ELECTRICAL MACHINES – II
(ELE3101)

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 pitch factor of a full pitch coil is
(a) 1 (b) 1.5 (c) 0 (d) 0.5

(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) In salient pole synchronous machine, the air gap is
(a) uniform under the whole pole shoe
(b) least under the middle of the pole shoe and increase outward
(c) largest under the middle of the pole shoe and increase outward
(d) least at one end of the pole shoe and increase to the maximum value at the other end.

(iv) 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

(v) When synchronous motor is running at synchronous speed, the damper winding produce
(a) damping torque (b) eddy current torque
(c) torque aiding the developed torque (d) no torque

(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) When a single phase supply is connected across a single phase winding, the nature of magnetic field produces is
(a) pulsating in nature.
(b) rotating in nature.
(c) constant in magnitude but rotating at synchronous speed
(d) constant in magnitude and direction.

(viii) The starting torque of an 3-ph 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) 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.

(x) In comparison to resistance-start induction motor the permanent capacitor motor is:
(a) More expensive (b) Better power factor
(c) Better starting torque (d) All of the above

Fill in the blanks with the correct word

(xi) A 3-phase, 11kV, 5MVA alternator has synchronous reactance of 10Ω per phase. Its excitation is such that the generated emf is 14kV. If the alternator is connected to the infinite bus bar, the maximum output at the given excitation 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 frequency of rotor current of a 50 Hz induction motor operating at 2% slip is _____.

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

Group - B

2. (a) Calculate the rms value of the induced emf per phase of a 8 pole, 3-phase, 50Hz alternator with 2 slots per pole per phase and 4 conductors per slot in two layers. The coil span is 160^0. The flux per pole has a fundamental component of 0.15 Wb and a 20% third harmonic component. *[(CO1)(Understand/LOCQ)]*

(b) A 60kVA, 220V, 50Hz, single phase alternator has effective armature resistance of 0.012 ohm and armature leakage reactance of 0.06 ohm. Compute the voltage induced in the armature when the armature is delivering rated current at a load power factor of (i) unity (ii) 0.8 lag (iii) 0.8 lead *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

3. (a) Fig. 1 shows three coils i, ii, iii with their magnetic axis coincident. Coils i, ii, ii are excited by three phase balanced currents $I_m \sin \omega t$, $I_m \sin(\omega t - 120^0)$, $I_m \sin(\omega t - 240^0)$ respectively. Find the magnitude of resultant m.m.f wave

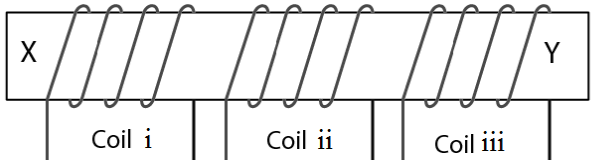

Fig.1. *[(CO1)(Analyse/HOCQ)]*

(b) Two identical 1500kW alternators operate in parallel. The governor of the first machine is such that the frequency drops uniformly from 50Hz on no-load to 48Hz on full-load. The corresponding uniform speed drop for the second machine is 50Hz to 47Hz (i) How the two machines will share a load of 2500kW? (ii) What is the maximum load that can be delivered without overloading either machine? *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) Derive the expression of mechanical power developed by the synchronous motor. *[(CO3)(Remember/LOCQ)]*

(b) A 15 MVA, 3-phase, star connected 11kV, 12-pole, 50Hz salient pole synchronous motor has reactance of $X_d = 6\Omega$, $X_q = 3\Omega$. At full load, unity power factor and rated voltage determine (i) the excitation voltage (ii) active power *[(CO3)(Remember/LOCQ)]*

6 + 6 = 12

5. (a) Explain the effect of damper bars in damping out the rotor oscillation. *[(CO3)(Understand/LOCQ)]*

(b) A synchronous motor motor improves the power factor of a load of 600 kW from 0.707 lagging to 0.95 lagging when carrying a load of 110kW. Find (i) the leading kVAr supplies by the motor (ii) KVA rating of the motor and (iii) power factor at which the motor operates. *[(CO3)(Remember/LOCQ)]*

(c) A synchronous motor is running at lagging power factor, how can it be made to run at a leading power factor? *[(CO3)(Apply/IOCQ)]*

4 + 6 + 2 = 12

Group - D

6. (a) The following test results were obtained on a 7.5 kW, 400 V, 4 pole, 50 Hz, delta connected induction motor with a stator resistance of 2 ohm/phase.

No-load: 400 V 5 A 400 W
Rotor blocked: 140 V 20A 1550 W

Obtain the approximate equivalent circuit model parameters and draw the approximate equivalent circuit. *[(CO4)(Apply/IOCQ)]*

(b) A 4 pole, 3-phase, 50 Hz, 230 V induction motor has a delta connected stator and star connected rotor. Each phase of winding has one-fourth the numbers of turns of each stator. The full-load speed is 1455 rpm. The rotor resistance is 0.3 ohm

and rotor standstill reactance is 1 ohm per phase. The rotor and stator windings are similar. Stator losses are equal to 50 W. Friction and windage losses are equal to 30 W. Calculate:

(i) Blocked rotor voltage per phase and full-load slip,
(ii) Rotor current per phase under full-load running condition,
(iii) Total rotor power input at full-load,
(iv) Rotor gross loss at full-load,
(v) Total mechanical power developed. *[(CO4) (Analyse /IOCQ)]*

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

7. (a) Why the efficiency of a 3-phase induction motor is less than that of a transformer? *[(CO4)(Remember/LOCQ)]*

(b) Show that the ratio of torque T at any slip 's' of 3 phase Induction Motor to its maximum torque can be derived as:

$\frac{T}{T_m} = \frac{2}{\frac{S_m}{s}+\frac{s}{S_m}}$ Where, Sm = slip at maximum torque *[(CO4)(Apply/IOCQ)]*

(c) The power input to a 6-pole, 50 Hz, 3-phase induction motor is 700 W at no-load and 10 kW at full load. The no-load copper losses may be assumed negligible while the full-load stator and rotor copper losses are 295 W and 310 W respectively. Find the full-load speed, shaft torque and efficiency of the motor assuming rotational and core losses to be equal. *[(CO4)(Evaluate/HOCQ)]*

2 + 5 + 5 = 12

Group - E

8. (a) Discuss why the single-phase induction motor do not have a starting torque. *[(CO5)(Understand/LOCQ)]*

(b) Discuss the modification necessary to operate a dc series motor satisfactorily on single-phase ac supply. *[(CO6)(Understand/LOCQ)]*

(c) Explain the working principle of (i) split phase (b) capacitor start single phase induction motor with the help of neat sketches. *[(CO5)(Understand/LOCQ)]*

3 + 3 + (3 + 3) = 12

9. (a) What is meant by Step Angle and Resolution of Stepper Motor? *[(CO6)(Remember/LOCQ)]*

(b) Develop the equivalent circuit of a 1-phase induction motor with two revolving field theory. *[(CO5)(Apply/IOCQ)]*

(c) A stepper motor has a step angle of 2.50. Determine (i) resolution (ii) no. of steps required for the shaft to make 25 revolutions (iii) shaft speed, if the stepping frequency = 3600 rps *[(CO6)(Evaluate /HOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.4	49	15.6