SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

SUBJECT : EE8401 / Electrical Machines-II

SEM / YEAR : IV / 2019-2020 (EVEN)

UNIT I - SYNCHRONOUS GENERATOR

Constructional details – Types of rotors – winding factors - emf equation – Synchronous reactance – Armature reaction – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus - Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input - Voltage regulation – EMF, MMF, ZPF and A.S.A methods – steady state power-angle characteristics – Two reaction theory – slip test - short circuit transients - Capability Curves.

PART – A

Q.No	Questions	BT Level	Competence	Course Outcome
1.	Identify the type of synchronous generators that are used in hydroelectric plant.	BTL 1	Remember	CO 1
2.	What are the advantages of salient pole type construction used for synchronous machines?	BTL 2	Understand	CO 1
3.	Why is the field system of an alternator made as a rotor?	BTL 3	Apply	CO 1
4.	Differentiate single layer and double layer winding.	BTL 4	Analyze	CO 2
5.	Summarize winding factors of an alternator.	BTL 5	Evaluate	CO 2
6.	Explain the role of damper winding in synchronous generator.	BTL 5	Evaluate	CO 2
7.	Calculate the pitch factor for the under given winding: 36 stator slots, 4 poles and coil span 1 to 8.	BTL 3	Apply	CO 2
8.	What is the necessity of chording in the armature winding of a synchronous machine?	BTL 4	Analyze	CO 2
9.	Write the equation for frequency of emf induced in an alternator.	BTL 6	Create	CO 1
10.	Summarize the essential elements for generating emf in alternators.	BTL 2	Understand	CO 1
11.	Distinguish between the 'Synchronous reactance' and the 'Potier reactance' of a synchronous generator.	BTL 6	Create	CO 1
12.	Tell, what is meant by armature reaction in an alternator?	BTL 1	Remember	CO 1
13.	Express what is meant by alternator on infinite bus-bars?	BTL 2	Understand	CO 1

14.	Demonstrate the conditions to be satisfied for parallel operation of alternators.	BTL 3	Apply	CO 1
15.	What is synchronizing power of an alternator?	BTL 1	Remember	CO 1
16.	Explain the causes of voltage drop in an alternator when loaded.	BTL 4	Analyze	CO 1
17.	Define voltage regulation.	BTL 1	Remember	CO 1
18.	List the various methods to determine the voltage regulation.	BTL 1	Remember	CO 6
19.	Why the concept of Two reaction theory is applied only to salient pole machines.	BTL 2	Understand	CO 1
20.	Distinguish between transient and sub-transient reactances.	BTL 1	Remember	CO 1
	PART – B			
1.	(i) Define armature reaction and explain the effect of armature reaction on different power factor loads of synchronous generators. (7) (ii) Derive the EMF equation of a 3-phase synchronous machine. (6)	BTL 1	Remember	CO 1
2.	Describe how the direct and quadrature-axis reactances of a salient-pole synchronous machine can be estimated by means of slip test. (13)	BTL 1	Remember	CO 6
3.	(i) Explain phasor diagram of one phase of a synchronous generator and describe the features of synchronous impedance. (6) (ii) A 3-phase, 50 Hz, star-connected alternator with 2-layer winding is running at 600 rpm. It has 12 turns/coil, 4 slots/pole/phase and a coil-pitch of 10 slots. If the flux/pole is 0.035 Wb sinusoidally distributed, find the phase and line emf's induced. Assume that the total turns/phase are series connected. (7)	BTL 4	Analyze	CO 1
4.	(i) Two similar, 3 phase alternators work in parallel and deliver a total real power of 1800 kW at 11 kV and at 0.85 pf lagging to the load. Each alternator initially supplied half the load power. The excitation of the first alternator is then increased such that its line current becomes 60 A lagging. Find the line current delivered by the second alternator. (6) (ii) Examine the given 50kVA, Y-connected, 440V, 3-phase, 50Hz alternator, has the effective armature resistance is 0.25Ω/phase. The synchronous reactance is 3.2Ω/phase and leakage reactance is 0.5Ω/phase. Determine at rated load at unity power factor: a) Internal e.m.f. **Ea** b) no load e.m.f. **Eo** c) percentage regulation on full load d) value of synchronous reactance which replaces armature reaction.(2+1+2+2)	BTL 1	Remember	CO 1 CO 6
5.	Describe the parallel operation of three phase alternators with help of a neat diagram. (13)	BTL 1	Remember	CO 1

