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) When the inductive load is thrown off, the terminal voltage of alternator will
(a) increase (b) decrease
(c) remain same (d) increase or decrease depending upon the load.

(ii) The speed of synchronous motor
(a) increases with increase in load (b) decreases as load increases
(c) varies with power factor (d) always remains constant.

(iii) The speed of 3 phase induction motor during maximum torque depends on
(a) mechanical load (b) rotor resistance only
(c) rotor reactance only (d) rotor resistance and reactance both.

(iv) In split phase motor, the main winding should have
(a) high resistance and low inductance
(b) low resistance and high inductance
(c) high resistance as well as high inductance
(d) low resistance as well as low inductance.

(v) In salient pole synchronous machine
(a) d-axis synchronous reactance > q-axis synchronous reactance
(b) d-axis synchronous reactance < q-axis synchronous reactance
(c) d-axis synchronous reactance = q-axis synchronous reactance
(d) q-axis synchronous reactance = 0.

(vi) 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.

(vii) 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.

(viii) If the space flux distribution is non sinusoidal, emf induced in the distributed winding will be
(a) more sinusoidal in comparison to the flux distribution.
(b) less sinusoidal in comparison to the flux distribution
(c) of the same shape of the flux distribution
(d) none of the above.

(ix) 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.

(x) The core loss and mechanical loss in case of an induction motor are determined from the
(a) no-load test (b) blocked rotor test
(c) load test (d) stator resistance test.

Fill in the blanks with the correct word

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

(xii) A 3-phase, 11 kV, 5 MVA alternator has synchronous reactance of 10Ω per phase. Its excitation is such that the generated emf is 14 kV. If the alternator is connected to the infinite bus bar, the maximum output at the given excitation is _____.

(xiii) The frequency of rotor current of a 50 Hz induction motor operating at 2% slip is _____.

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

(xv) If the no of pole is increased then the speed of induction motor will_____.

Group - B

2. (a) Explain how the rotating magnetic field is being created in the synchronous machine. *[(CO1)(Understand/LOCQ)]*

(b) In an alternator, explain why short-circuit characteristic is a straight line whereas open circuit characteristic is a curve. *[(CO2)(Understand/LOCQ)]*

(c) A 3-phase, 11000 V, star connected turbo-alternator, having synchronous reactance of 5Ω per phase and negligible resistance has an armature current of 150A at unity power factor when operating on constant frequency and constant busbar voltage. If the steam admission is raised by 10% and the emf is raised by 30%, determine the new value of current and power factor. *[(CO2)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

3. (a) Define pitch factor and derive an expression for it. *[(CO1)(Remember/LOCQ)]*

(b) What should be the value of chording angle for eliminating third harmonics? *[(CO2)(Apply/IOCQ)]*

(c) A 2 MVA, 3-phase, 8-pole alternator is connected to 6000 V, 50 Hz busbars and a synchronous reactance of 5Ω per phase. Calculate the synchronizing power and the synchronizing torque per mechanical degree of rotor displacement at no load. Assume normal excitation. *[(CO2)(Understand/IOCQ)]*

(3 + 3) + 2 + 4 = 12

Group - C

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

   (b) A synchronous motor is operating at 0.2 p.f lagging at half full load, with E_f, V_t, X_s remaining constant. Analyze whether its p.f is worsened or improved when it is made to operate at full load. *[(CO3)(Analyse/IOCQ)]*

   (c) A synchronous motor improves the power factor of a load of 500kW from 0.7 lagging to 0.9 lagging. Simultaneously the motor carries a load of 90 kW. Find (i) kVA rating of the motor and (ii) power-factor at which motor operates. *[(CO3)(Understand/LOCQ)]*

4 + 4 + (2 + 2) = 12

5. (a) Explain how the damper winding prevents hunting. *[(CO3)(Understand/LOCQ)]*

   (b) The synchronous reactance per phase of a 3-phase, star connected 6600V synchronous motor is 10Ω. For a certain load the input is 900 kW at normal voltage and the induced line emf is 8900V. Determine the line current and the power factor. *[(CO3)(Understand/LOCQ)]*

   (c) A synchronous machine is running under steady-state conditions at rated voltage and rated frequency. At an excitation voltage of 1.5 p.u., the rated current flows at 0.8 p.f. leading. Is the synchronous machine operating as a motor or a generator? Explain. *[(CO3)(Analyse/HOCQ)]*

4 + 4 + 4 = 12

Group - D

6. (a) A 100 kW, 440 V, 3-phase, 6-pole, 50 Hz, wound-rotor induction motor has a full-load 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 are 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) 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)]*

6 + (2 + 1 + 1 + 1 + 1) = 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 ohms 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 universal motor (ac operated) has a 2-pole armature with 960 conductors. At a certain load , the motor speed is 5000 rpm and the armature current is 4.6 A, the armature terminal voltage and input are respectively 100 V and 300 W. Compute effective armature reactance and maximum value of useful flux/pole, assuming an armature resistance of 3.5 ohm. *[(CO6)(Apply/IOCQ)]*

(b) Give the reasons why a single-phase induction motor has poor performances as compared to a 3-phase induction motor. *[(CO5)(Understand/LOCQ)]*

(3 + 3) + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	50	35.4	14.6

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 speed characteristics.
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.*