Code No:R2022024 **R20** **SET - 1**

II B. Tech II Semester Regular Examinations, June/July - 2022

INDUCTION AND SYNCHRONOUS MACHINES

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 70**

Answer any **FIVE** Questions each Question from each unit

All Questions carry **Equal** Marks

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UNIT-I

1 a) Describe the constructional features of both squirrel-cage induction motor and slipring induction motor. Also discuss the merits of one over other? [7M]

b) A 20kW, 6pole, 400V, 50Hz, 3 Phase induction motor has a full load slip of 0.025. If the torque lost in mechanical losses is 10 Nm, find the rotor ohmic losses, motor input and efficiency. Stator losses are 800 watts. [7M]

Or

2 a) Discuss the similarities between transformer and an induction machine. Hence, explain why an induction machine is called a generalized transformer? [7M]

b) A 6-pole, 50 Hz, 3-phase induction motor running on full load develops a useful torque of 160 N-m when the rotor emf makes 120 complete cycles per minute. Calculate the shaft power output. If the mechanical torque lost in friction and that for core-loss is 10 N-m, compute (i) The copper-loss in the rotor windings (ii) The input to the motor, and (iii) The efficiency The total stator loss is given to be 800W. [7M]

UNIT-II

3 a) Derive the general expression for the torque developed in the three-phase induction motor? Also derive the expression for maximum torque? [7M]

b) A 3 phase SCIM has a rotor starting current of 6 times its full load value. The motor has a full load slip of 5%. Determine [7M]

(i) the starting torque in terms of full load torque

(ii) slip at which max. torque occurs

(iii) maximum torque in terms of full load torque

Or

4 a) Write a short note on cogging and crawling? [7M]

b) A 6pole, 50Hz, 3 Phase IM has a rotor resistance of 0.2Ω per phase and a maximum torque of 160 Nm at 875 rpm. Calculate [7M]

(i) the torque for a full load slip of 4 %

(ii) the resistance to be added to the rotor circuit to obtain 80 % of full load torque at starting

Rotational losses and stator impedance are neglected.

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UNIT-III

5 a) With the help of a neat diagram, explain the working of DOL starter used for starting three phase IM. [7M]

b) The ratio of maximum torque to full – load torque in a 3- phase squirrel –cage induction motor is 2:1. Determine the ratio of actual starting torque to full – load torque for the following cases: (i) Direct starting, (ii) Star –delta starting, and (iii) Autotransformer started tapping of 70%. The rotor resistance and standstill reactance per phase are 0.5 Ω and 5 Ω respectively. [7M]

Or

6 a) Using double field revolving field theory explain the torque–slip characteristics of a single-phase induction motor and prove that it cannot produce starting torque. [7M]

b) Explain the construction and working of AC series motor. What are the differences between AC series motor and DC series motor? [7M]

UNIT-IV

7 a) List the differences between salient pole and non-salient pole alternators. [7M]

b) A 3 phase 16-pole alternator has the following data: Number of slots=192, conductors/slot =8; coil span 10 slots, speed of the alternator=375 rpm, flux per pole =55 m wB. Calculate phase and line emf voltage. [7M]

Or

8 a) Explain the effect of variation of mechanical input on the parallel operation of alternators with necessary phasor diagrams [7M]

b) Write Short notes on two reaction theory and hence draw and explain the phasor diagram of a salient pole alternator for leading p.f. load. [7M]

UNIT-V

9 a) Derive an expression for power developed in a cylindrical rotor synchronous motor in terms of load angle and synchronous impedance? [7M]

b) A 3-Phase, 50Hz, 2000V, synchronous motor has a synchronous reactance of 10 Ω/ph and negligible armature resistance. The motor delivers a power of 120 kW and the efficiency is 88%. If the torque angle is 12^0 electrical, determine the back emf of the motor. Assume the armature winding is star connected. [7M]