<table>
<tr><td>6.</td><td>(i) Sketch and explain the open-circuit and short-circuit characteristics of synchronous machines. (5)
(ii) Define the terms synchronous reactance and voltage regulation of alternator. Explain synchronous impedance method for determining regulation of an alternator. (8)</td><td>BTL 4</td><td>Analyze</td><td>CO 6</td></tr>
<tr><td>7.</td><td>Predict the full load voltage regulation of a 3-phase star-connected, 1000kVA, 11,000V alternator has rated current of 52.5A. The ac resistance of the winding per phase is 0.45Ω. The test results are given below:
OC Test: field current = 12.5A, voltage between lines=422V
SC Test: field current = 12.5A, line current = 52.5A
(i) For 0.8 pf lagging and (ii) 0.8 pf leading. (7+6)</td><td>BTL 2</td><td>Understand</td><td>CO 6</td></tr>
<tr><td>8.</td><td>The following data were obtained for the OCC of a 10MVA, 13kV, 3-phase, 50Hz, Y- connected synchronous generator:
<table>
<tr><td>Field Current (A)</td><td>50</td><td>75</td><td>100</td><td>125</td><td>150</td><td>162.5</td><td>200</td><td>250</td><td>300</td></tr>
<tr><td>O.C. voltage (kV)</td><td>6.2</td><td>8.7</td><td>10.5</td><td>11.8</td><td>12.8</td><td>13.2</td><td>14.2</td><td>15.2</td><td>15.9</td></tr>
</table>
An excitation of 100A causes the full load current to flow during the short-circuit test. The excitation required to give the rated current at zero pf and rated voltage is 290A.
(i) Calculate the adjusted synchronous reactance of the machine.
(ii) Calculate the leakage reactance of the machine assuming the resistance to be negligible.
(iii) Determine the excitation required when the machine supplies full-load at 0.8 pf lagging by using the leakage reactance and drawing the mmf phasor diagram. What is the voltage regulation of the machine? Also calculate the Voltage regulation for this loading using the adjusted synchronous reactance. Compare and comment upon the two results. (4+3+6)</td><td>BTL 3</td><td>Apply</td><td>CO 6</td></tr>
<tr><td>9.</td><td>Describe the principle and construction of slow speed operation generator with neat diagram. (13)</td><td>BTL 2</td><td>Understand</td><td>CO 1</td></tr>
<tr><td>10.</td><td>(i) Describe the POTIER method of determining the regulation of an alternator. (5)
(ii) A 3.3kV alternator gave the following results:
<table>
<tr><td>Field current (A)</td><td>16</td><td>25</td><td>37.5</td><td>50</td><td>70</td></tr>
<tr><td>O.C. voltage (kV)</td><td>1.55</td><td>2.45</td><td>3.3</td><td>3.75</td><td>4.15</td></tr>
</table>
A field current of 18A is found to cause the full load current to flow through the winding during short circuit test. Predetermine the full load voltage regulation at (a) 0.8 pf lag and (b) 0.8 pf lead by MMF method. (4+4)</td><td>BTL 3</td><td>Apply</td><td>CO 6</td></tr>
<tr><td>11.</td><td>(i) What is meant by Synchronizing? State the conditions for paralleling alternator with infinite busbars. (5)
(ii) Point out the assumptions made in the potier method and explain the effect of these assumptions on the accuracy of the voltage regulation. (8)</td><td>BTL 4</td><td>Analyze</td><td>CO 1
CO 6</td></tr>
<tr><td>12.</td><td>Discuss the two reaction theory of salient pole alternator. (13)</td><td>BTL 2</td><td>Understand</td><td>CO 1</td></tr>
</table>

13.	Generalize the EMF & MMF methods of determining the regulation of an alternator. (13)	BTL 6	Create	CO 6
14.	Summarize the discussion on capability curve with its boundaries of synchronous machine. (13)	BTL 5	Evaluate	CO 1

PART – C

1. A 1.1 MVA, 2.2 kV, 3-phase, star-connected alternator gave the following test result during OC and SC tests:

Field Current (A)	10	20	30	40	50
Open circuit voltage (kV)	0.88	1.65	2.20	2.585	2.86
Short circuit current (A)	200	400	-	-	-

The effective resistance of the 3-phase winding is 0.22Ω/ph. Estimate the full-load voltage regulation at 0.8pf lagging
i) By synchronous impedance method and
ii) Ampere-turn method. (8+7)

BTL 5 | Evaluate | CO 6

2.	Generalize the Equivalent circuit and phasor diagrams of a Synchronous generator for different power factor loading. (15)	BTL 6	Create	CO 1

