College of Engineering, Pune

Department of Electrical Engineering

Third Year B.Tech- (Electrical)

(Electric Machinery-II)

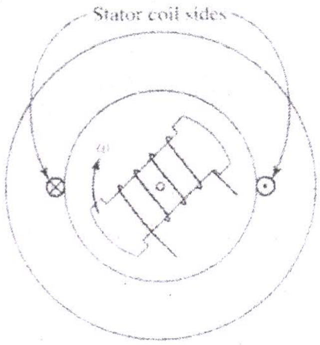
Date- 15th Nov 2013 | Timing: 3 hrs

Academic Year: 2013- 14 | Max. Marks: 100

Autumn Semester

Instructions:

1. ***Question 9** is compulsory and carry **20** marks. All other questions carry equal marks.*
2. *Solve **any FIVE** questions from remaining.*
3. *State Clearly the assumptions made*

Q. 1		Consider an armature with eight slots uniformly distributed over 360 electrical degrees corresponding to a span of one pole pair. The air gap is of uniform length, the slot openings are very small and the reluctance of the iron is negligible. The winding consists of eight single turned coils, each carrying a direct current of 10 A. Coil sides placed in any of the slot 1-4 carry current directed into the paper; those placed in any of the slots 5-8 carry current out of the paper. Draw the mmf wave for following
	a	Consider all eight coils are placed with one side in slot 1 and the other in slot 5. Remaining slots empty.
	b	Consider that four coils have one side in slot 1 and the other in slot 5. The remaining four coils have one side in slot 3 and the other in slot 7
	c	Now consider two coils in 1 and 5, two in slot 2 and 6, two in 3 and 7, and two in 4 and 8.
	d	Let the armature now consists of 16 slots per 360 electrical degrees with one coil side per slot.
	e	Now let the two coils in 1and 5 carry 5 Amps; two coils in 2 and 6 carry 10 Amps and two in 3 and 7 carry 5 amps.
Q.2		Fig. 1 shows a two pole rotor revolving inside a smooth stator which carries a coil of 110 turns. The rotor produces a sinusoidal space distribution of flux at the stator surface. The peak value of the flux density wave being 0.85 T when the current in the rotor is 15 A. The magnetic circuit is linear. The inside diameter of the stator is 11 cm, and its axial length is 0.17 m. The rotor is driven at a speed of 50 r/sec.  Fig. 1

	a	The rotor is excited by a current of 15 A. Taking zero time as the instant when the axis of the rotor is vertical, find the expression for the instantaneous voltage generated in the open circuited stator coil.
	b	The rotor is now excited by a 50 Hz sinusoidal alternating current whose peak value is 15 A. Consequently the rotor current reverses every half revolution; it is timed to be at its maximum just as the axis of the rotor is vertical. Taking zero time as the instant when the axis of the rotor is vertical, find the expression for the instantaneous voltage generated in the open circuited stator coil. Can this scheme be used as a dc generator without commutator ?
Q3		**Derive the expression for**
	a	Power developed by a salient pole synchronous machine
	b	Maximum torque of an induction motor
Q4		**Write Short notes on**
	a	Excitation systems for Synchronous Machines
	b	Double and Deep bar rotors
	c	Types of single phase motors
Q.5		A 460-V, 50-kW, 60-Hz, three-phase synchronous motor has a synchronous reactance of $X_s = 4.15\ \Omega$ and an armature-to-field mutual inductance, $L_{af} = 83$ mH. The motor is operating at rated terminal voltage and an input power of 40 kW. Calculate the magnitude and phase angle of the line-to-neutral generated voltage $\hat{E}_{af}$ and the field current I_f if the motor is operating at (*a*) 0.85 power factor lagging, (*b*) unity power factor, and (*c*) 0.85 power factor leading.
Q.6		A four-pole, 60-Hz, 24-kV, 650-MVA synchronous generator with a synchronous reactance of 1.82 per unit is operating on a power system which can be represented by a 24-kV infinite bus in series with a reactive impedance of $j0.21\ \Omega$. The generator is equipped with a voltage regulator that adjusts the field excitation such that the generator terminal voltage remains at 24 kV independent of the generator loading. a. The generator output power is adjusted to 375 MW. (i) Draw a phasor diagram for this operating condition. (ii) Find the magnitude (in kA) and phase angle (with respect to the generator terminal voltage) of the terminal current. (iii) Determine the generator terminal power factor. (iv) Find the magnitude (in per unit and kV) of the generator excitation voltage E_{af}.