Or

10 a) What is hunting phenomenon in synchronous motor? What are the drawbacks of hunting? What are different methods of suppression? [7M]

b) A 1000 kVA, 11,000 V, 3-Phase star connected synchronous motor has an armature resistance and reactance per phase of 3.5 Ω and 40 Ω respectively. Determine the induced emf and angular retardation of the motor when fully loaded at (i) unity pf and (ii) 0.8 pf lead. [7M]

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UNIT-I

1 a) Describe the principle of operation of 3 phase IM. Explain why the rotor is forced to rotate in the direction of Rotating Magnetic Field. [7M]

b) A 10 kW, 3 Phase, 50 Hz, 4 pole IM has a full load slip of 0.03. Mechanical and stray load losses at full load are 3.5 % of output power. Compute [7M]
(i) Power delivered by stator to rotor
(ii) Electromagnetic (internal) torque at full load
(iii)Rotor ohmic losses at full load

Or

2 a) Explain the terms: Airgap power P_g, internal mechanical power developed P_m and shaft power P_{sh}. How are these terms related with each other? Also show that,P_g: rotor ohmic loss: P_m = 1:s: (1-s) [7M]

b) A 3 phase, 50 Hz IM has full load speed of 1440 rpm. For this motor, calculate the following: (i) number of poles (ii) full load slip (iii) rotor frequency (iv) speed of stator field with respect to stator structure and rotor structure (v) speed of rotor field with respect to rotor structure, stator structure and stator field [7M]

UNIT-II

3 a) Derive the condition for maximum torque developed in a 3 phase IM and hence prove that, to increase the starting torque extra resistance must be added in the rotor circuit? [7M]

b) In a 3 phase IM, stator reactance equals the rotor reactance at standstill while each resistance is one-fourth of this value. If the motor develops 220 Nm at 3 % slip, what will be its starting torque and pull out torques. [7M]

Or

4 a) Draw the torque-slip characteristics of a 3-phase induction motor. Explain them briefly. [7M]

b) Write a short note on double cage rotor and deep bar rotor SCIMs. [7M]

UNIT-III

5 a) Explain the starting of IM using Auto transformer starter. [7M]

b) The short circuit current of SCIM on normal voltage is 3.5 times the full load current and the full load slip ids 4%. Determine the percentage tapping required to an autotransformer starter to start the motor against 1/3rd full load torque. Neglect magnetizing current. [7M]

Or
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6 a) Using double field revolving field theory explain the torque–slip characteristics of a single-phase induction motor and prove that it cannot produce starting torque? [7M]

b) Write a short note on (i) AC series motor (ii) Split phase IM [7M]

UNIT-IV

7 a) What is armature reaction? Explain the effect of armature reaction on the terminal voltage of an alternator at ZPF lag and ZPF lead with the help of necessary phasor diagram. [7M]

b) The open and short circuit test readings for a three-phase star connected 1000 kVA 2000 V and 50 Hz alternator are [7M]

V_{OC}(Line)	800	1500	1760	2000	2350	2600
I_{SC}(A)	-	200	250	300	-	-
I_F(A)	10	20	25	30	40	50

The armature effective resistance is 0.2 Ω/ phase. Estimate the full load voltage regulation using M.M.F. method for 0.8 pf lag.

Or

8 a) What is synchronizing power of an alternator? Derive an expression for synchronizing power between the two alternators when they are connected in parallel? [7M]

b) The governors of each 2000 kW, rating turbo alternators running in parallel are so adjusted that the frequency of one of the alternators drops uniformly from 50 Hz to 45 Hz and that of other from 50 Hz to 47 Hz from No load to full load. Calculate the load on each machine when the total load is 3000 kW [7M]

UNIT-V

9 a) Explain different methods of starting synchronous motor. [7M]

b) A synchronous motor takes 20 kW at 400 V supply mains. The synchronous reactance of the motor is 4 Ω. Find the p.f. at which the motor would operate when the exciting current is so adjusted that the generated e.m.f. is 550 V. Assume the star connected stator. [7M]