3. A 3 phase Y-connected, 1000 KVA, 2000V, 50HZ, alternator gave the following open-circuit and short circuit test readings:

I_f(A)	10	20	25	30	40	50
$V_{O.C}$ (V)	800	1500	1760	2000	2350	2600
$I_{S.C}$ (A)	-	200	250	300	-	-

The armature effective resistance per phase s 0.2 Ω. Draw the characteristic curves and Deduce the full load percentage regulation at (i) 0.8 p.f lagging, (i) 0.8 p.f leading by MMF method. (8+7)

BTL 5 | Evaluate | CO 6

4.	Formulate clearly the A S A method of determining the regulation of an alternator. (15)	BTL 6	Create	CO 6

UNIT II - SYNCHRONOUS MOTOR

Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed - Hunting – natural frequency of oscillations – damper windings - synchronous condenser.

PART – A

Q.No	Questions	BT Level	Competence	Course Outcome
1.	List the main parts of synchronous motor.	BTL 1	Remember	CO 3
2.	Show the two fundamental characteristics of a rotating magnetic field.	BTL 3	Apply	CO 3
3.	Point out why synchronous motor is not a self-starting motor.	BTL 4	Analyze	CO 3
4.	Why a 3-phase synchronous motor will always run at synchronous speed?	BTL 5	Evaluate	CO 3
5.	Discuss how can we change the operating speed of synchronous motor.	BTL 2	Understand	CO 3
6.	Write down the significance of V and inverted V curves.	BTL 5	Evaluate	CO 3
7.	Discuss about 'Torque angle'.	BTL 2	Understand	CO 3

8.	Develop voltage equation of synchronous motor.	BTL 6	Create	CO 3
9.	Illustrate the typical torque angle characteristics of synchronous machine.	BTL 3	Apply	CO 3
10.	Name the various torques associated with a synchronous motor.	BTL 1	Remember	CO 3
11.	Name the starting methods of synchronous motor.	BTL 1	Remember	CO 3
12.	How does a change of excitation affect its power factor?	BTL 1	Remember	CO 3
13.	A 3-phase synchronous motor driving a constant load torque draws power from infinite bus at leading power factor. How power angle and power factor will change if the excitation is increased?	BTL 2	Understand	CO 3
14.	Invent what happens when the load on the synchronous motor is changed.	BTL 6	Create	CO 3
15.	What is hunting.	BTL 1	Remember	CO 3
16.	Express the causes of hunting.	BTL 2	Understand	CO 3
17.	Explain the methods of reducing the space harmonics in a machine.	BTL 4	Analyze	CO 3
18.	What for damper windings are provided in a synchronous machines?	BTL 3	Apply	CO 3
19.	How the synchronous motor can be used as synchronous condenser?	BTL 4	Analyze	CO 3
20.	List the inherent disadvantages of synchronous motor.	BTL 1	Remember	CO 3
	PART – B			
1.	Explain briefly the features and principle of operation of three-phase synchronous motor. (13)	BTL 2	Understand	CO 3
2.	(i) Tabulate the characteristic features of synchronous motor. (3) (ii) Describe how the behaviour of a synchronous motor differ from that of a 3 phase induction motor. (4) (iii) Describe the reasons for the synchronous motor fails to start. (6)	BTL 1	Remember	CO 3
3.	(i) Show that the synchronous motor is a variable power factor motor. (7) (ii) List the advantages of salient pole in synchronous motor. (6)	BTL 1	Remember	CO 3
4.	Draw the simplified equivalent circuit of synchronous motor and examine the effect of loading in synchronous motor at various power factors with help of phasor diagrams. (13)	BTL 1	Remember	CO 3
5.	(i) Derive the mechanical power developed per phase of a synchronous motor. (7) (ii) Derive the expression for maximum torque developed per phase of synchronous motor. (6)	BTL 2	Understand	CO 3
6.	(i) Explain in detail the V curve and inverted V curve of a synchronous motor. (7) (ii) Explain in detail the method of starting of (6)	BTL 4	Analyze	CO 3

