm. How much resistance must be inserted in the rotor to obtain the half of maximum torque at starting? (Ignore the magnetising current and stator leakage impedance.)

4 + 4 + 4 = 12

3. (a) A 3-phase, 440 V, 1500 rpm slip-ring induction motor is operating with 3% slip and taking a stator current of 45 A. Speed of the motor is reduced at constant torque to 1200 rpm using stator voltage control. Calculate the new value of stator current.

(b) The rotor of a 4-pole, 50 Hz, slip-ring induction motor has a resistance of 0.35 Ω per phase and running at 1440 rpm at full load. Calculate the external resistance per phase which must be added to lower the speed to 1220 rpm, the torque being the same as before.

(c) A 400 V, 3-phase, 50 Hz, 4-pole, star-connected induction motor takes a line current of 15 A with 0.85 p.f. lagging. Its total stator losses, rotor copper losses and mechanical losses are 6%, 5% and 4% of the input respectively. Calculate (i) rotor speed (ii) torque developed in the rotor and (iii) shaft torque.

4 + 4 + 4 = 12

Group - C

4. (a) Explain the function of two stator windings in a single-phase induction motor.

(b) Explain with neat diagrams the operation of a single-phase capacitor-start capcitor-run induction motor. Which capacitor has a higher value, the start or run-capacitor ? Give reason.

(c) Why the reversal of rotation of single-phase induction motors is never a problem?

3 + (4 + 2) + 3 = 12

5.(a) 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.

(b) Explain how the stationary, pulsating m.m.f. wave of single-phase induction motor can be considered as equivalent of two equal but oppositely rotating m.m.f. wave.

(c) Discuss the working of induction generator. Mention its advantage and disadvantage.

3+ 3+ (2+ 4) =12

Group – D

6. Draw and explain the phasor diagram of a salient-pole synchronous generator supplying full-load lagging current. Derive an expression for real power output per phase of the above generator. (The resistance of the armature may be neglected.)

(5 + 7) = 12

7. (a) A 440 V, 10kVA, star connected alternator has reactance due to armature reaction twice that of leakage reactance when rated current is supplied at 0.8 p.f. lagging. Armature resistance R=0.25 Ω, leakage reactance X1=0.7Ω. Find (a) no load voltage (b) no load voltage required to produce rated current in the armature when alternator terminals are short circuited.

(b) A 10MVA, 20kV star connected alternator has armature resistance of 0.5Ω. The machine is supplying 75A current at 0.17 p.f. leading when the terminal voltage is 25 kV. Under this condition, when the load is removed, the terminal voltage becomes 20 kV. Determine the synchronous reactance of the machine.

(c) A 3 - phase star-connected synchronous generator supply current of 10 A having phase angle of 20^0 lagging at 440 V. Find the load angle and the component of armature current I_d and I_q if X_d = 12 Ω and X_q= 7 Ω. (Assume armature resistance to be negligible.)

6 + 3 + 3 = 12

Group – E

8.(a) Derive the expression of mechanical power developed by the synchronous motor.

(b) A 3-phase, Y-connected synchronous motor takes 48 kW at 690 V (line), the p.f. being 0.8 lag. The induced emf is now increased by 30%, the power input being same. Find the new current and p.f. Z_s equals (0 + j2) ohm/phase.

6 + 6 = 12

9.(a) How the power factor of a synchronous motor can be controlled?

(b) What do you understand by a synchronous condenser ? Explain with the help of phasor diagram, its operation and application.

(c) A 3300 V delta-connected motor has synchronous reactance per phase (delta) of 18 Ω. It operates at a leading p.f. of 0.70 when drawing 800 kW from the mains. Calculate its excitation emf.

2+ 5 + 5 = 12