Q.7		A three-phase Y-connected 220-V (line-to-line) 7.5-kW 60-Hz six-pole induction motor has the following parameter values in Ω/phase referred to the stator: $$R_1 = 0.294 \quad R_2 = 0.144$$ $$X_1 = 0.503 \quad X_2 = 0.209 \quad X_m = 13.25$$ The total friction, windage, and core losses may be assumed to be constant at 403 W, independent of load. For a slip of 2 percent, compute the speed, output torque and power, stator current, power factor, and efficiency when the motor is operated at rated voltage and frequency.
Q8		The following data apply to a 125-kW, 2300-V, three-phase, four pole, 60-Hz squirrel-cage induction motor: Stator-resistance between phase terminals = 2.23 Ω No-load test at rated frequency and voltage: Line current = 7.7 A Three-phase power = 2870 W Blocked-rotor test at 15 Hz: Line voltage = 268 V Line current = 50.3 A Three-phase power = 18.2 kW a. Calculate the rotational losses. b. Calculate the equivalent-circuit parameters in ohms. Assume that $X_1 = X_2$. c. Compute the stator current, input power and power factor, output power and efficiency when this motor is operating at rated voltage and frequency at a slip of 2.95 percent.
Q9		**Solve [any Two]**
	A	Linear induction motors have been proposed for a variety of applications including high-speed ground transportation. A linear motor based on the induction-motor principle consists of a car riding on a track. The track is a developed squirrel-cage winding, and the car, which is 4.5 m long and 1.25 m wide, has a developed three-phase, 12-pole-pair armature winding. Power at 75 Hz is fed to the car from arms extending through slots to rails below ground level. a. What is the synchronous speed in km/hr? b. Will the car reach this speed? Explain your answer. c. What is the slip if the car is traveling 95 km/hr? What is the frequency of the track currents under this condition? d. If the control system controls the magnitude and frequency of the car currents to maintain constant slip, what is the frequency of the armature-winding currents when the car is traveling 75 km/hr? What is the frequency of the track currents under this condition?

B Figure [redacted]3 shows a system consisting of a three-phase wound-rotor induction machine whose shaft is rigidly coupled to the shaft of a three-phase synchronous motor. The terminals of the three-phase rotor winding of the induction machine are brought out to slip rings as shown. With the system supplied from a three-phase, 60-Hz source, the induction machine is driven by the synchronous motor at the proper speed and in the proper direction of rotation so that three-phase, 120-Hz voltages appear at the slip rings. The induction motor has four-pole stator winding.

a. How many poles are on the rotor winding of the induction motor?

b. If the stator field in the induction machine rotates in a clockwise direction, what is the rotation direction of its rotor?

c. What is the rotor speed in r/min?

d. How many poles are there on the synchronous motor?

e. It is proposed that this system can produce dc voltage by reversing two of the phase leads to the induction motor stator. Is this proposal valid?

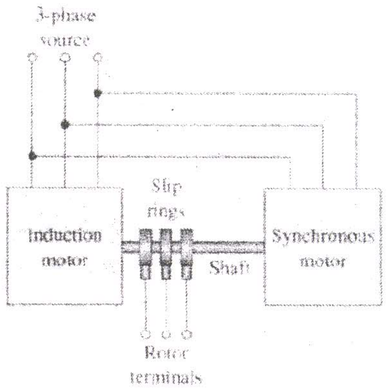


Figure [redacted]3 Interconnected induction and synchronous machines

C The full-load torque angle of a synchronous motor at rated voltage and frequency is 35 electrical degrees. Neglect the effects of armature resistance and leakage reactance. If the field current is held constant, how would the full-load torque angle be affected by the following changes in operating condition?

a. Frequency reduced 10 percent, load torque and applied voltage constant.

b. Frequency reduced 10 percent, load power and applied voltage constant.

c. Both frequency and applied voltage reduced 10 percent, load torque constant.

d. Both frequency and applied voltage reduced 10 percent, load power constant.

The End