MAY 2025

409/3(N)

INDUCTION, SYNCHRONOUS AND SPECIAL ELECTRICAL MACHINES

Time Allowed: 2.5 Hours *Full Marks: 60*

Answer to Question No. 1 of Group A must be written in the main answer script. In Question No. 1, out of 2 marks for each MCQ, 1 mark is allotted for right answer and 1 mark is allotted for correctexplanation of the answer.

Answer any Five (05) Questions from Group-B.

GROUP-A

1. Choose the correct answer from the given alternatives and explain your answer (any ten): 2x10=20

i. In three phase induction motor –
a) Both stator & rotor core is laminated b) only stator core is laminated
c) only rotor core is laminated d) none of these

ii. With the increase in rotor resistance, the starting torque in the induction motor will-
a) Increase b) decrease c) remain same d) none of these

iii. A three-phase induction motor draws 50 KW from 220V, 50 Hz mains. The rotor EMF makes 100 oscillations/minute. If the stator losses are 2 kW, the rotor copper loss would be
a) 0.16 KW b) 1.6 KW c) 0.32 KW d) 3.2 KW

iv. The Slip of a single-phase induction motor is 0.04. Then slip due to backward rotating field is
a) 0.94 b) 0.96 c) 1.94 d) 1.96

v. The power factor of single-phase induction motor at light loads is
a) unity b) leading c) lagging d) None of these

vi. A 1 phase motor which does not have any winding on its rotor is
a) Shaded pole motor b) hysteresis motor c) reluctance motor d) series motor

vii. When several alternators are operating in parallel, the power factor at which each operates is determined by_____.
a) power factor of the load. b) driving torque of the prime mover. c) its field excitation.
d) none of the above.

viii. For zero power factor leading power load, the armature flux in an alternator
a) distorts the rotor flux. b) aids the rotor flux. c) opposes the rotor flux.
d) does not affect the rotor flux.

ix. A synchronous generator has a synchronous reactance of 5 ohms and is supplying a load current of 10 A. The terminal voltage is 400 V. What is the generated EMF?
a) 380 V b) 420 V c) 450 V d) 480 V

x. When the synchronous motor runs at synchronous speed, the voltage induced in the damper Winding is_____.
a) maximum b) minimum c) zero d) none of the above

xi. At full load, the rotor poles of a synchronous motor are displaced by a mechanical angle of 1° from their no-load position. If the machine has 40 poles, then torque angle is _____.
a) 40° electrical b) 20° electrical c) 10° electrical d) none of the above

xii. The significance of the load angle in a synchronous motor is to:
a) Indicate the efficiency b) Determine the power factor c) Represent the phase difference between rotor and stator magnetic fields d) Measure the mechanical losses

xiii. Operation of stepper motor at high speeds is called_____.
a) inching b) cogging c) crawling d) slewing

xiv. What is the role of the Hall-effect sensor in a BLDC motor?
a) To measure the current in the stator windings b) To provide feedback on the rotor position c) To regulate the motor's temperature d) To provide external power supply to the motor

xv. Which of the following is a primary characteristic of an AC servomotor?
a) It operates at a fixed speed regardless of load b) It provides continuous rotation without the need for feedback c) It operates in an open-loop system without feedback d) It provides precise control of speed and position with feedback

GROUP-B
Answer any Five (05) questions.

2. i) Explain speed torque characteristics of a three-phase induction motor.
ii) A three-phase, 4 pole, 50 Hz induction motor has a star connected rotor. The rotor has a resistance of 0.2 Ωper phase and standstill reactance of 2.4 Ω per phase. The induced EMF between slip rings at standstill is 120 V. If the full load speed is 1440 rpm, calculate at full load (a) the slip (b) the EMF induced in rotor per phase (c) the rotor reactance per phase (d) the rotor current (e) rotor power factor. Assume the slip rings are to be short circuited. (3+5)

3. i) A 3-phase, 400/200-V, Y-Y connected wound-rotor induction motor has 0.06Ω rotor resistance and 0.3 Ω standstill reactance per phase. Find the additional resistance required in the rotor circuit to make the starting torque equal to the maximum torque of the motor.
ii) Derive the torque equation of a 3-phase induction motor under running condition and obtain the condition for maximum running torque. (4+4)

4. i) Draw and explain the operation of star-delta starting.
ii) Explain speed control of 3-phase induction motor by connecting rheostat at the rotor terminals. (4+4)

5. i) Explain the double-field revolving theory of a single-phase induction motor with suitable diagram.
ii) Explain operating principle of shaded-pole type single-phase induction motor and its torque-speed characteristics. (4+4)

6. i) Draw and explain the synchronous impedance method of determination of voltage regulation.
ii) A 500 kVA, 3300 V, 50 Hz, 3 phase star connected alternator has effective armature resistance and synchronous reactance per phase 0.3 Ω and 4 Ω respectively. Calculate full load voltage regulation at 0.8 power factor lagging. (4+4)

7. i) Draw and explain power v/s load angle characteristics of an alternator.
ii) Two 50 MVA, 3-phase alternators operate in parallel. The settings of the governors are such that the rise in speed from full-load to no-load is 2% in one machine and 3% in the other, the characteristics being straight line in both cases. If each machine is fully loaded when total load is 100 MW, what would be the load on each machine when the total load is 60 MW? (3+5)

8. i) Explain with necessary phasor diagram that synchronous motor is a variable power factor motor.
ii) Describe different starting methods of synchronous motor. (4+4)

9. i) Write short note on: Brushless Excitation system of a 3-phase alternator.
ii) A 4-pole, 3-phase, 50 Hz, star-connected alternator has 60 slots with 4 conductors per slot. Coils are short-pitched by 3 slots. If the phase spread is 60°, find the line voltage induced for a flux per pole of 0.943 Wb, distributed sinusoidally, All the turns per phase in series. (4+4)

10. Explain working principle and torque-speed characteristics of any two of the following motors. (4+4)
a) BLDC motor. b) Stepper motor. c) AC servo motor.