Or

10 a) What is synchronous condenser? What are the advantages of installing a synchronous condenser in an electrical system? Illustrate your answer with an example? [7M]

b) An industrial plant has an average load demand of 800 kW at a pf of 0.71 lag. A synchronous motor of 400 kVA is installed for driving an additional load and improving the plant power factor. The synchronous motor load is 160 kW at an efficiency of 90%. For synchronous motor operation at rated kVA, calculate the total load kVA and the resultant pf. [7M]

Code No: R2022024 **R20** **SET - 3**

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UNIT-I

1 a) Develop the phasor diagram of three phase IM. How does it differ from the phasor diagram of transformer? [7M]

b) A 3-phase 400 V, 50 Hz induction motor takes a power input of 35kW at its full load speed of 980 rpm. The total stator losses are 1 kW and friction and windage losses are 1.5 kW. Calculate (i) slip (ii) rotor ohmic losses (iii) Shaft power (iv) shaft torque and (v) efficiency [7M]

Or

2 a) Develop and explain the equivalent circuit of Three phase IM. [7M]

b) A 10 kW, 400 V, 3 phase, 4 pole, 50 Hz delta connected IM is running at no load with a line current of 8 A and an input power of 660 W. At full load, the line current is 18 A, and the input power is 11.2 kW. Stator effective resistance per phase is 1.2 Ω and friction, windage loss is 420 watts. For negligible rotor ohmic losses to at no load, calculate (i) stator core loss (ii) total rotor losses at full load (iii) full load speed (iv) internal torque (v) shaft torque (vi) motor efficiency [7M]

UNIT-II

3 a) Explain the speed control of three phase IM with V/f control. [7M]

b) A 746kW, 3 phase, 50 Hz, 16 pole IM has a rotor impedance of (0.02+j0.15) Ω at stand still. Full load torque is obtained at 360rpm. Calculate (i) the ratio of maximum torque to full load torque (ii) speed at maximum torque (iii) the rotor resistance to be added to get maximum starting torque [7M]

Or

4 a) Briefly explain the procedure to draw the circle diagram of three phase IM. [7M]

b) A 12pole, 3Phase, 600V, 50Hz. Star connected IM has rotor resistance and standstill reactance of 0.03 and 0.5 Ω per phase respectively. Calculate (i) Speed at maximum torque (ii) ratio of full load torque to maximum torque, if the full load speed is 495 rpm. [7M]

UNIT-III

5 a) With the help of neat circuit, explain the starting of IM suing Y/Δ starter. [7M]

b) Calculate the steps in a 5-step rotor resistance starter for a 3 phase IM. The slip at the maximum starting current is 2 % with slip ring short circuited and the rotor resistance per phase is 0.02Ω. [7M]
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Or

6 a) Write a short note on different methods of starting single phase IM. [7M]

b) Explain the construction and working of AC series motor. What are the differences between AC series motor and DC series motor? [7M]

UNIT-IV

7 a) Why stationary armature is preferred over rotating armature? Explain the classification of alternators based on rotor used. [7M]

b) A three-phase star connected alternator has an open circuit voltage of 6000V. The armature resistance and synchronous resistance are 0.4Ω and 4Ω per phase respectively. Find the terminal voltage and the phase difference between terminal voltage and open circuit EMF at a power factor of 0.9 leading. Given load current is 140A. [7M]

Or

8 a) Explain the effect of armature reaction on the performance of an alternator. How it depends on the load p.f. Explain with suitable diagrams. [7M]

b) Two identical 3 MVA alternators are running in parallel. The frequency drops from no load to full load for the two alternators are 50 Hz to 47 Hz and 50 Hz to 48 Hz respectively. [7M]
i. How they will share a load of 4000 kW?
ii. What is maximum unity factor load which they can supply jointly without any one of them over loaded?