7.	(i) What are 'constant excitation circles and constant power circle' for a synchronous motor? How are they derived? (8) (ii) A 3-phase star connected synchronous motor rated at 187kVA, 2300V, 47A, 50Hz, 187.5 rpm has an effective resistance of 1.5 ohm and a synchronous reactance of 20 ohm per phase. Determine the internal power developed by the motor when it is operating at rated current and 0.8 power factor leading. (5)	BTL 1	Remember	CO 3
8.	A 5kW, three-phase Y-connected 50 Hz, 440V, cylindrical rotor synchronous motor operates at rated condition with 0.8 pf leading. The motor efficiency excluding field and stator losses is 95% and Xs=2.5Ω. Calculate: i) Mechanical power developed (4) ii) Armature Current (2) iii) Back emf (2) iv) Power angle (2) v) Maximum or pull out torque of the motor. (3)	BTL 4	Analyze	CO 3
9.	A 6600V, 3 phase, star connected synchronous motor draws a full load current of 80A at 0.8pf leading. The armature resistance is 2.2Ω and reactance of 22Ω per phase. If the stray losses of the machine are 3200W. Find (i) Emf induced (ii) Output power (iii) Efficiency of the machine. (5+4+4)	BTL 2	Understand	CO 3
10.	Generalize the effect of changing field current excitation at constant load on synchronous motor.	BTL 6	Create	CO 3
	(13)			
11.	Examine in detail the effect of varying excitation on armature current and power factor of synchronous motor.	BTL 3	Apply	CO 3
	(13)			
12.	A 1000 kVA, 11000 V, 3–phase star-connected synchronous motor has an armature resistance and reactance per phase of 3.5Ω and 40 Ω respectively. Determine the induced emf and angular retardation of the rotor when fully loaded at 0.8 p.f. lagging and 0.8 p.f. leading. (13)	BTL 5	Evaluate	CO 3
13.	Illustrate the phenomenon of hunting and the use of damper winding with the help of dynamic equations.	BTL 3	Apply	CO 3
	(13)			
14.	With phasor diagram illustrate how synchronous motor can be used as a synchronous condenser. (13)	BTL 4	Analyze	CO 3
	PART – C			
1.	Deduce the expression for power delivered by a synchronous motor in terms of load angle (α). (15)	BTL 5	Evaluate	CO 3
2.	A 3300V, delta connected motor has a synchronous reactance per phase of 18 ohm. It operates at a leading power factor of 0.707 when drawing 800 kW from the mains. Calculate its excitation emf. (15)	BTL 5	Evaluate	CO 3

3.	Formulate the power flow equations for a synchronous motor. (15)	BTL 6	Create	CO 3
4.	What if, the effect of varying field current and load change on a Synchronous motor. (15)	BTL 6	Create	CO 3

UNIT III - THREE PHASE INDUCTION MOTOR

Constructional details – Types of rotors – Principle of operation – Slip – cogging and crawling - Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Double cage induction motors – Induction generators – Synchronous induction motor.

PART – A

Q.No	Questions	BT Level	Competence	Course Outcome
1.	Demonstrate why the stator core of induction motor made of silicon content steel stamping.	BTL 3	Apply	CO 4
2.	Why are the slots on the cage rotor of induction motor usually skewed.	BTL 2	Understand	CO 4
3.	Classify the two types of 3-phase induction motor.	BTL 2	Understand	CO 4
4.	Describe why an induction motor is called a 'rotating transformer'.	BTL 1	Remember	CO 4
5.	Why is it objectionable to start large three phase induction motor by switching it directly on the line?	BTL 6	Create	CO 4
6.	A 3-phase induction motor is wound for 4 poles and is supplied from 50 Hz system. Calculate the speed at which the magnetic field of the stator is rotating.	BTL 4	Analyze	CO 4
7.	Why an induction motor will never run at its synchronous speed?	BTL 2	Understand	CO 4
8.	Define Pullout torque.	BTL 1	Remember	CO 4
9.	Describe cogging in an induction motor.	BTL 1	Remember	CO 4
10.	What measure can be taken for minimizing the effect of crawling in a 3-phase induction motor?	BTL 4	Analyze	CO 4
11.	Explain the power development stages in an induction motor.	BTL 3	Apply	CO 4
12.	Identify the condition of maximum torque developed in three phase induction motor.	BTL 1	Remember	CO 4
13.	Explain why an induction motor, at no-load, operates at very low power factor.	BTL 3	Apply	CO 4
14.	Describe how do change in supply voltage and frequency affect the performance of a 3 phase induction motor.	BTL 2	Understand	CO 4
15.	Generalize why staring torque of a squirrel cage induction motor cannot be altered when the applied voltage is constant.	BTL 6	Create	CO 4
16.	Explain the purpose of conducting blocked rotor test.	BTL 4	Analyze	CO 4
17.	Draw the torque-slip characteristic of double-cage induction motor.	BTL 5	Evaluate	CO 4

