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ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E. /B.Tech / B. Arch (Full Time) - END SEMESTER EXAMINATIONS, NOV / DEC 2024

ELECTRICAL AND ELECTRONICS ENGINEERING
Semester V
EE5501 ELECTRICAL MACHINES II
(Regulation 2019)

Time: 3hrs Max.Marks: 100

CO1	Understand the concepts of windings, MMFs and rotating magnetic fields.
CO2	Understand the operation of ac machines.
CO3	Analyse the performance characteristics of ac machines.
CO4	Analyse the starting and speed control of ac machines.
CO5	Understand the field applications of ac machines.

BL – Bloom's Taxonomy Levels
(L1-Remembering, L2-Understanding, L3-Applying, L4-Analysing, L5-Evaluating, L6-Creating)

PART- A(10x2=20Marks)
(Answer all Questions)

Q.No.	Questions	Marks	CO	BL
1	Can the pitch factor of a three-phase distributed winding be unity? Justify.	2	1	2
2	If the angular frequency of a 6 P synchronous motor's excitation is 377 rad/sec, then calculate its angular velocity in rad/sec.	2	1	3
3	Draw the current sheet of DC excitation of a synchronous machine and comment on the nature of field distribution of it around the air-gap.	2	1	2
4	If φ_m is the flux produced by each phase of a three excitation, then what is the magnitude of resultant flux component in the air-gap?	2	1	2
5	A three phase, 4 kW, 400V, 50 Hz, 4 P slip ring induction motor develops a maximum torque of 100 Nm. It has rotor resistance = 0.5 Ω/phase and rotor leakage reactance = 1.0 Ω/phase. If the rotor resistance is doubled then what will be the new value of maximum torque?	2	3	4
6	A three phase, 400V, 50 Hz, 4 P induction motor is connected to a three phase 400V, 50 Hz power supply and runs at full-load condition. The number of poles is suddenly changed to 6 P and the load applied is still the same. Comment on the machines performance in terms developed torque.	2	3	5
7	Draw the torque (vs.) speed curves of a split-phase motor and a shaded pole motor.	2	4	2
8	Why is a capacitor start capacitor run motor better than a permanent split capacitor motor?	2	4	2

9	Draw the EMF phasor diagram of a synchronous machine, which experiences the armature reaction with magnetizing effect.	2	5	4
10	State whether a synchronous motor can start by itself with a low frequency power supply (say 5 Hz). Justify your answer.	2	5	4

PART- B (5x 13 = 65Marks)

(Restrict to a maximum of 2 subdivisions)

Q.No.	Questions	Marks	CO	BL
11 (a)	Draw the concentrated and distributed windings and their respective MMF distribution in the air-gap.	13	1	2
	OR			
11 (b)	Show that the harmonics can be reduced in three-phase ac machines, if its armature windings are short pitched and distributed.	13	1	3
12 (a)	Prove that a single-phase ac excitation fails to build torque in rotating machines but could develop torque under alternative or favourable conditions. Follow graphical approach for the proof.	13	1	3
	OR			
12 (b)	Explain the principle of operation of three-phase induction motor using the concept of rotating magnetic fields and obtain the expressions for slip, developed torque and output power.	13	2	3
13 (a)	A 440 V, 50 Hz, Y-connected induction motor is rated at 75 kW. The equivalent circuit parameters are $r_1 = 0.075\ \Omega$; $x_1 = 0.17\ \Omega$; $r'_2 = 0.065\ \Omega$; $x'_2 = 0.17\ \Omega$; $X_m = 7.2\ \Omega$. The core losses are 1.1 kW, friction windage losses are 1.0 kW, and stray load losses are 150 W. For a slip of 0.045 per unit, determine (i) motor speed in rad/sec; (ii) line current and power factor; (c) shaft torque and (d) overall efficiency.	13	3	3
	OR			
13 (b)	A three-phase, 6-pole, 50 Hz slip ring induction motor runs at a slip of 0.03 per unit under full load condition. Find the value of resistance to be added externally in series per-phase of the rotor to reduce the speed by 10%. Assume that the resistance of the rotor per-phase is 0.2 Ω.	13	4	4
14 (a)	Explain the double revolving field theory of single phase induction motors.	13	3	3
	OR			

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	OR			
14 (b)	The main and auxiliary windings of a 120 V, 60 Hz, split phase motor have the following locked rotor parameters: $R_{main} = 2.0\ \Omega$, $X_{main} = 3.5\Omega$, $R_{aux} = 9.15\Omega$ and $X_{aux} = 8.4\ \Omega$. If the motor is connected to a 120 V and 60 Hz power supply then determine the locked rotor current in each winding and the phase displacement angle.	**13**	3	2
15 (a)	The open-circuit and short-circuit test data of a three-phase 150 MW, 13 kV, 0.85 p.f. 50 Hz, synchronous generator is obtained as follows: I_f (A): 200, 450, 600, 750, 850, 1200 $V_{o.c.}$ (kV) (Line): 4, 8.7, 10.8, —, 13.3, 15.4 $I_{s.c.}$ (A): —, —, —, 8000, —, — Assume the armature resistance is negligible. Calculate the (i) short-circuit ratio, (ii) unsaturated synchronous reactance of the machine, (iii) voltage regulation at rated load condition and at 0.8 p.f. lagging and (iv) input power of the machine.	**13**	4	3
	OR			
15 (b)	Explain in detail the construction and theory of salient pole synchronous machines. Suggest a suitable method to determine the direct axis and quadrature axis reactance components and hence load angle δ.	**13**	4	2

PART- C(1x 15=15Marks)

(Q.No.16 is compulsory)

Q.No.	Questions	Marks	CO	BL
16.	a) A 460 V, 100 HP, four-pole, Δ-connected, 60 Hz, three-phase induction motor has a full-load slip of 5 percent, an efficiency of 92 percent and a power factor of 0.87 lagging. At start-up the motor develops 1.9 times the full load torque but draws 7.5 times the rated current at the rated voltage. This motor is to be started with an auto-transformer reduced voltage starter. what voltage is to be applied using the starter such that the motor shall develop rated torque at starting?	**8**	5	6
	b) A 480 V, 60 Hz, Δ-connected, four pole synchronous generator has a direct-axis reactance of 0.1 Ω and a quadrature-axis reactance of 0.075 Ω. Its armature resistance may be neglected. At full load this generator supplies 1200 A at a power factor of 0.8 lagging. Compute the developed torque of the machine using both cylindrical rotor theory (assume $x_s = x_d$) and two-reaction theory.	**7**	4	4

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