UNIT-V

9 a) Explain, why synchronous motor is not self-starting? Explain any one method of starting a synchronous motor. [7M]

b) A 3-phase star connected synchronous motor is designed for a terminal voltage of 3300V and its synchronous impedance is (0.25 + j 2.00) Ω/ph. The excitation is adjustable to a value which corresponds to an open circuit terminal voltage of 3500V. Determine the current and p.f. from an input of 750kW. [7M]

Or

10 a) Explain the variation of current and power factor with excitation in synchronous motor. [7M]

b) A synchronous motor absorbing 50 kW is connected in parallel with a factory load of 200 kW at 0.80 lagging pf. If the resultant power factor after connecting SM is 0.92 lagging, how much leading kVAR is to be supplied by synchronous motor? At what power factor is it working? [7M]

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UNIT-I

1 a) Explain why a 3 phase IM, at no load, operates at a very low pf. [7M]

b) A 3 phase, 50 Hz IM has a full load speed of 960 rpm. Calculate [7M]
(i) number of poles (ii) slip frequency (iii) Speed of rotor field with respect to rotor structure, with respect to stator structure and with respect to stator field.

Or

2 a) With the help of rotor equivalent circuit of an IM, show that the power transferred magnetically from stator to rotor is given by $I_2^2 \frac{r_2}{s}$. [7M]

b) A 40 Hp three-phase induction motor has a full load slip of 4%. The stator losses amount to 4% of the input and the mechanical losses are 1% of the output. If the current in each phase of the rotor is 50 A. Find the resistance per phase of the rotor and the efficiency of this machine. [7M]

UNIT-II

3 a) Draw and explain the torque Vs slip characteristics of three phase IM in all modes of operation. [7M]

b) Explain the speed control of IM using V/f control method. [7M]

Or

4 Draw the circle diagram for a 3.73 kW, 200 V, 50 Hz, 4 pole, 3 Phase Y connected IM from the following test data: [14M]
No- Load test data: 200 V, 5 A, 350 W
Blocked rotor test: 100V, 26A, 1700 W
Estimate from the diagram for full load condition, the line current, power factor and the maximum torque in terms of the full load torque. The rotor cu loss at stand still is half the total Cu loss.

UNIT-III

5 a) Explain the construction and working of AC series motor. [7M]

b) Develop the equivalent circuit of single-phase IM using double field revolving theory. [7M]

Or

6 a) Explain the construction and working of DOL starter used for IM. [7M]

b) A SCIM, when started by means of a Y/Δ starter takes 180% of full load line current and develops 35% of full load torque at starting. Calculate the starting torque and current in terms of full load values, if an auto transformer with 75 % tapping is employed. [7M]

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UNIT-IV

7 a) Explain the constructional details of rotor of both salient pole and cylindrical rotor synchronous machines. [7M]

b) The stator of a three phase, 16 pole alternator has 144 slots and there are 4 conductors per slot connected in two layers and the conductors of each phase are connected in series. If the speed of the alternator is 375rpm, calculate the emf induced per phase. Resultant flux in the air gap is 0.05 Webers per pole sinusoidally distributed. Assume the coil span as 150^0 electrical. [7M]

Or

8 a) Derive the EMF equation of Alternator from fundamentals clearly showing the expressions for pitch and distributions factors. [7M]

b) A 100 kVA, 3000 V, 50 Hz, 3 phase Y connected alternator has an effective armature resistance of 0.2 Ω. The filed current of 40 A produces a short circuit current of 200 A and an open circuit emf of 1040 V(Line value), find the full load voltage regulation at 0.8 pf lagging and 0.8 pf leading. [7M]

UNIT-V

9 a) Draw and explain the 'V-curves' and 'inverted V-curves' of synchronous motor. [7M]

b) A 3-ϕ, 6000 V, star connected synchronous motor has effective per phase synchronous reactance/ phase of 15 Ω & negligible armature resistance. For a certain load, the input is 800 kW at normal voltage and the induced line EMF is 8500 V. Determine: (i) Line current (ii) Power factor. [7M]

Or

10 a) Explain hunting of synchronous machines and methods of its prevention. [7M]

b) A 500V, 6-pole, 3-phase, 50Hz, star-connected synchronous motor has a resistance and synchronous reactance of 0.3Ω and 3Ω per phase respectively. The open circuit voltage is 600V. If the friction and core losses total 1kw, calculate the line current and power factor when the motor output is 100hp. [7M]