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) 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 speed regulation of a synchronous motor is
(a) Unity (b) Zero
(c) infinity (d) always less than one

(iii) A synchronous motor, connected to an infinite bus of voltage Vt, is working at leading power factor. Its excitation voltage is
(a) > Vt (b) = Vt
(c) < Vt (d) independent of power factor

(iv) In a salient pole synchronous machine where Xd=d-axis synchronous reactance, Xq=quadrature-axis synchronous reaction,
(a) Xq=Xd (b) Xq>Xd
(c) Xq<Xd (d) Xq=0

(v) If the prime mover of the alternator supplying load to an infinite bus is suddenly shunt down, then it will
(a) stop
(b) continue to run as an alternator
(c) continue to run as synchronous motor in the reverse direction
(d) continue to run as synchronous motor in the same direction

(vi) The operation of an Induction motor is based on
(a) Lenz's law (b) Ampere's Law
(c) principle of mutual induction (d) principle of self induction

(vii) The relationship between rotor frequency f2 , slip 's' and the stator supply frequency f1 is given by
(a) f1 = sf2 (b) f2 = sf1 (c) f2 = f1(1-s) (d) f2 = √s f

(viii) When a single phase induction motor picks up certain speed, its starting winding is disconnected and the motor continues running on
(a) rotor winding (b) armature winding
(c) main winding (d) compensating winding

(ix) Phase splitting can be accomplished in a single phase induction motor
(a) by adding a capacitor in series with auxiliary winding
(b) by causing the auxiliary winding to have high reactance
(c) by causing the auxiliary winding to have low resistance
(d) any of the above methods

(x) The direction of rotation of a split phase/capacitor-start/two-capacitor motor can be reversed by reversing the connections to supply of
(a) auxiliary winding only (b) main winding only
(c) either (a) or (b) (d) both (a) and (b) together

Group – B

2. (a) What are the advantages of short pitch a winding in rotating electrical machine? Find the expression of pitch factor of a winding. [(CO1) (Remember/LOCQ)]

(b) Analyze the effect of armature flux upon the main field flux on alternator for lagging p.f load. [(CO2) (Analyze /IOCQ)]

(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)]

(2 + 2) + 5 + 3 = 12

3. (a) Why the rating of alternator are rated in kVA? What is the necessity of mentioning the p.f at their name plate? [(CO2) (Remember/LOCQ)]

(b) A 3-phase, 2-pole stator has double–layer full pitch winding with 4 slots per pole per phase. If each coil has N_c turns and i is the conductor current, then sketch the m.m.f. waveform produce by a phase alone. [(CO1) (Apply/IOCQ)]

(c) A three-phase star connected alternator having per phase impedance of (1.5+j8)Ω is delivering constant power load at 50 A to an infinite bus bar at 6600 V and 0.8 lagging power factor. Evaluate the percentage change necessary in excitation to raise the power factor to unity. [(CO2)(Evaluate/HOCQ)]

(2 + 2) + 5 + 3 = 12

Group - C

4. (a) Show that synchronous motor has no starting torque.[(CO3)(Remember/LOCQ)]

(b) A 3-phase star connected synchronous motors of rating 50MVA, 33kV, 50Hz has Xd=6Ω and Xq=3 Ω.
The machine has 8 numbers of poles. If the machine is working under full load at unity pf, then solve for
(i) Excitation voltage of the machine.
(ii) Active power delivered by the machine.
(iii) Synchronizing power and synchronizing torque per electrical degree.
[(CO3) (Apply/IOCQ)]

(c) A synchronous motor is supplying a constant load. Explain whether its efficiency will be greater at 0.8 p.f lead or 0.8 lag. [(CO3)(Evaluate/HOCQ)]

3 + (2 + 2 + 1) + 4 = 12

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

(b) A 3-phase, star connected, 6600V synchronous motor has a synchronous reactance per phase of 10Ω. For a certain load, the input is 900kW at normal voltage and induced line emf is 8000V. Neglect armature resistance, solve for line current and power factor. [(CO3) (Apply/IOCQ)]

(c) In Fig.1 (A) and (B), explain with the help of phasor diagram whether the synchronous machine is working as generator or a motor, with field winding on rotor and the direction of rotation shown. In case synchronous machine is operated at no load, show the orientation of field pole on the relevant diagram. [(CO3)(Evaluate/HOCQ)]

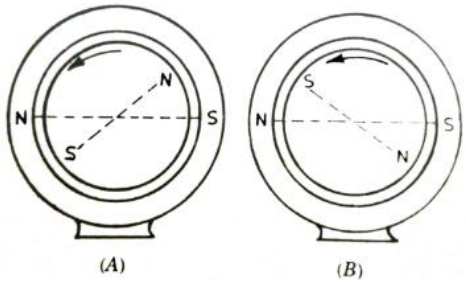

Fig.1

4 + (2 + 2) + (3 + 1) = 12

Group- D

6. (a) Explain the conditions under which rotor frequency is smaller/equal/greater than stator current frequency in an Induction Motor.
[(CO4) (Understand /LOCQ)]

(b) Compare between Synchronous Motor and Induction Motor.
[(CO4) (Analyse/IOCQ)]

(c) A 3-phase, 500 V, 50 Hz Induction Motor with 6 poles gives an output of 20 KW at 950 rpm with a p.f. of 0.8. The mechanical losses are equal to 1 KW. Determine for this load (i) slip (ii) rotor copper losses (iii) input if the stator losses are 1500 W (iv) line current. [(CO4)(Evaluate/HOCQ)]

3 + 5 + 4 = 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 Tm 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) 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 (a) resolution (b) no. of steps required for the shaft to make 25 revolutions (c) shaft speed, if the stepping frequency = 3600 rps. [(CO6) (Evaluate /HOCQ)]

4 + 4 + 4 = 12

9. (a) Why does a pure single phase induction motor does not have a starting torque but has running torque? [(CO5) (Remember/LOCQ)]

   (b) Construct the phasor diagram of a single phase a.c. series motor with relevant explanations. [(CO6) (Apply/IOCQ)]

   (c) A 2-pole, 50 Hz, single phase induction motor has an effective rotor resistance and leakage reactance of 0.4 Ω and 6.0 Ω respectively. If the motor is running at 2700 rpm, determine the frequencies of the rotor current components and the relative magnitudes of the forward and backward fluxes. Neglect magnetizing current and stator impedances. [(CO5) (Evaluate /HOCQ)]

3 + 4 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	28.13	38.54%	33.33%

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

Department & Section	Submission Link
EE	https://classroom.google.com/c/NDA1MjQ0MTgzMDY5/a/NDYyOTcyNjEzNjg2/details