18.	State the merits and demerits of double squirrel cage induction machines.	BTL 1	Remember	CO 4
19.	List the applications of 3-phase induction motor.	BTL 1	Remember	CO 4
20.	Explain about an induction generator?	BTL 5	Evaluate	CO 4
	PART – B			
1.	Describe the construction and working principle of 3 phase induction motor. (13)	BTL 1	Remember	CO 4
2.	(i) Distinguish between Synchronous motor and Induction motor. (5) (ii) Discuss the phenomena of Cogging or magnetic locking and Crawling in an induction motor. (8)	BTL 2	Understand	CO 4
3.	(i) A 3 phase induction motor has a starting torque of 100% and a maximum torque of 200% of the full load torque. Evaluate: (a) Slip at which maximum torque occurs. (b) Full load slip. (c) Rotor current at starting in per unit of full-load rotor current. (3+2+2) (ii) An induction motor has an efficiency of 0.9 when the shaft load is 45 kW. At this load, stator ohmic loss and rotor ohmic loss each is equal to the iron loss. The mechanical loss is one-third of the no-load losses. Neglect ohmic losses at no-load. Calculate the slip. (6)	BTL 5	Evaluate	CO 4
4.	(i) Explain in detail the equivalent circuit of 3 phase induction motor. (5) (ii) A 40 kW, 3 phase slip-ring induction motor of negligible stator impedance runs at a speed of 0.96 times synchronous speed at rated torque. The slip at maximum torque is four times the full load value. If the rotor resistance of the motor is increased by 5 times, determine: (a) The speed, power output and rotor copper loss at rated torque. (b) The speed corresponding to maximum torque. (4+4)	BTL 4	Analyze	CO 4
5.	Sketch and Explain the torque slip characteristics of 3 phase cage and slip-ring induction motors. Show the stable region in the graph. (13)	BTL 4	Analyze	CO 4
6.	Derive the expression for torque under running condition of a 3-phase induction motor and obtain the condition for maximum torque. (13)	BTL 1	Remember	CO 4
7.	Discuss the different power stages of an induction motor with losses. (13)	BTL 2	Understand	CO 4
8.	A 50 HP, 6–Pole, 50 Hz, slip ring IM runs at 960 rpm on full load with a rotor current of 40 A. Allow 300 W for copper loss in S.C. and 1200 W for mechanical losses, find R_2 per phase of the 3- phase rotor. (13)	BTL 1	Remember	CO 4
9.	A 100kW, 330V, 50Hz, 3 phase, star connected induction motor has a synchronous speed of 500 rpm. The full load slip is 1.8% and full load power factor 0.85. Stator copper loss is 2440W, iron loss is 3500W, and rotational loss is 1200W. Calculate (i) rotor copper loss, (ii) the line current and (iii) the full load efficiency.	BTL 3	Apply	CO 4
	(5+4+4)			
10.	(i) Point out the effect of change in supply voltage on starting torque, torque and slip. (7)	BTL 3	Apply	CO 4

	(ii) Point out the effect of variation of rotor resistance and rotor reactance on maximum torque, efficiency and power factor of an induction motor. (6)			
11.	(i) Explain in detail the construction of circle diagram of an induction motor. (8) (ii) Derive the expression for torque, slip and draw speed torque characteristics. (5)	BTL 4	Analyze	CO 4
12.	The test readings of a 3 phase 14.71 kW, 400 V, 50 Hz, star connected induction motor is given below: No load test : 400 V, 9 A, Cos ϕ = 0.2 Short Circuit Test: 200 V, 50 A, Cos ϕ =0.4. From the Circle Diagram estimate: (i) Line current (ii) Power Factor (iii) Slip (iv) Efficiency at full load. Also evaluate the maximum power output. (3+3+3+4)	BTL 2	Understand	CO 4
13.	Describe the following: i) induction generator ii) double cage rotor induction motors. (6+7)	BTL 1	Remember	CO 4
14.	Generalize about Synchronous-induction motor and different methods of DC excitation of rotor winding. (13)	BTL 6	Create	CO 4
PART – C				
1.	Explain how the rotating magnetic field is produced in an induction motor. (15)	BTL 5	Evaluate	CO 4
2.	Develop an equivalent circuit for three phase induction motor. State the difference between exact and approximate equivalent circuit. (15)	BTL 6	Create	CO 4
3.	A 415 V, 11 kW, 50 Hz, delta connected, three-phase energy efficient induction motor gave the following test results: No load test : 415 V, 5.8 A, 488 W Blocked rotor test : 40 V, 18.4 A, 510 W Stator resistance per phase=0.7 Ω. For full-load condition, find i) line current ii) power factor iii) input power iv) slip and v) efficiency. (3+3+3+3+3)	BTL 5	Evaluate	CO 4
4.	A 3-phase, 400 V induction motor gave the following test reading: No-load : 400 V, 1250 W, 9 A Short circuit: 150 V, 4 kW, 38 A Draw the circle diagram. If the normal rating is 14.9 kW, find from the circle diagram, the full-load value of current, power factor and slip. (15)	BTL 6	Create	CO 4

