18/11/13.

B.E. / B.TECH. (FULL TIME) DEGREE EXAMINATIONS, NOV/DEC 2013

ELECTRICAL AND ELECTRONICS ENGINEERING BRANCH

4

FIFTH SEMESTER

EE 9304 – ELECTRICAL MACHINES II

(REGULATIONS 2008)

PART – A (10 x 2 = 20 Marks)

1. 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. 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.

3. A 50 Hz, three phase induction motor with synchronous speed of 100 rad/sec develops a shaft torque of 150 Nm when the rotor emf makes 120 complete cycles per minute. Compute the shaft power output for this motor.

4. Draw the speed (vs.) torque curves of slip ring induction motor whose stator supply voltage is changed such that $V'_1 > V''_1 > V'''_1$.

5. In a synchronous machine the armature reaction produces magnetizing effect under favourable conditions. Justify using the necessary phasor diagram.

6. State whether a synchronous motor can start by itself with a low frequency power supply (say 5 Hz). Justify your answer.

7. What is called torque angle of a synchronous machine?

8. State the load angle at which a synchronous machine produces maximum power and whether it can be achieved practically?.

9. Draw the torque (vs.) speed curve of a shaded pole motor.

10. Why is a capacitor start capacitor run motor better than a permanent split capacitor motor?

PART – B (5 x 16 = 80 Marks)

11. (a). 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. [8]

11. (b). Show that the synchronous motor can act as a power factor booster when connected across lagging power factor loads in the power systems. [8]

12. (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. [16]

(Or)

12. (b) A 480 V, 50 Hz, Y-connected, six-pole synchronous generator is rated at 50 kVA, at 0.8 p.f. lagging. It has a synchronous reactance of 1.0 Ω per phase. Assume that this generator is connected to a steam turbine capable of supplying up to 45 kW. The friction and windage losses are 1.5 kW, and the core losses are 1.0 kW.

(i) Sketch the capability curve for this generator, including the prime mover power limit.

(ii) Can this generator supply a line current of 56 A at 0.7 p.f. lagging. Why or why not?

(iii) If the generator supplies 30 kW of real power, what is the maximum amount of reactive power that can be simultaneously supplied? [16]

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 0.04 per unit, determine (i) motor speed in rad/sec; (ii) line current and power factor; (c) shaft torque and (d) overall efficiency. [16]

(Or)

13 (b). Enumerate the step-by-step procedure used to construct a circle diagram of a three-phase induction machine. Construct the circle diagram and mark the motoring, generating and braking region of operations. For the motoring region obtain the maximum developed torque and maximum output power. Further show the power flow in the linear operating region of the motor. [16]

14 (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. (i) what voltage is to be applied using the starter such that the motor shall develop rated torque at starting? (ii) what will be the motor starting current and the line current drawn from the supply at this voltage? [16]

(Or)

14 (b). (i) Discuss the speed control technique where both voltage and frequency are controlled simultaneously such that voltage to frequency ratio remains constant. Draw the torque (Vs.) speed curves and also draw the load torque profile for this speed control technique. [8]

(ii) 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. [8]

15. a). (i). Explain the double revolving field theory of single phase induction motors. [8]

(ii) The main and auxiliary windings of a 120 V, 60 Hz, split phase motor have the following locked rotor parameters: R_{main} = 2.0 Ω, X_{main} = 3.5Ω, R_{aux} = 9.15Ω and X_{aux} = 8.4 Ω. 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. [8]

(Or)

15. b). With neat sketches explain the principle of operation of universal motor. [16]