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UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2018

Program: B.Tech. Electrical, PSE **Semester – IV**

Subject (Course): Synchronous and Asynchronous Machines **Max. Marks: 100**
Course Code: ELEG 257 **Duration: 3 Hrs**
No. of page/s: 03

SECTION A [5x4 = 20]

1. **A 110 V, 60 Hz, 4-pole, single phase induction motor is rotating in the clockwise direction at a speed of 1710 rpm. Determine its per unit slip:**
   (a) In the direction of rotation
   (b) In the opposite direction

   If the rotor resistance at standstill is 12.5 Ω, determine the effective rotor resistance in each branch. **[CO_3]**

2. **Draw the electrical equivalent circuit of cylindrical rotor synchronous generator and clearly specify all the resultant voltages at every stage.** **[CO_1]**

3. **A synchronous motor on load draws a current at leading power factor of α. The phase angle between the excitation EMF and the current in time phasor diagram is ψ. What is the angle between excitation MMF and the armature reaction MMF?** **[CO_5]**

4. **The full load current of a 3 phase, 15 kW, 440V, 4-pole, 50 Hz, Y-connected induction motor is 30 A. Its test data are:**
   No-load test: 440V, 8A, 1200W;
   Blocked rotor test: 100V, 21A, 800W;
   Calculate the motor efficiency at full load. **[CO_4]**

5. **Briefly elucidate the following parameters:** **[CO_1]**
   (a) Phase spread
   (b) Phase group
   (c) Coil span
   (d) Pitch factor

SECTION B [10x4]

6. **A 440V, 3-phase, Δ connected, synchronous motor has synchronous reactance of 36Ω/phase. Its armature winding resistance is negligible. When the motor runs at a speed of 188.5 rad/s, it consumes 9kW and the excitation voltage is 560 V. [CO_5]**

   Determine:
   (a) The power factor
   (b) The power angle
   (c) The line-to-line excitation voltage for a +ve phase sequence
   (d) The torque developed by the motor

7. **A 150 kVA, 4000V, 50Hz, Y-connected alternator has effective armature resistance of 0.3 Ω/phase. A field current of 40A produces short circuit line current of 200A and an open circuit EMF of 1080V between lines. [CO_3]**
   Calculate the full load regulation of the alternator at:
   (a) 0.8 power factor lagging
   (b) 0.8 power factor leading

8. **A salient pole alternator has X_d= 1 pu and X_q =0.65 pu. Draw phasor diagram of the machine when operating at full load at p.f. of 0.8 lagging. Find the load angle and induced EMF in per unit (pu). [CO_1]**

9. **Explain the principle of operation of capacitor-split type, single phase induction motor with necessary diagrams and phasors. Also, specify two real-world applications for this type of motor. [CO_2]**

SECTION C [20x2]

Q. 10 is compulsory. Although, attempt any one question out of Q. 11 and Q.12

10. **A 10kW, 415V, 3 phase, 4-pole, 50 Hz slip-ring induction motor (SRIM) develops rated output at rated voltage and frequency and with its slip rings short circuited. The maximum torque is equal to twice the full load torque, and occurs at a slip of 8% with zero external resistance in the rotor circuit. Stator resistance and rotational losses are neglected. [CO_4,CO_1]**
    Determine:
    (a) Slip and rotor speed at full load [4]

(b) Rotor ohmic loss at full load [4]

(c) Starting torque at rated voltage and frequency [4]

(d) Starting current (in terms of full load current) [4]

(e) Stator current at maximum torque (in terms of full load current) [4]

11. **[CO_5, CO_3]**

(a) Enlist the merits of installing synchronous condensers in an electrical system? [6]

(b) Discuss the following terms w.r.t. Synchronous motors operation: [6]

(i) Normal Excitation

(ii) Over-Excitation

(iii) Under-Excitation

(c) Find the capacity of the synchronous condenser required to raise the power factor of the plant from 0.6 lagging to 0.94 lagging. The plant has a total connected load of 2400 kW. [8]

12. **[CO_5, CO_1]**

(a) A 4 MVA, 22 kV, 50 Hz, 4-pole alternator is connected to an infinite bus-bar. It has synchronous reactance of 15 %.