UNIT IV - STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

Need for starting – Types of starters – DOL, Rotor resistance, Autotransformer and Star-delta starters – Speed control – Voltage control, Frequency control and pole changing – Cascaded connection - V/f control – Slip power recovery scheme - Braking of three phase induction motor: Plugging, dynamic braking and regenerative braking.

PART – A

Q.No	Questions	BT Level	Competence	Course Outcome
1.	What is the need of starter for induction motor?	BTL 1	Remember	CO 4

2.	Identify the cheapest method of starting a three phase induction motor?	BTL 1	Remember	CO 4
3.	Express the relationship between staring torque and full load torque of DOL Starter?	BTL 2	Understand	CO 4
4.	List the advantages of rotor resistance starter based induction motor starting.	BTL 1	Remember	CO 4
5.	Illustrate Auto transformer starting of 3-phase Induction Motor.	BTL 3	Apply	CO 4
6.	Describe about the star-delta starter.	BTL 1	Remember	CO 4
7.	Give the typical magnitude of starting current & torque for induction motor?	BTL 2	Understand	CO 4
8.	What are the different methods of speed control employed in three phase cage induction motor?	BTL 1	Remember	CO 4
9.	Summarize the different methods of speed control on stator side of induction motor.	BTL 5	Evaluate	CO 4
10.	Summarize the different methods of speed control from rotor side of induction motor.	BTL 2	Understand	CO 4
11.	Criticize "is speed control by changing the applied voltage is simpler".	BTL 5	Evaluate	CO 4
12.	What if "the number of poles of an induction motor Increases".	BTL 6	Create	CO 4
13.	Show the cascade connections of induction motor.	BTL 3	Apply	CO 4
14.	Illustrate the advantages and disadvantages of V/F speed control of an induction motor.	BTL 3	Apply	CO 4
15.	Generalize how is super-synchronous speed achieved, while controlling the speed of an induction motor.	BTL 6	Create	CO 4
16.	Discuss the advantages of slip power scheme. And also mention the types.	BTL 2	Understand	CO 4
17.	Point out the two advantages of speed control of induction motor by injecting an e.m.f in the rotor circuit.	BTL 4	Analyze	CO 4
18.	What type of braking is employed during deceleration of an induction motor?	BTL 1	Remember	CO 4
19.	What are the conditions for regenerative braking of an induction motor to be possible?	BTL 4	Analyze	CO 4
20.	Compare Plugging, Dynamic braking and Regenerative braking.	BTL 4	Analyze	CO 4
PART – B				
1.	Discuss the various starting methods of induction motors. (13)	BTL 1	Remember	CO 4
2.	Describe why starters are necessary for starting 3-phase induction motors? Name the different types of starters and explain DOL Starter. (13)	BTL 1	Remember	CO 4
3.	With neat diagrams explains the working of any two types of starters used for squirrel cage type 3 phase induction motor. (13)	BTL 4	Analyze	CO 4

