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) The rotor power output of a three-phase induction motor is 15kW and the corresponding slip is 4 percent. The rotor copper loss will be
(a) 600 W (b) 650 W (c) 625 W (d) 700 W.

(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) A centre zero ammeter connected in the rotor circuit of a six-pole 50Hz induction motor makes 30 oscillations in one minute. The rotor speed is
(a) 970 rpm (b) 990 rpm (c) 1010 rpm (d) 1030rpm.

(iv) If the supply voltage decrease by 4%, the torque in a three-phase induction motor would decrease by
(a) 4% (b) 8% (c) 16% (d) 6%.

(v) A 4 pole, three phase induction motor is running at 4% slip at full load. If the speed of the motor is 720 rpm, the supply frequency is
(a) 16Hz (b) 25Hz (c) 50Hz (d) 100Hz.

(vi) 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.

(vii) When a 3-phase synchronous motor is running at synchronous speed, the damper winding produces
(a) damping torque (b) eddy current torque
(c) torque adding the developed torque (d) no torque.

(viii) The phase of an alternator is RYB. If the direction of field current is reversed, the phase sequence will be
(a) RYB (b) RBY (c) BYR (d) none of the above.

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

(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) Two wattmeters are connected to measure the power input to a 3-phase induction motor running at no-load. One wattmeter gives negative reading. Why? Explain.

(b) Why the air gap between the stator core and rotor of an induction motor is made very small?

(c) Explain the phenomena cogging and crawling of a 3-phase induction motor and how to minimize this effect.

3 + 3 + (2 + 2 + 2) = 12

3. (a) The rotor circuit resistance and standstill reactance of a 3-phase induction motor are respectively 0.02Ω and 0.1Ω per phase. At normal voltage, the full-load slip is 4%. Estimate the % change in stator voltage to develop full load torque at half full load speed.

(b) The rotor of an 4-pole, 50Hz, 3-phase induction motor has a resistance of 0.3Ω per phase and runs at 1460 r.p.m. if the load torque remail unchanged, calculate the additional rotor resistance that will reduce this speed by 10%

(c) Why V/f ratio is kept constant while controlling the speed of a 3-phase induction by varying the supply voltage and frequency?

4 + 4 + 4 = 12

Group – C

4. (a) A 230 V, 350 W, 50 Hz, 4-pole, single-phase induction motor gave the following test results:
No load test : 230 V, 84 W, 2.8 A
Block rotor test : 110 V, 460 W, 6.2 A.

The stator winding resistance is 5.0 Ω and during the block rotor test, the auxiliary winding is kept in open circuit condition. Determine the equivalent circuit parameters.

(b) Explain why a single-phase induction motor, as compared to a 3-phase induction motor, has larger slip, less efficiency and more noise.

(c) Explain the principle of working of a shaded-pole type single phase induction motor.

5 + 3 + 4 = 12

5. (a) What is universal motor? How is it different from DC series motor? Mention its application.

(b) A 230 V, 50 Hz, resistance-start single phase induction motor has the following data at standstill:
Main winding impedance, $Z_m = (4 + j12)\ \Omega$
Auxiliary winding impedance, $Z_a = (10 + j10)\ \Omega$
Find the value of external resistance required in series with the auxiliary winding to get maximum torque at starting. Derive the formula used.

(c) Give the condition under which self excited generator may fail to build up voltage.

(2 + 2 + 1) + (2 + 3) + 2 = 12

Group – D

6. (a) Explain how an alternator connected to infinite busbar can be made to operate at leading and lagging pf for a fixed active power output.

(b) An alternator is connected to an infinite bus at terminal voltage of 1 pu. It delivers active power of 0.9 pu. The synchronous reactance of alternator is 1.5pu. Determine the minimum excitation to deliver corresponding power at stability limit.

(c) A 40 MVA, 10 kV, 50Hz, star-connected three phase salient pole synchronous generator has $X_d = 2.9\ \Omega$ and $Xq = 1.3\ \Omega$. It delivers rated load at 0.8 pf lagging. The armature resistance is negligible. Determine the power developed by the generator and percentage voltage regulation.

4 + 4 + 4 = 12

7. (a) Two alternators working in parallel supply a lighting load of 2500kW and a motor load of 4000kW at a pf of 0.8. One machine is loaded up to 5000 kW at 0.75 pf lagging. What is the load and pf of the other machine?

(b) State and explain the conditions for parallel operation of alternators.

(c) A synchronous generator is connected to an infinite bus with excitation voltage E_r=1.2 pu. The generator has synchronous reactance of 1.1 pu and is delivering real power (P) of 0.5 pu to the bus. Assume the infinite bus voltage to be 1.0 pu. Neglect stator resistance. Find the reactive power (Q) in pu supplied by the generator to the bus.

4 + 4 + 4 = 12

Group – E

8. (a) Explain why a synchronous motor is not self starting and what are the starting methods of synchronous motor?

(b) A 20MVA, 3-phase star connected 15kV, 6 pole, 50Hz salient-pole synchronous motor, with negligible armature resistance, has reactance of $X_d = 6\Omega$ and $X_q = 4\Omega$. At full load, unity power-factor and rated voltage compute: (i) Power developed. (ii) synchronizing torque per electrical degree

(c) A salient-pole synchronous motor with damper bars is connected to an infinite bus system. Its field current is reduced to zero and the load on synchronous motor is gradually increased. It has been found in practice that after the motor has fallen out of steps, it continues running at sub-synchronous speed. Explain how it happens. What will happen to the magnitude of armature current and its p.f.?

(2 + 2) + 4 + 4 = 12

9. (a) Explain the effect of excitation on armature current and power factor in a synchronous motor.

(b) A three-phase, star connected 440V synchronous motor takes a power input of 5kW at rated voltage. Its synchronous reactance is 8Ω per phase and resistance is negligible. If its excitation voltage is adjusted equal to the 75% of rated voltage, compute the power factor and armature current.

(c) A synchronous motor improves the power factor of a load of 600kW from 0.7lagging to 0.9 lagging when the synchronous motor itself carrying a load of 110kW. Find (i) the kVAr supplied by the motor (ii) kVA rating of the motor.

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