Determine the synchronizing power and synchronizing torque per mechanical degree of phase displacement:

(i) At no-load [5]

(ii) At full load with 0.6 p.f. lagging [5]

(b) Illustrate the phenomenon of "Hunting" in synchronous motors. Why it is harmful for motor operation? [6]

(c) Which of the following is not a necessary condition to be fulfilled for synchronizing two alternators? [2]

(1) Same frequency

(2) Same speed

(3) Same terminal voltage

(4) Same phase sequence

(d) An inverted V-curve of an alternator connected to infinite bus-bar is the variation of: [2]

(1) Power factor vs field current at constant load

(2) Terminal voltage vs field current at constant load

(3) Armature current vs field current at constant load

(4) Power factor vs armature current at constant load

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SECTION A [5x4 = 20]

1. **What is an infinite bus? Describe its characteristics? [CO_3]**

2. **Describe the key differences in construction of rotors of a 3 phase alternator used in hydroelectric plant and steam plant. [CO_1]**

3. **A 20 HP, 3-phase, 50 Hz, 4-pole induction motor has a full load slip of 3%. The friction and windage losses are 500W. Calculate the rotor copper loss. [CO_4]**

4. **A purely single-phase induction motor does not have a starting torque, but has a running torque. Why? [CO_2]**

5. **Draw the OCC and SCC of an alternator. Obtain the expression of saturated and unsaturated synchronous impedance. [CO_5]**

SECTION B [10x4]

6. **A 3 phase, 50 Hz, 4 -pole, Wye - connected synchronous generator has 72 slots with 4 conductors per slot. The coil span is 2 slots less than pole pitch. If the machine gives 6600 V between lines on an open circuit. Determine the useful flux per pole. [CO_3 CO_1]**

7. **Derive an expression for power developed in a cylindrical rotor alternator in terms of power angle and synchronous impedance. [CO_1]**

8. **A three phase, 20 pole, 440V, 50 Hz Y-connected synchronous motor is having its induced emf magnitude same as that of terminal voltage magnitude under no-load condition. The synchronous reactance of the machine is 10 Ω.**
Suddenly, the motor is loaded and the rotor slips by an angle of 3^0 and again reaches synchronism. Determine power input of the machine. [CO_3]

9. **Draw and explain Y-Δ starting method for three phase induction motors. Explain the advantages and limitations of this method. [CO_5]**

SECTION C [20x2]

Q.10 is compulsory. Although, attempt any one question out of Q.11 and Q.12

10. **A 5000 kVA, 6600 V, 3 phase, Y-connected alternator has a resistance of 0.075 Ω per phase. Find the voltage regulation for a load of 500 A at power factor 0.71 lagging, by using ZPF method. The test data are as under : [CO_1, CO_3]**

Field Current (A)	OC Voltage (V)	ZPF Terminal Voltage (V)
32	3100	0
50	4900	1850
75	6600	4250
100	7500	5800
140	8300	7000

11. **[CO_1, CO_5, CO_3]**
(a)A 22 kV, Y-connected alternator is delivering 20 MW at 0.8 pf lagging to an infinite bus bar at 22 kV. Induced EMF in the generator is 1.2 times the terminal voltage. Determine the synchronous reactance of the machine. [Assume: armature resistance to be negligible] [10]

(b) A 350 kVA, 3.3 V, 50 Hz, 3 phase Y-connected alternator has the following data:
(i) Field winding resistance (hot) = 200W [10]

(ii) Armature winding resistance (per phase) = 0.2 W

(iii) Open circuit core loss = 1250 W

(iv) Friction and windage loss = 1100 W

(v) DC field supply = 400V

Calculate the efficiency of the alternator at half load with 0.7 lagging power factor.

12. A 440 V, three phase, Δ connected synchronous motor runs at rated voltage and with an excitation EMF of 560 V. Its synchronous impedance (per phase) is (0.5+j0.5) Ω and friction windage and iron losses are 1000 W. [CO_5, CO_3]

Calculate:

(a) Shaft power output

(b) Line current

(c) Power factor

(d) Efficiency for:

(i) Maximum power output

(ii) Maximum power input