4.	Discuss the following starters for three phase induction motor: (i) Autotransformer starter. (6) (ii) Star-Delta Starter. (7)	BTL 2	Understand	CO 4
5.	(i) Describe a starter available for a 3-phase slip ring induction motor. (5) (ii) A small squirrel cage induction motor has a starting current of six times the full load current and a full load slip of 0.5. Estimate in pu of full-load values, the line current and starting torque with the following methods of starting ((a) to (d)). (a) Direct Switching, (b) Stator resistance starting with motor current limited to 2p.u, (c) auto-transformer starting with motor current limited to 2p.u, and (d) Y-delta starting. (e) What auto transformer ratio would give 1pu starting torque? (1+2+2+2+1)	BTL 2	Understand	CO 4
6.	The ratio of maximum torque to full load torque in a 3 phase squirrel cage induction motor is 2.5:1. Evaluate the ratio of actual torque to full load torque for the following cases: (4+4+5) (i) Direct starting (ii) Star delta Starting (iii) Auto-transformer starting having voltage per phase at starting as 65% of supply. The rotor resistance and reactance per phase are 0.4 ohm and 4 ohm, respectively.	BTL 5	Evaluate	CO 4
7.	The rotor resistance per phase of a 3-phas, 60 kW induction motor is 0.020 W. Design a starter for this induction motor having six notches, where the upper current limit has to be the full load current so that the slip is 2.5%. (13)	BTL 6	Create	CO 4
8.	A 15 H.P., three phase, 6 pole, 50 Hz, 400 V, delta connected IM runs at 960 rpm on full load. If it takes 86.4A on direct starting. Calculate the ratio of starting torque to full-load torque with a star- delta starter. Full load efficiency and power factor are 88% and 0.85 respectively. (13)	BTL 3	Apply	CO 4
9.	Describe the following: (i) Rotor Resistance Starter for Starting Slipring Induction Motor. (ii) Speed Control of an induction motor by changing the frequency and Poles. (7+6)	BTL 1	Remember	CO 4
10.	Illustrate the rotor rheostat control of 3 phase slip ring induction motor. (13)	BTL 3	Apply	CO 4
11.	Discuss the cascade operation of induction motors to obtain variable speed. (13)	BTL 2	Understand	CO 4
12.	Explain the following methods of speed control scheme. (i) Cascaded connection. (ii) V/f Control. (7+6)	BTL 4	Analyze	CO 4
13.	(i) Explain briefly the various speed control schemes of induction motor. (7) (ii) Explain in detail the scherbius system of speed control. (6)	BTL 4	Analyze	CO 4

14.	A 400 V induction motor runs at a speed of 1440 rpm when supplied from a 50 Hz source. Find its speed at 30 Hz when the load torque is constant. The frequency is varied while maintaining the ratio (V/f) constant. (13)	BTL 1	Remember	CO 4
PART – C				
1.	Summarize the different types of braking of three phase induction motor. (15)	BTL 5	Evaluate	CO 4
2.	Explain the different methods of slip power recovery schemes. (15)	BTL 5	Evaluate	CO 4
3.	Generalize the different types of Starters used to start the induction motor. (15)	BTL 6	Create	CO 4
4.	A 3 phase 50 Hz, 12 pole, 200 kW slip-ring induction motor drives a fan whose torque is proportional to the square of speed. At full load, the motor slip is 0.045. The rotor resistance measured between any two slip-rings is 61 mΩ. Invent what resistance should be added in the rotor circuit to reduce the fan speed to 450 rpm? (15)	BTL 6	Create	CO 4

UNIT V – SINGLE PHASE INDUCTION MOTORS AND SPECIAL MACHINES

Constructional details of single phase induction motor – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor - Shaded pole induction motor - Linear induction motor – Repulsion motor - Hysteresis motor - AC series motor - Servo motors - Stepper motors - introduction to magnetic levitation systems.

PART – A

Q.No	Questions	BT Level	Competence	Course Outcome
1.	Summarize why single phase induction motor is not self-starting. What are the various methods available for making a single-phase motor self-starting?	BTL 5	Evaluate	CO 5
2.	Discuss the double revolving field theory.	BTL 2	Understand	CO 5
3.	Distinguish the terms rotating and pulsating magnetic fields.	BTL 4	Analyze	CO 5
4.	Identify the inherent characteristics of plain 1-phase induction motor.	BTL 1	Remember	CO 5
5.	Show the no load vector diagram for single phase induction motor.	BTL 3	Apply	CO 5
6.	Develop the Speed torque characteristics of single phase induction motor.	BTL 6	Create	CO 5
7.	Name the two windings of a single-phase induction motor.	BTL 1	Remember	CO 5
8.	Examine why centrifugal switches are provided in many 1-phase induction motors.	BTL 3	Apply	CO 5
9.	Design the capacitor rating required for an induction motor?	BTL 6	Create	CO 5
10.	Illustrate why capacitor-start induction motors are advantageous.	BTL 3	Apply	CO 5
11.	Explain how the direction of a capacitor-start motor can be reversed.	BTL 4	Analyze	CO 5

12.	Summarize the advantages of capacitor start induction motor over split-phase induction motor.	BTL 2	Understand	CO 5
13.	What is the role of ‘magnetic bridges’ in the operation of a shaded pole induction motor?	BTL 1	Remember	CO 5
14.	State the limitations of shaded pole motors.	BTL 2	Understand	CO 5
15.	Predict the type of motor that is used for ceiling fan.	BTL 1	Remember	CO 5
16.	Specify the use of single-phase induction motor.	BTL 1	Remember	CO 5
17.	What is the principle of operation of a linear induction motor?	BTL 1	Remember	CO 5
18.	What is the necessity of having laminated yoke in an ac series motor?	BTL 4	Analyze	CO 5
19.	Discuss the working principle of repulsion motor.	BTL 2	Understand	CO 5
20.	What is the principle of reluctance motor?	BTL 5	Evaluate	CO 5
PART – B				
1.	Give the classification of single phase motors. Explain any two types of single phase induction motors. (13)	BTL 2	Understand	CO 5
2.	Using double field revolving theory, compose why a single phase induction motor is not self-starting. Also obtain the equivalent circuit of single phase induction motor with necessary equations. (13)	BTL 6	Create	CO 5
3.	(i) Illustrate the operation of single phase induction motor with double field revolving theory. (7) (ii) A 220 V, 6-pole, 50 Hz, single phase induction motor has the following equivalent circuit parameters as referred to the stator. (3+3) $R_{1m} = 3.0\ \Omega$, $X_{1m} = 5.0\ \Omega$ $R_2 = 1.5\ \Omega$, $X_2 = 2.0\ \Omega$ Neglect the magnetizing current. When the motor runs at 97% of the synchronous speed, Compute the following: (i) The ratio E_{mf}/E_{mb} (ii) The ratio T_f/T_b	BTL 3	Apply	CO 5
4.	Describe the no-load test and blocked rotor test for obtaining the equivalent circuit parameters of a single phase induction motor. (13)	BTL 1	Remember	CO 5
5.	The equivalent circuit parameters of a 230 V, 50 Hz, single phase induction motor having friction, windage loss and core loss of 50 W are given below: $R_{1m} = 2.4\ \Omega$, $X_{1m} = 3.2\ \Omega$ $R_{2'} = 4.7\ \Omega$, $X_{2'} = 2.8\ \Omega$ and $X_m = 90\ \Omega$. Examine (i) Input current (2) (ii) Power Factor (3) (iii) Developed power (3) (iv) Output power and (3) (v) Efficiency for a slip of 0.04. (2)	BTL 3	Apply	CO 5

6.	The equivalent impedance of the main and auxiliary winding in a capacitor motor are (15+j25)Ω and (50+ j120)Ω respectively, while the capacitance of the capacitor is 12μF. Estimate the line current at starting a 230 V, 50Hz supply. (13)	BTL 2	Understand	CO 5
7.	(i) Explain in detail the operation of capacitor start and run induction motor. (7) (ii) Explain with suitable diagram the working principle of split-phase induction motor. (6)	BTL 4	Analyze	CO 5
8.	Explain the working of linear induction motor and also write its applications. (13)	BTL 5	Evaluate	CO 5
9.	Describe briefly about the Repulsion motor. (13)	BTL 1	Remember	CO 5
10.	Discuss the construction, operation and characteristics of the following: (i) Repulsion motor. (7) (ii) Servo motor. (6)	BTL 2	Understand	CO 5
11.	Explain briefly the following: (i) Linear induction motor. (7) (ii) AC Series motor. (6)	BTL 4	Analyze	CO 5
12.	(i) Describe what kind of modifications have to be done on a DC series motor to make it to work with single phase AC supply. State the applications of AC series motors. (6) (ii) Describe the constructional details, principle of operation and the application of Hysteresis motor. (7)	BTL 1	Remember	CO 5
13.	Describe the construction and working principle of the following special machines: (i) Stepper motors. (7) (ii) Shaded pole induction motor. (6)	BTL 1	Remember	CO 5
14.	(i) Explain the theory of brushless DC Machines. (7) (ii) Write short notes on Stepper Motor. (6)	BTL 4	Analyze	CO 5
	PART – C			
1.	Summarize the constructional details, principle of operation and the application of Hysteresis motor and AC Series motor. (15)	BTL 5	Evaluate	CO 5
2.	Explain briefly the determination of Steady state Equivalent Circuit parameters of Single Phase Induction Motor from No-load and Blocked Rotor Tests. (15)	BTL 5	Evaluate	CO 5
3.	Generalize about Magnetic Levitation Systems. (15)	BTL 6	Create	CO 5
4.	A 220 V, single phase induction motor gave the following test results: Blocked rotor test: 120V, 9.6 A, 460 W; No-load test: 220V, 4.6 A, 125 W. The Stator winding resistance is 1.5 Ω, and during the blocked rotor test, the starting winding is open. Prepare the Equivalent circuit parameters, core, friction and windage losses. (15)	BTL 6	Create	CO 5

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